Hot-Mix Asphalt Level II Technician Course

LAKE LAND COLLEGE

2023-2024

Illinois Department of Transportation
Central Bureau of Materials

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PREFACE:

The objective of this course is to give the student a working knowledge of HMA plant operations, mix proportioning, mixture related problem solving techniques, and basic lay-down operations needed for producing and placing of asphalt mixtures in the State of Illinois.

To supplement the lecture portion of this class, students will be put in groups to discuss unusual and recurring problems that can and/or has been experienced in the field. The object of the discussion groups is to determine solutions based off of the presented information and any personal experience. After completing the lecture portion of the course there will be a written exam.

The current Illinois Department of Transportation Standard Specifications for Road and Bridge Construction manual is effective as of January 1, 2022 and this class manual will present the information herein based on these specifications along with other supporting documents. It must be understood that the official date of an IDOT-let contract and included contract specification references will determine what specific documents and requirements will control the work to be performed by the contractor.

References in this manual and supporting specifications will use the term "IDOT QC/QA" as a description of the program but it should be understood that the term has recently been changed to "IDOT QMTP" (**Q**uality **M**anagement **T**raining **P**rogram). This new term better exemplifies the purpose of the program.

IDOT has implemented **P**ayment **F**or **P**erformance (PFP) specifications for HMA projects. This particular specification normally applies to mixture quantities in excess of 8,000 tons, although there are some exceptions. **Q**uality **C**ontrol for **P**erformance (QCP) specifications is typically for pay items or projects that don't meet PFP requirements. See the official specifications for specifics. Both types of contracts will utilize different aspects of the original QC/QA specifications.

Both types of specifications, PFP and QCP, will utilize pay factors applied to contract pay items which can and will affect the Contractor's ability to be successful when completing a HMA project in Illinois.

Although PFP and QCP specifications will not be the main focus of this class, references will be made throughout class in order to help the technician understand the importance of proper mixture control and complying with HMA contracts in Illinois. The emphasis will be on suggested ways to control the HMA production process.

Bottom line, a complete understanding of all specifications is beneficial in comprehending the importance of the contractor responsibilities of mixture control when placing HMA products in the State of Illinois.

Knowledge of all applicable specifications pertaining to HMA is vital to be successful as a HMA Quality Control manager and/or a Level II HMA technician.

Successful completion of this course will allow an individual to act in the capacity of a Quality Control manager and/or a Level II HMA technician. However, this course alone will not prepare you for what lies ahead…

…………… **ONLY EXPERIENCE CAN DO THAT!**

Hot Mix Asphalt Level II Technician Schedule Overview

Note: Schedule is tentative and can be altered to improve the class

Class starts promptly at 8:00 am and should conclude no later than 5:00 pm

DAY 1

I. Registration, Orientation, and Introductions

II. Chapter 1

A. HMA Mixtures QC/QA Specifications

1) High ESAL
2) Low ESAL

B. Bituminous Materials

C. Aggregate Specifications

1) Fine Aggregate Specifications
2) Coarse Aggregate Specifications
3) Coarse Aggregate Friction Policy

III. Chapter 2

A. General Plant Information
B. Batch Plants
C. Weigh Checks
D. Special Problems
E. Dryer-Drum Plants

IV. Chapter 3

Surge and Storage Bins

DAY 2

V. Chapter 4

Basic Proportioning and Adjustments

A. Aggregate Blending Information
B. Dryer-Drum Plant Set-up
C. RAP and/or RAS Plant Set-up
D. Batch Plant Set-up
E. Mixture Adjustment

DAY 3

VI. Chapter 5

Segregation

VII. Chapter 6

Laydown and Compaction

1) Paving Operations
2) Pavers & Rollers
3) Yield Calculations
4) Quantity Corrections

VIII. Chapter 7

Test Strip Specifications & Procedures

IX. Chapter 12

PFP & QCP Specifications

X. Chapter 11

Responsibilities & Duties Checklist
Model QC/QA Plan
Model QC/QA Addendum

DAY 4

XI. Chapter 8

Nuclear Gauges & Core Correlation Guideline Procedures

XII. Chapter 9

Mixture Evaluation & Examples

DAY 5

XII. Written Examination (4.5 hour time limit starting at 8:00 am)

Phone Policy:

Phones are a major distraction to the class and students during class. Please be responsible and turn your phone to silent or turn it off all together during class. Continued class disturbance, due to a phone, will result in the appropriate action being taken to control the situation. This could result in longer class sessions or the student being asked to leave class (see attendance policy). **PLEASE BE RESPONSIBLE FOR THE BENEFIT OF EVERYONE IN CLASS**!

Attendance Policy:

Students are required to attend all class sessions in their entirety or risk disqualification from receiving a HMA Level II Technician certification.

Students are required to be on time to all class sessions, including the first day of class, or risk disqualification from receiving a HMA Level II Technician certification.

If the student misses any class session(s), the student will be required to make up the missed session(s) in a future class. Class certification will not be approved by the instructor until all class requirements are completed, which includes the attendance policy. **There will be no exceptions to this policy!**

Prerequisite Courses:

Students are required to successfully complete: A Mixture Aggregate Technician Course (3-Day Aggregates)
or an Aggregate Technician Course (5-Day Aggregates)

and the HMA Level I Technician Course

NOTE: If you do not meet the prerequisite requirement for the HMA Level II Technician Course, the HMA Level II Technician certification will not be issued **AND** the course will have to be repeated in its entirety by the student, paying all appropriate class fees.

Written Test Policy:

Students are required to successfully complete a written test to complete the class and receive the HMA Level II Technician certification. The time limit for the written test will be 4.5 hours.

A minimum grade of 70% must be achieved in order to pass the test to receive the HMA Level II Technician certification.

Cell phones are not allowed during testing and cannot be used as a calculator. **Class failure will result if it is found that a student used a cell phone during the test**. A retest will not be allowed and the student will be required to repeat the entire class paying all appropriate class fees.

Retest Policy:

If the student fails the written test, a retest may be completed. A minimum grade of 70% will be required to pass the retest. There is no fee for the retest. The student will be required to complete the retest before the end of Lake Land College’s academic year, which runs from September 1st through August 31st (officially the last business day in August).

Arrangements for the retest must be made through the Lake Land College IDOT QMTP department. Call Kathy Willenborg at 217-234-5285.

Failure of the retest or failure to comply with the academic year retest time limit shall require the student to retake the class, in its’ entirety, paying all appropriate class fees.

Lake Land College Course and Instructor Evaluation

Course: **HMA Level II Technician** Section Number ________________ Date ____________________

Instructors: **Galen Altman**

Purpose: The main emphasis at Lake Land College is teaching. In this regard, each instructor must be continuously informed of the quality of his/her teaching skills and the respects in which these skills can be improved. As a student, you are in a position to judge the quality of instruction and materials used from direct experience, and in order to help maintain the quality of instruction at Lake Land, you are asked to complete this evaluation in an objective, **fair** and **honest** manner.

Please do not sign your name: Your anonymity will be protected so that you can be **forthright** with your evaluation of this course and the instructors. Your participation in this evaluation is greatly valued and appreciated.

Directions: Please enter the appropriate scale which seems most appropriate to you for the course and instructors. On the back of this form you are encouraged to record any comments that will clarify a particular rating. Please refer to the item on which you are commenting by noting its assigned letter.

Rate the following using this scale: **1 – Ineffective 2 – Weak 3 – Average 4 – Good 5 – Strong**

Course Evaluation: (Circle your choice)

			Rating
A)	**Objectives**	The objectives of this course were clearly and adequately covered.	1 2 3 4 5
B)	**Content**	The content covered was relevant and met the requirements of the course.	1 2 3 4 5
C)	**Organization**	Classroom activities were organized and clearly related to the subject.	1 2 3 4 5
D)	**Materials**	Instructional material and resources were current and clearly related to the course.	1 2 3 4 5
E)	**Presentation**	Content of lessons was presented so that it was understandable to the students.	1 2 3 4 5
F)	**Points of View**	When appropriate, different points of view and/or methods were used.	1 2 3 4 5
G)	**Exam**	The exam correlated well with the information covered during the class.	1 2 3 4 5

Instructor Evaluation: (Circle your choice)

			Steve	Galen
H)	**Preparation**	Was organized and prepared for each session.	1 2 3 4 5	1 2 3 4 5
I)	**Knowledge**	Was knowledgeable of the information presented.	1 2 3 4 5	1 2 3 4 5
J)	**Vocabulary**	Used appropriate and understandable terminology and vocabulary.	1 2 3 4 5	1 2 3 4 5
K)	**Participation**	Encouraged students to participate and solicited student responses.	1 2 3 4 5	1 2 3 4 5
L)	**Interest**	Indicated an interest/enthusiasm for teaching of the subject matter.	1 2 3 4 5	1 2 3 4 5
M)	**Familiarity**	Was familiar and up to date with current industry practices.	1 2 3 4 5	1 2 3 4 5
N)	**Mannerisms**	Conducted themselves in a professional manner.	1 2 3 4 5	1 2 3 4 5
O)	**Helpfulness**	Indicated a willingness to help the students as time permitted.	1 2 3 4 5	1 2 3 4 5
P)	**Impartiality**	Was fair and impartial in dealings with students in accordance to classroom policies.	1 2 3 4 5	1 2 3 4 5

↓↓↓ ↓↓↓ ↓↓↓ **Please continue filling out the other side of this form** ↓↓↓ ↓↓↓ ↓↓↓

Lake Land College Course and Instructor Evaluation

Rate the following using this scale: **1 – Ineffective 2 – Weak 3 – Average 4 – Good 5 – Strong**

SUMMARY:

Considering everything, how would you rate the instructor? (Circle your choice)

Galen

1 2 3 4 5 **1 2 3 4 5**

Please record any general impressions and/or comments about the instructors you might have:

Galen - Comments ____

____

____

Q) Considering everything, how would you rate this course? (Circle your choice)

1 2 3 4 5

Please record any general impressions and/or comments about the class and/or materials used:

General Comments ____

____

____

____

____

Please place the completed evaluation in the provided receptacle before you leave.

Do not sign your name or hand the evaluation to an instructor in order to protect your anonymity.

We thank you for your interest and participation in this course and hope you walked out more knowledgeable of the subject matter.

Cost Responsibility Example

Plant Production @ 325 Tons per Hour

325 TPH X 10 Hr/Day = 3250 Tons/Day

3250 Tons/Day X $100/Ton = $325,000 per Day

The Quality Control Manager and Level II HMA Technician are responsible:

1. To be knowledgeable of any and all specifications that applies to applicable HMA contracts in their control.

2. The proper production and placement of all HMA materials included in the contract(s) as described by the applicable specifications for the contract.

3. To address all concerns or problems that might/will arise while implementing the work of the contract.

4. To be familiar with all testing requirements for HMA established in the Manual of Test Procedures of Materials and applicable specifications.

As a Quality Control Manager and/or Level 2 HMA Technician, this translates to a **great responsibility** being placed on his/her shoulders. PFP and QCP contracts increase this responsibility even more.

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Beneficial references to specifications pertaining to HMA found the Standard Specifications for Road and Bridge Construction adopted 04/01/2016

Item	**Article**
Subgrades, Subbases, Base Course	**300**
HMA Base Course	355
HMA Base Course Widening	356
Surface Courses, Pavements, Rehabilitation and Shoulders	**400**
HMA Binder & Surface Course	406
HMA Pavement (Full-Depth)	407
HMA Incidental Surfacing	408
HMA Shoulders	482
Materials	**1000**
Fine Aggregates	1003
Coarse Aggregates	1004
Coarse Aggregate 'HMA Friction Policy' 1004.03	1004
Finely Divided Minerals	1010
Mineral Filler	1011
Hydrated Lime	1012
Hot-Mix Asphalt	1030
Reclaimed Asphalt Pavement & Reclaimed Asphalt Shingles	1031
Bituminous Materials	1032
Equipment	**1100**
Rollers	1101.01
Pavement Surface Test Equipment	1101.10
HMA Equipment	**1102**
HMA Plants – Requirements for All Plants	1102.01 (a)
Batch Plant Requirements	1102.01 (b)
Dryer Drum Plant Requirements	1102.01 (c)
Spreading & Finishing Machines	1102.03
Heating Equipment	1102.07

NOTE: In addition to the above specification references, the Manual of Test Procedures contains important information needed to help the HMA Level II Technician to determine testing and equipment specification compliance.

SECTION 1030. HOT-MIX ASPHALT

1030.01 Description. This section describes the materials, mix designs, proportioning, mixing, and transportation requirements to produce and place hot-mix asphalt (HMA) following the Quality Management Program (QMP) designated in the plans.

Warm mix asphalt (WMA) is an asphalt mixture which can be produced at temperatures lower than allowed for HMA by utilizing qualified WMA technologies. WMA is produced with the use of additives, a water foaming process, or a combination of both. WMA shall conform to all HMA specifications unless specificly noted.

For simplicity of text, the following HMA nomenclature applies to this Section.

Mixture Type	Application	Mixture-Nominal Maximum Aggregate Size
High ESAL	Binder Course	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75, SMA-12.5, SMA-9.5
	Surface Course	IL-9.5, IL-9.5FG, SMA-12.5, SMA-9.5
Low ESAL 1/	Binder Course	IL-19.0L, IL-9.5L
	Surface Course	IL-9.5L

1/ High ESAL mixtures may be used in similar Low ESAL mixture applications.

1030.02 Materials. Materials shall be according to the following.

	Item	Article/Section
(a)	Coarse Aggregate	1004.03
(b)	Fine Aggregate	1003.03
(c)	Reclaimed Asphalt Pavement	1031
(d)	Mineral Filler	1011
(e)	Hydrated Lime	1012.01
(f)	Slaked Quicklime (Note 1)	
(g)	Performance Graded Asphalt Binder	1032
(h)	Fibers (Note 2)	
(i)	WMA Technologies (Note 3)	
(j)	Reclaimed Asphalt Shingles	1031
(k)	Collected Dust	1102.01(a)(4)
(l)	Truck Bed Release Agents for HMA (Note 4)	1030.12
(m)	Liquid Anti-Strip (Note 5)	
(n)	Packaged, Dry, Rapid Hardening Mortar or Concrete	1018

Note 1. Slaked quicklime shall be according to ASTM C 5.

Note 2. A stabilizing additive such as cellulose or mineral fiber shall be added to stone matrix asphalt (SMA) mixtures and shall meet the requirements listed in Illinois Modified AASHTO M 325. Prior to approval and use of fibers, the Contractor shall submit a notarized certification by the producer of these materials stating they meet these requirements.

Note 3. WMA additives or foaming processes shall be selected from the Department's qualified producer list "Technologies for the Production of Warm Mix Asphalt (WMA)".

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Note 4. Truck Bed Release Agents for HMA shall be selected from the Department's Qualified Product List "Asphalt Release Agents for Vehicles Transporting Hot-Mix Asphalt".

Note 5. Liquid additives to control stripping shall be shown effective by the Contractor by completing tensile strength and tensile strength ratio (TSR) testing according to AASHTO T 283 for the mix design and submitting the results to the Engineer.

1030.03 Equipment. Equipment shall be according to the following.

	Item	Article/Section
(a)	Hot-Mix Asphalt Plant	1102.01
(b)	Storage Tanks for Asphalt Binders (Note 1)	1102.01(a)(6)
(c)	Heating Equipment (Note 2)	1102.07

Note 1. Tanks for the storage of asphalt binder shall be clearly and uniquely identified. Different grades of asphalt binder shall not be blended.

Note 2. The asphalt binder shall be transferred to the asphalt tanks and brought to a temperature of 250 to 350 °F (120 to 180 °C). If, at anytime, the asphalt binder temperature exceeds 350 °F (180 °C), the asphalt binder shall not be used. Polymer modified asphalt binder, when specified, shall be shipped, maintained, and stored at the mix plant according to the manufacturer's requirements.

1030.04 Reference Documents. The HMA mixtures shall be designed, sampled, tested, and accepted according to the following.

(a) Appendices listed in the Manual of Test Procedures for Materials.

(1) Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants
(2) Model Annual Quality Control Plan for Hot-Mix Asphalt Production
(3) Model Quality Control Addendum for Hot-Mix Asphalt Production
(4) Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt
(5) Hot-Mix Asphalt Test Strip Procedures
(6) Hot-Mix Asphalt QC/QA QC Personnel Responsibilities and Duties Checklist
(7) Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples
(8) Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations
(9) Hot-Mix Asphalt QC/QA Control Charts
(10) Hot-Mix Asphalt Mix Design Verification Procedure
(11) Calibration of Equipment for Asphalt Binder Content Determination (Nuclear Asphalt Binder Content Gauge and Ignition Oven)
(12) Hot-Mix Asphalt Mix Design Procedure for Dust Correction Factor Determination
(13) Calibration of the Ignition Oven for the Purpose of Characterizing Reclaimed Asphalt Pavements (RAP)
(14) Hot-Mix Asphalt Composite Sample Blending and Splitting Diagram

(15) Hot-Mix Asphalt (HMA) Production Gradation Windage Procedure for Minus #200 (minus 75 µm) Material
(16) Stripping of Hot-Mix Asphalt Mixtures Visual Identification and Classification
(17) Procedure for Introducing Additives to Hot-Mix Asphalt Mixtures and Testing in the Lab
(18) Ignition Oven Aggregate Mass Loss Procedure
(19) Procedure for Internal Angle Calibration of Superpave Gyratory Compactors (SGCs) Using the Dynamic Angle Validator (DAV-2)
(20) Segregation Control of Hot-Mix Asphalt
(21) Determination of Aggregate Bulk (Dry) Specific Gravity (Gsb) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)
(22) Use of Corrections Factors for Adjusting the Gradation of Cores to Estimate the Gradation of the In-Place Pavement
(23) Off-Site Preliminary Test Strip Procedures for Hot-Mix Asphalt
(24) Hot-Mix Asphalt Production Inspection Checklist
(25) Hot-Mix Asphalt Rounding Test Values
(26) Hot-Mix Asphalt Laboratory Equipment
(27) Illinois Specification 101 Minimum Requirements for Electronic Balances
(28) Hot-Mix Asphalt PFP Pay Adjustments
(29) Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations
(30) Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
(31) Hot-Mix Asphalt PFP Dispute Resolution
(32) Hot-Mix Asphalt QCP Pay Adjustments
(33) Best Practices for Hot-Mix Asphalt PFP and QCP
(34) Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions

(b) Illinois Modified AASHTO procedures listed in the Manual of Test Procedures for Materials.

AASHTO M 323	Standard Specification for Superpave Volumetric Mix Design
AASHTO M 325	Standard Specification for Stone Matrix Asphalt (SMA)
AASHTO R 30	Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)
AASHTO R 35	Standard Practice for Superpave Volumetric Design for Asphalt Mixtures
AASHTO R 46	Standard Practice for Designing Stone Matrix Asphalt (SMA)
AASHTO T 30	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T 164	Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
AASHTO T 166	Standard Method of Test for Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T 209	Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Asphalt Mixtures

AASHTO T 283	Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
AASHTO T 287	Standard Method of Test for Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
AASHTO T 305	Standard Method of Test for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO T 308	Standard Method of Test for Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
AASHTO T 312	Standard Method of Test for Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 324	Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures
AASHTO T 393	Standard Test Method for Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

(c) Illinois Modified ASTM procedures listed in the Manual of Test Procedures for Materials.

ASTM D 2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 8159	Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures

(d) Bureau of Materials Policy Memorandums.

(1) 1-08 Performance Graded Asphalt Binder Qualification Procedure

(2) 4-08 Approval of Hot-Mix Asphalt Plants and Equipment

(3) 6-08 Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design

(4) 21-08 Minimum Department and Local Agency Laboratory Requirements for Construction Materials Testing or Mix Design

1030.05 Mixture Design. The Contractor shall submit designs for each required mixture. The mixture design shall be performed at a HMA mix design laboratory according to the Bureau of Materials Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. Each design shall be verified and approved by the Department as detailed in the document "Hot-Mix Asphalt Mixture Design Verification Procedure”.

(a) Mixture Composition. The Job Mix Formula (JMF) represents the mix design comprised of aggregate gradation and asphalt binder content that produce the desired mix criteria in the laboratory. The ingredients of the mix design shall be combined in such proportions as to produce a mixture conforming to the composition limits by weight unless by volume is specified. The JMF shall fall within the following limits.

MIXTURE COMPOSITION (% PASSING) [1/]																
Sieve Size	IL-19.0		IL-19.0L [2/]		SMA-12.5 [3/]		SMA-9.5 [3/]		IL-9.5		IL-9.5L [2/]		IL-9.5FG		IL-4.75	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
1 1/2 in. (37.5 mm)																
1 in. (25 mm)		100		100												
3/4 in. (19 mm)	90	100	95	100		100		100								
1/2 in. (12.5 mm)	75	89			90	99	95	100		100		100		100		100
3/8 in. (9.5 mm)					50	85	70	95	90	100	95	100	90	100		100
#4 (4.75 mm)	40	60	38	65	20	40	30	50	32	69	52	80	60	75 [7/]	90	100
#8 (2.36 mm)	26	42			16	24 [4/]	20	30	32	52 [5/]	38	65	45	60 [7/]	70	90
#16 (1.18 mm)	15	30						21	10	32			25	40	50	65
#30 (600 µm)								18					15	30		
#50 (300 µm)	6	15						15	4	15			8	15	15	30
#100 (150 µm)	4	9							3	10			6	10	10	18
#200 (75 µm)	3.0	6.0	3.0	7.0	8.0	11.0 [6/]	8.0	11.0 [6/]	4.0	6.0	4.0	8.0	4.0	6.5	7.0	9.0 [6/]
#635 (20 µm)						≤ 3		≤ 3								
Dust/Asphalt Binder Ratio		1.0		1.0						1.0		1.0		1.0		1.0

Notes:
1/ Based on percent of total aggregate weight.
2/ Percent passing the #30 (600 µm) sieve shall be less than 50 percent of the percentage passing the #4 (4.75 mm) sieve for IL-19.0L and #8 (2.36 mm) for the IL-9.5L.
3/ When the bulk specific gravity (Gsb) of the component aggregates vary by more than 0.20, the blend gradations shall be based on percent by volume.
4/ When establishing the Adjusted Job Mix Formula (AJMF) the percent passing the #8 (2.36 mm) sieve shall not be adjusted above 24 percent.
5/ The mixture composition shall not exceed 44 percent passing the #8 (2.36 mm) sieve for surface courses with Ndesign = 90.
6/ Additional minus #200 (75 µm) material required by the mix design shall be mineral filler, unless otherwise approved by the Engineer.
7/ When the mixture is used as a binder, the maximum shall be increased by 5 percent passing.

(b) Volumetric Requirements. The target value for the air voids of the HMA shall be 4.0 percent at the design number of gyrations. The voids in the mineral aggregate (VMA) of the HMA design shall be based on the nominal maximum size of the aggregate in the mix, and shall conform to the following requirements.

	Voids in the Mineral Aggregate (VMA), % Minimum for Ndesign				
Mix Design	30	50	70	80	90
IL-19.0		13.5	13.5		13.5
IL-9.5		15.0	15.0		15.0
IL-9.5FG		15.0	15.0		15.0
IL-4.75 1/		18.5			
SMA-12.5 1/		16.0		17.0	
SMA-9.5 1/		16.0		17.0	
IL-19.0L	13.5				
IL-9.5L	15.0				

1/ Maximum draindown shall be 0.3 percent according to Illinois Modified AASHTO T 305.

(c) Contractor Determination of Tensile Strength and Tensile Strength Ratio (TSR). The mixture designer shall determine if the proposed mix design meets minimum tensile strength requirements and is resistant to stripping. These determinations shall be made based on tests performed according to Illinois Modified AASHTO T 283.

The proposed mix design shall have a minimum conditioned tensile strength of 60 psi (415 kPa) for non-polymer modified performance graded (PG) asphalt binders and 80 psi (550 kPa) for polymer modified PG asphalt binders except modified PG 64-28 or lower asphalt binders which shall have a minimum tensile strength of 70 psi (485 kPa).

The conditioned to unconditioned TSR shall be equal to or greater than 0.85 for 6 in. (150 mm) specimens. Mixtures, either with or without an additive, with TSRs less than 0.85 for 6 in. (150 mm) specimens will be considered unacceptable. Also, the conditioned tensile strength for mixtures containing an anti-strip additive shall not be lower than the conditioned tensile strength of the same mixture without the anti-strip additive.

If it is determined that an additive is required, the additive may be hydrated lime, slaked quicklime, or a liquid additive. Dry hydrated lime shall be added at a minimum rate of 1.0 percent by weight of total dry aggregate. Slurry shall be added in such quantity as to provide the required amount of hydrated lime solids by weight of total dry aggregate. The method of application shall be according to Article 1102.01(a)(8).

(d) Mix Design Verification Testing. Mix designs shall be submitted for verification according to the document "Hot-Mix Asphalt Mixture Design Verification Procedure".

High ESAL mixture designs shall meet the following requirements for tensile strength, TSR, Hamburg wheel, and I-FIT criteria. Low ESAL mixture designs shall meet TSR and I-FIT criteria.

If a mix fails the Department's verification testing, the Contractor shall make necessary changes to the mix and provide passing volumetric, tensile strength, TSR, Hamburg wheel, and I-FIT procedure results before resubmittal. The Department will verify the passing results.

(1) Tensile Strength. The minimum allowable conditioned tensile strength shall be according to Article 1030.05(c).

(2) TSR. The minimum TSR shall be according to Article 1030.05(c).

(3) Hamburg Wheel Test. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth is based on the high temperature binder grade of the mix as specified in the mix requirements table on the plans and shall be according to the following.

Illinois Modified AASHTO T 324 Requirements 1/	
PG Grade	Minimum Number of Wheel Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000 2/
PG 76-xx (or higher)	20,000 2/

1/ When WMA is produced at temperatures of 275 ± 5 °F (135 ± 3 °C) or less, loose mix shall be oven aged at 270 ± 5 °F (132 ± 3 °C) for two hours prior to gyratory compaction of Hamburg wheel specimens.

2/ For IL-4.75 binder course, the minimum number of wheel passes shall be reduced by 5,000.

(4) I-FIT. The minimum flexibility index (FI) shall be as follows.

Illinois Modified AASHTO T 393		
Mixture	Short Term Aging, Minimum FI	Long Term Aging, Minimum FI 2/
HMA 1/	8.0	5.0 3/
SMA	16.0	10.0
IL-4.75	12.0	-

1/ All mix designs, except for SMA and IL-4.75 mixtures.

2/ Required for surface courses only.

3/ Production long term aging FI for HMA shall be a minimum of 4.0.

1030.06 Quality Management Program. The Quality Management Program (QMP) will be shown on the plans as Pay for Performance (PFP), Quality Control for Performance (QCP), or Quality Control / Quality Assurance (QC/QA) for each HMA mixture or full-depth pavement according to the following.

PFP shall be used on interstate, freeway, and expressway resurfacing and full-depth projects having a minimum quantity of 8,000 tons (7,260 metric tons) per mix.

QCP shall be used on mainline mixture quantities between 1,200 and 8,000 tons (1,016 and 7,620 metric tons) as well as shoulder applications greater than 8 ft (2.4 m) wide and at least 1,200 tons (1,016 metric tons).

QC/QA shall be used for mixtures less than 1,200 tons (1,016 metric tons), shoulder applications 8 ft (2.4 m) wide or less, hand method, variable width shoulders, incidental surfacing, intermittent resurfacing, driveways, entrances, minor sideroads, sideroad returns, patching, turn lanes less than 500 ft (152 m) in length, temporary pavement, and shared-use paths or bike lanes unless paved with the mainline pavement.

The following shall apply to PFP, QCP, and QC/QA.

(a) Laboratory. The Contractor shall provide a laboratory, at the plant, according to the Bureau of Materials Policy Memorandum, “Minimum Private Laboratory Requirements for Construction Materials Testing or Mix Design”. The requirements for the laboratory and equipment for production and mix design are listed in the document "Hot-Mix Asphalt Laboratory Equipment".

The Engineer may inspect measuring and testing devices at any time to confirm both calibration and condition. If laboratory equipment becomes inoperable, the Contractor shall cease mix production. If the Engineer determines the equipment is not within the limits of dimensions or calibration described in the appropriate test method, the Engineer may stop production until corrective action is taken.

(b) Annual QC Plan and QC Addenda. The Contractor shall submit, in writing to the Engineer, a proposed Annual QC Plan following the format of the document “Model Annual Quality Control Plan for Hot-Mix Asphalt Production" for each HMA plant for approval before each construction season. This shall include documentation that each HMA plant has been calibrated and approved by the Department. Job-specific QC Addenda to the Annual QC Plan must be submitted in writing to the Engineer following the format of the document "Model Quality Control Addendum for Hot-Mix Asphalt Production" for approval before the pre-construction conference. The Annual QC Plan and the QC Addenda shall address all elements involved in the production and quality control of the HMA incorporated in the project.

Production of HMA shall not begin without written approval of the Annual QC Plan and QC Addenda by the Engineer.

The approved Annual QC Plan and QC Addenda shall become part of the contract between the Department and the Contractor but shall not be construed, in itself, as acceptance of any HMA produced. Failure to execute the contract according to the approved Annual QC Plan and QC Addenda shall result in suspension of HMA production or other appropriate actions as directed by the Engineer.

The Annual QC Plan and QC Addenda may be amended during the progress of the work, by either party, subject to mutual agreement. Revisions shall require proper justification and be provided to the Department by the Contractor to ensure product quality. Any revision in the Annual QC Plan or QC Addenda must be approved in writing by the Engineer.

(c) General Quality Control (QC) by the Contractor. The Contractor's quality control activities shall ensure mixtures meet contract requirements.

(1) Inspection and Testing. The Contractor shall perform or have performed the inspection and testing required to conform with contract requirements. QC includes the recognition of obvious defects and their immediate correction. QC may require increased testing, communication of test results to the plant or the job site, modification of operations, suspension of HMA production, rejection of material, or other actions as appropriate.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer prior to the start of the next day's production.

(2) Personnel. The Contractor shall provide a QC Manager who shall have overall responsibility and authority for quality control. This individual shall have successfully completed the Department's "Hot-Mix Asphalt Level II" course.

In addition to the QC Manager, the Contractor shall provide sufficient personnel to perform the required visual inspections, sampling, testing, and documentation in a timely manner. Mix designs shall be developed by personnel who have successfully completed the Department's "Hot-Mix Asphalt Level III" course. Technicians performing mix design testing and plant sampling/testing shall have successfully completed the Department's "Hot-Mix Asphalt Level I" course. The Contractor may also provide a Gradation Technician who has successfully completed the Department's "Gradation Technician Course" to run gradation tests only under the supervision of a Hot-Mix Asphalt Level II Technician. The Contractor shall provide a Hot-Mix Asphalt Density Tester who has successfully completed the Department's "Nuclear Density Testing" course to run all nuclear density tests on the job site.

Only quality control personnel shall perform the required QC duties. The Contractor is referred to the document "Hot-Mix Asphalt QC Personnel Responsibilities and Duties Checklist" for a description of personnel qualifications and duties.

(d) Additional Contractor and Department Duties.

(1) The Engineer will initiate and witness asphalt binder sampling by the Contractor at a minimum frequency of one injection line-sample per week, per HMA plant. Sample containers will be furnished by the Department. The Engineer will take possession of and submit the properly identified samples, according to Policy Memorandum 1-08, to the Central Bureau of Materials for testing.

(2) Immediately upon completion of coring for density samples or thickness checks, the Contractor shall remove water from the core holes and fill the holes with packaged, dry, rapid hardening mortar or concrete. The cementitious material shall be mixed in a separate container, placed in the hole, consolidated by rodding, and struck-off flush with the adjacent pavement. Depressions in the surface of filled core holes greater than 1/4 in. (6 mm) at the time of final inspection shall require removal and replacement of the fill materials.

1030.07 Pay for Performance (PFP). PFP is a program that evaluates pay parameters using percent within limits to determine a pay adjustment. Monetary deductions for dust/AB ratios and unconfined edge densities may also apply.

(a) Definitions.

(1) Quality Control (QC). QC includes all production and construction activities by the Contractor necessary to achieve a level of quality.

(2) Quality Assurance (QA). QA includes all monitoring and testing activities by the Engineer necessary to assess product quality, to identify acceptability of the product, and to determine payment.

(3) Percent Within Limits (PWL). PWL is the percentage of material within the quality limits for a given quality characteristic.

(4) Quality Characteristic. The characteristics that are evaluated by the Department to determine payment using PWL. The quality characteristics (i.e. pay parameters) for this program are air voids, field VMA, and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(5) Quality Level Analysis (QLA). QLA is a statistical procedure for determining the amount of in-place mixture within specification limits.

(6) Mixture Lot. A mixture lot will begin once an acceptable test strip has been completed and the adjusted job mix fomula (AJMF) has been determined. If the test strip is waived, the mixture lot will begin with the start of production. A mixture lot consists of ten mixture sublots. If

seven or fewer mixture sublots remain at the end of production of a mixture, the test results for these sublots will be combined with the previous lot for evaluation of PWL and pay factors.

(7) Mixture Sublot. A mixture sublot for air voids and field VMA will be a maximum of 1,000 tons (910 metric tons). If the project quantity is less than 8,000 tons (7,260 metric tons), the sublot size will be adjusted to achieve a minimum of 8 tests.

a. If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1,000 tons (910 metric tons), the last mixture sublot will be that quantity.

b. If the remaining quantity is 200 tons (180 metric tons) or less, the quantity shall be combined with the previous mixture sublot.

(8) Density Lot. A density lot consists of 30 density intervals. If 19 or fewer density intervals remain at the end of production of a mixture, the test results for these sublots will be combined with the previous lot for evaluation of percent within limits and pay factors.

(9) Density Interval. A density interval will be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges or cold joints between lanes, the paving lane is defined as the total combined width of the lanes paved in that single pass. If the paving lane width is greater than 20 ft (6 m), the density intervals will be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in. (75 mm). If the last density interval for a lift is less than 200 ft (60 m), it will be combined with the previous density interval.

(10) Density Specimen. A density specimen shall consist of a 4 in. (100 mm) core taken at a random test location within each density interval.

(11) Density Test. A density test shall consist of testing a density specimen according to Illinois Modified AASHTO T 166.

When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be based on the running average of four Department test results including the current day of production. Initial G_{mm} will be based on the average of the first four test results.

(12) Unconfined Edge Density. The location of the unconfined edge density test sample will be randomly selected within each 0.5 mile (800 m) sublot for each mixture with an unconfined edge according to the document "Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions". The last sublot may be less than 0.5 mile (800 m) but at least 200 ft (60 m). If longitudinal joint sealant (LJS) is used at a joint, the joint will not be included in the unconfined edge density testing.

(13) Pay Adjustment. The pay adjustment is calculated using the test results of the pay parameters (air voids, field VMA and density).

(14) Combined Full-Depth Pay Adjustment. For full-depth pavements, the composite pay factors for all incorporated mixtures are combined to determine the combined full-depth pay adjustment.

(15) Monetary Deduction. In addition to the pay adjustment for the pay parameters air voids, field VMA, and density for each mix or full-depth pavement, it will be determined if there is a monetary deduction for dust/AB ratio and/or unconfined edge density.

(b) Quality Control (QC) by the Contractor. The Contractor's QC plan shall include the schedule of testing for both quality characteristics used to determine pay and other quality characteristics required to control the product. The schedule shall include sample time and location. The minimum test frequency shall be according to the following.

Minimum Quality Control Sampling and Testing Requirements		
Quality Characteristic	Minimum Test Frequency	Sampling Location
Mixture Gradation	1/day	per QC Plan
Asphalt Binder Content		
G_{mm}		
G_{mb}		
Density	per QC plan	per QC Plan

The Contractor shall submit QC test results to the Engineer within 48 hours of sampling.

(c) Initial Production Testing. The Contractor shall split and test the first two samples with the Department for comparison purposes. The Contractor shall complete all tests and report all results to the Engineer within two working days of sampling. The Engineer will make Department test results of the initial production testing available to the Contractor within two working days from the receipt of the samples.

(d) Additional Contractor Duties. The Contractor shall obtain the random mixture samples identified by the Engineer according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". One composite sample per sublot shall be collected in the presence of the Engineer. The composite sample shall be split into four equal mix samples. The Contractor shall transport the Department's mix sample to the location designated by the Engineer.

The Contractor shall provide personnel and equipment to collect density specimens for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Contractor shall cut the cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. The Contractor shall transport the Department's secured density specimens to the location designated by the Engineer.

(e) Quality Assurance (QA) by the Engineer. The Department's laboratories which conduct PFP testing will participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program. The Engineer will test each mixture sublot for air voids, field VMA, and dust/AB ratio; and each density interval for density to determine payment according to the document "Hot-Mix Asphalt PFP Pay Adjustments". A sublot shall begin once an acceptable test-strip has been completed and the AJMF has been determined.

(1) Air Voids, Field VMA, and Dust/AB Ratio. For each sublot, the Engineer will determine the random tonnage for the sample and the Contractor shall be responsible for obtaining the sample according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". The Engineer will not disclose the random location of the sample until after the truck containing the random tonnage has been loaded and en-route to the project.

(2) Density. For each density interval, the Engineer will determine the random location for the density test according to the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Engineer will not disclose the random location of the sample until after the final rolling.

The Engineer will witness and secure all mixture and density samples.

(f) Test Results. The Department's test results for the first mixture sublot and density interval, of every lot will be available to the Contractor within three working days from the receipt of secured samples. Test results for remaining sublots will be available to the Contractor within ten working days from receipt of the secured sample that was delivered to the Department's testing facility or a location designated by the Engineer.

The Engineer will maintain a complete record of Department test results. Copies will be furnished upon request. The records will contain, at a minimum, all the Department test results, raw data, random numbers used and resulting calculations for sampling locations, and QLA calculations.

(g) Dispute Resolution. Dispute resolution testing will only be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results and meets the requirements listed in the document "Hot-Mix Asphalt PFP Dispute Resolution". If dispute resolution is chosen, the Contractor shall submit a request in writing within four working days of receipt of the Department results of the QLA for the lot in question. The Engineer will document receipt of the request. The request shall specify Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute) as defined in the document "Hot-Mix Asphalt PFP Dispute Resolution". The Central Bureau of Materials laboratory will be used for dispute resolution testing.

(h) Acceptance by the Engineer. To be considered acceptable, all the Department's test results shall be within the acceptable limits listed below.

Acceptable Limits		
Parameter		Acceptable Range
Air Voids		2.0 – 6.0 %
Field VMA		-1.0 – +3.0 % 1/
Density	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 2/

1/ Based on minimum required field VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

In addition, the PWL for any quality characteristic shall be 50 percent or above for any lot. No visible pavement distress shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

1030.08 Quality Control for Performance (QCP). QCP is a program that uses step-based pay without an incentive to determine pay adjustment. A monetary deduction for dust/AB ratios also applies.

(a) Definitions.

(1) Quality Control (QC). QC includes all production and construction activities by the Contractor necessary to achieve a level of quality.

(2) Quality Assurance (QA). QA includes all monitoring and testing activities by the Engineer necessary to assess product quality, to identify acceptability of the product, and to determine payment.

(3) Pay Parameters. Pay parameters are air voids, field VMA and density. Field VMA will be calculated using the combined aggregates bulk specific gravity (G_{sb}) from the mix design.

(4) Mixture Lot. A mixture lot will begin once an acceptable test strip has been completed and the AJMF has been determined. If the test strip is waived, a mixture lot will begin with the start of production. A mixture lot will consist of four sublots unless it is the last or only lot, in which case it may consist of as few as one sublot.

(5) Mixture Sublot. A mixture sublot for air voids, field VMA, and dust/AB ratio will be a maximum of 1,000 tons (910 metric tons).

a. If the remaining quantity is greater than 200 tons (180 metric tons) but less than 1,000 tons (910 metric tons), the last mixture sublot will be that quantity.

b. If the remaining quantity is 200 tons (180 metric tons) or less, the quantity will be combined with the previous mixture sublot.

(6) Density Interval. Density intervals will be every 0.2 miles (320 m) for lift thicknesses of 3 in. (75 mm) or less and 0.1 miles (160 m) for lift thicknesses greater than 3 in. (75 mm). In cases where paving is completed over multiple lanes in a single pass of one or more pavers to eliminate unconfined edges or cold joints between lanes, the paving lane is defined as the total combined width of the lanes paved in that single pass. If the paving lane width is greater than 20 ft (6 m), the density intervals will be every 0.1 mi. (160 m) for lift thicknesses of 3 in. (75 mm) or less and 0.05 mi. (80 m) for lift thicknesses greater than 3 in. (75 mm). If the last density interval for a lift is less than 200 ft (60 m), it will be combined with the previous density interval.

(7) Density Sublot. A density sublot will be the average of five consecutive density intervals.

a. If fewer than three density intervals remain outside a density sublot, they will be included in the previous density sublot.

b. If three to five density intervals remain, they will be considered a density sublot.

(8) Density Specimen. A density specimen shall consist of a 4 in. (100 mm) core taken at a random location within each density interval.

(9) Density Test. A density test shall consist of testing a density specimen according to Illinois Modified AASHTO T 166.

When establishing the target density, the HMA maximum theoretical specific gravity (G_{mm}) will be based on the running average of four Department test results. Initial G_{mm} will be based on the average of the first four test results. If less than four G_{mm} results are available, an average of all available Department G_{mm} test results will be used.

(10) Pay Adjustment. The pay adjustment is calculated using the test results of the pay parameters (air voids, field VMA and density).

(11) Combined Full-Depth Pay Adjustment. For full-depth pavements, the composite pay factors for all incorporated mixtures are combined to determine the combined full-depth pay adjustment.

(12) Monetary Deduction. In addition to the pay adjustment for the pay parameters air voids, field VMA, and density for each mix or full-depth pavement, it will be determined if there is a monetary deduction for dust/AB ratio.

(b) Quality Control (QC) Testing by the Contractor. The Contractor's QC plan shall include the schedule of testing for both pay parameters and non-pay parameters necessary to control the product. The minimum test frequency shall be according to the following table.

Minimum Quality Control Mixture Sampling and Testing Requirements		
Quality Characteristic		Minimum Test Frequency
Air Voids	G_{mb}	1 per sublot
	G_{mm}	
Washed Mixture Gradation		
Asphalt Binder Content		
Dust/AB Ratio 1/		
Field VMA		

1/ Dust/AB ratio is not used in the calculation of the pay adjustment but is used to verify the mix is within acceptable limits and determine if there are monetary deductions for this parameter.

The Contractor's results from mix sample testing of split samples, in conjunction with additional quality control tests, shall be used to control production.

The Contractor shall submit their mix sample test results from the split sample to the Engineer within 48 hours of the time of sampling.

(c) Additional Contractor Duties. The Contractor shall obtain the random mixture samples at locations identified by the Engineer according to the document, "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling". One composite sample per sublot shall be collected in the presence of the Engineer. The composite sample shall be split into four equal mix samples. The Contractor shall transport the Department's mix sample to the location designated by the Engineer.

The Contractor shall provide personnel and equipment to collect density specimens for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Contractor shall cut the cores within the same day and prior to opening to traffic unless otherwise approved by the Engineer. The Contractor shall transport the Department's secured density specimens to the location designated by the Engineer.

(d) Quality Assurance (QA) by the Engineer. The Department's laboratories which conduct QCP testing will participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program. Quality Assurance by the Engineer will be as follows.

(1) Air Voids, Field VMA, and Dust/AB Ratio. The Engineer will determine the random tonnage for the sample and the Contractor shall be responsible for obtaining the sample according to the document "Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling Procedure". The Engineer will not disclose the random location of the sample until after

the truck containing the random tonnage has been loaded and en-route to the project.

(2) Density. For each density interval, the Engineer will determine the random location for the density test according to the document "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations". The Engineer will not disclose the random location of the sample until after the final rolling.

The Engineer will witness and secure all mixture samples to be tested by the Department.

The Engineer will select at random one sublot mixture sample from each lot for testing of air voids, field VMA and dust/AB ratio. The Engineer will test a minimum of one mixture sample per project. The Engineer will test all pavement cores for density. QA test results will be available to the Contractor within ten working days from receipt of split mixture samples and cores from the last sublot from each lot.

The Engineer will maintain a complete record of all Department test results and copies will be provided to the Contractor with each set of sublot results. The records will contain, at a minimum, the originals of all Department test results and raw data, random numbers used and resulting calculations for sampling locations, and pay calculations.

When the QA mixture test results are compared to QC results for a sublot and they are within the precision limits listed in the following table, the QA sublot results will be defined as the final mixture results for that sublot. When QA results are compared to QC results for a sublot and they do not meet the precision limits listed in the following table, the Department will verify the results by testing the retained split sample. The retest results will replace all of the original results and will be defined as the final mixture results for that sublot.

If the final mixture QA results for the random sublot do not meet the 100 percent sublot pay factor limits listed in the document "Hot-Mix Asphalt QCP Pay Adjustments" or do not compare to QC results within the precision limits in the following table, the Engineer will test all sublot split mixture samples for the lot.

Test Parameter	Limits of Precision
G_{mb}	0.030
G_{mm}	0.026
Field VMA	1.0 %

If the dust/AB ratio results for the random sublot do not fall within 0.6 and 1.2, the Department will test the remaining sublots for that lot to determine the dust/AB ratio monetary deductions.

(e) Acceptance by the Engineer. To be acceptable, all of the Department's test results will be within the acceptable limits listed in the following table.

Test Parameter		Acceptable Limits
Air Voids		2.0 – 6.0 %
Field VMA		-1.0 – +3.0 % 1/
Density	IL-19.0, IL-9.5, IL-9.5FG, IL-4.75	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 2/

1/ Based on minimum required VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

In addition, no visible pavement distresses shall be present such as, but not limited to, segregation, excessive coarse aggregate fracturing or flushing.

1030.09 Quality Control / Quality Assurance (QC/QA). QC/QA is a method specification acceptance program with no pay adjustments or deductions.

(a) Required Mixture Tests. The Contractor shall complete testing of all required mixture samples within 3 1/2 hours of sampling.

(1) Mixture Sampling. The Contractor shall obtain required mixture samples according to the document, “Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples”.

(2) Frequency. The Contractor shall use the test methods identified to perform the following mixture tests at a frequency not less than that indicated.

Frequency of Mixture Tests [3/, 4/]

Parameter	Production Tons (Metric Tons) Per Day	Initial Daily Plant Tests	Daily Random Tests	Test Method
Aggregate Gradation of Washed Ignition Oven or Solvent Extraction	All	1	1	Illinois Modified AASHTO T 30
Asphalt Binder Content	All	1	1	Illinois Modified AASHTO T 164, T 287, T 308 [1/]
Field VMA [2/]	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO R 35
	≥ 1200 (1090)	1	1	
Air Voids Bulk Specific Gravity of Gyratory Sample	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO T 312
	≥ 1200 (1090)	1	1	
Maximum Specific Gravity of Mixture	< 1200 (1090)	1	1 for first 2 days	Illinois Modified AASHTO T 209
	≥ 1200 (1090)	1	1	
Draindown IL-4.75, SMA-12.5 and SMA-9.5	All		1	Illinois Modified AASHTO T 305

1/ The ignition oven shall not be used if the calibration factor exceeds 1.5 percent.

2/ The combined G_{sb} used in the VMA calculation shall be listed in the approved mix design.

3/ If the day's production is less than 250 tons (225 metric tons) per mix, gradation analysis, air voids, field VMA and asphalt binder content tests will not be required on a specific mixture. A minimum of one set of mixture tests for each mix shall be performed for each five consecutive production-day period when the accumulated tonnage produced in that period exceeds 500 tons (450 metric tons). A Hot-Mix Asphalt Level II Technician shall oversee all QC operations.

4/ If the required tonnage of any mixture for a single pay item is less than 250 tons (225 metric tons) in total, the Contractor may propose intentions of waiving the "Required Mixture Tests" in the QC Addenda. The mixture shall be produced using a mix design that has been verified as specified and validated by the Department's recent acceptable field test data. A Hot-Mix Asphalt Level II Technician shall oversee all quality control operations for the mixture.

(3) Dust/AB Ratio and Moisture Content. During production, the dust/AB ratio and the moisture content of the mixture at discharge from the mixer shall meet the following.

Parameter	All Mixtures
Dust/AB Ratio 1/	0.6 to 1.2
Moisture, max.	0.3 %

1/ Does not apply to SMA.

If at any time the dust/AB ratio or moisture content of the mixture falls outside the stated limits, production of the HMA shall cease. The cause shall be determined and corrective action satisfactory to the Engineer shall be initiated prior to resuming production.

(4) Additional HMA Samples. The Contractor shall, when necessary, take and test additional samples (designated "check" samples) at the plant during HMA production. These samples in no way replace the required plant samples described above. Check samples shall be tested only for the parameters deemed necessary by the Contractor. Check sample test results shall be noted in the Plant Diary but shall not be plotted on the control charts. The Contractor shall detail the situations in which check samples will be taken in the Annual QC Plan.

(b) Required Density Tests. The Contractor shall control the compaction process by testing the mix density at random locations as determined according to the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations", and recording the results on forms approved by the Engineer. The Contractor shall follow the density testing procedures detailed in the document "Illinois Modified ASTM D 2950, Standard Test Method for Density of Bituminous Concrete In-Place by Nuclear Method". When required, the Contractor shall be responsible for establishing the correlation to convert nuclear density results to core densities according to the document "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt". The Engineer may require a new nuclear/core correlation if the Contractor's gauge is recalibrated during the project.

(1) Paving. For paving, density tests shall be performed at randomly selected locations within 0.5 mile (800 m) intervals for each lift of 3 in. (75 mm) or less in thickness. For lifts in excess of 3 in. (75 mm) in thickness, a test shall be performed within 0.25 mile (400 m) intervals. In no case shall more than one-half day's production be completed without performing QC density testing.

Longitudinal joint density testing shall also be performed at each random density test location. Longitudinal joint testing shall be located at a distance equal to 4 in. (100 mm) from each pavement edge.

(a) Confined Edge. Each confined edge density shall be represented by a one-minute nuclear density reading or a core density and shall be included in the average of density readings or core densities taken across the mat which represent the Individual Test.

(b) Unconfined Edge. Each unconfined edge joint density shall be represented by an average of three one-minute nuclear density readings or a single core density at the given density test location and shall meet the density requirements specified in the Density Control Limits table below. The three one-minute nuclear density readings shall be spaced 10 ft (3 m) apart longitudinally along the unconfined pavement edge and centered at the random density test location.

Density testing will not be required on longitudinal joints treated with longitudinal joint sealant (LJS).

(2) Patching. For patching, density tests shall be performed each day on randomly identified patches following the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations". Density testing frequency shall be a minimum of one test per half day of production per mix.

(c) Control Limits. The AJMF values shall be plotted on the control charts within the following control limits.

CONTROL LIMITS						
Parameter	IL-19.0, IL-9.5, IL-9.5FG, IL-19.0L, IL-9.5L		SMA-12.5, SMA-9.5		IL-4.75	
	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4	Individual Test	Moving Avg. of 4
% Passing: 1/						
1/2 in. (12.5 mm)	± 6 %	± 4 %	± 6 %	± 4 %		
3/8 in. (9.5mm)			± 4 %	± 3 %		
# 4 (4.75 mm)	± 5 %	± 4 %	± 5 %	± 4 %		
# 8 (2.36 mm)	± 5 %	± 3 %	± 4 %	± 2 %		
# 16 (1.18 mm)			± 4 %	± 2 %	± 4 %	± 3 %
# 30 (600 µm)	± 4 %	± 2.5 %	± 4 %	± 2.5 %		
Total Dust Content # 200 (75 µm)	± 1.5 %	± 1.0 %			± 1.5 %	± 1.0 %
Asphalt Binder Content	± 0.3 %	± 0.2 %	± 0.2 %	± 0.1 %	± 0.3 %	± 0.2 %
Air Voids	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %	± 1.2 %	± 1.0 %
Field VMA 2/	-0.7 %	-0.5 %	-0.7 %	-0.5 %	-0.7 %	-0.5 %

1/ Based on washed ignition oven or solvent extraction gradation.

2/ Allowable limit below minimum design VMA requirement

DENSITY CONTROL LIMITS			
Mixture Composition	Ndesign	Individual Test (includes confined edges)	Unconfined Edge Joint Density, minimum
IL-4.75	50	93.0 – 97.4 %	91.0 %
IL-9.5FG	50 – 90	93.0 – 97.4 %	91.0 %
IL-9.5	90	92.0 – 96.0 %	90.0 %
IL-9.5, IL-9.5L,	< 90	92.5 – 97.4 %	90.0 %
IL-19.0	90	93.0 – 96.0 %	90.0 %
IL-19.0, IL-19.0L	< 90	93.0 1/ – 97.4 %	90.0 %
SMA-9.5, SMA-12.5	50 or 80	93.5 – 97.4 %	91.0 %

1/ 92.0 percent when placed as first lift on an unimproved subgrade.

(d) Control Charts. Standardized control charts shall be maintained by the Contractor at the laboratory and shall be accessible at all times for review by the Engineer.

Control limits for each required parameter, both individual tests and the average of four tests, shall be plotted on control charts as described in the document "Hot-Mix Asphalt QC/QA Control Charts".

The results of individual required tests listed in Article 1030.09(c) obtained by the Contractor shall be recorded on the control chart immediately upon completion of a test, but no later than 24 hours after sampling. Only the required tests and resamples shall be recorded on the control chart.

Control Chart Requirements	All Mixtures
Gradation 1/ 3/	% Passing Sieves: 1/2 in. (12.5 mm) 2/ # 4 (4.75 mm) # 8 (2.36 mm) # 30 (600 µm)
Total Dust Content 1	# 200 (75 µm)
Volumetric	Asphalt Binder Content
	Bulk Specific Gravity
	Maximum Specific Gravity of Mixture
	Air Voids
	Density
	Field VMA

1/ Based on washed ignition oven or solvent extraction.

2/ Does not apply to IL-4.75.

3/ SMA also requires the 3/8 in. (9.5mm) sieve.

(e) Corrective Action for Required Mixture Tests.

(1) Individual Test Results. When an individual test result exceeds its control limit, the Contractor shall immediately resample and retest. If at the end of the day no material remains from which to resample, the first sample taken the following day shall serve as the resample as well as the first sample of the day. This result shall be recorded as a retest. If the retest passes, the Contractor may contine the required test frequency. Additional check samples should be taken to verify mix compliance.

a. If the retest for air voids, field VMA, or asphalt binder content exceeds control limits, HMA production shall cease and immediate corrective action shall be instituted by the Contractor. After corrective action, HMA production shall be restarted, the HMA production shall be stabilized, and the Contractor shall immediately resample and retest. The corrective action shall be documented.

b. Gradation. For gradation retest failures, immediate corrective action shall be instituted by the Contractor. After corrective action, the Contractor shall immediately resample and retest. The corrective action shall be documented.

(2) Moving Average. When the moving average values trend toward the moving average control limits, the Contractor shall take corrective action and increase the sampling and testing frequency. The corrective action shall be documented.

The Contractor shall notify the Engineer whenever the moving average values exceed the moving average control limits. If two consecutive moving average values fall outside the moving average control limits, the Contractor shall cease mixture production. Corrective action shall be immediately instituted by the Contractor. Mixture production shall not be reinstated without the approval of the Engineer.

(3) Dust Control. If the washed ignition oven or solvent extraction gradation test results indicate fluctuating dust, corrective action to control the dust shall be taken. If the Engineer determines that positive dust control equipment is necessary, the equipment as specified in Article 1102.01(c)(7) shall be installed prior to the next construction season.

(f) Corrective Action for Required Nuclear Density Tests. When an individual nuclear density test exceeds the control limits, the Contractor shall immediately retest in a location that is halfway between the failed test site and the finish roller. If the retest passes, the Contractor shall continue the normal density test frequency. An additional density check test should be performed to verify the mix compaction.

If the retest fails, the Contractor shall immediately conduct one of the following procedures.

(1) Low Density. If the failing density retest indicates low densities, the Contractor shall immediately increase the compaction effort, review all mixture test results representing the HMA being produced, and make corrective action as needed. The Contractor shall immediately perform a second density retest within the area representing the increased compaction effort and mixture adjustments.

(2) High Density. If the failing density retest indicates high densities, the Contractor shall cease production and placement until all mixture test results are reviewed and corrective action is taken. If the high density failure is a result of a change in the mixture, existing material in the surge bin may be subject to rejection by the Engineer. After restart of HMA production, a second density retest shall then be performed in the area representing the mixture adjustments.

If the second retest from either procedure passes, production and placement of the HMA may continue. The increased compaction effort for low density failures shall not be reduced to that originally being used unless it is determined by investigation that the cause of the low density was unrelated to compaction effort, the cause was corrected, and tests show the corrective action has increased the density within the required limits.

If the second retest fails, production and placement of the HMA shall cease until the Contractor has completed an investigation and the problem(s) causing the failing densities has/have been determined. If the Contractor's corrective action is approved by the Engineer, production and placement of the HMA may then be resumed. The Contractor shall increase the frequency of density testing to show, to the satisfaction of the Engineer, that the corrective action taken has corrected the density problem.

(g) Additional Contractor Duties.

(1) The Contractor shall complete the sampling as required for the Department's random mixture verification tests. One sample weighing approximately 150 lb (70 kg) shall be collected for each 3,000 tons (2,720 metric tons) of mix, with a minimum of one per mixture for mixtures with less than 3,000 tons (2,720 metric tons). The mixture shall be sampled according to the document, "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples".

(2) The Contractor shall complete split verification sample tests listed in the Limits of Precision table in Article 1030.09(h)(2).

(3) The Contractor shall provide personnel and equipment to collect density verification cores for the Engineer. Core locations will be determined by the Engineer following the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations" at density verification intervals defined in Article 1030.09(b). After the Engineer identifies a density verification location and prior to opening to traffic,

the Contractor shall cut a 4 in. (100 mm) diameter core. With the approval of the Engineer, the cores may be cut at a later time.

(h) Verification by the Engineer. The Engineer will observe the Contractor's quality control processes and complete testing of the test strip samples, identify random verification mixture sample locations, conduct mixture verification testing, identify random density verification locations, conduct density verification testing, and identify asphalt binder samples for testing.

(1) The Engineer will determine the random verification mixture sample locations according to the document "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples". The Engineer will randomly identify one sample for each 3,000 tons (2,720 metric tons) of mix, with a minimum of one sample per mix. The Engineer will witness, secure and take possession of the verification mixture sample. Department mixture testing will be completed on asphalt binder content, bulk specific gravity, maximum specific gravity and field VMA. If an anti-strip additive was used in the mixture, the Department will also test for stripping according to Illinois Modified AASHTO T 283. If the mixture fails to meet the minimum tensile strength and TSR criteria as specified in Article 1030.05(d), no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

Differences between the Contractor's and the Department's split verification sample test results will be considered acceptable if within the following limits.

Test Parameter	Limits of Precision
Asphalt Binder Content	0.3 %
Maximum Specific Gravity of Mixture	0.026
Bulk Specific Gravity	0.030
Field VMA	1.0 %

If comparison of the mixture verification test results are outside the above limits of precision, the Engineer will complete an investigation. The investigation may include review and observation of the Contractor's and the Department's technician performance, testing procedure, and equipment.

(2) After final rolling and prior to paving subsequent lifts, the Engineer will identify the random density verification test locations. Cores will be used for density verification for all paving greater than or equal to 3 ft (1 m) in width when the paving length exceeds 300 ft (90 m). The Engineer may utilize nuclear gauges for paving less than 3 ft (1 m) in width, for any paving 300 ft (90 m) or less in length, and for patches. Additional items or locations where nuclear gauges will be used will be shown in the plans.

Density verification test locations will be determined according to the document "Hot-Mix Asphalt QC/QA Procedure for Determining Random

Density Locations". The density testing interval for paving wider than or equal to 3 ft (1 m) will be 0.5 miles (800 m) for lift thicknesses of 3 in. (75 mm) or less and 0.2 miles (320 m) for lift thicknesses greater than 3 in. (75 mm). The density testing interval for paving less than 3 ft (1 m) wide will be 1 mile (1,600 m). If a day's paving will be less than the prescribed density testing interval, the length of the day's paving will be the interval for that day. The density testing interval for mixtures used for patching will be 50 patches with a minimum of one test per mixture per project.

The Engineer will witness the Contractor coring, and secure and take possession of all density samples at the density verification locations. The Engineer will test the cores collected by the Contractor for density according to Illinois Modified AASHTO T 166 or AASHTO T 275.

A density verification test will be the result of a single core or the average of the nuclear density tests at one location. The results of each density test must be within acceptable limits. The Engineer will promptly notify the Contractor of observed deficiencies.

(i) Acceptance by the Engineer. Final acceptance will be based on the following.

(1) Acceptable limits. To be considered acceptable, the Department's verification test results shall be within the following acceptable limits.

Parameter		Acceptable Limits
Field VMA		-1.0 – +3.0 % 1/
Air Voids		2.0 – 6.0 %
Density	IL-9.5, IL-19.0, IL-4.75, IL-9.5FG	90.0 – 98.0 %
	SMA 12.5, SMA 9.5	92.0 – 98.0 %
Dust / AB Ratio		0.4 – 1.6 2/

1/ Based on minimum required VMA as stated in the mix design volumetric requirements in Article 1030.05(b).

2/ Does not apply to SMA.

(2) The Contractor's process control charts and actions.

In addition, no visible pavement distress such as, but not limited to, segregation, excessive coarse aggegate fracturing, or flushing shall be present.

If any of the above is not met, the work will be considered in non-conformance with the contract.

(j) Documentation. The Contractor shall be responsible for maintaining the Annual QC Plan and QC Addendum.

The Contractor shall be responsible for documenting all observations, records of inspection, adjustments to the mixture, test results, retest results, and corrective actions in a bound hardback field book or bound hardback diary which will become the property of the Department.

The Contractor shall be responsible for the maintenance of all permanent records whether obtained by the Contractor, the Contractor's consultants, or the producer of the HMA.

The Contractor shall provide the Engineer full access to all documentation throughout the progress of the work.

Adjustments to mixture production and test results shall be recorded and sent to the Engineer on forms approved by the Engineer.

1030.10 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

For each contract, a 300 ton (275 metric ton) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3,000 tons (2,750 metric ton) or more according to the document "Hot-Mix Asphalt Test Strip Procedures".

An off-site preliminary test strip may be required for new mixture types according to the document "Off-Site Preliminary Test Strip Procedures for Hot-Mix Asphalt".

When a test strip is constructed, the Contractor shall collect and split the mixture according to the document "Hot-Mix Asphalt Test Strip Procedures". Within two working days after sampling the mixture placed in the test strip, the Contractor shall deliver prepared samples to the District laboratory for verification testing. The Contractor shall complete mixture tests stated in Article 1030.09(a). The Department will complete testing of loose mixture samples and gyratory cylinders provided by the Contractor. Mixture sampled shall include enough material for the Department to conduct mixture tests detailed in Article 1030.09(a) and in the document "Hot-Mix Asphalt Mixture Design Verification Procedure" Section 3.3. The mixture test results shall meet the requirements of Articles 1030.05(b) and 1030.05(d), except tensile strength and TSR testing will only be conducted on the first use of a mix design for the year and Hamburg wheel tests will only be conducted on High ESAL mixtures.

"When a test strip is not required, each HMA mixture with a quantity of 3,000 tons (2,750 metric tons) or more shall still be sampled on the first day of production: I-FIT and Hamburg wheel testing for High ESAL; I-FIT testing for Low ESAL. Within two working days after sampling the mixture, the Contractor shall deliver gyratory cylinders to the District laboratory for Department verification testing. The High ESAL mixture test results shall meet the requirements of Articles 1030.05(d)(3) and 1030.05(d)(4). The Low ESAL mixture test results shall meet the requirements of Article 1030.05(d)(4)."

If the test strip mixture fails to meet the requirements for tensile strength or TSR, a resample shall be provided by the Contractor to the Department. Failure of a resampled mixture test shall result in the Contractor stopping production. The Contractor shall take corrective action and re-submit for testing according to Article 1030.05(d), substitute an approved mix design, or submit a new mix design for mix verification testing according to Article 1030.05(d).

Based on the test results from the test strip, if any JMF adjustment or plant change is needed, the JMF shall become the Adjusted Job Mix Formula (AJMF). If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted.

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If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced. In no case shall the target for the amount passing be outside the mixture composition limits stated in Article 1030.05(a).

The limitations between the JMF and AJMF are as follows.

Parameter	High ESAL Adjustment	Low ESAL Adjustment
1/2 in. (12.5 mm)	± 5.0 %	± 6.0 %
# 4 (4.75 mm)	± 4.0 %	± 5.0 %
# 8 (2.36 mm)	± 3.0 %	
# 30 (600 µm)	1/	
# 200 (75 µm)	1/	± 2.5 %
Asphalt Binder Content	± 0.3 %	± 0.5 %

1/ In no case shall the target for the amount passing be greater than the JMF.

Adjustments outside the above limitations will require a new mix design.

Production is not required to stop after a growth curve has been constructed for PFP and QCP mixtures. For QC/QA mixtures, volumetric test results that are within Acceptable Limits shall be available to the Engineer before production may resume.

Upon notification by the Engineer of a failing Hamburg wheel or I-FIT test, the Contractor shall immediately resample and the Department will test. Paving may continue as long as all other mixture criteria is being met. If the second set of Hamburg wheel or I-FIT tests fail, no additional mixture shall be produced until the Engineer receives both passing Hamburg wheel and I-FIT tests.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting mixture tests.

1030.11 Preparation of Mixture for Cracks, Joints, and Flangeways. When the mixture is prepared in a batch-type mixing plant, the heated aggregate and the asphalt binder shall be measured separately and accurately by weight or by volume. The heated aggregate and asphalt binder shall be mixed in a pug mill mixer. When the aggregate is in the mixer, the asphalt binder shall be added and mixing continued until a homogeneous mixture is produced in which all particles of aggregate are coated uniformly. The mixing time will be determined by the Engineer.

When the mixture is prepared in a dryer drum plant, the heated aggregate and asphalt binder shall be accurately proportioned and mixed in the dryer drum plant.

For all types of plants, the ingredients shall be combined in such proportions as to produce a mixture according to the following composition limits by weight.

Mixture Composition	
Fine Aggregate (FA 1, FA 2 or FA 3)	93 - 96 %
Asphalt Binder (PG 58-28, PG 64-22)	6 - 9 %

With the permission of the Engineer, an approved cold-lay sand asphalt mixture may be used in lieu of the above mixture.

1030.12 Transportation. Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's qualified product list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (19 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

(a) Ambient air temperature is below 60 °F (15 °C).

(b) The weather is inclement.

(c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

(d) The mixture being placed is SMA.

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped.

SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from roadways or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). RAS is the material produced from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material by weight of RAS, as defined in Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources". RAS shall come from a facility source on the Department's "Qualified Producer List of Certified Sources for Reclaimed Asphalt Shingles" where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

(a) RAP Stockpiles. The Contractor shall construct individual RAP stockpiles meeting one of the following definitions. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e. "Homogeneous Surface").

Prior to milling, the Contractor shall request the Department provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mixture composition of the mix design.

(2) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogeneous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one

aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. Conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(4) Conglomerate "D" Quality (Conglomerate DQ). Conglomerate DQ RAP stockpiles shall be according to Articles 1031.02(a)(1) through 1031.02(a)(3), except they may also consist of RAP from HMA shoulders, bituminous stabilized subbases, or HMA (High or Low ESAL) binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content.

(5) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, non-bituminous surface treatment (i.e. high friction surface treatments), pavement fabric, joint sealants, plant cleanout, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. Each stockpile shall be signed indicating what type of RAS is present.

Unless otherwise specified by the Engineer, mechanically blending manufactured sand (FM 20 or FM 22) or fine FRAP up to an equal weight of RAS with the processed RAS will be permitted to improve workability. The sand shall be B quality or better from an approved Aggregate Gradation Control System source. The sand shall be accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

Additional processed RAP/FRAP/RAS shall be stockpiled in a separate working pile, as designated in the QC Plan, and only added to the original stockpile after the test results for the working pile are found to meet the requirements specified in Articles 1031.03 and 1031.04.

1031.03 Testing. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during or after stockpiling.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2,000 tons (1,800 metric tons)

and one sample per 2,000 tons (1,800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4,000 tons (3,600 metric tons).

(2) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the Department proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each sample shall be split to obtain two equal samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS or RAS blended with manufactured sand shall be sampled and tested during stockpiling according to the Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Shingle (RAS) Source”.

Samples shall be collected during stockpiling at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1,000 tons (900 metric tons) and one sample per 500 tons (450 metric tons) or a minimum of once per week, whichever is more frequent, thereafter. A minimum of five samples are required for stockpiles less than 1,000 tons (900 metric tons).

Before testing, each sample shall be split to obtain two test samples. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction and test for unacceptable materials on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

The Contractor shall obtain and make available all of the test results from the start of the original stockpile.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

(a) Limits of Precision. The limits of precision between the Contractor’s and the Department’s split sample test results shall be according to the following.

Test Parameter	Limits of Precision		
% Passing	RAP	FRAP	RAS
1/2 in. (12.5 mm)	6.0 %	5.0 %	
# 4 (4.75 mm)	6.0 %	5.0 %	
# 8 (2.36 mm)	4.0 %	3.0 %	4.0 %
# 30 (600 µm)	3.0 %	2.0 %	4.0 %
# 200 (75 µm)	2.5 %	2.2 %	4.0 %
Asphalt Binder	0.4 %	0.3 %	3.0 %
G_{mm}	0.035	0.030	

If the test results are outside the above limits of precision, the Engineer will immediately investigate.

(b) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation, and when applicable G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	FRAP/Homogeneous/ Conglomerate
1 in. (25 mm)	
1/2 in. (12.5 mm)	± 8 %
# 4 (4.75 mm)	± 6 %
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	
# 30 (600 µm)	± 5 %
# 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.4 % 1/
G_{mm}	± 0.03 2/

1/ The tolerance for FRAP shall be ± 0.3 percent.

2/ For stockpile with slag or steel slag present as determined in the Manual of Test Procedures Appendix B 21, "Determination of Aggregate Bulk (Dry) Specific Gravity (Gsb) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)".

If more than 20 percent of the test results for an individual parameter (individual sieves, G_{mm}, and/or asphalt binder content) are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the Department for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for solvent extractions according to the document "Calibration of the Ignition

Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(c) Evaluation of RAS and RAS Blended with Manufactured Sand or Fine FRAP Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. Individual test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAS
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	± 5 %
# 30 (600 µm)	± 4 %
# 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 2.0 %

If more than 20 percent of the test results for an individual parameter (individual sieves and/or asphalt binder content) are out of the above tolerances, or if the unacceptable material exceeds 0.5 percent by weight of material retained on the No. 4 (4.75 mm) sieve, the RAS or RAS blend shall not be used in Department projects. All test data and acceptance ranges shall be sent to the Department for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogeneous, conglomerate, and conglomerate DQ stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile. RAP originating from roadways under state jurisdiction shall be designated as follows.

Class B Quality	Class C Quality	Class D Quality
Class I Surface	Class I Binder	Bituminous Aggregate Mixture (BAM) Stabilized Subbase
HMA (High ESAL) Surface	HMA (High ESAL) Binder	
SMA	HMA (Low ESAL)	BAM Shoulder

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Coarse and fine FRAP stockpiles containing plus No. 4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate sample to the District Office. Consultant laboratory services will be at no additional cost to the Department. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 327. A maximum loss of 15.0 percent will be applied for all HMA applications.

1031.06 Use of RAP/FRAP and/or RAS in HMA. The use of RAP/FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

(a) RAP/FRAP. The use of RAP/FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. Homogeneous RAP stockpiles containing steel slag will be approved for use in all HMA (High ESAL and Low ESAL) surface and binder mixture applications.

(3) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be FRAP or homogeneous in which the coarse aggregate is Class B quality or better. FRAP from conglomerate stockpiles shall be considered equivalent to limestone for frictional considerations. Known frictional contributions from plus No. 4 (4.75 mm) homogeneous FRAP stockpiles will be accounted for in meeting frictional requirements in the specified mixture.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP, homogeneous, or conglomerate, in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, homogeneous, or conglomerate.

(6) When the Contractor chooses the RAP option, the percentage of asphalt binder replacement (ABR) shall not exceed the amounts indicated in Article 1031.06(c)(1) below for a given Ndesign.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

(1) RAP/RAS. When RAP is used alone or RAP is used in conjunction with RAS, the percentage of virgin ABR shall not exceed the amounts listed in the following table.

HMA Mixtures - RAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	30	30	10
50	25	15	10
70	15	10	10
90	10	10	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the RAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When RAP/RAS ABR exceeds 20 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

(2) FRAP/RAS. When FRAP is used alone or FRAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the following table.

HMA Mixtures - FRAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	55	45	15
50	45	40	15
70	45	35	15
90	45	35	15
SMA	- -	- -	25
IL-4.75	- -	- -	35

1/ For Low ESAL HMA shoulder and stabilized subbase, the FRAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When FRAP/RAS ABR exceeds 20 percent for all mixes, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

1031.07 HMA Mix Designs. At the Contractor's option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) RAP/FRAP and/or RAS. RAP/FRAP and/or RAS mix designs shall be submitted for verification. If additional RAP/FRAP and/or RAS stockpiles are tested and found that no more than 20 percent of the individual parameter test results, as defined in Article 1031.04, are outside of the control tolerances set for the original RAP/FRAP and/or RAS stockpile and HMA mix design, and meets all of the requirements herein, the additional

RAP/FRAP and/or RAS stockpiles may be used in the original mix design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP, and RAS stone bulk specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing RAP/FRAP and/or RAS shall be as follows.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP/FRAP and/or RAS feed system to remove or reduce oversized material.

If the RAP/FRAP and/or RAS control tolerances or HMA test results require corrective action, the Contractor shall cease production of the mixture containing RAP/FRAP and/or RAS and either switch to the virgin aggregate design or submit a new mix design.

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

(b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(c) RAP/FRAP and/or RAS. HMA plants utilizing RAP/FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAP/FRAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate and RAP/FRAP/RAS moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP/FRAP/RAS are recorded in a wet condition.)

i. A positive dust control system shall be utilized when the combined contribution of reclaimed material passing the No. 200 sieve exceeds 1.5 percent.

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

e. RAP/FRAP/RAS weight to the nearest pound (kilogram).

f. Virgin asphalt binder weight to the nearest pound (kilogram).

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Applications. RAP in aggregate applications shall be according to the Bureau of Materials Policy Memorandum, “Reclaimed Asphalt Pavement (RAP) for Aggregate Applications” and the following.

(a) RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP in aggregate surface course (temporary access entrances only) and aggregate wedge shoulders, Type B shall be as follows.

(1) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except “Non-Quality” and “FRAP”. The testing requirements of Article 1031.03 shall not apply.

(2) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.

SECTION 1032. BITUMINOUS MATERIALS

1032.01 Description. Bituminous materials shall include asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils. All bituminous materials used in a given construction shall be prepared from petroleum and be uniform in character, appearance, and consistency.

1032.02 Measurement. Asphalt binders, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils will be measured by weight.

A weight ticket for each truck load shall be furnished to the Engineer. The truck shall be weighed at a location approved by the Engineer. The ticket shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material.

When an emulsion or cutback is used for prime or tack coat, the percentage of asphalt residue of the actual certified product shall be shown on the producer's bill of lading or attached certificate of analysis. If the producer adds extra water to an emulsion at the request of the purchaser, the amount of water shall also be shown on the bill of lading.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

1032.03 Delivery. When bituminous materials are not approved at their source by the Department, they shall be delivered far enough in advance of their use to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt binder, when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 350 °F (175 °C).

Petroleum asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.0149 in. (0.4 mm). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter.

Petroleum asphalts PAF-3 and PAF-4 shall be shipped in new, open end, metal drums. The thickness of the metal used shall be not less than the 0.0149 in. (0.4 mm). The seams shall be constructed so that the filled drums will withstand shipping and handling. The inside of the drums shall be coated with talc or other approved material to facilitate peeling. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter. Petroleum asphalts PAF-3 and PAF-4 may, when specified, be shipped in approved 100 lb (45 kg) cartons.

1032.04 Spraying Application. The spraying application temperature ranges for bituminous material applied by a pressure distributor shall be according to the following table.

Spraying Application Temperature Ranges		
Type and Grade of Bituminous Material	Temperature Ranges	
	°F min. - max.	°C min. - max.
PEP	60 - 130	15 - 55
MC-30, E-2	85 - 190	30 - 90
MC-70, RC-70, SC-70, E-3	120 - 225	50 - 105
MC-250, SC-250, E-4	165 - 270	75 - 130
MC-800, SC-800	200 - 305	95 - 150
MC-3000, SC-3000	230 - 345	110 - 175
PG 46-28	275 - 350	135 - 175
PG 52-28, PG 58-22, PG 58-28, PG 64-22	285 - 350	140 - 175
RS-1, CRS-1	75 - 130	25 - 55
RS-2, CRS-2	110 - 160	45 - 70
NTEA	160 - 180	70 - 80
SS-1, SS-1h, CSS-1, CSS-1h SS-1hP, CSS-1hP	75 - 130	25 - 55
HFE-90, HFE-150, HFE-300 HFRS-2P, CRS-2P, HFRS-2	150 - 180	65 - 80
LJS, FLS	265 - 330	130 - 165

1032.05 Performance Graded Asphalt Binder. These materials will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be free from water and shall not foam when heated to any temperature below the actual flash point.

When requested, producers shall provide the Engineer with viscosity/temperature relationships for the performance graded asphalt binders delivered and incorporated in the work.

(a) Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Air blown asphalt will not be allowed.

(b) Polymer Modified Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans. Elastomers shall be added to the base asphalt binder to achieve the specified performance grade and shall be either a styrene-butadiene diblock or triblock copolymer without oil extension, or a styrene-butadiene rubber. Air blown asphalts, acid modification, and other modifiers will not be allowed. Asphalt modification at hot-mix asphalt plants will not be allowed. The modified asphalt binder shall be smooth, homogeneous, and be according to the requirements shown in Table 1 or 2 for the grade shown on the plans.

Table 1 - Requirements for Styrene-Butadiene Copolymer (SB/SBS) Modified Asphalt Binders

Test	Asphalt Grade SB/SBS PG 64-28 SB/SBS PG 70-22 SB/SBS PG 70-28	Asphalt Grade SB/SBS PG 76-22 SB/SBS PG 76-28
Separation of Polymer ITP, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Force Ratio AASHTO T 300, f_2/f_1 1/	0.30 min.	0.35 min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	60 min.	70 min. 2/

1/ Shall have a minimum elongation of 300 mm prior to rupture.

2/ When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

Table 2 - Requirements for Styrene-Butadiene Rubber (SBR) Modified Asphalt Binders		
Test	Asphalt Grade SBR PG 64-28 SBR PG 70-22 SBR PG 70-28	Asphalt Grade SBR PG 76-22 SBR PG 76-28
Separation of Polymer ITP, "Separation of Polymer from Asphalt Binder" Difference in °F (°C) of the softening point between top and bottom portions.	4 (2) max.	4 (2) max.
Toughness ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	110 (12.5) min.	110 (12.5) min.
Tenacity ASTM D 5801, 77 °F (25 °C), 20 in./min. (500 mm/min.), in.-lbs (N-m).	75 (8.5) min.	75 (8.5) min.
TESTS ON RESIDUE FROM ROLLING THIN FILM OVEN TEST (AASHTO T 240)		
Elastic Recovery ASTM D 6084, Procedure A, 77 °F (25 °C), 100 mm elongation, %	40 min.	50 min.

Note. When SBS/SBR PG 76-22 or SBS/SBR PG 76-28 is specified for mixture IL-4.75, the elastic recovery shall be a minimum of 80.

The following grades may be specified as tack coats.

Asphalt Grade	Use
PG 58-22, PG 58-28, PG 64-22	Tack Coat

1032.06 Emulsified Asphalts. Emulsified asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Emulsified Asphalt Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be homogeneous and shall show no separation of asphalt after thorough mixing, within 30 days after delivery, provided separation has not been caused by freezing. The emulsified asphalts shall coat the aggregate to the satisfaction of the Engineer and be according to the following requirements.

(a) Anionic Emulsified Asphalt. Anionic emulsified asphalts shall be according to AASHTO M 140, except as follows.

(1) The cement mixing test will be waived when the emulsion is being used as a tack coat.

(2) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(b) Cationic Emulsified Asphalt. Cationic emulsified asphalts shall be according to AASHTO M 208, except as follows.

(1) The cement mixing test will be waived when the emulsion is being used as a tack coat or slurry seal.

(2) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(c) High Float Emulsion. High float emulsions are medium setting and shall be according to the following table.

Test	HFE-90	HFE-150	HFE-300
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS 1/	50 min.	50 min.	50 min.
Sieve Test, retained on No. 20 (850 µm) sieve, (AASHTO T 59), %	0.10 max.	0.10 max.	0.10 max.
Storage Stability Test, 1 day, (AASHTO T 59), %	1 max.	1 max.	1 max.
Coating Test (All Grades), (AASHTO T 59), 3 minutes	stone coated thoroughly		
Distillation Test, (AASHTO T 59): Residue from distillation test to 500 °F (260 °C), % Oil distillate by volume, %	 65 min. 7 max.	 65 min. 7 max.	 65 min. 7 max.
Characteristics of residue from distillation test to 500 °F (260 °C): Penetration at 77 °F (25 °C), (AASHTO T 49), 100 g, 5 sec, dmm	90-150	150-300	300 min.
Float Test at 140 °F (60 °C), (AASHTO T 50), sec.	1200 min.	1200 min.	1200 min.

1/ The emulsion shall be pumpable.

(d) Penetrating Emulsified Prime (PEP). The PEP shall be according to the following.

Test (AASHTO T 59)	Result
Viscosity, Saybolt Furol, at 77 °F (25 °C), SFS	75 max.
Sieve test, retained on No. 20 (850 µm) sieve, %	0.10 max.
Distillation to 500 °F (260 °C) residue, %	38 min.
Oil distillate by volume, %	4 max.

The PEP shall be tested according to the Bureau of Materials Illinois Laboratory Test Procedure (ILTP), "Sand Penetration Test of Penetrating Emulsified Prime (PEP)". The time of penetration shall be equal to or less than that of MC-30. The depth of penetration shall be equal to or greater than that of MC-30.

(e) Polymer-Modified Emulsified Asphalt. Polymer-modified emulsified asphalts shall be according to AASHTO M 316, except as follows.

(1) The cement mixing test will be waived when the polymer-modified emulsion is being used as a tack coat.

(2) CQS-1hP (formerly CSS-1h Latex Modified) emulsion for micro-surfacing treatments shall use latex as the modifier.

(3) Upon examination of the storage stability test cylinder after standing undisturbed for 24 hours, the surface shall show minimal to no white, milky colored substance and shall be a homogenous brown color throughout.

(4) The distillation for all polymer-modified emulsions shall be performed according to AASHTO T 59, except the temperature shall be 374 ± 9 °F (190 ± 5 °C) to be held for a period of 15 minutes and measured using an ASTM 16F (16C) thermometer.

(5) The specified temperature for the Elastic Recovery test for all polymer-modified emulsions shall be 50.0 ± 1.0 °F (10.0 ± 0.5 °C).

(6) The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

(f) Non-Tracking Emulsified Asphalt. Non-Tracking Emulsified Asphalt (NTEA) shall be according to the following.

Test	Requirement
Saybolt Viscosity at 77 °F (25 °C), (AASHTO T 59), SFS	20-100
Storage Stability Test, 24 hr, (AASHTO T 59), %	1 max.
Residue by Distillation, 500 ± 10 °F (260 ± 5 °C), or Residue by Evaporation, 325 ± 5 °F (163 ± 3 °C), (AASHTO T 59), %	50 min.
Sieve Test, No. 20 (850 µm), (AASHTO T 59), %	0.3 max.
Tests on Residue from Distillation/Evaporation	
Penetration at 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	40 max.
Softening Point, (AASHTO T 53), °F (°C)	135 (57) min.
Ash Content, (AASHTO T 111), % [1/]	1 max.

1/ The Solubility in Trichloroethylene test according to AASHTO T 44 may be run in lieu of Ash Content and shall meet a minimum of 97.5 percent.

The different grades are, in general, used for the following.

Grade	Use
SS-1, SS-1h, RS-1, RS-2, CSS-1, CRS-1, CRS-2, CSS-1h, HFE-90, SS-1hP, CSS-1hP, NTEA	Tack coat or fog seal
PEP	Prime coat
RS-2, HFE-90, HFE-150, HFE-300, CRS-2P, HFRS-2P, CRS-2, HFRS-2	Bituminous surface treatment
CQS-1hP	Micro-surfacing
CQS-1h	Slurry sealing
CRS-2P, HFRS-2P	Cape seal

1032.07 Rapid Curing Liquid Asphalt. Rapid curing liquid asphalt will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be a rapid curing cutback asphalt consisting of a petroleum residuum fluxed with a suitable distillate. The liquid asphalt shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grade RC-70
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm^2/s)	70 to 140
Distillation Test: (AASHTO T 78)	
Distillate, percent by volume of total distillate to 680 °F (360 °C)	
Distillate to 374 °F (190 °C)	10 min.
Distillate to 437 °F (225 °C)	50 min.
Distillate to 500 °F (260 °C)	70 min.
Distillate to 600 °F (315 °C)	85 min.
Residue from distillation to 680 °F (360 °C), percent volume by difference	55 min.
Tests on residue from distillation:	
Penetration, 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	80 to 120
Ductility at 77 °F (25 °C), (AASHTO T 51), mm[1/]	1000 min.
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The grade is, in general, used for the following.

Grade	Use
RC-70	Tack coat and soil curing

1032.08 Medium Curing Liquid Asphalts. Medium curing liquid asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure". The Department will maintain a qualified producer list. These materials shall be medium curing cutback asphalts consisting of a petroleum residuum fluxed with a suitable distillate. They shall be free from water, show no separation on standing, and shall be according to the requirements listed in the following table.

Test	Grades				
	MC-30	MC-70	MC-250	MC-800	MC-3000
Flash Point, (Tag open cup), (AASHTO T 79), °F (°C) 1/	100 min. (38 min.)	100 min. (38 min.)	-- --	-- --	-- --
Flash Point, (Cleveland open cup), (AASHTO T 48), °F (°C)	-- --	-- --	150 min. (65 min.)	150 min. (65 min.)	150 min. (65 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm^2/s)	30 to 60	70 to 140	250 to 500	800 to 1600	3000 to 6000
Distillation Test (AASHTO T 78):					
Distillate, % by volume of total distillate to 680 °F (360 °C):					
Distillate to 437 °F (225 °C)	25 max.	20 max.	10 max.	--	--
Distillate to 500 °F (260 °C)	40 to 70	20 to 60	15 to 55	35 max.	15 max.
Distillate to 600 °F (315 °C)	75 to 93	70 to 90	60 to 87	45 to 80	15 to 75
Residue from distillation to 680 °F (360 °C), % volume by difference	50 min.	55 min.	67 min.	75 min.	80 min.
Tests on residue from distillation:					
Penetration at 77 °F (25 °C), 100 g, 5 sec, (AASHTO T 49), dmm	120 to 250	120 to 250	120 to 250	120 to 250	120 to 250
Ductility at 77 °F (25 °C), (AASHTO T 51), mm 2/	1000 min.	1000 min.	1000 min.	1000 min.	1000 min.
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.	99.5 min.	99.5 min.	99.5 min.	99.5 min.

1/ Flash point by Cleveland open cup may be used for products having a flash point above 175 °F (80 °C).

2/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
MC-30	Prime coats
MC-70	Soil curing
MC-250, MC-800, MC-3000	Surface treatments and seal coats

1032.09 Slow Curing Liquid Asphalts. Slow curing liquid asphalts will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be slow curing liquid asphalts produced by the distillation of petroleum. The liquid asphalts shall be residues, distillates, or residues fluxed to the desired consistency with petroleum distillates. Each shipment of liquid asphalt shall be uniform in appearance and consistency. All grades shall be free from water and shall not foam when heated to 225 °F (107 °C). The residues of specified penetration shall be smooth and homogeneous in appearance. This material shall be according to the requirements listed in the following table.

Test	Grades			
	SC-70	SC-250	SC-800	SC-3000
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	150 min. (65 min.)	175 min. (80 min.)	200 min. (93 min.)	225 min. (107 min.)
Viscosity, Kinematic, at 140 °F (60 °C), (AASHTO T 201), cSt (mm²/s)	70 to 140	250 to 500	800 to 1600	3000 to 6000
Residue of 100 penetration, (ASTM D 243), %	50 min.	60 min.	70 min.	80 min.
Ductility at 77 °F (25 °C), of residue of specified penetration, (AASHTO T 51), mm 1/	1000 min	1000 min	1000 min	1000 min.
Loss on heating at 325 °F (163 °C), 50 g, 5 hours, (ASTM D 6/D 6M), %	11 max.	8 max.	5 max.	4 max.
Solubility in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

1/ If ductility is less than 1000 mm at 77 °F (25 °C), the material will be acceptable if the ductility is more than 1000 mm at 60 °F (15 °C).

The different grades are, in general, used for the following.

Grade	Use
SC-70	For dust layer and for prime coats
SC-250	For road mix and traveling plant mix surfaces dense-graded aggregate type
SC-800	For plant mix surfaces dense-graded aggregate type
SC-3000	Surface treatments and seal coats

1032.10 Road Oils. Road oils will be accepted according to the Bureau of Materials Policy Memorandum, "Cutback Asphalt and Road Oil Qualification Procedure." The Department will maintain a qualified producer list. These materials shall be slow curing asphaltic oils. They shall show no separation on standing and shall be according to the requirements listed in the following table.

Test	Grades		
	E-2 Light	E-3 Medium	E-4 Heavy
Water, by volume, percent	0.5 max.	0.5 max.	0.5 max.
Flash Point, Cleveland open cup, (AASHTO T 48) °F (°C)	200 min. (93 min.)	200 min. (93 min.)	200 min. (93 min.)
Viscosity, Kinematic, at 122 °F (50 °C), (AASHTO T 201), cSt (mm^2/sec),	168 to 285	285 to 510	510 to 785
Viscosity, Saybolt Furol, at 122 °F (50 °C), (AASHTO T 59), SFS	80 to 135	135 to 240	240 to 370
Solubility in trichloroethylene, (AASHTO T 44), %	99.5 min.	99.5 min.	99.5 min.
Residue of 100 penetration, ASTM D 243, %	50 min.	55 min.	60 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), of residue of specified penetration, mm	1000 min.	1000 min.	1000 min.

The different grades are used for surface treatment of earth roads.

1032.11 Asphalt Fillers (Prepared from Petroleum). These materials shall be free from water and shall not foam when heated to the flash point. They shall be according to the requirements listed in the following table.

Test	Grades			
	PAF-1	PAF-2	PAF-3	PAF-4
Flash Point, Cleveland open cup, (AASHTO T 48), °F (°C)	450 min. (232 min.)	450 min. (232 min.)	450 min. (232 min.)	475 min. (246 min.)
Softening Point, ring and ball method, (AASHTO T 53), °F (°C)	122 min. (50 min.)	135 min. (57 min.)	167 to 185 (75 to 85)	180 min. (82 min.)
Penetration at 32 °F (0 °C), 200g, 60 sec	30 min.	15 min.	10 min.	15 min.
Penetration at 77 °F (25 °C), (AASHTO T 49), 100g, 5 sec	80 to 100	40 to 55	25 to 40	30 to 50
Penetration at 115 °F (46.1 °C), 50g, 5 sec	--	190 max.	90 max.	80 max.
Loss on heating at 325 °F (163 °C), 50 g, 5 hrs., (ASTM D 6/D 6M), %	1.0 max.	1.0 max.	1.0 max.	1.0 max.
Penetration at 77 °F (25 °C), 100 g, 5 sec, of asphalt after heating at 325 °F (163 °C), as compared with penetration of asphalt before heating, %	70.0 min.	70.0 min.	70.0 min.	70.0 min.
Ductility at 77 °F (25 °C), (AASHTO T 51), mm	400 min.	150 min.	25 min.	25 min.
Bitumen soluble in trichloroethylene, (AASHTO T 44), %	99.0 min.	99.0 min.	99.0 min.	99.0 min.

The different grades are, in general, used for the following.

PAF-1 & PAF-2	For filling cracks in portland cement concrete pavement.
PAF-3	For sealing expansion and contraction joints in portland cement concrete pavement and for undersealing portland cement concrete pavement.
PAF-4	For sealing expansion and contraction joints in portland cement concrete pavement and for filler in brick pavement.

1032.12 Longitudinal Joint Sealant (LJS). Longitudinal joint sealant (LJS) in the form of spray applied liquid or pre-formed roll will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure". The Department will maintain a qualified producer list. The bituminous material used for the LJS shall be according to the following table. Elastomers shall be added to a base asphalt and shall be either a styrene-butadiene diblock or triblock copolymer without oil extension, or a styrene-butadiene rubber. Air blown asphalt, acid modification, or other modifiers will not be allowed.

Test	Test Requirement	Test Method
Dynamic shear @ 88°C (unaged), G*/sin δ, kPa	1.00 min.	AASHTO T 315
Creep stiffness @ -18°C (unaged), Stiffness (S), MPa m-value	300 max. 0.300 min.	AASHTO T 313
Ash Content, %	1.0 – 4.0 1/	AASHTO T 111
Elastic Recovery, 100 mm elongation, cut immediately, 25°C, % 2/	70 min.	ASTM D 6084 (Procedure A)
Separation of Polymer, Difference in °C of the softening point (ring and ball) 2/	3 max.	ILTP "Separation of Polymer from Asphalt Binder"

1/ For LJS in a pre-formed roll, the ash content shall be a maximum of 20 percent.

2/ For LJS in a pre-formed roll, this test shall be waived.

1032.13 Full Lane Sealant (FLS). Full lane sealant (FLS) will be accepted according to the Bureau of Materials Policy Memorandum, "Performance Graded Asphalt Binder Qualification Procedure". The Department will maintain a qualified producer list. The bituminous material used for the FLS shall be according to Article 1032.12, except fillers shall not be added and the ash content test shall be waived.

SECTION 1033. TEMPORARY RUBBER AND TEMPORARY PLASTIC RAMPS

1033.01 Temporary Rubber Ramps. For butt joints, temporary rubber ramp material shall be according to the following.

Property	Test Method	Requirement
Durometer Hardness, Shore A	ASTM D 2240	80 ±10
Tensile Strength, psi (kPa)	ASTM D 412	800 (5500) min.
Elongation, %	ASTM D 412	100 min.
Specific Gravity	ASTM D 297	1.1 - 1.3
Brittleness, °F (°C)	ASTM D 746	-40 (-40)

1002.03 Water Intake. Water from shallow, muddy, or marshy surfaces shall not be used. The intake of the pipeline shall be enclosed to exclude silt, mud, grass, and other solid materials; and there shall be a minimum depth of 2 ft (600 mm) of water below the intake at all times.

SECTION 1003. FINE AGGREGATES

1003.01 Materials. Fine aggregate materials shall be according to the following.

(a) Description. The natural and manufactured materials used as fine aggregate are defined as follows.

(1) Sand. Sand shall be the fine granular material resulting from the natural disintegration of rock. Sand produced from deposits simultaneously with, and by the same operations as, gravel coarse aggregate may contain crushed particles in the quantity resulting normally from the crushing and screening of oversize particles.

(2) Silica Sand. Silica sand shall be composed of not less than 99.5 percent silica ($Si0_2$).

(3) Stone Sand. Stone sand shall be produced by washing, or processing by air separation, the fine material resulting from crushing rock quarried from undisturbed, consolidated deposits, or crushing gravel. The acceptance and use of crushed gravel stone sand shall be according to the Bureau of Materials Policy Memorandum, "Crushed Gravel Producer Self-Testing Program".

(4) Chats. Chats shall be the tailings resulting from the separation of metals from rocks in which they occur.

(5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

(6) Slag Sand. Slag sand shall be the graded product resulting from the screening of air-cooled blast furnace slag. Air-cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace.

The acceptance and use of air-cooled blast furnace slag sand shall be according to the Bureau of Materials Policy Memorandum, "Crushed Slag Producer Certification and Self-Testing Program".

(7) Granulated Slag Sand. Granulated slag sand shall be the graded product resulting from the screening of granulated slag. Granulated slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. Granulated

slag sand is formed by introducing a large volume of water under high pressure into the molten slag.

(8) Steel Slag Sand. Steel slag sand shall be the graded product resulting from the screening of crushed steel slag. Crushed steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen, or electric arc furnace. The acceptance and use of steel slag sand shall be according to the Bureau of Materials Policy Memorandum, "Slag Producer Self-Testing Program".

(9) Crushed Concrete Sand. Crushed concrete sand shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete sand shall be according to the Bureau of Materials Policy Memorandum, "Recycling Portland Cement Concrete Into Aggregate".

(10) Construction and Demolition Debris Sand. Construction and demolition debris sand shall be the angular fragments resulting from mechanical crushing/screening of unpainted exterior brick, mortar, and/or concrete with small amounts of other materials. Construction and demolition debris sand shall be according to the Bureau of Materials Policy Memorandum, "Construction and Demolition Debris Sand as a Fine Aggregate for Trench Backfill".

(b) Quality. The fine aggregate shall meet the quality standards listed in the following table. Except for the minus No. 200 (75 µm) sieve material, all fine aggregate shall meet specified quality requirements before being proportioned for mix or combined to adjust gradation. The blended materials shall meet the minus No. 200 (75 µm) sieve requirements.

FINE AGGREGATE QUALITY			
QUALITY TEST	CLASS		
	A	B	C
Na_2SO_4 Soundness 5 Cycle, Illinois Modified AASHTO T 104, % Loss max.	10	15	20
Minus No. 200 (75 µm) Sieve Material, Illinois Modified AASHTO T 11, % max. [4/]	3	6 [1/]	10 [1/]
Organic Impurities Check, Illinois Modified AASHTO T 21	Yes [2/]	---	---
Deleterious Materials: [3/] [5/]			
Shale, % max.	3.0	3.0	---
Clay Lumps, % max.	1.0	3.0	---
Coal, Lignite, & Shells, % max.	1.0	3.0	---
Conglomerate, % max.	3.0	3.0	---
Other Deleterious, % max.	3.0	3.0	---
Total Deleterious, % max.	3.0	5.0	---

1/ Does not apply to Gradations FA 20 or FA 21.

2/ Applies only to sand. Sand exceeding the colorimetric test standard of 11 (Illinois Modified AASHTO T 21) will be checked for mortar making properties according to Illinois Modified ASTM C 87, and shall develop a compressive strength at the age of 14 days when using Type I or II Cement of not less than 95 percent of the comparable standard.

3/ Applies only to sand.

4/ Fine aggregate used for hot-mix asphalt (HMA) shall not contain more than three percent clay (2 micron or smaller) particles as determined by Illinois Modified AASHTO T 88.

5/ Tests shall be run according to ITP 204.

(c) Gradation. All aggregates shall be produced according to the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System".

The gradations prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably uniform and shall not be subject to the extreme percentages of gradation represented by the tolerance limits of the various sieve sizes.

The gradation numbers and corresponding gradation limits are listed in the following tables.

FINE AGGREGATE GRADATIONS											
Grad No.	Sieve Size and Percent Passing										
	3/8	No. 4	No. 8 [4/]	No. 10	No. 16	No. 30 [5/]	No. 40	No. 50	No. 80	No. 100	No. 200 [1/]
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4 [7/]	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 [3/]								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 [3/]	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	[6/]	[6/]		8±8						2±2
FA 23	100	80±10	57±13		39±11	26±8		18±7		12±6	10±5
FA 24	100	95±5	77±13		57±13	35±10		19±6		15±6	10±5

Art. 1003.01 Fine Aggregates

FINE AGGREGATE GRADATIONS (Metric)											
Grad No.	Sieve Size and Percent Passing										
	9.5 mm	4.75 mm	2.36 mm [4/]	2.00 mm	1.18 mm	600 µm [5/]	425 µm	300 µm	180 µm	150 µm	75 µm [1/]
FA 1	100	97±3			65±20			16±13		5±5	
FA 2	100	97±3			65±20			20±10		5±5	
FA 3	100	97±3		80±15			50±20		25±15		3±3
FA 4 [7/]	100				5±5						
FA 5	100	92±8								20±20	15±15
FA 6		92±8 [2/]								20±20	6±6
FA 7		100		97±3			75±15		35±10		3±3
FA 8			100				60±20			3±3	2±2
FA 9			100					30±15		5±5	
FA 10				100			90±10		60±30		7±7
FA 20	100	97±3	80±20		50±15			19±11		10±7	4±4
FA 21 [3/]	100	97±3	80±20		57±18			30±10		20±10	9±9
FA 22	100	[6/]	[6/]		8±8						2±2
FA 23	100	80±10	57±13		39±11	26±8		18±7		12±6	10±5
FA 24	100	95±5	77±13		57±13	35±10		19±6		15±6	10±5

1/ Subject to maximum percent allowed in Fine Aggregate Quality Table.

2/ 100 percent shall pass the 1 in. (25 mm) sieve, except that for bedding material 100 percent shall pass the 3/8 in. (9.5 mm) sieve. If 100 percent passes the 1/2 in. (12.5 mm) sieve, the No. 4 (4.75 mm) sieve may be 75 ± 25.

3/ For all HMA mixtures. When used, either singly or in combination with other sands, the amount of material passing the No. 200 (75 µm) sieve (washed basis) in the total sand fraction for mix design shall not exceed ten percent.

4/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±15 percent. The midpoint shall not be changed without Department approval.

5/ For each gradation used in HMA, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±13 percent. The midpoint shall not be changed without Department approval.

6/ For fine aggregate gradation FA 22, the aggregate producer shall set the midpoint percent passing, and the Department will apply a range of ±10 percent. The midpoint shall not be changed without Department approval.

7/ When used as backfill for pipe underdrains, Type 3, the fine aggregate shall meet one of the modified FA 4 gradations shown in the following table.

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FA 4 Modified		
Sieve Size	Percent Passing	
	Option 1	Option 2
3/8 in. (9.5 mm)	100	100
No. 4 (4.75 mm)		97 ± 3
No. 8 (2.36 mm)		5 ± 5
No. 10 (2 mm)	10 ± 10	
No. 16 (1.18 mm)	5 ± 5	2 ± 2
No. 200 (75 µm)	1 ± 1	1 ± 1

(d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.

(e) Storage of Fine Aggregate. Sites for storage of all fine aggregates shall be grubbed and cleaned prior to storing the material.

Stockpiles shall be built according to the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System (AGCS)" and the following.

(1) Fine aggregate of various gradations and from different sources shall be stockpiled separately.

(2) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.

(3) Fine aggregates for portland cement concrete and HMA shall be handled in and out of the stockpiles in such a manner that will prevent contamination, segregation, and degradation.

At the time of use, the fine aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign materials which may have become mixed during transportation and handling.

(f) Shipping Tickets. Shipping tickets for the material shall be according to the Bureau of Materials Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

1003.02 Fine Aggregate for Portland Cement Concrete and Mortar. The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of washed sand, washed stone sand, or a blend of washed sand and washed stone sand approved by the Engineer. Stone sand produced through an air separation system approved by the Engineer may be used in place of washed stone sand.

(b) Quality. The fine aggregate for portland cement concrete shall meet Class A Quality, except the minus No. 200 (75 µm) sieve Illinois Modified AASHTO T 11 requirement in the Fine Aggregate Quality Table shall not apply to washed stone sand or any blend of washed stone sand and washed sand approved by the Engineer. The fine aggregate for masonry mortar shall meet Class A Quality.

(c) Gradation. The washed sand for portland cement concrete shall be Gradation FA 1 or FA 2. Washed stone sand for portland cement concrete, which includes any blend with washed sand, shall be Gradation FA 1, FA 2, or FA 20. Fine aggregate for masonry mortar shall be Gradation FA 9.

(d) Use of Fine Aggregates. The blending, alternate use, and/or substitution of fine aggregates from different sources for use in portland cement concrete will not be permitted without the approval of the Engineer. Any blending shall be by interlocked mechanical feeders at the aggregate source or concrete plant. The blending shall be uniform, and the equipment shall be approved by the Engineer.

(e) Alkali Reaction.

(1) ASTM C 1260. Each fine aggregate will be tested by the Department for alkali reaction according to ASTM C 1260. The test will be performed with Type I or II portland cement having a total equivalent alkali content (Na_2O + $0.658K_2O$) of 0.90 percent or greater. The Engineer will determine the assigned expansion value for each aggregate, and these values will be made available on the Department's Alkali-Silica Potential Reactivity Rating List. The Engineer may differentiate aggregate based on ledge, production method, gradation number, or other factors. An expansion value of 0.03 percent will be assigned to limestone or dolomite fine aggregates (manufactured stone sand). However, the Department reserves the right to perform the ASTM C 1260 test.

(2) ASTM C 1293 by Department. In some instances, such as chert natural sand or other fine aggregates, testing according to ASTM C 1260 may not provide accurate test results. In this case, the Department may only test according to ASTM C 1293.

(3) ASTM C 1293 by Contractor. If an individual aggregate has an ASTM C 1260 expansion value that is unacceptable to the Contractor, an ASTM C 1293 test may be performed by the Contractor to evaluate the Department's ASTM C 1260 test result. The laboratory performing the ASTM C 1293 test shall be approved by the Department according to the Bureau of Materials Policy Memorandum "Minimum Laboratory Requirements for Alkali-Silica Reactivity (ASR) Testing".

The ASTM C 1293 test shall be performed with Type I or II portland cement having a total equivalent alkali content (Na_2O + $0.658K_2O$) of 0.80 percent or greater. The interior vertical wall of the ASTM C 1293 recommended container (pail) shall be half covered with a wick of absorbent material consisting of blotting paper. If the testing laboratory desires to use an alternate container, wick of absorbent material, or amount of coverage inside the container with blotting paper, ASTM C 1293 test results with an alkali-reactive aggregate of known expansion characteristics shall be provided to the Engineer for review and approval. If the expansion is less than 0.040 percent after one year, the aggregate will be assigned an ASTM C 1260 expansion value of 0.08 percent that will be valid for two years, unless the Engineer determines the aggregate has changed significantly. If the aggregate is manufactured into multiple gradation numbers, and the other gradation numbers have the same or lower ASTM C 1260 value, the ASTM C 1293 test result may apply to multiple gradation numbers.

The Engineer reserves the right to verify a Contractor's ASTM C 1293 test result. When the Contractor performs the test, a split sample shall be provided to the Engineer. The Engineer may also independently obtain a sample at any time. The aggregate will be considered reactive if the Contractor or Engineer obtains an expansion value of 0.040 percent or greater.

1003.03 Fine Aggregate for Hot-Mix Asphalt (HMA). The aggregate shall be according to Article 1003.01 and the following.

(a) Description. Fine aggregate for HMA shall consist of sand, stone sand, chats, slag sand, or steel slag sand. For gradation FA 22, uncrushed material will not be permitted. Fine aggregate for SMA shall consist of stone sand, slag sand, or steel slag sand.

(b) Quality. The fine aggregate for all HMA shall be Class B Quality or better.

(c) Gradation. The fine aggregate gradation for all HMA shall be FA 1, FA 2, FA 20, FA 21, or FA 22. The fine aggregate gradation for SMA shall be FA/FM 20 or FA/FM 22.

For mixture IL-4.75 and surface mixtures with an Ndesign = 90, at least 50 percent of the required fine aggregate fraction shall consist of either stone sand, slag sand, or steel slag meeting the FA 20 gradation.

For mixture IL-9.5FG, at least 67 percent of the required fine aggregate fraction shall consist of either stone sand, slag sand, steel slag sand, or combinations thereof meeting FA 20 gradation.

For mixture IL-19.0, Ndesign = 90 the fine aggregate fraction shall consist of at least 67 percent manufactured sand meeting FA 20 or FA 22 gradation. For mixture IL-19.0, Ndesign = 50 or 70 the fine aggregate fraction shall consist of at least 50 percent manufactured sand meeting FA 20 or FA 22 gradation. The manufactured sand shall be stone sand, slag sand, steel slag sand, or combinations thereof.

Gradation FA 1, FA 2, or FA 3 shall be used when required for prime coat aggregate application for HMA.

1003.04 Fine Aggregate for Bedding, Backfill, Trench Backfill, Embankment, Porous Granular Backfill, and French Drains. The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of sand, stone sand, chats, wet bottom boiler slag, slag sand, or granulated slag sand. Crushed concrete sand, construction and demolition debris sand, and steel slag sand produced from an electric arc furnace may be used in lieu of the above for trench backfill.

(b) Quality. The fine aggregate shall be reasonably free from an excess of soft and unsound particles and other objectionable matter.

(c) Gradation. The fine aggregate gradations shall be as follows.

Application	Gradation
Granular Embankment, Granular Backfill, Trench Backfill, and Bedding and Backfill for Pipe Culverts and Storm Sewers	FA 1, FA 2, or FA 6 through FA 21
Porous Granular Embankment, Porous Granular Backfill, French Drains, and Bedding and Backfill for Pipe Underdrains, Type 1	FA 1, FA 2, or FA 20, except the percent passing the No. 200 (75 µm) sieve shall be 2±2
Backfill for Pipe Underdrains, Type 3	FA 4 Modified (see Article 1003.01(c))

1003.05 Fine Aggregate for Membrane Waterproofing. The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of sand, stone sand, wet bottom boiler slag, slag sand, or chats.

(b) Quality. The fine aggregate shall meet the Class B Quality Deleterious Count, and when subjected to Illinois Modified AASHTO T 104, the weighted average loss shall not be more than ten percent.

(c) Gradation. The fine aggregate shall be Gradation FA 8.

1003.06 Fine Aggregate for Controlled Low-Strength Material (CLSM). The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of sand.

(b) Quality. The fine aggregate shall be reasonably free from an excess of soft and unsound particles and other objectionable matter.

(c) Gradation. The fine aggregate gradation shall be FA 1 or FA 2. Blending of fine aggregate will not be permitted.

1003.07 Fine Aggregate for Select Fill Used for Retaining Wall Applications Utilizing Soil Reinforcement. The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of sand or stone sand.

(b) Quality. The fine aggregate shall have a maximum sodium sulfate (Na_2SO_4) loss of 15 percent according to Illinois Modified AASHTO T 104.

(c) Gradation. The fine aggregate shall be FA 1, FA 2, or FA 20.

(d) Internal Friction Angle. The effective internal friction angle for the fine aggregate shall be a minimum 34 degrees according to AASHTO T 236 on samples compacted to 95 percent density according to Illinois Modified AASHTO T 99. The AASHTO T 296 test with pore pressure measurement may be used in lieu of AASHTO T 236. If the Contractor's design uses a friction angle greater than 34 degrees this greater value shall be taken as the minimum required.

(e) pH. The pH shall be determined according to Illinois Modified AASHTO T 289.

(1) When geosynthetic soil reinforcement is used, the fine aggregate pH shall be 4.5 to 9.0 for permanent applications, and 3.0 to 10.0 for temporary applications.

(2) When steel reinforcement is used, the fine aggregate pH shall be 5.0 to 10.0.

(f) Corrosion Mitigation. The fine aggregates shall also meet the following when used in conjunction with steel soil reinforcement in non-temporary wall applications.

(1) Resistivity. The resistivity according to Illinois Modified AASHTO T 288 shall be greater than 3000 ohm centimeters for galvanized reinforcement, and 1500 ohm centimeters for aluminized Type 2 reinforcement.

(2) The chlorides shall be less than 100 parts per million according to Illinois Modified AASHTO T 291 or ASTM D 4327. For either test, the sample shall be prepared according to Illinois Modified AASHTO T 291.

(3) The sulfates shall be less than 200 parts per million according to Illinois Modified AASHTO T 290 or ASTM D 4327. For either test, the sample shall be prepared according to Illinois Modified AASHTO T 290.

(4) The organic content shall be a maximum of 1.0 percent according to Illinois Modified AASHTO T 267.

(g) Test Frequency. Prior to the start of construction, the Contractor shall provide internal friction angle and pH test results to demonstrate the select fill material meets the specification requirements. Resistivity, chlorides, sulfates, and organic content test results shall also be provided if steel reinforcement is used. The laboratory performing the Illinois Modified AASHTO T 288 test shall be approved by the Department according to the Bureau of Materials Policy Memorandum "Minimum Laboratory Requirements for Resistivity Testing". These test results shall be no more than 12 months old. In addition, a sample of select fill material will be obtained by the Engineer for testing and approval before construction begins. Thereafter, the minimum frequency of subsequent sampling and testing at the jobsite will be one per 40,000 tons (36,300 metric tons) of select fill.

1003.08 Fine Aggregate for Micro-Surfacing and Slurry Sealing. The aggregate shall be according to Article 1003.01 and the following.

(a) Description. The fine aggregate shall consist of stone sand, wet bottom boiler slag, slag sand, granulated slag sand, steel slag sand, or crushed concrete sand.

(b) Quality. The fine aggregate shall be Class B Quality.

(c) Gradation. Rut filling mixes shall be FA 23. Surface mixes shall be FA 24.

(d) Use of Fine Aggregates. The blending, alternate use, and/or substitutions of aggregates from different sources for use in this work will not be permitted without the approval of the Engineer. Any blending shall be by interlocked mechanical feeders. The blending shall be uniform, compatible with the other components of the mix, and the equipment shall be approved by the Engineer.

If blending aggregates, the blend shall have a washed gradation preformed every other day or a minimum of three tests per week. Testing shall be completed before the aggregate receives final acceptance for use in the mix.

Aggregates shall be screened at the stockpile prior to delivery to the paving machine to remove oversized material or contaminants.

SECTION 1004. COARSE AGGREGATES

1004.01 Materials. Coarse aggregate materials shall be according to the following.

(a) Description. The natural and manufactured materials used as coarse aggregate are defined as follows.

(1) Gravel. Gravel shall be the coarse granular material resulting from the reduction of rock by the action of the elements and having subangular to rounded surfaces. It may be partially crushed.

(2) Chert Gravel. Chert gravel shall be the coarse granular material occurring in alluvial deposits resulting from reworking by weathering and

erosion of chert bearing geological formations and containing a minimum of 80 percent chert or similar siliceous material.

(3) Crushed Gravel. Crushed gravel shall be the product resulting from crushing, by mechanical means, and shall consist entirely of particles obtained by crushing gravel. The acceptance and use of crushed gravel shall be according to the Bureau of Materials Policy Memorandum, "Crushed Gravel Producer Self-Testing Program".

(4) Crushed Stone. Crushed stone shall be the angular fragments resulting from crushing undisturbed, consolidated deposits of rock by mechanical means. Crushed stone shall be divided into the following, when specified.

a. Carbonate Crushed Stone. Carbonate crushed stone shall be either dolomite or limestone. Dolomite shall contain 11.0 percent or more magnesium oxide (MgO). Limestone shall contain less than 11.0 percent magnesium oxide (MgO).

b. Crystalline Crushed Stone. Crystalline crushed stone shall be either metamorphic or igneous stone, including but is not limited to, quartzite, granite, rhyolite and diabase.

(5) Wet Bottom Boiler Slag. Wet bottom boiler slag shall be the hard, angular by-product of the combustion of coal in wet bottom boilers.

(6) Crushed Slag. Crushed slag shall be the graded product resulting from the processing of air-cooled blast furnace slag. Air-cooled blast furnace slag shall be the nonmetallic product, consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed in a molten condition simultaneously with iron in a blast furnace. It shall be air-cooled and shall have a compact weight (Illinois Modified AASHTO T 19) of not less than 70 lb/cu ft (1100 kg/cu m). The acceptance and use of air-cooled blast furnace slag shall be according to the Bureau of Materials Policy Memorandum, "Crushed Slag Producer Certification and Self-Testing Program".

(7) Crushed Sandstone. Crushed sandstone shall be the angular fragments resulting from crushing, by mechanical means, a cemented sand composed predominantly of quartz grains. Sandstone shall have an Insoluble Residue of 50.0 percent or higher.

(8) Crushed Concrete. Crushed concrete shall be the angular fragments resulting from crushing portland cement concrete by mechanical means. The acceptance and use of crushed concrete shall be according to the Bureau of Materials Policy Memorandum, "Recycling Portland Cement Concrete Into Aggregate".

(9) Chats. Chats shall be the tailings resulting from the separation of metals from the rocks in which they occur.

(10) Crushed Steel Slag. Crushed steel slag shall be the graded product resulting from the processing of steel slag. Steel slag shall be the nonmetallic product which is developed in a molten condition simultaneously with steel in an open hearth, basic oxygen, or electric furnace. The acceptance and use of crushed steel slag shall be according to the Bureau of Materials Policy Memorandum, "Slag Producer Self-Testing Program".

(b) Quality. The coarse aggregate shall be according to the quality standards listed in the following table.

COARSE AGGREGATE QUALITY				
QUALITY TEST	CLASS			
	A	B	C	D
Na_2SO_4 Soundness 5 Cycle, Illinois Modified AASHTO T 104 1/, % Loss max.	15	15	20	25 2/
Los Angeles Abrasion, Illinois Modified AASHTO T 96 11/, % Loss max.	40 3/	40 4/	40 5/	45
Minus No. 200 (75 µm) Sieve Material, Illinois Modified AASHTO T 11	1.0 6/	---	2.5 7/	---
Deleterious Materials 10/				
Shale, % max.	1.0	2.0	4.0 8/	---
Clay Lumps, % max.	0.25	0.5	0.5 8/	---
Coal & Lignite, % max.	0.25	---	---	---
Soft & Unsound Fragments, % max.	4.0	6.0	8.0 8/	---
Other Deleterious, % max.	4.0 9/	2.0	2.0 8/	---
Total Deleterious, % max.	5.0	6.0	10.0 8/	---
Oil-Stained Aggregate 10/, % max.	5.0	---	---	

1/ Does not apply to crushed concrete.

2/ For aggregate surface course and aggregate shoulders, the maximum percent loss shall be 30.

3/ For portland cement concrete, the maximum percent loss shall be 45.

4/ Does not apply to crushed slag or crushed steel slag.

5/ For hot-mix asphalt (HMA) binder mixtures, except when used as surface course, the maximum percent loss shall be 45.

6/ For crushed aggregate, if the material finer than the No. 200 (75 µm) sieve consists of the dust from fracture, essentially free from clay or silt, this percentage may be increased to 2.5.

7/ Does not apply to aggregates for HMA binder mixtures.

8/ Does not apply to Class A seal and cover coats.

9/ Includes deleterious chert. In gravel and crushed gravel aggregate, deleterious chert shall be the lightweight fraction separated in a 2.35 heavy media separation. In crushed stone aggregate, deleterious chert shall be the lightweight fraction separated in a 2.55 heavy media separation. Tests shall be run according to Illinois Modified AASHTO T 113.

10/ Test shall be run according to ITP 203.

11/ Does not apply to crushed slag.

All varieties of chert contained in gravel coarse aggregate for portland cement concrete, whether crushed or uncrushed, pure or impure, and irrespective of color, will be classed as chert and shall not be present in the total aggregate in excess of 25 percent by weight (mass).

Aggregates used in Class BS concrete (except when poured on subgrade), Class PS concrete, and Class PC concrete (bridge superstructure products only, excluding the approach slab) shall contain no more than two percent by weight (mass) of deleterious materials. Deleterious materials shall include substances whose disintegration is accompanied by an increase in volume which may cause spalling of the concrete.

(c) Gradation. All aggregates shall be produced according to the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System (AGCS)".

The sizes prescribed may be manufactured by any suitable commercial process and by the use of any sizes or shapes of plant screen openings necessary to produce the sizes within the limits of the sieve analysis specified.

The gradation of the material from any one source shall be reasonably close to the gradation specified and shall not be subject to the extreme percentages of gradation represented by the tolerance limits for the various sieve sizes. The gradation numbers and corresponding gradation limits are listed in the following table.

Art. 1004.01 Coarse Aggregates

Grad No.	COARSE AGGREGATE GRADATIONS												
	Sieve Size and Percent Passing												
	3 in.	2 1/2 in.	2 in.	1 1/2 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 200 1/
CA 1	100	95±5	60±15	15±15	3±3								
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4
CA 3		100	93±7	55±20	8±8		3±3						
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4
CA 5				97±3 2/	40±25		5±5		3±3				
CA 6				100	95±5		75±15		43±13		25±15		8±4
CA 7				100	95±5		45±15 7/		5±5				
CA 8				100	97±3	85±10	55±10		10±5		3±3 3/		
CA 9				100	97±3		60±15		30±15		10±10		6±6
CA 10					100	95±5	80±15		50±10		30±15		9±4
CA 11					100	92±8	45±15 4/ 7/		6±6		3±3 3/ 5/		
CA 12						100	95±5	85±10	60±10		35±10		9±4
CA 13						100	97±3	80±10	30±15		3±3 3/		
CA 14							90±10 6/	45±20	3±3				
CA 15							100	75±15	7±7		2±2		
CA 16							100	97±3	30±15		2±2 3/		
CA 17	100								65±20		45±20	20±10	10±5
CA 18	100				95±5				75±25		55±25	10±10	2±2
CA 19	100				95±5				60±15		40±15	20±10	10±5
CA 20							100	92±8	20±10	5±5	3±3		

Grad No.	COARSE AGGREGATE GRADATIONS (metric)												
	Sieve Size and Percent Passing												
	75 mm	63 mm	50 mm	37.5 mm	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	300 µm	75 µm 1/
CA 1	100	95±5	60±15	15±15	3±3								
CA 2		100	95±5		75±15		50±15		30±10		20±15		8±4
CA 3		100	93±7	55±20	8±8		3±3						
CA 4			100	95±5	85±10		60±15		40±10		20±15		8±4
CA 5				97±3 2/	40±25		5±5		3±3				
CA 6				100	95±5		75±15		43±13		25±15		8±4
CA 7				100	95±5		45±15 7/		5±5				
CA 8				100	97±3	85±10	55±10		10±5		3±3 3/		
CA 9				100	97±3		60±15		30±15		10±10		6±6
CA 10					100	95±5	80±15		50±10		30±15		9±4
CA 11					100	92±8	45±15 4/ 7/		6±6		3±3 3/ 5/		
CA 12						100	95±5	85±10	60±10		35±10		9±4
CA 13						100	97±3	80±10	30±15		3±3 3/		
CA 14							90±10 6/	45±20	3±3				
CA 15							100	75±15	7±7		2±2		
CA 16							100	97±3	30±15		2±2 3/		
CA 17	100								65±20		45±20	20±10	10±5
CA 18	100				95±5				75±25		55±25	10±10	2±2
CA 19	100				95±5				60±15		40±15	20±10	10±5
CA 20							100	92±8	20±10	5±5	3±3		

1/ Subject to maximum percent allowed in Coarse Aggregate Quality table.

2/ Shall be 100 percent passing the 1 3/4 in. (45 mm) sieve.

3/ When used in HMA (High and Low ESAL) mixtures, the percent passing the No. 16 (1.18 mm) sieve for gradations CA 11, CA 13, or CA 16 shall be 4±4 percent.

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4/ When using gradation CA 11 for IL-19.0 and IL-19.0L binder, the percent passing the 1/2 in. (12.5 mm) sieve may also be 15±10 percent.

5/ The No. 16 (1.18 mm) requirement will be waived when CA 11 is used in the manufacture of portland cement concrete.

6/ Shall be 100 percent passing the 5/8 in. (16 mm) sieve.

7/ When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. The Contractor may combine two or more coarse aggregate sizes, consisting of CA 7, CA 11, CA 13, CA 14, and CA 16, provided a CA 7 or CA 11 is included in the blend.

Note: When CA 7, CA 8, CA 11, CA 13, CA 14, CA 15, or CA 16 are used under paved median, Notes 3, 4, 5, and 6 shall apply.

(d) Incompatibility. Incompatibility of any of the gradations or combinations of gradations permitted resulting in unworkable mixtures, nonadherence to the final mix gradation limits, or any other indication of incompatibility shall be just cause for rejection of one or both of the sizes.

(e) Storage. Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

The stockpiles shall be built according to the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System (AGCS)" and the following.

(1) Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

(2) Separate stockpiles shall be provided for the various kinds of aggregates.

(3) Stockpiles shall be separated to prevent intermingling at the base. If partitions are used, they shall be of sufficient heights to prevent intermingling.

(4) Coarse aggregates shall be handled in and out of the stockpiles in such a manner that will prevent contamination and degradation.

(5) Crushed concrete, crushed slag, or lightweight aggregate for portland cement concrete shall be stockpiled in a moist condition (saturated surface dry or greater) and the moisture content shall be maintained uniformly throughout the stockpile by periodic sprinkling.

At the time of use, the coarse aggregate shall be free from frozen material, material used to caulk rail cars, and all foreign material which may have become mixed during transportation and handling.

(f) Shipping Tickets. Shipping tickets for the material shall be according to the Bureau of Materials Policy Memorandum, "Designation of Aggregate Information on Shipping Tickets".

1004.02 Coarse Aggregate for Portland Cement Concrete. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, or crushed sandstone.

(b) Quality. The coarse aggregate shall be Class A quality.

(c) Gradation. The gradations of coarse aggregate used in the production of portland cement concrete for pavements and structures shall be according to Table 1 of Article 1020.04. Washing equipment will be required where producing conditions warrant.

(d) Combining Sizes. Each size shall be stored separately and care shall be taken to prevent them from being mixed until they are ready to be proportioned. Separate compartments shall be provided to proportion each size.

(1) When Class BS concrete is to be pumped, the coarse aggregate gradation shall have a minimum of 45 percent passing the 1/2 in. (12.5 mm) sieve. The Contractor may combine two or more coarse aggregate sizes, consisting of CA 7, CA 11, CA 13, CA 14, or CA 16, provided a CA 7 or CA 11 is included in the blend.

(2) If the coarse aggregate is furnished in separate sizes, they shall be combined in proportions to provide a uniformly graded coarse aggregate grading within the following limits.

Class of Concrete 1/	Combined Sizes	Sieve Size, in. (mm), and Percent Passing						
		2 1/2 (63)	2 (50)	1 3/4 (45)	1 1/2 (37.5)	1 (25)	1/2 (12.5)	No. 4 (4.75)
PV 2/								
	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3
SI and SC 2/								
	CA 3 & CA 7	100	95±5	---	---	55±25	20±10	3±3
	CA 3 & CA 11	100	95±5	---	---	55±25	20±10	3±3
	CA 5 & CA 7	---	---	100	98±2	72±22	22±12	3±3
	CA 5 & CA 11	---	---	100	98±2	72±22	22±12	3±3

1/ See Table 1 of Article 1020.04.

2/ Any of the listed combination of sizes may be used.

(e) Mixing Gravel, Crushed Gravel, Crushed Stone, and Crushed Slag Coarse Aggregates. Two different specified sizes of crushed stone, gravel, and crushed gravel from one source or any two sources may be combined in any consistent ratio in a mix; but the use of alternate batches of crushed stone, gravel, or crushed gravel of any one size or combination of sizes will not be permitted. Coarse aggregates of any one size from different sources shall not be mixed without permission from the Engineer. Crushed slag shall not be combined or mixed with gravel, crushed gravel, or crushed stone aggregates.

(f) Freeze-Thaw Rating. When coarse aggregate is used to produce portland cement concrete for base course, base course widening, pavement (including precast), driveway pavement, sidewalk, shoulders, curb, gutter, combination curb and gutter, median, paved ditch, concrete superstructures on subgrade such as bridge approach slabs (excluding precast), concrete structures on subgrade such as bridge approach footings, or their repair using concrete, the gradation permitted will be determined from the results of the Department's Freeze-Thaw Test (Illinois Modified AASHTO T 161). A list of freeze-thaw ratings for all Class A quality coarse aggregate sources will be available. The gradations permitted for each rating shall be as follows.

Freeze-Thaw Rating (Top Size) in.	mm	Gradation Permitted
1 1/2 in.	(37.5 mm)	Combined CA 5 & CA 7, Combined CA 5 & CA 11, CA 7, or CA 11
1 in.	(25 mm)	CA 7 or CA 11
3/4 in.	(19 mm)	CA 11
1/2 in.	(12.5 mm)	CA 13, CA 14, or CA 16
NON-ACC		Not Acceptable

Additional requirements may be placed on coarse aggregates when used in continuously reinforced concrete pavement. Such requirements will be stipulated on the most recent Freeze-Thaw Rating List.

(g) Alkali Reaction.

(1) ASTM C 1260. Each coarse aggregate will be tested by the Department for alkali reaction according to ASTM C 1260. The test will be performed with Type I or II portland cement having a total equivalent alkali content (Na_2O + $0.658K_2O$) of 0.90 percent or greater. The Engineer will determine the assigned expansion value for each aggregate, and these values will be made available on the Department's Alkali-Silica Potential Reactivity Rating List. The Engineer may differentiate aggregate based on ledge, production method, gradation number, or other factors. An expansion value of 0.05 percent will be assigned to limestone or dolomite coarse aggregates. However, the Department reserves the right to perform the ASTM C 1260 test.

(2) ASTM C 1293 by Department. In some instances testing a coarse aggregate according to ASTM C 1260 may not provide accurate test

results. In this case, the Department may only test according to ASTM C 1293.

(3) ASTM C 1293 by Contractor. If an individual aggregate has an ASTM C 1260 expansion value that is unacceptable to the Contractor, an ASTM C 1293 test may be performed by the Contractor according to Article 1003.02(e)(3).

If lightweight aggregate is specified for structures, it shall be according to ASTM C 330, the second paragraph of Article 1004.01(c), and Articles 1004.01(d) and 1004.01(e). Lightweight aggregate of any one size from different sources shall not be mixed without permission of the Engineer. Lightweight aggregate may be combined or mixed with gravel, crushed gravel, or crushed stone.

1004.03 Coarse Aggregate for Hot-Mix Asphalt (HMA). The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate for HMA shall be according to the following table.

<table>
<tr><th>Use</th><th>Mixture</th><th colspan="2">Aggregates Allowed</th></tr>
<tr><td>Class A</td><td>Seal or Cover</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag
Crushed Concrete</td></tr>
<tr><td>HMA
Low ESAL</td><td>Stabilized Subbase or Shoulders</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Gravel
Crushed Gravel
Carbonate Crushed Stone
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[1/]
Crushed Concrete</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>Binder
IL-19.0
or IL-19.0L

SMA Binder</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Concrete[3/]</td></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>C Surface and Binder
IL-9.5
IL-9.5FG
or IL-9.5L

SMA
Ndesign 50 Surface</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td rowspan="6">HMA
High ESAL</td><td rowspan="6">D Surface and Binder
IL-9.5
or IL-9.5FG

SMA
Ndesign 50
Surface</td><td colspan="2"><u>Allowed Alone or in Combination</u> [5/]:

Crushed Gravel
Carbonate Crushed Stone (other than Limestone)[2/]
Crystalline Crushed Stone
Crushed Sandstone
Crushed Slag (ACBF)
Crushed Steel Slag[4/]
Crushed Concrete[3/]</td></tr>
<tr><td colspan="2"><u>Other Combinations Allowed:</u></td></tr>
<tr><td>Up to...</td><td>With...</td></tr>
<tr><td>25% Limestone</td><td>Dolomite</td></tr>
<tr><td>50% Limestone</td><td>Any Mixture D aggregate other than Dolomite</td></tr>
<tr><td>75% Limestone</td><td>Crushed Slag (ACBF) or Crushed Sandstone</td></tr>
</table>

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Art. 1004.03 Coarse Aggregates

Use	Mixture	Aggregates Allowed	
HMA High ESAL	E Surface IL-9.5 or IL-9.5FG SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> [5/]: Crushed Gravel Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag Crushed Concrete[3/] No Limestone.	
		<u>Other Combinations Allowed:</u>	
		Up to...	*With...*
		50% Dolomite[2/]	Any Mixture E aggregate
		75% Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone
		75% Crushed Gravel or Crushed Concrete[3/]	Crushed Sandstone, Crystalline Crushed Stone, Crushed Slag (ACBF), or Crushed Steel Slag
HMA High ESAL	F Surface IL-9.5 or IL-9.5FG SMA Ndesign 80 Surface	<u>Allowed Alone or in Combination</u> [5/]: Crystalline Crushed Stone Crushed Sandstone Crushed Slag (ACBF) Crushed Steel Slag No Limestone.	
		<u>Other Combinations Allowed</u>:	
		Up to...	*With...*
		50% Crushed Gravel, Crushed Concrete[3/], or Dolomite[2/]	Crushed Sandstone, Crushed Slag (ACBF), Crushed Steel Slag, or Crystalline Crushed Stone

1/ Crushed steel slag allowed in shoulder surface only.

2/ Carbonate crushed stone shall not be used in SMA Ndesign 80. In SMA Ndesign 50, carbonate crushed stone shall not be blended with any of the other aggregates allowed alone in Ndesign 50 SMA binder or Ndesign 50 SMA surface.

3/ Crushed concrete will not be permitted in SMA mixes.

4/ Crushed steel slag shall not be used as binder.

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5/ When combinations of aggregates are used, the blend percent measurements shall be by volume.

(b) Quality. For surface courses, the coarse aggregate shall be Class B quality or better. For SMA surface and binder courses the coarse aggregate shall be Class B Quality or better. For Class A (seal or cover coat), and other binder courses, the coarse aggregate shall be Class C quality or better.

(c) Gradation. The coarse aggregate gradations shall be as listed in the following table.

Use	Size/Application	Gradation No.
Class A-1, A-2, & A-3	3/8 in. (10 mm) Seal	CA 16 or CA 20
Class A-1	1/2 in. (13 mm) Seal	CA 15
Class A-2 & A-3	Cover Coat	CA 14
HMA High ESAL	IL-19.0	CA 11 1/
	SMA 12.5 2/	CA 13, CA 14, or CA 16 3/
	SMA 9.5 2/	CA 13, CA 14, or CA 16 3/
	IL-9.5	CA 16
	IL-9.5FG	CA 16
HMA Low ESAL	IL-19.0L	CA 11 1/
	IL-9.5L	CA 16

1/ CA 16 or CA 13 may be blended with CA 11.

2/ The coarse aggregates shall be capable of being combined with the fine aggregates and mineral filler to meet the approved mix design and the mix requirements noted herein.

3/ The specified coarse aggregate gradations may be blended.

(d) Flat and Elongated Particles. For SMA the coarse aggregate shall meet the criteria for Flat and Elongated Particles listed in Illinois Modified AASHTO M 325.

(e) Absorption. For SMA the coarse aggregate shall also have water absorption ≤ 2.5 percent.

1004.04 Coarse Aggregate for Granular Embankment Special; Granular Subbase; and Aggregate Base, Surface, and Shoulder Courses. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, or crushed sandstone, except gravel shall not be used for subbase granular material, Type C.

The coarse aggregate for aggregate base course and aggregate shoulders, if approved by the Engineer, may be produced by blending aggregates from more than one source, provided the method of blending results in a uniform product. The components of a blend need not be of the same kind of material. The source of material or blending proportions shall not be changed during the progress of the work without written permission from the Engineer. Where a natural aggregate is deficient in fines, the material added to make up deficiencies shall be a fine aggregate of Class C quality or higher according to Section 1003 and/or mineral filler meeting the requirements of Article 1011.01.

(b) Quality. The coarse aggregate shall be Class D Quality or better.

(c) Gradation. The coarse aggregate gradation shall be used as follows.

Use	Gradation
Granular Embankment, Special	CA 6 or CA 10 1/
Granular Subbase:	
Subbase Granular Material, Ty. A	CA 6 or CA 10 2/
Subbase Granular Material, Ty. B	CA 6, CA 10, CA 12, or CA 19 2/
Subbase Granular Material, Ty. C	CA 7, CA 11, or CA 5 & CA 7 3/
Aggregate Base Course	CA 6 or CA 10 2/
Aggregate Surface Course:	
Type A	CA 6 or CA 10 1/
Type B	CA 6, CA 9, or CA 10 4/
Aggregate Shoulders	CA 6 or CA 10 2/

1/ Gradation CA 2, CA 4, CA 9, or CA 12 may be used if approved by the Engineer.

2/ Gradation CA 2 or CA 4 may be used if approved by the Engineer.

3/ If the CA 5 and CA 7 blend is furnished, proper mixing will be required either at the source or at the jobsite according to Article 1004.02(d).

4/ Gradation CA 4 or CA 12 may be used if approved by the Engineer.

(d) Plasticity. All material shall comply with the plasticity index requirements listed below. The plasticity index requirement for crushed gravel, crushed stone, and crushed slag may be waived if the ratio of the percent passing the No. 200 (75 µm) sieve to that passing the No. 40 (425 µm) sieve is 0.60 or less.

Use	Plasticity Index - Percent 1/	
	Gravel	Crushed Gravel, Stone, & Slag
Granular Embankment, Special	0 to 6	0 to 4
Granular Subbase:		
Subbase Granular Material, Type A	0 to 9	---
Subbase Granular Material, Type B	0 to 9	---
Aggregate Base Course	0 to 6	0 to 4
Aggregate Surface Course:		
Type A	2 to 9	---
Type B 2/	2 to 9	---
Aggregate Shoulders	2 to 9	---

1/ Plasticity Index shall be determined by the method given in AASHTO T 90. Where shale in any form exists in the producing ledges, crushed stone samples shall be soaked a minimum of 18 hours before processing for plasticity index or minus No. 40 (425 µm) material. When clay material is added to adjust the plasticity index, the clay material shall be in a minus No. 4 (4.75 mm) sieve size.

2/ When Gradation CA 9 is used, the plasticity index requirement will not apply.

1004.05 Coarse Aggregate for Blotter, Embankment, Backfill, Trench Backfill, Bedding, and French Drains. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be gravel, crushed gravel, crushed stone, crushed concrete, crushed slag, chats, crushed sandstone, or wet bottom boiler slag.

For pipe underdrains, Type 2, the crushed stone shall be a crystalline crushed stone.

(b) Quality. The coarse aggregate shall consist of sound durable particles reasonably free of objectionable deleterious material.

(c) Gradation. The coarse aggregate gradations shall be as follows.

Application	Gradation
Blotter	CA 15
Granular Embankment, Granular Backfill, Trench Backfill, and Bedding and Backfill for Pipe Culverts and Storm Sewers	CA 6, CA 9, CA 10, CA 12, CA 17, CA 18, and CA 19
Porous Granular Embankment, Porous Granular Backfill, and French Drains	CA 7, CA 8, CA 11, CA 15, CA 16 and CA 18
Bedding and Backfill for Pipe Underdrains, Type 2	CA 16, except the percent passing the No. 16 (1.18 mm) sieve shall be 4 ± 4 percent.

1004.06 Coarse Aggregate for Select Fill Used for Retaining Wall Applications Utilizing Soil Reinforcement. The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be crushed gravel or crushed stone.

(b) Quality. The coarse aggregate shall have a maximum sodium sulfate (Na_2SO_4) loss of 15 percent according to Illinois Modified AASHTO T 104.

(c) Gradation. The coarse aggregate shall be CA 6 thru CA 16, except when geosynthetic or geotextile soil reinforcement is utilized the coarse aggregate shall be CA 12 thru CA 16.

(d) Internal Friction Angle. The effective internal friction angle for the coarse aggregate shall be a minimum 34 degrees according to AASHTO T 236 on samples compacted to 95 percent density according to Illinois Modified AASHTO T 99. The AASHTO T 296 test with pore pressure measurement may be used in lieu of AASHTO T 236. If the Contractor's design uses a friction angle greater than 34 degrees, this greater value shall be taken as the minimum required.

(e) pH. pH shall be determined according to Illinois Modified AASHTO T 289.

(1) When geosynthetic soil reinforcement is used, the coarse aggregate pH shall be 4.5 to 9.0 for permanent applications, and 3.0 to 10.0 for temporary applications.

(2) When steel reinforcement is used, the coarse aggregate pH shall be 5.0 to 10.0 according to Illinois Modified AASHTO T 289.

(f) Corrosion Mitigation. The coarse aggregates shall also meet the following when used in conjunction with steel soil reinforcement in non-temporary wall applications:

(1) Resistivity. The resistivity according to Illinois Modified AASHTO T 288 shall be greater than 3000 ohm centimeters for galvanized reinforcement, and 1500 ohm centimeters for aluminized Type 2 reinforcement. However, the resistivity requirement is not applicable to CA 7, CA 8, CA 11, CA 13, CA 14, CA 15, and CA 16.

(2) The chlorides shall be less than 100 parts per million according to Illinois Modified AASHTO T 291 or ASTM D 4327. For either test, the sample shall be prepared according to Illinois Modified AASHTO T 291.

(3) The sulfates shall be less than 200 parts per million according to Illinois Modified AASHTO T 290 or ASTM D 4327. For either test, the sample shall be prepared according to Illinois Modified AASHTO T 290.

(4) The organic content shall be a maximum of 1.0 percent according to Illinois Modified AASHTO T 267.

(g) Test Frequency. Prior to the start of construction, the Contractor shall provide internal friction angle and pH test results demonstrating the select fill material meets the specification requirements. Resistivity, chlorides, sulfates, and organic content test results shall also be provided if steel reinforcement is used. The laboratory performing the Illinois Modified AASHTO T 288 test shall be approved by the Department according to the Bureau of Materials Policy Memorandum "Minimum Laboratory Requirements for Resistivity Testing". These test results shall be no more than 12 months old. In addition, a sample of select fill material will be obtained by the Engineer for testing and approval before construction begins. Thereafter, the minimum frequency of subsequent sampling and testing at the jobsite will be one per 40,000 tons (36,300 metric tons) of select fill. Testing to verify the internal friction angle will only be required when the wall design utilizes a minimum effective internal friction angle greater than 34 degrees.

SECTION 1005. STONE AND BROKEN CONCRETE FOR EROSION PROTECTION, SEDIMENT CONTROL, AND ROCKFILL

1005.01 Stone for Erosion Protection, Sediment Control, and Rockfill. The material will be sampled and inspected according to the Bureau of Materials Policy Memorandum, "Inspection of Large Sized Aggregate and Rip Rap used for Erosion Protection, Sediment Control, Rockfill, and Aggregate Subgrade Improvement". The material shall be according to the following.

(a) Description. The material shall be stone, quarried from undisturbed, consolidated deposits (ledges) of rock reasonably free of shale and shaly stone. The ledges shall be sufficiently thick to produce the desired dimensions. The stone shall be reasonably free of laminations, seams, cracks, and other structural defects or imperfections tending to destroy its resistance to weather. Field stone or boulders will not be accepted.

Bedding material shall be crushed stone, crushed gravel, crushed sandstone, or crushed slag meeting the requirements of Article 1004.01(a).

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AASHTO Section	***Illinois Modification***
1.2	Revise the last sentence as follows: Alternatively, field cores with a diameter of 150 mm (5.91 in.), 255 mm (10 in.), 300 mm (12 in.), or saw-cut slab specimens may be tested.
2.1	Revise the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards: ▪ R 30, Mixture Conditioning of Hot Mix Asphalt (HMA) ▪ T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens ▪ T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures ▪ T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
2.1	Delete: R 97
2.1	Illinois Manual of Test Procedures: ▪ Appendix B6, Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples ▪ Appendix B7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix E3, PFP and QCP Random Density Procedure ▪ Appendix E4, PFP and QCP Hot Mix Asphalt Random Jobsite Sampling
4.1	Revise the second sentence as follows: The specimen is submerged in a temperature-controlled water bath at 50 ± 1.0°C (122 ± 1.8°F).
5.1	Delete the first sentence of the last paragraph:
Note 1	Revise as follows: Reference the NCHRP Report of available devices in the market meeting the relevant requirements as proposed in the NCHRP Report to verify the sinusoidal wave requirement of the Hamburg wheel tracking device.
5.2	Replace the second sentence with the following: The thermometer for measuring the temperature of the water bath shall have a suitable range to determine 50 ± 1 °C (122 ± 1.8 °F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2).

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AASHTO Section	***Illinois Modification***
5.3.2	Delete
5.3.4	Delete
5.3.5	Delete
Note 3	Delete
5.8	Replace with the following: Ovens – shall meet the temperature requirements listed in the document “Hot-Mix Asphalt Laboratory Equipment”. Thermometers for measuring temperature of aggregate, binder, and asphalt mixtures shall have a suitable range to determine 50 – 450 °F (10 – 232 °C). The thermometers may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 1.35 °F (0.75 °C) (see Note 3). **Note 3** - Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.
6.1	Replace Section 6.1 with the following: *Number of Test Specimens* – A single slab specimen, two 150 mm (5.91 in.) diameter gyratory compacted specimens, or field cores according to Section 6.4 will be tested under each wheel in the Hamburg Wheel Tester. A test is currently defined as HMA specimens being tested using two wheels. However, if the District has sufficient experience with how their mixtures perform in the Hamburg Wheel Tester, a test may be conducted using a single wheel, at the discretion of the District.
6.2.2	Replace with the following: The mixing temperature shall be according to IL Modified AASHTO T 312.
6.2.4	Replace with the following: Laboratory mixed test samples shall be conditioned at the appropriate compaction temperature according to the short-term conditioning procedure in IL Modified AASHTO R 30.
6.2.5	Replace with the following: The compaction temperature shall be according to IL Modified AASHTO T 312.

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AASHTO Section	***Illinois Modification***
6.2.6.2	Replace with the following: *Compacting SGC Cylindrical Specimens*--Material shall be compacted into specimens using an SGC according to IL Modified AASHTO T 312. Compact three 160 mm tall gyratory cylinders to an air void level of 7.5 ± 0.5 %. If I-FIT long-term aging is conducted compact four 160 mm tall gyratory cylinders. Cut a 62 ± 2 mm disc from both the top and bottom of two of the 160 mm tall gyratory cylinders (for a total of four individual Hamburg Wheel test specimens). Position each of the test specimens so that the wheel is run on the as-compacted face. The I-FIT specimens are cut from the middle of the third and fourth gyratory cylinders. If the lab is not capable of compacting 160 mm tall gyratory cylinders, then compact two 115 mm tall gyratory cylinders instead of each 160 mm tall cylinder.
6.3.1	Replace with: Obtain field-mixed asphalt mixture sample in accordance with Appendix B.6 or E.4 of sufficient size to determine G_{mm} and make the 160 mm tall gyratory cylinders required in Section 6.2.6.2. Appendix B.6 shall be used in QC/QA applications and Appendix E.4 shall be used in QCP or PFP applications.
6.4.1	Replace sentence one with the following: *Cutting Field Cores or Field Slab Specimens*--Field cores or field slab specimens may be taken from compacted HMA pavements according to Appendix B7 and Appendix E3. Appendix B.7 shall be used in QC/QA applications and Appendix E.3 shall be used in QCP or PFP applications. Replace sentence five with the following: The height of a field core specimen may need to be adjusted to fit the specimen mounting system.
Note 5	Renumber Note 5 to be Note 4, and replace the second sentence with the following: In order for the total sample height to be 62±2 mm (2.4±0.1 in.), the sample must be trimmed with a wet saw if it is too tall. If the sample is too short then it must be shimmed up with Plaster of Paris (or equivalent).
Note 6	Renumber Note 6 to be Note 5.

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AASHTO Section	***Illinois Modification***
7.3	Replace the second sentence with the following: Refer to Sections 6.2.6.2 and 6.3.1 for air void requirements for SCG compacted cylinders and prepared test specimens.
Note 7	Renumber Note 7 to be Note 6.
8.6.1	Replace with the following: *Test Temperature*-The test temperature shall be 50±1°C (122±1.8°F).
8.6.2	Replace with the following: *Maximum Rut Depth*-The maximum allowable rut depth shall be less than or equal to 12.5 mm (0.5 in.). When setting the machine up for testing, the maximum rut depth should be set at a value greater than 12.5 mm (16.0 mm suggested) to avoid a premature end of the test caused by temporary rut depth spikes.
8.6.3	Add the following: *Selecting the Number of Wheel Passes*-The minimum number of wheel passes shall be according to Article 1030.05(d)(3) in the Illinois Department of Transportation Standard Specifications for Road and Bridge Construction. It may be useful to run every test for 20,000 wheel passes to collect additional data on moisture sensitivity.
8.6.4	Replace the first sentence with the following: Enter a start delay of 30 min to precondition the test specimens.
Note 8	Renumber Note 8 to be Note 7.
Note 9	Renumber Note 9 to be Note 8.
Note 10	Renumber Note 10 to be Note 9.

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(continued)
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AASHTO Section	***Illinois Modification***
8.8.4	Replace with the following: Each wheel on the wheel-tracking device shall shut off independent of the other wheel. The end of a test for each wheel can occur when the specified number of wheel passes listed in Section 8.6.3 or the number of passes otherwise specified has occurred on that wheel. Further, each wheel on the device shall be set to lift independently when the LDT displacement is 16.0 mm (0.63 in.) for that wheel. The HWTD measures the rut depth at multiple points per pass across the specimen. The maximum rut depth is defined as the average rut depth of the point with the deepest rut depth and the rut depth of the two points physically closest to it. The testing device software automatically saves the test data file for each wheel.
8.8.4.1 New Section	Add the following: If the test was conducted using two wheels, the two wheels should have an average rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.3. The test result is reported as the average of the two rut depths. A test is considered as failing if the **average** rut depth exceeds 12.5 mm at, or less than, the prescribed number of passes. If one wheel exceeds the 12.5 mm rut depth at, or less than, the prescribed number of passes, the maximum rut depth difference between the two wheels at failure shall be 6.25 mm. An additional test will be completed to replace the original if the maximum rut depth difference is exceeded. If the test was conducted using a single wheel, a passing test from that wheel shall have a rut depth less than or equal to 12.5 mm at the prescribed number of passes in section 8.6.3.
Note 11	Renumber Note 11 to be Note 10.
8.9.2	Replace the first sentence with the following: Precondition the test specimens in the water bath for 30 min after the water has reached the selected test temperature.
8.9.3	Replace the first sentence with the following: Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 30 min.
9.1	Delete

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AASHTO Section	***Illinois Modification***
9.1.1	Delete
9.1.2	Delete
9.3	Delete the first sentence.
9.4	Revise the second sentence to read: From this plot, the following values may be obtained:
9.5	Revise the first sentence to read: The following test parameters may be calculated, all expressed in “Passes.”
Note 12	Delete
Appendix A2.2	The thermometer for measuring the temperature of the water bath shall have a suitable range to determine 50 ± 1 °C (122 ± 1.8 °F). The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.25 °C (± 0.45 °F) (see Note 2).
A6.4	Delete
A6.5	Delete
Table A1.1	Delete
Figure A1.1	Delete
A7.13	Delete
A7.14	Delete
A7.15	Delete
X1.1	Replace with the following: Follow the manufacturer’s recommendations for lubrication and cleaning.

Standard Method of Test for

Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures

AASHTO Designation: T 324-23

AASHTO

Technically Revised: 2023 **Editorially Revised: 2023**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method describes a procedure for testing the rutting and moisture-susceptibility of asphalt mixture pavement samples in the Hamburg wheel-tracking device.

1.2. The method describes the testing of a submerged, compacted asphalt mixture in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. A laboratory compactor has been designed to prepare slab specimens. Also, the Superpave Gyratory Compactor (SGC) has been designed to compact specimens in the laboratory. Alternatively, field cores having a diameter of 150 mm (6 in.), 250 mm (10 in.), or 300 mm (12 in.), or saw-cut slab specimens may be tested.

1.3. The test method is used to determine the premature failure susceptibility of asphalt mixture due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.

1.4. This test method measures the potential for moisture damage effects because the specimens are submerged in temperature-controlled water during loading.

1.5. This test method is intended to be the standard; however, agencies may require deviations for various reasons, including test temperature, maximum rut depth calculation, equipment, or others. Deviations must be documented and made available to any accreditation or certifying entities or stakeholders, such as contractors and material producers, upon request.

1.6. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Mixture Conditioning of Asphalt Mixtures
- R 97, Sampling Asphalt Mixtures
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D6027/D6027M, Standard Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes
- D8079, Standard Practice for Preparation of Compacted Slab Asphalt Mix Samples Using a Segmented Rolling Compactor
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

2.4. *National Cooperative Highway Research Program*:

- NCHRP Web-Only Document 219, *Hamburg Wheel-Track Test Equipment Requirements and Improvements to AASHTO T 324*. NCHRP Project 20-07/Task 361. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 2016. Available from https://www.trb.org/Publications/Blurbs/173895.aspx; login required.

3. SIGNIFICANCE AND USE

3.1. This test measures the rutting and moisture susceptibility of an asphalt mixture specimen.

4. SUMMARY OF METHOD

4.1. A laboratory-compacted specimen of asphalt mixture, a saw-cut slab specimen, or a core taken from a compacted pavement is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath at a temperature specified by the agency. The deformation of the specimen, caused by the wheel loading, is measured.

4.2. The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation may coincide with stripping of the asphalt binder from the aggregate in the asphalt mixture specimen.

5. APPARATUS

5.1. *Hamburg Wheel-Tracking Device*—An electrically powered machine capable of moving a 203.2 ± 2.0-mm (8 ± 0.08-in.) diameter, 47 ± 0.5-mm (1.85 ± 0.02-in.) wide steel wheel over the center (*x* and *y* axes) of the test specimen. The load on the wheel is 703 ± 4.5 N (158.0 ± 1.0 lb). The wheel reciprocates over the specimen, with the position varying sinusoidally over time. A maximum level of deviation from a perfectly sinusoidal wave is defined through the root mean square error (RMSE), which is calculated as follows:

$$\text{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \quad (1)$$

where:

e_i = deviation from a pure sinusoidal curve, and

n = number of data points.

The maximum allowable deviation from a sinusoidal wave through the entire track length is set at an RMSE of 2.54 mm (0.1 in.) unless otherwise specified by the agency. The wheel makes 52 ± 2 passes across the specimen per minute. The maximum speed of the wheel, reached at the midpoint of the specimen, is 0.305 ± 0.02 m/s (1 ± 0.066 ft/s).

Note 1—Verify the sinusoidal wave requirement of the Hamburg wheel-tracking device using a Hamburg wheel-tracking device verification/calibration kit.

5.2. *Temperature Control System*—A water bath capable of controlling the temperature within ±1.0°C (1.8°F) over a range of 25 to 70°C (77 to 158°F) with a mechanical circulating system stabilizing the temperature within the specimen tank. The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 75°C (68 to 167°F), and an accuracy of ±0.25°C (±0.45°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.3. *Impression Measurement System*:

5.3.1. A linear displacement transducer (LDT) device capable of measuring the depth of the impression (rut) of the wheel to within 0.15 mm (0.006 in.), over a minimum range of 0 to 20 mm (0 to 0.8 in.).

5.3.2. The system shall measure the depth of the impression at a minimum at the following locations along the track length: –114 (–4.5), –91 (–3.6), –69 (–2.7), –46 (–1.8), –23 (–0.9), 0 (0), +23 (+0.9), +46 (+1.8), +69 (+2.7), +91 (+3.6), and +114 (+4.5) mm (in.) with zero being the midpoint of the track unless otherwise specified by the agency. The midpoint of the track shall be marked by the manufacturer.

5.3.3. The system measures the rut depth, without stopping the wheel, at least every 20 passes. Rut depth is expressed as a function of the wheel passes. The device will also disengage if the average LDT displacement (read from the micro-control unit, not the screen) is 40.90 mm (1.6 in.) or greater for an individual specimen. Note that the screen readout subtracts the initial LDT reading from the total displacement.

5.3.4. The maximum level of deviation from the 11 preset locations is defined through the RMSE, which is calculated as follows:

$$\mathrm{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \quad (2)$$

where:

e_i = deviation from the preset location after considering the effect of curvature of the aluminum apparatus (Table A1.1); and

n = number of data points.

5.3.5. The maximum allowable RMSE at the 11 preset locations after considering the effect of curvature of the aluminum apparatus (Table A1.1), discussed in the NCHRP Web-Only Document 219, is 1.27 mm (0.05 in.).

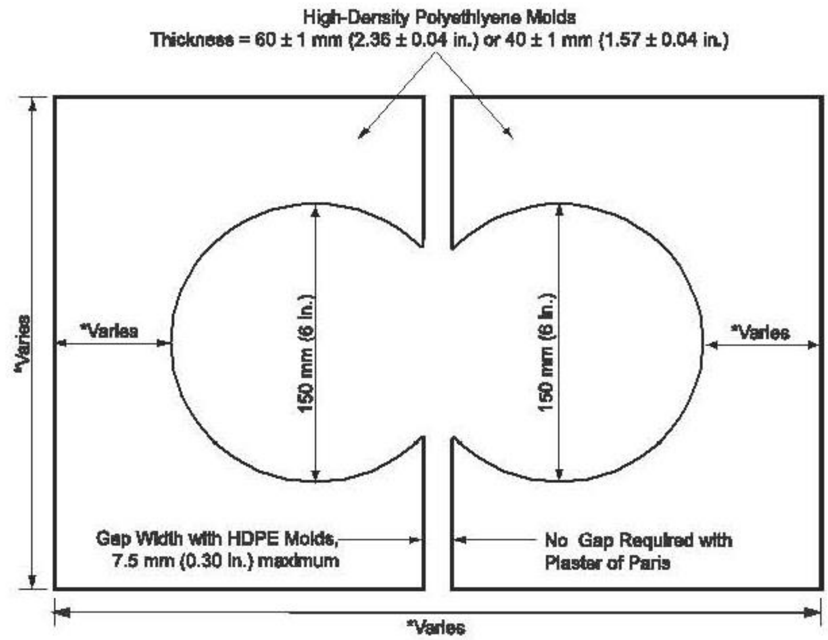
Note 3—The locations of the deformation readings should be verified using the aluminum apparatus presented in Section A6.4.

5.4. *Wheel Pass Counter*—A non-contacting solenoid that counts each wheel pass over the specimen. The signal from this counter is coupled to the wheel impression measurement, allowing for the rut depth to be expressed as a function of the wheel passes.

5.5. *Slab Specimen Mounting System*—A stainless steel tray that is mounted rigidly to the machine. The mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.

5.6. *Cylindrical Specimen Mounting System*—An assembly consisting of two high-density polyethylene (HDPE) molds or plaster of Paris, in accordance with Section 8 to secure the specimen (as shown in Figures 1 and 2), placed on a stainless steel tray that is mounted rigidly to the machine. This mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.

Figure 1—Cylindrical Specimen Mounting System



* Dimensions may vary depending on the manufacturer.

Figure 2—Schematic of Cylindrical Specimen Mounting System

5.7. *Linear Kneading Compactor*—A hydraulic-powered unit that uses a series of vertically aligned steel plates to compact molded asphalt mixtures into flat, rectangular slabs of predetermined thickness and density.

5.8. *Ovens*—For heating aggregate and asphalt binders to their appropriate mixing temperature. Oven(s) for heating shall be properly standardized and capable of operation at the temperatures required, between 100 to 175°C (212 to 347°F), within ±5°C (±9°F), as corrected, if necessary, by calibration. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 140 to 175°C (284 to 347°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.9. *Superpave Gyratory Compactor (SGC)*—And molds conforming to T 312.

5.10. Bowls, spoon, spatula, etc.

6. SPECIMEN PREPARATION

6.1. *Number of Test Specimens*—Prepare two test specimens for each test, either slab specimens or cylinders.

6.2. *Laboratory-Produced Asphalt Mixture:*

6.2.1. Batch mixture proportions in accordance with the desired job mix formula.

6.2.2. Use the mixing temperature at which the asphalt binder achieves a viscosity of 170 ± 20 cSt. For modified asphalt binders, use the mixing temperature recommended by the binder manufacturer.

6.2.3. Dry-mix the aggregates and mineral admixture (if used) first, then add the correct percentage of asphalt binder. Mix the materials to coat all aggregates thoroughly. (Wet-mix the aggregates if using a lime slurry or other wet material.)

6.2.4. Condition test samples at the appropriate compaction temperature in accordance with the short-term conditioning procedure for mechanical properties in R 30.

6.2.5. Use the compaction temperature at which the asphalt binder achieves a viscosity of 280 ± 30 cSt. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer.

6.2.6. *Laboratory Compaction of Specimens*—Compact either slab specimens or SGC cylindrical specimens.

6.2.6.1. *Compacting Slab Specimens*—Heat molds and tools to compaction temperature. Compact slab specimens 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide using a Linear Kneading Compactor (or equivalent such as a compactor meeting ASTM D8079). Specimen thickness must be at least twice the nominal maximum aggregate size, generally yielding a specimen 38 to 100 mm (1.5 to 4 in.) thick. Allow compacted slab specimens to cool at normal room temperature on a clean, flat surface until cool to the touch.

6.2.6.2. *Compacting SGC Cylindrical Specimens*—Compact two 150-mm (6-in.) diameter specimens in accordance with T 312. Specimen thickness must be at least twice the nominal maximum aggregate size, generally yielding a specimen 38 to 100 mm (1.5 to 4 in.) thick. Allow compacted specimens to cool at normal room temperature on a clean, flat surface until cool to the touch.

6.3. *Field-Produced Asphalt Mixture—Loose Mix*:

6.3.1. Obtain a sample of asphalt mixture in accordance with R 97.

6.3.2. *Laboratory Compaction of Specimens*—Compact either slab specimens or SGC cylindrical specimens in accordance with Section 6.2.6.

6.4. *Field-Produced Asphalt Mixture—Field Compacted (Core/Slab Specimen)*:

6.4.1. *Cutting Field Cores or Field Slab Specimens*—Field cores or field slab specimens consist of wet saw-cut compacted specimens taken from asphalt mixture pavements. Cut field cores 300 mm (12 in.), 250 mm (10 in.), or 150 mm (6 in.) in diameter. Cut field slab specimens approximately 260 mm (10.25 in.) wide by 320 mm (12.5 in.) long. Use a slab specimen thickness of 38 to 100 mm (1.5 to 4 in.). The height of a field core or field slab specimen is typically 38 mm (1.5 in.) but may be adjusted to fit the specimen mounting system by wet saw-cutting. Cut field cores in accordance with Section 6.4.2.

Note 5—Take care to load the sample so it is level to the surface of the mold. Trim the sample if it is too tall or use shims if it is too short (supporting with plaster if needed). Calibrate the down pressure from the wheel to be 703 ± 4.5 N (158.0 ± 1.0 lb.) at the center, level to the top of the mold position. Even a small change in elevation will change the down pressure significantly.

6.4.2. *Cutting SGC Cylindrical Specimens and Field Cores*—Cut specimens after they have cooled to room temperature using a wet or dry saw. Saw the specimens along equal secant lines (or chords) such that when joined together in the molds, there is no space between the cut edges. The amount of material sawed from the SGC cylindrical specimens may vary to achieve a gap width no greater than 7.5 mm (0.3 in.) between the molds.

Note 6—To cut specimens consistently may require the use of a jig.

7. DETERMINING AIR VOID CONTENT

7.1. Determine the bulk specific gravity of the specimens in accordance with T 166.

7.2. Determine the maximum specific gravity of the mixture in accordance with T 209.

7.3. Determine the air void content of the specimens in accordance with T 269. The recommended target air void content is 7.0 ± 0.5 percent for laboratory-compacted SGC cylindrical specimens and 7.0 ± 1.0 percent for laboratory-compacted slab specimens. Field specimens may be tested at the air void content at which they are obtained.

8. PROCEDURE

8.1. *Slab and Large Field Core Specimen Mounting*—Use plaster of Paris to rigidly mount the 300 mm (12 in.), 250 mm (10 in.), or slab specimens in the mounting trays. Mix the plaster at approximately a 1:1 ratio of plaster to water. Pour the plaster to a height equal to that of the specimen to fill the air space between the specimen and the sides of the mounting tray. The slab specimen will be in direct contact with the mounting tray; however, plaster may flow underneath the specimen. If the thickness of the Slab or Large Field Core Specimen is the same as the height of the mounting tray, the plaster underneath the specimen must not exceed 2 mm (0.08 in.). If the thickness of the Slab or Large Field Core Specimen is less than the height of the mounting tray, plaster and/or shims from aluminum, HDPE, or other suitable material shall be used underneath the specimen as necessary to bring the top of the specimen level with the top of the mounting tray and to prevent any movement of the specimen in the mounting tray during testing. Allow the plaster at least 1 h to set. If using other mounting material, it should be able to withstand 890 N (200 lb) of load without cracking.

8.2. *SGC Cylindrical and Field Core Specimen Mounting*—Rigidly mount the 150-mm [5.91-in.] or 152-mm [6-in.] diameter samples in the mounting tray using HDPE molds meeting the dimensions outlined in Figure 2 or use plaster of Paris. For HDPE molds, place the molds in the mounting tray and insert the cut specimens in the molds. Shim the molds in the mounting tray as necessary. Secure the molds into the mounting tray. If plaster of Paris is used, pour the plaster to a height equal to that of the specimen to fill the air space between the specimen and the sides of the mounting tray. The specimen will be in direct contact with the mounting tray; however, plaster may flow underneath the specimen. For SGC Cylindrical Specimens the plaster underneath the specimen must not exceed 2 mm (0.08 in.) in thickness. For Field Core Specimens plaster and/or shims from aluminum, HDPE, or other suitable material shall be used underneath the specimen as necessary to bring the top of the specimen level with the top of the HDPE molds and to prevent any movement of the specimen in the molds during testing. Allow the plaster at least 1 h to set.

Note 7—Cores drilled with a 152-mm [6-in.] drill bit may not fit in the 150-mm [5.91-in.] HDPE mold and may require further trimming and mounting in plaster of Paris.

8.3. Place the mounting tray(s) with the test specimens into the device. Adjust the height of the specimen tray as recommended by the manufacturer, and secure by hand-tightening the bolts.

8.4. Turn the testing device and all components on.

8.5. Start the software used to communicate with the testing device.

8.6. Enter the pertinent project information and testing configuration requirements.

8.6.1. Select the test temperature based on the applicable specifications.

8.6.2. Select the maximum allowable rut depth based on the applicable specifications.

8.6.3. Select the maximum number of passes based on the applicable specifications.

8.6.4. Enter a start delay of 45 min to precondition the test specimens. The temperature of the specimens in the mounting tray will be the test temperature selected in Section 8.6.1 on completion of this preconditioning period.

8.7. Proceed to Section 8.8 to operate the testing device in "Auto" mode. Proceed to Section 8.9 to operate the testing device in "Manual" mode.

Note 8—Perform the test in "Auto" mode for testing devices manufactured in the United States later than 1998, where software will automatically open and close the valves to fill and drain the water bath. Perform the test in "Manual" mode for devices made available to the United States prior to 1998.

8.8. *Performing the Test in Auto Mode*:

8.8.1. Adjust the height of the LDT in accordance with the manufacturer's recommendations.

Note 9—The LDT for each steel wheel is automatically zeroed at the start of the test. The software will display a zero at the start of the test.

8.8.2. If using cylindrical specimens, lower the wheels onto the edge of the test specimens such that a majority of the wheel is in contact with the HDPE molds in the mounting tray. If using slabs, lower the wheels onto the specimen no more than 5 min prior to the beginning of the test. In either case, the sample must not be submerged longer than 60 ± 5 min prior to starting the test. This includes the conditioning time.

8.8.3. Start the test by selecting the "Start" button of the testing device software.

Note 10—The start delay time or preconditioning time will start after the water heats to the test temperature selected in Section 8.6.1.

8.8.4. The wheel-tracking device will stop when 20,000 passes have occurred, when some other predetermined number of passes has occurred, or when the test has achieved the maximum impression depth established in Section 8.6.2. The testing device software automatically saves the test data file.

8.8.5. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.8.6. Proceed to Section 8.10.

8.9. *Performing the Test in Manual Mode*:

8.9.1. Close the drain valve(s) and fill the water bath of the wheel-tracking device with water until the float device(s) raises to a horizontal position.

Note 11—Adjust the amount of hot and cold water if necessary, as the water temperature may vary.

8.9.2. Precondition the test specimens in the water bath for 45 min after the water has reached the selected test temperature. Do not place the sample in the conditioning bath more than 60 ± 5 min prior to beginning the test. This includes the preconditioning time.

8.9.3. Lower the wheels onto the specimens after the test specimens have preconditioned at the selected test temperature for 45 min. For machines that start automatically after the selected preconditioning time, it is allowable to lower the wheels before the preconditioning cycle. The wheel must not be in contact with the specimen for more than 5 min prior to starting the wheel.

8.9.4. Ensure the micro-control unit's LDT reads between 10 and 18 mm (0.4 and 0.7 in.). Adjust the LDT height to obtain this reading. Loosen the two screws on the LDT mount and slide the LDT up or down to the desired height. Tighten the screws.

8.9.5. Start the test.

8.9.6. The wheel-tracking device will stop when 20,000 passes have occurred, when some other predetermined number of passes has occurred, or when the test has achieved the maximum impression depth established in Section 8.6.2.

8.9.7. Open the valve(s) beneath the tanks and drain the water bath. Raise the wheel(s) and remove the specimen mounting tray(s) and rutted specimens.

8.10. Clean the water bath, heating coils, wheels, and temperature probe with water and scouring pads or per the manufacturer's recommendations. Use a wet-dry vacuum to remove particles that have settled to the bottom of the baths. Clean the filter element and spacers after every test or per the manufacturer's recommendations. Do not use solvents to clean the water bath.

8.11. Turn the wheels after each test, so the same section of the wheel surface is not in contact with the test specimen from test to test. This rotation will provide for even wear over the entire wheel. The test should operate with a smooth movement across the test specimen.

9. CALCULATIONS

9.1. *For the purposes of this method, a "test" is defined as:*

9.1.1. Two 320-mm (12.5-in.) long by 260-mm (10.25-in.) wide slab specimens, two 250-mm (10-in.) diameter core specimens, or two 300-mm (12-in.) diameter core specimens representing similar material run in the Hamburg wheel-tracking device simultaneously; or

9.1.2. Four 150-mm (6-in.) diameter cylindrical or core specimens grouped in pairs (1 and 1a) representing similar material run in the Hamburg wheel-tracking device simultaneously.

9.2. The test results will be reported as the average value of both specimens (a) or both pairs of specimens (b). Alternatively, the specifying agency may choose to define a "test" as a single slab or core specimen or as a pair of 150-mm (6-in.) diameter cylindrical specimens.

9.3. The maximum rut depth shall be calculated based on the average rut depth for the five middle deformation locations (i.e., located at –46 (–1.8), –23 (–0.9), 0, +23 (+0.9), and +46 (+1.8) mm (in.)) or other suitable method as specified by the agency. Plot the rut depth versus number of passes for each test for each deformation location.

9.4. Figure 3 shows a typical plot of the output produced by the Hamburg wheel-tracking device. From this plot, obtain the following values:

9.4.1. Slope and intercept of the first steady-state portion of the curve, and

9.4.2. Slope and intercept of the second steady-state portion of the curve.

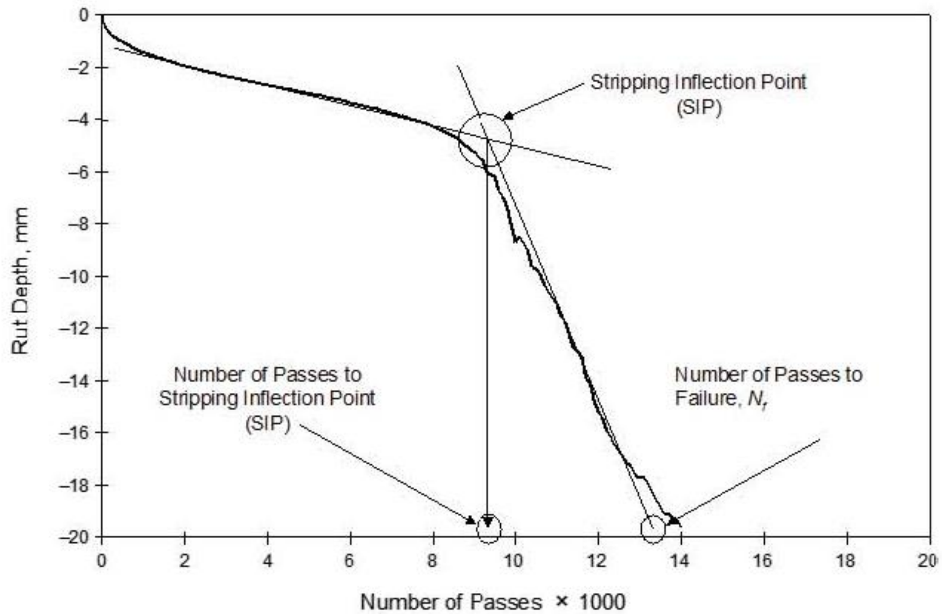


Figure 3—Hamburg Curve with Test Parameters

9.5. Calculate the following test parameters, all expressed in "Passes."

$$\text{stripping inflection point (SIP)} = \frac{\text{intercept (second portion)} - \text{intercept (first portion)}}{\text{slope (first portion)} - \text{slope (second portion)}} \quad (3)$$

where failure rut depth is the specified maximum allowable rut depth for the test.

Note 12—The specifying agency may choose to define a "test" as an individual slab or core specimen or as a pair of specimens as defined in Section 9.1.

10. REPORT

10.1. *The report may include the following parameters:*

10.1.1. Asphalt mixture production (field or lab);

10.1.2. Compaction method (slab or SGC cylindrical specimen);

10.1.3. Number of passes at maximum impression;

10.1.4. Maximum impression;

10.1.5. Test temperature;

10.1.6. Specimen(s) air voids;

10.1.7. Type and amount of anti-stripping additive used;

10.1.8. Creep slope;

10.1.9. Strip slope; and

10.1.10. Stripping inflection point.

11. PRECISION AND BIAS

11.1. Work is underway to develop precision and bias statements for this standard.

12. KEYWORDS

12.1. Compacted asphalt mixture; moisture-susceptibility; rutting; wheel-track testing.

ANNEX A—EVALUATING HAMBURG WHEEL-TRACKING DEVICE

(Mandatory Information)

A1. SCOPE

A1.1. This Annex covers the evaluation of the Hamburg wheel-tracking device as a check for compliance with the requirements outlined in Sections 5.1 and 5.2. Included are measurements of the wheel s diameter and width, visual inspection of critical surface conditions, verification of the water bath temperature, LDT calibration, wheel loading assembly, wheel travel, and rut measurement.

A1.2. Minimum frequency of this evaluation is 12 months, except for water bath temperature, which is 6 months.

A2. APPARATUS

A2.1. *Measurement Instrument (Calipers or Micrometer)*—With appropriate range and a minimum resolution of 0.1 mm (0.004 in.). The measurement instrument shall be standardized annually.

A2.2. *Reference Thermometer*—With a minimum range of 25 to 70°C (77 to 158°F) with a minimum resolution of 0.1°C (± 0.2°F) and accurate to ± 0.5°C (± 0.9°F).

A2.3. *Hamburg Wheel-Tracking Device Verification/Calibration Kit*—Containing equipment necessary to complete all measurements in Section A6.

Note A1—Calibration kits are available from several equipment manufacturers.

PROCEDURES

A3. MEASURING THE DIAMETER OF THE HAMBURG WHEEL

A3.1. *Perform a visual inspection of the wheel*: The wheel shall be free of residue and deep gouges. Identify any wear that may be visible on the wheel.

A3.2. Determine the maximum diameter of the wheel by measuring it at several locations. Place a removable mark at the maximum diameter position. Record the maximum diameter to the nearest 0.1 mm (0.004 in.).

A3.3. Measure the diameter at a 90-degree orientation to the maximum diameter. Record this diameter to the nearest 0.1 mm (0.004 in.).

A3.4. Each individual diameter measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual measurements are assigned a “fail” rating, the wheel is considered to be out of conformance and shall not be used.

A4. MEASURING THE WIDTH OF THE HAMBURG WHEEL

A4.1. *Perform a visual inspection of the wheel loading surface*: The edge shall be free of residue and deep gouges. Identify any wear that may be visible on the edge of the wheel.

A4.2. Determine the maximum width of the wheel by measuring it at several locations. Place a removable mark at this position. Record the maximum width to the nearest 0.1 mm (0.004 in.).

A4.3. Measure the width at a 90-degree, 180-degree, and 270-degree orientation to the maximum width. Record each width to the nearest 0.1 mm (0.004 in.).

A4.4. Each individual width measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual measurements is assigned a “fail” rating, the wheel is considered to be out of conformance and shall not be used.

A5. VERIFYING THE WATER BATH TEMPERATURE

A5.1. Verify the water bath temperature is within ±1.0°C (±1.8°F) of the temperature readout from the testing device or software every 6 months.

A5.2. Measure the water bath temperature at four locations per the manufacturer’s recommendations.

A5.3. Average the four measurements and report this as the water bath verification temperature.

A6. VERIFYING THE LDT CALIBRATION, WHEEL ASSEMBLY, RUT MEASUREMENT, AND WHEEL TRAVEL

A6.1. Verify the LDT calibration in accordance with ASTM D6027/D6027M or per the manufacturer’s recommendations.

A6.2. Verify the load from the wheel loading assembly at the level of the initial height of the test per the manufacturer’s recommendations to be 703 ± 4.5 N (158.0 ± 1.0 lb). A calibrated load cell, accurate to 0.4 N (0.1 lb), is sufficient for this check. Align the center of the load cell with the middle of the wheel width as well as the center axis of the wheel.

A6.3. Verify that the wheel is reciprocating on the test sample at 52 ± 2 passes per min.

A6.4. Verify that rut measurements are obtained at the 11 preset locations defined in Section 5.2.1 using the aluminum apparatus presented in Figure A1.1. The maximum allowable RMSE at the 11 preset locations after considering the effect of curvature of the aluminum apparatus (Table A1.1) discussed in NCHRP Web-Only Document 219 is 1.27 mm (0.05 in.).

A6.5. The wheel position varying sinusoidally over time shall be verified to have a maximum RMSE of 2.54 mm (0.1 in.) from a perfectly sinusoidal wave unless otherwise specified by the agency.

Table A1.1—Offset Values for Displacement Readings

Position (in.)	Position (mm)	Offset (mm)
–4.5	–114	0.79
–3.6	–91	0.50
–2.7	–69	0.28
–1.8	–46	0.13
–0.9	–23	0.03
0.0	0	0.00
0.9	23	0.03
1.8	46	0.13
2.7	69	0.28
3.6	91	0.50
4.5	114	0.79

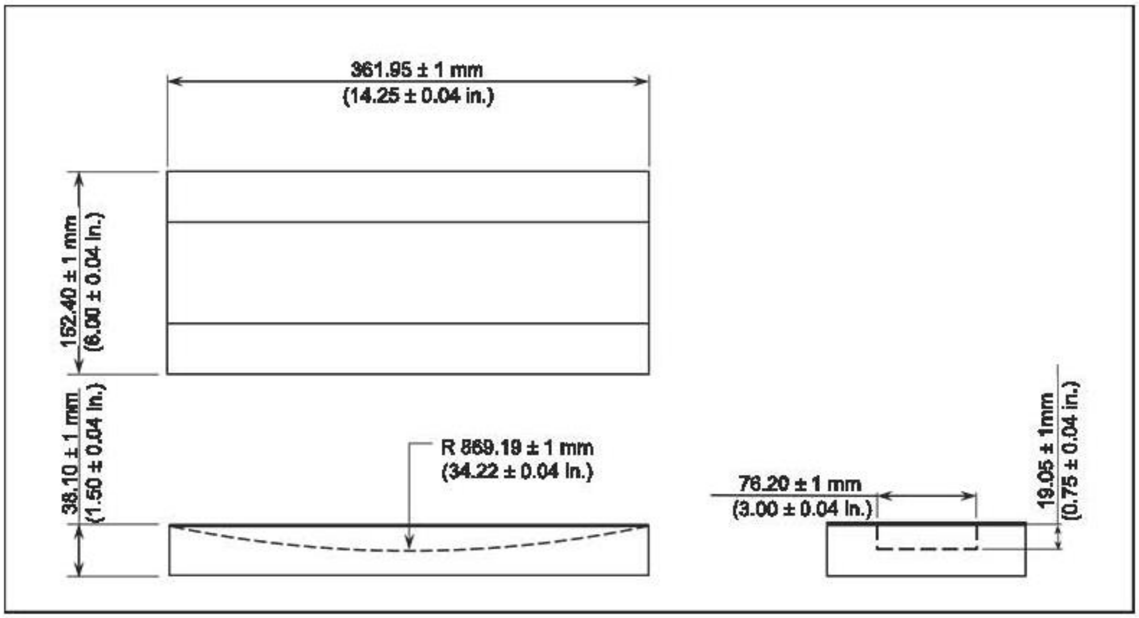


Figure A1.1—Details of the Metal Specimen

A7. INSPECTION REPORT

A7.1. *Record and report the following information:*

A7.2. Name of evaluator.

A7.3. Date.

A7.4. Equipment owner.

A7.5. Location of evaluation.

A7.6. Hamburg wheel-tracking device.

A7.7. Diameter measurements of the wheel to the nearest 0.1 mm (0.004 in.).

A7.8. Width of the loading surface of the wheel to the nearest 0.1 mm (0.004 in.).

A7.9. Water bath temperature to the nearest 0.1°C (0.1°F).

A7.10. LDT.

A7.11. Wheel assembly load reading to the nearest 0.1 N (0.1 lb.).

A7.12. Wheel travel (passes per min.).

A7.13. RMSE at the 11 preset locations after taking into account the effect of curvature of the aluminum apparatus to the nearest 0.01 mm (0.004 in.).

A7.14. Deviation from a perfectly sinusoidal wave as defined through the RMSE to the nearest 0.01 mm (0.004 in.).

A7.15. Allowable maximum deviation from a perfectly sinusoidal wave as defined through the RMSE to the nearest 0.01 mm (0.004 in.) unless equal to 2.54 mm (0.1 in.).

APPENDIX

(Nonmandatory Information)

X1. MAINTENANCE

X1.1. Grease all of the grease fittings with fresh grease every 20 tests (not to exceed 2 months) per the manufacturer's recommendations.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
Revised Date: December 1, 2023

Standard Method of Test

for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

Reference AASHTO T 393-22

Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
2.1	Replace the individual AASHTO Standards with the appropriate Illinois modified AASHTO Standards:
2.1	Delete: R 67
2.1	Add reference to: ▪ Appendix B.7, Hot-Mix Asphalt QC/QA Procedure for Determining Random Density Locations ▪ Appendix E.3, PFP and QCP Random Density Procedure
6.1.7	Replace the second sentence with the following: The thermometer for measuring the temperature of water baths shall have a suitable range to determine 25 ± 0.5 °C. The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.13 °C.
6.1.9	Replace with the first three sentences with the following: *Oven*—A forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining a uniform temperature of 95 ± 3 °C. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall have a suitable range to determine 95 ± 3 °C. The thermometer may optionally meet the requirements of M 339M/M 339 and optionally have an accuracy of ± 0.75 °C.
9.1.1	Replace with the following: *SGC Specimens*—Prepare one laboratory SGC cylinder in the SGC according to T 312 with the compaction height of 160 mm ± 1 mm. Compact two 160 ± 1 mm tall SGC cylinders if long-term aging is to be conducted. Determine the bulk specific gravity (G_{mb}) and air voids of the SGC cylinder according to T 166 and T 269, respectively. The air voids of the 160 ± 1 mm tall SGC cylinders shall be 7.5 ± 0.5%. From the middle of each 160 mm ± 1 mm tall specimen, obtain two cylindrical 50 ± 1 mm thick discs with smooth, parallel faces by saw cutting each face (see Figure 4). Cut each disc into two dimensionally equivalent halves resulting in four individual I-FIT specimens from each 160 ± 1 mm tall SGC cylinder. A minimum of three individual test specimens are required for one I-FIT test.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
Revised Date: December 1, 2023

Standard Method of Test
for
Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

Reference AASHTO T 393-22

Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
Note 6	Replace with the following: The height of the gyratory compacted cylinders should be 160 ± 1 mm and contain 7.5 ± 0.5 percent air voids. If a lab does not have the capability to compact 160 ± 1 mm tall gyratory cylinders, then two 115 ± 1 mm tall gyratory cylinders with 7.5 ± 0.5 percent air voids may be compacted and used instead to replace each 160 ± 1 mm tall gyratory cylinder. A 50 ± 1 mm thick disc will be cut from the middle of each 115 mm tall gyratory cylinder, which will result in four individual I-FIT specimens (see Figure 4). Although the required air voids are determined from the SGC cylinders, it is also required to continue to determine the air voids on the individual semi-circular I-FIT test specimens to identify if 7.5 ± 0.5% air voids on the SGC cylinders is appropriate to produce individual semi-circular test specimens with 7.0 ± 1.0% air voids.
9.1.2	Replace the first sentence with the following: Obtain pavement cores in accordance with Appendix B.7 or Appendix E.3. Appendix B.7 shall be used in QC/QA applications and Appendix E.3 shall be used in QCP or PFP applications.
10.1	Replace with the following: Perform a long-term aging procedure on I-FIT specimens as defined in Section 7.3 of IL modified AASHTO R 30.
Note 8	Delete
12.1	Re-number Note 9 to be Note 8.
12.2	Re-number Note 10 to be Note 9.
12.7 New Section	When four individual I-FIT specimens that are within specification are tested, the Flexibility Index value that is farthest from the average of the four test specimens shall be discarded as an outlier to lower the variability of the average Flexibility Index value that is reported. The test specimen that is discarded as an outlier shall be removed from the calculations of average and COV for peak load, post-peak slope, fracture energy, and Flexibility Index.
12.8 New Section	When three individual I-FIT specimens are tested, all three specimens will be included in the average and COV for peak load, post-peak slope, fracture energy, and flexibility index.

Illinois Modified Test Procedure
Effective Date: December 1, 2018
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Standard Method of Test
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Reference AASHTO T 393-22
Note: Illinois Modified AASHTO T 393 replaces all references to AASHTO TP 124.

AASHTO Section	***Illinois Modification***
14.1.7	Delete
14.1.8	Delete
14.1.9	Delete
Appendix X1.4.1.4.5	Replace Equation X1.10b with the following: $FI = \frac{G_f}{\lvert m \rvert} \times A$
Appendix X2	Delete

This Page Is Reserved

Standard Method of Test for

Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT)

AASHTO Designation: T 393-22[1]

AASHTO

Adopted with Revisions: 2021 **Editorially Revised: 2022**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This test method covers the determination of Mode I (tensile opening mode during crack propagation) cracking resistance properties of asphalt mixtures at intermediate test temperatures. Specimens are tested in the semicircular bend geometry, which is a half disc with a notch parallel to the direction of load application. The data analysis procedure associated with this test determines the fracture energy (G_f) and post peak slope (*m*) of the load–load line displacement (LLD) curve. These parameters are used to develop a flexibility index (FI) to predict the fracture resistance of an asphalt mixture at intermediate temperatures. The FI can be used as part of the asphalt mixture approval process.

1.2. These procedures apply to test specimens having a nominal maximum aggregate size (NMAS) of 19 mm or less. Lab compacted and pavement core specimens can be tested according to this test procedure. A thickness correction factor will need to be developed and applied for pavement cores tested at a thickness less than 45 mm.

1.3. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish and follow appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 67, Sampling Asphalt Mixtures after Compaction (Obtaining Cores)

- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D8, Standard Terminology Relating to Materials for Roads and Pavements
- D3549/D3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

2.4. *Other Publications:*

- Al-Qadi, I. L., H. Ozer, J. Lambros, A. El Khatib, P. Singhvi, T. Khan, and B. Doll. *Testing Protocols to Ensure Performance of High Asphalt Binder Replacement Mixes Using RAP and RAS*, FHWA ICT-15-07. Illinois Center for Transportation, Rantoul, IL, 2015.
- Doll. B., H. Ozer, J. Rivera-Perez, J. Lambros, and I. L. Al-Qadi. Investigation of Viscoelastic Fracture Fields in Asphalt Mixtures Using Digital Image Correlation. *International Journal of Fracture*, Vol. 205, No. 1. Springer Nature Switzerland AG, January 2017,pp. 37–56.
- Ozer, H., I. L. Al-Qadi, J. Lambros, A. El-Khatib, P. Singhvi, and B. Doll. Development of the Fracture-Based Flexibility Index for Asphalt Concrete Cracking Potential Using Modified Semi-Circle Bending Test Parameters. *Construction and Building Materials*, Vol. 115. Science Direct, Elsevier B.V., Amsterdam, Netherlands, 2016a, pp. 390–401.
- Ozer, H., and P. Singhvi, T. Khan, J. Rivera, I. L. Al-Qadi. Fracture Characterization of Asphalt Mixtures with RAP and RAS Using the Illinois Semi-Circular Bending Test Method and Flexibility Index. *Transportation Research Record*, Vol. 2575. Transportation Research Board, National Research Council, Washington, DC, 2016b, pp. 130–137.
- Ozer, H., I. L. Al-Qadi, P. Singhvi, J. Bausano, R. Carvalho, X. Li, and N. Gibson. Assessment of Asphalt Mixture Performance Tests to Predict Fatigue Cracking in an Accelerated Pavement Testing Trial. *International Journal of Pavement Engineering*, Special Issue for Cracking in Flexible Pavements and Asphalt Mixtures: Theories to Modeling, and Testing to Mitigation, 2017.
- RILEM Technical Committee 50-FMC. Determination of the Fracture Energy of Mortar and Concrete by Means of Three-Point Bend Tests on Notched Beams. *Materials and Structures*, No. 106, July–August 1985. Springer Netherlands for International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), Dordrecht, The Netherlands, 1985, pp. 285–290.

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *critical displacement, u_1*—displacement at the intersection of the post-peak slope with the displacement-axis.

3.1.2. *displacement at peak load, u_0*—recorded displacement at peak load.

3.1.3. *final displacement*, u_{final}—recorded displacement at the 0.1 kN cut-off load.

3.1.4. *flexibility index,* FI—index intended to characterize the cracking resistance of asphalt mixture, calculated by multiplying the ratio of fracture energy to post-peak slope by a constant multiplier.

3.1.5. *fracture energy, G_f*—energy required to create a unit surface area of a crack.

3.1.6. *ligament area,* $Area_{lig}$—cross-sectional area of specimen through which the crack propagates, calculated by multiplying ligament width (test specimen thickness) and ligament length.

3.1.7. *linear variable displacement transducer (LVDT)*—sensor device for measuring linear displacement.

3.1.8. *load line displacement (LLD)*—displacement measured in the direction of the load application.

3.1.9. *post-peak slope, m*—slope at the first inflection point of the load–LLD curve after the peak.

3.1.10. *semicircular bend (SCB) geometry*—a half disc with a notch parallel to the direction of load application.

3.1.11. *work of fracture (W_f)*—calculated as the area under the load–LLD curve.

4. SUMMARY OF METHOD

4.1. A superpave gyratory compactor (SGC) compacted asphalt mixture specimen or an asphalt pavement core is trimmed and cut in half to create a semicircular test specimen. A notch is sawn in the flat side of the semicircular specimen opposite the curved edge. The specimen is conditioned and maintained through testing at 25 ± 0.5°C. The specimen is positioned in the fixture with the notched side down centered on two rollers. A load is applied along the vertical radius of the specimen and the load and load line displacement (LLD) are measured during the entire duration of the test. The load is applied such that a constant LLD rate of 50 mm/min is obtained and maintained for the duration of the test. The I-FIT fixture and I-FIT specimen geometry for an SGC laboratory compacted specimen are shown in Figure 1.

4.2. Fracture energy (G_f), post-peak slope (m), displacement at peak load (u_0), critical displacement (u_1), and a flexibility index (FI) are calculated from the load and LLD results.

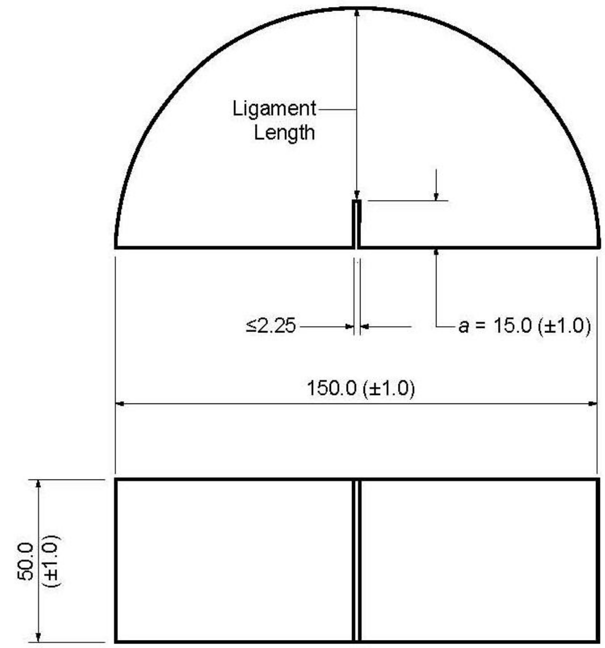


Figure 1—I-FIT SGC Laboratory Compacted Specimen Configuration (dimensions in millimeters)

5. SIGNIFICANCE AND USE

5.1. The I-FIT is used to determine fracture resistance parameters of an asphalt mixture at an intermediate temperature (Al-Qadi et al., 2015; Ozer et al., 2016a; Ozer et al., 2016b). From the fracture parameters of G_f and m obtained, the FI of an asphalt mixture is calculated. The FI provides a means to identify brittle mixtures that may be prone to premature cracking. The range for an acceptable FI will vary according to local environmental conditions, application of mixture, nominal maximum aggregate size (NMAS), asphalt binder content, asphalt binder performance grade (PG), air voids, and expectation of service life, etc. (Al-Qadi et al., 2015; Ozer et al., 2016a; Ozer et al., 2016b; Ozer et al., 2017).

5.2. The calculated FI indicates an asphalt mixture's overall capacity to resist cracking related damage (Al-Qadi et al., 2015). Generally, a mixture with higher FI can resist crack propagation for longer time duration under tensile stress. The FI should not be directly used in structural design and analysis of pavements. FI values, obtained using this procedure, are used in ranking the cracking resistance of alternative mixtures for a given layer in a structural design. The G_f parameter is dependent on specimen size, loading time, and temperature. Fracture mechanisms for viscoelastic materials are influenced by crack front viscoelasticity and bulk material (far from the crack front) viscoelasticity. Total calculated G_f from this test includes the amount of energy dissipated by crack propagation, viscoelastic mechanisms away from the crack front, and other inelastic irreversible processes (frictional and damage processes at the loading support points) (Doll et al., 2016).

5.3. G_f is one of the parameters used to calculate the FI, which is further used to predict AC mixture fracture potential. It also represents the main parameter input in more complex analyses based on a theoretical crack (cohesive zone) model. In order to be used as part of a cohesive zone model, fracture energy as calculated from the experiment shall be corrected to determine energy associated with crack propagation only. A correction factor may be used to eliminate other sources of inelastic energy contributing to the total fracture energy calculated directly from the experiment.

5.4. This test method and FI can be used to rank the cracking resistance of asphalt mixtures containing various asphalt binders, modifiers of asphalt binders, aggregate blends, fibers, and recycled materials.

5.5. The specimens can be readily obtained from SGC compacted cylinders or from pavement cores with a diameter of 150 mm.

6. APPARATUS

6.1. *Testing Machine*—An I-FIT system consists of a closed-loop axial loading device, a load measuring device, a bend test fixture, specimen deformation measurement devices, and a control and data acquisition system. A constant displacement-rate device, such as a closed loop, feedback-controlled servo-hydraulic load frame, shall be used.

Note 1—An electromechanical, screw-driven machine may be used if results are comparable to a closed loop, feedback-controlled servo-hydraulic load frame.

6.1.1. *Axial Loading Device*—The loading device shall be capable of delivering loads in compression with a maximum resolution of 10 N and a capacity of at least 10 kN.

6.1.2. *Bend Test Fixture*—The fixture is composed of a loading head, a steel base plate, and two steel rollers with a nominal diameter (*D*) of 25 mm. The tip of the loading head has a contact curvature with a radius of 12.5 ± 0.05 mm. The horizontal loading head shall pivot relative to the vertical loading axis to conform to slight specimen variations. The length of the two roller supports in Figure 2 and Figure 3 shall be a minimum of 65 mm. Illustrations of the loading and supports are shown in Figures 2 and 3.

6.1.2.1. *Method A*—Typically two steel rollers with a nominal diameter of 25 mm are mounted on bearings through their axis of rotation and attached to the steel base plate with brackets. One of the steel rollers may pivot on an axis perpendicular to the axis of loading to conform to slight specimen variations. A distance of 120 ± 0.1 mm between the two steel rollers is maintained throughout the test.

6.1.2.2. *Method B*—An alternate fixture design uses two steel rollers with a nominal diameter of 25 mm that each rotate in a U-shaped roller support steel block. The initial roller position is fixed by springs and backstops that establish the initial test span dimension of 120 ± 0.1 mm. The support rollers are allowed to rotate away from the backstops during the test; but remain in contact with the sample.

6.1.3. *Internal Displacement Measuring Device*—The displacement measurement can be performed using the machine's stroke (position) transducer if the resolution of the stroke is sufficient (0.01 mm or lower). The fracture test displacement data may be corrected for system compliance, loading-pin penetration and specimen compression by performing a calibration of the testing system.

6.1.4. *External Displacement Measuring Device*—If an internal displacement measuring device does not exist or has insufficient precision, an externally applied displacement measurement device such as a linear variable differential transducer (LVDT) accurate to 0.01 mm can be used (Figure 2 and Figure 3).

6.1.5. *Control and Data Acquisition System*—Time and load, and LLD (using external and/or internal displacement measurement device) are recorded. The control data acquisition system is required to apply a constant LLD rate at a precision of 50 ± 1 mm/min and collect data at a minimum sampling frequency of 20 Hz in order to obtain a smooth load–LLD curve.

Note 2—The use of two LLD transducers 180 degrees from one another and on each side of a test specimen may be used. In this approach, an average LLD value is computed to control the test. Controlling the test using an average LLD value may reduce test variability.

6.1.6. *Saw*—Laboratory saw capable of cutting asphalt specimens; must be capable of cutting the notch described in Figure 1.

6.1.7. *Conditioning Chamber*—Water bath or environmental chamber of sufficient size, capable of maintaining a uniform temperature, used within their proper operating temperature range, to conditioned samples at 25 ± 0.5°C. The thermometer for measuring the temperature of water baths shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 30°C, and an accuracy of ±0.13°C.

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer, Special order; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

6.1.8. *Measuring Device*—Caliper or ruler accurate to ±0.1 mm for specimen thickness and area measurement.

6.1.9. *Oven*—A forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining a uniform temperature of 95°C within ±3°C. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 25 to 185°C, and an accuracy of ±0.75°C.

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; IEC 60584 thermocouple thermometer, Type T, Class 1; or E2877 digital metal stem thermometer.

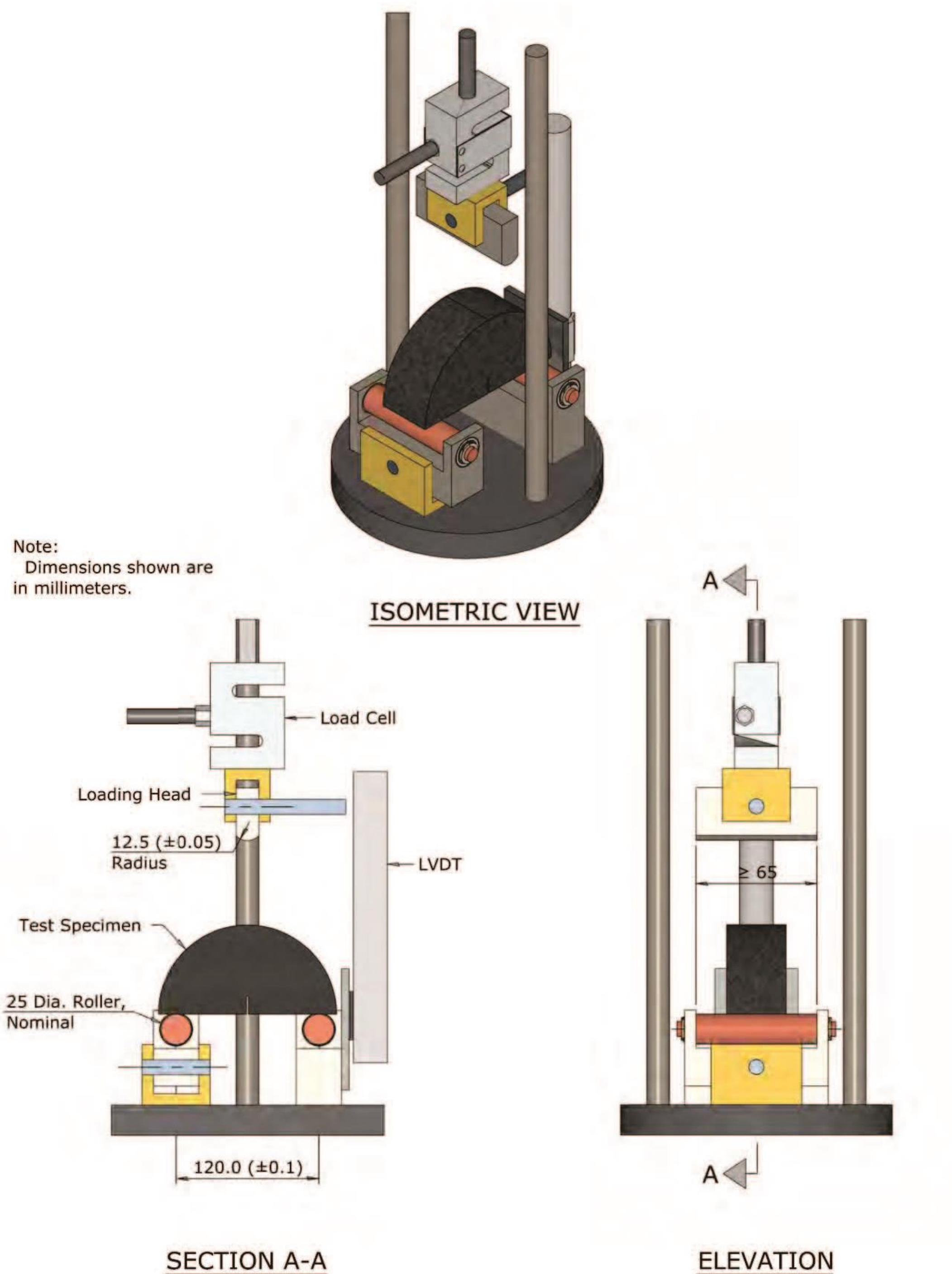


Figure 2—Method A—Isometric, Cross-Section, and Elevation of the I-FIT Fixture (dimensions in millimeters)

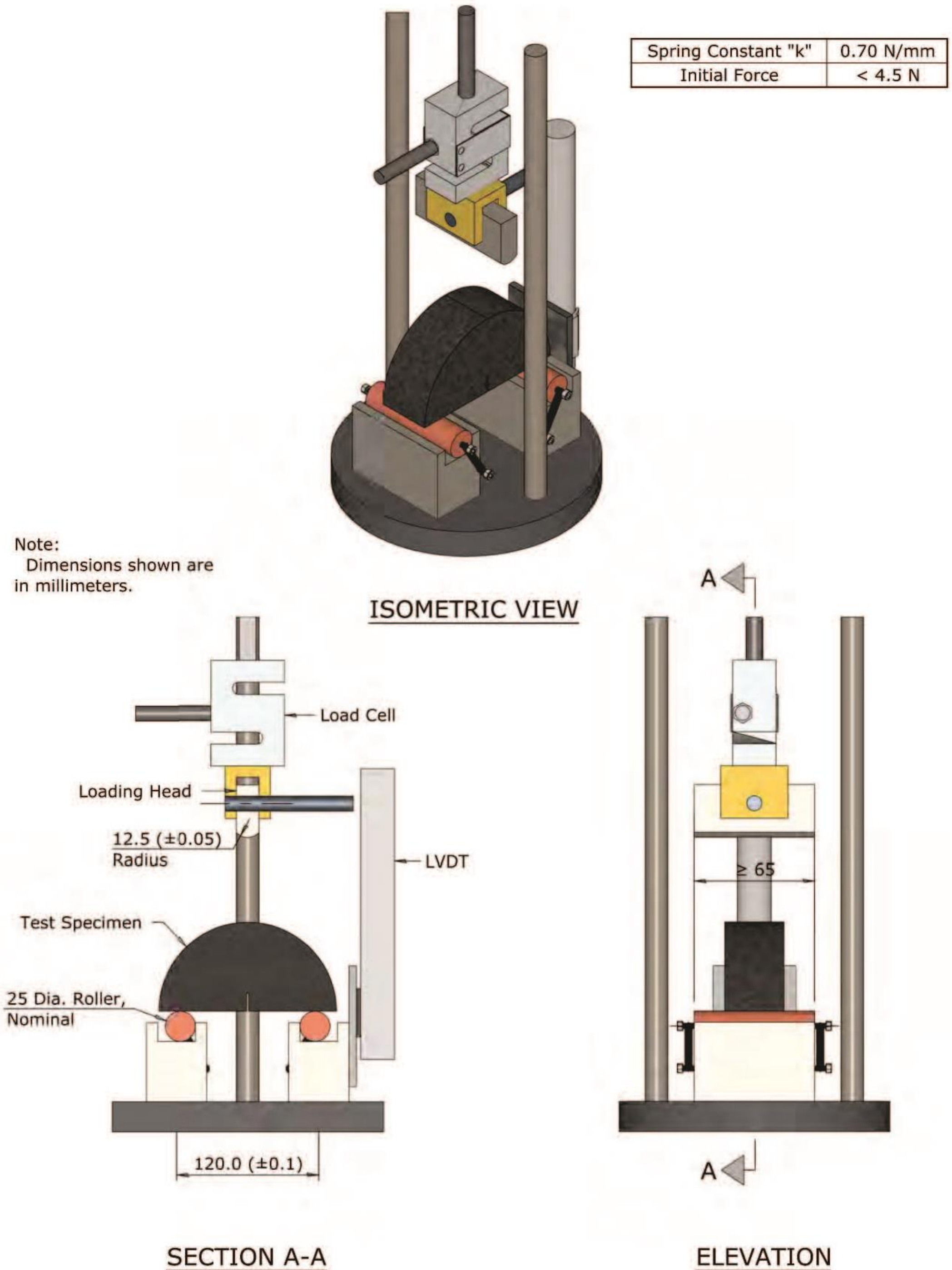


Figure 3—Method B—Isometric, Cross-Section, and Elevation of the I-FIT Fixture (dimensions in millimeters)

7. HAZARDS

7.1. Standard laboratory caution should be used in handling, compacting, and fabricating asphalt mixtures test specimens in accordance with T 312 and when using a saw for cutting specimens.

8. CALIBRATION AND STANDARDIZATION

8.1. A water bath as used in AASHTO T 283 or an environmental chamber will be used to maintain the specimen at a constant and uniform temperature.

8.2. Verify the calibration of all measurement components (such as load cells and LVDTs) of the testing system.

8.3. If any of the verifications yield data that does not comply with the accuracy specified, correct the problem prior to proceeding with testing. Appropriate action may include maintenance of system components, calibration of system components (using an independent calibration agency, service by the manufacturer, or in-house resources), or replacement of the system components.

9. PREPARATION OF TEST SPECIMENS AND PRELIMINARY DETERMINATIONS

9.1. *Test Specimen Size*—For mixtures with an NMAS of 19 mm or less, prepare the test specimens from a lab compacted SGC specimen or from pavement cores. If laboratory compacted SGC specimens are used, the final I-FIT specimens shall have smooth parallel faces with a thickness of 50 ± 1 mm and a diameter of 150 ± 1 mm (see Figure 4). If pavement cores are used, refer to Figure 1 for the notch width and notch length dimensions and tolerances. The final pavement core I-FIT specimen dimensions shall be 150 ± 8 mm in diameter with smooth parallel faces 25 to 50 ± 1 mm thick depending on available field layer thickness.

Note 5—A typical laboratory saw for mixture specimen preparation can be used to obtain cylindrical discs with smooth parallel surfaces. A tile saw is recommended for cutting the 15 ± 1 mm notch in the individual I-FIT specimens. Diamond-impregnated cutting faces and water cooling are recommended to minimize damage to the specimen. When cutting the I-FIT specimens into semi-circular halves, it is recommended not to push the two halves against each other because it may create an uneven base surface of the test specimen that can affect the I-FIT results.

9.1.1. *SGC Specimens*—Prepare one laboratory SGC specimen according to T 312 in the SGC with the compaction height a minimum of 160 ± 1 mm. From the middle of each 160 ± 1 mm tall specimen, obtain two cylindrical 50 ± 1 mm thick discs with smooth, parallel faces by saw cutting (see Figure 4). For laboratory compacted specimens, the bulk specific gravity and the air voids shall be determined for each of the two circular discs according to T 269. The air voids for each disc shall be 7.0 ± 1.0 percent. Cut each disc into two dimensionally equivalent halves resulting in four individual I-FIT specimens. A minimum of three individual test specimens are required for one I-FIT result.

Note 6—The height of the gyratory compacted specimens should be 160 ± 1 mm to achieve a target 7.0 ± 1.0 percent air voids in each disc (see Figure 4). If a lab does not have the capability to compact 160 ± 1 mm tall gyratory specimens, then two 115 ± 1 mm tall gyratory specimens may be compacted and used instead to replace each 160 ± 1 mm tall gyratory specimen. A 50 ± 1 mm thick disc will be cut from the middle of each gyratory specimen, which will result in four individual I-FIT specimens (see Figure 4).

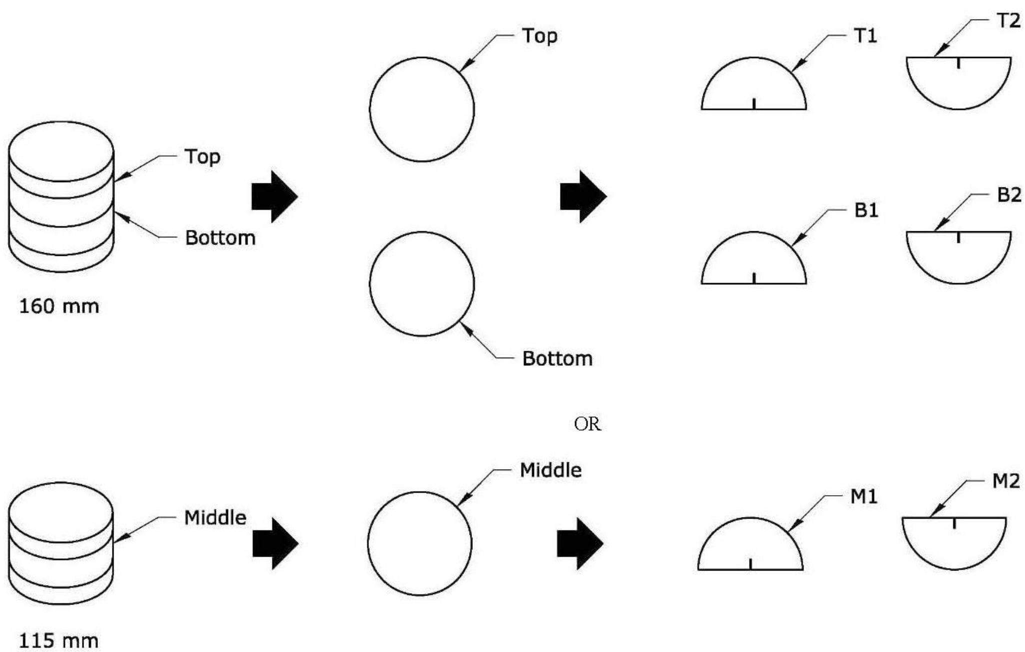


Figure 4—Specimen Preparation from 160 mm or 115 mm Tall SGC Specimens

9.1.2. *Pavement Cores*—Obtain pavement cores in accordance with R 67. Obtain one 150 mm diameter pavement core if the lift thickness is greater than or equal to 100 mm, or two 150 mm diameter pavement cores if the lift thickness is less than 100 mm.

9.1.2.1. *Pavement Core Specimen Preparation*—Prepare four replicate I-FIT specimens using pavement cores obtained from a pavement lift, with smooth, parallel surfaces that conform to the height and diameter requirements specified herein. To preserve and maximize core thickness, the as-compacted face shall be utilized as well as a sawed face. The thickness of test specimens in most cases for pavement cores may vary from 25 to 50 ± 1 mm. If the lift thickness is less than 50 ± 1 mm, test specimens should be prepared as thick as possible but in no case be less than two times the nominal maximum aggregate size of the mixture or 25 ± 1 mm, whichever is greater. If lift thickness is greater than 50 ± 1 mm, a 50 ± 1 mm disc shall be prepared as specified in Section 9.1. Cores from pavements with lifts greater than 75 ± 1 mm may be cut to provide two cylindrical specimens of equal thickness. In the upper-most pavement layer when cored, the as-compacted face will remain intact and one cut will be made to produce a disc at least two times the nominal maximum aggregate size of the mixture or 25 ± 1 mm, whichever is greater. In all subsequent discs cut from that pavement core, two sawed faces may be used to produce smooth, parallel surfaces.

9.1.2.2. *Determining the Bulk Specific Gravity*—Determine the bulk specific gravity directly on each disc obtained from pavement cores according to T 166.

9.1.2.3. *Determining the Air Voids*—The air void contents of each disc shall be determined according to T 269. Pavement cores will not be subject to air void content tolerances.

9.1.2.4. *Cutting Semicircular Test Specimens*—Cut each cylindrical disc in half to produce two dimensionally equivalent semicircular test specimens.

9.2. *Notch Cutting*—Cut a notch along the axis of symmetry of each individual semicircular specimen to a depth of 15 ± 1 mm and ≤2.25 mm in width (see Figure 1).

Note 7—If the notch terminates in an aggregate particle 9.5 mm or larger on both faces of the specimen, the specimen shall be discarded.

9.3. *Determining Specimen Dimensions*—Measure the notch depth on both faces of the specimen and record the average value to the nearest 0.5 mm. Measure and record the ligament length (see Figure 1) and thickness of each specimen. The ligament length may be measured *directly* on both faces of the specimen with the average value recorded, or the ligament length may be measured *indirectly* by subtracting the notch depth from the entire width (radius) of the specimen on both faces of the specimen and averaging the two measurements. Measure the specimen thickness approximately 19.0 mm on either side of the notch and on the curved edge directly across from the notch. Average the three measurements and record as the average thickness to the nearest 0.1 mm.

10. LONG-TERM AGING

10.1. Perform a long-term aging procedure on I-FIT specimens as defined by the specifying agency.

Note 8—The I-FIT specimen long-term aging procedure in Appendix X2 may be used.

11. TEST PROCEDURE

11.1. *Conditioning*—Test specimens shall be conditioned in a water bath or an environmental chamber at 25 ± 0.5°C for 2 h ± 10 min.

11.1.1. *Test Temperature Control*—Immediately after removing the test specimen from the conditioning water bath or environmental chamber, complete positioning and testing of the I-FIT specimen within 5 ± 1 min to ensure that the specimen temperature is maintained.

11.2. *Position Specimen*—Position the test specimen in the test fixture on the rollers so that it is centered in both the "x" and the "y" directions and so that the vertical axis of loading is aligned to pass from the center of the top radius of the specimen through the middle of the notch.

11.3. *Contact Load*—First, impose a contact load of 0.1 ± 0.01 kN in stroke control with a loading rate of 0.05 kN/s.

11.3.1. *Record Contact Load*—Record the contact load to ensure it is achieved.

11.3.2. *Loading*—After the contact load of 0.1 kN is reached, the test is conducted using LLD control at a rate of 50 mm/min. The test stops when the load drops below 0.1 kN.

11.3.3. Repeat Sections 11.1 through 11.3.2 for each test specimen.

12. PARAMETERS

12.1. *Determining Work of Fracture (W_f)*—The work of fracture is calculated as the area under the load–LLD curve (see Figure 5). If the test is stopped prior to reaching 0.1 kN, the remainder of the load–LLD curve should be produced by extrapolation techniques.

The area under the load–LLD curve is calculated using a numerical integration technique. In order to apply the numerical integration, raw load-displacement data shall be divided into two curves described by an appropriate fitting equation. A polynomial equation with a degree of six is sufficient for the curve prior to peak load (Equation 1). An exponential-based function (Equation 2) is used for the post-peak load portion of the curve. Then, analytical integration shall be applied to calculate the area under each curve (Equation 3).

For displacements (u) prior to the peak load (P_{max}):

$$P_1(u) = c_1 \times u^6 + c_2 \times u^5 + c_3 \times u^4 + c_4 \times u^3 + c_5 \times u^2 + c_6 \times u^1 + c_7 \quad (1)$$

where:

c_i = polynomial coefficients.

For displacements (u) after the peak load (P_{max}) to the cut-off displacement (u_{final}):

$$P_2(u) = \Sigma_i^{n=4} d_i \exp\left[-\left(\frac{u-e_i}{f_i}\right)^2\right] \quad (2)$$

where:

d, e, f = polynomial coefficients, n is the number of exponential terms.

Work of fracture can be analytically or numerically calculated using the integral equation below and boundaries of displacement:

$$W_f = \int_0^{u_0} P_1(u)\,du + \int_{u_0}^{u_{final}} P_2(u)\,du \quad (3)$$

where:

u_0 = displacement at the peak load;

u_{final} = displacement at the 0.1 kN cut-off load.

Note 9—Due to the relative difference between the compliance of testing frame and specimen, displacement recorded may vary. A correction factor may need to be considered to correct recorded displacements when applicable.

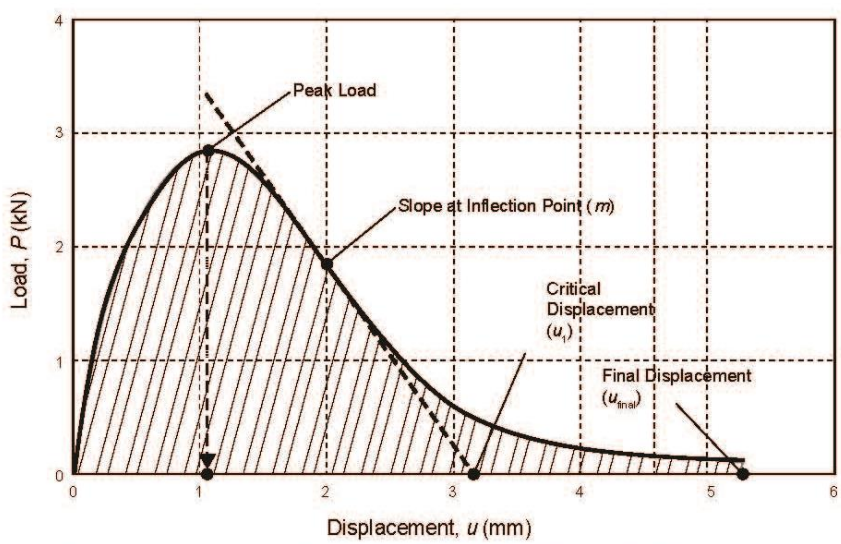


Figure 5—Recorded Load (P)–Load Line Displacement (u) Curve

12.2. *Fracture Energy (G_f)*—The fracture energy G_f, determined as per the RILEM TC 50-FMC (1985) approach, is calculated by dividing the work of fracture (the area under the load–LLD curve; see Figure 5) by the ligament area (the product of the ligament length and the thickness of the specimen) of the I-FIT specimen prior to testing:

$$G_f = \frac{W_f}{\text{Area}_{\text{lig}}} \times 10^6 \tag{4}$$

where:

G_f	=	fracture energy (Joules/m²);
W_f	=	work of fracture (Joules);
P	=	load (kN);
u	=	load line displacement (mm);
Area_{lig}	=	ligament area = $(r - a) \times t$, (mm²);
r	=	specimen radius (mm);
a	=	notch length (mm);
t	=	specimen thickness (mm).

Note 10—G_f is a size dependent property. This specification does not aim at calculating size independent G_f. Therefore, cracking resistance of asphalt mixtures quantified with G_f may vary when the notch length to radius ratio changes.

12.3. *Determining Post-Peak Slope (m)*—The inflection point is determined on the load–LLD curve (Figure 5) after the peak load. The slope of the tangential curve drawn at the inflection point represents post-peak slope.

12.4. *Determining Displacement at Peak Load (u_0)*—The displacement when peak load is reached.

12.5. *Determining Critical Displacement (u_1)*—Intersection of the tangential post-peak slope with the displacement axis yields the critical displacement value. A straight line is drawn connecting the inflection point and displacement axis with a slope m.

12.6. *Flexibility Index (FI)*—FI can be calculated from the parameters obtained using the load–LLD curve (Al-Qadi et al. (2015), Ozer et al. (2016a), Ozer et al. (2016b)). The factor A is used for unit conversion and scaling. A is equal to 0.01. Complete details of the analysis procedure are provided in Appendix X1.

$$FI = \frac{G_f}{|m|} \times A \tag{5}$$

where:

$|m|$ = absolute value of post-peak load slope m (kN/mm).

13. CORRECTION FACTORS

13.1. *Correction Factors for Flexibility Index*—Flexibility index correction factors for pavement core specimen thickness and differences between field and lab compaction may be needed. A thickness correction factor may be applied for pavement cores tested at thickness less than 45 mm. The correction factors may require local calibration to consider locally available materials and mixture design requirements.

14. REPORT

14.1. *Report the following information*:

14.1.1. Bulk specific gravity of each specimen tested, to the nearest 0.001;

14.1.2. Air void content of each disc, to the nearest 0.1 percent;

14.1.3. The number of cut faces for each specimen tested, if pavement cores were used;

14.1.4. Average thickness t and average ligament length of each specimen tested, to the nearest 0.1 mm;

14.1.5. Initial notch length a, to the nearest 0.5 mm;

14.1.6. Average and coefficient of variation (COV) of peak load, to the nearest 0.1 kN;

14.1.7. Average and COV of recorded time at peak load, to the nearest 0.1 s;

14.1.8. Average and COV of load-line displacement at the peak load (u_0), to the nearest 0.1 mm;

14.1.9. Average and COV of critical displacement (u_1), to the nearest 0.1 mm;

14.1.10. Average and COV of post-peak slope (m), to the nearest 0.1 kN/mm;

14.1.11. Average and COV of fracture energy G_f, to the nearest 1 J/m^2; and

14.1.12. Average and COV of flexibility index to the nearest 0.1.

15. PRECISION AND BIAS

15.1. *Precision:*

15.1.1. *Single-Operator Precision*—The single-operator coefficient of variation of flexibility index has been found to be 27.1 percent. Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ from each other by more than 75.9 percent of their average.

15.1.2. *Multi-laboratory Precision*—The multi-laboratory coefficient of variation of flexibility index has been found to be 34.1 percent. Therefore, results of two properly conducted tests by two different laboratories on specimens of the same material are not expected to differ from each other by more than 95.5 percent of their average.

Table 1—Precision Estimates[a]

		Components of Variance		Variances	
Material	Average FI	Single Operator	Between Laboratory	Single Operator	Multi-laboratory
2017	5.2	2.36	0.49	2.36	2.85
2018	23.1	36.85	7.64	36.85	44.49
2019	9.6	5.90	9.55	5.90	15.44

		Standard Deviations		Coefficients of Variation (%)	
Material	Average FI	Single Operator	Multi-laboratory	Single Operator	Multi-laboratory
2017	5.2	1.54	1.69	29.6	32.5
2018	23.1	6.07	6.67	26.3	28.9
2019	9.6	2.43	3.93	25.3	41.0

[a] Based on a multi-laboratory study of state departments of transportation, private, and academic laboratories in 2017, 2018, and 2019. Three materials (all 9.5-mm NMAS mixtures) with varying contents of RAP were used (a different mixture was used each year). Approximately 12 specimens were tested per material on at least 30 devices per year.

15.2. *Bias*—No information can be presented on the bias of the procedure because no material having an accepted reference value is available.

16. KEYWORDS

16.1. Asphalt mixture; flexibility index; fracture energy; Illinois flexibility index test (I-FIT); semicircular bend (SCB); stiffness; work of fracture.

APPENDIXES

X1. CALCULATIONS[2]

X1.1. *Scope*:

X1.1.1. This appendix presents the framework and algorithms used to process the load–LLD curve and to compute the critical variables such as fracture energy, slope (after the crack begins propagating), and flexibility index. The algorithm consists of the following steps:

X1.1.1.1. Preprocessing the raw load–LLD curve;

X1.1.1.2. Pre-peak calculations; and

X1.1.1.3. Post-peak calculations.

X1.2. *Preprocessing*:

X1.2.1. The algorithm starts with preprocessing the raw test output file containing the load and displacement data. The first step of pre-processing is to trim the tail of the curve. The data points whose load values are smaller than 0.1 kN are removed. Because the load–LLD curve exhibits different characteristics before and after the peak load, the trimmed load–LLD curve is divided into two parts: pre-peak and post-peak. To do this, the peak load at which maximum load value is reached is identified. The values of the load–LLD curve before the peak load are assigned to the pre-peak segment; the remaining data are assigned to the post-peak segment. The calculations required for pre-peak and post-peak segments are explained in Sections X1.3 and X1.4.

X1.3. *Pre-Peak Calculations*:

X1.3.1. *The following steps are completed to process the pre-peak segment of the load–LLD curve*:

X1.3.1.1. The beginning (u_i, P_i) and end (u_0, P_{max}) coordinates of the load–LLD curve are captured.

X1.3.1.2. A polynomial equation with a degree of six is fitted to the pre-peak segment of the load–LLD curve (Equation X1.1).

$$P_1(u) = c_1 \times u^6 + c_2 \times u^5 + c_3 \times u^4 + c_4 \times u^3 + c_5 \times u^2 + c_6 \times u^1 + c_7 \qquad (X1.1)$$

where:

c_i = polynomial coefficients.

X1.3.1.3. A new set of data is generated with equal displacement increments using the polynomial function bounded by the beginning and end points found in Section X1.3.1.1. The increments used to divide the data are found by dividing the displacement at the peak load by 1000. A new displacement vector (u_{pre}) is generated from u_i to u_0 with calculated increments. The new loading vector is computed by substituting the value of the displacement vector in Equation X1.1. The purpose of generating a dataset with higher resolution is to increase the accuracy of the numerical integration described in Section X1.3.1.4.

X1.3.1.4. Numerical integration is applied to calculate area under the pre-peak segment of the load–LLD curve. The integral for area calculation is given in Equation X1.2. A trapezoidal integration technique is used for the numerical integration of Equation X1.2. When analytical integration tools are available, analytical integration is recommended to improve accuracy.

$$W_f\,(\text{pre-peak}) = \int_0^{u_0} P_1(u)\,du \qquad (X1.2)$$

X1.3.1.5. When the load–LLD curve starts with a residual load at zero displacement, the curve needs to be extrapolated to modify the area calculated in the previous step. In such cases, the curve is linearly extrapolated to the displacement coordinate where the load is zero. The displacement at the zero load (u_r) is found. The area under the extrapolated segment is added to calculate total pre-peak area X1. Numerical integration is applied to find the residual area shown by the additional term in Equation X1.3. The second part of the sum comes from the additional area of extrapolation.

$$W_f\,(\text{pre-peak}) = \int_0^{u_0} P_1(u)\,du + u_r \times P_r \times 0.5 \qquad (X1.3)$$

where:

P_r = residual load at zero displacement; and

u_r = calculated displacement at zero load.

X1.4. *Post-Peak Calculations*:

X1.4.1. An algorithm was developed to process the post-peak segment of the load–LLD curve to calculate area under the curve as well as the inflection point and slope at the inflection point. Explanations of each step are given in Sections X1.4.1.1 through X1.4.1.3.

X1.4.1.1. The beginning (u_0, P_0) and end (u_f, P_f) coordinates of the post-peak load–LLD curve are captured (see Figure X1.1). The raw data records are stored in two vectors as $u_{\mathbf{post}} = \{u_0, \ldots, u_f\}$ and $P_{\mathbf{post}} = \{P_0, \ldots, P_f\}$.

X1.4.1.2. In this step, candidate lower bounds for parameter f in Equation X1.4 are initialized and kept in a vector. This parameter can govern the first derivative of the post-peak segment resulting in abnormal slope values. For example, if a lower bound is not defined for this parameter, it may go to zero, which creates a spike-like, spurious slope. On the other hand, if the bound is defined too high, accuracy of the fitted curve may be compromised. Therefore, candidate values for the lower bounds for this parameter were found to be $f_{\mathbf{bounds}} = \{0.9, 0.7, 0.5, 0.3, 0.1, 0.05, 0.01, 0.005, 0.001\}$. The optimum value is found iteratively looping over the values initialized in the $f_{\mathbf{bounds}}$. The order of the values should be descending.

$$P_2(u) = \Sigma_i^{n=4}\, d_i \exp\left[-\left(\frac{u-e_i}{f_i}\right)^2\right] \qquad (X1.4)$$

where:

d, e, f = polynomial coefficients, and

n = number of exponential terms.

X1.4.1.3. All model parameters in Equation X1.4 are regularized by setting lower and upper bounds for each of them. Upper and lower bounds for each parameter except f are initialized as 10 and –10, respectively. Because of the limitations of the regression function used in MATLAB (the function called "fit"), the regularization had to be conducted in a heuristic way.

X1.4.1.3.1. A regression function that input $u_{\mathbf{post}}$ and $P_{\mathbf{post}}$ are developed by fitting the Gaussian function (Equation X1.4) to the post-peak segment of the data bounded by the limits defined in Section X1.4.1. The number of Gaussian terms is selected as four. Then, the inflection points at which the second derivative of the fitted equation becomes zero are extracted, and the first derivatives indicating the slopes (m_i) are computed at the extracted inflection points (u_i).

X1.4.1.3.2. It is possible that the second derivative of the fitted equation $P_2(u)$ may not have any roots (i.e., there is no inflection point; hence, no slope can be found). If $P_2(u)$ does not have any roots, the next value in the vector fbounds should be selected before proceeding with the remaining steps. If a root or roots of $P_2(u)$ exists, proceed to the next step.

X1.4.1.3.3. At each inflection point found, draw the tangential slope by extrapolating a line intersecting the displacement axis, as shown in Figure X1.1. The first derivative value at the inflection is defined as the post-peak slope (m) as shown below.

$$m = \left[\frac{\partial P_2(u)}{\partial u}\right]_{u=u_{\text{inf}}} \qquad (X1.5)$$

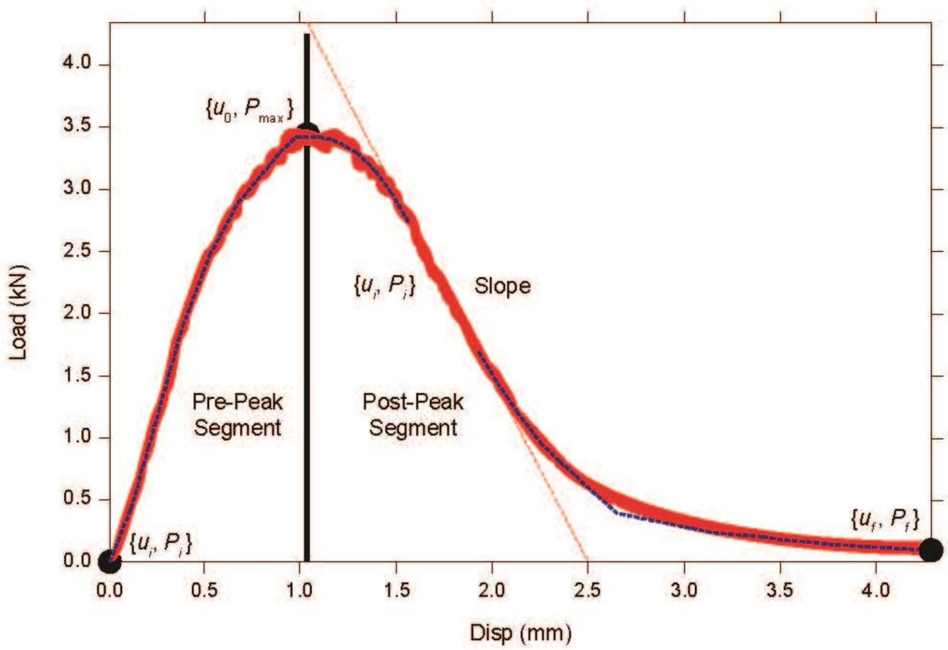


Figure X1.1—Demonstration of Pre-Peak and Post-Peak Segments

X1.4.1.3.4. It is common that the fitted equation may produce more than one slope when there is more than one root found in the previous step. There is only one slope considered consistent with the definition of the tests; the remaining slopes are spurious and need to be eliminated. To find the most representative slope and eliminate the unrealistic slope(s), three visual based criteria are implemented. The criteria, grading, and elimination processes are as follows:

- *Criterion 1*—Incremental displacement values (u_n) are generated with equal increments between u_0 and u_i. A linear slope equation, $S(u)$, is described by using the slope (see Equation X1.5) and passing through the inflection point (u_i). The mean value of difference between slope equation and post-peak load–LLD curve is calculated using Equation X1.6.

$$C1 = \frac{\sum_{n=1}^{M}\left[S(u_n) - P_2(u_n)\right]}{M} \qquad (X1.6)$$

where:

M = number of displacement values such that ($u_0 < u_n < u_i$). Equal sizes of increments are used to create M-times displacement values (u_n). M may vary depending on the length between u_0 and u_i;

$S(u_n)$ = value of slope equation calculated at $u = u_n$; and

$P_2(u_n)$ = value of post-peak load–LLD curve calculated at $u = u_n$.

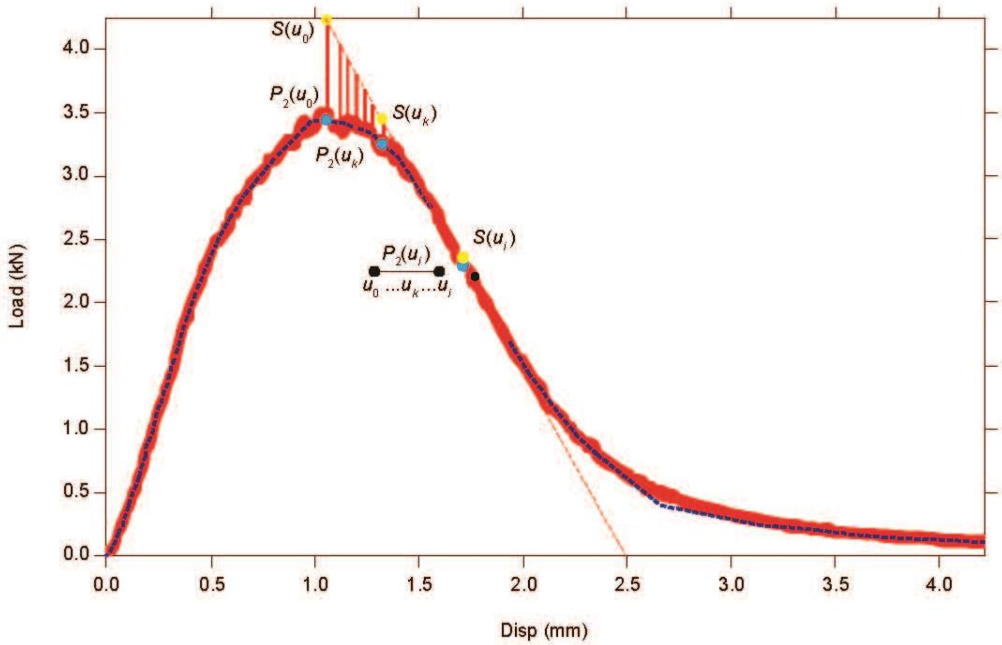


Figure X1.2—Checking Mean Difference for Criterion 1

- *Criterion 2*—Incremental displacement values (u_n) are generated with equal increments between u_0 and u_t. The u_t is found by taking 30 percent of $P_i = P_2(u_i)$ (load corresponding to the inflection point) (see Figure X1.3). The same linear slope equation, $S(u)$, is used as in Criterion 1. The mean value of difference between slope equation and post-peak load–LLD curve is calculated using Equation X1.7.

$$C2 = \frac{\sum_{n=1}^{M}\left[P_2(u_n) - S(u_n)\right]}{M} \qquad (X1.7)$$

where:

M = number of displacement values such that ($u_0 < u_n < u_t$). Equal sizes of increments are used to create M-times displacement values (u_n). M may vary depending on the length between u_0 and u_t;

$S(u_n)$ = value of slope equation calculated at $u = u_n$;

$P_2(u_n)$ = value of post-peak load–LLD curve calculated at $u = u_n$.

The ideal slope line should be perfectly tangential or remain below the fitted curve. Therefore, the slope lines with negative means are eliminated. The grading scheme for this criterion is similar to the previous one. If more than one slope remains after elimination, slopes are ranked in an ascending order according to the mean difference (C2). The slope with lowest mean difference is ranked highest.

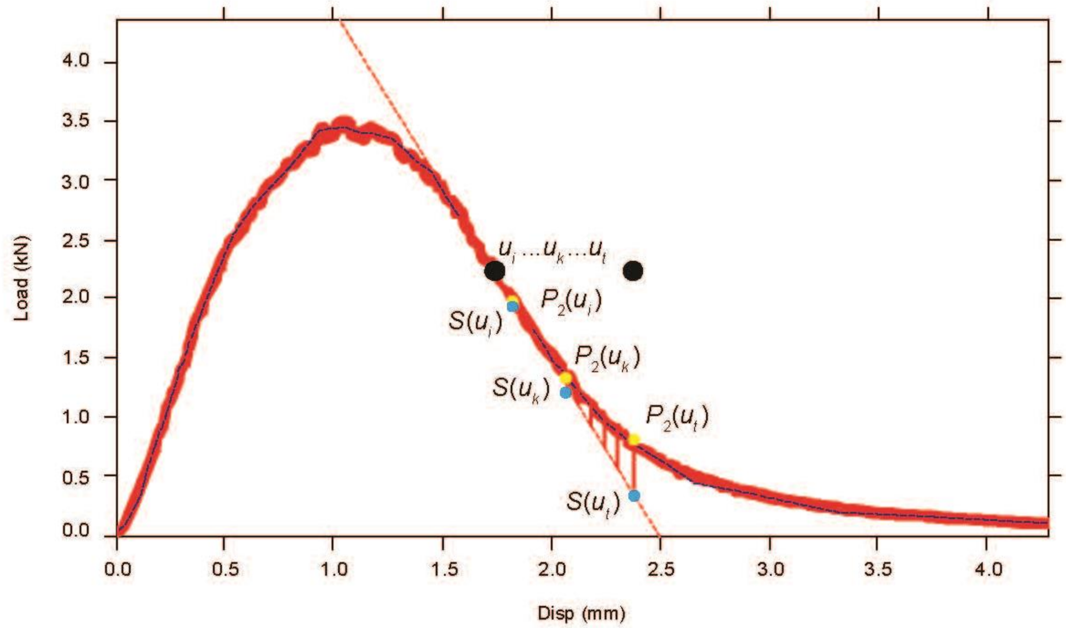


Figure X1.3—Checking Mean Difference for Criterion 2

- *Criterion 3*—The value of this criterion is –x coordinate of inflections points (i.e., u_i). If there are multiple candidates for slope line, they are ranked with an ascending order according to their u_i. For example, slopes found at smaller inflection points ranked higher than the slope found at the tail part of the curve.

X1.4.1.3.5. If at least one realistic slope is found, and the R2 of the fit is higher than 0.997, the fit is accepted and the loop is stopped. In that case, the framework jumps to Section X1.4.4 to calculate fracture energy and report the representative slopes along with other required test outcomes. Otherwise, the loop continues—that is, the next value from f_{bound} is selected to modify the lower bound for the parameter f. Sections X1.4.1.3.1 through X1.4.1.3.5 are repeated until a representative slope and satisfactory R2 is found.

X1.4.1.4. Using the satisfactory fit, $P_2(u)$, and representative inflection point and post-peak slope values (m), the test parameters required in the report section of the specification are calculated.

X1.4.1.4.1. Representative slope is reported as the one with the highest score from the grading process (Section X1.4.1.3.4).

X1.4.1.4.2. Similar to the pre-peak area calculation, a new displacement vector between up and u_{final} by an increment of 0.005 is generated. Then corresponding load values are calculated by feeding this generated displacement vector to the fitted regression functions. The purpose of generating new sets of data with increased resolution is to increase the accuracy of the numerical integration in the next step.

X1.4.1.4.3. A trapezoidal numerical integration technique (Figure X1.2) is employed for the integral shown in Equation X1.8 to calculate the area under the post-peak segment of the curve.

$$W_f(\text{post-peak}) = \int_{u_0}^{u_{\text{final}}} P_2(u)\,du \qquad (X1.8)$$

X1.4.1.4.4. The total area under the load–LLD curve is found by adding the pre-peak and post-peak areas. Then the work of fracture is calculated using the Equation X1.9.

$$W_f = W_f(\text{post-peak}) + W_f(\text{pre-peak}) \quad (X1.9)$$

X1.4.1.4.5. Total energy and slope are inputted to Equations X1.10a and X1.10b to compute fracture energy and flexibility index.

$$G_f = \frac{W_f}{\text{Area}_{\text{lig}}} \times 10^6 \quad (X1.10a)$$

$$FI = \frac{G_f}{|m|} \times As \quad (X1.10b)$$

X2. LONG-TERM AGING PROCEDURE

X2.1. *Scope*:

X2.1.1. This appendix includes and summarizes the findings of the R27-175 study conducted by the Illinois Center for Transportation through the Illinois Department of Transportation to evaluate the long-term aging effects on hot mix asphalt surface mixtures using the Illinois Flexibility Index Test and to develop a corresponding long-term-aging protocol.

X2.2. *Procedure*:

X2.2.1. Prepare surface mixture test specimens according to Section 9.

X2.2.2. Place the four test specimens, notched face down, on a tray (pan), with a barrier between the test specimens and the tray (e.g., parchment paper, a non-stick cooking mat, heavy duty aluminum foil).

X2.2.3. Place the tray with the specimens in a preheated force-draft oven set at 95 ± 3°C (203 ± 5°F).

X2.2.4. Leave the specimens (undisturbed) in the oven at this temperature for 72 h ± 1 h.

X2.2.5. Remove the entire tray from the oven and place in front of a cooling fan at room temperature for at least 1 h.

X2.2.6. If the specimen is not cooled in front of a fan, allow the specimens to cool at room temperature overnight.

X2.2.7. Remove the specimen from the barrier.

X2.2.8. After the specimens have cooled and the barrier has been removed, proceed to Section 11.

[1] Formerly AASHTO Provisional Standard TP 124. First published as a full standard in 2021.
[2] Appendix X1 written by Hasan Ozer, Osman Erman Gungor, and Imad Al-Qadi, Illinois Center for Transportation, University of Illinois at Urbana-Champaign.

HMA Level II Technician

Asphalt Plant Operations & Equipment

Information pertaining to:

Standard Specifications pertaining to:

Asphalt Plant Operations

1. General Plant Information

The Illinois asphalt industry utilizes two types of plants to produce HMA material; Dryer-drum and batch, with the Dryer-drum plant being the most common plant in use today. Batch plants are still in use but are rapidly being replaced by the more efficient Dryer-drum plant. A third type of plant, the continuous plant, dominated the asphalt industry in the earlier years of asphalt production but has since been phased out and with none currently in use in Illinois. In most cases, the components of both the dryer-drum and batch plants are similar but there are also some distinct differences.

The asphalt production process begins when individual stockpiled aggregates products are placed into aggregate bins referred to as “cold feeds” (this manual will continue to refer to these aggregate bins as cold feeds). Illinois requires all asphalt plants to have a minimum of four cold feeds equipped with adjustable feeder units to deliver the proper amounts or “proportions” of each aggregate ingredient onto an endless collector belt, or in some plants, to the boot of a bucket elevator. The aggregate blending process starts at the cold feeds where the individual cold feeds deposit the aggregate materials onto a main collector belt or a “cold elevator” which then transports the aggregate materials to the dryer. This feeder system is termed the "cold feed" because the aggregates have not been heated and dried yet.

In a dryer-drum plant, the cold feed aggregates are carried by an endless conveyor belt into a scalping screen to blend the aggregate materials and remove any oversize material. With a dryer-drum plant this is the only screening unit utilized which helps to speed up the production process. The screened material is then deposited onto and carried by another endless belt across a weigh belt system and then into the upper end of a revolving cylindrical dryer where a fuel oil, coal or gas burner heats and dries the aggregates. There are a small number of asphalt plants in use that use coal as a fuel source to heat and dry the aggregate materials.

A batch plant will utilize a grizzly screen, to scalp oversize material but can also use a scalping screen, such as found on a dryer-drum plant. The cold elevator carries the collected aggregates into the revolving cylinder dryer where the aggregate materials are heated and dried. The batch plant will use similar fuels to heat and dry the aggregates as a dryer-drum plant. Once the materials exit the batch plant dryer, a bucket elevator system, termed the "hot elevator", then transports the hot aggregates from the dryer to a screening system at the top of the batch plant tower where the hot aggregate materials are screened into the specific sizes based on the configuration of the screen deck. The hot screened material is then directed into separate compartments or storage bins, termed as "hot bins", located directly beneath the screens.

Mineral filler, often termed "dust", is usually stored in a silo near the plant and is transported through a low-pressure air pipe directly into the dryer (dryer-drum plant) or into the weigh hopper (batch plant). On some of the older plants, the dust is transported by a conveyor or dust elevator to a bin at the top of the plant and then is augured into the weigh hopper. This material is difficult to handle because, when it builds up pressure, it surges forward through screw conveyors, under gates, and over baffles placed to retard its flow. Indications are that the best results are obtained with the bin kept half-filled and dust added to it at the same rate as it is used in the mixture.

When a low air pressure system is used with a positive cut off system, handling the dust is greatly improved. This is referred to as “positive dust control” and is a required operation on newer plants.

With a dryer-drum plant, the weight of the aggregate is determined when the aggregate material passes across a weigh sensing unit referred to as a “weigh belt” or “weighbridge”. This weighing system uses load cells to sense the weight of material going into the dryer on the endless belt. This information is sent to the plant computer, which in turn, determines how much liquid asphalt binder is required to coat the heated aggregate and the amount of mineral filler required for the mixture.

The hot liquid asphalt binder is pumped from a storage tank and injected directly into the dryer-drum, coating the heated aggregates. Mineral filler, when used, will be injected into the dryer-drum directly after the hot asphalt to insure proper mixing, coating and consolidation. The plant computer controls the amount of asphalt binder based on mix percentages, weigh belt information and aggregate moisture information. Once the materials have been sufficiently mixed, the finished HMA material exits the dryer-drum onto a conveyor system, commonly referred to as a “slat conveyor” to transport the materials to a storage system, usually a surge bin or storage silo. This storage system allows the dryer-drum plant to run in a continuous operation.

In a batch plant, the weighing of aggregate materials is accomplished when the individual hot bin aggregates are deposited into a weigh hopper located directly below the hot bins. The weigh hopper collects the individually weighed “hot-bin” materials based upon the material proportions necessary to produce a batch of the desired mixture. The plant operator weighs each size of hot-bin material by means of bin gate controls operated manually or automatically. If needed, mineral filler is augured into the weigh hopper after the hot-bin aggregates have been weighed. As soon as all the aggregate material is weighed, the contents of the weigh hopper is discharged into a heated pug mill mixer located directly below the weigh hopper. After a short “dry” mixing time, which is needed to re-blend the dry aggregates, hot liquid asphalt binder is injected into the pug mill where it coats the aggregate material as the mixing process continues. Once mixed, the finished asphalt mixture is then dropped into a waiting truck or diverted into a surge of storage bin.

The hot liquid asphalt binder is pumped from a storage tank into a steam, electrical or hot oil heated weighing container, termed an "asphalt weigh bucket". The required amount of binder is weighed out at the same time as the weighing of the hot-bin aggregates. Instead of weighing the asphalt, it is sometimes measured by volume with automatic measuring devices installed in the lines or pumps that that can be calibrated to deliver the specified amount.

2. Cold Feed System

In order for an asphalt contractor to produce an acceptable and workable mixture that will hold up to the traffic demands of the roadway the materials will be placed upon, aggregate materials have to be blended to meet the correct proportions determined from the design process. In most cases, the aggregate volume will make up approximately 95% of the total volume of the asphalt mixture.

First, aggregate materials have to be controlled during the production process to insure the consistency of the gradations. Aggregate materials used in asphalt mixtures are required to be produced under the "Aggregate Control Gradation System" (AGCS). Once produced, the aggregate materials have to be transported and stockpiled correctly to further insure consistency of the material gradations using the proper stockpiling and handling methods required in the AGCS program. As the stockpiled aggregate materials are placed into the cold feeds, care has to be taken to avoid segregation, degradation and contamination of these materials.

Proper control the percentages of aggregate materials begin at the cold feed system of an asphalt plant.

Beginning of the Standard Specification Article 1102.01(a)(3)

"(3) Aggregate/RAP/RAS Bins and Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) used, in the proper proportions so that uniform production and uniform temperature will be obtained. A minimum of four bins and feeders for aggregate will be required. If RAP is used, one additional bin and feeder will be required for each RAP fraction used. If RAS is used, one additional bin and feeder will be required. The bins shall be designed to prevent overflow of material from one bin to another. If any of the materials used in preparing the mixture become intermixed in a bin compartment, the compartment shall be emptied and the intermixed material shall not be used. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the HMA production when any bin becomes empty. All feeders shall be calibrated to the desired volumes and/or weights for each material/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. The controls of the total quantity of combined materials fed to the dryer shall be by a variable speed system. Other methods may be approved by the Engineer. When the proportioning gates of the feeders are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer."

End of the Standard Specification Article 1102.01(a)(3)

Cold Feed System Types

There are three types of cold feed systems commonly used (see examples on page 2-5):

a) **Open Top Bins**: Open top bins usually have up to six compartments and are usually charged by end loaders, crane with a clamshell, or belt conveyor. The top of each bin shall have a divider, approximately 2.0 feet in height, between each compartment to keep the aggregate from spilling over into the next compartment.

   When charged with an end loader, the top of the compartment shall be at least 2 feet wider than the width of the end loader bucket.

   When charged with a crane, the bucket shall not be more than one half the minimum width of the top of the bin compartment. The maximum length of the bucket when fully open shall be at least one foot less than the length of the top of the bin compartment.

b) **Bunkers**: Bunkers are usually fed by trucks, car unloaders or bottom dump freight cars emptying directly into the bunker.

c) **Tunnel Systems**: Bulkheads separate Stockpiles over tunnel systems. Aggregates are usually stockpiled over the tunnel by end loaders, trucks or belt conveyors. Extra care should be taken not to cause segregation of the aggregate materials when belt conveyors are used to build stockpiles that will supply the cold feed system

When charging cold feed bins and tunnel systems with a front end loader, the loader should stay off the stockpile as much as possible. The weight of the loader will cause potential degradation of the materials and vibration from the loader can cause fines to filter down to the bottom of the stockpile. The end loader operator should work the stockpile so the material fed to the plant will be uniform. The end loader operator should keep the bins above one-half full to insure a uniform feed.

Each bin should have a variable speed feeder under it that can be adjusted from the control panel and a master control switch that will speed up or slow down all of the feeders at the same time.

Open Top Bin Systems

Bunker system

Tunnel Systems

Feeder Types

There are several types of feeders: reciprocating plate, vibratory, apron feeder and continuous belt types. Continuous belt feeders are the most common units used by the HMA industry and are what will be referred to in this manual. The feeders should be located beneath the bins in such a manner as to insure a uniform flow of aggregate to a belt that carries the aggregate to the cold feed elevator.

Improperly adjusted cold feeders may cause the following:

a) A sudden increase/decrease of cold or wet material may cause a considerable change of temperature in the aggregate leaving the dryer.

b) A sudden increase in the cold feed can overload the screens (batch plant), creating a carryover of the fine aggregate into coarse aggregate hot bins and ruin the screening efficiency of the screen deck.

c) Erratic feeding may cause some hot bins (batch plant) to overfill while starving others. In addition:

    1) Layers of variable grading in the hot bins can lead to alternating coarse and fine batches.

    2) The dust collection system may become overloaded.

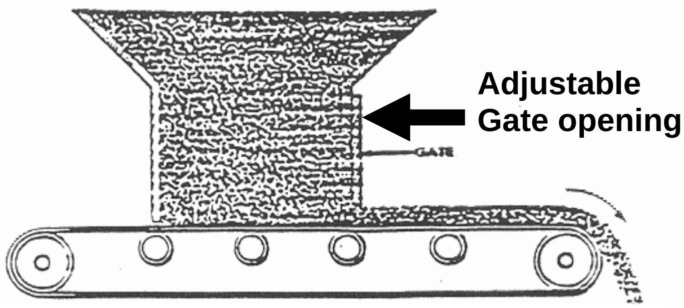
    3) It may reduce draft air.

Cold Feed Calibrations

Control of HMA begins with the gradation and controlling the proper amounts of coarse and fine aggregates going into the mixture. The Quality Control Manager and/or Level 2 HMA technician is required to control the material on the #4 and #8 sieves to meet the mix design requirements (this is the breaking point of the fine and coarse aggregate materials in the combined gradation). This involves proper proportioning of the aggregate materials entering the plant at the cold feeds. With a dryer-drum plant, this is the only place to control the combined gradation. While a batch plant can be proportioned at the hot bins or cold feeds, wasting of expensive aggregate materials will probably result of unbalanced cold feeds if relying solely on the hot bins. To establish proportioning control, specifications require the Contractor /Producer to calibrate the cold feed system before producing HMA from either type of plant to ensure the proper proportions of ingredients.

The Contractor/Producer is required to provide documentation of the rate of materials coming from the cold feeds established when calibrating the cold feeds. During the calibration process the Contractor/Producer will document the weighing, testing and plotting of the appropriate gate and motor speed settings of all the feeders and furnish a copy of the documentation to the Engineer upon request. Once calibrated, it shall be the responsibility of the Contractor/Producer to see that the required gate openings and feeder settings are maintained when production begins.

The Quality Control Manager and/or Level 2 HMA technician shall observe that the setting of the gates and feeders will produce the required percentage of each material in accordance with the preliminary proportions determined by the method described in Chapter 4, "Blending Aggregates" of this manual. This is not difficult in the case of the belt feeders, since the amounts delivered are roughly proportional to the gate openings. The reciprocating and vibrating type feeders are more difficult to set because the amount fed through a given gate varies with the gradation and moisture content of the aggregate (wet sand feeds slower than dry sand and the fine material feeds slower than coarse).



Continuous Belt Feeder
Most common feeder used in the industry

Note that the first setting of the cold feeds is only approximate and adjustments might have to be made to meet mixture specification compliance. The adjustments, to obtain accurate plant settings, must be made after the start of production and is based on the results of sieve analysis’s of a combined belt sample (dryer-drum) or hot-bin samples (batch plant). Adjustments are usually necessary to meet required mixture proportions and, in the case of batch plants, obtain and maintain proper levels of the hot-bins. These adjustments are also used to control the approximate total quantity of material fed through the dryer.

When material from the cold feed gates is discharged onto a belt conveyor, the individual cold feed output may be checked by shutting down all feeders except one. The feeder to be checked is then set to a predetermined calibration point. The cold feeder being calibrated is filled to normal operating level with the material to be run with during production. The plant is started and brought to normal operating speed.

There are two methods normally used to calibrate cold feeds:

a) The first method involves measuring the amount of material discharged from a cold feeder during a predetermined time at a predetermined feeder speed with a predetermined feeder gate opening.

   This process involves diverting all the material coming from the feeder at the set time, speed and gate opening into a tared truck. At the end of the predetermined time, the feeder is shut down and all remaining material on the conveyor belt continues to be diverted into the tared truck. Once the conveyor belt(s) is clear of material, the truck is weighed in order to determine a net weight of material obtained during the calibration process. Calculations are then performed to determine the amount of material delivered by the feeder, expressed in “Dry Tons per Hour”. These calculations will be covered later in this chapter.

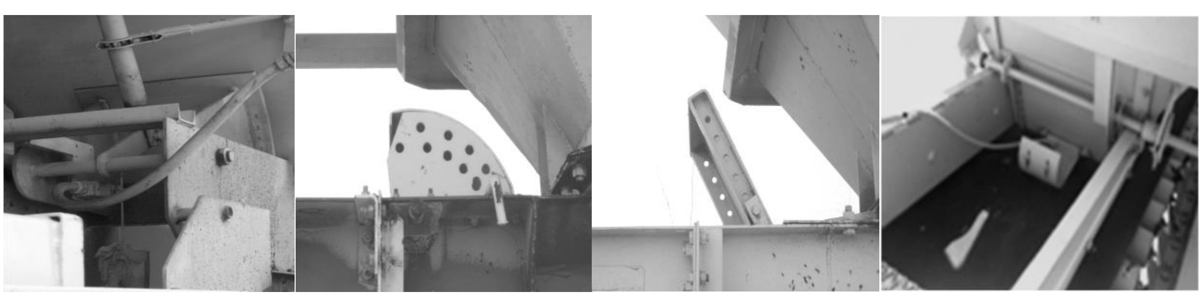
b) The second method involves removing material from a measured distance on a conveyor belt. Once the plant is stopped the material, including the fines, is removed and weighed. The weight of material, divided by the length in feet of the belt section, multiplied by the belt speed in feet per minute, will give the amount of material delivered per minute from that gate opening.

With either method, each material and feeder used, with the appropriate gate opening and settings, will be determined in the same manner and the results are plotted. Each individual aggregate material, in each feeder used, at each gate opening is required to be calibrated with either method. This data is plotted to provide information needed to establish preliminary plant settings and will be used to check material proportions during production.

Gates that feed coarse aggregate should not be set at less than 1-1/2 to 2 times the largest aggregate size to prevent clogging of the opening. For example, if a gate is feeding aggregate with 1-inch maximum size, the gate should not be set at less than 1-1/2 or 2 inches. In most cases, gate openings are set wide open to allow maximum production but sometimes it may be necessary to restrict the opening width to limit or provide better control of materials. This is especially true when mixture ingredients amount to a small percentage of the total volume of mix being produced.

Once the calibrations are established and production settings implemented into the plant, it is important that the cold feed settings are not changed. If the cold feed gate openings or feeder settings are changed or modified, changes in the ingredient percentages will result which will affect mix properties, such as air voids, density and binder content. This could also cause specification limits to be exceeded resulting in unacceptable material being produced. It will be the responsibility of the Quality Control Manager and/or Level 2 HMA technician to verify the proper setting of each aggregate feeder. The plant operator shall be limited to using only the master control to increase or decrease the amount of material being fed into the dryer. The plant operator should contact the Quality Control Manager and/or Level 2 HMA technician to determine what adjustments need to be made if problems arise.

A calibration of each feeder and each material being fed through a particular feeder is required for production of HMA to insure the proper proportions of ingredients are incorporated into the mixture. This would include any coarse aggregates, fine aggregates, and RAP or RAS materials. All plant units shall be operated so that they will function properly and produce HMA mixtures having uniform temperatures and mix characteristics and properly calibrated cold feeds will help to insure this is met. The cold feeder and the dryer control shall have a workman specifically assigned to these operations if uniform results are not obtained.



Different gate opening controls

Cold Feed Calibration Example

Feeder	Material	Gate Setting	Truck Tare	% Moisture	Date	Insp.
#1	FM-02	6-Hole	17680	6.6%	3-6-15	RW

Time (min)	FPM/RPM	Ave FPM/RPM	Gross Wt. (lbs.)	Net Wt. (lbs.)	Ave Net Wt. (lbs.)	Ave Wet TPH	Ave Dry TPH
6	10.4	10.5	22280	4600	4700	23.5	22.0
6	10.6		22480	4800			
6	10.5		22380	4700			
3	24.3	24.3	22820	5140	5100		
3	24.1		22740	5050			
3	24.5		22790	5110			
3	37.0	37.0	25760	8080	8060		
3	37.0		25740	8060			
3	37.1		25720	8040			

Ave Wet TPH Formula: $\frac{\text{Ave Net Wt (lbs)}}{\text{Time (min)}} \times 0.03 = $ **Ave Wet TPH**

(0.03 is a constant factor that converts lbs/min to ton/hour)

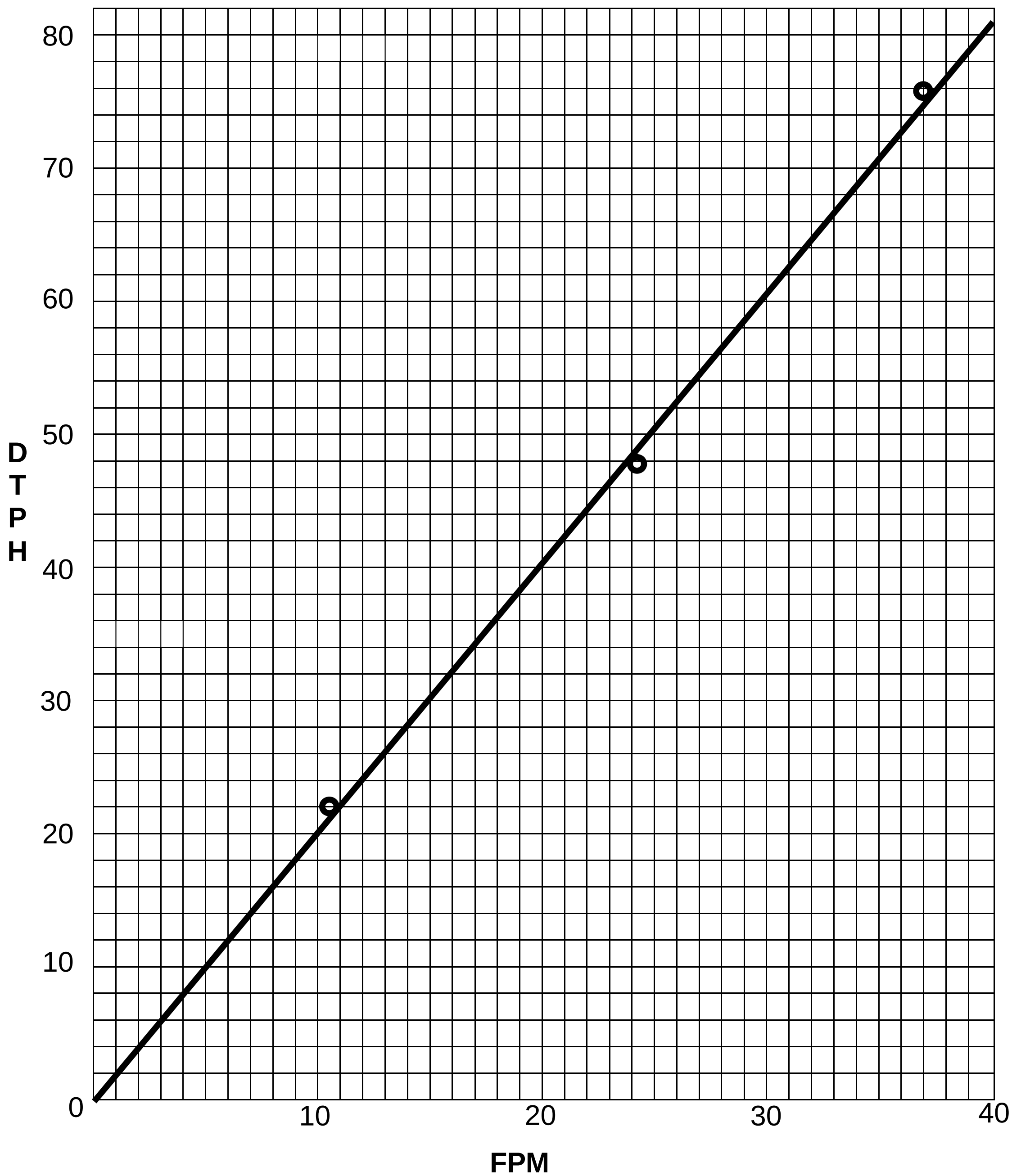
Example: $\frac{4700}{6} \times 0.03 = $ **23.5 Wet TPH**

Ave Dry TPH Formula: $\frac{\text{Ave Wet TPH}}{1 + \left(\frac{\text{\% Moisture}}{100}\right)} = $ **Ave Dry TPH**

Example: $\frac{23.5}{1 + \left(\frac{6.6}{100}\right)} = \frac{23.5}{1 + 0.066} = \frac{23.5}{1.066} = $ **22.0 Dry TPH**

Mattoon Plant 912-01 Feeder #1 @ 6-hole FM-02 @ 6.6% Moisture

Dry Tons per Hour (DTPH) / Feet per Minute (FPM)



3. <u>Cold Elevator</u>

Cold elevators systems deliver aggregates from the cold feeds into the dryer by way of continuous belt conveyor systems. The cold elevator will usually employ a scalping screen to remove foreign or oversize material. This is important for the dryer-drum plant since this typically is the only screening of the aggregate materials.

Dryer-drum Plant Cold Elevator Conveyor

Batch Plant Cold Elevator

The dryer-drum plant employs a weigh bridge on the cold elevator conveyor which senses the weight of material passing into the dryer which in turn signals the correct amount of liquid asphalt binder for the mixture. This weighing process employs a load-bearing system, usually load cells, to determine the weight of aggregate. The weigh bridge, like any weighing device used to produce materials paid by weight, has to be calibrated to ensure proper operation (this subject will be discussed later in this chapter). Once calibrated, the weigh bridge can be used to calibrate the cold feeds. This will greatly speed up the calibration process since the aggregate material does not have to be loaded into a truck to be weighed as described in the previous section on calibrating cold feeds.

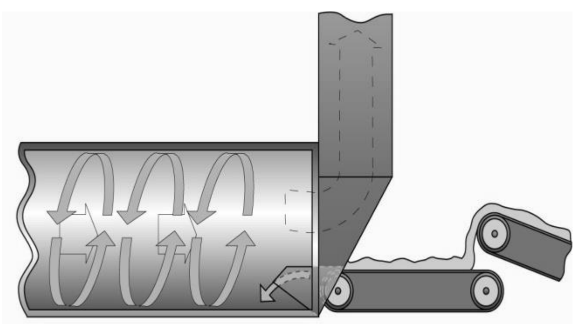
Dryer-Drum Cold Elevator Scalping Screen

Weigh Bridge

Another important part of the cold elevator for a dryer-drum plant is a diversion chute usually located just before the aggregates enter the dryer. This diversion chute serves three main purposes: a means to sample the combined aggregates to determine compliance with the established gradation targets for the mixture, to divert and catch material run through a cold feed during the cold feed calibration process and to empty the feed belts when changing mixtures.

Dryer-drum Diversion Chutes

On a batch plant, the cold elevator is normally used just to transport the aggregates from the cold feed system into the dryer. Since a batch plant will screen the hot aggregates into hot bins, where the gradation sampling takes place, a diversion chute is not needed. Some manufacturers will place a diversion chute to catching material during the cold feed calibration process or cleaning off the conveyor belt when switching mixtures. Other manufacturers will use slinger belts to divert the aggregates before they enter the dryer. Some manufacturers design their plant with a scalping screen at the aggregate's point of entry into the dryer, which is blocked to divert the materials from entering the dryer.



Batch Plant Slinger Belt, Scalping Screen and Scalping Material Diverter

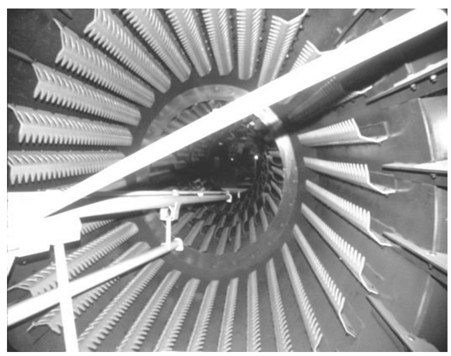
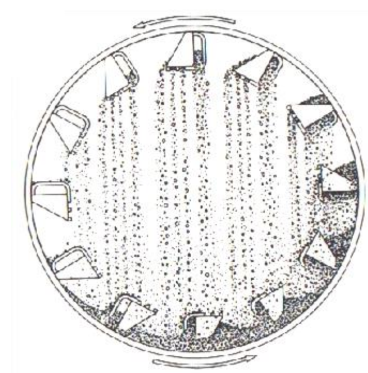
4. Dryer

The dryer is a revolving cylinder, usually from 3 to 12 feet in diameter and from 20 to 60 feet in length, in which aggregate is dried and heated by an oil, coal or gas burner. The cylinder is equipped with longitudinal cups, or channels, called "lifting flights", which lift the aggregate and drop it in veils through the burner flame and hot gases. The slope of the cylinder, its speed, diameter and the arrangement and number of lifting flights control the length of time required for the aggregate to pass through the dryer. The dryer drum is sloped to allow gravity and the flighting arrangement to pull the aggregates through while heating and drying the aggregates. The slope and flighting arrangement will then influence the speed of the aggregates through the dryer affecting the heating and drying potential, segregation and coating of the aggregates with the liquid asphalt binder (dryer-drum).

Beginning of the Standard Specification Article 1102.01(a)(1) 2nd paragraph

"(1)… For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general not vary more than 20 °F (10 °C) for each mix type being produced. In all cases, the mix temperature shall not be more than 350 °F (180 °C) or less than 250 °F (120 °C). Wide variations in the mixture temperature of successive loads may be cause for rejection of the HMA.

End of the Standard Specification Article 1102.01(a)(1) 2nd paragraph

Dryer Lifting Flights Aggregate Veil


Burner Units

The dryer performs two main functions:

a) Heats the aggregates to insure proper coating of the liquid asphalt binder

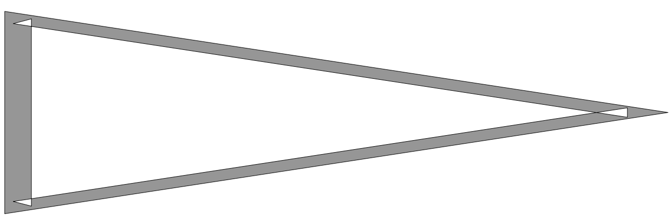
b) Removes moisture from the aggregate, which:

1) The heat of the dryer vaporizes the surface and internal moisture.

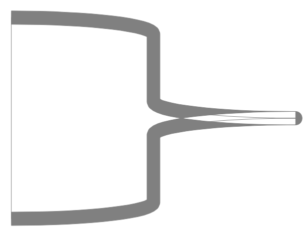
2) The vapor is drawn off by the draft air.

The temperature of the dryer is controlled by the amount of fresh air and amount of fuel. These two factors, along with the type of burner used, must be in balance with the potential drying capacity of the dryer to provide the necessary amount of heat and still maintain efficient combustion performance.

Burners of the same combustion efficiency have different burning characteristics. Some burners produce a "long controlled flame" which reaches far into the dryer. Other burners tend to produce a fine dispersal of fuel at the nozzle end and, therefore, quick combustion. If the flame is of the "blossom" type, with the heat concentrated close to the burner



Long Controlled Flame



Blossom Flame

Crowding more material through the dryer than it can properly handle causes most problems that arise in dryer operation. However, there are other factors that will affect efficient dryer operation. Several of these factors involve the proper operation of the burner. If the blower air, draft air, and amount of fuel oil are not in balanced adjustment, it may cause incomplete combustion of the fuel, possibly leaving an oily coating on the aggregate particles that are harmful to the finished mixture. Lack of balance between the blower air and the draft air also can create backpressure within the dryer, causing "puff back" at the burner end of the dryer. "Puff back" indicates that the draft is not sufficient to accommodate the air pressure being introduced by the burner blower.

Most dryers are designed for average aggregate moisture content, usually 5%. Very wet aggregate will reduce the dryer capacity and require corrective measures:

a) Increase the amount of heat by burning more fuel while the flow of aggregate remains constant.

b) Reducing the aggregate flow.

There is a limit to the amount of potential heat available and beyond that limit the rate of aggregate flow must be reduced to insure proper drying and heating of the aggregate materials.

The following table demonstrates the effect of moisture has on production levels.

Aggregate TPH vs. % Moisture
(Drum Diameter & Length vs. % Surface Moisture Removed = TPH)

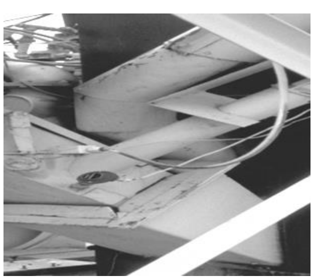
Drum size	2%	3%	4%	5%	6%	7%	8%	9%	10%
5' x 22'	178	140	116	100	84	79	74	63	58
6' x 24'	278	220	178	158	137	121	116	100	89
7' x 30'	420	336	273	236	205	184	163	147	137
8' x 32'	541	430	352	305	263	236	210	194	173
9' x 36'	719	578	478	410	357	315	284	257	236
10' x 40'	956	761	630	541	473	430	378	341	315

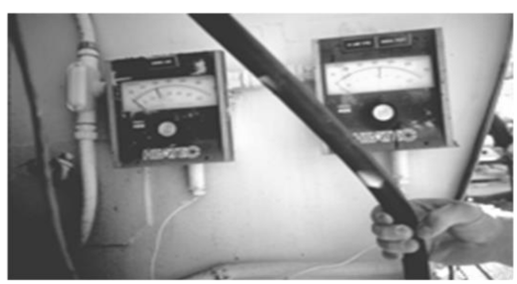
Aggregates with highly absorptive characteristics may require longer drying periods. This can be accomplished by reducing the incline (slope) of the dryer, by rearranging the dryer lifting flights or slowing of production. By increasing the dryer time, this will remove more moisture than increasing the heat. Double drying is another option on some aggregate materials, such as air cooled blast-furnace slag. The dryer will not remove all of the absorbed moisture out of the aggregate but will only heat the aggregate and surface dry it. The still retained absorbed moisture, referred to as “residual moisture”, will come out of the aggregate in the lag time it takes the material to travel from the dryer to the pug mill if heated properly.

Too much residual moisture could come out after the aggregates have been coated with the liquid asphalt binder, which can cause a washing effect by removing (washing) the liquid asphalt binder from the aggregate while in transportation. This can be referred to as “drained down” which is evidenced by pooling of the liquid asphalt binder on the truck bed. Another issue with too much aggregate moisture is that some mixes can inherit tenderness characteristics which can be evidenced but unwanted moving or shoving of the mix during the compaction process.

Because of this, specifications state the amount of residual moisture will not exceed 0.3% in the dried aggregate. This is determined by running moisture samples at the plant. The specifications will also specify the temperature range of the aggregate for mixing. These specifications can vary with the type of mix and asphalt being used. Generally, moisture requirements will be met whenever a steady temperature is maintained.

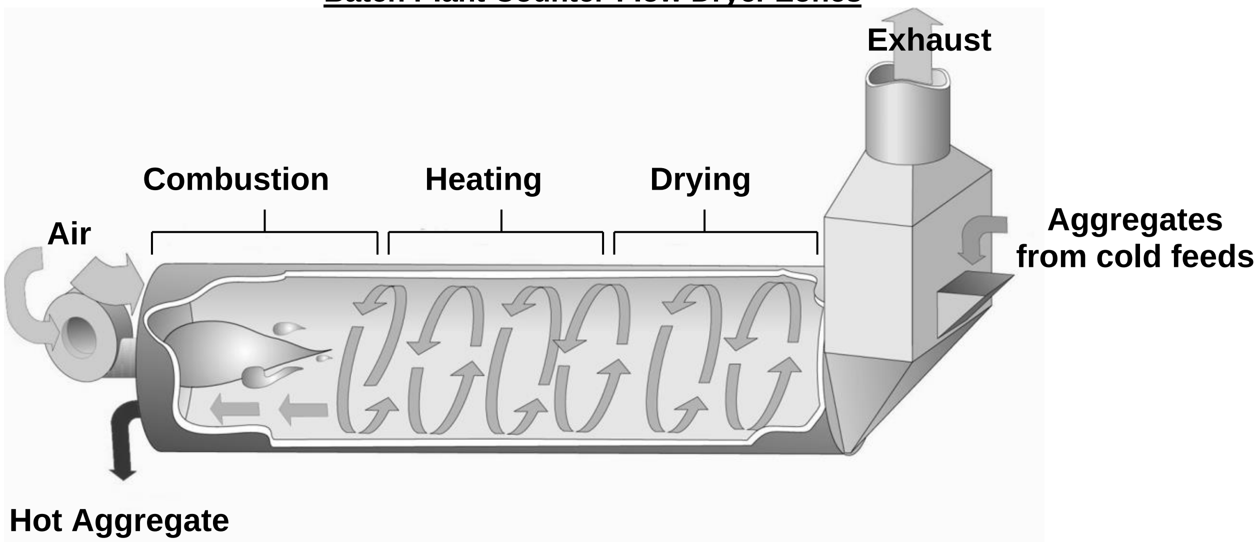
Either a recording thermometer or a recording pyrometer having at least two terminals that measures aggregate temperature is required for asphalt plants. The latter has a much faster reaction speed to changes in temperature and hence is more desirable.



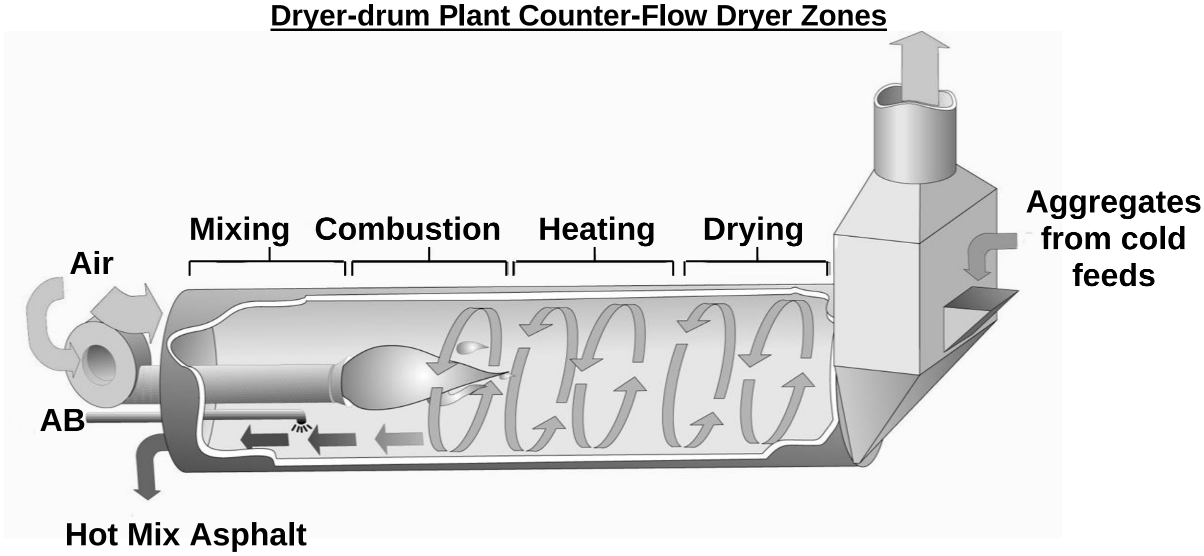


Plant Temperature Controls

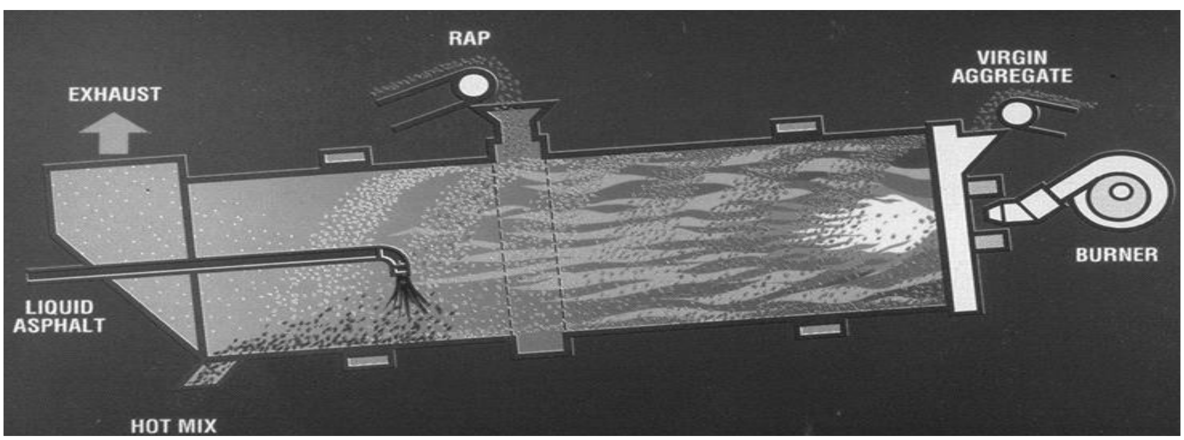
Batch Plant Counter-Flow Dryer Zones



Dryer-drum Plant Counter-Flow Dryer Zones



Dryer-drum Plant Parallel-Flow Dryer Zones



5. Dust Collection

Aggregate products used in HMA mixtures will naturally include a certain percentage of dust or dust will be generated through shipping and handling of the material through a process called degradation. This 'dust' will range in size from around #16 size particles to less than #200 size particles, commonly referred to as "minus 200 material". Dust is a critical component of an asphalt mixture. It is needed to create friction in the mastic (glue) to help hold the mixture together and as a filler of void spaces in the mixture. Too much dust can have a detrimental effect on the finished roadway causing the mixture to move or deform under traffic. This causes a dangerous situation called "rutting" where the HMA material, especially in the wheel lane areas of the pavement, can distort and shove outward resulting in channeling of the pavement that can hold water. Another result of too much dust is the undesirable movement of the mixture during placement (referred to as "shoving") because the excess dust will take on a characteristic similar to a liquid providing excessive lubrication which causes slippage of the aggregate particles. It is imperative that the amount of dust in the mixture be controlled to achieve the proper results. In order for asphalt plants to control the dust in the mix, plants have to be outfitted with proper equipment to manage dust.

The dust collection equipment then is an integral part of the asphalt plant because of the part it plays in providing an even flow of adequate air volume through the plant, the retrieval of the dust and removal of moisture laden air. It is important that a proper balance be achieved between the airflow necessary for optimum drying performance and that which will permit proper dust control. Plants demonstrating problems with dust control will be required to upgrade with a system referred to as PDCE or positive dust control equipment which requires all dust to be accurately weighed to an accuracy of 0.50% of the actual weight of dust material being put into the mixture.

There are two types or sizes of dust created during the production of HMA. A coarse dust called "primary dust" with particle sizes generally ranging between the #16 and #200 sieves with a small amount of minus #200 material. A finer dust, referred to as "secondary dust" or "mineral filler", has particle sizes ranging between the #50 to minus #200. Because of the apparent differences in the gradations of the dust materials it is important that they are stored and handled separately and kept from any intermingling. The two systems used in HMA production for dust control are the primary and secondary dust collectors.

Beginning of the Standard Specification Article 1102.01(a)(4) in part

"(4) Dust Collection. The plant shall be equipped with a primary dust collector, approved by the Engineer, connected to a secondary dust collector (baghouse or wet-wash)…"

End of the Standard Specification Article 1102.01(a)(4) in part

Primary Dust Collector

The purpose of the primary collector is to 'collect' the dust particles being carried by the airflow from the dryer. As the aggregates pass through the dryer, the exhaust gases (airflow) will carry the suspended dust thru ductwork into the primary dust collector. Working properly, the dust collection equipment will collect and return a portion of the fine aggregate back into the mix.

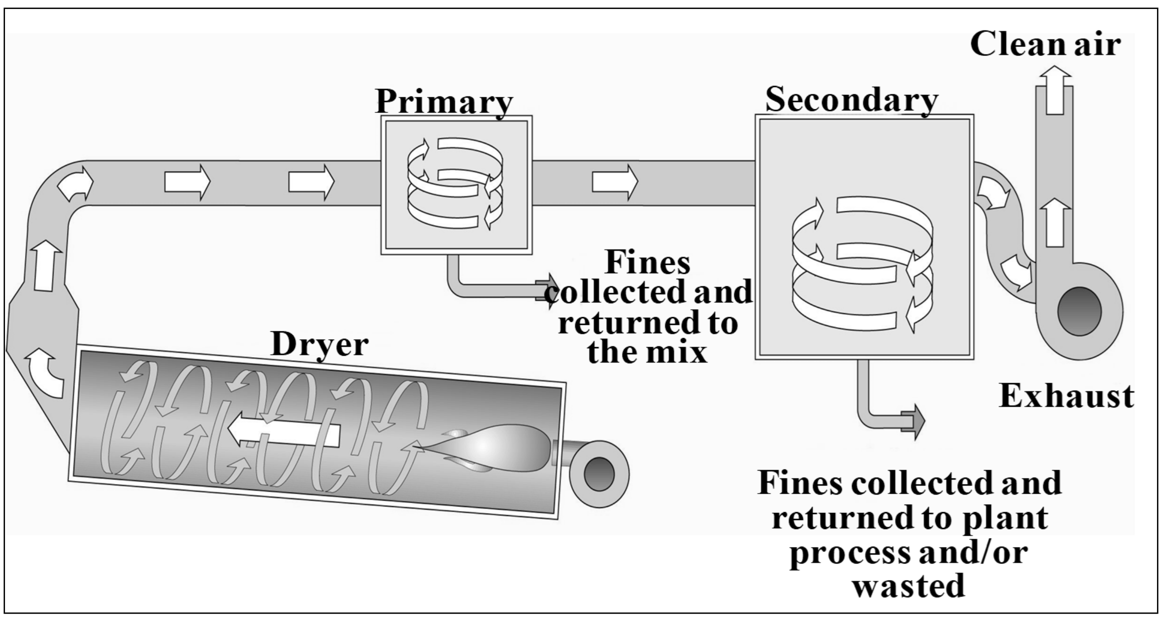
Many factors affect the efficiency of a dust collector, e.g. particle size and shape, gradation of fines, size and proportion of the collectors. Proper operational procedures are needed to prevent condensation in the dust collector so the system needs to keep the air temperatures above the dew point to avoid condensation. Any condensation or moisture can affect the proper removal of dust or cause slowing of the airflow which will influence the efficiency of the dust removal and/or plant production rates.

On start-up, it usually helps to preheat the air system slightly before beginning production. After starting, normal good dryer operating procedures will usually insure trouble-free operation; however, when operating in unusually low temperatures, it is sometimes helpful to insulate the dust collector housing.

The primary dust collector is not designed to pull a 100% of the dust out of the air flow. Most primary collectors will work in a 70% to 93% efficiency range. The remaining finer dust will stay in suspension and be carried to the secondary collector system, either a baghouse, or wet washer.

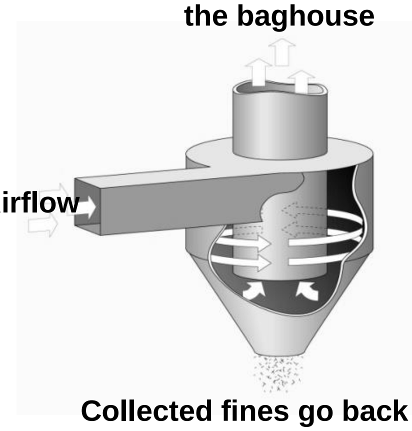
<u>Cyclone Dust Collector</u>

The cyclone collector uses a centrifugal force or cyclonic wind action to remove the larger dust particles from the air flow from the dryer. In the cyclone collector, the dust-laden air is forced into a whirling motion. The heavier dust particles in the exhaust gas stream are separated by centrifugal force against the collector shell and are carried to the lower outlet.



Cyclone Dust Collection System

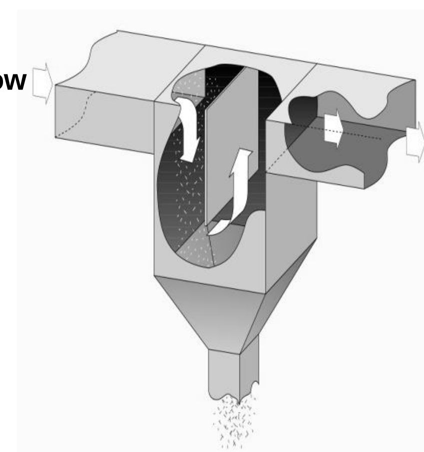
Cyclone Primary Dust Collector



Knockout Dust Collector

Knock out boxes, or sometimes called skimmers, are a part of the dryer ductwork and operate by slowing the air flow down thus allowing the heavier dust particles to drop out of suspension from the air flow commonly referred to as ‘knocking’ the dust out of the air.

Dryer-drum Knockout Box



Secondary Dust Collector

The purpose of the secondary dust collector is to remove any fines or dust that wasn’t removed in the primary collector. The secondary dust collector serves two main purposes;

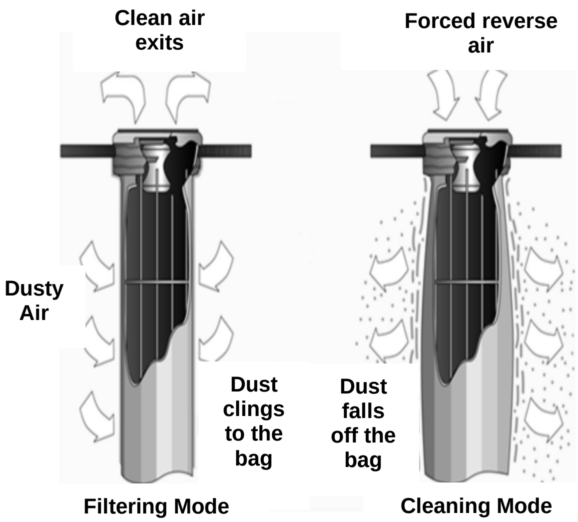
a) To filter out the minute dust particulate matter from the exhaust air so that it won’t be expelled into the environment.

b) To reclaim and allow for storage of the minus #200 dust materials for incorporation back into the HMA mixture, if needed.

There are two types of secondary dust collectors that are typically used on an asphalt plant, the wet-wash and the baghouse. Because of stringent pollution requirements and the importance of accurate dust control for HMA mixes, baghouse collectors are being used instead of the wet-wash systems today.

The operation of a baghouse is relatively simple; air flow is generated by a large blower fan which brings dust-laden air from the primary dust collector into the baghouse. This dust-laden air then passes through filter bags where the dust collects on the outer surface. The dust is removed from the filter bags by shaking, pulsing, or air reversal periodically and collected in a hopper or silo where it can then be fed back into the mix as filler. The dust collected from the baghouse is required to be discharged directly into a separate hopper or silo for temporary storage and/or distribution back into the mixture. But in no case will intermingling of primary and secondary dust in the same hopper or silo be permitted.

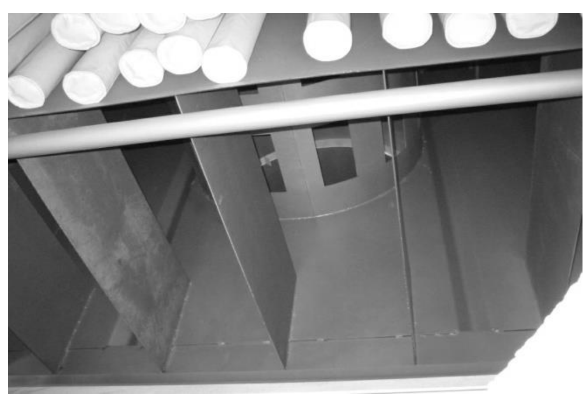
The requirement for a primary dust collector may be waived, provided that the baghouse is equipped internally with a "knock-out box" capable of performing the same function as a primary collector.



Cleaning of the filter bags

Inside a Baghouse

Baghouse



Baghouse Knock-out Box

A wet-wash secondary dust collector works on the principle of ‘wetting’ the dust particles once the air has traveled through a primary dust collector and then flushing the fines and water into a holding pond. This process has a wide range of variability which makes it hard to control the dust with this type of system.

Wet-wash Dust Collectors

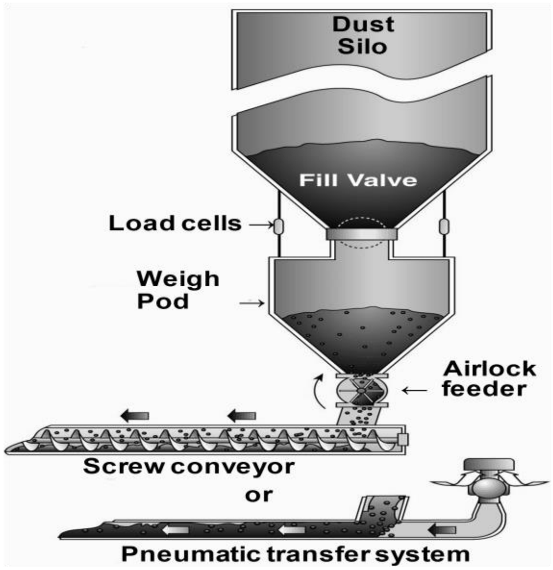
Proper operation of the dust removal system is important with an asphalt plant. Any change in the volume of air going through the baghouse will affect the amount of -#200 material collected by the primary dust collection system. The banks of dust bags in a baghouse will have a set cleaning sequence to prevent segregation in the baghouse.

Also as moisture in the stockpiled aggregate increases and in the baghouse increases, the volume of air getting through the bags in the baghouse will decrease. This is because the bags will become plugged and the damp dust can’t be removed as efficiently. Once the bags become plugged the air flow through the plant is slowed making the primary dust collector more efficient. This extra efficiency will allow more of the #50 thru the #200 material and minus #200 material to be collected in the primary collector and be returned to the mixture. When this happens, the minus #200 material will increase in the mixture and greatly affect the air voids and density of the mixture. The ratio of dust to air voids in an asphalt mix is usually 1:1, so for a one percent increase in dust it is expected that the mix will lose one percent in air voids. As discussed earlier, an increase of dust in an asphalt mix can lead to tenderness, unwanted movement and rutting of the mixture on the roadway. If the stockpiled aggregates become saturated due to heavy rains then the plant will probably need to slow production down in order to effectively remove the excess moisture that will be encountered during production.

Mineral Filler and Dust Collection Feed Systems

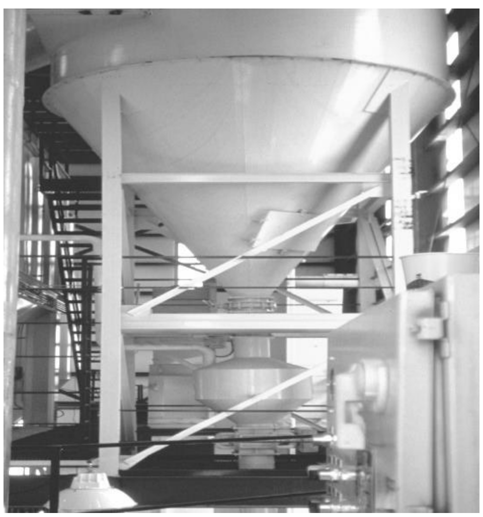
The collected primary and secondary dust material are two completely different gradations of materials and are required to be stored separately and kept from intermingling. The primary dust is identified as a coarser grained material with the grain size ranging from approximately the #16 down to minus 200 material with the majority size being between the #30 and above the #200 sieve. Secondary dust is a lighter and finer sized dust which will register around 80 to 90 percent passing the #200 sieve. Newer plants will use weigh-pods which help to accurately measure and control the amount of dust material being put back into the mixture.

Not all dust generated in an HMA plant will be used and, in certain cases, excessive amounts need to be wasted or transferred to another plant for use.

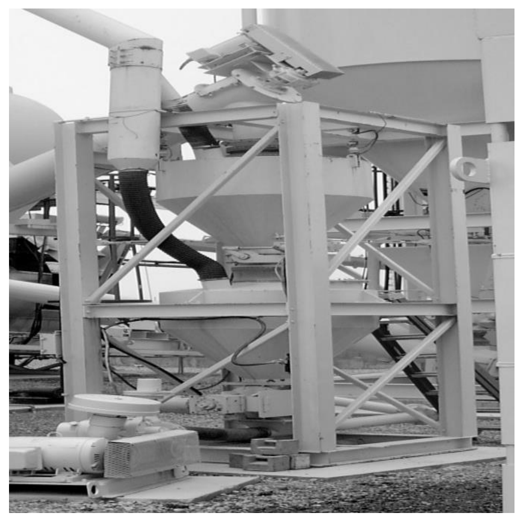


Weigh Pod System

Dust storage tanks w/weigh pod



Single Weigh-pod System



Dual Weigh-pod System

6. Surge/Storage Bins

In order to for asphalt plants to run continuously (dryer-drum) or to increase production (batch) most producers will employ the use of a HMA storage system. Two common systems used are surge bins and storage silos. A surge bin is a temporary storage usually holding 30 to 50 tons of mixture. This temporary storage creates a cushion for the plant to continue running while waiting for trucks since a dryer-drum plant is not designed to start and stop. Storage bins are designed to hold materials for up to 20 hours, with approval, and will hold 100 plus tons. These components are discussed in greater detail in Chapter 3 of this manual.

<u>Beginning of the Standard Specification Article 1102.01(a)(5) in part</u>

"(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix…"

"…No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant…"

<u>End of the Standard Specification Article 1102.01(a)(5) in part</u>

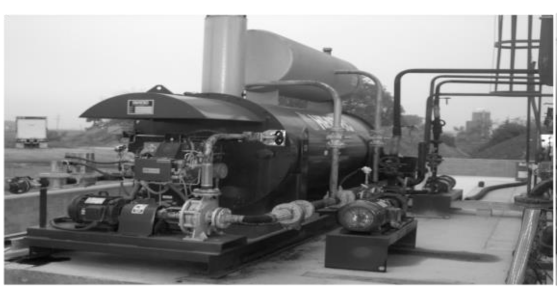
Storage Silos

Surge Bin

7. <u>Storage for Liquid Asphalt Binder</u>

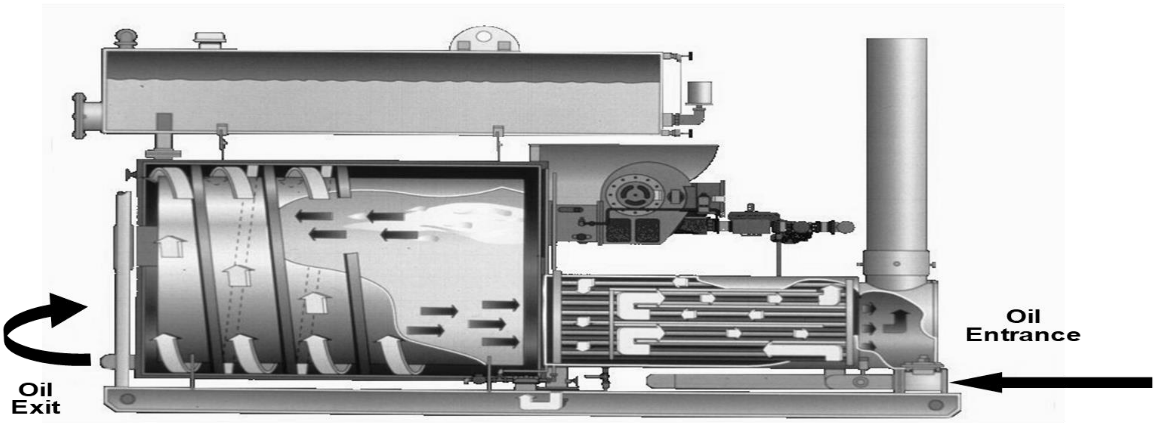
Due to the quantities of liquid asphalt binders needed to produce HMA mixes, the liquid asphalt binders need to be stored on site at an asphalt plant. Storage is in large cylindrical tanks positioned vertically or horizontally. While asphalt plants will still use horizontal storage tanks, the vertical tanks tend to be more efficient. The vertical storage tanks are reported to heat and mix the liquid asphalt binder more efficiently by taking advantage to the natural rise and fall caused by hot and cold liquid materials, respectively (heated materials will naturally rise while the cooler materials will fall).

Heaters are used to heat circulated liquid asphalt binder to keep it at the proper temperature for incorporation into a mix.



Hot Oil Heater

Unloading of an AB tanker



Liquid Asphalt Binder Heating System

To insure the correct liquid asphalt binder is being used, the storage tanks are required to be identified properly. Also, each different type or grade of liquid asphalt binder material will be stored in separate tanks to prevent intermingling of different grades materials.

<u>Beginning of the Standard Specification Article 1102.01(a)(6) in part</u>

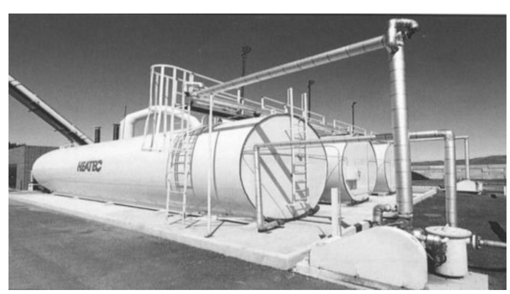
"(6) Storage Tanks for Asphalt Binders. Tanks for the storage of asphalt binder shall be clearly and uniquely identified, and equipped to heat and hold the material at the required temperatures..... An armored thermometer or pyrometer which will accurately show temperatures between 200 and 400 °F (95 and 205 °C) shall be suitably located in the asphalt binder line or within the tank. The instrument shall be located so as to indicate to the plant personnel, the temperature of the asphalt binder."

<u>End of the Standard Specification Article 1102.01(a)(6) in part</u>

Liquid asphalt binder is normally transported to the plant by tank truck or on rail (if rail service is available). The temperature range of the liquid asphalt binder should be from 250° F to 350° F for HMA mixtures and shall not be unloaded if above 350° F.

With temperatures above 350° F, important volatiles will be damaged or cooked off resulting in poor performance of the 'glue' used to hold the HMA mixture together. This is true for most all liquid asphalt binders except the newer polymer binder materials now being used. For the new polymer binders, refer to manufacture recommendations for heating temperatures and methods.

Vertical Storage Tanks



Horizontal Storage Tanks

8. Anti-Strip Additives

An anti-strip additive is a product added to HMA mixture to help increase to cohesiveness or bonding of the liquid asphalt binder to the aggregate material of the mixture. Once the bond is lost between the aggregate and liquid asphalt binder, the mixture will start to unravel which will lead to potholes and shortened pavement life. Determination of whether the anti-strip additive is needed is established by running the Tensile Strength test (TSR) during the mix design process. Currently there are two forms of anti-strip additives that may be used; a liquid additive and hydrated lime. Contract specifications for the job and mix design results will control the rate and type of anti-strip additive that is required to be used.

Beginning of the Standard Specification Article 1102.01(a)(8) in part

"(8) Equipment for Anti-Strip Additives. When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt binder by means of an approved in-line blending system located between the plant supply tank and distribution on the heated aggregate.".....“When lime is used as the anti-stripping additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate..."

End of the Standard Specification Article 1102.01(a)(8) in part

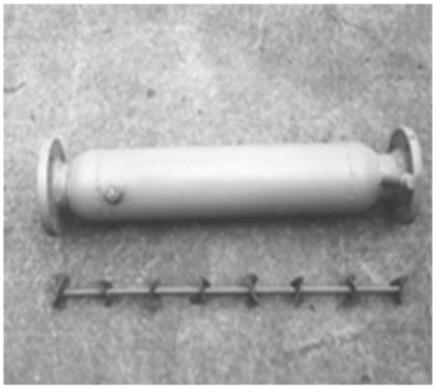
Effects of Liquid Asphalt Binder Stripping

The two forms of anti-strip additives are currently being used in Illinois at this time, liquid and dry hydrated lime.

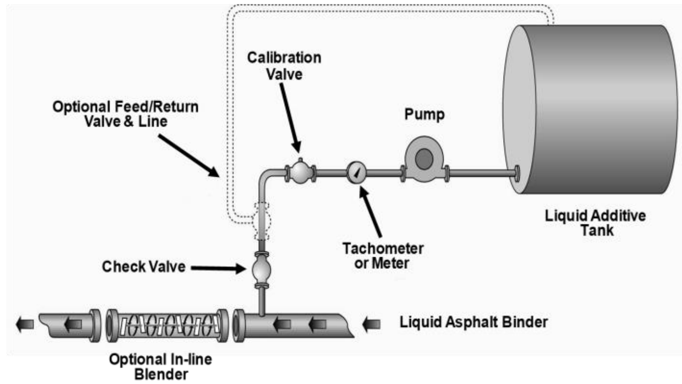
a) Liquid anti-strip additive. There are a couple of ways liquid additives can be added.

1) The additive may be added by means of a dispensing unit and inline blender. The dispensing unit and inline blender shall be capable of controlling the introduction of the additive into the liquid asphalt binder within ± 10% of the amount specified or required. The inline blender should be located as close to the weigh bucket or spray bar as possible.

2) The correct amount of liquid anti-strip additive may be added to the liquid asphalt binder as it is unloaded into a storage tank at the plant if the proper equipment is used (such as an inline blender and variable speed anti-strip pump in combination with a known amount of liquid asphalt binder being pumped from the transport).



Inline Blender Unit



Anti-strip Delivery Unit

b) Hydrated lime or slaked quicklime may be used in place of a liquid additive. There are three methods used when hydrated lime is employed as an anti-strip additive:

1) Hydrated lime is mixed with water to create a slurry. A pugmill is then used to coat the aggregates with this slurry. The aggregates are then sent to the dryer where the coating is baked onto the aggregates as they move through the dryer.

2) Dry hydrated lime can be applied to damp aggregates in a pugmill prior to introducing the aggregates into the dryer (no slurry).

3) With a Dryer-drum plant, the hydrated lime can be injected onto the hot aggregates prior to adding the liquid asphalt binder. Equipment used in this method is similar to the secondary dust equipment using weigh pods or a metering system.

   With a batch plant, the hydrated lime will be added into the weigh hopper during the batching process or using a method approved by the Engineer.

This dried-on coating will create a better bond between the liquid asphalt binder and the aggregates.

9. <u>RAP and/or RAS Equipment</u>

RAP is an acronym for ‘Reclaimed Asphalt Pavement’ and is created during the cold milling process when HMA has reached the limits of its life on the road. Roadways are milled to remove or profile the driving surface to create a level stable base on which the new material will be placed. When RAP is used, it is limited to the cold millings removed from roadways or airfields maintained under federal, state or local agency jurisdiction to insure the quality of materials.

RAS is an acronym for ‘Recycled Asphalt Shingles’. RAS is available from two sources:

a) The waste generated at an asphalt shingle manufacturing facility

b) The waste generated from the tear-off during roof replacement.

Both of these products contain recyclable materials that can replace some of the ‘virgin’ materials used in HMA. In turn, this will reduce production costs, reduce the demand for the production of new materials and is beneficial to the environment by keeping these materials out of the landfills.

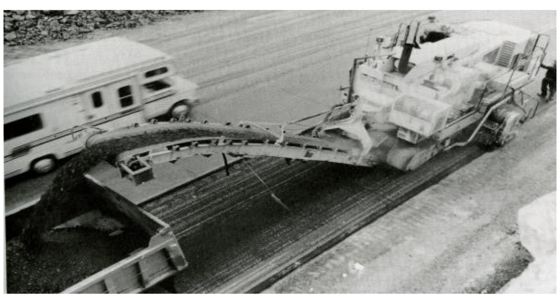
Each of these recycled products will contribute a certain percentage of aggregates and liquid asphalt binder to the mixture making them attractive ingredients for HMA producers. With the current specifications, these materials can be used in most HMA mixtures placed on Illinois roads. Specifications pertaining to and covering RAP and RAS are found in chapter 4 of this manual.

When a producer opts to include RAP or RAS in a mixture, the material has to be crushed, screened or fractionated to the proper size for the mixture in which it is to be used. Producers are required to document the weights of all mixture ingredients, including RAP and RAS materials, used in HMA mixes produced in Illinois. This can be achieved by a weigh-bridge (dryer-drum plant) or weigh hopper (batch plant). RAP and RAS cold feeds are to be calibrated.

Beginning of the Standard Specification Article 1102.01(a)(9)

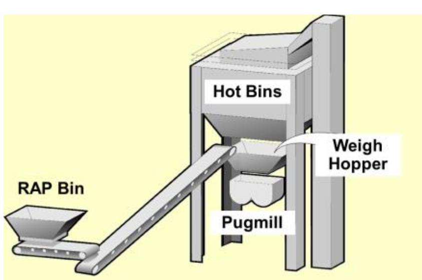
“(9) Equipment for RAP/RAS. When the RAP/RAS option is used, the plant shall be modified to ensure a homogenous, uniformly coated mix is obtained. A scalping screen, gator, crushing unit, or comparable sizing device shall be used in the RAP/RAS feed system to remove or reduce oversized material. Modifications shall be approved by the Engineer.”

End of the Standard Specification Article 1102.01(a)(9)

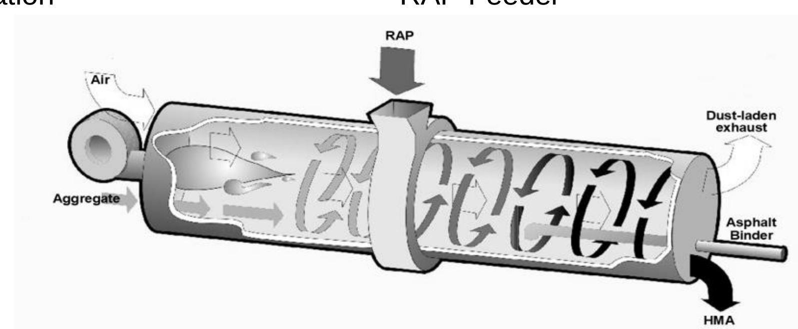


Cold Milling Operation

RAP Feeder

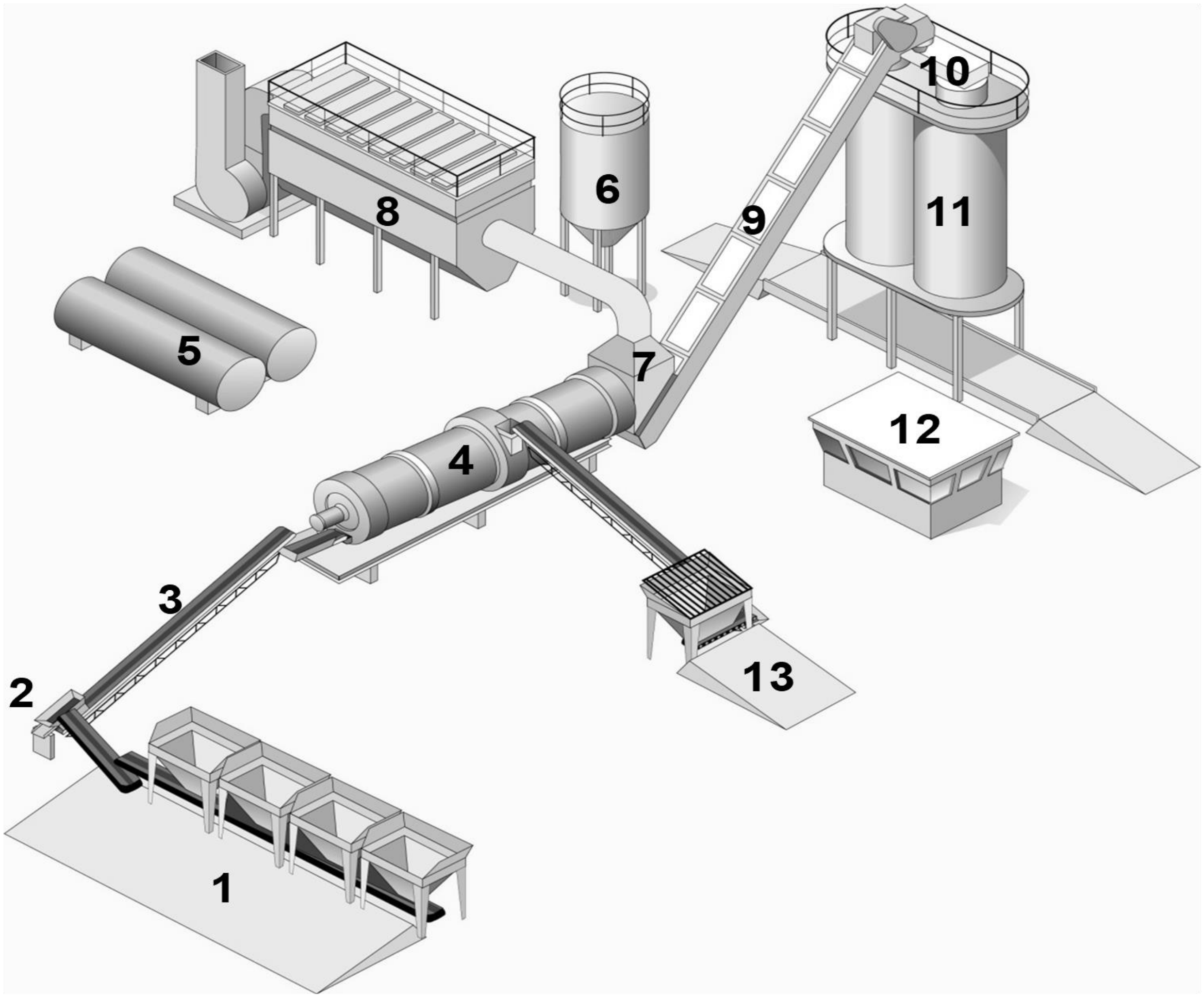


Batch Plant



Dryer-drum Plant

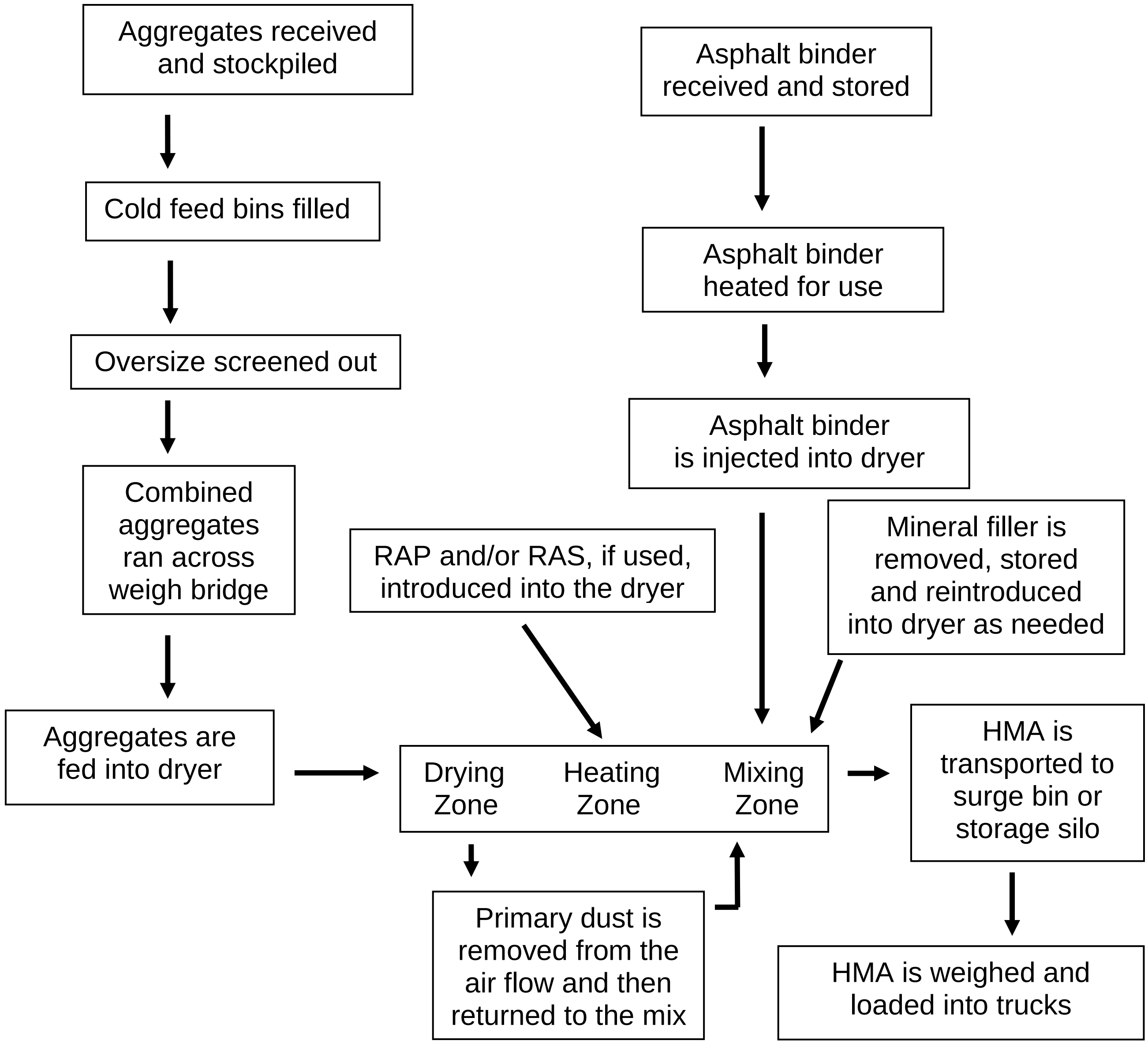
Dryer-Drum Plant Layout



Major Parts of a Dryer-Drum Plant

1. **Cold Feed Bins**
2. **Scalping Screen**
3. **Weigh Belt**
4. **Drum Mixer**
5. **Hot Asphalt Binder Storage**
6. **Mineral Filler System**
7. **Primary Dust Collector**
8. **Secondary Dust Collector**
9. **Slat Conveyor / Elevator**
10. **Gob Hopper**
11. **Surge or Storage Bins**
12. **Control Trailer**
13. **RAP and/or RAS Feeder**

Dryer-Drum Plant Material Flow Chart



DRYER-DRUM COMPONENTS AND OPERATION

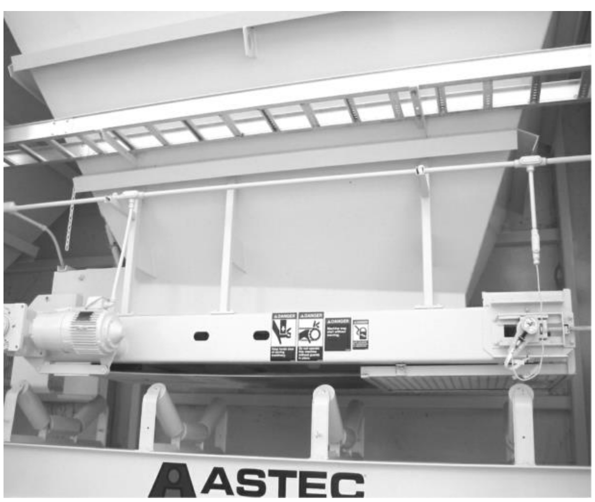
Although the dryer-drum plant and batch plant is very similar in how the final product is created there are major differences in the equipment and the processes used to produce the HMA material. When dealing with dryer-drum plant requirements refer to Articles 1102.01 (a) and 1102.01 (c) of the Standard Specifications.

1. <u>Cold Feed System</u> See Article 1102.01(c)(8)(a)

In most cases, the cold feed system is basically the same for dryer-drum and batch plants; a minimum of four bins with dividers, adjustable locking gates, variable speed belts and automatic master controls. But because of some differences in plant operations, the cold feeds for dryer-drum plants have extra requirements for the cold feed system including; individual cut-off controls, speed of the feeder measured in TPH or RPM off of the tail shaft. The greatest difference is that all the aggregate proportioning is done at the cold feeds which require accurate calibrations of the feeders.

Since there are no bins used to measure the aggregate materials, the cold feed system will be equipped with a cut-off system to detect the absence of materials from an empty or plugged feeder. The cut-off system is usually triggered by limit switches on arms located at the gate opening of the feeder. The limit switch is held open by the flow of material and activates an alarm in the control room when materials stop.

Since the aggregate ingredients of the HMA mixture make up approximately 90% to 95% of the total mixture volume, it is of great importance that the cold feed system is working properly and feeding the correct amount of aggregate materials to fulfill the aggregate proportions of the mix established during the design process. Because of this, specifications require the aggregate/RAP feeders to be accurate within ±1.0% and the RAS feeders ±0.50% of the actual material being delivered by the feeders as compared to the calibration results.



Non-bridging Cold Feed

Open Top Cold Feed Bins

2. Scalping Screen See Article 1102.01(c)(2)

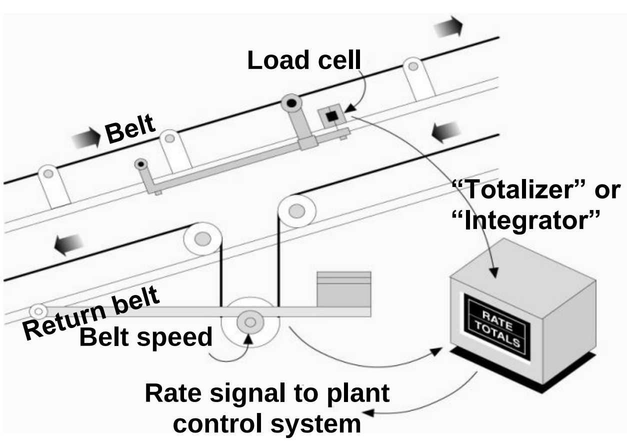
The cold feeds will be equipped with a vibrating scalping screen system to remove any foreign or oversize materials before the combined materials enter the dryer. The scalping screens can be individual scalping screens on each feeder or one single scalping unit. This vibrating scalping system will be equipped with screens meeting the maximum nominal top size for the mixture to insure no oversize aggregates get into the mixture. With a dryer-drum plant, this is the only time the aggregate materials are screened. In addition to removing oversize or foreign materials, the screening unit will mix the aggregate materials into a combined state helping to create gradation consistency. It should be noted that the vibrating scalping unit will be independent of the weigh bridge.

Single Scalping Screen

Individual Bin Scalping Screens

3. Weigh-Bridge (Weigh-belt) Conveyor System See Article 1102.01(c)(3)

A dryer-drum plant runs in a continuous non-stop motion and is not designed to store the heated aggregates of the mixture in bins like the batch plant. Because of this continuous non-stop production, a dryer-drum requires a piece of equipment, not found on a batch plant, to weigh the aggregate materials. Instead of using scale heads or weigh buckets, the dryer-drum plant employs a continuous belt weighing system that determines the weight of aggregate material as it passes across a weigh-bridge. This continuous weighing system normally utilizes load cells that senses the weight of material on the belt as it passes across. During windy conditions, the weigh-bridge has to have rigid wind guards in place to prevent gusting winds from affecting the weighing capability during production.



Weigh-bridge

Information from the load cells and speed sensor is sent to the control console. These aggregate weight readings are then corrected for moisture and converted to dry tons per hour. Based on preset percentages of asphalt binder, mineral filler, and any other additive, the computer will then determine the correct amounts of these ingredients needed to produce the mixture at the desired rate of production.

In order to insure the weigh-bridge is working properly, specifications require that the weigh-bridge be calibrated at the beginning of the production season and checked on a daily basis when producing asphalt mix. The daily check is referred to as the “six minute” check. An example of a six-minute check can be found on page 2-34 of this manual.

Calibration of the Weigh-Belt Conveyor

The calibration process for the weigh-bridge conveyor is somewhat similar to calibrating cold feeds where material will be run over the weigh-bridge and collected. A tared truck and an approved truck scale must be available to collect the material for weighing. Before the calibration process begins, the plant controls for moisture have to be set to zero percent so there will be no moisture correction during this operation. While the belt is running without load (empty), the digital aggregates readout should read ‘0’ tons per hour. Once this has been accomplished, the procedure will be as follows:

a) Feed material from one or more of the aggregates feeders over the weigh-belt conveyor and divert that material into a tared truck.

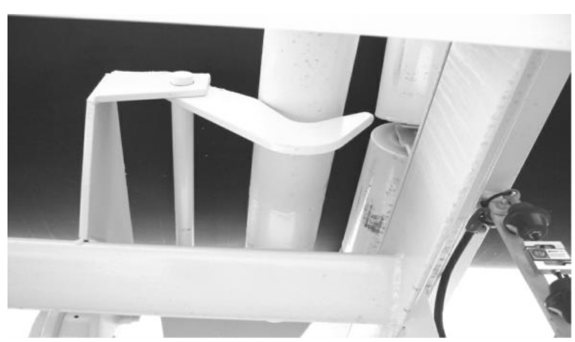
b) When the truck is nearly full, shut off the aggregates feeder(s) and allow the belts to clear and all of the material to go into the truck.

c) Weigh the truck and also read the accumulated tons of material on the control console.

   NOTE: For proportioning control, the weight of material in the truck and the console reading shall not vary more than 0.5 percent.

This process will be performed at least three times per production rate for a minimum of three production rates. In other words, this process is done a minimum of nine times to insure a complete check on the range of production rates. On the weigh belt, these rates shall be 50%, 75%, and 100% of the approved plant production rate. On a RAP or RAS weigh belt; the calibration rates are normally 10% of the lowest production rate and 50% of the highest approved plant production rate. See the next page for an example of a calibration.

Weigh Bridge Load Cell



Hanging Weight on Weigh-bridge

Weight-Belt Conveyor Calibration Example (@ 500 TPH)

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
250	44520	18520	26000	13.000	13.015	0.1%
	44120	18520	25600	12.800	12.812	0.1%
	44260	18520	25740	12.870	12.920	0.4%
375	44360	18520	25840	12.920	12.935	0.1%
	44580	18520	26060	13.030	12.982	- 0.4%
	43980	18520	25460	12.730	12.780	0.4%
500	43980	18520	25460	12.730	12.750	0.2%
	43880	18520	25360	12.680	12.710	0.2%
	44580	18520	26060	13.030	12.980	- 0.4%

RAP or RAS Weigh Belt Conveyor Calibration Example (@ 500 TPH)

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
50	43250	19260	24260	12.130	12.180	0.4%
	43480	19260	24220	12.110	12.175	0.5%
	43520	19260	24260	12.130	12.150	0.2%
250	44520	19260	25260	12.630	12.680	0.4%
	44360	19260	25100	12.550	12.580	0.2%
	43200	19260	23940	11.970	11.982	0.1%

6-Minute Check Target Value

Once the main weighbridge is calibrated, a target value for the daily verification checks (6-minute checks) shall be established. To establish this target value, weights furnished by the manufacturer shall be hung on the weighbridge. With the weigh-bridge belt running empty and the weight(s) hung on the weigh-bridge, the plant operator will determine and record a reading for six (6) minutes from the accumulated tons counter. The process shall be performed at least three times to establish an average target value.

Once this target value has been established, a daily verification check, referred to as a six-minute check, shall be run twice per day when producing HMA materials. These daily checks are usually accomplished when preparing the plant for production in the morning and after the plant has been cleaned out at the end of the production day. These daily readings shall be within 2.0% of the established target value.

If the accumulated tons vary from the six-minute target value, one of the following reasons may have caused the difference.

a. Computer malfunctions.
b. Not maintaining proper voltage to belt conveyor.
c. Conveyor not at same angle.
d. Load cell malfunctioning.
e. Weights improperly hung on weigh bridge.
f. Moisture still set at console.
g. Weigh idlers binding with weighbridge framework.

The above listing should by no means be construed to be the only reasons for variations greater than 2.0%. If an investigation does not reveal the cause of the difference, a recalibration of the main weigh belt conveyor shall be performed.

Example of a 6-Minute Check for a Dryer-Drum Plant

Target (from weight belt calibration) **20.2 accumulated tons**

Allowable Tolerance = ± 2.0% **20.2 X 0.02 = ± 0.4**

Allowable range: **20.2 – 0.4 = 19.8** & **20.2 + 0.4 = 20.6**

The acceptable range is 19.8 to 20.6 accumulated tons

Example:

Print Number	Time	Accumulated tons	6 Minute check
1st	**5:00**	**20.6**	**---------**
2nd	**5:06**	**41.0**	**20.4**
3rd	**5:12**	**61.3**	**20.3**
4th	**5:18**	**81.5**	**20.2**

Class problem

Determine if this is a valid 6-minute check Target: 35.7 accumulated tons

Print Number	Time	Accumulated tons	6 Minute check
1st	**6:30**	**28.9**	--------
2nd	**6:36**	**65.1**	
3rd	**6:42**	**100.2**	
4th	**6:48**	**136.4**	

4. Dryer Drum Mixer See Article 1102.01(c)(6)

The minimum capacity rate for a dryer for a dryer-drum plant shall be 60 tons per hour and is similar to the dryer used on a batch plant but with a few differences:

a) Aggregates are heated, dried, mixed and coated with liquid asphalt binder in the dryer

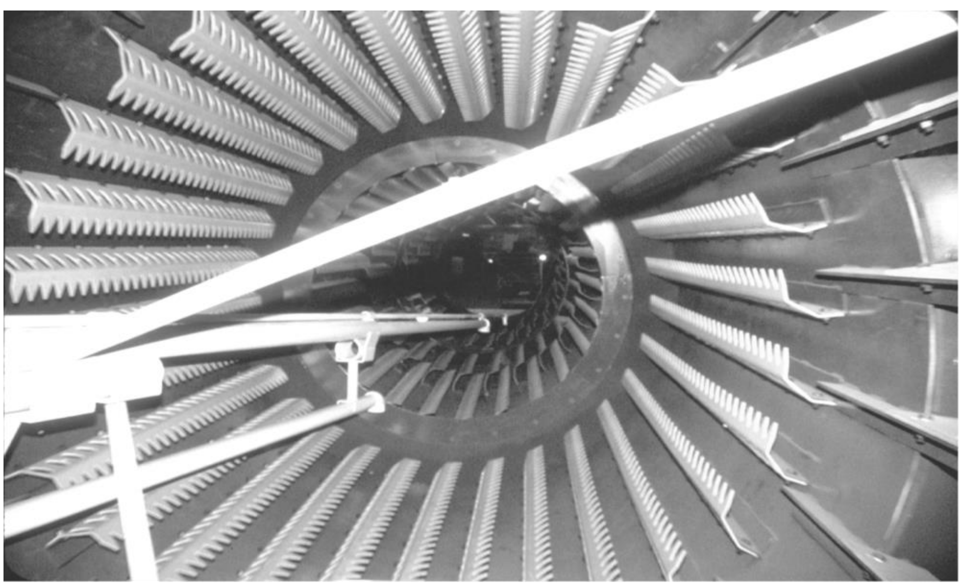
b) RAP and/or RAS is introduced into the dryer drying zone

c) Primary dust and mineral filler are introduced into the dryer mixing zone

There are two types of drums used on a dryer-drum plant, single and dual drum. The single drum unit incorporates the heating, drying and mixing of the aggregates in the first 2/3s of the drum. The liquid asphalt, primary dust, mineral filler is introduced in the final 1/3 of the drum, the mixing zone. RAP and/or RAS, when used, is introduced into the drum approximately 1/2 way into the drying zone. This takes direct advantage of the heated aggregates to soften these materials for proper incorporation into the mixture.

The dual drum heats, dries and mixes the aggregates in one drum then mixes and coats the aggregates with asphalt binder in another drum. This can be completed with separate drums or an inner-outer drum system.

In either type of dryer-drum plant, the aggregate materials are required to be in the drying portion of the system long enough to be properly dried and heated. Use of retarding dams, adjusting the drum slope or arrangement of the lifting flights will help to insure proper heating and drying of the aggregate materials.

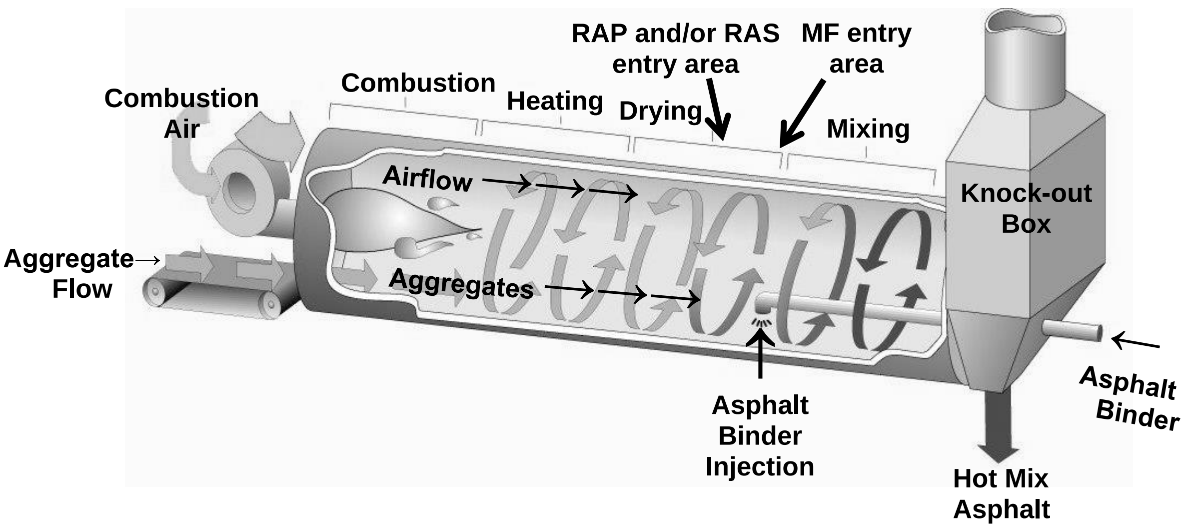


Interior of a Dryer-Drum dryer with MF & asphalt binder piping and flighting

Dryer drums utilize two main systems of airflow thru the plant: parallel and counter flow:

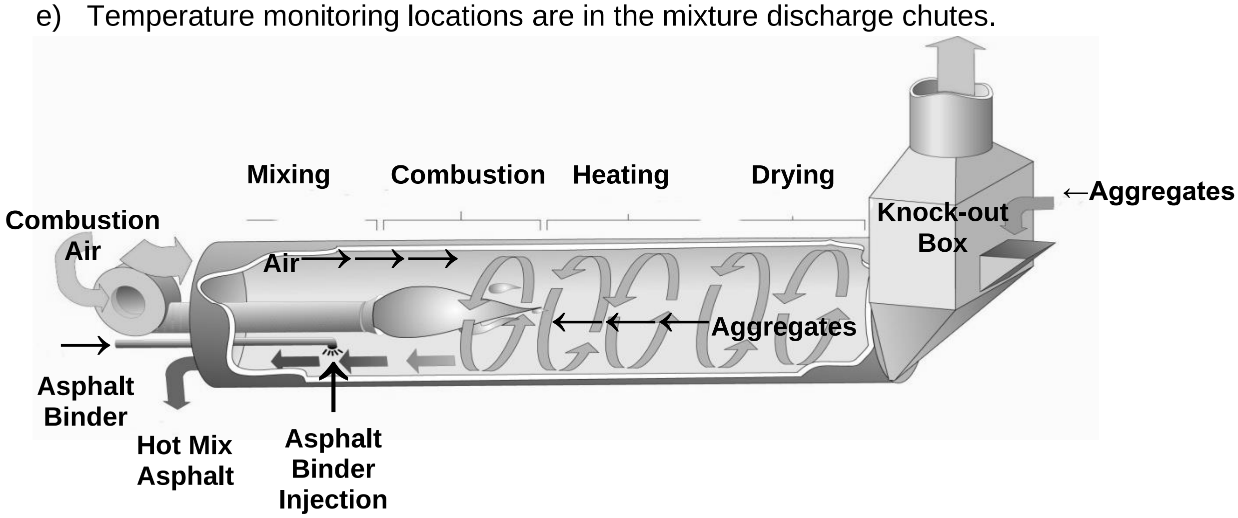
Parallel Flow Dryer-Drum Operation

a) Aggregate material enters at the burner end.
b) Aggregate material flows in the same direction (parallel) as the air flows.
c) Aggregate materials are heated and dried in first 2/3rds of the drum.
d) RAP or RAS is added approximately half way down the drum.
e) Asphalt binder and MF are added simultaneously and all ingredients are mixed in the remaining 1/3 of the drum.
f) Pyrometer is mounted in the drum discharge chute to monitor the mixture discharge temperature.

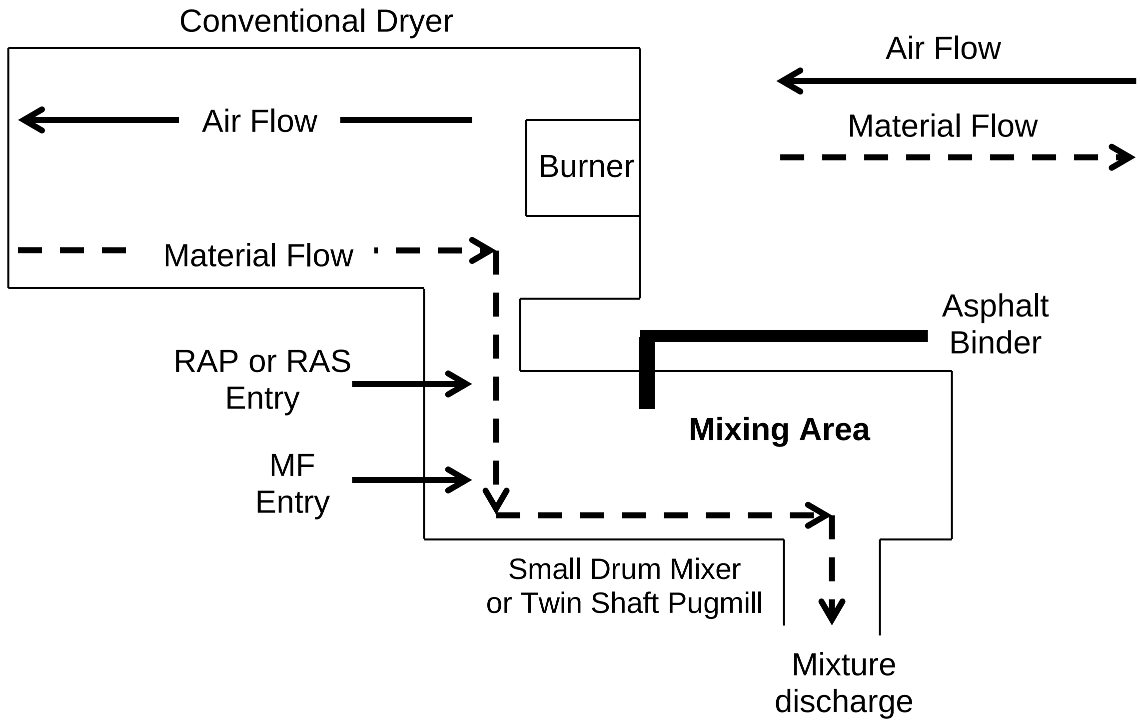


Counter Flow Dryer-Drum Operation

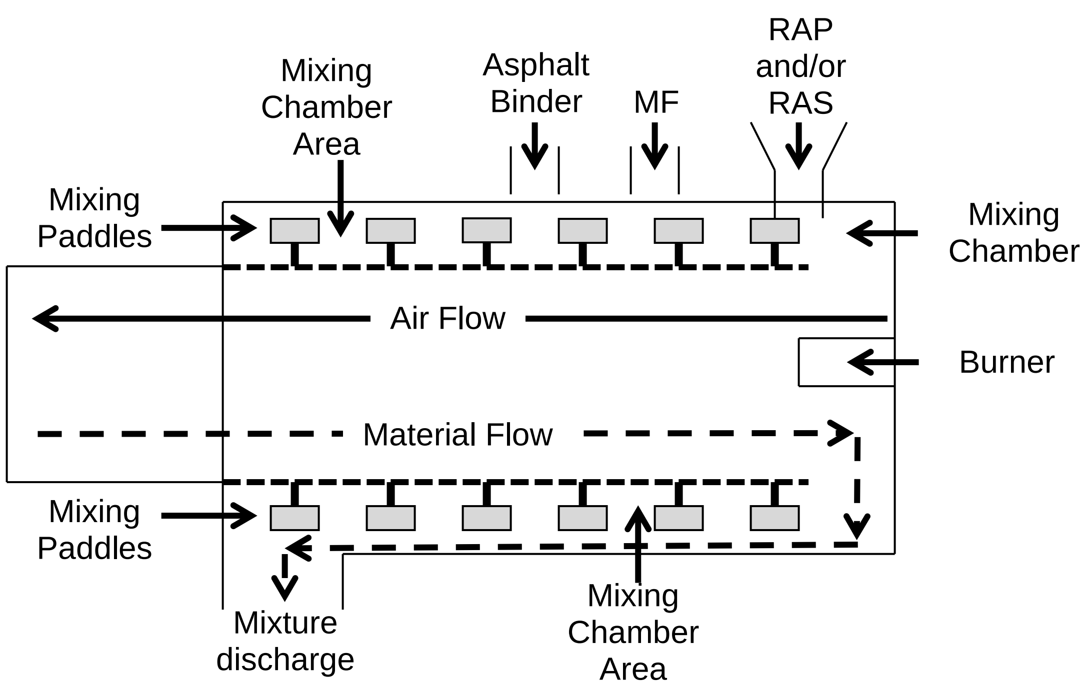
a) Material enters the drum at the opposite end from the burner.
b) Material flows in the opposite direction (counter) as the air flows.
c) Aggregate heating and drying areas differ among manufacturers.
d) RAP, RAS, Asphalt binder and MF entry points will differ.
e) Temperature monitoring locations are in the mixture discharge chutes.



Counter Flow Dryer-Drum with a Conventional Dryer



"Double Barrel" Counter Flow Dryer-Drum



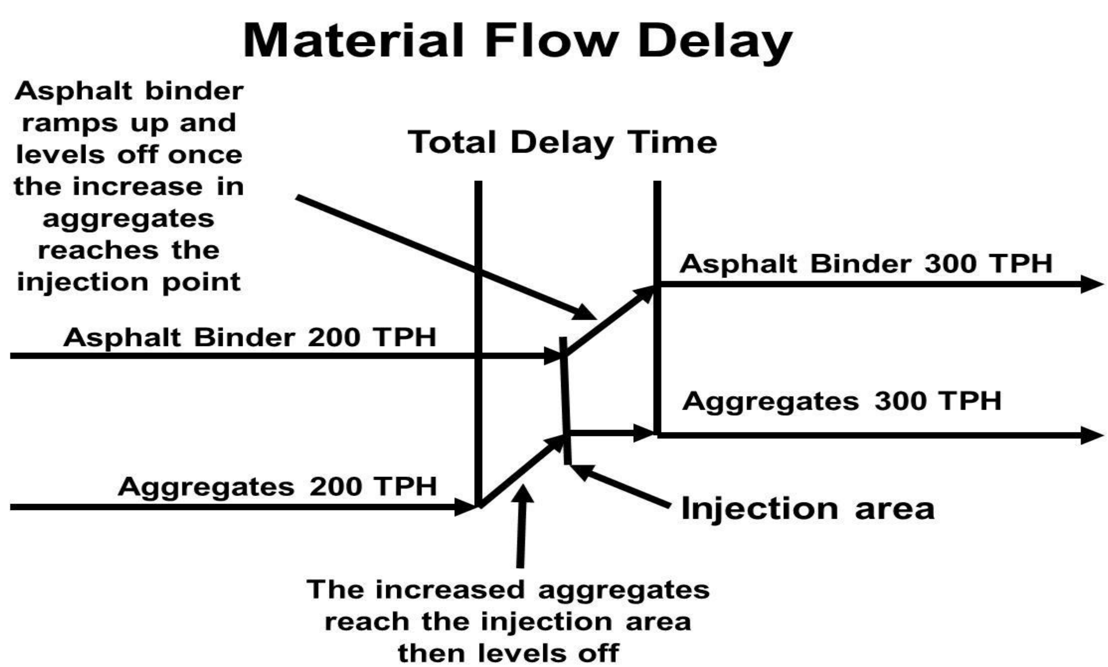
5. <u>Liquid Asphalt Binder Systems</u> See Article 1102.01(c)(8)(d)

The liquid asphalt binder system for a dryer-drum plant is similar to the batch plant. The same type of storage facilities are used, vertical and horizontal tanks. The main difference between the dryer-drum and batch plant is the delivery system used to incorporate the liquid asphalt binder into the mixture. Most dryer-drum plant manufacturers will employ a pump and metering system differing from the batch plant which normally uses a pump and weigh bucket system. There are three basic types of asphalt metering systems used on a dryer-drum plant: volumetric/mechanical, volumetric/electronic and mass flow.

The delivery system for the liquid asphalt binder will utilize an automatic shut-off system in the event that the liquid asphalt binder stops flowing during production. The computer control system coordinates the amount of liquid asphalt binder needed with the information obtained from the weigh-bridge in order to meet mixture requirements. The control system sends instructions to the asphalt control valve to increase or decrease the amount being delivered in order to maintain the correct rate of flow of the liquid asphalt binder.

A unique situation with a dryer-drum plant is the delays needed when changing the production rate while still maintaining the correct percentage of liquid asphalt binder for the mixture during the transition change.

When the plant production rate is increased or decreased, the change in the rate of feed for the aggregate materials has to take place before the change in the rate for the liquid asphalt binder. As the aggregates materials are increased/decreased, there is a period of time for the aggregate materials to travel from the cold feeds to the point of injection for the liquid asphalt binder. The increase or decrease of liquid asphalt binder has to be delayed until the increased/decreased aggregates reach the injection location. This delay is referred to as a “material flow delay”.



Calibration of the Liquid Asphalt Binder System

The liquid asphalt binder system is required to be calibrated in order to insure proper delivery of the required percentages to meet mixture specifications and is performed comparably to the aggregate calibration process. The liquid asphalt binder is measured and collected under controlled circumstances (time vs. amount delivered). Although different manufacturer systems will require different procedures to calibrate the liquid asphalt system, the procedure is to have a collection receptacle (usually a tank truck) and an approved scale to weigh the collected material. A basic description of the calibration process is:

a) Connect the collection receptacle to the asphalt binder system and pre charge (fill) the line.
b) Set the meter to zero (0) or take an initial reading.
c) Set the asphalt binder readout on the gallon counter or ton counter on the control console to zero.
d) Pump 1,000 gallons (approximately 8,000 lbs.) into the collection receptacle.
e) Weigh the collection receptacle and determine the net weight of the asphalt binder.
f) The asphalt binder metering system (console) be in a tolerance of 0.4% of that actually delivered (net weight).

It is important during the calibration process to:

a) Maintain a constant temperature on the asphalt binder.
b) Avoid “hot” loads being added to storage.
c) Avoid pumping from a low storage level.
d) Avoid air being sucked into the line.

The meter weight and the actual weight in the collection receptacle must be within 0.4%. This procedure shall be performed at least three times at each of three flow rates and the flow rates should be at or near the expected minimum, middle and maximum amounts of asphalt binder required.

Example Calibration of Asphalt Binder Delivery System

<u>Plant Production Rate</u> **500 TPH** **<u>Type of System</u>** **Pump pushing Pump**

Rate	Gross Wt. (lbs.)	Tare Wt. (lbs.)	Net Wt. (lbs.)	Net Wt. (tons)	Console Wt.	Difference
6	4500	250	4250	2.125	2.130	0.2%
	3800	262	3538	1.769	1.772	0.2%
	4000	242	3758	1.879	1.881	0.1%
18	4412	231	4181	2.091	2.089	- 0.1%
	4316	265	4051	2.026	2.021	- 0.2%
	4385	244	4141	2.071	2.079	0.4%
30	4325	300	4025	2.013	2.020	0.4%
	4368	324	4044	2.022	2.026	0.2%
	4259	285	3974	1.987	1.994	0.4%

6. Mineral Filler Systems See Article 1102.01(c)(8)(d)

A dryer-drum plant will employ similar mineral filler components as found in a batch plant. There could be two storage systems, one for plant generated mineral filler and one for purchased mineral filler. Either system will use a metering system to put mineral filler back into the mixture during production. Three types of metering systems used are the vane feeder, a holding pod with a vane feeder and a weigh depletion pod. Operation of these systems are similar to the asphalt binder and is interfaced with the weigh-bridge to make certain proper amounts of mineral filler are put into the mixture based on input control percentages and the amount of aggregates going across the weigh-bridge. Material delays are set into the system to allow for material rate changes as discussed earlier.

Mineral filler can be added by weight or volume so the system used has to be calibrated within allowable tolerances to ensure proper delivery into the mixture. The mineral filler is also required to be added at the same point in the dryer as the liquid asphalt binder as this will help to incorporate the mineral filler into the mixture without out loss of "fugitive" dust to the dust collection system. Mineral filler systems are required to be fitted with a cut-off system in the event the feeder becomes plugged or running short of mineral filler.


Mineral Filler Storage Systems

7. Dust Collection Systems See Article 1102.01(c)(8)(d)(c)

Dryer-drum plants employ similar dust collection systems as the batch plant, primary and secondary, as discussed in the general plant information in the beginning of this chapter.

Primary Dust Collectors

The primary dust collection equipment will use either a knockout box or a cyclone collector depending on the type of dryer and airflow. With a parallel airflow dryer with knockout box, the fines are drawn through the material that is being mixed, which allows some of the particles to become trapped and thus are returned to the mixture. The particles that do not become trapped continue back to the knockout box, which through a drop in the airflow velocity allows the coarser material to drop out and be remixed in the final mixing area of the drum. The finer material still remaining in the airflow will continue on to the secondary collector. A counter airflow dryer with cyclone collector will remove the dust material in a manner similar to a batch plant system, except that the re-entry points will vary among manufacturers.

Secondary Dust Collectors

The secondary collection equipment used on most plants today will be a baghouse although the wet-wash system is still allowed in Illinois but because of strict EPA restrictions the wet-wash systems have just about been eliminated in their use with HMA plants throughout the United States.

The operation of the baghouse is the same as at batch plants, however the fines are normally returned to the mix immediately through the mineral filler system. Some baghouse systems are equipped with a means to monitor the amount of fines being collected and allows for the addition or waste of all or part of that being collected.

The wet-wash system works in a similar manner as a standard wet-wash system found on a batch plant. As with any wet-wash system, care needs to be taken to insure the system is operating correctly because the material being wasted has already been weighed and the liquid asphalt binder being added is based on the original weight of material passing over the weigh-bridge.


Baghouses

8. Slat Conveyor or Skip-Bucket System

Since a Dryer-drum plant needs storage to maintain constant production, slat conveyors or skip-bucket systems are used to transport the HMA to the top of the silo or surge bin. The continuous conveying system is required to be enclosed, heated and/or insulated.


Slat Conveyor Conveyor Slats

9. Surge or Storage Bins

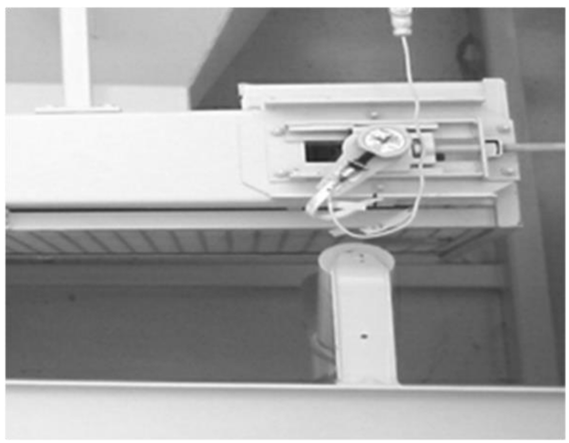
A surge or storage bin, although not required by specification, is essential on a dryer-drum plant to maintain continuous plant operations. Surge and storage bins are discussed at the beginning of this chapter and in detail in chapter 3 of this manual.

10. Plant Controls

See Article 1102.01(c)(9)

Besides normal control for plant operation dryer-drum plants require built in checks and safety guards in case of equipment malfunction or operator error. The plant controls are interlocked to set off an alarm or shut down plant operations if a failure occurs in any part of the process from the cold feeds to the storage bins. The following is brief descriptions of a few of the required controls per specification:

a) Cold feeds – variable speeds, total and proportionate, for individual bins and combined aggregate conveyors. These units will display rates in TPH or RPM. Individual bins will be outfitted with control systems to detect the absence of material flow.



Tachometer Sensor

Flow Detection Paddles

b) Weigh-bridge will be equipped with an alarm for when the actual production rate differs with the preset rate.

c) The liquid asphalt binder system will be interfaced with the aggregate flow on the weigh-bridge, the RAP and/or RAS feeder and the mineral filler system to ensure proper delivery.

d) An automatic printer is required to document in hard copy the different ingredients and their percentages being put into the mixture every six minutes or on demand.

e) Moisture compensators are used to adjust the aggregate weights for added moisture weight that will be lost during the drying process. Moisture percentages for individual aggregates or combined aggregates are input into the plant computer. Some newer plants employ automatic detectors located in the feeder system. Plant technicians need to run moisture percentages on individual stockpiled aggregates or on a combined aggregate sample obtained from a diverter chute. The following is an example of how to determine the composite moisture percentage to input into the plant controls:

Example:

Composite Aggregate Moisture Example					
Feeder #	Material	Stockpile moisture %	Mix percentages	Calculation	Proportionate moisture %
1	CM11	5.0	50.0	5.0 x 0.50	2.5
2	CM16	5.0	10.0	5.0 x 0.10	0.5
3	FM20	6.0	20.0	6.0 x 0.20	1.2
4	FM02	7.0	20.0	7.0 x 0.20	1.4
Total Composite Moisture					5.6

Given information:

Feeder #	Material		Stockpile Moisture	Mix Percentage
Feeder #1	CM11	Coarse aggregate	5.0%	50.0%
Feeder #2	CM16	Coarse aggregate	5.0%	10.0%
Feeder #3	FM20	Fine aggregate	6.0%	20.0%
Feeder #4	FM02	Fine aggregate	7.0%	20.0%

To determine the percentage to be set on the composite moisture compensator, the following calculations would be made:

Coarse Aggregate #1	5.0 x 0.50	=	2.5%
Coarse Aggregate #2	5.0 x 0.10	=	0.5%
Fine aggregate #1	6.0 x 0.20	=	1.2%
Fine aggregate #2	7.0 x 0.20	=	1.4%
			Total 5.6%

A total of 5.6% would be set in the moisture compensator as the total composite moisture.

NOTE: Some control consoles use individual aggregate moisture percentages.

Class Problem

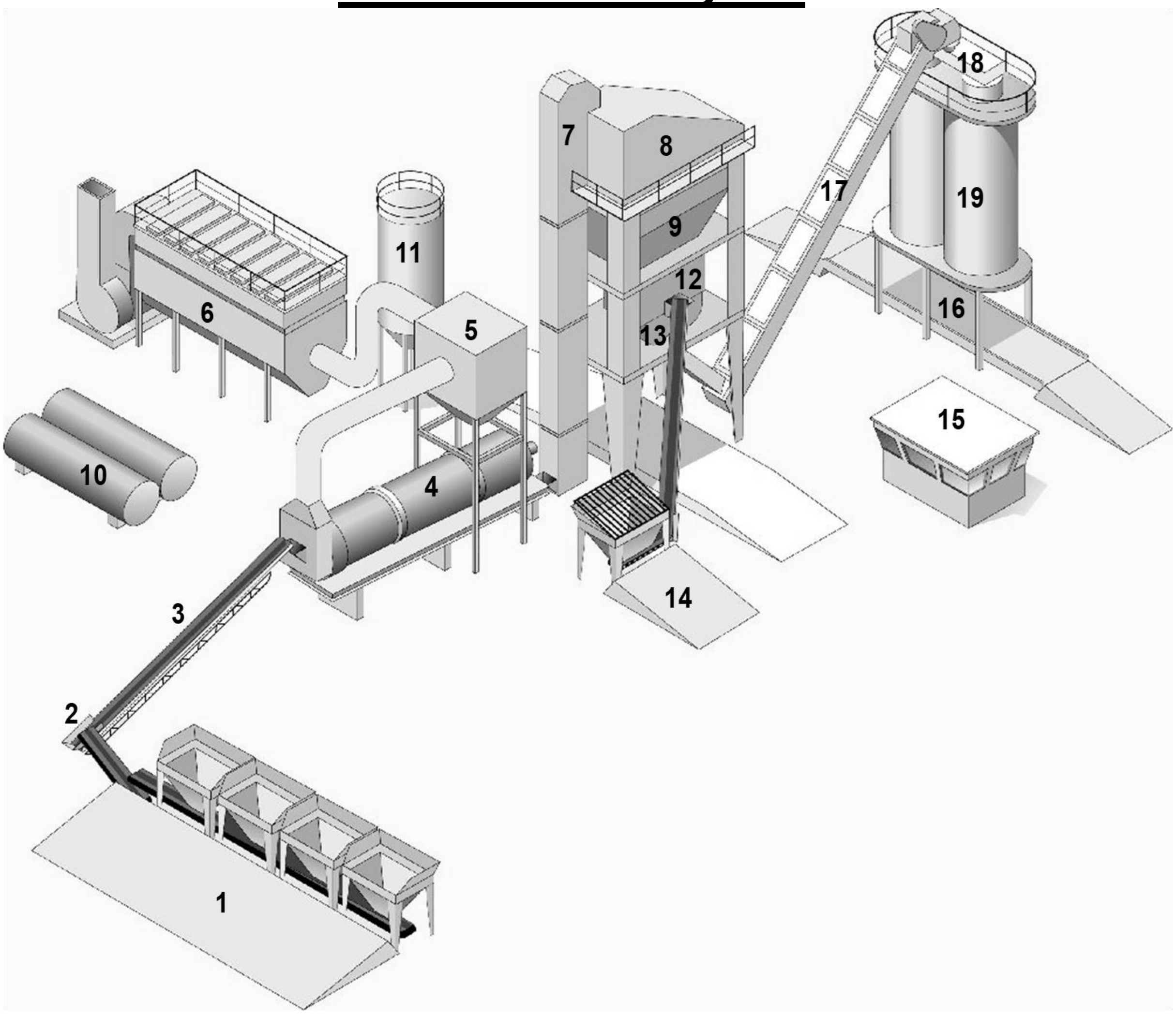
With the given information, determine the amount of composite moisture that needs to be put into the plant computer moisture compensator:

Ingredients	Mix Percent	Moisture Percent	Proportionate Moisture
Coarse Agg. #1	47.6%	4.7%	
Coarse Agg. #2	17.5%	6.3%	
Fine Agg. #1	21.0%	5.5%	
Fine Agg. #2	13.9%	6.1%	
Total Composite Moisture Percentage			

NOTE: This chapter only deals with general industry plant information based on specification requirements. Due to the extensive variations in types of the equipment supplied by the numerous manufacturers, specific operations, different configurations and calibration procedures, plant processes and equipment descriptions may need to be modified to accommodate the differences due to equipment and manufacturers available to the producer.

Descriptions in this class manual are general in nature and may or may not apply to your particular situation and/or equipment. Always refer to the manufacture's recommendations when operating or calibrating equipment.

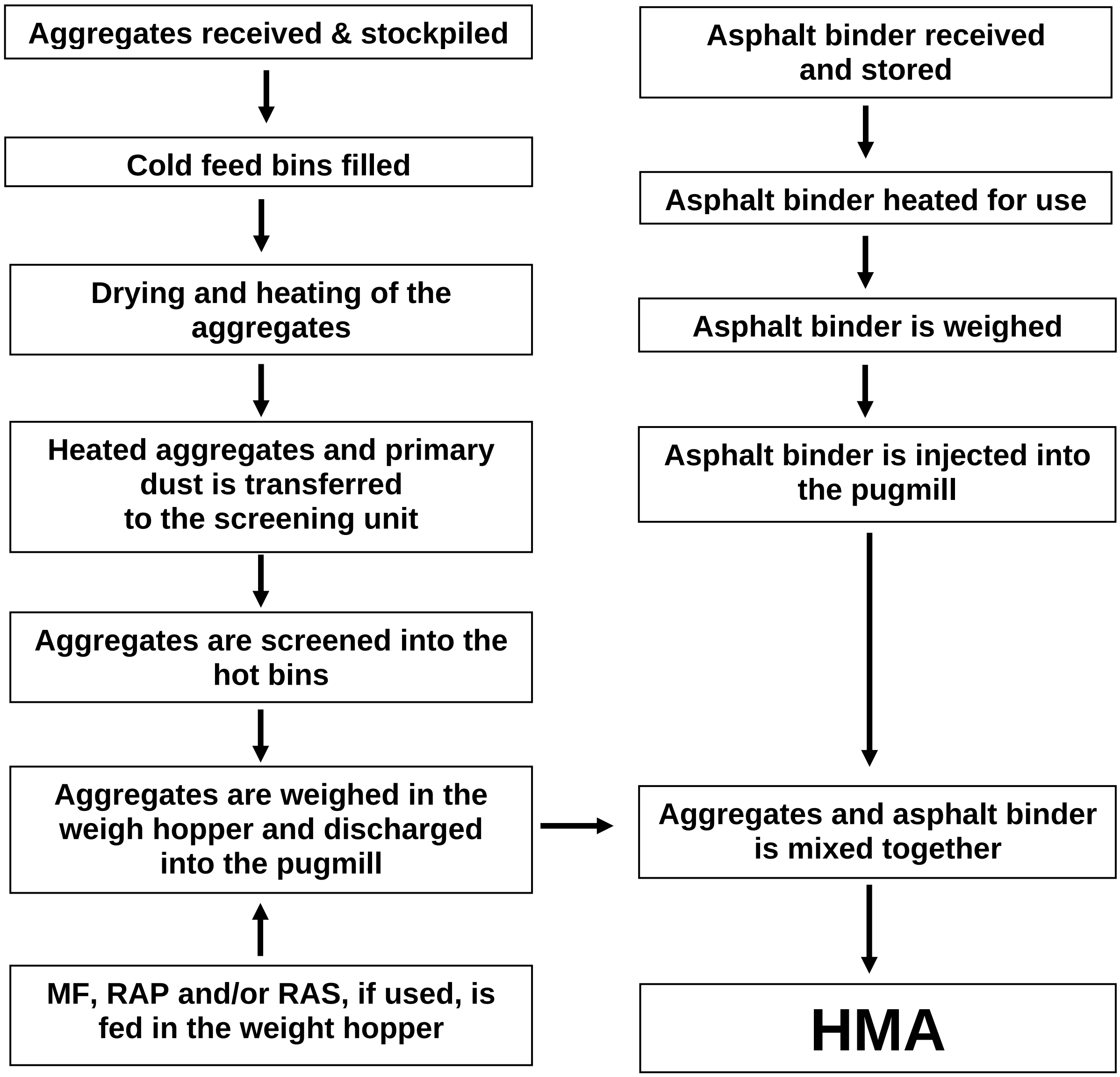
Batch Plant Layout



Major Parts of a Batch Plant

1. Cold Feed Bins
2. Scalping Screen
3. Cold Elevator
4. Dryer
5. Primary Dust Collector
6. Secondary Dust Collector
7. Hot Elevator
8. Screen Unit
9. Hot Bins
10. Asphalt Binder Storage Tanks
11. Dust Collection Tank
12. Weigh Hoppers
13. Pug Mill
14. RAP and/or RAS Feeder (optional)
15. Control Trailer
16. Scales (optional)
17. Slat Conveyor (optional)
18. Gob Hopper (optional)
19. Mix Silos or Storage Bins (optional)

Batch Plant Material Flow Chart



As described earlier in this chapter, the batch plant and dryer-drum plant are very similar in how the finished product is created; aggregate is heated and dried then coated with the liquid asphalt binder to make the HMA material that is placed onto our roadways. That is where the similarities end. The dryer-drum plant utilizes equipment that measures the ingredients at a flow rate, in TPH or RPM, while the batch plant measures the ingredients based on weight per batch. The following is descriptions of the batch plant operations and equipment. When dealing with batch plant requirements refer to Articles 1102.01(a) & (b) of the Standard Specifications.

1. Cold Feed System See Article 1102.01(a)(3)

The cold feed system used with a batch plant is very similar to the cold feed system used with a dryer-drum plant. See the descriptions in the general section and dryer-drum section of this chapter.

2. Cold Elevator

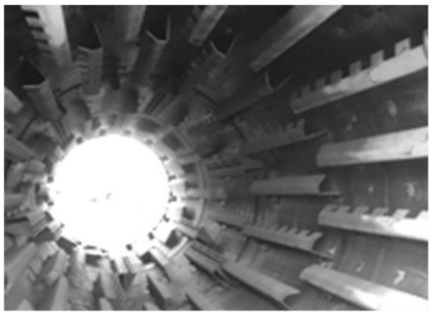
The cold elevator system used with a batch plant is similar to the cold feed system used with a dryer-drum plant with the exceptions of the scalping screen used and no weigh-bridge. See the descriptions in the general section of this chapter.

Scalping (grizzly) screen

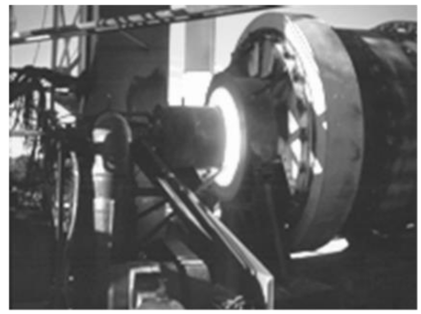
Cold elevator leading into the dryer

3. Dryer See Article 1102.01(b)(1)

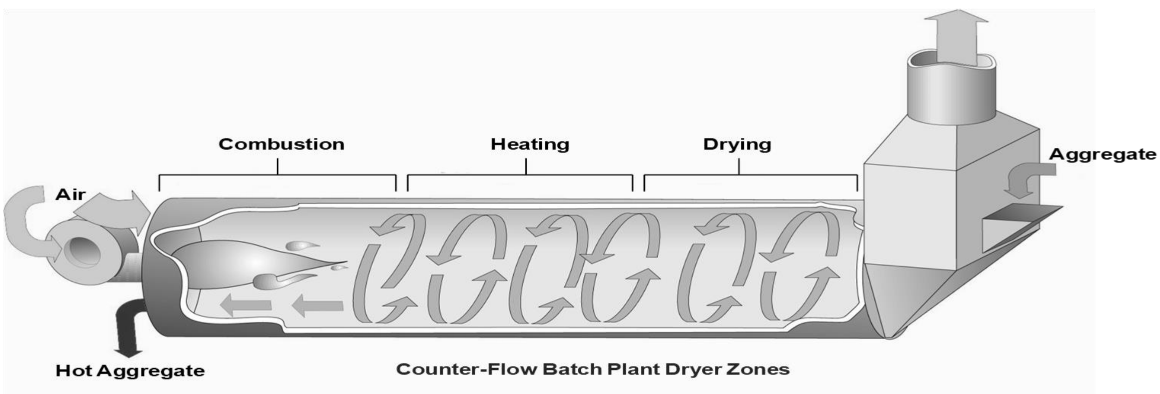
The dryer used with a batch plant is similar to that used with a dryer-drum plant with the exception that the dryer is only used to heat and dry the combined aggregate material. The piping found in the dryer-drum dryer will be absent in the batch plant dryer as mineral filler and the liquid asphalt binder is brought into the mixture during the weighing process and pugmill, respectively. See the descriptions of the dryer in the general section and dryer-drum section of this chapter.



Inside of a batch plant dryer



Batch Plant



4. Primary Dust Collector See Article 1102.01(b)(3)

The batch plant is required to be equipped with an approved dust collecting system. The system will collect both primary and secondary dust that is created during the production process.

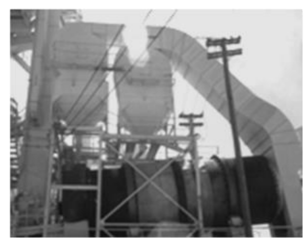
Normally, a batch plant will employ a cyclone-type collector, which utilizes centrifugal force to remove the heavier dust particles from the exhaust gas stream. This centrifugal force creates a whirling motion (a whirlwind cyclonic action) forcing the dust-laden air to the outside of the unit. The pressure on the outside of the unit is lower and this allows the heavier dust to fall out of suspension. The heavy dust will then fall to the bottom of the unit where it is then diverted to an storage hopper. The finer dust in the exhaust gas stream will remain in suspension and is carried out to the secondary collector (either a baghouse, or wet washer). Dry cyclone collectors will normally operate in the 70% - 93% efficiency range.

Once removed, the collected primary dust is to be stored in an approved hopper with a low-bin indicator. This hopper will be equipped to either waste unneeded dust or feed it into the boot of the hot elevator at a uniform rate. The feed rate of the dust will be determined by a variable speed vane feeder or auger feeder during the production. Primary dust will only be fed into the boot of the hot elevator when a full stream of aggregate is flowing from the dryer.

When feeding the collected primary dust into the boot of the hot elevator, the system is to be equipped with a flow detector and automatic shut-off. This is done to prevent the primary dust from continuing to be fed into the hot elevator in the event there is a stoppage of the heated mixture aggregates flowing from the dryer for any reason, thus contaminating the hotbins.

Newer batch plants will utilize a knock out box or skimmer, which is incorporated into the dryer ductwork. These units work by slowing the exhaust gas stream flow allowing the heavier dust particles to drop or fall out of suspension, be collected and reintroduced or wasted as necessary. These units need to meet all requirements of a cyclone collector and when used in this capacity, they are considered to be primary dust collectors and can replace the cyclone units.

Horizontal Cyclone Collector



Dual Vertical Cyclone Collectors

5. **Secondary Dust Collector** See Article 1102.01(b)(3)

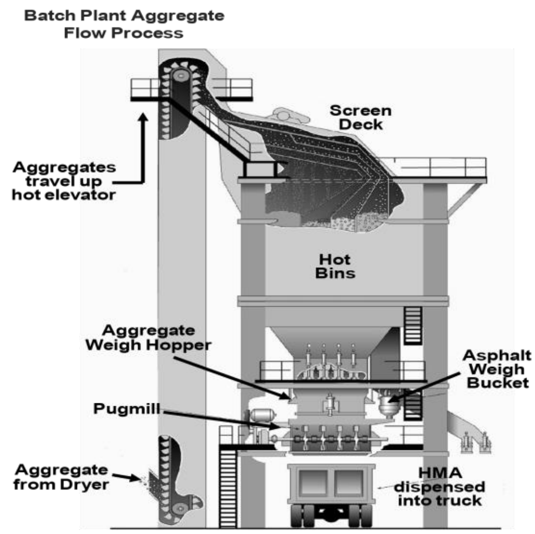
The batch plant secondary dust collector can be a wet collector but most of the industry will utilize a baghouse dust collector because of stringent pollution requirements.

The operation of a baghouse is relatively simple where filter bags collects the fine dust on the outer surface of the bags as air passes through the bags. The dust is released by shaking, pulsing, or air reversal into a hopper, and fed back into the mix as filler when needed.

Secondary Baghouse Dust Collectors

6. Batch Tower

The main difference between a batch plant and a dryer-drum plant is the way the aggregates are handled throughout the plant. While the dryer-drum plant sends a steady stream of combined aggregates through the plant in a continuous motion, the batch plant will dry and grade the combined aggregates into "hot bins" and then recombine the sized aggregates which help to better control the required gradations for the mixture. In order to carry out this extra operation, a batch plant will include a batch tower to hold the necessary equipment. The batch tower will include: a hot elevator, vibrating screening unit, hot bins, weigh hopper, scales, and a pug mill.

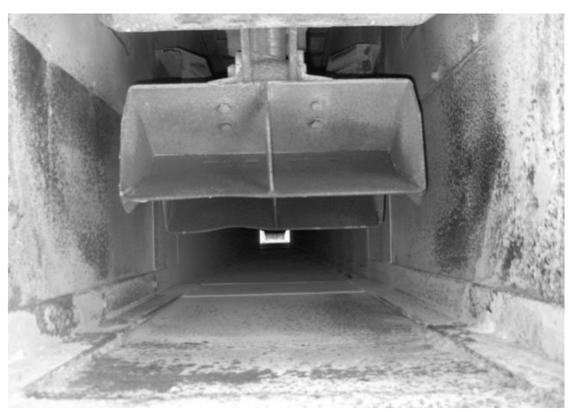


Batch Tower

7. Hot Elevator

The hot dry aggregates are carried to the screening unit on top of the batch tower by a "hot elevator" which normally will employ "buckets" to carry the hot aggregate materials.

Base of the Hot Elevator



Hot Elevator Buckets

8. Screening Unit See Article 1102.01(b)(10)

The screening unit on batch plants can be either a flat vibrating screening unit or inclined vibrating screen unit. Aggregate from the dryer is delivered to the screening unit, which is mounted over the hot bins. The function of the screening unit is to accurately separate the aggregate into the specified sizes. To properly perform this function, the effective screening area must be large enough to handle the maximum feed. Although screen size will vary between different manufacturers and the size of the plant, the common size is a 12 foot by 5 foot screen, which is also used in half sizes, 6 foot by 5 foot.

Issues with the screen deck include excessively worn screens, torn screens, blinding and overcrowding. Any of these issues will affect the gradation of materials going into the hot-bins which in turn will affect the properties of the HMA mixture, including density and air voids.

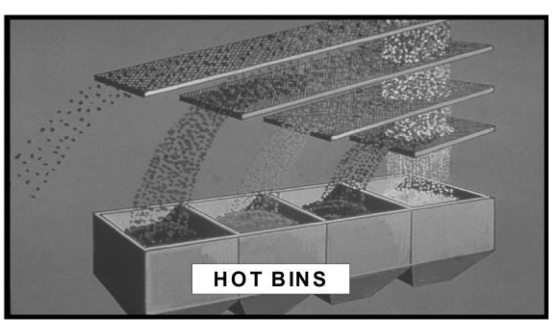
Beginning of the Standard Specification Article 1102.01(b)(10) in part

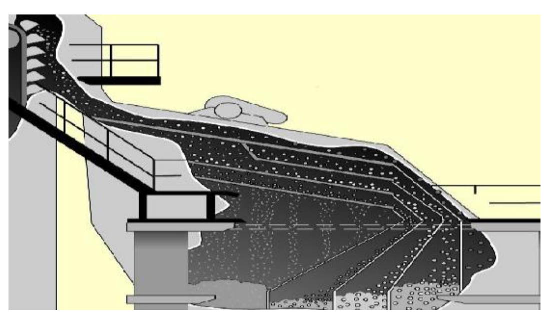
"(10) Screens…Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than neither the nominal size nor more than 10 percent over size for that bin."

End of the Standard Specification Article 1102.01(b)(10) in part

The condition and cleanliness of the screens will, to a large extent, control their efficiency. If the effective screening area is reduced by plugged screen openings, or if more material is fed to the screens than they can handle, the usual result is "carryover". Carryover is the depositing of finer material in a bin that should contain the next larger size aggregate. When this occurs, uniformity of aggregate grading is often impaired. When carryover fluctuates, lack of uniformity in the aggregate gradation will cause a corresponding lack of uniformity in the mixture, resulting in alternate fat and lean areas in the finished mix. Carryover increases the amount of fine aggregate in the total mix, and since fine aggregate has much more surface area per unit of weight requiring asphalt coating, this condition should be kept at a minimum.

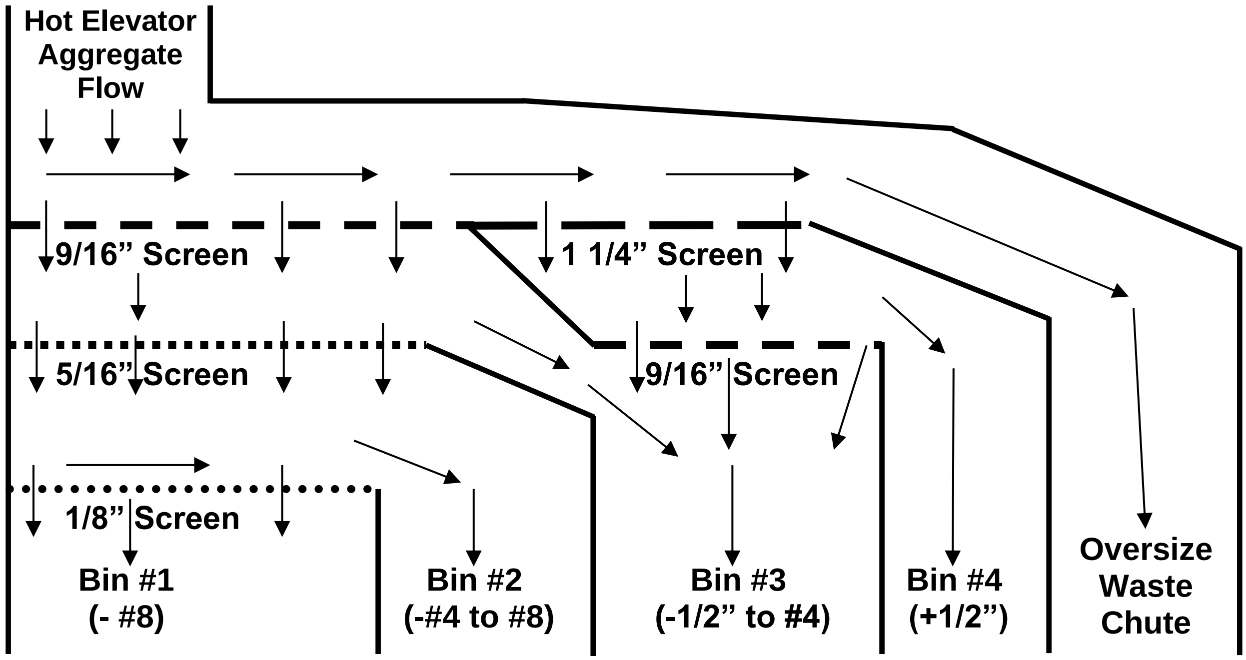
Excessive carryover, or its fluctuations, will be apparent to the technician from the sieve analysis made from the contents of the individual hot bins. Cleaning the screens, regulating the quantity of material coming from the cold feed, or combination of both may be required if conditions warrant to protect the screening efficiency.





Screen Decks

Aggregate Stream-flow for a Typical Batch Plant Screen Deck



10. Hot Aggregate Bins See Article 1102.01(b)(11)

The purpose of the hot bins is to separate the combined hot aggregates, taken from the dryer, into 3 or 4 fractionalized sizes (depending on the type of mixture) which is then proportionately put back together in the weigh hopper. The advantage of the batch plant over the dryer-drum plant is the fractionalization of aggregates gives better control of the gradation of the aggregates to meet the mixture gradation requirements. Dryer-drum plants have a distinct advantage over batch plants because of the extra time needed to separate the aggregates and recombine them. Another advantage of the dryer-drum plant is the extra equipment and maintenance required to perform this fractionalization of materials. These are two of a number of reasons why the dryer-drum plant is replacing the batch plant as the asphalt plant of choice by the industry. Currently, dryer-drum plants make up about 85% of the industry while batch plants come in with the remaining 15%.

Typical hot aggregate bin setups:

a) Surface mixtures use a three hot bin setup separating the combined aggregates into various sizes. Generally, the #3 bin will contain 1/2" to #4 size material, the #2 bin will contain #4 to #8 size material and the #1bin will contain #8 to #200 size material unless directed otherwise by the Engineer.

b) Binder mixtures use a four hot bin setup separating the combined aggregates into various sizes. Generally, the #4 bin will contain +1/2" size material, the #3 bin will contain 1/2" to #4 size material, the #2 bin will contain #4 to #8 size material and the #1 bin will contain #8 to #200 size material unless directed otherwise by the Engineer.

c) Although not common, when a five hot bin setup is used, the combined aggregate materials will separate into the following various sizes. Generally, the #5 bin will contain +1/2” size material, the #4 bin will contain -1/2” to 5/16” size material, the #3 bin will contain -5/16” to #4 size material, the #2 bin will contain - #4 to #8 size material and the #1 bin will contain -#8 to #200 size material unless directed otherwise by the Engineer.

Some issues with the hot bin system is size intermingling (contamination) caused by worn or damaged screens, plugged waste chutes, worn bin gates, holes worn in the bin walls or fines collecting in the bin corners (usually the #1 bin) and shortages or overruns of the bin levels. When intermingling of aggregate in the hot bin occurs, the mixture gradation changes, which can affect mixture attributes such as density and air voids. Routine sieve analysis of the aggregate in the hot bins will detect and confirm these issues. The attending plant technician, with experience, will learn to recognize contaminated hot bin samples

Aggregate size contamination can occur from worn or damaged screens allowing oversize materials into the wrong bins. Another form of bin contamination can be caused by plugged waste overflow chutes which allow material to cross over bin partition walls as a bin overfills with material. Because of this potential contamination of materials, each hot bin shall be equipped with an overflow pipe to prevent aggregate from backing up and overflowing into other bins. The overflow pipes shall not be connected to the boot of the hot elevator.

As the hot aggregates are discharged from each hot bin the plant computer and hydraulics control the doors of the hot bins. If these doors don’t close completely or wear out from normal use, the hot aggregates will continue to be released from the bin replacing other size of materials during the weighing process, which then will affect the gradation of the mixture, and in turn, affecting the density and air voids of the mixture. Another issue, which is discouraged, is the plant operator using manual controls to weigh up the individual hot bins, which can affect the mixture, if care is not taken to be as exact as possible with the required weights for each batch.

Because of the constant wearing and friction on the metal walls of the bins, holes can be created. A past practice, which is not allowed, is to cut holes in the bin partition walls to help keep the bins balanced. Both issues will allow material to pass from one bin into another, changing the gradation and mixture properties.

Sometimes material tends to hang up in the bin corners, usually with the finer fractions of the aggregates in the #1 hot bin. As the material falls into the #1 bin, the fines will build up into the vertical corners of the bin and eventually release into the weigh hopper into a batch of mixture. This will result in an excessive amount of fines, which tends to dry up the mix. This surge of fine material normally occurs when the bin material has been reduced to a low level. Welding fillet plates in the bin corners to eliminate the 90-degree angles can alleviate the condition.

If the aggregate materials coming into the plant are segregated, fine or coarse, this will create bin shortages or excesses and must be corrected proportionally by adjusting the cold feeds. This problem can be determined by excess material coming out the overflow chute or constantly waiting on material during the weighing process. To remedy this problem, the stockpiled aggregates need to be in the proper gradations matching the design and following the correct handling procedures of the aggregates established with the AGCS program while feeding material into the plant.

Another issue with a batch plant hot bins is when you change the type of HMA mixture, the plant hot bins should be emptied of all the material. Because of the different gradations of individual aggregate products and the unique combined gradation of the mixture, the hot bin gradations will be different for each type of mixture, especially when switching between surface and binder mixtures.

Hot Bin Sampling

Because the batch plant recombines the aggregates into a unique gradation and the fluctuations in the individual shelf gradations used in the mixtures, the Level 2 HMA technician needs to take and run gradations on the individual hot bins in order to control the mixture and determine gradation compliance with the mixture specifications.

Beginning of the Standard Specification Article 1102.01(b)(11) in part

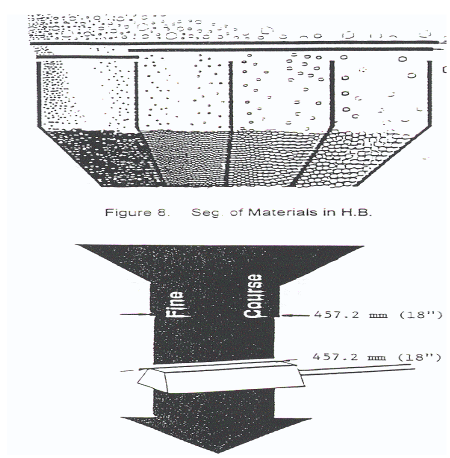
“(11)… Bins shall be so constructed that samples can be readily obtained…“

End of the Standard Specification Article 1102.01(b)(11) in part

Most modern HMA plants are equipped with devices for sampling hot bin aggregates. This will vary from sampling "gates" or "windows" in the sides of the bins, to devices for diverting the flow of aggregate from the bins into sample containers. In the case of batch plants, however, the best place to obtain a representative sample is from the bin gates as the material falls into the weigh hopper. It is essential that sampling facilities be constructed and located so that the samples obtained will be representative of the material in the bins.

Even though the hot bins are the best location to get representative samples, there can be problems. As the aggregates flow over the plant screens, finer particles fall through the screens first, followed by the coarser material. The finer gradation of material will fall to the near side of the bin while the coarser particles will fall to the far side of the bin, thus segregating the material. This is most apparent in the #1 bin but can happen in the other bins on certain types of mixes.

Correct use of sampling device



As the material is drawn from the bin into the weigh hopper the stream will consist of predominantly fine material at one edge and coarse material at the other. Therefore, the sample will be composed of the fine portion or the coarse portion of aggregates and will not represent the actual material being used in the mixture.

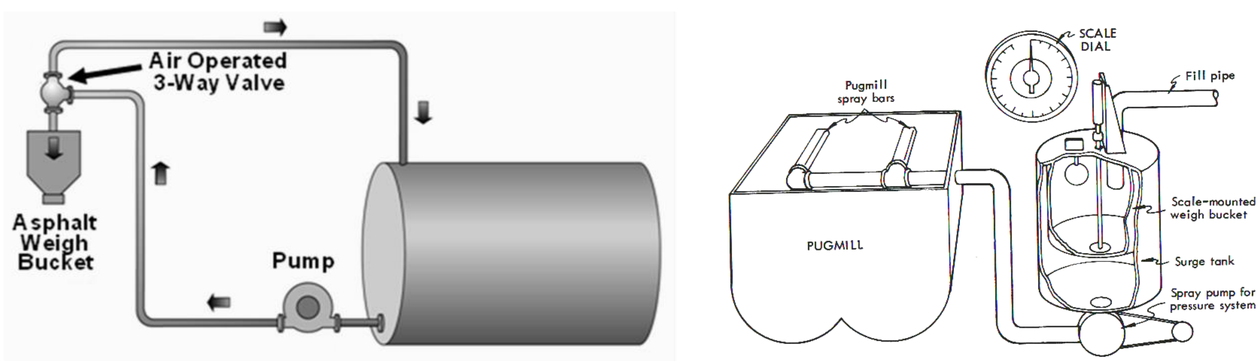
The hot bin sampling pan should be a minimum of 3" in depth. The width and length of the sampling pan shall be equal to the stream of the discharge of material.

Hot bin samples are taken to determine, by sieve analysis, the amount of aggregate needed from each bin to produce the combined gradation to meet the control target values. These samples shall be taken in accordance with the Department's procedures outlined in the “Initial Daily Plant and Random Sampling” document found in the Manual of Test Procedures for Materials. After the plant has been in operation a few days and the cold feeder setting and the hot bin weights have become well established, the hot bin samples shall be tested in accordance with Sampling Frequency requirements of the specifications. Additional hot bin check samples can be taken as a visual check for blanked or broken screens, which will require immediate corrective action.

11. <u>Liquid Asphalt Binders</u> See Article 1102.01(b)(5)

The liquid asphalt binders and storage requirements are the same for the batch plant as for the dryer-drum plant. The requirements can be found in the general information section in beginning of this chapter.

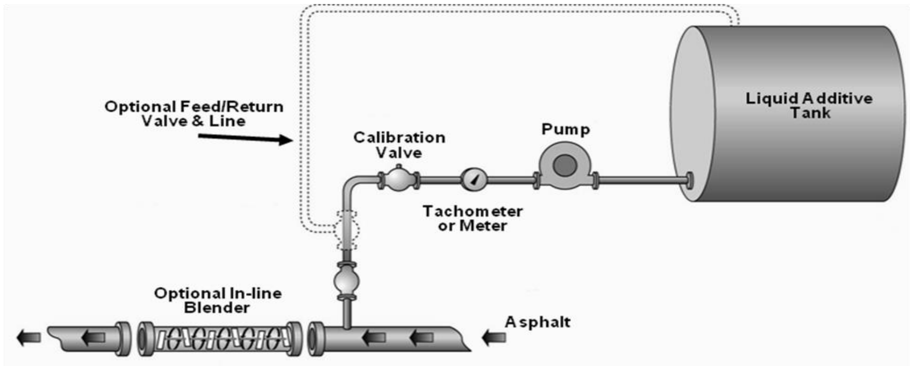
The one main difference for a batch plant is that a weigh bucket is used to determine the amount binder being incorporated into the mixture since the mixture ingredients are controlled by weights. Once weighed, the liquid asphalt binder is then metered or pumped into the pugmill. The binder is weighed as the same time as the weighing of the hot bin aggregates.



Typical Liquid Asphalt Pumping & Weighing System

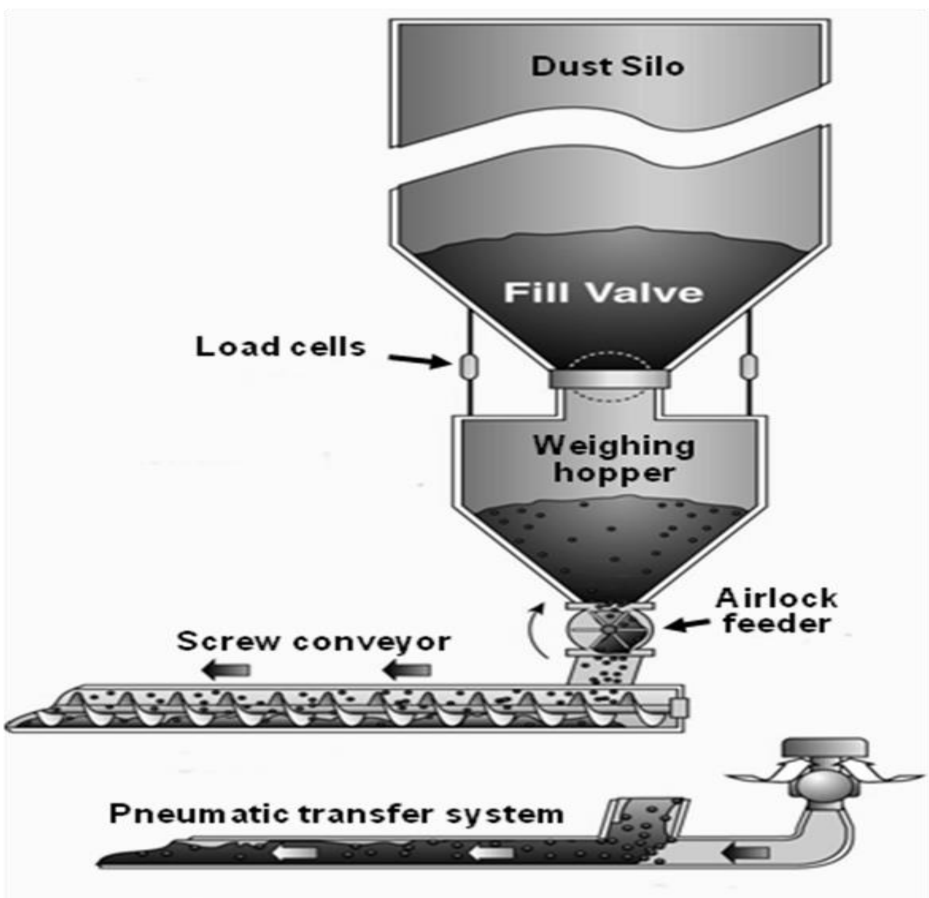
12. Anti-strip Additives

Anti-strip additives are the similar for a batch plant as for a dryer-drum plant.



13. Dust Collection System See Article 1102.01(b)(3)

The dust collection system is similar for a batch plant as for a dryer-drum plant.



14. Weigh Hoppers

See Article 1102.01(b)(2)

Since a batch plant controls the materials by weight then an emphasis is put on the weighing equipment to ensure proper proportioning of the ingredients. The two main weigh hoppers used in a batch plant is for aggregates and liquid asphalt binder.

Beginning of the Standard Specification Articles 1102.01(b)(2) in part

"(2) Equipment for Weighing or Measuring Aggregate/RAP/RAS. The equipment shall include a means for accurately weighing each size of aggregate/RAP/RAS in a weigh hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the pugmill mixer while a batch is being weighed.…"

End of the Standard Specification Article 1102.01 (b)(2) in part

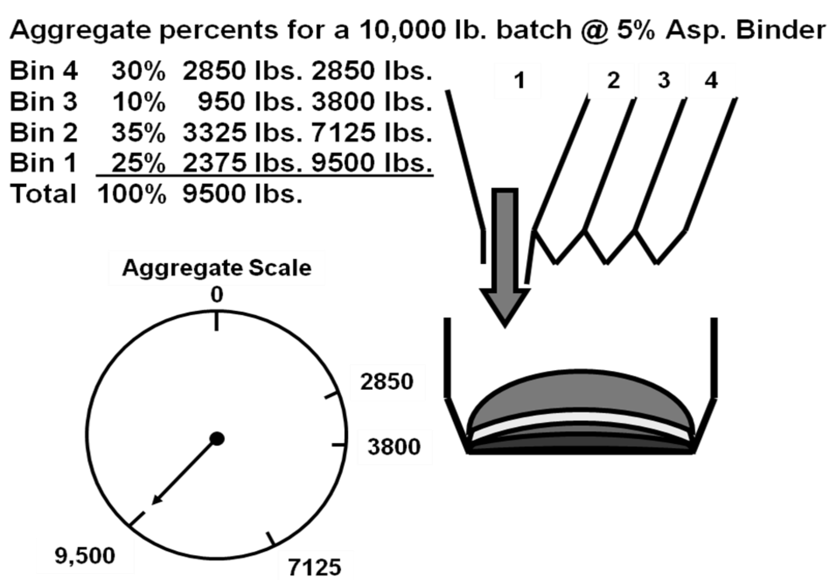
Beginning of the Standard Specification Article 1102.01 (b)(5) in part

"(5) Equipment for Weighing or Measuring Asphalt Binder. The equipment used for weighing or measuring the asphalt binder shall consist either of an approved weigh bucket or metering device…"

End of the Standard Specification Article 1102.01 (b)(5) in part

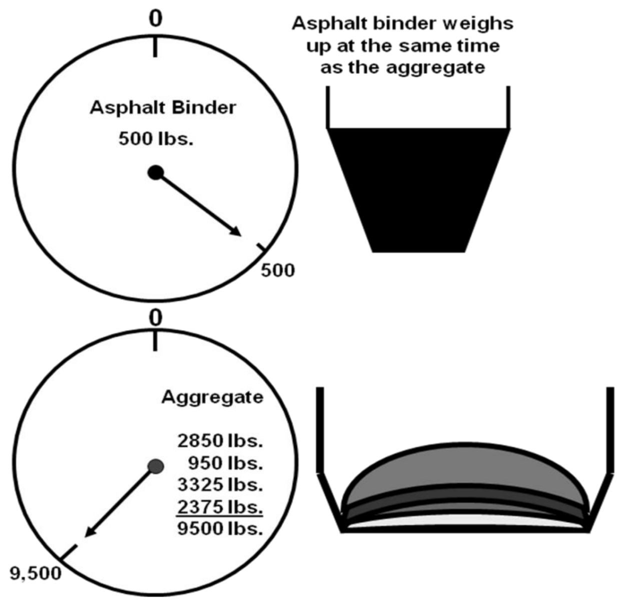
Aggregate Weigh Hopper

The aggregate weigh hopper is located directly below the hot bins, which consists of an approved weigh box or hopper that is to be suspended on scales of ample size to hold a full batch. The gates of the hot bins shall close tightly so that no material is allowed to leak into the mixer while the batch is being weighed.



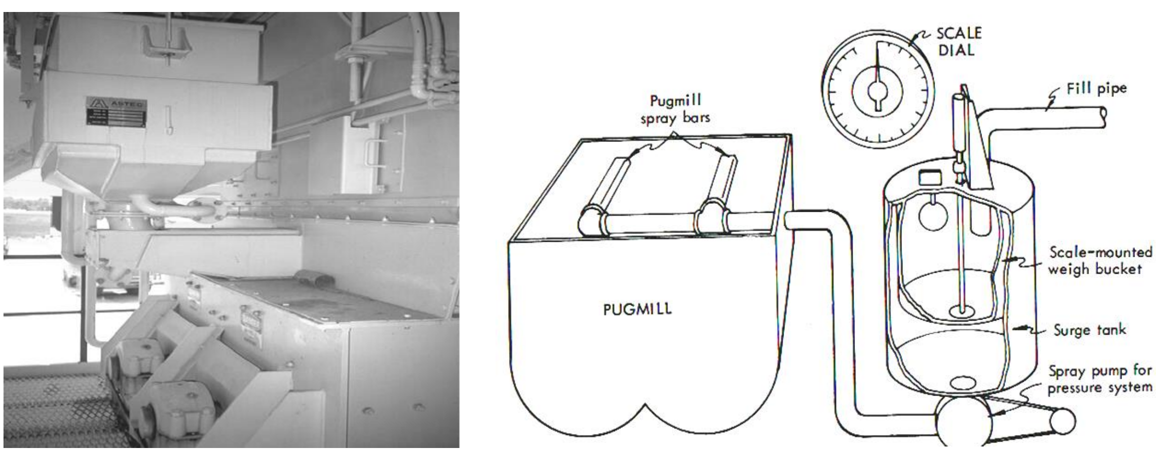
Batching Process

After the ‘graded’ material falls into the respective hot bins, it is then discharged into the aggregate weigh hopper located directly below the hot bins. The hot bins are individually discharged into the weigh hopper starting with the largest aggregate and concluding with the smallest (finest) sized material. The materials are discharged to a pre-determined accumulated weight. If mineral filler, RAP or RAS is to be added to the batch, they are typically added into the aggregate weigh hopper at the end of the weighing process. Also, as the aggregates are being batched, the liquid asphalt binder is being weighed into an “asphalt weigh bucket” to a predetermined weight.



Liquid Asphalt Binder Weigh Hopper

The asphalt binder weigh hopper shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and completely suspended from a springless dial scale or load cell.



Binder Weigh Bucket System

Scale Calibration

Specifications stipulate any material paid for by weight, with federal, state or local agency funds, require the weighing devices to be properly calibrated by an approved testing agency. The Quality Control Manager and/or Level 2 HMA technician must acquaint themselves with the applicable provisions of Section 1102 of the Standard Specifications. Scales will be a springless dial type complying with the requirements of Article 1103.02(c) of the Standard Specifications. Load cells with digital readouts may be used if approved by the Engineer.

Weigh hoppers and scales shall be provided with suitable protection from the wind and the accuracy and sensitivity of each weighing device shall then be checked to the full weight of any batch that will be used. The specifications require that the contractor furnish ten standard 50-pound weights for this purpose. It is also acceptable for the test weights to be furnished by a recognized commercial scale repairman. The calibration of the scales shall be done in the presence of the Engineer or his authorized representative.

Beginning of the Standard Specification Article 1102.01(b)(6) in part

"(6) Accuracy of Scales. The scales shall meet the requirements of The Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to ensure their continued accuracy Ten standard 50 lb (25 kg) weights meeting the requirements of NIST shall be available at the HMA plant for use in calibrating and testing the weighing equipment. The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net weight (mass), on truck scales, of a truck load of HMA."

End of the Standard Specification Article 1102.01(b)(6) in part

Once the scales have been calibrated and determined to be accurate, a scale check is performed on the weigh hopper(s) to insure continued accuracy. Before the start of any scale check, the scales should be carefully cleaned and inspected for any issue that could cause inaccuracy and/or loss of sensitivity. The scale shall first be balanced with the hopper empty and no load. Then the standard weights, mentioned previously, are placed on the scale one at a time and documenting the reading matches the applied weights.

When using a metering system the metering devices shall be calibrated in accordance with instructions given a dryer-drum plant operation.

Scale head

15. <u>Pugmill Mixer</u> See Article 1102.01(b)(7)

<u>Beginning of the Standard Specification Article 1102.01(b)(7) in part</u>

"(7) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances....The mixer shall be heated by an approved method and shall have a capacity of not less than 2,000 lb. (905 kg)… The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer…"

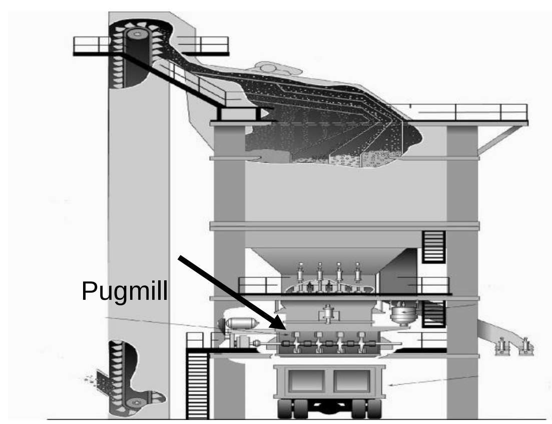
<u>Beginning of the Standard Specification Article 1102.01(b)(7) in part</u>

The pugmill is the unit that mixes the hot dry aggregates and liquid asphalt binder. The mixer is required to be a heated, twin-shaft unit mixing a minimum of 1 ton of material up to the rated maximum capacity. The pugmill will be interlocked with the hot bin gates, the weigh hoppers and the exit door to ensure no material enters or leaves during the mixing operation.

After the weighing of the aggregates, including mineral filler, RAP and/or RAS (if used), the aggregates will drop into the pugmill to start the mixing process. Since the hot bin materials were fractionalized into different sizes, the pugmill will "dry mix" the aggregates for a minimum of 10 seconds to ensure a uniform gradation. Once the aggregates are dry mixed, the "wet mixing" period starts and the liquid asphalt binder is injected into the pugmill. The wet mixing period will last a minimum of 35 seconds to ensure proper coating of the aggregates. If needed, the mixing times can be increased in the case of coating or mixing issues.

One problem when using RAP or RAS materials is that these materials are at a colder temperature than the hot bin aggregates so adjustments to mixing time and mix temperature is needed to make sure these ingredients break down and mix properly with the heated aggregates. The minimum dry and wet mixing time is a total of 45 seconds but can be increased to ensure a consistent mixture. In order to use RAP and/or RAS materials, the hot bins aggregates need to be "super-heated" to off-set the loss of temperature caused by the cold, damp recycled materials. This subject is covered in more detail in chapter 4 of this manual.

Pugmill Mixer



Pugmill Mixer Location

Weigh Check Information

Per IDOT specification, any material paid for by weight is required to be weighed for verification on approved certified scales. The following is information on documenting pay quantities based on weigh tickets and is found in the IDOT "Documentation of Contract Quantities, FY 2020:

Beginning of the IDOT "Documentation of Contract Quantities, FY 2020 (page A-21)

Pay quantities established based on truck weight tickets are not directly measured by Department representatives. For this reason, the following steps are taken to ensure that the quantities shown on the weight ticket are accurate:

1. *The total weight of a truck cannot be obtained by adding separate axle weightings (see Obtaining Tare and Gross Weights of Trucks below).*

2. *The scale must be checked by the Department of Agriculture (DOA). In accordance with the DOA's Bureau of Weights and Measures Inspection Program, permanent scales are to be checked during each period of 12 months, which means that the scale is inspected at sometime within each calendar year. Temporary scales are to checked at each setup. A check by a DOA-approved commercial scale company will be acceptable if the DOA is unable to provide a current inspection. The date on the decal, identification number on the decal and location of the scale shall be recorded in the Quantity Book.* ***No payment is to be made for items measured on an unapproved scale.***

3. *A State representative is to be at the scale to witness the weightings and initial the tickets. This requirement may be waived under certain conditions (see Daily Tare Weights, Automatic Ticket Printers, Weekly Independent Weight Checks, and Small Quantities).*

4. *Every effort should be made to personally collect and initial the delivery tickets for tonnage pay items, however, the inspector is only to initial those tickets that he/she personally collects. A memorandum should be written to the contract file explaining why the inspector was not present in witnessing the delivery material. A daily yield check should be conducted to justify the total amount placed.*

For certain materials, a correction factor is to be applied to the pay quantity shown on the tickets (see Aggregate Moisture Correction and Agricultural Ground Limestone Correction).

Obtaining Tare and Gross Weights of Trucks

All materials, which are paid for on the basis of truck weights, shall be weighed in accordance with the following procedure. Reference for this procedure is the Illinois Weights and Measures Act, which refers to the National Bureau of Standards Handbook 44.

"A vehicle or a coupled vehicle combination shall be commercially weighed on a vehicle scale only as a single draft. That is, the total weight of such a vehicle or combination shall not be determined by adding together the results obtained by separately and not simultaneously weighing each end of such vehicle or individual elements of such coupled combination. However:

(a) The weight of a coupled combination may be determined by uncoupling the various elements (tractor, semi-trailer, trailer), weighing each unit separately as a single draft, and adding together the results, or

(b) The weight of a vehicle or coupled-vehicle combination may be determined by adding together the weights obtained while all individual elements are resting simultaneously on more than one scale platform."

Daily Tare Weights

(Example, page F-37) To determine the pay weight of material delivered by truck, both gross and tare weights must be measured. Ordinarily, both measurements are to be witnessed by a representative of the Department. Frequently, however, the contractor's or suppliers loading operations make two separate weightings for each truck burdensome. For this reason, the Department permits the tare weights of each truck to be measured a minimum of once each day, and the measured tare weight of each is then to be used for the remainder of the day.

When daily tare weights are used, the inspector is to witness and record the tare weights for each truck used in that day's supply operation. The inspector's record must identify each truck, the tare weight of the truck, and whether the driver was in the truck during the measurement. Form BC 1465, Report of Truck Tare Weights, is available for this use. (See Small Quantities)

Weight Checks

A weight check is a comparison of the net weight of material shown on the delivery ticket to the net weight measured on another scale. The purpose of a weight check is to give some assurance that the amount of material paid for, as shown on the delivery tickets, is the amount of material delivered to the job site.

For HMA tonnage items, contractors determine the shipping weight either by direct weighing or by using the nominal batch weights. The Standard Specifications require that scales used to measure HMA mixtures be equipped with automatic printers (Art. 1102.01(a)(7)). For batch plants the specifications also allow the use of the batch weights, instead of direct scale measurement, when surge or storage bins are not used. There are three types of weight checks described in the following sections, one for weekly Independent Weight Checks, and two types (which should be alternated) for ticket weights determined from batch weights. All three types require reweighing the net weight of the material on the selected truck. The difference between them is the source of the weight for comparison with the independent scales.

QC Checks by Contractor

On HMA QC/QA contracts, the contractor is also required to perform scale checks and independent weight checks as part of the QC process. Scale checks performed by the contractor are for the purpose of ensuring the accuracy of the scale equipment. The procedures used by the contractor are the same as used by state representatives for performing the three types of weight checks described in the section above, except the contractor may use the approved platform scales at the plant site or a commercial scale approved by the Engineer. The plant scale must not be the scale used for the original *measurement, but may be owned or controlled by the contractor or material supplier. QC checks performed by the contractor do not satisfy the requirement for independent weight checks to be performed by Department personnel.*

Automatic Ticket Printers

Article 1102.01 (a)(9) defines an automatic ticket printer as follows:

"The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights except as provided in a, below.

- *a. If the platform scale equipment measures gross weight (mass), the printer will record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.*
- *b. If scale equipment on a platform scale zeros out the truck tare as a minimum.*
- *c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.*
- *d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum."*

For any weights recorded by an automatic ticket printer, no inspector will be required to witness the weighing and initial the ticket at the scale location. If tare weights or net weights are not automatically measured, then an inspector must still witness and record the tare weights (see Daily Tare Weights).

Weekly Independent Truck Weight Check/Action Report (Example pages, F-38-40)

A weekly random check must be performed by a State (or Local Agency and QC) representative to verify the actual weight of material delivered. Independent weight checks are to be performed as follows:

1) *The check weights will be measured on an independent, approved platform scale other than the scale on which the original measurement is performed and not owned or controlled by the contractor or material supplier. The independent scale must be approved, and the DOA decal information is to be recorded on the <u>BIC 2367</u>.*

2) *Trucks are to be selected after leaving the plant, preferably at the paving location. Inspections should be unannounced and randomly scheduled. Under no circumstances should the inspector report to the plant and request a truck be loaded for an independent weight check.*

3) *Gross and tar weights must be measured and recorded, so that the actual net weight of material can be determined. Ensure the independent scale has been zeroed prior to determining both the gross and tare weights.*

4) *The independently measured net weight must agree with the weight shown on the tickets within a tolerance of 0.5 percent (HMA) 0.7 percent (aggregate):*

Tolerance (%) = (delivery ticket net wt – weight check net wt) X 100 / (weight check net wt)

5) *The RE and contractor shall be provided a copy of the BIC 2367. The information shall also be reported to the District office which in turn inform any other RE being supplied from the same producer. The independent weight check results are to be recorded and placed in the job file available for inspection, with corrective action taken for deviations from tolerance noted.*

6) *If the independent weight check results are not within tolerance, at the contractor's request, the empty vehicle may be reweighed on a second independent approved scale. The three empty weights will be analyzed to determine the validity of the independent weight check.*

7) *Independent weight checks must be performed at least once per week per scale (this includes any scale and batch weights) when any item is placed for which payment is based on weight tickets. If the same scale is used for several contracts during the week, a weight check performed for any one of the contracts will be sufficient for all of the contracts, as long as a copy of the check is included in the records for each of the projects. (See Small Quantities)*

8) *The contractor must respond to the Engineer, in writing, within 7 calendar days as to the cause and correction of the deficient scale.*

Note:

a.) *The DOA performs maintenance checks of scales that have current decals. If a scale is out of tolerance a red tag is used and the scale is not usable. The scale cannot be used during the time it has a red tag.*

b.) *The Office of Quality Compliance and Review (BIC) is conducting random independent weight checks utilizing statewide independent scales. When an independent weight check is performed by BIC, the Resident can utilize the weight check to satisfy the weekly independent weight check requirement outlined above.*

(See Article 109.01 for additional instructions)

Documentation for Payment of Bituminous Mixtures Based on Batch Weights

The Specifications provide for measurement of the mixtures by either weighing the mixtures on approved platform scales or on the basis of plant batch weights. When measured on the basis of plant batch weights, occasional checks shall be made by weighing full truckloads of the mixture on the approved platform scale at the plant site, or on a commercial scale approved by the Engineer.

This check serves two purposes:

- *(a) To check the accuracy of the scales, either batch, surge bin or the platform scales; or*
- *(b) The accuracy of batching the mixture.*

The frequency of check weighing should be a minimum of one per week; however, when the plant is in continuous daily operation, the frequency preferably should be one per day.

The accuracy of the scales should be checked by observing the actual scale weight of the batches produced and comparing the total with the net weight of a truck load from the platform scale. Variation between these weights of more than 0.5 percent would indicate the batch scales or the platform scales should be checked by the Illinois Department of Agriculture.

Scale Accuracy Check *(0.50%Tolerance)*

1. *Tare a truck on an approved platform scale* *15000 lbs*

2. *As you observe the scale dial stopping on or near the preset scale face marker, record the actual accumulative aggregate weight. Add in the mineral filler and paving asphalt weights.*

   3979.0
   3951.0
   4149.0
   3960.0
   4101.0
   4149.0
   24,289 lbs

3. *Gross the truck on the platform scale.* *39,401 lbs*

$$\text{Tolerance, } 0.50\% = \frac{\text{net wt. (3-1) - Summation of weighed batches}}{\text{net wt. (3-1)}} \times 100$$

$$= \frac{24{,}401 - 24{,}289}{24{,}401} \times 100$$

$$= 0.46\% \text{ O.K}$$

Scale Accuracy Check Class Problem

Truck tare weight (item 1 above) **22,100 lbs.**

Observed weights (item 2 above)

10,020
10,000
10,040
30,060 lbs

Gross truck weight (item 3 above) **52,320 lbs.**

Net weight ________ **lbs.**

Scale Accuracy Percent ________ **%**

The accuracy of batching the mixture should be randomly checked with the batch weights compared to the platform scales. The results, with an allowance for accuracy in weighing, should be checked within 0.5 percent of the gross load on the platform scale. If batch weights vary more than 0.5 percent, the batch scales should be recalibrated.

Batching Accuracy Check (0.50%Tolerance)

1. *On an approved platform scale, weigh a random truck after it has been loaded.* — *37,840.0 lbs*
2. *Empty it on the job.*
3. *Tare the returning truck on the platform scale* — *14,191.0 lbs*

Actual net weight = 23,649.0 lbs

4. *Record load ticket =* — *24,000.0 lbs*

Tolerance, 0.50% $= \dfrac{\text{load ticket (4) - act. net wt. (1-3)}}{\text{act. net wt. (1-3)}} \times 100$

$= \dfrac{24{,}000 - 23{,}649}{23{,}649} \times 100 = 1.48\%$

Recheck and/or recalibrate scales

Batching Accuracy Check Class Problem

Given information:

Gross truck weight	**(item 1 above)**	**52,140 lbs.**
Truck tare weight	**(item 3 above)**	**21,640 lbs.**
Load ticket weight	**(item 4 above)**	**30,400 lbs.**

Net weight ___________ **Batching Accuracy Percent** ____________

The Specifications also require the batch scales to be calibrated at the beginning of each construction season and at other times as deemed necessary by the Engineer. The accuracy certification will be by the Department of Agriculture.

The calibration and check weighing results are to be recorded and placed in the job file available for inspection with corrective action taken for deviations from tolerance noted.

Each of the above checks can be run on alternate occasions. Report these accuracy checks on Form MI 305, Bituminous Daily Plant Output (Contractor), or form BIC 2367, Independent Weight Check, (Agency), or other methods using the above format. Results shall be placed in the job file.

End of the IDOT "Documentation of Contract Quantities, FY 2020 (page A-25)

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

Subject:
Independent Weight Checks and Scale Checks

CONSTRUCTION MEMORANDUM 00-08

Effective: ***October 1, 2000***
Expires: ***Indefinite***

This Construction Memorandum supersedes Construction Memorandum No. 00-08 effective April 1, 2000. This outlines the Department's Policy for the performance of independent weight checks for pay items where the method of measurement for payment is based on weight.

WEIGHT CHECKS

The Documentation Section of the Construction Manual outlines three types of weight checks which must be performed by state (or Local Agency) representatives. They include one for weekly Independent Weight Checks, and two types (which should be alternated) for ticket weights determined from batch weights.

The weekly Independent Weight Check will be documented on form BC 2367. A copy of the form BC 2367 (performed by Department personnel) will be forwarded to the Central Bureau of Construction and the Office of Quality Compliance and Review.

The two weight checks for batch plants may be reported on 1) the Bituminous Daily Plant Output Report form MI-305 or 2) the Independent Weight Check form BC 2367 or 3) other methods using the format described in the Documentation Section of the Construction Manual. Results shall be placed in the job file. Do not forward copies to the Central Bureau of Construction nor the Office of Quality Compliance and Review.

QC CHECKS BY CONTRACTOR

The Documentation Section of the Construction Manual outlines the Scale checks which must be performed by Contractors as part of the QC process on QC/QA contracts. The Scale Checks will be documented on form BC 2367 and/or the Bituminous Daily Plant Output Report. ***Copies of QC Checks by the Contractor should not be forwarded to the Central Bureau of Construction nor the Office of Quality Compliance and Review.***

Gary Gould
Engineer of Construction

Eric E. Harm
Engineer of Materials & Physical Research

Special HMA Problems

a) Extreme Mixture Temperatures

Regardless of precautions, the plant operator may at times lose control of the heating of the aggregates with the result that the mixture discharged is either extremely hot or cold. It is important that the Quality Control Manager and/or Level 2 HMA technician knows how to proceed under such circumstances.

Extremely high temperatures usually occur at the start of the operations and the Quality Control Manager and/or Level 2 HMA technician shall endeavor to be on hand to observe the first few batches discharged and to take the temperature of the mixture. The experienced Quality Control Manager and/or Level 2 HMA technician is able to spot the extremely hot batches from blue smoke rising from the mix. Often the first batch will be too hot and the second cooler, in which case the temperature probably will drop back to normal. However, if the second and third batches are also hotter than the maximum permitted, it is probable that the bins contain considerable amounts of overheated aggregates. In such event, the mixing shall be stopped and the overheated aggregates shall be drawn from the bins, discharged through the mixer into trucks. This is termed "pulling the bins". The overheated batches of mix shall be discarded.

Cold batches also usually occur at the start of the operations and, like the extremely hot batches, are the result of erroneous judgment by the plant operator in setting the valves controlling the amount of heat applied in the dryer. Cold batches can be detected by a rather grayish color of the mixture, caused by the larger pieces of the aggregate not having become completely coated with asphalt binder. If the coarse aggregate particles in the first batch are seriously uncoated and the mixture is very cold, the mixing shall be stopped and the bins pulled. If the uncoated condition is only slightly apparent in the first batch, and if the temperature of the mixture is near the minimum permitted, the wet mixing time shall be lengthened to one minute, or more if necessary, to obtain proper coating. After the temperature set by the Engineer is reached, the normal mixing time may be used.

The use of batches having temperatures outside the limits set by the specifications is not allowed. If the Quality Control Manager and/or Level 2 HMA technician, by being alert and by having knowledge of just what to do, is able to aid the plant operator in the production of a satisfactory mixture, confidence in his judgment will result, and his decisions are not likely to be seriously questioned.

b) Flushing of Mixture in Trucks

Foaming of the asphalt binder as it comes into contact with aggregates not sufficiently dry causes flushing of the mixture when it is discharged into trucks. It is characterized by a sloppy foaming appearance of the mixture with the asphalt binder coming to the top. This difficulty is ordinarily experienced only in an IL-19.0 mixture, because the coarse aggregate particles are larger than in the case of an IL-9.5 mixture and are, therefore, more difficult to dry. The situation is aggravated by any condition tending to make the drying more difficult, such as rain or cold weather.

Sometimes the use of higher temperatures will dry the aggregate and stop the flushing, but may in other instances have the effect of increasing its severity. The most satisfactory remedy is to remove more moisture from the aggregates by having the contractor slow down the feed of material through the dryer. The revolutions of the dryer may be reduced to seven or eight per minute, or its slope or pitch may be reduced. Most dryer-drums have a slope of 1" to 1 1/4" per foot, and any slope steeper than that is likely to cause problems, especially when combined with a fast rate of turning (improperly coated aggregates, etc.).

Another flushing condition is when the hot HMA mixture is discharged into a truck bed and comes in contact with standing or puddled water. Upon contact with the hot HMA material, the water will quickly vaporize, turning into steam which then will wash or strip the asphalt binder from the aggregate materials. This is evident by puddling of the asphalt binder in the truck bed.

c) Flushing of Compacted Mixture on Road

Flushing of the compacted mixture is entirely different from flushing in the trucks, though the same term denotes both. A mixture, creating this condition, is often referred to as being "rich" or "fat". This situation usually occurs with surface mixtures (IL-9.5) and is characterized by a shiny oily appearance on the compacted mixture which is due to a thin film of asphalt binder rising to the surface. This can be caused by an excess of asphalt binder in relation to the voids in the mixture, and is corrected either by reducing the asphalt binder content of the mixture or by increasing the percentage of material passing the # 8 sieve.

d) Texture of Compacted Surface Course Mixture

Experience has shown that the desired surface texture is obtained when the mixture contains between 28 and 40 percent of the aggregate passing the # 8 sieve. A mixture containing less than 28 percent is termed "open", and a mixture containing more than 40 percent is termed "closed" or "tight". Sometimes there seems to be a point where the compacted mixture takes on a spotty appearance, part of it being open and part of it being closed. This may be avoided by decreasing the percentage of aggregate passing the # 8 sieve.

e) Intermixing of Aggregates in Bins (Batch Plant)

If hot bin samples indicate that any bin contains an undue quantity of a material belonging in some other bin, check [Section 1102.01 (b)(10) of the Standard Specifications] to determine if intermingling is excessive.

The Plant Superintendent should be notified of this condition and it should be corrected as soon as possible. If the intermingling is not excessive and can be controlled by proportioning, the work can continue and repairs made after the plant has stopped production for the day.

The following could be causes for this intermingling of aggregate sizes:

Fine Aggregates in Larger Aggregate Bins

a) Overloading or feeding material too fast and carrying finer material into the larger aggregate bins.

b) By having a clogged or blinded screen, which does not allow the fine material to pass through.

c) By having a hole in the partition between the bins.

d) By the overfilling of the fines bin which allows the material to spill over the top of the divider plate.

Large Aggregate in the Sand Bin

a) An oversize sand screen.

b) A hole in the screen.

c) A hole in the partition between the bins.

f) Errors in Batching

It happens occasionally that even an experienced mixer operator makes a mistake and discharges a batch without asphalt binder, commonly known as a "white batch", or a batch containing asphalt binder and no aggregate or only a part of the aggregate. Most plant operators, if able to look into the truck from where they work, usually will notice any mistake of this kind and take steps to correct it.

Otherwise, the Quality Control Manager and/or Level 2 HMA technician shall inform the operator, and the mixing shall be discontinued until the truck containing the defective HMA batch is removed and another takes its place. At the contractor's option, the defective HMA batch either shall be shoveled from the load or the entire load discarded. In the event that asphalt binder alone is discharged into the truck, it is necessary not only to discharge the asphalt binder from the truck but also to clean the truck bed completely. Otherwise a part of the next load transported in this truck will contain too much asphalt binder and soft flushed spots will occur on the finished HMA pavement surface.

g) Other Problems

If the mixer gate leaks asphalt binder or aggregate during the mixing operations, the contractor shall repair it immediately. This condition usually is easily corrected and shall not be tolerated. Excessive dripping of water from the plant into the mixture in the trucks shall not be permitted.

Any unusual problems arising shall be brought to the attention of the Resident Engineer, District Bituminous Supervisor, or District Materials office.

TABLE A-4 – POSSIBLE CAUSES OF DEFICIENCIES IN HMA PLANT-MIX PAVING MIXTURES

Types of deficiencies that may be encountered in producing hot plant-mix paving mixtures.	Aggregates Too Wet	Inadequate Bunker Separation	Aggregate Feed Gates Not Properly Set	Over-rated Dryer Capacity	Dryer Set Too Steep	Improper Dryer Operation	Temp. Indicator Out of Adjustment	Aggregate Temperatures Too High	Worn Out Screens	Faulty Screen Operation	Bin Overflows Not Functioning	Leaky Bins	Segregation of Aggregates in Bins	Carryover in Bins Due to Overloading Screens	Aggregate Scales Out of Adjustment	Improper Weighing	Feed of Mineral Filler Not Uniform	Insufficient Aggregates in Hot Bins	Improper Weighing Sequence	Insufficient Asphalt Binder	Too Much Asphalt Binder	Faulty Distribution of Asp. Binder to Aggregates	Asphalt Binder Scales Out of Adjustment	Asphalt Binder Meter Out of Adjustments	Undersize or Oversize Batch	Mixing Time Not Proper	Improperly Set or Worn Paddles	Faulty Dump Gate	Asp. Binder and Agg. Feed Not Synchronized	Occasional Dust Shakedown in Bins	Irregular Plant Operation	Faulty Sampling
Asp. Binder Content Does Not Check JMF			A												B	B				A	A	A	B	C	B	B	B		C			A
Aggregate Gradation Does not Check JMF		A	A						B	B	B	B	A	A	B	B	B	A							B		B	B	C	B		A
Excessive Fines in Mix		A	A							B	B	B	A	A	B	B	B	A							B	B			C	B		A
Uniform Temperatures Difficult to Maintain	A			A	A	A	A	A																							A	
Truck Weights Do Not Check Batch Weights												B		B	B										B							
Free Asphalt Binder on Mix in Truck															B	B					A	A	B	C	B		B		C			
Free Dust on Mix in Truck																			B									B				
Large Aggregates Uncoated	A			A	A	A	A													A		A	B	C	B	B	B		C		A	
HMA Mixture in Truck not Uniform										B	B	A	A	A	B	B	B	A	B			A	B	C		B	B	B	C	B	A	
HMA Mixture in Truck Fat on One Side																			B			A			B	B					A	
HMA Mixture Flattens in Truck						A																A	A	B	C	B			C		A	
HMA Mixture Burned			A			A	A	A																							A	
HMA Mixture Too Brown or Gray	A			A	A	A	A			B				A						A			B	C	B				C		A	
HMA Mixture Too Fat															B	B	B	A			A	A	B	C	B				C		A	
HMA Mixture Smokes in Truck						A	A	A																							A	
HMA Mixture Steams in Truck	A			A	A	A	A																								A	
HMA Mixture Appears Dull in Truck						A	A	A											A											A	A	

A – Applies to Batch and Drum Mix Plants. B – Applies to Batch Plants only. C – Applies to Drum Mix Plants only.

<u>Beginning of the Standard Specification Section 1102 (Hot-Mix Asphalt Equipment)</u>

"SECTION 1102. HOT-MIX ASPHALT EQUIPMENT

1102.01 Hot-Mix Asphalt Plant. *The hot-mix asphalt (HMA) plant shall be the batch-type or dryer drum plant. The plants shall be evaluated for prequalification rating and approval to produce HMA according to the Bureau of Materials Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment". Once approved, the Contractor shall notify the Bureau of Materials to obtain approval of all plant modifications. The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements.*

(a) Requirements for All Plants. All HMA plants shall be according to the following.

(1) General. The plant shall be approved before production begins. All HMA plants shall be capable of producing HMA within the specification tolerances for gradation and asphalt binder content. The plant owner shall be responsible for demonstrating this capability through a production and testing program defined by the Bureau of Materials Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment". If the plant fails to maintain this capability, the Department may require the demonstration to be repeated at any time. Failure to maintain the capability may result in loss of plant approval status. Accessibility to the top of truck beds shall be provided by dual platforms or other suitable device to enable the Engineer to obtain samples and mixture temperature data.

For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general not vary more than 20 °F (10 °C) for each mix type being produced. In all cases, the mix temperature shall not be more than 350 °F (180 °C) or less than 250 °F (120 °C). Wide variations in the mixture temperature of successive loads may be cause for rejection of the HMA.

During the drying process, the moisture content of the aggregate shall be reduced such that the moisture content of the HMA at time of discharge from the mixer will not exceed 0.3 percent. For certain aggregates such as air-cooled blast furnace slag, and other highly absorptive aggregates, special handling and treatment such as double drying may be required.

Whenever a HMA plant is being used to produce mixtures as defined in Article 1030.01, all hot bins shall be emptied and all aggregate in the dryer and on all collector conveyors shall be removed prior to starting production or resuming once production has been interrupted for the purpose of producing a different mixture.

(2) Storage Facilities. The plant used in the preparation of the HMA shall be located where it will have adequate storage and transportation facilities. Sufficient space shall be provided for separate stockpiles of each gradation, source, and quality of aggregate required. If necessary to prevent the intermixing of the different materials, or if stockpiles join together, suitable partitions shall be used between adjacent stockpiles. All aggregates shall be kept separated until they are fed in their proper proportions onto a belt conveyor or into the boot of the cold aggregate elevator. The aggregates shall be handled in such a manner as to prevent contamination, degradation and segregation.

(3) Aggregate/RAP/RAS Bins and Feeders. The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) used, in the proper proportions so that uniform production and uniform temperature will be obtained. A minimum of four bins and feeders for aggregate will be required. If RAP is used, one additional bin and feeder will be required for each RAP fraction used. If RAS is used, one additional bin and feeder will be required. The bins shall be designed to prevent overflow of material from one bin to another. If any of the materials used in preparing the mixture become intermixed in a bin compartment, the compartments hall be emptied and the intermixed material shall not be used. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked. Each bin shall have a cutoff system that shall automatically stop the HMA production when any bin becomes empty. All feeders shall be calibrated to the desired volumes and/or weights for each material/mixture, to the satisfaction of the Engineer. This calibration may require plant modification. The controls of the total quantity of combined materials fed to the dryer shall be by a variable speed system. Other methods may be approved by the Engineer. When the proportioning gates of the feeders are once set for proper blending, they shall be locked or bolted securely and their positions shall not be changed unless directed by the Engineer.

(4) Dust Collection. The plant shall be equipped with a primary dust collector, approved by the Engineer, connected to a secondary dust collector (baghouse or wet-wash).

a. IL-4.75. For mixture IL-4.75 mineral filler and collected dust (baghouse) shall be proportioned according to the following.

1. Mineral filler shall not be stored in the same silo as collected dust (baghouse).

2. Additional minus No. 200 (75 µm) material needed to meet the Job Mix Formula (JMF) shall be manufactured mineral filler, unless otherwise approved by the Engineer.

3. Collected dust (baghouse) may be used in lieu of manufactured mineral filler according to the following.

(a.) Sufficient collected dust (baghouse) is available for production of the IL-4.75 mixture for the entire project.

(b.) A mix design was prepared based on collected dust (baghouse).

4. A combination of collected dust (baghouse) and manufactured mineral filler may be used according to the following.

(a.) The amount (proportion) of each shall be established and not varied.

(b.) A mix design was prepared based on the established proportions.

b. Stone Mix Asphalt (SMA). SMA shall be according to the following.

1. Mineral Filler. When producing SMA, the mineral filler system shall accurately proportion the large amounts of mineral filler required for the mixture. Alteration or adjustment of the current system may be required. Mineral filler shall not be stored in the same silo as collected dust.

2. Dust collected during the production of SMA may be returned to the SMA mixture. Additional collected dust (baghouse) may be used in lieu of manufactured mineral filler according to all of the following.

(a.) Sufficient collected dust (baghouse) is available for the entire project production of the SMA mixture.

(b.) A mix design was prepared based on collected dust (baghouse).

(c.) Approval of the Engineer.

(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be eight hours unless longer retention time is authorized in writing by the Engineer. The bin(s) shall be insulated and/or heated, and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. The conveying system used to transport the mix from the mixer to the bin(s) shall be enclosed, heated and/or insulated for effective control of mix temperature.

No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant. The mix as discharged from the bin(s) shall meet all specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at any time, by the Engineer, for unsatisfactory operation.

IL-4.75 and SMA mixtures which contain aggregate having absorptions greater than or equal to 2.5 percent, or which contain steel slag sand, shall have a minimum surge bin storage plus haul time of 1.5 hours.

(6) Storage Tanks for Asphalt Binders. Tanks for the storage of asphalt binder shall be clearly and uniquely identified, and equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity or other approved means so that no flame shall be in contact with the tank. All asphalt binder lines and fittings shall be steam, electric or hot oil jacketed. Provisions shall be made for sampling the asphalt binder from the line leading to the weigh bucket or metering device. If more than one grade of asphalt binder is required for concurrent operations, adequate storage and separate piping to the weigh bucket or metering device for each grade, or other methods approved by the Engineer that prevent intermingling of the asphalt binders, shall be provided. An armored thermometer or pyrometer which will accurately show temperatures between 200 and 400 °F (95 and 205 °C) shall be suitably located in the asphalt binder line or within the tank. The instrument shall be located so as to indicate to the plant personnel, the temperature of the asphalt binder.

(7) Equipment for Weighing HMA. The HMA shall be weighed on an approved scale furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified. For dryer drum plants the load-out scale used to weigh HMA shall be equipped with an automatic printer. Batch plants shall have an automatic printer to record the weight of all ingredient materials. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights, except as provided in paragraph a., below.

a. If the platform scale equipment measures gross weight (mass), the printer will record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.

b. If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.

c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.

d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Weights (Masses) shall be shown in tons (metric tons) to the nearest 0.01 ton (0.01 metric ton).

(8) Equipment for Anti-Strip Additives. When an anti-stripping additive is required and a liquid additive is used, it shall be added to the asphalt binder by means of an approved in-line blending system located between the asphalt binder supply tank and distribution on the heated aggregate. The in-line blending system shall be installed in such a location that the liquid additive cannot recirculate and contaminate the asphalt binder supply tank. The in-line blending system shall be capable of delivering a consistent and controllable stream of material to the asphalt binder under all operating weather conditions and shall be capable of controlling the introduction of additive into the asphalt binder within ±10 percent of the amount specified or required. The Contractor shall use methods and procedures for handling and storage of the additive which meet the manufacturer's safety recommendations.

When hydrated lime is used as the anti-strip additive, a separate bin or tank and feeder system shall be provided to store and accurately proportion the lime onto the aggregate either as a slurry, as dry lime applied to damp aggregates, or as dry lime injected onto the hot aggregates prior to adding the liquid asphalt cement. If the hydrated lime is added either as a slurry or as dry lime on damp aggregates, the lime and aggregates shall be mixed by a power driven pugmill to provide a uniform coating of the lime prior to entering the dryer. If dry hydrated lime is added to the hot dry aggregates in a dryer-drum plant, the lime shall be added in such a manner that the lime will not become entrained into the air stream of the dryer-drum and that thorough dry mixing shall occur prior to the injection point of the liquid asphalt. When a batch plant is used, the hydrated lime shall be added to the mixture in the weigh hopper or as approved by the Engineer. The feeder system shall be controlled by a proportioning device which shall provide accuracy to within ±10 percent of the specified amount of hydrated lime solids. The proportioning device shall have a convenient and accurate means of calibration and shall be interlocked with the aggregate feed or weight system so as to maintain the required proportion. A flow indicator or sensor shall be provided and interlocked with the plant controls such that the production of the mixture will be interrupted if there is a stoppage of the hydrated lime feed. The stockpiling of hydrated lime treated aggregate will not be permitted. The methods of introducing and mixing the anti-stripping additive and aggregate shall be subject to approval by the Engineer prior to beginning production.

(9) Equipment for RAP/RAS. When the RAP/RAS option is used, the plant shall be modified to ensure a homogenous, uniformly coated mix is obtained. A scalping screen, gator, crushing unit, or comparable sizing device shall be used in the RAP/RAS feed system to remove or reduce oversized material. Modifications shall be approved by the Engineer.

(10) Stabilizing Additive. When a stabilizing additive such as a cellulose or mineral fiber is required to prevent asphalt binder draindown, adequate dry storage shall be provided for the stabilizing fiber additive. A separate feed system shall be provided to proportion the fiber into the mixture uniformly and in desired quantities. The feed system shall be interlocked with the aggregate feed or weigh system to maintain the correct proportions for all rates of production and batch sizes. The proportion of fibers shall be controlled at all times within ± 10 percent of the amount of fibers required. The fiber system shall provide in-

process monitoring consisting of either a digital display of output or a printout of the feed-rate, in pounds per minute. Flow indicators or sensing devices for the fiber system shall be provided and interlocked with plant controls so mix production shall be interrupted if fiber introduction fails, or if the output rate is not within the specified tolerances.

a. Batch Plant. Stabilizing additive shall be pneumatically added through a separate inlet directly into the weigh hopper above the pugmill. The addition of fibers shall be timed to occur during the hot aggregate charging of the hopper. Adequate mixing time will be required to ensure proper blending of the aggregate and fiber additive. Both the wet and dry mixing times shall each be increased a minimum of five seconds beyond the standard mixing time. The actual mixing time increase shall be determined by the Engineer based on individual plant characteristics. If concentrations of mastic (fiber, asphalt binder, and fines) are visible behind the paver, the batch size shall be reduced in ten percent increments until the problem is alleviated.

b. Drum Mix Plant. Stabilizing additive shall be introduced using specialized equipment to mix the asphalt binder with loose fibers at the time of introduction into the drum mixer. This equipment shall be approved by the Engineer. Care shall be taken to ensure the loose fibers do not become entrained in the exhaust system of the plant.

(b) Batching Plants. 1102.01 (b) Batch plants shall be according to the following.

(1) Dryers. The plant shall be equipped with a revolving cylindrical dryer or dryers capable of heating and drying all of the fine and coarse aggregates to a temperature of 250 to 350 ºF (120 to 180 ºC).

(2) Equipment for Weighing or Measuring Aggregate/RAP/RAS. The equipment shall include a means for accurately weighing each size of aggregate/RAP/RAS in a weigh hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the pugmill mixer while a batch is being weighed.

The scale shall be a springless dial scale complying with the requirements of Article 1103.02(c). Load cells with digital readouts may be used if approved by the Engineer. The scale shall have a capacity of not more than twice the weight (mass) of the approved capacity of the mixer.

(3) Dust Collection. Material collected from the primary collector shall be discharged into a hopper which is equipped with the means of either wasting stored dust or metering and conveying its contents into the boot of the hot elevator. Metering of dust from the hopper shall be accomplished by either an adjustable variable speed vane or auger feeder. Feed shall be actuated by a control located in the discharge chute between the dryer and the hot elevator, and shall only occur when aggregate is being discharged from the dryer. In all cases, the hopper used for storing the primary material shall be equipped with a low-bin indicator.

Material collected in the secondary collector (baghouse) shall not be stored internally, but shall be discharged directly into a silo. Feed of the material from the silo to the mix shall be accomplished only by weight (mass). In no case shall the collected secondary material be returned to the hot elevator. To meet job mix formula criteria, it may be necessary to waste some or all of the collected secondary material.

(4) Mineral Filler System. The mineral filler shall be weighed in the aggregate weigh hopper. It shall be conveyed to the weigh hopper by approved means. The feeding method shall operate in such manner as will enable small fractions of the material to be weighed. The chute used to introduce the mineral filler into the weigh hopper shall be so constructed that none of the material is retained in it after the required amount has been deposited in the weigh hopper.

(5) Equipment for Weighing or Measuring Asphalt Binder. The equipment used for weighing or measuring the asphalt binder shall consist either of an approved weigh bucket or metering device. If a weigh bucket is used, it shall be a non-tilting type and shall be completely suspended from a springless dial scale. Load cells with digital readouts may be used if approved by the Engineer. The weigh bucket, its discharge valve or valves and spray bar shall be adequately heated and shall have a capacity of at least 15 percent in excess of the weight (mass) of asphalt binder required in any batch. Adequately heated, quick-acting, non-drip valves shall be used in charging the bucket.

If a metering device is used, it shall be of an approved design and have a capacity of at least 15 percent in excess of the quantity of asphalt binder used in a batch. The controls shall be constructed so that they may be locked at any dial setting and will automatically reset to that reading after the addition of asphalt binder to the mix. The dial shall be in full view of the mixer operator. The flow of asphalt binder shall be automatically controlled so that it will begin when the dry mixing period is over. The section of the asphalt line between the charging valve and the spray bar shall be provided with a valve and outlet for calibrating-verifying the meter.

Either the weigh bucket or the meter device shall discharge all the asphalt binder required for one batch in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of asphalt binder the full length of the mixer.

(6) Accuracy of Scales. The scales shall meet the requirements of The Weights and Measures Act of the State of Illinois. The scales shall be calibrated at the beginning of each construction season and as often as the Engineer may deem necessary to ensure their continued accuracy. Ten standard 50 lb (25 kg) weights meeting the requirements of NIST shall be available at the HMA plant for use in calibrating and testing the weighing equipment. The scales shall be inspected frequently for sensitivity, sluggishness or damage. They shall be checked for accuracy at intervals of not more than one week by obtaining the net weight (mass), on truck scales, of a truck load of HMA.

(7) Pugmill Mixer. The batch mixer shall have a rating plate attached showing the manufacturer's rated capacity, and shall be an approved type capable of producing a uniform mixture within the job tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of the blades from all fixed and moving parts shall not exceed 3/4 in. (19 mm).

The capacity of the pugmill mixer will be determined by the Engineer based on 115 percent of the calculated net volume of the mixer below the center of the mixer shafts and 100 lb/cu ft (1600 kg/cu m) material. If the mixer will not operate efficiently at the approved capacity, or if its production does not coordinate with other plant units, the right is reserved to reduce the size of the batch until the desired efficiency is obtained. The Engineer's decision as to the permissible capacity of the pugmill mixer will be final.

The mixer shall be heated by an approved method and shall have a capacity of not less than 2000 lb (905 kg) for any composition required under these specifications. The amount of material which the Contractor will be permitted to mix per batch shall be determined by the Engineer. The mixer shall be of the twin-shaft type.

(8) Time Lock. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh hopper gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the asphalt binder bucket or meter throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh hopper gate and the start of introduction of asphalt binder. The wet mixing period is the interval of time between the start of introduction of asphalt binder and the opening of the mixer gate.

The heated aggregates, RAP/RAS when used, and mineral filler shall be mixed in the pugmill mixer for a period of not less than 10 seconds. The asphalt binder shall then be added and the mixing continued. The time required to add the asphalt binder shall be not more than 15 seconds. The total time required for adding the asphalt binder and completing the wet mixing period shall be not less than 35 seconds, or longer if necessary, to produce a homogeneous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. When the RAP/RAS option is used, the mix time may vary in relation to the nature of the aggregate. The total mixing time shall be a minimum of 45 seconds consisting of dry and wet mixing. The times of dry and wet mixing shall be set by the Engineer. The same size batch weights shall be used in the production of HMA, unless permission to change is granted in writing by the Engineer.

The control of the timing shall be flexible and capable of being set at intervals of five seconds or less throughout a total cycle. The setting of time intervals shall be at the direction of the Engineer.

(9) Batch Counter. An approved mechanical batch and/or tonnage counter

shall be installed as part of the time lock device. It shall register only upon the actuation of the asphalt weigh bucket or valve release. It shall not register any dry batches or any material released during the operation of pulling the bins.

(10) Screens. The screens used in separating the aggregates shall be of the vibrating types, and when operated at normal speeds shall separate the aggregates satisfactorily. The screening system shall be equipped with a scalping screen having openings not more than 1/2 in. (13 mm) larger than the largest size aggregate used in preparing the HMA. The screening system shall have a tailing pipe for the removal of oversized aggregate. The discharge point of the tailing pipe shall be located so that it will not create a hazard or nuisance. The screens shall produce aggregate in the proper bins, as required.

Efficiency of separation based on laboratory sieves, shall be such that no more than 20 percent of the material in the bin is smaller than neither the nominal size nor more than 10 percent over size for that bin.

(11) Hot Aggregate Bin. The plant shall be equipped with a minimum of four aggregate storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to ensure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for mineral filler, and the plant shall be equipped to feed the material into the aggregate weigh hopper. Each bin shall be provided with overflow pipes, of such size and at such locations as to prevent backing up of material into other compartments or bins. Material from the overflow pipe shall not be returned to the hot elevator. Each compartment shall be provided with its individual outlet gate, constructed so that when the gate is closed, there shall be no leakage. Gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. A sampling device having the same width as the hot aggregate bin outlet gates shall be provided for this purpose. Hot aggregate bins shall not be modified in any manner nor shall divider plates be removed.

(12) Temperature Recording Instrument. The plant shall be equipped with either a recording pyrometer or a recording thermometer having at least two terminals when a single dryer is used, and at least three terminals when a dual dryer is used. The type and accuracy of the recording instrument shall be approved by the Engineer. Unless otherwise approved, one terminal shall be installed at a suitable location at the discharge of each dryer and the others near the discharge gate in each bin compartment used for fine aggregate. The temperature recording instrument shall be capable of making accurate charts of the temperatures during the day's run. The recording instrument shall be installed at a point free from the dust and vibration of the plant. If this instrument is not located as to indicate clearly to the plant operator the temperature of the mineral aggregates at the discharge of each dryer, a non-recording pyrometer shall also be installed in view of the plant operator. At the end of each day's run, the record sheet of the recording instrument shall be submitted to the Engineer.

(c) Dryer Drum Plants. Dryer drum plants shall be according to the following.

(1) General. General requirements shall be according to Article 1102.01(a), except a hotmix surge bin meeting the requirements of (5) shall be utilized.

The heated aggregates, mineral filler, asphalt binder, and RAP/RAS when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, dryer drum slope, etc.) to ensure that these conditions are met.

(2) Vibrating Scalping Screen. The combined aggregates, and RAP/RAS if used, shall pass over a vibrating scalper that will remove all material and aggregate greater than the nominal top size gradation permitted by the specification for the mixture being produced, or as set by the Engineer, prior to the aggregates being placed on the weigh belt. The scalper shall be independent of other proportioning or weighing equipment.

(3) Aggregate/RAP/RAS Weighing Equipment. The combined aggregates, and RAP/RAS if used, shall be weighed on continuous belt weighing devices meeting the requirements of the NIST Handbook #44. The weigh belts shall be self-aligning with a gravity belt takeup and rigid wind guards at the weighing section. Sun screens may be required by the Engineer at the weighing section. Means shall be provided to divert the aggregate/RAP/RAS into a truck, after passing over the weigh belt scales.

(4) Mineral Filler System. Mineral filler shall be proportioned to the mixing zone of the HMA plant by a variable speed vane feeder and storage system or other systems approved by the Engineer. Means must be provided to divert material from the proportioning unit for purposes of calibration. The feeder shall be provided with an automatic cutoff system in the event the feeder is blocked or is devoid of material.

(5) Asphalt Binder System. The asphalt binder system shall consist of a temperature compensating meter and pump. Other asphalt binder systems may be used if approved by the Engineer. The pump and meter shall be installed as close to the asphalt binder storage tank(s) as possible using rigid pipe with a minimum of piping length and bends. The diameter of the pipe shall be consistent throughout the system. Means shall be provided to automatically stop the plant in the event asphalt binder ceases to flow through the meter.

(6) Dryer Drum Mixer. Dryer drum mixer components shall have a minimum capacity of 60 tons (55 metric tons) per hour of HMA. The units shall have a recording pyrometer or thermometer that records the discharge temperature of the mixture.

a. Single Unit Dryer Drum Mixers. The single unit dryer drum mixer shall be a revolving cylindrical drum capable of heating, drying, and mixing the *combined aggregates, RAP/RAS if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications. The dryer burner shall be equipped with automatic controls.*

b. Dual Unit Dryer Drum Mixers. The dryer portion of the dual unit dryer drum mixer shall be a revolving cylindrical drum capable of heating and drying the combined aggregates to the required specifications. The mixer portion of the dual unit dryer drum mixer shall be either a revolving cylindrical drum or a continuous twin shaft pugmill with a compatible mixing capacity to the dryer production rating. The unit shall be capable of mixing the heated and dried combined aggregates, RAP/RAS if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications.

(7) Secondary Dust Collector. The collected baghouse dust shall be returned to the dryer at a uniform rate at a point where the asphalt binder is added to the mixing zone of the HMA plant.

If positive dust control equipment (PDCE) is required, it shall consist of a system that is an integral part of the production process. The system shall accurately weigh all of the secondary dust collected in the baghouse, transfer the material to a storage silo, accurately weigh the required amount of fines to be returned from the storage silo, and transfer them back to the mixture. The PDCE weighing devices shall have an accuracy of 0.5 percent of the actual weight of the material. The system shall be capable of automatically monitoring the dust collection process and adjusting the amount of asphalt binder added to the mixture. The entire system shall be interlocked with the plant controls to respond to production rate changes, start up, and shut down situations. The weighing process shall be displayed and recorded in 0.1 units. The PDCE shall be capable of accurately wasting dust without having any adverse effects on the mixture.

(8) Proportioning Control Systems.

a. Aggregate/RAP/RAS Feed Control. Each feeder shall have an adjustable feed control, which can be locked, with a master control that will automatically increase or decrease the production rate of each feeder proportionately when the total rate of production is changed. The revolutions per minute (RPM), tons/hour (TPH), etc. of all feeders shall be measured at the tail shaft of the feeder. The aggregate/RAP feeders shall have an accuracy of ±1.0 percent of the actual quantity of material incorporated. RAS feeders shall have an accuracy of ± 0.5 percent of the actual quantity of material incorporated.

b. Aggregate/RAP/RAS Weighing. The main proportioning weigh belt shall be electronically interfaced with the asphalt binder, RAP/RAS if used, and mineral filler system to proportion the required amount of each material simultaneously to the mixer. The aggregate, and RAP/RAS if used, weighing systems shall have an accuracy of ±0.5 percent of the actual material weighed by the belts. The weighing system shall also have a high-

low adjustable tolerance indicator that will signal the operator audibly when the actual production rate differs from the preset rate by more than 3.0 percent.

c. *Mineral Filler Control. Mineral filler shall be added to the mixer by a variable speed proportioning system interfaced with the aggregate weigh belt that will indicate total dry aggregate combined (aggregates + mineral filler) weight (mass) to the asphalt proportioning system. The mineral filler system shall have an accuracy of ±0.5 percent if the mineral filler is measured by weight (mass), or ±8.0 percent if the mineral filler is measured solely by volume of the actual material measured by the system. The mineral filler shall be added in the mixer at the same point the asphalt binder is added such that no mineral filler is lost as fugitive dust. Other systems will be permitted if approved by the Engineer.*

d. *Asphalt Binder Control. The required quantity of asphalt binder shall be proportioned to the mixer via a temperature compensating meter that will correct the quantity of asphalt binder to 60 °F (15 °C), or a system approved by the Engineer. This system shall be electronically interfaced with the combined dry aggregates, RAP/RAS if used, and mineral filler. The meter shall have an accuracy of ±0.4 percent of the actual material metered.*

e. *Aggregate/RAP/RAS Moisture Compensators. The moisture compensation devices shall be capable of electronically converting the wet aggregate/RAP/RAS weight (mass) to dry aggregate/RAP/RAS weight (mass). Other systems will be permitted if approved by the Engineer.*

(9) Control Console. The following items shall be part of the operator's control console.

a. *Aggregate/RAP/RAS Feed Controls. The variable speed controls, both total and proportional for each feeder and combined aggregates, shall be indexed in units with a minimum unit of 0.1. The rate in RPM or TPH, etc. shall be displayed by a digital readout for each feeder with a minimum unit of 0.1 RPM or 1 TPH, etc.*

b. *Aggregate/RAP/RAS Weight (Mass) Indicator. The accumulated wet weight (mass) of material in tons (metric tons) that passes over each weigh belt shall be available at the control console with a minimum unit of 0.1 ton (0.1 metric ton). The dry weight (mass) of material, in TPH, passing over each weigh belt shall be displayed by digital readouts with a minimum unit of 1 TPH.*

c. *Mineral Filler Control. Mineral filler shall be controlled by a variable speed control with a minimum unit of 0.1 and shall be displayed in RPM, or TPH, etc. with a minimum unit of 0.1 RPM or 0.1 TPH, etc.*

d. *Asphalt Binder Control. The asphalt binder control shall be capable of presetting the actual asphalt binder content directly as a percent of the total weight (mass) of mixture with a minimum unit of 0.1 percent. The* *asphalt binder rate shall be displayed to a minimum unit of 0.1. A control shall be provided to set the specific gravity or weight/gallon (mass/liter) of the asphalt binder. The temperature of the asphalt binder shall be recorded by a recording pyrometer or thermometer at the console.*

e. *Aggregate/RAPRAS Moisture Compensators. The compensators shall be part of the operator's console and shall have a minimum unit of 0.1 percent. The control shall be lockable if the moisture setting is not printed as part of the record.*

f. *HMA Temperature. The temperature of the mixture shall be recorded in °F (°C) by a recording pyrometer or thermometer at the console.*

(10) *Recording of Proportions. The plant shall be equipped with a digital printer that will automatically print the following data at six minute intervals during production time and on demand. All readings shall show the date, month and year, and time to the nearest minute for each print.*

a. *Accumulated dry aggregate/RAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).*

b. *Accumulated mineral filler in revolutions, tons (metric tons), etc., to the nearest 0.1 unit.*

c. *Accumulated asphalt binder in gallons (liters), tons (metric tons), etc., to the nearest 0.1 unit.*

d. *Aggregate/RAP/RAS Moisture Compensators in percent as set at the panel. (Required when accumulated dry aggregate/RAP/RAS is printed in wet Aggregate/RAP/RAS weight (mass)).*

Another system approved by the Engineer, such as a fully computerized system, that will provide the control and documentation of the above equipment, will be permitted.”

End of the Standard Specification Section 1102 (Hot-Mix Asphalt Equipment)

SURGE AND STORAGE BINS

Surge and storage bins are designed to hold or store HMA mixtures at an asphalt plant. Because of the individual batching process at a batch plant, mix storage is not required but can be an option. A dryer-drum plant works in a continuous operation so the plant needs to have a means to retain HMA material in order to offset loading inconsistencies that might occur during the production day. A dryer-drum plant is not designed to shut down at a moment's notice except in an emergency. If a surge bin and/or storage silo system is to be utilized, prior to usage, the Central Bureau of Materials must approve the unit.

Surge and/or storage bins are to be designed and operated to prevent segregation and heat loss, so the systems are to be insulated and/or heated, as well as, being enclosed and weather-proof. Heating is normally accomplished by circulating hot oil or water through piping in the outer shell.

Surge bins are used to create a temporary accumulation of material to buffer the effects of inconsistent loading of trucks throughout the day that might occur due to various factors (traffic, etc.). In most cases, surge bins are usually designed to hold less than 100 tons of HMA but this could vary depending on the design and intended use of the equipment. A surge bin can hold HMA material up to eight (8) hours or longer with approval from the Engineer.

Storage silo/bins are normally used for long term or overnight storage of HMA materials. When approved by the Engineer, the producer may store HMA materials up to a maximum of twenty (20) hours from the time the first batch of HMA material is added to the silo/bin. After the silo/bin is filled, the top shall be closed or sealed until such time as the contractor is prepared to utilize all of the HMA material from the storage. The contractor shall keep the District office informed when they intend to store HMA material.

When HMA mixture is stored a small amount of material can become oxidized in the cone area of the silo/bin. This "plug" of HMA material generally indicates a hardening of the HMA material when tested and shall be wasted [approximately 1 to 2 thousand pounds] before the HMA material is drawn from the bin for use on a project.

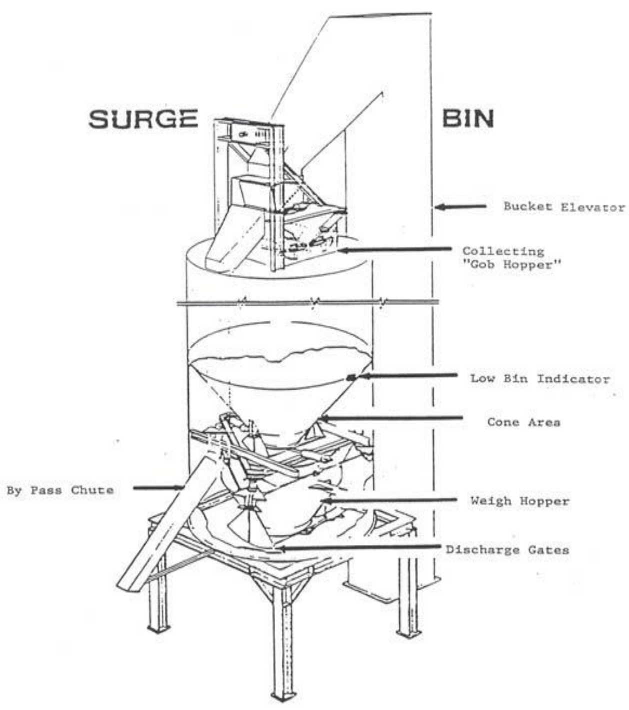
Another issue with storage systems is the storage of HMA mixtures that contain aggregate with water absorption greater than 2.75 percent. These types of materials should not be stored overnight.

Equipment

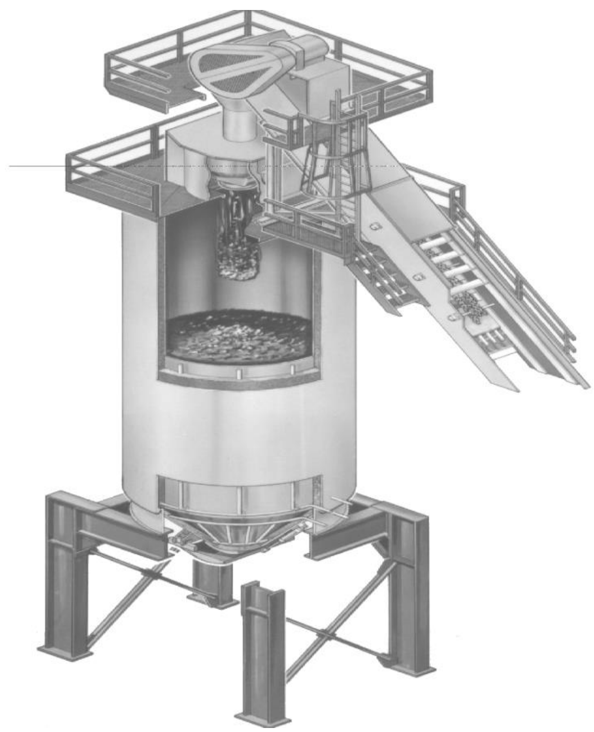
The complete surge system (Figure 1, page 3-2) shall be designed and operated to prevent segregation and loss of temperature. If segregation is detected, a listing of types, probable causes and possible solutions are covered in Chapter 5 of this manual.

Both, surge or silo system, will be equipped with low level indicator and an automatic cut-off system to prevent the bin from emptying below the discharge cone. The cut-off system will stop the discharge or flow of HMA material from the surge or silo bin in order to prevent possible segregation due to low levels of material. An alarm system, audible to personnel in the immediate plant area, shall be employed to signal if and when the system is being bypassed. Ideally, the only time a surge bin and/or a storage silo is emptied would be when production is finished for the day or when switching to a different type of mixture (binder to surface, etc.)

Storage Silos



Surge Bin (Figure 1)



Storage silo with a gob hopper

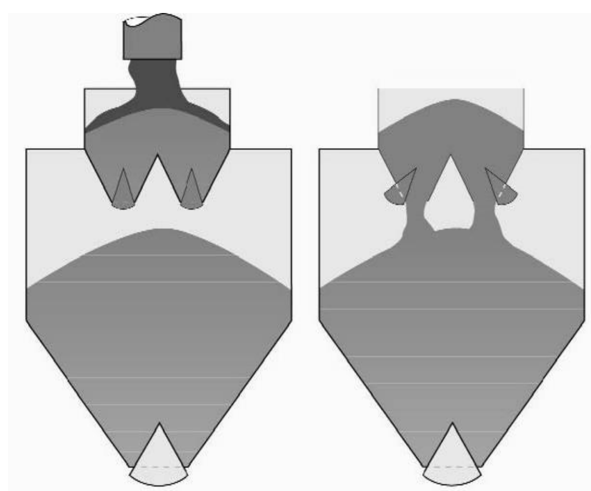
<u>Operation</u>

Proper operation levels of surge or silo systems should be around 1/2 to 3/4 full. Levels lower than 1/2 of the bin will create an inverted cone, while levels above 3/4 of the bin will create an upright cone, both of which will introduce the possibility of segregation in the bin.

Although not required by specifications, most surge/storage systems will include a collecting (gob) hopper on top of the surge or silo system (below). The collecting (gob) hopper enables the HMA mix to be deposited en mass into the bin helping to reduce or minimize the possibility of segregation. When a collecting (gob) hopper is used the possibility of segregation is greatly reduced. The Quality Control Manager/Level 2 HMA Technician is required to make sure that the collecting hopper discharge gates do not remain open after the hopper is empty.

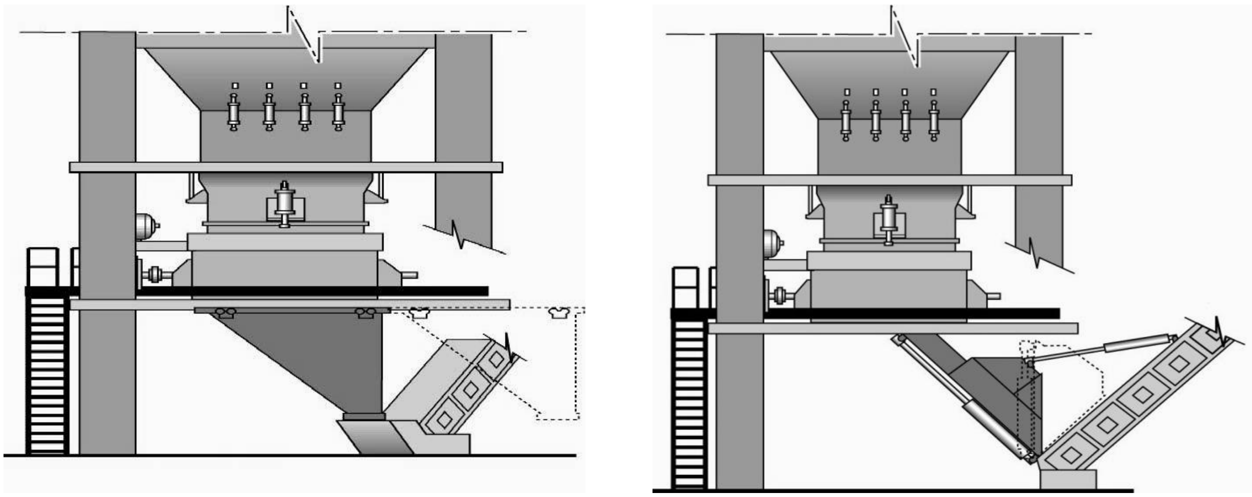
Silo Discharge Gate

Gob Hopper

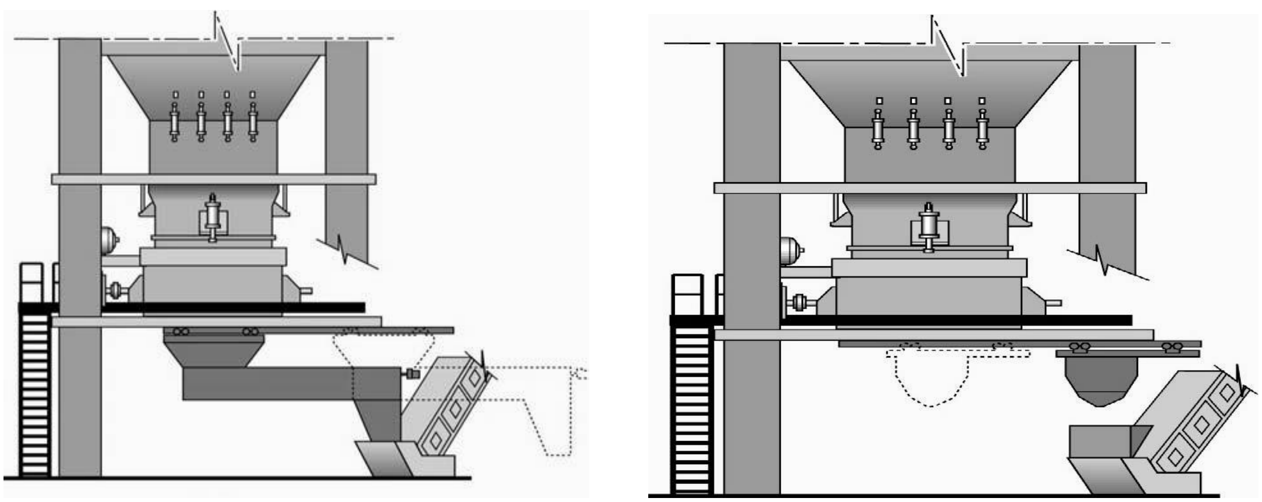


Surge bin pant-leg system

For **batch plants**, the conveying system used to transport the HMA mix from the pugmill or drum mixer to the bin(s) may be a continuous type or a skip hoist type. The continuous type shall be enclosed, heated and/or insulated. The skip hoist type must have sufficient capacity to transport an entire batch and mass dump it into the bin.



Continuous Conveying System



Skip Hoists Conveying System

Documentation of Material Weights

When surge/storage bins or continuous plants are used in the production of HMA mixtures, the HMA material must be weighed either on a platform (truck) scale, weigh hopper scale suspended below the surge/storage bin, load cells or with another approved system.

The weighing device shall be equipped with an automatic ticket printer conforming to current Illinois Department of Transportation specifications, and shall have been approved by the Illinois Department of Agriculture.

State of Illinois
Department of Transportation
Bureau of Materials and Physical Research
Springfield

POLICY MEMORANDUM

Revised: January 1, 2008	05-08.0
This Policy Memorandum supersedes number 07-26 dated July 15, 2007	

TO: *REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS*
SUBJECT: *STORAGE OF HOT-MIX ASPHALT*

1.0 SCOPE

1.1 To establish the requirements for granting a maximum storage time of 20 hours for hot mix asphalt silos.

2.0 ***Purpose***

2.1 The January 1, 2007 Standard Specifications for Road and Bridge Construction, Section 1102.01(a)(6), allows for the storage of hot mix asphalt in surge systems designed and operated to prevent segregation and loss of temperature. The specification allows for a maximum retention of 8 hours. Longer retention times must be approved in writing by the Engineer.

3.0 PROCEDURE

3.1 Illinois Test Procedure 401, located in the "Manual of Test Procedures for Materials" shall be used to evaluate the effect of additional storage time on the mix.

4.0 APPROVAL PROCEDURE

4.1 Based on the Bureau's evaluation of the test data, permission for mixture storage for up to a maximum of 20 hours may be granted. In lieu of testing, the Bureau may grant approval based on satisfactory performance of other similar surge bin systems.

4.2 If overnight storage is permitted, the Bureau will send a letter to the Contractor, with a copy to the District, stating the conditions whereby the Contractor may store hot-mix asphalt.

David L. Lippert, P.E.
Engineer of Materials
and Physical Research

JST/dkt

Beginning of the Standard Specification Article 1102.01(a)(5)

(5) Hot-Mix Surge Bins. The Contractor may use a hot-mix surge system in the manufacture of HMA provided the bin(s) meet the following requirements and are operated to the satisfaction of the Engineer. The complete surge system shall be designed and operated to prevent segregation and loss of temperature of the mix. Maximum retention time shall be eight hours unless longer retention time is authorized in writing by the Engineer. The bin(s) shall be insulated and/or heated and of an enclosed weatherproof type. A combination low level indicator and cutoff system shall be provided that will automatically stop the discharge of mix from the surge bin(s) when the mix falls below the top of the discharge cone. The conveying system used to transport the mix from the mixer to the bin(s) shall be enclosed, heated and/or insulated for effective control of mix temperature.

No surge system will be approved by itself but shall be considered as part of a complete operating HMA plant. The mix as discharged from the bin(s) shall meet all specification requirements for the mix being produced. Approval for the use of a surge system may be withdrawn at any time, by the Engineer, for unsatisfactory operation.

IL-4.75 and SMA mixtures which contain aggregate having absorptions greater than or equal to 2.5 percent, or which contain steel slag sand, shall have a minimum surge bin storage plus haul time of 1.5 hours.

End of the Standard Specification Article 1102.01(a)(5)

Beginning of the Standard Specification Article 1102.01(a)(7)

(7) Equipment for Weighing HMA. The HMA shall be weighed on an approved scale furnished by the Contractor meeting the requirements of The Weights and Measures Act of the State of Illinois. Each time the scale is moved, the accuracy shall be retested and certified. For dryer drum plants the load-out scale used to weigh HMA shall be equipped with an automatic printer. Batch plants shall have an automatic printer to record the weight of all ingredient materials. The automatic printer shall be an integral part of the scale equipment or the scale and printer shall be directly connected in a manner that will prohibit the manual entry of weights, except as provided in paragraph a., below.

a. If the platform scale equipment measures gross weight (mass), the printer shall record the gross weight (mass) as a minimum. Tare and net weights (masses) shall be shown on weigh tickets and may be printed automatically or entered manually.

b. If scale equipment on a platform scale zeros out the truck tare automatically, the printer shall record the net weight (mass) as a minimum.

c. If the scale equipment on a surge bin weigh hopper zeros automatically after discharging each batch, the printer shall record the net weight (mass) as a minimum.

d. If the scale equipment on surge bins automatically shuts down the feed system weighing and weighs the amount in the silo before and after discharge, the printer shall record the net weight (mass) as a minimum.

The automatic printer shall produce a weight ticket in triplicate. Weights (Masses) shall be shown in tons (metric tons) to the nearest 0.01 ton (0.01 metric ton).

End of the Standard Specification Article 1102.01(a)(7)

Beginning of the Standard Specification Article 1102.01 (c) (1)

(c) Dryer Drum Plants. Dryer drum plants shall be according to the following.

(1) General. General requirements shall be according to Article 1102.01(a), except a hot-mix surge bin meeting the requirements of (5) shall be utilized.

The heated aggregates, mineral filler, asphalt binder, and RAP/RAS when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly. If a question as to the degree of coating should arise, AASHTO T 195 shall be used. If the Engineer ascertains that proper mixing is not being obtained, adjustments shall be made in the plant operation (production rate, dryer drum slope, etc.) to ensure that these conditions are met.

End of the Standard Specification Article 1102.01 (c) (1)

‘

This Page Is Reserved

Chapter 4 - HMA Proportioning & Blending of Aggregates

Information pertaining to: **Page**

HMA Proportioning & Blending of Aggregates

Introduction

1. General

Cold feed blending of aggregates is an important part in the setup and production of HMA mixes. Improper setup of the cold feeds can cause an incorrect gradation of the combined belt samples (dryer-drum) or the hot bins (batch). Proper setting of the cold feeds will help cure gradation issues and helps to balance the overall production, as well as, reducing or eliminating waste material. Care should be taken, especially on wet or cold days, to adjust the feed rate in order to enable the drier to heat and dry the aggregates satisfactorily.

2. Blending of Two Fine Aggregates

Regardless of what type of plant is used, whenever a mixture calls for a sand blend or two or more aggregates products with similar gradations, the only place to proportion the materials are at the cold feeds. Once the materials become combined, neither plant offers a way to separate them. For example, in a batch plant, approximately 90% of the combined sands will be screened into #1 hot bin. With a dryer-drum plant, there is no screening of the materials so inaccurate gradations will show up directly on the roadway. Once combined, the gradation can’t be changed and if they are in the wrong proportions, mixture attributes (density and air voids) will be adversely affected and can cause an unworkable, unstable mixture being placed on the roadway. The Contractor could loss contract money or be required to remove and replace the questionable materials at their own expense should variations in the design blends occur.

Because of this, it is necessary to properly set the feeders for those aggregates so that the combined material gradations will match that which was achieved in the HMA design. The Quality Control Manager and/or Level 2 HMA technician must ensure that once these blend percentages are set at the cold feeders, only the master control is used to increase or decrease the total amount of aggregates are being fed to the plant. **In no case,** shall one of the feeders be turned down or off to reduce the amount of material fed to the drier to balance the plant.

3. Gradation Target Values

One of the best results of the AGCS system is the requirement of the Master Bands for the aggregate products used in HMA. Since the aggregate producers are required to manufacture the aggregates with tighter gradation bands, the shelf gradations used to create HMA mixtures are more consistent. This consistency carries over to the proportioning process allowing the Quality Control Manager and/or Level 2 HMA technician to better manage the combined gradations. A byproduct is smoother running plants with less wasted materials. Once the cold feeds are properly calibrated and filled with reliable gradations of aggregates, the result is better, more dependable HMA mixtures that will perform longer on our roadways. This is due to the requirement of the Master Band Target values and the stringent limits applied to the values (± 8%).

When producing mixture, the producer of the aggregates, Quality Control Manager and/or Level 2 HMA technician, are responsible to make sure the materials adhere to the tight controls on the gradation as the aggregate materials are produced, handled and used in the HMA mixtures being placed on Illinois roadways. The overall benefit is longer lasting roadways for the taxpayers.

4. Preliminary Information

Before a mixture can be produced there is a lot of behind the scenes preparation that has to be completed. The first process is the HMA producer deciding which ingredients are to be used in the mixture. Due to transportation, availability of materials and cost factors, most HMA producers are already established in what aggregate products they will use in their mixtures. The HMA producer will gather representative materials to come up with an approved design, which establishes the materials needed to be used in the mixture.

Once the mix design is in place and ready to go, the HMA producer will decide the production rate at which they want to run for the job and the plant will be given the initial settings, based on current stockpile gradations and the mix design targets. The plant will run, producing mixture, then a combined gradation sample and hot mix sample will be taken to determine the mixture attributes, air voids and control sieves gradations. Any needed adjustment will be made to further meet specification requirements for the mixture being produced. Changes or adjustments will be reflected in the plant settings to continue to producing the mixture.

5. Initial Plant Settings (needed to maintain proper aggregate blending)

There are three common types of initial plant settings used by dryer-drum plant manufacturers. These initial settings are obtained with the mix design and stockpile gradations.

Two terms commonly used when determining initial plant settings:

a) **100% Aggregate** — This term applies only to the aggregate portion of the mixture, including the mineral filler.

b) **100% Mixture** — This term applies to the total mixture ingredients, including aggregates, mineral filler and liquid asphalt binder.

When determining the initial plant settings it will be necessary to convert 100% aggregate to 100% mixture and in some instances, the reverse, 100% mixture converted to 100% aggregate. The two calculations needed for these conversions are:

100% aggregates converted to 100% mixture = aggregate percent x correction factor

100% mixture converted to 100% aggregates = mixture percent ÷ correction factor

The three initial plants settings commonly used by the industry are:

100% Aggregate — All aggregate settings, including miner filler, will total 100%. The liquid asphalt binder is treated as a separate ingredient setting in the plant.

Note: This is how mix designs are expressed and is used when determining the initial plant settings.

100% Mixture — All ingredients, aggregate, mineral filler and liquid asphalt binder, will total 100%, nothing is separate.

100% Agg w/o MF — All aggregate settings, excluding mineral filler, will total 100%. Mineral filler is treated like an additive and entered independently, as is the liquid asphalt binder.

For the following examples, information from the design on page 4-5 will be used.

100% Aggregate Method

Using the 100% aggregate method, the Quality Control Manager and/or Level 2 HMA technician will input the aggregate percent straight from the design. For the initial plant settings to work, the stockpiled materials gradations need to be in close proximity to the gradations used during the design process, otherwise adjustments will need to be made for any differences in the gradations.

Source	Material	Design Percentage	Initial Plant Settings	Corrected Settings**
Vulcan	032 CM16	48.8	48.8	N/A
Nokomis	032 CM16	16.2	16.2	N/A
Nokomis	038 FM20	14.2	14.2	N/A
CIM	037 FM01	19.5	19.5	N/A
Bm CR	004 MF02	1.3	1.3	N/A
Total		100.0	100.0	
Asp. Mt.	10127	5.4	5.4	

100% Mixture Method

Using the 100% mixture method, the Quality Control Manager and/or Level 2 HMA technician will need to convert the 100% aggregate percentages into mix percentages to make room for the asphalt binder percentage. And, like with the 100% aggregate method, the stockpile gradations need to be close to the mix design gradations or adjustments will need to be made.

To convert the aggregate percentages to mix percentages, a correction factor (**CF**) has to be determined using the total asphalt binder percentage with the following formula (3 decimal places):

$$\text{Correction Factor (CF)} = \frac{100.0 - \text{Mix Design Asphalt Binder \%}}{100} = \frac{100 - 5.4\%}{100} = 0.946$$

Once the correction factor (**CF**) has been determined, the mix design aggregate percent's are **multiplied** by the correction factor:

Mix Design Agg. Pcts.			CF		Initial Settings	Corrected Settings**
032CM16	48.8	*	0.946	=	46.2	46.3 **
032CM16	16.2	*	0.946	=	15.3	15.3
038FM20	14.2	*	0.946	=	13.4	13.4
037FM01	19.5	*	0.946	=	18.4	18.4
004MF01	1.3	*	0.946	=	1.2	1.2
	100.0				94.5	94.6 **
Asphalt Binder	5.4				5.4	5.4
					99.9	100.0 **

** **Adjusted +0.1% due to rounding errors**. Since the percentages are being rounded to the 10th of a percent, a minor amount of "rounding error" can occur. This rounding error can only account for ±0.1%, if there is more than 0.1% of error then a mathematical mistake has been made and needs to be corrected.

This rounding error is added or removed from the **largest contributing percentage** of material of the mixture (not necessarily the largest size of material) since this will have the least overall effect on the mixture.

100% Aggregate w/o Mineral Filler Method

Using the 100% aggregate w/o mineral filler method, the Quality Control Manager and/or Level 2 HMA technician will input the aggregate percents straight from the design, like with the 100% aggregates method, except the mineral filler will be excluded and treated as an independent additive similar to the asphalt binder. Again, for the initial plant settings to work, the stockpiled materials gradations need to be in close proximity to the gradations used during the design process, otherwise adjustments will need to be made.

To go from 100% aggregate, the HMA design, to 100% aggregate without mineral filler, a correction factor will need to be determined for the mineral filler with the following formula (3 decimal places):

$$\text{MF Correction Factor} \quad \frac{100.0 - \text{MF\%}}{100.0} = \frac{100.0 - 1.3}{100.0} = 0.987$$

Once the correction factor has been determined the mix design aggregate percents, except the mineral filler, is **divided** by the mineral filler correction factor:

Mix Design Aggregate Pcts.			Factor		Initial Settings	Corrected Settings**
032CM16	48.8	÷	0.987	=	49.4	N/A
032CM16	16.2	÷	0.987	=	16.4	N/A
038FM20	14.2	÷	0.987	=	14.4	N/A
037FM02	19.5	÷	0.987	=	19.8	N/A
Total	98.7				100.0	
004MF01	1.3				1.3	
	100.0					
Asphalt Binder	5.4				5.4	

Note: In this case, no rounding error was created so no corrected percentages are needed.

6. AGCS Gradation Targets

When proportioning a plant, it is necessary to know the critical sieves of the aggregate products. This will help to understand what size of material controls the gradation or what product will furnish the needed changes for the combined gradation to meet the critical sieve requirements for HMA mixtures.

AGCS Master Band and Critical Sieve Designation		
Gradation	**Master Band Sieve**	**Master Band (%)**
CA/CM 07	**1/2” (12.5 mm)**	**± 8**
CA/CM 11	**1/2” (12.5 mm)**	**± 8**
CA/CM 13	**# 4 (4.75 mm)**	**± 8**
CA/CM 16	**# 4 (4.75 mm)**	**± 8**
FA/FM 01, 02	**- #8 (- 2.36 mm)**	**± 15**
FA/FM 20, 21, 22	**- #8 (- 2.36 mm)**	**± 15**

HMA Superpave Mix Design Example

Date: 12/07/2016

Design No. ---------→	84BIT1234	Producer & Number→	2251-05	Asphalt Products
Design Lab ---------→	PP	Material Code ------→	19523	HMA Surf CSE N70 C

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size	032CM16	032CM16	038FM20	037FM02	004MF01		10127
(Prod #)	51912-02	51352-03	51352-03	50510-04	52102-07		2260-01
(Name)	Vulcan	Nokomis	Nokomis	CIM	Bm CR St		Asp. Mt.
(Loc)	Kankakee	Nokomis	Nokomis	Vandalia	Blom, IN		Urbana
Agg %	48.8	16.2	14.2	19.5	1.3		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2	100.0	100.0	100.0	100.0	100.0		100.0	90-100	100		100
3/8	98.0	97.0	100.0	100.0	100.0		98.5	66-100	99	52	62
#4	37.0	34.0	100.0	100.0	100.0		58.6	24-65	59	28	38
#8	9.0	7.0	74.0	87.0	100.0		34.3	16-48	34		
#16	5.4	4.8	46.0	64.0	100.0		23.1	10-32	24		
#30	5.2	4.0	28.0	40.0	100.0		16.3		16	12	20
#50	4.0	3.5	16.0	15.0	100.0		9.0	4-15	9		
#100	3.8	3.3	9.0	3.0	98.0		5.5	3-10	6		
#200	3.5	3.0	5.9	1.6	88.0		4.5	2-6	4.5	3.2	6.2
					RAP AB %=====➔						

	#1	#2	#3	#4	#5	#6	Blend	
Bulk Sp Gr	2.635	2.614	2.595	2.480	2.800		2.588	Bulk Sp Gr
Appr Sp Gr	1	1	1	1	1			Apparent Sp Gr
Absorp %	1.1	1.4	1.6	2.4	1		1.5	Absorption %
							1.030	AB Sp Gr
							0.87	Dust/AB Ratio

HMA Aging Time = 1 hour @ 154° C

Summary of Superpave Gyratory Test Data

	N-Initial 10				N-Design 70				Adjusted G_{se}			
PB	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9
G_{mb} (Corr)	2.079	2.083	2.099	2.110	2.317	2.318	2.340	2.353	2.317	2.318	2.340	2.353
G_{mm}	2.473	2.455	2.437	2.420	2.473	2.455	2.437	2.420	2.473	2.455	2.438	2.420
P_a	15.9	15.2	13.9	12.8	6.3	5.6	4.0	2.8	6.3	5.6	4.0	2.8
VMA	23.2	23.5	23.3	23.3	14.4	14.8	14.5	14.4	14.4	14.8	14.5	14.4
Field VMA	24.8	25.1	24.9	24.9	16.2	16.6	16.3	16.3	16.2	16.6	16.3	16.3
VFA	31.4	35.4	40.4	44.9	56.4	62.3	72.4	80.8	56.2	62.3	72.4	80.8
V_{be}	7.3	8.3	9.4	10.5	8.1	9.2	10.5	11.7	8.1	9.2	10.5	11.7
P_{be}	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1
G_{se}	2.643	2.644	2.644	2.644	2.643	2.644	2.644	2.644	2.644	2.644	2.644	2.644
P_{ba}	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Optimum Mixture Design Data

Slope: 9.9 Does design require Anti-Strip Additive (yes or no) No Anti-Strip Material Code #

Number of Revolutions 70

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**5.4**	**2.438**	**2.340**	**4.0**	**14.5**	**16.3**	**72.2**	**2.644**	**2.588**	**0.75**	
Adj. Data	5.4	2.438	2.340	4.0	14.5	16.3	72.4	2.644	2.588	0.75	
Min. Requirements				4.0	14.5		65-75			0.75	0.75
State Results											

Dryer-drum Plant Set-up Step by Step Instructions

a) Copy information from the design over to the worksheet:

Design formula - job mix formula (JMF)
Mix design aggregate percents
Mix design optimum asphalt binder percentage

b) Determine the average stockpile gradations and place information on the worksheet

c) Multiply each gradation column by the respective Agg% to get the Bin% for each sieve size rounding answer to the nearest 0.1%

d) Calculate combined gradation for each sieve size rounding answers to the whole percent **EXCEPT** the #200 material (which is always rounded to the tenth of a percent)

e) Calculate the correction factor

f) Multiply each Agg% by the correction factor to obtain the respective Mix% and record to the nearest 10th of a percent

g) Transfer the optimum AB% to the "New Bit" location

h) Total the Mix%s (this must total 100.0%), adjust as needed for rounding error**

** Rounding error can only account for 0.1 difference

i) Determine the production rate (TPH) for the mix

j) Calculate the TPH rate for each individual mix ingredient

IN CLASS or REAL WORLD

Adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don't match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, gradations, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

Dryer-Drum Set-up Class Example #1

Date: 12/07/16

Design No. ---------→	84BIT1234	Producer & Number→	2251-05 / Asphalt Products
Design Lab ---------→	PP	Material Code ------→	19513 / HMA Surf CSE N50 C

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16		037FM02	004MF01		10127
(Prod #)		51912-02		50510-04	52102-07		2260-01
(Name)		Vulcan		CIM	Bm CR St		Asp. Mt.
(Loc)		Kankakee		Vandalia	Blom, IN		Urbana
Agg %		67.0		31.0	2.0		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2		100.0		100.0	100.0		100.0	90-100	100		100
3/8		97.5		100.0	100.0		98.3	66-100	98	90	100
#4		38.6		100.0	100.0		58.9	24-65	59	28	65
#8		8.0		87.0	100.0		34.4	16-48	34	28	48
#16		5.6		60.0	100.0		24.0	10-32	24	10	32
#30		5.2		35.0	100.0		16.0		16		
#50		5.0		13.0	100.0		9.2	4-15	9	4	15
#100		4.7		7.0	98.0		7.3	3-10	7	3	10
#200		4.2		2.0	92.0		5.2	2-6	5.2	4	6

RAP AB %=====→

Optimum Mixture Design Data

Number of Revolutions: 50

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**5.2**	**2.438**	**2.340**	**4.0**	**14.5**	**16.3**	**72.2**	**2.644**	**2.588**	**0.75**	

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**		**100**	**100**
3/8		**96**		**100**	**100**
# 4		**39**		**100**	**100**
# 8		**9**		**86**	**100**
# 16		**7**		**59**	**100**
# 30		**5**		**35**	**100**
# 50		**5**		**14**	**100**
# 100		**5**		**9**	**97**
# 200		**4.2**		**2.1**	**91.0**

Drier-Dryer-Drum Set-up Class Example #1

Feeder	RAP	#1	#2	#3	#4	------	New Bit			
Size			**CM16**		**FM02**	**MF01**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**		**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2			**100**		**100**	**100**		**100**		
3/8			**96**		**100**	**100**		**98**		
#4			**39**		**100**	**100**		**59**		
#8			**9**		**86**	**100**		**34**		
#16			**7**		**59**	**100**		**24**		
#30			**5**		**35**	**100**		**16**		
#50			**5**		**14**	**100**		**9**		
#100			**5**		**9**	**97**		**7**		
#200			**4.2**		**2.1**	**91.0**		**5.2**		
AB								**5.2**		

Dryer-Drum Set-up Class Example #2

Date: 12/07/2016

Design No. ---------→	35BIT0000	Producer & Number→	1977-01	XYZ Asphalt
Design Lab ---------→	PP	Material Code ------→	19534	HMA Surf CSE N90 D

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16	038FM20		004MF01		10112
(Prod #)		51972-02	50972-02		52102-07		2260-01
(Name)		Material	Material		Bm CR St		Asp. Mt.
(Loc)		Service	Service		Blom. IN		Urbana
Agg %		66.3	31.5		2.2		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Formula	Range Min	Range Max
1											
3/4											
1/2		100.0	100.0		100.0		100.0	100	100		100
3/8		95.9	100.0		100.0		97.3	90-100	97	90	100
#4		36.3	98.1		100.0		57.2	28-65	57	28	65
#8		9.6	76.5		100.0		32.7	28-48	33	28	48
#16		6.6	52.0		100.0		23.0	10-32	23	10	32
#30		4.5	34.0		100.0		15.9		16		
#50		4.0	17.3		100.0		10.3	4-15	10	4	15
#100		3.7	9.8		98.0		7.8	3-10	8	3	10
#200		2.0	7.3		95.0		5.7	4-6	5.7	4	6

RAP AB %=====→

Optimum Mixture Design Data

Number of Revolutions: 90

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**6.1**	**2.425**	**2.327**	**4.0**	**14.7**	**16.5**	**68.1**	**2.644**	**2.588**	**0.89**	

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**	**100**		**100**
3/8		**95**	**100**		**100**
# 4		**37**	**99**		**100**
# 8		**8**	**78**		**100**
# 16		**6**	**54**		**100**
# 30		**5**	**32**		**100**
# 50		**4**	**16**		**100**
# 100		**3**	**11**		**98**
# 200		**2.2**	**7.1**		**94.0**

Drier-Dryer-Drum Set-up Class Example #2

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2			**100**	**100**		**100**		**100**		
3/8			**95**	**100**		**100**		**97**		
#4			**37**	**99**		**100**		**57**		
#8			**8**	**78**		**100**		**33**		
#16			**6**	**54**		**100**		**23**		
#30			**5**	**32**		**100**		**16**		
#50			**4**	**16**		**100**		**10**		
#100			**3**	**11**		**98**		**8**		
#200			**2.2**	**7.1**		**94.0**		**5.7**		
AB								**6.1**		

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RAP/RAS Proportioning Procedures

HMA Mix Recycling

1. General

The asphalt industry remains the country's number one recycler. About 96 percent of the industry is reported to be using recycling materials and/or green procedures. This is due to a number of factors, including; economics, regulations and competition. The Federal Highway Administration, in cooperation with the National Asphalt Pavement Association, began focusing on three areas; RAP, RAS and WMA.

Because of this focus, the asphalt pavement industry is committed to environmental stewardship by increasing the use of recycled materials, RAP and RAS, and warm mix asphalt (WMA) technology helping to reduce energy, cut plant and paving emissions, improve working conditions and conserve natural resources.

Reclaimed **A**sphalt **P**avement (**RAP**) is one of the most recycled and reused highway construction materials consisting of the cold millings or crushed HMA mixtures removed from roadways. When HMA materials reach the end of their life expectancy on the roadways the material is roto-milled (ground off) to make room for new materials. The incorporation of RAP into HMA mixtures began in the 1970s due to the oil embargo and has continued to grow ever since. RAP will contribute to the HMA mixture a certain percentage of the coarse and fine aggregates, as well as mineral filler and liquid asphalt binder.

Reclaimed **A**sphalt **S**hingles (**RAS**) includes shingle manufacturer's waste and roof tear-off material. Although RAS was introduced to the asphalt industry in the mid-1980s the use of RAS has increased in recent years. RAS contains high levels of asphalt binder content, high-quality fine aggregate, mineral filler and fibers which is very compatible for use in HMA mixtures.

Warm-**M**ix **A**sphalt (**WMA**) is achieved by introducing certain types of additives and utilizing different production processes that reduce mixing and placement temperatures of conventional hot mix asphalt. Warm-mix technology began in Europe and was first introduced to the United States in 2004. The warm-mix technology continues to grow at a rapid rate because of economic, environmental and workplace benefits.

Only RAP and RAS will be discussed in this chapter.

RAP/RAS materials are commonly introduced into HMA mixture during the production process by heat transfer (batch plant), a direct heating method (dryer-drum plant) or an indirect heating method (both types of plants). Other acceptable methods, other than what is described here, may be used, with approval, for the incorporation of RAP/RAS into HMA mixtures.

In the **heat transfer method**, the recycled material is fed directly into the plant aggregate weigh hopper on top of the uncoated heated aggregates. Since the recycled materials are not normally heated prior to incorporation into the mixture, the heated virgin aggregates are required to be superheated in order to offset the cooling effect caused by the ambient-temperature of the recycled materials (See Table 2 on page 4-15). After all of the aggregates, heated and recycled, are weighed, they are deposited into the pug mill where the heat from the superheated aggregates will transfer to the cooler materials allowing the recycled materials to soften and be incorporated into the mixture during the "dry" mixing process. In order to meet the required asphalt binder mix percentage, additional "new" liquid asphalt binder is added to the batch during the "wet" mixing process. This method is commonly used in a batch plant.

In the **direct heating method**, the recovered asphalt pavement material is 'directly' added through a port located approximately half-way down the drier. This port is located where the recycled materials will be protected from the burner flame by the veil of tumbling aggregates inside the drier. The recycled materials will be heated and incorporated into the mixture when the hot virgin aggregates and gases soften the RAP/RAS and take advantage of the mixing action. Additional new liquid asphalt binder will be injected shortly after the introduction of the RAP. This method is commonly used in a dryer-drum plant.

In the **indirect heating method**, the recovered asphalt pavement is added to the drum behind the burner or in another chamber. The required amount of new asphalt binder is then added after the point of entry of the RAP.

NOTE: Some of the above information was obtained from the NAPA website (asphaltpavement.org) and from the "Asphalt Pavement Mix Production Survey; Reclaimed Asphalt Pavement, Reclaimed Asphalt Shingles, Warm-mix Asphalt Usage: 2009-2010" document.

2. General RAP Sampling Procedure

The first step in establishing a recycled HMA mix is to extract and analyze the RAP material. The analyzed RAP material data will permit the contractor to add 'recycled' aggregates and liquid asphalt binder to the mixture to meet the combined gradation and mix properties as allowed by the specifications. This may be done in the following manner:

a. A series of samples will be taken at random locations from the roadway during the milling process. Liquid asphalt binder content and aggregate gradations tests will be run on these samples.

b. Or, if the RAP material is being placed or is located in an existing stockpile, the stockpile can be sampled at random locations and the liquid asphalt binder content and aggregate gradations tests will be run on these samples.

c. The producer is required to obtain split samples for assurance testing purposes of the materials for IDOT.

d. After obtaining the average gradations and asphalt binder contents of the sampled RAP materials (See Table 1 example below), these values will be used in the design process and the information will be reported to IDOT.

Table 1 - RAP Stockpile Sample Gradation Example

	Sieves											
Test #	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#8**	**#16**	**#30**	**#50**	**#100**	**#200**	**Asphalt Binder**
1	100	95	81	75	65	49	31	27	25	13	7.8	4.2
2	100	96	86	76	67	48	32	26	24	12	7.6	3.9
3	100	94	83	74	60	47	36	28	23	13	7.5	3.9
4	100	95	84	73	62	46	33	27	22	14	7.6	4.3
5	100	93	86	74	63	43	35	24	21	13	7.5	3.9
6	100	92	80	72	64	40	32	24	20	12	7.1	4.0
7	100	90	89	71	65	48	31	28	19	12	7.5	3.8
8	100	95	88	78	64	46	30	27	25	13	7.8	4.0
9	100	96	81	71	62	45	32	29	22	13	7.2	4.2
10	100	96	82	72	62	43	34	30	26	13	7.8	4.1
Average	100	94	84	74	63	46	33	27	23	13	7.5	4.0

<u>TABLE 2</u>
Temperature Suggested for Virgin Aggregates

Moisture Content %	Recycled Mix Discharge Temperature ºC (ºF)							
	104ºC	(220ºF)	116ºC	(240ºF)	127ºC	(260ºF)	138ºC	(**280ºF**)
Ratio : **20%** Reclaimed Material / **80%** New Aggregate								
0	138	(280)	152	(305)	166	(330)	179	(355)
1	143	(290)	157	(315)	171	(340)	185	(365)
2	152	(305)	166	(330)	179	(355)	193	(380)
3	160	(320)	174	(345)	188	(370)	202	(395)
4	168	(335)	182	(360)	196	(385)	210	(410)
5	177	(350)	191	(375)	204	(400)	218	(425)
Ratio: **30%** Reclaimed Material / **70%** New Aggregate								
0	152	(305)	168	(335)	185	(365)	199	(390)
1	160	(320)	179	(355)	195	(385)	213	(415)
2	177	(350)	193	(380)	210	(410)	224	(435)
3	191	(375)	207	(405)	224	(435)	238	(460)
4	204	(400)	221	(430)	238	(460)	252	(485)
5	218	(425)	235	(455)	252	(485)	266	(510)
Ratio: **40%** Reclaimed Material / **60%** New Aggregate								
0	171	(340)	191	(375)	210	(410)	227	(440)
1	191	(375)	210	(410)	229	(445)	246	(475)
2	213	(415)	229	(445)	249	(480)	268	(515)
3	232	(450	252	(485)	271	(520)	288	(550)
4	254	(490)	271	(520)	291	(555)	310	(590)
5	277	(530)	293	(560)	313	(595)	332	(630)
Ratio: **50%** Reclaimed Material / **50%** New Aggregate								
0	199	(390)	221	(430)	243	(470)	266	(510)
1	229	(445)	252	(435)	274	(525)	296	(565)
2	260	(500)	282	(540)	304	(580)	327	(620)
3	291	(555)	313	(595)	335	(635)	357	(675)
4	324	(615)	346	(655)	368	(695)	391	(735)
5	354	(670)	377	(710)	399	(750)	421	(790)

Note: Procedures for sampling and testing of RAS materials are too extensive to be covered in this manual or class. Some information can be obtained by referring to the “Reclaimed Asphalt Pavement and Reclaimed Asphalt Shingles BDE document found on page 4-19 in this chapter and/or by contacting the appropriate District Materials Engineer.

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Beginning of Article 1031- Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS) of Standard for Road and Bridge Construction, January 2022

Mixture Composition	
Fine Aggregate (FA 1, FA 2 or FA 3)	93 - 96 %
Asphalt Binder (PG 58-28, PG 64-22)	6 - 9 %

With the permission of the Engineer, an approved cold-lay sand asphalt mixture may be used in lieu of the above mixture.

1030.12 Transportation. Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's qualified product list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (19 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

(a) Ambient air temperature is below 60 °F (15 °C).

(b) The weather is inclement.

(c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

(d) The mixture being placed is SMA.

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped.

SECTION 1031. RECLAIMED ASPHALT PAVEMENT AND RECLAIMED ASPHALT SHINGLES

1031.01 Description. Reclaimed asphalt pavement and reclaimed asphalt shingles shall be according to the following.

(a) Reclaimed Asphalt Pavement (RAP). RAP is the material produced by cold milling or crushing an existing hot-mix asphalt (HMA) pavement. The Contractor shall supply written documentation that the RAP originated from roadways or airfields under federal, state, or local agency jurisdiction.

(b) Reclaimed Asphalt Shingles (RAS). RAS is the material produced from the processing and grinding of preconsumer or post-consumer shingles. RAS shall be a clean and uniform material with a maximum of 0.5 percent unacceptable material by weight of RAS, as defined in Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Sources". RAS shall come from a facility source on the Department's "Qualified Producer List of Certified Sources for Reclaimed Asphalt Shingles" where it shall be ground and processed to 100 percent passing the 3/8 in. (9.5 mm) sieve and 93 percent passing the #4 (4.75 mm) sieve based on a dry shake gradation. RAS shall be uniform in gradation and asphalt binder content and shall meet the testing requirements specified herein. In addition, RAS shall meet the following Type 1 or Type 2 requirements.

(1) Type 1. Type 1 RAS shall be processed, preconsumer asphalt shingles salvaged from the manufacture of residential asphalt roofing shingles.

(2) Type 2. Type 2 RAS shall be processed post-consumer shingles only, salvaged from residential, or four unit or less dwellings not subject to the National Emission Standards for Hazardous Air Pollutants (NESHAP).

1031.02 Stockpiles. RAP and RAS stockpiles shall be according to the following.

(a) RAP Stockpiles. The Contractor shall construct individual RAP stockpiles meeting one of the following definitions. Stockpiles shall be sufficiently separated to prevent intermingling at the base. Stockpiles shall be identified by signs indicating the type as listed below (i.e. "Homogeneous Surface").

Prior to milling, the Contractor shall request the Department provide documentation on the quality of the RAP to clarify the appropriate stockpile.

(1) Fractionated RAP (FRAP). FRAP shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in FRAP shall be crushed aggregate and may represent more than one aggregate type and/or quality, but shall be at least C quality. FRAP shall be fractionated prior to testing by screening into a minimum of two size fractions with the separation occurring on or between the No. 4 (4.75 mm) and 1/2 in. (12.5 mm) sieves. Agglomerations shall be minimized such that 100 percent of the RAP in the coarse fraction shall pass the maximum sieve size specified for the mixture composition of the mix design.

(2) Homogeneous. Homogeneous RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures and represent: 1) the same aggregate quality, but shall be at least C quality; 2) the same type of crushed aggregate (either crushed natural aggregate, ACBF slag, or steel slag); 3) similar gradation; and 4) similar asphalt binder content. If approved by the Engineer, combined single pass surface/binder millings may be considered "homogeneous" with a quality rating dictated by the lowest coarse aggregate quality present in the mixture.

(3) Conglomerate. Conglomerate RAP stockpiles shall consist of RAP from Class I, HMA (High and Low ESAL) mixtures. The coarse aggregate in this RAP shall be crushed aggregate and may represent more than one

aggregate type and/or quality, but shall be at least C quality. This RAP may have an inconsistent gradation and/or asphalt binder content prior to processing. Conglomerate RAP shall be processed prior to testing by crushing to where all RAP shall pass the 5/8 in. (16 mm) or smaller screen. Conglomerate RAP stockpiles shall not contain steel slag.

(4) Conglomerate "D" Quality (Conglomerate DQ). Conglomerate DQ RAP stockpiles shall be according to Articles 1031.02(a)(1) through 1031.02(a)(3), except they may also consist of RAP from HMA shoulders, bituminous stabilized subbases, or HMA (High or Low ESAL) binder mixture. The coarse aggregate in this RAP may be crushed or round but shall be at least D quality. This RAP may have an inconsistent gradation and/or asphalt binder content.

(5) Non-Quality. RAP stockpiles that do not meet the requirements of the stockpile categories listed above shall be classified as "Non-Quality".

RAP/FRAP containing contaminants, such as earth, brick, sand, concrete, sheet asphalt, non-bituminous surface treatment (i.e. high friction surface treatments), pavement fabric, joint sealants, plant cleanout, etc., will be unacceptable unless the contaminants are removed to the satisfaction of the Engineer. Sheet asphalt shall be stockpiled separately.

(b) RAS Stockpiles. Type 1 and Type 2 RAS shall be stockpiled separately and shall not be intermingled. Each stockpile shall be signed indicating what type of RAS is present.

Unless otherwise specified by the Engineer, mechanically blending manufactured sand (FM 20 or FM 22) or fine FRAP up to an equal weight of RAS with the processed RAS will be permitted to improve workability. The sand shall be B quality or better from an approved Aggregate Gradation Control System source. The sand shall be accounted for in the mix design and during HMA production.

Records identifying the shingle processing facility supplying the RAS, RAS type, and lot number shall be maintained by project contract number and kept for a minimum of three years.

Additional processed RAP/FRAP/RAS shall be stockpiled in a separate working pile, as designated in the QC Plan, and only added to the original stockpile after the test results for the working pile are found to meet the requirements specified in Articles 1031.03 and 1031.04.

1031.03 Testing. RAP/FRAP and RAS testing shall be according to the following.

(a) RAP/FRAP Testing. When used in HMA, the RAP/FRAP shall be sampled and tested either during or after stockpiling.

(1) During Stockpiling. For testing during stockpiling, washed extraction samples shall be run at the minimum frequency of one sample per 500 tons (450 metric tons) for the first 2,000 tons (1,800 metric tons)

and one sample per 2,000 tons (1,800 metric tons) thereafter. A minimum of five tests shall be required for stockpiles less than 4,000 tons (3,600 metric tons).

(2) After Stockpiling. For testing after stockpiling, the Contractor shall submit a plan for approval to the Department proposing a satisfactory method of sampling and testing the RAP/FRAP pile either in-situ or by restockpiling. The sampling plan shall meet the minimum frequency required above and detail the procedure used to obtain representative samples throughout the pile for testing.

Each sample shall be split to obtain two equal samples of test sample size. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

(b) RAS Testing. RAS or RAS blended with manufactured sand shall be sampled and tested during stockpiling according to the Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Shingle (RAS) Source".

Samples shall be collected during stockpiling at the minimum frequency of one sample per 200 tons (180 metric tons) for the first 1,000 tons (900 metric tons) and one sample per 500 tons (450 metric tons) or a minimum of once per week, whichever is more frequent, thereafter. A minimum of five samples are required for stockpiles less than 1,000 tons (900 metric tons).

Before testing, each sample shall be split to obtain two test samples. One of the two test samples from the final split shall be labeled and stored for Department use. The Contractor shall perform a washed extraction and test for unacceptable materials on the other test sample according to Illinois Modified AASHTO T 164. The Engineer reserves the right to test any sample (split or Department-taken) to verify Contractor test results.

The Contractor shall obtain and make available all of the test results from the start of the original stockpile.

1031.04 Evaluation of Tests. Evaluation of test results shall be according to the following.

(a) Limits of Precision. The limits of precision between the Contractor's and the Department's split sample test results shall be according to the following.

Test Parameter	Limits of Precision		
% Passing	RAP	FRAP	RAS
1/2 in. (12.5 mm)	6.0 %	5.0 %	
# 4 (4.75 mm)	6.0 %	5.0 %	
# 8 (2.36 mm)	4.0 %	3.0 %	4.0 %
# 30 (600 µm)	3.0 %	2.0 %	4.0 %
# 200 (75 µm)	2.5 %	2.2 %	4.0 %
Asphalt Binder	0.4 %	0.3 %	3.0 %
G_{mm}	0.035	0.030	

If the test results are outside the above limits of precision, the Engineer will immediately investigate.

(b) Evaluation of RAP/FRAP Test Results. All of the extraction results shall be compiled and averaged for asphalt binder content and gradation, and when applicable G_{mm}. Individual extraction test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	FRAP/Homogeneous/ Conglomerate
1 in. (25 mm)	
1/2 in. (12.5 mm)	± 8 %
# 4 (4.75 mm)	± 6 %
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	
# 30 (600 µm)	± 5 %
# 200 (75 µm)	± 2.0 %
Asphalt Binder	± 0.4 % 1/
G_{mm}	± 0.03 2/

1/ The tolerance for FRAP shall be ± 0.3 percent.

2/ For stockpile with slag or steel slag present as determined in the Manual of Test Procedures Appendix B 21, "Determination of Aggregate Bulk (Dry) Specific Gravity (Gsb) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)".

If more than 20 percent of the test results for an individual parameter (individual sieves, G_{mm}, and/or asphalt binder content) are out of the above tolerances, the RAP/FRAP shall not be used in HMA unless the RAP/FRAP representing the failing tests is removed from the stockpile. All test data and acceptance ranges shall be sent to the Department for evaluation.

With the approval of the Engineer, the ignition oven may be substituted for solvent extractions according to the document "Calibration of the Ignition

Oven for the Purpose of Characterizing Reclaimed Asphalt Pavement (RAP)".

(c) Evaluation of RAS and RAS Blended with Manufactured Sand or Fine FRAP Test Results. All of the test results, with the exception of percent unacceptable materials, shall be compiled and averaged for asphalt binder content and gradation. Individual test results, when compared to the averages, will be accepted if within the tolerances listed below.

Parameter	RAS
# 8 (2.36 mm)	± 5 %
# 16 (1.18 mm)	± 5 %
# 30 (600 µm)	± 4 %
# 200 (75 µm)	± 2.5 %
Asphalt Binder Content	± 2.0 %

If more than 20 percent of the test results for an individual parameter (individual sieves and/or asphalt binder content) are out of the above tolerances, or if the unacceptable material exceeds 0.5 percent by weight of material retained on the No. 4 (4.75 mm) sieve, the RAS or RAS blend shall not be used in Department projects. All test data and acceptance ranges shall be sent to the Department for evaluation.

1031.05 Quality Designation of Aggregate in RAP/FRAP.

(a) RAP. The aggregate quality of the RAP for homogeneous, conglomerate, and conglomerate DQ stockpiles shall be set by the lowest quality of coarse aggregate in the RAP stockpile. RAP originating from roadways under state jurisdiction shall be designated as follows.

Class B Quality	Class C Quality	Class D Quality
Class I Surface	Class I Binder	Bituminous Aggregate Mixture (BAM) Stabilized Subbase
HMA (High ESAL) Surface	HMA (High ESAL) Binder	
SMA	HMA (Low ESAL)	BAM Shoulder

(b) FRAP. If the Engineer has documentation of the quality of the FRAP aggregate, the Contractor shall use the assigned quality provided by the Engineer.

If the quality is not known, the quality shall be determined as follows. Coarse and fine FRAP stockpiles containing plus No. 4 (4.75 mm) sieve coarse aggregate shall have a maximum tonnage of 5,000 tons (4,500 metric tons). The Contractor shall obtain a representative sample witnessed by the Engineer. The sample shall be a minimum of 50 lb (25 kg). The sample shall be extracted according to Illinois Modified AASHTO T 164 by a consultant laboratory prequalified by the Department for the specified testing. The consultant laboratory shall submit the test results along with the recovered aggregate sample to the District Office. Consultant laboratory services will be at no additional cost to the Department. The District will forward the sample to the Central Bureau of Materials Aggregate Lab for MicroDeval Testing, according to Illinois Modified AASHTO T 327. A maximum loss of 15.0 percent will be applied for all HMA applications.

1031.06 Use of RAP/FRAP and/or RAS in HMA. The use of RAP/FRAP and/or RAS shall be the Contractor's option when constructing HMA in all contracts.

(a) RAP/FRAP. The use of RAP/FRAP in HMA shall be as follows.

(1) Coarse Aggregate Size. The coarse aggregate in all RAP shall be equal to or less than the nominal maximum size requirement for the HMA mixture to be produced.

(2) Steel Slag Stockpiles. Homogeneous RAP stockpiles containing steel slag will be approved for use in all HMA (High ESAL and Low ESAL) surface and binder mixture applications.

(3) Use in HMA Surface Mixtures (High and Low ESAL). RAP/FRAP stockpiles for use in HMA surface mixtures (High and Low ESAL) shall be FRAP or homogeneous in which the coarse aggregate is Class B quality or better. FRAP from conglomerate stockpiles shall be considered equivalent to limestone for frictional considerations. Known frictional contributions from plus No. 4 (4.75 mm) homogeneous FRAP stockpiles will be accounted for in meeting frictional requirements in the specified mixture.

(4) Use in HMA Binder Mixtures (High and Low ESAL), HMA Base Course, and HMA Base Course Widening. RAP/FRAP stockpiles for use in HMA binder mixtures (High and Low ESAL), HMA base course, and HMA base course widening shall be FRAP, homogeneous, or conglomerate, in which the coarse aggregate is Class C quality or better.

(5) Use in Shoulders and Subbase. RAP/FRAP stockpiles for use in HMA shoulders and stabilized subbase (HMA) shall be FRAP, homogeneous, or conglomerate.

(6) When the Contractor chooses the RAP option, the percentage of asphalt binder replacement (ABR) shall not exceed the amounts indicated in Article 1031.06(c)(1) below for a given Ndesign.

(b) RAS. RAS meeting Type 1 or Type 2 requirements will be permitted in all HMA applications as specified herein.

(c) RAP/FRAP and/or RAS Usage Limits. Type 1 or Type 2 RAS may be used alone or in conjunction with RAP or FRAP in HMA mixtures up to a maximum of 5.0 percent by weight of the total mix.

(1) RAP/RAS. When RAP is used alone or RAP is used in conjunction with RAS, the percentage of virgin ABR shall not exceed the amounts listed in the following table.

HMA Mixtures - RAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	30	30	10
50	25	15	10
70	15	10	10
90	10	10	10

1/ For Low ESAL HMA shoulder and stabilized subbase, the RAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When RAP/RAS ABR exceeds 20 percent, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

(2) FRAP/RAS. When FRAP is used alone or FRAP is used in conjunction with RAS, the percentage of virgin asphalt binder replacement shall not exceed the amounts listed in the following table.

HMA Mixtures - FRAP/RAS Maximum ABR % 1/ 2/			
Ndesign	Binder	Surface	Polymer Modified Binder or Surface
30	55	45	15
50	45	40	15
70	45	35	15
90	45	35	15
SMA	- -	- -	25
IL-4.75	- -	- -	35

1/ For Low ESAL HMA shoulder and stabilized subbase, the FRAP/RAS ABR shall not exceed 50 percent of the mixture.

2/ When FRAP/RAS ABR exceeds 20 percent for all mixes, the high and low virgin asphalt binder grades shall each be reduced by one grade (i.e. 25 percent ABR would require a virgin asphalt binder grade of PG 64-22 to be reduced to a PG 58-28).

1031.07 HMA Mix Designs. At the Contractor’s option, HMA mixtures may be constructed utilizing RAP/FRAP and/or RAS material meeting the detailed requirements specified herein.

(a) RAP/FRAP and/or RAS. RAP/FRAP and/or RAS mix designs shall be submitted for verification. If additional RAP/FRAP and/or RAS stockpiles are tested and found that no more than 20 percent of the individual parameter test results, as defined in Article 1031.04, are outside of the control tolerances set for the original RAP/FRAP and/or RAS stockpile and HMA mix design, and meets all of the requirements herein, the additional

RAP/FRAP and/or RAS stockpiles may be used in the original mix design at the percent previously verified.

(b) RAS. Type 1 and Type 2 RAS are not interchangeable in a mix design.

The RAP, FRAP, and RAS stone bulk specific gravities (G_{sb}) shall be according to the "Determination of Aggregate Bulk (Dry) Specific Gravity (G_{sb}) of Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS)" procedure in the Department's Manual of Test Procedures for Materials.

1031.08 HMA Production. HMA production utilizing RAP/FRAP and/or RAS shall be as follows.

To remove or reduce agglomerated material, a scalping screen, gator, crushing unit, or comparable sizing device approved by the Engineer shall be used in the RAP/FRAP and/or RAS feed system to remove or reduce oversized material.

If the RAP/FRAP and/or RAS control tolerances or HMA test results require corrective action, the Contractor shall cease production of the mixture containing RAP/FRAP and/or RAS and either switch to the virgin aggregate design or submit a new mix design.

(a) RAP/FRAP. The coarse aggregate in all RAP/FRAP used shall be equal to or less than the nominal maximum size requirement for the HMA mixture being produced.

(b) RAS. RAS shall be incorporated into the HMA mixture either by a separate weight depletion system or by using the RAP weigh belt. Either feed system shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes. The portion of RAS shall be controlled accurately to within ± 0.5 percent of the amount of RAS utilized. When using the weight depletion system, flow indicators or sensing devices shall be provided and interlocked with the plant controls such that the mixture production is halted when RAS flow is interrupted.

(c) RAP/FRAP and/or RAS. HMA plants utilizing RAP/FRAP and/or RAS shall be capable of automatically recording and printing the following information.

(1) Dryer Drum Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Accumulated weight of dry aggregate (combined or individual) in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

d. Accumulated dry weight of RAP/FRAP/RAS in tons (metric tons) to the nearest 0.1 ton (0.1 metric ton).

e. Accumulated mineral filler in revolutions, tons (metric tons), etc. to the nearest 0.1 unit.

f. Accumulated asphalt binder in gallons (liters), tons (metric tons), etc. to the nearest 0.1 unit.

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

h. Aggregate and RAP/FRAP/RAS moisture compensators in percent as set on the control panel. (Required when accumulated or individual aggregate and RAP/FRAP/RAS are recorded in a wet condition.)

i. A positive dust control system shall be utilized when the combined contribution of reclaimed material passing the No. 200 sieve exceeds 1.5 percent.

(2) Batch Plants.

a. Date, month, year, and time to the nearest minute for each print.

b. HMA mix number assigned by the Department.

c. Individual virgin aggregate hot bin batch weights to the nearest pound (kilogram).

d. Mineral filler weight to the nearest pound (kilogram).

e. RAP/FRAP/RAS weight to the nearest pound (kilogram).

f. Virgin asphalt binder weight to the nearest pound (kilogram).

g. Residual asphalt binder in the RAP/FRAP/RAS material as a percent of the total mix to the nearest 0.1 percent.

The printouts shall be maintained in a file at the plant for a minimum of one year or as directed by the Engineer and shall be made available upon request. The printing system will be inspected by the Engineer prior to production and verified at the beginning of each construction season thereafter.

1031.09 RAP in Aggregate Applications. RAP in aggregate applications shall be according to the Bureau of Materials Policy Memorandum, "Reclaimed Asphalt Pavement (RAP) for Aggregate Applications" and the following.

(a) RAP in Aggregate Surface Course and Aggregate Wedge Shoulders, Type B. The use of RAP in aggregate surface course (temporary access entrances only) and aggregate wedge shoulders, Type B shall be as follows.

(1) Stockpiles and Testing. RAP stockpiles may be any of those listed in Article 1031.02, except "Non-Quality" and "FRAP". The testing requirements of Article 1031.03 shall not apply.

End of Article 1031 – Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS from the Standard for Road and Bridge Construction, January 2022

(2) Gradation. One hundred percent of the RAP material shall pass the 1 1/2 in. (37.5 mm) sieve. The RAP material shall be reasonably well graded from coarse to fine. RAP material that is gap-graded or single sized will not be accepted.

SECTION 1032. BITUMINOUS MATERIALS

1032.01 Description. Bituminous materials shall include asphalt binders, emulsified asphalts, rapid curing liquid asphalt, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils. All bituminous materials used in a given construction shall be prepared from petroleum and be uniform in character, appearance, and consistency.

1032.02 Measurement. Asphalt binders, emulsified asphalts, rapid curing liquid asphalts, medium curing liquid asphalts, slow curing liquid asphalts, asphalt fillers, and road oils will be measured by weight.

A weight ticket for each truck load shall be furnished to the Engineer. The truck shall be weighed at a location approved by the Engineer. The ticket shall show the weight of the empty truck (the truck being weighed each time before it is loaded), the weight of the loaded truck, and the net weight of the bituminous material.

When an emulsion or cutback is used for prime or tack coat, the percentage of asphalt residue of the actual certified product shall be shown on the producer's bill of lading or attached certificate of analysis. If the producer adds extra water to an emulsion at the request of the purchaser, the amount of water shall also be shown on the bill of lading.

Payment will not be made for bituminous materials in excess of 105 percent of the amount specified by the Engineer.

1032.03 Delivery. When bituminous materials are not approved at their source by the Department, they shall be delivered far enough in advance of their use to permit the necessary tests to be made. When not delivered in tank cars or tank trucks, the bituminous materials shall be delivered in suitable containers or packages, plainly labeled to show the kind of material, the name of manufacturer, and the lot or batch number. Each shipment and each carload shall be kept separate until the material has been accepted.

Asphalt binder, when delivered in tank cars or tank trucks, shall be delivered at a temperature not to exceed 350 °F (175 °C).

Petroleum asphalts PAF-1 and PAF-2 shall be shipped in new, double end, metal drums. The thickness of the metal used shall not be less than 0.0149 in. (0.4 mm). The side seams of the drums shall be double lapped, spot welded single lapped, or stitch welded single lapped. The seams shall meet the approval of the Engineer. The drums shall be manufactured so that there will be no leakage during hot weather. The capacity of each drum shall be approximately 460 lb (210 kg), the drums being 35 in. (890 mm) maximum in height and approximately 22 in. (560 mm) in diameter.

RAP or RAS Dryer-drum Proportioning Set-up Instructions

Given:

RAP mix%	=	**25.0% (from design)**
AB% in the RAP	=	**4.5% (from design or sample averages)**
AB% mix target	=	**5.7% (from design)**

RAP gradation (from the design or stockpile averages)
Aggregate material gradations (stockpile averages)
Mineral filler gradation, if needed (typically from the design)

Step 1 **Enter all Agg%s from the design including the "RAP%" in the respective Agg% locations**

Example: 25.0 (RAP), 53.5 (CM16), 20.8 (FM20), 1.2 (MF)

Step 2 **Multiply each respective gradation (% Pass) by the respective "Agg % then divide the answer by 100 and record as the % Bin**

(Round the answer to one decimal place)

Example: 1/2" Sieve (RAP) $\frac{100\% \text{ Pass} \times 25.0}{100} = 25.0$ **(%bin on 1/2" sieve)**

Example: 3/8" Sieve (RAP) $\frac{96\% \text{ Pass} \times 25.0}{100} = 24.0$ **(%bin on 3/8" sieve)**

Step 3 **For each respective gradation sieve, add the "%Bin" across the worksheet and record the answer in the combined gradation column**

(Round the answer to a whole number except for the #200 which is to the nearest 10th of a percent)

			Answer		Recorded
Example (1/2"):	**25.0 + 53.0 + 20.8 + 1.2**	=	**100.0**	=	**100**
Example (#200):	**2.0 + 0.9 + 0.8 + 1.1**	=	**4.8**	=	**4.8**

Step 4 **Determine the correction factor (CF) using the total "AB% mix target" (5.7%)**

(Answer to 3 decimal places)

Example: $\frac{100 - 5.7}{100} = \frac{94.3}{100} = 0.943$ **(CF)**

Step 5 **Calculate the "Mix%s" of all "Virgin" ingredients, except the RAP and/or RAS, by multiplying the respective "Agg%" by the "CF" (determined in Step 4). Record in the respective Mix% location**

(Round the answer to one decimal place)

Example: CM16 53.0 x 0.943 = 50.0

Step 6 **Determine the "RAP or RAS Mix%" with the following calculation:**
(Round the answer to one decimal place)

$$\text{RAP Mix\%} = \text{RAP Agg\%} \div \frac{(100 - \text{RAP AB\%})}{100} \times \text{Correction Factor (from Step 4)}$$

Example: $25.0 \div \frac{(100 - 4.5)}{100} \times 0.943 = 24.7$ **(RAP Mix%)**

Enter this answer in the respective RAP Mix% location

NOTE: RAS Mix% is calculated using the same formula using the RAS Agg% and RAS AB%

Step 7 **Total all of the Mix%s**

Example: **24.7 + 50.0 + 19.6 + 1.1 = 95.4**

Step 8 **Subtract this total (Step 7) from 100.0 to achieve the New Bit of the mix**

Example: **100.0 - 95.4 = 4.6**

Enter this answer in the New Bit location

NOTE: <u>There will be no rounding errors to check or correct on this work sheet</u>

Step 9 **Determine the rate of production**

Example: **300 TPH**

Step 10 **Multiply each respective "Mix%" by the rate of production (TPH). Divide this answer by 100 and enter the answer in the respective location for each Mix%**
(Round answer to one decimal place)

Example: **RAP Mix% (24.7 x 300 TPH) ÷ 100 = 74.1 (TPH)**

Step 11 **Insure the proper settings are incorporated into the plant console**

IN CLASS or IN REAL WORLD

Adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don't match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, gradations, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

Information for Recycle Dryer-drum Set-up using RAP

Example #1:

Mix Design Information				
Date:	12/07/16		Design #:	84BIT1234
Plant:	2251-01		Material Code:	19534R
Tech. :	R. Watson		Type of Mix:	N90 'D' Surface

Agg. size: Prod. #: Name: Location:	032CM16 51352-03 Nokomis Nokomis	038FM20 50510-04 CIM Vandalia	004MF01 52102-07 Bm CR St Blom, In	RAP 50973-07 XYZ Asphalt Effingham, IL	Design Formula Gradation
Agg %	**53.0**	**20.8**	**1.2**	**25.0**	
Sieve					
1/2	100.0	100.0	100.0	**100**	**100**
3/8	93.0	100.0	100.0	**96**	**96**
#4	40.0	100.0	100.0	**70**	**60**
#8	16.0	92.0	100.0	**46**	**40**
#16	6.0	60.0	100.0	**33**	**24**
#30	4.0	45.0	100.0	**20**	**17**
#50	3.0	23.0	100.0	**15**	**11**
#100	2.0	6.0	100.0	**10**	**7**
#200	1.6	3.8	90.0	**7.9**	**4.8**
			AB	**4.5**	**5.7**

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**	**100**		**100**
3/8		**95**	**100**		**100**
# 4		**37**	**100**		**100**
# 8		**17**	**91**		**100**
# 16		**6**	**64**		**100**
# 30		**5**	**43**		**100**
# 50		**3**	**21**		**100**
# 100		**2**	**5**		**100**
# 200		**1.7**	**4.0**		**90.0**

Recycle Dryer-Drum Set-up using RAP - Problem #1

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%								= 100%		
TPH								Prod Rate 300 TPH		
Agg%	25.0		53.0	20.8		1.2		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2	100		100	100		100		100		
3/8	96		95	100		100		96		
#4	70		37	100		100		60		
#8	46		17	91		100		40		
#16	33		6	64		100		24		
#30	20		5	43		100		17		
#50	15		3	21		100		11		
#100	10		2	5		100		7		
#200	7.9		1.7	4.0		90.0		4.8		
AB	4.5							5.7		

Recycle Dryer-Drum Set-up Problem (RAP & RAS) #2

Date: 12/07/2016

No. --------->	81BIT1234	Producer & Number>	165-06	HMA Production
Design Lab --------->	PP	Material Code ------>	19523R	HMA Surf CSE N70 C REC

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size	RAS	RAP	032CM16	038FM20			10127
(Prod #)	7483-01	165-06	55555-05	16414-06			2260-01
(Name)	RAS Mat	JFG Asp	Mat Ser	Joliet St			Asp. Mt.
(Loc)	Kankakee	Thornton	Chicago	Joliet			Urbana
Agg %	3.0	15.0	56.0	26.0			100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Form	Range Min	Range Max
1											
3/4											
1/2	100	100	100.0	100			100.0	100	100		100
3/8	100	93	98	100			97.9	90-100	98	90	100
#4	100	67	36	100			59.3	28-65	59	28	65
#8	94	46	9	83			36.3	28-48	36	28	48
#16	75	34	5	58			25.3	10-32	25	10	32
#30	48	27	4	36			17.1		17		
#50	40	18	3	15			9.5	4-15	10	4	15
#100	34	12	3	5			5.8	3-10	6	3	10
#200	27.4	9.4	3.5	3.0			5.0	4-6	5.0	4.0	6.0
AB%	27.0	4.5									

Optimum Mixture Design Data

Number of Revolutions: 70

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	**5.4**	**2.438**	**2.340**	**4.0**	**15.4**	**16.3**	**73.9**	**2.644**	**2.618**		

Average Stockpile Gradations

Sieve Size	CM11	CM16	FM20	FM02	MF01
1					
3/4					
1/2		**100**	**100**		
3/8		**97**	**100**		
# 4		**38**	**100**		
# 8		**9**	**80**		
# 16		**5**	**60**		
# 30		**4**	**38**		
# 50		**4**	**15**		
# 100		**3**	**4**		
# 200		**3.0**	**3.9**		

Recycle Dryer-Drum Set-up using RAP & RAS - Problem #2

Feeder	R1	R2	#1	#2	#3	MF	New Bit			
Size	RAS	RAP		CM16	FM20					
Mix%								= 100%		
TPH								Prod Rate - 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2	100	100		100	100			100		
3/8	100	93		97	100			98		
#4	100	67		38	100			59		
#8	94	46		9	80			36		
#16	75	34		5	60			25		
#30	48	27		4	38			17		
#50	40	18		4	15			10		
#100	34	12		3	4			6		
#200	27.4	9.4		3.0	3.9			5.0		
AB	27.0	4.5						5.4		

Detailed Batch Plant Proportioning Procedures

Hot Bin Proportioning-Passing Method

1. General

This method of hot bin proportioning is used for batch and continuous type plants. A passing specification is used in the proportioning of HMA mixtures for State and Local Agencies. For ease of understanding, a HMA surface mix will be explained first and then a HMA binder mix.

2. IL-9.5 High ESAL HMA Surface Mixture

The mixture to be proportioned is a HMA surface mix as outlined in the standard specifications utilizing a three (3) hot bin system in the production of a surface mixture. There are 6 basic steps needed to obtain initial plant settings for a batch plant.

Step #1: Obtain **representative** hot bin samples and to perform a complete sieve analysis of each sample according to the ITP procedures referenced in the AGCS Policy Memorandum. The established target values are shown below on the "Proportioning Worksheet".

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %							= 100 %		
Sieve Sizes	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1"									
3/4"									
1/2"		**100**	**100**	**100**					
							100		100
3/8"		**70**	**100**	**100**					
							90	90	100
#4		**8.0**	**79.9**	**100**					
							59	32	69
#8		**1.0**	**6.9**	**98.0**					
							34	32	52
#16		**1.0**	**1.0**	**76.9**					
							24	10	32
#30		**1.0**	**1.0**	**43.7**					
							17		
#50		**1.0**	**1.0**	**30.1**					
							10	3	10
#100		**1.0**	**1.0**	**14.0**					
							6		
#200		**0.4**	**0.3**	**9.7**					
							3.5	4	6
AB							**5.5**	5.2	5.8

Step #2: After the sieve analysis is complete, it is necessary to **compute the Agg% needed from each hot bin**. To do this we first need to know the approximate size(s) of aggregate contained in each of the hot bins. In Chapter 2, "Batch Plant Operations", the functions of the "screening unit" and "hot bins" are discussed. An example of a typical screening unit, screen sizes, and the approximate gradation of aggregate in each is shown below.

If totally efficient screening could be achieved, you can see that the primary size of material in Bin #1 would be minus #8 material, Bin #2 would consist essentially of material smaller than the #4 sieve but larger than the #8, and Bin #3 would be 1/2" to #4 in size. (NOTE: when Bin #4 is used, binder mixtures, the material would be plus 1/2 inch in size.) By utilizing this information in conjunction with our target values, we are able to approximate the initial aggregate percentage needed from each hot bin as follows:

In this example, the Target Values (from page 4-34) call for 34% passing the #8 sieve, so we would estimate that 34% would be required from the #1 hot bin since the #1 bin represents minus 8 material in the gradation.

For bin #2 [#4 to #8] the Target Values require 59% passing the #4, however 34% will pass the #8 sieve. Therefore, the amount needed from Bin #2 is the difference between 59% and 34% or 25%.

Similarly for Bin #3 [1/2" to #4]

Target Value 1/2"	=	100.0% passing
Target Value #4	=	- 59.0% passing
Bin #3 estimate	=	41.0%

For this example, it was determined that no mineral filler was needed, see minus #200 determination in Sec. 4, page 4-39 of this manual.

This information is then recorded in the appropriate slots (Agg%s) below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit		
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200			
Mix %							= 100%	
Lbs/Batch							Batch Size = 4000 lbs	
Agg %		**41.0**	**25.0**	**34.0**			= 100%	

<u>Step #3</u>: **<u>Calculate the individual bin percent</u>** (% Bin on the work sheet). To do this we simply take the Agg % (expressed as a decimal) and multiply it by each percent passing (% Pass) calculation obtained from the sieve analysis. Record the result to the nearest 10th of a percent.

For example in Bin #1: 34% (.34) x the amount passing the 1/2" sieve (100.0%) or 0.34 x 100.0% = 34.0% and is recorded on the worksheet in "% Bin" slot corresponding to the 1/2" and Bin #1. This procedure is followed for the remaining sieves in the Bin #1 column and repeated for Bins #2 and #3. The completed calculations are shown below.

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %		**41.0**	**25.0**	**34.0**			= 100 %		
Sieve Sizes	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1"									
3/4"									
1/2"		**100**	**100**	**100**					
		41.0	**25.0**	**34.0**			**100**		100
3/8"		**70**	**100**	**100**					
		28.7	**25.0**	**34.0**			**90**	90	100
#4		**8.0**	**79.9**	**100**					
		3.3	**20.0**	**34.0**			**59**	32	69
#8		**1.0**	**6.9**	**98.0**					
		0.4	**1.7**	**33.3**			**34**	32	52
#16		**1.0**	**1.0**	**76.9**					
		0.4	**0.3**	**25.7**			**24**	10	32
#30		**1.0**	**1.0**	**43.7**					
		0.4	**0.3**	**14.9**			**17**		
#50		**1.0**	**1.0**	**30.1**					
		0.4	**0.3**	**10.2**			**10**	3	10
#100		**1.0**	**1.0**	**14.0**					
		0.4	**0.3**	**4.8**			**6**		
#200		**0.4**	**0.3**	**9.7**					
		0.2	**0.1**	**3.3**			**3.5**	4	6
AB							**5.5**	5.2	5.8

<u>Step #4</u>: **<u>Compute the combined gradation</u>** on the worksheet. This is done by adding horizontally the % Bins (calculated in Step #2) across for each individual sieve size.

For example; the combined gradation for the 1/2" sieve would be 41.0% (% in Bin #3) + 25.0% (% in Bin #2) + 34.0% (% in Bin #1) = 100% [combined gradation passing the 1/2" sieve].

This procedure is then followed for the remaining sieves through the combined gradation of the #200 sieve. The correct calculations are shown below.

NOTE: All combined gradation percents are rounded to the nearest whole percent, **<u>EXCEPT</u>** the minus #200% **<u>WHICH IS ALWAYS</u>** rounded to the nearest **<u>0.1%</u>.**

Proportioning Worksheet

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit			
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200				
Mix %							= 100 %		
lbs/Batch							Batch Size = 4000 lbs		
Agg %		**41.0**	**25.0**	**34.0**			= 100 %		
Sieve Sizes	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1”									
3/4”									
1/2”		**100**	**100**	**100**					
		41.0	**25.0**	**34.0**		**100**	**100**		100
3/8”		**70**	**100**	**100**					
		28.7	**25.0**	**34.0**		**88**	**90**	90	100
#4		**8.0**	**79.9**	**100**					
		3.3	**20.0**	**34.0**		**57**	**59**	32	69
#8		**1.0**	**6.9**	**98.0**					
		0.4	**1.7**	**33.3**		**35**	**34**	32	52
#16		**1.0**	**1.0**	**76.9**					
		0.4	**0.3**	**25.7**		**26**	**24**	10	32
#30		**1.0**	**1.0**	**43.7**					
		0.4	**0.3**	**14.9**		**16**	**17**		
#50		**1.0**	**1.0**	**30.1**					
		0.4	**0.3**	**10.2**		**11**	**10**	3	10
#100		**1.0**	**1.0**	**14.0**					
		0.4	**0.3**	**4.8**		**6**	**6**		
#200		**0.4**	**0.3**	**9.7**					
		0.2	**0.1**	**3.3**		**3.6**	**3.5**	4	6
AB							**5.5**	5.2	5.8

At this point the combined gradations should be compared to the target values for compliance (within allowable tolerances, reference to the applicable Standard Specifications). Minor aggregate percentage (Agg %) adjustments may be necessary at this time, due to screening inefficiency (screen carry-over). If further adjustments are made, this would require recalculation of the combined gradations to assure the desired HMA mixture will be produced. If the stockpiled material gradations are similar to the gradations used in the design process and the hot-bin gradations are representative of the combined material to be used, this step won't be necessary.

<u>Step #5</u>: After assurance that the correct Agg%s have been selected, **<u>the Agg%s need to be converted into individual batch weights</u>** which is required in order that the operator may weigh out the proper amount from each hot bin.

To do this, we first must convert each Agg% into a Mix%. Mix% is defined to include all ingredients of the total mixture; aggregates, recycle, MF and the asphalt binder. This conversion from 100% Agg% to 100% Mix% makes room for the AB%, proportionately. The total Mix%, which will include the AB%, must total 100.0%.

The procedure is as follows: Subtract the AB% (obtained from the HMA mix design, 5.5% in this example) from 100.0% (100.0% - 5.5% = 94.5%) to obtain a correction factor. Now multiply each Agg% by this correction factor percent (as a decimal), including the MF when used.

For example:

100.0% - 5.5 = 94.5%	Bin #1:	0.945 x 34.0%	= 32.1%	32.1%
	Bin # 2	0.945 x 25.0%	= 23.6%	23.6%
	Bin # 3	0.945 x 41.0%	= 38.7%	**38.8%***
	AB		= <u>5.5%</u>	<u>5.5%</u>
		Total	= 99.9%	**<u>100.0%</u>**

***NOTE**: During the actual calculations, the Mix% from Bin # 3 was 38.7% but due to the fact that the total Mix% including the asphalt binder **<u>must</u>** add up to 100% it was necessary to adjust one of the bins by 0.1%. The bin with the largest Mix%, in this case Bin #3, is to be adjusted by 0.1% since this will have the least effect on the final mixture. This adjustment is only applied to 'virgin' aggregate materials, not recycle aggregates. This adjustment is due to a rounding error accrued during calculation of the Mix%s and is considered insignificant to HMA mixture quality. This normally has to be done because most HMA plant computer systems will require an entry totaling 100% Mix% in order to operate correctly.

These calculated Mix%s are then recorded in the appropriate Mix% slot on the worksheet as shown below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit		
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200			
Mix %		**38.8**	**23.6**	**32.1**		**5.5**	= 100%	
Lbs/Batch							Batch Size = 4000 lbs	
Agg %		**41.0**	**25.0**	**34.0**			= 100%	

Step #6: **Calculate the individual Pounds per Batch (Batch Weights)** for each of the hot bins. This is done by multiplying the approved batch size (4,000 lb. in this example) by each respective Mix% (expressed as a decimal).

For example:					
Bin # 1	32.1 %	(0.321) x 4,000 lbs.	=	1,284 lbs.
Bin # 2	23.6 %	(0.236) x 4,000 lbs.	=	944 lbs.
Bin # 3	38.8 %	(0.388) x 4,000 lbs.	=	1,552 lbs.
Asphalt Binder	5.5 %	(0.055) x 4,000 lbs.	=	220 lbs.
Total	100.0 %			4,000 lbs.

Record these weights in the appropriate spot as shown below.

Bin #	Bin 4	Bin 3	Bin 2	Bin 1	MF	New Bit		
Size	+ 1/2	1/2 - #4	#4 - #8	- #8	- #200			
Mix %		**38.8**	**23.6**	**32.1**		**5.5**	= 100%	
Lbs/Batch		**1552**	**944**	**1284**		**220**	Batch Size = 4000 lbs	
Agg %		**41.0**	**25.0**	**34.0**			= 100%	

3. HMA Binder Mixture Proportioning

When proportioning a HMA binder mixture, the same procedure is utilized with one additional step. As shown on page 4-40, "Aggregate Stream-flow for a Typical Batch Plant Screen Deck", Bin #4 will contain +1/2" material (see Step #2 on page 4-36). Therefore, the Agg% needed for Bin #4 is computed by subtracting the Target Value percent passing for the 1/2" sieve from 100%. The Agg% for Bin #4 would be included in each previously described step.

4. Minus #200 Determination

To determine whether or not to add mineral filler, and at what percent, is based on experience with the aggregate materials being used and a thorough knowledge of the specific characteristics and capabilities of the plant. When proportioning the minus #200 material, the dust percent **should never be greater than the job mix formula** and is normally proportioned 1.0%-1.5% below the job mix formula. Consequently, the established Target Value shall reflect this adjustment during the evaluation process during start-up. This adjustment is commonly referred to as a “windage factor”, which is due to additional minus #200 generated during the handling and production process.

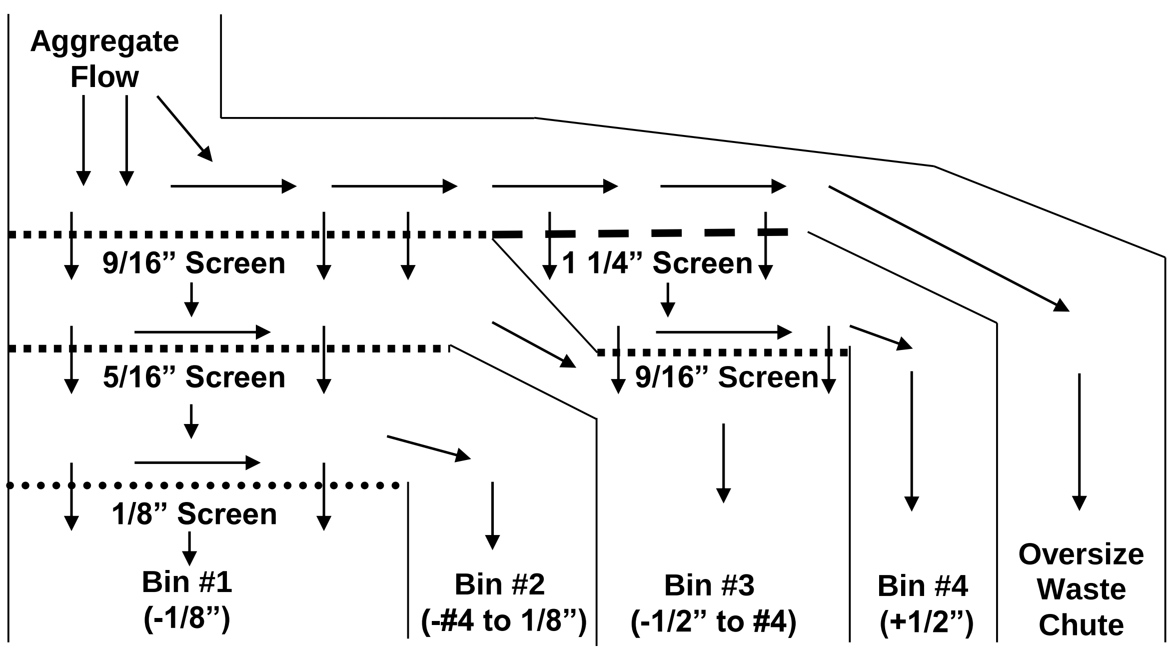
Once the Agg%s have been determined (Step #2),the process to add dust to meet the #200 target is to multiply each Bin% only for each #200 sieve for Bins #2, #3 (& #4) gradations. Total the results to determine the combined gradation for the #200 sieve for the mixture and compare the sum to the #200 target. Normally, if there is a 0.8% or greater difference then **1.0% of dust or more** needs to be added. Most HMA Batch plants cannot accurately handle dust in amounts less than 1.0%. The amount determined will be added as Agg% for the MF. The respective amount added needs to be subtracted from the Bin #1 Agg% to insure all of the Agg%s total 100%. This subtraction is **only** from Bin #1 because both Bin #1 and the MF represents minus 8 material and will only affect the finer (sand) portion of the mixture gradation. The sum of the Bin #1 Agg% and the MF Agg% **has to equal** the target for the #8 sieve. Once the dust has been determined, the rest of the steps will be completed and the other targets (1/2”, #4, #8 & #30) will be left as calculated, **no further adjusting is done**. Agg %s for Bins #2, #3 (& #4) are left as originally determined.

Controlling Elements for Hot Bins

BIN #	CONTROLS
4	+ 1/2” (retained above the 1/2”)
3	% Passing the 1/2” to the #4
2	% Passing the # 4 to the #8
1	% Passing the # 8
MF	% Passing the #200

Controlling elements may vary dependent upon the plant screen deck arrangement

Aggregate Stream-flow for a Typical Batch Plant Screen Deck



9. Batch Plant Set-up Step by Step Instructions

a) Run representative hot bin samples and record the gradations on the worksheet
b) Copy information from the design over to the worksheet:

Design formula - job mix formula (JMF)
Adjust the JMF MF% for windage (real world **NOT** in this class)
Mineral Filler gradation
Mix design optimum asphalt binder percentage

c) Copy the #8 mix design target to the #1 bin Agg%
d) Determine the difference between the #4 and #8 mix design targets and copy the answer to the #2 bin Agg% (once determined this value will not change)
e) Determine the difference between the 1/2” and #4 mix design targets and copy the answer to the #3 bin Agg% (once determined this value will not change)
f) Determine the +1/2” material (1” mix design target minus the 1/2” mix design target) and copy the answer to the #4 bin Agg% (binder mixtures only) (once determined this value will not change)
g) Determine the amount of #200 material being contributed to the mix by each bin and compare to the #200 target (with the windage factor applied)
h) Add MF to the mix as needed (see step ‘g’ above) to meet the #200 target
i) If MF is needed, subtract the percentage amount from the #1 bin **ONLY** so the Agg%s total 100% (the Agg %s is required to total 100%)
j) Multiply the gradations by the respective Agg%s (Bin #1, #2, #3, #4 & MF) rounding answer to the nearest 0.1%
k) Calculate combined gradation for each sieve size rounding answers to the whole percent **EXCEPT** the #200 material (which is always rounded to the tenth of a percent)
l) Calculate the correction factor
m) Multiply each Agg% by the correction factor to obtain the respective Mix% and record to the nearest 10^{th} of a percent
n) Transfer the optimum AB% to the “New Bit” location
o) Total the Mix%s, adjust as needed for any rounding error (this must total 100.0%)
p) Determine the production rate (#s per batch) for the mix
q) Calculate the individual #s per batch for each mix ingredient

IN CLASS or REAL WORLD adjustments are not normally made on a set-up

A plant set-up is the process of establishing plant settings to start making mix. Ideally, if the current stockpile gradations are close to what was used during the design process, the calculated combined gradation should be close enough to start making mix. If these calculated results don’t match the targets exactly, but are within two to three of percent of the targets, adjusting the plant settings will typically be taken care of later after sampling and completion of some mixture plant tests (air voids, AB content, hot-bins, density, etc.). Once the tests are completed and the information is available, adjustments can then be made. In the unfortunate circumstance that the calculated information is significantly different from the mixture targets, the stockpile gradations, cold feed settings and/or calibrations should be rechecked.

On a batch plant set-up, **the only decision that needs to be made** is whether extra dust needs to be put into the mix or not, and if so, how much will be added. The minimum amount of dust to be added is 1% (there has to be at least 1% dust in the dust Agg% or more). No dust can be added if less than 1% is needed (MF Agg%). If dust is added to the mix, the amount added (MF Agg%) will be removed (subtracted) from the #1 bin Agg% (**#1 bin only**) so all of the Agg%s can total 100%. The sum of Bin #1 Agg% and the MF Agg% **has to equal** the mix design target for the #8 sieve. Once the dust has been determined, the remaining critical sieve targets will be calculated and left as is, **no further adjusting is done**.

HMA Superpave Mixture Design Example #1

Date: 12/07/2016

Design No. ---------→	35BIT0000	Producer & Number→	1977-01	XYZ Asphalt
Design Lab ---------→	PP	Material Code ------→	19534	HMA Surf CSE N90 D

Agg. No.	#1	#2	#3	#4	#5	#6	Asphalt
Size		032CM16	038FM20	037FM01	004MF01		10112
(Prod #)		51972-02	50972-02	50510-04	52102-07		2260-01
(Name)		Material	Material	CIM	Bm CR St		Asp. Mt.
(Loc)		Service	Service	Vandalia	Blom. IN		Urbana
Agg %		66.3	19.9	11.6	2.2		100.0

Agg # Sieve Size	#1	#2	#3	#4	#5	#6	Blend	Max Spec	Formula	Range Min	Range Max
1											
3/4											
1/2		100.0	100.0	100.0	100.0		100.0	100	100		100
3/8		97.9	100.0	100.0	100.0		98.6	90-100	99	90	100
#4		36.3	98.1	100.0	100.0		57.4	28-65	57	28	65
#8		9.6	70.0	91.0	100.0		32.5	28-48	33	28	48
#16		6.6	42.0	70.0	100.0		23.1	10-32	23	10	32
#30		5.5	30.1	60.0	100.0		18.6		19	15	23
#50		5.0	14.3	16.0	100.0		9.9	4-15	10	4	15
#100		4.7	10.2	1.2	99.0		7.4	3-10	7	3	10
#200		3.5	6.8	1.0	88.8		5.7	4-6	5.7	4.2	7.2

RAP AB %=====→

Optimum Mixture Design Data

Number of Revolutions: 90

	AB%	G_{mm}	G_{mb}	% Voids P_a	VMA	Design Field VMA	VFA	G_{se}	G_{sb}	TSR	TSR W/Anti
Optimum Data	6.1	2.425	2.327	4.0	14.7	16.5	68.1	2.644	2.588	0.89	

Average Hotbin Gradations

Sieve Size	Bin #4	Bin #3	Bin #2	Bin #1
1				
3/4				
1/2		100	100	100
3/8		96	100	100
# 4		6	90	100
# 8		1	6	95
# 16		1	1	70
# 30		1	1	54
# 50		1	1	30
# 100		1	1	18
# 200		1.0	1.0	10.0

Batch Plant Set-up Example 1 — Surface Mixture

Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **2000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1									
3/4									
1/2		100	100	100	100		**100**		
3/8		96	100	100	100		**99**		
#4		6	90	100	100		**57**		
#8		1	6	95	100		**33**		
#16		1	1	70	100		**23**		
#30		1	1	54	100		**19**		
#50		1	1	30	100		**10**		
#100		1	1	18	99		**7**		
#200		1.0	1.0	10.0	88.8		**5.7**		
AB							**6.1**		

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Batch Plant Set-up Example 2							**Binder Mixture**		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1	100	100	100	100	100		**100**		
3/4	90	100	100	100	100		**95**		
1/2	20	80	100	100	100		**71**		
3/8	18	39	95	100	100		**59**		
#4	1	5	82	100	100		**40**		
#8	1	1	11	93	100		**27**		
#16	1	1	1	50	100		**16**		
#30	1	1	1	35	100		**11**		
#50	1	1	1	17	100		**7**		
#100	1	1	1	11	99		**5**		
#200	0.3	0.3	0.2	6.9	87.7		**3.1**		
AB							**5.9**		

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10. Mixture Adjustment Procedures

a) Insure the gradation samples are representative (resample if necessary).

b) Isolate the problem areas by comparing the combined gradations to the target values.

c) Determine what change(s), the amount of change, and the effect that the changes will have on the overall gradation. Is the mixture coarse or fine?

d) Work the combined gradation values to the nearest tenth of a percent and allow for rounding to help achieve the desired results

(i.e. - 34.5 = 35, 34.4 = 34).

When all of the changes are completed, **round the final combined gradation values to the whole percent** except for the #200 material, which is always rounded to the nearest tenth of a percent.

e) Increase/decrease the appropriate aggregate percentages to insure the new aggregate percentages total l00% when making an adjustment.

f) Recalculate the combined gradations, using the new adjusted percentages and compare the new combined gradation with the target values.

g) If changes are acceptable, recalculate the new rates, TPH (dryer-drum) or batch weights (batch plant) and insure the changes are incorporated into the plant settings.

h) If changes are not acceptable, make further adjustments to the bin percentages, and repeat the process.

i) Once the adjustments have been made and the plant has operated for a little while, take some 'check' gradation samples to verify the changes made were right to obtain the desired results.

j) It is important to understand where your size of material comes from:

1/2" material	Binder	CM11, CM07, etc.
#4 material	Surface	CM16, CM13, etc.
- #8 material	Sand	FM01, FM02, FM20, FM21, FM22
- #200 material*****	Dust	MF (purchased or plant generated)

***** Can be contributed by certain aggregate products

AGCS Master Band and Critical Sieve Designation		
Gradation	**Critical Sieve**	**Master Band (%)**
CA/CM 07	**1/2" (12.5 mm)**	**± 8**
CA/CM 11	**1/2" (12.5 mm)**	**± 8**
CA/CM 13	**# 4 (4.75 mm)**	**± 8**
CA/CM 16	**# 4 (4.75 mm)**	**± 8**
FA/FM 01, 02	**- #8 (- 2.36 mm)**	**± 15**
FA/FM 20, 21, 22	**- #8 (- 2.36 mm)**	**± 15**

Binder mix example:

Material	MB Sieve/Target		Range	Mix Percentage
CM11	1/2”	55%	47% – 63% (± 8%)	50% (typical)

0.50 X 47 = 23.5 Coarse

0.50 X 55 = 27.5 Middle → 31.5 – 23.5 = **8.0% possible change in the gradation**

0.50 X 63 = 31.5 Fine

Control limits for the 1/2” sieve (from chapter 1)	Individual tests	Moving Ave. (of 4)
	± 6	± 4

Surface mix example:

Material	MB Sieve/Target		Range	Mix Percentage
CM16	#4	32%	24% – 40% (± 8%)	60% (typical)

0.60 X 24 = 14.4 Coarse

0.60 X 32 = 19.2 Middle → 24.0 – 14.4 = **9.6% possible change in the gradation**

0.60 X 40 = 24.0 Fine

Control limits for the #4 sieve (from chapter 1)	Individual tests	Moving Ave. (of 4)
	± 5	± 4

Dryer-drum Plant Adjustment Step by Step Instructions

a) Determine if the mix is coarse or fine

b) Start with the #8 sieve. Add or remove minus #8 material (sand) as needed to meet the #8 target

c) Any adjustment made (±) to the sand (Bin #1) Agg%, it is then corrected oppositely in the material farthest to the left (always make the opposite adjustment to the far left) so the Agg% totals 100% (if #8 material is added an equal amount is subtracted from the farthest left bin)

d) Recalculate all #8 sieve gradations that have changed due to the adjustments (repeat steps ‘b’ & ‘c’ as necessary to meet the #8 target)

e) Calculate all changes to the #200 sieves and check to see if the target is met

f) Add or remove MF as needed to meet the #200 target (any changes is added or subtracted to the farthest left material so the Agg% total 100%)

g) Recheck the #8 target if dust was added or subtracted to make sure it still meets the #8 target (repeat steps ‘b’ thru ‘g’ until the #8 and #200 targets have been met)

h) Calculate all changes affecting the #30 sieve (make adjustments with the sand and/or MF as needed)

i) If any changes were made to meet the #30 target, recheck all changes that affected the #8, #30 & #200 targets

j) Once the minus #8 material targets (#8, #30 & #200) have been met, **typically**, any remaining adjustments will be made only with the coarse aggregate materials

k) Calculate all changes to all of the affected #4 sieves and check to see if the target has been met

l) **Surface mixtures** - Make adjustments by adding or removing CM16s (#4 material) and correcting the Agg% (100% total) with the sand(s) as necessary

m) **Binder mixtures** - If the mixture is coarse, add CM16s (#4 material) as necessary correcting the Agg% total with the CM11s (1/2” material)

n) **Binder mixtures** - If the mixture is fine, add CM11s as necessary to meet the 1/2” target, recalculating all sieves affected by the changes correcting with the CM16s Agg%

o) Once you have the mix adjusted, recalculate all critical sieves and Agg% total to determine if the combined gradation meets the mix targets and the Agg% totals 100%

p) If all targets have been met, complete a new blank worksheet calculating **all** sieves for the mixture

q) Finish completing the worksheet (calculate the non-critical sieves, the Mix%s, AB and rate of production)

Dryer Drum Worksheet

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	**RAP**	**#1**	**#2**	**#3**	**#4**	**------**	**-----**			
Size		**CM11**	**CM16**		**FM01**	**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Production Rate 600 TPH**		
Agg%		51.3	17.0		29.4	2.3		**= 100%**		
Sieve Size	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**% Pass**	**Comb Grad**	**Target**	**Control Limits**	
	% Bin	**% Bin**	**% Bin**	**% Bin**	**% Bin**	**% Bin**			**Min**	**Max**
1										
3/4										
1/2		41	100		100	100	70	73		
		21.0	17.0		29.4	2.3				
3/8										
#4		3	32		99	100	38	43		
		1.5	5.4		29.1	2.3				
#8		2	8		92	100	32	36		
		1.0	1.4		27.0	2.3				
#16										
#30		2	3		57	100	21	23		
		1.0	0.5		16.8	2.3				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.4	3.5		
		0.8	0.4		0.1	2.1				
AB								4.0		

Dryer Drum Final Results Sheet

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	**RAP**	**#1**	**#2**	**#3**	**#4**	**------**	**-----**			
Size		**CM11**	**CM16**		**FM01**	**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Production Rate 600 TPH**		
Agg%								**= 100%**		
Sieve Size	**% Pass / % Bin**	**% Pass / % Bin**	**% Pass / % Bin**	**% Pass / % Bin**	**% Pass / % Bin**	**% Pass / % Bin**	**Comb Grad**	**Target**	**Control Limits Min**	**Control Limits Max**
1										
3/4										
1/2		41	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		2	8		92	100		36		
#16										
#30		2	3		57	100		23		
#50										
#100										
#200		1.5	2.4		0.5	90.0		3.5		
AB								4.0		

Dryer Drum Worksheet

Dryer-Drum Adjustment Problem #2 Fine Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%		40.0	18.0		39.0	3.0		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		40	100		100	100	76	73		
		16.0	18.0		39.0	3.0				
3/8										
#4		3	32		99	100	49	43		
		1.2	5.8		38.6	3.0				
#8		3	7		92	100	41	36		
		1.2	1.3		35.9	3.0				
#16										
#30		2	3		58	100	27	23		
		0.8	0.5		22.6	3.0				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.9	3.5		
		0.6	0.4		0.2	2.7				
AB								4.0		

Dryer Drum Final Results Sheet

Dryer-Drum Adjustment Problem #2 Fine Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%								= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		40	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		3	7		92	100		36		
#16										
#30		2	3		58	100		23		
#50										
#100										
#200		1.5	2.2		0.5	90.0		3.5		
AB								4.0		

Dryer Drum Worksheet

Dryer-Drum Adjustment Class Problem #3										
Feeder		#1	#2	#3	#4	MF	New Bit			
Size			CM 11	CM 16	FM 20	MF 01				
Mix%								= 100%		
TPH								Production Rate 200 TPH		
Agg%			37.0	25.0	38.0			= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			36	100	100	100	76	**80**		
			13.3	25.0	38.0					
3/8										
#4			3	49	80	100	44	**47**		
			1.1	12.3	30.4					
#8			1	16	75	100	33	**35**		
			0.4	4.0	28.5					
#16										
#30			1	3	28	100	12	**13**		
			0.4	0.8	10.6					
#50										
#100										
#200			0.5	2.3	8.2	90.0	3.9	**4.1**		
			0.2	0.6	3.1					
AB								**4.7**		

Dryer Drum Final Results Sheet

Dryer-Drum <u>Adjustment</u> Class Problem #3										
Feeder		**#1**	**#2**	**#3**	**#4**	**MF**	**New Bit**			
Size			**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%								**= 100%**		
TPH								**Production Rate 200 TPH**		
Agg%								**= 100%**		
Sieve Size	**% Pass** / **% Bin**	**% Pass** / **% Bin**	**% Pass** / **% Bin**	**% Pass** / **% Bin**	**% Pass** / **% Bin**	**% Pass** / **% Bin**	**Comb Grad**	**Target**	**Control Limits** Min	**Control Limits** Max
1										
3/4										
1/2			36	100	100	100		**80**		
3/8										
#4			3	49	80	100		**47**		
#8			1	16	75	100		**35**		
#16										
#30			1	3	28	100		**13**		
#50										
#100										
#200			0.5	2.3	8.2	90.0		**4.1**		
AB								**4.7**		

Batch Plant Worksheet

Batch Plant Adjustment Example						Surface Mixture			
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New Bit			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200				
Mix%							= 100%		
#'s							Batch Size - Lbs. = **10000**		
Agg%		41.0	25.0	34.0	0.0		= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1									
3/4									
1/2		100	100	100	100	100	**100**		
		41.0	25.0	34.0					
3/8		88	100	100	100	95	**96**		
		36.1	25.0	34.0					
#4		8	92	100	100	60	**65**		
		3.3	23.0	34.0					
#8		1	2	98	100	34	**38**		
		0.4	0.5	33.3					
#16		1	1	70	100	25	**27**		
		0.4	0.3	23.8					
#30		1	1	49	100	17	**20**		
		0.4	0.3	16.7					
#50		1	1	25	100	9	**10**		
		0.4	0.3	8.5					
#100		1	1	12	100	5	**7**		
		0.4	0.3	4.1					
#200		0.2	0.4	8.9	87.7	3.2	**4.6**		
		0.1	0.1	3.0					
AB							**5.5**		

Note: This example has been adjusted for windage

Batch Plant Final Results Sheet

Batch Plant Adjustment Example						Surface Mixture			
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1/2		100	100	100	100		**100**		
3/8		88	100	100	100		**96**		
#4		8	92	100	100		**65**		
#8		1	2	98	100		**38**		
#16		1	1	70	100		**27**		
#30		1	1	49	100		**20**		
#50		1	1	25	100		**10**		
#100		1	1	12	100		**7**		
#200		0.2	0.4	8.9	87.7		**4.6**		
AB							**5.5**		

Note: This example has been adjusted for windage

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Chapter 4 Homework

The homework won't help you

if you don't try to work the problems!

Don't spend a long time on any one problem
but work on each problem.

Give each problem a fair try.

The problems are designed to help you
understand the concepts of proportioning.

On the dryer-drum set-up problem,
if you can get close to the targets then you have done well.

You are not expected to be an expert at proportioning or adjusting mixes when you leave this class

but

You should be able to understand the concepts that have been presented so as to do well in the "real world" and prepare for the test.

Given information for
Dryer-Drum Set-up Homework Problem #1

Aggregate Stockpile & Mixture Design Information						
Feeder	#1	#2	#3	#4		Design Gradation
Agg. size:	032CM11	032CM16	038FM20	037FM02	004MF01	
Agg %	49.0	23.5	13.0	13.0	1.5	
Sieve						
1	100	100	100	100	100	100
3/4	85	100	100	100	100	94
1/2	44	100	100	100	100	73
3/8	19	97	100	100	100	60
#4	10	34	100	100	100	39
#8	7	9	75	92	100	27
#16	4	6	42	65	100	18
#30	3	5	29	40	100	13
#50	2	4	16	14	100	7
#100	2	3	8	3	97	5
#200	1.8	1.9	5.8	1.7	90.0	3.7
AB						4.0

Drier-Dryer-Drum Set-up Homework Problem #1

Feeder		#1	#2	#3	#4	MF	-----			
Agg							**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										

AB										

Given information for
Recycle Dryer-drum Set-up Homework Problem #2:

Average Stockpile Gradation & Design Information						
Feeder	**RAP**	**#1**	**#2**	**#3**	**MF**	
Agg. size:	**RAP**	**042CM11**	**032CM16**	**037FM02**	**004MF01**	**Design Formula**
Agg %	**25.0**	**33.0**	**20.0**	**21.0**	**1.0**	
Sieve						
1”	**100**	**100**	**100**	**100**	**100**	**100**
3/4”	**94**	**91**	**100**	**100**	**100**	**96**
1/2	**85**	**40**	**100**	**100**	**100**	**75**
3/8	**79**	**15**	**92**	**100**	**100**	**66**
#4	**63**	**3**	**40**	**99**	**100**	**47**
#8	**46**	**2**	**15**	**92**	**100**	**36**
#16	**37**	**2**	**6**	**60**	**100**	**24**
#30	**31**	**2**	**4**	**45**	**100**	**19**
#50	**23**	**1**	**4**	**14**	**100**	**10**
#100	**13**	**1**	**4**	**3**	**98**	**6**
#200	**7.6**	**1.0**	**4.0**	**2.2**	**88.0**	**4.3**
AB	**4.5**					**4.0**

Drier-Recycle Dryer-Drum Set-up Homework Problem #2										
Feeder		**R1**	**#1**	**#3**	**#3**	**MF**	**New Bit**			
Agg		**RAP**	**CM11**	**CM16**	**FM02**	**MF**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AB										

Given information for
Batch Plant Set-up Homework Problem #3:

Average Hotbin Gradation & Design Information

Hotbin	Gradations	Batch Size – 8000 lbs.				Design Gradation Formula
Sieve		Bin #3	Bin #2	Bin #1	MF	
1/2		100	100	100	100	100
3/8		93	100	100	100	97
#4		4	94	100	100	55
#8		2	6	92	100	33
#16		2	1	74	100	27
#30		1	1	45	100	17
#50		1	1	23	100	10
#100		1	1	14	99	7
#200		0.5	0.4	5.9	88.0	3.7
AB						5.3

Batch Plant Set-up Homework Problem #3

Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	**+ 1/2**	**-1/2 +#4**	**-4 +#8**	**- #8**	**- #200**	Bit			
Mix%							= 100%		
#'s							**lbs/ Batch** = **8000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1									
3/4									
1/2									
3/8									
#4									
#8									
#16									
#30									
#50									
#100									
#200									
AB									

Dryer Drum Worksheet

Dryer-Drum Adjustment Homework Problem #4									
Feeder		#1	#2	#3	MF	New Bit			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%							= 100%		
TPH							**Prod Rate - TPH =** **300**		
Agg%		37.0	29.0	33.0	1.0		= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1									
3/4									
1/2		34	100	100	100	76	**74**		
		12.6	29.0	33.0	1.0				
3/8									
#4		3	32	99	100	44	**43**		
		1.1	9.3	32.7	1.0				
#8		2	9	96	100	36	**36**		
		0.7	2.6	31.7	1.0				
#16									
#30		1	8	42	100	18	**17**		
		0.4	2.3	13.9	1.0				
#50									
#100									
#200		1.0	5.5	3.8	85.0	4.2	**3.1**		
		0.4	1.6	1.3	0.9				
AB							**4.4**		

Dryer Drum Final Results Sheet

Drier-Drum Adjustment Homework Problem #4									
Feeder		#1	#2	#3	MF	**New Bit**			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%							= 100%		
TPH							**Prod Rate - TPH = 300**		
Agg%							= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1		100	100	100	100		**100**		
3/4		91	100	100	100		**96**		
1/2		34	100	100	100		**74**		
3/8		14	97	100	100		**64**		
#4		3	32	99	100		**43**		
#8		2	9	96	100		**36**		
#16		1	8	56	100		**23**		
#30		1	8	42	100		**17**		
#50		1	7	16	100		**10**		
#100		1	6	6	100		**5**		
#200		1.0	5.5	3.8	85.0		**3.1**		
AB							**4.4**		

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Segregation of HMA Materials

Segregation is a #1 cause of pavement destruction and is required to be addressed by the contractor by specification

Segregation can reduce pavement life by 3-5 years or more depending on the severity of the segregation

The state will impose penalties on contracts/jobs to reduce segregation and make the contractor responsible for problems

Segregation can cause:

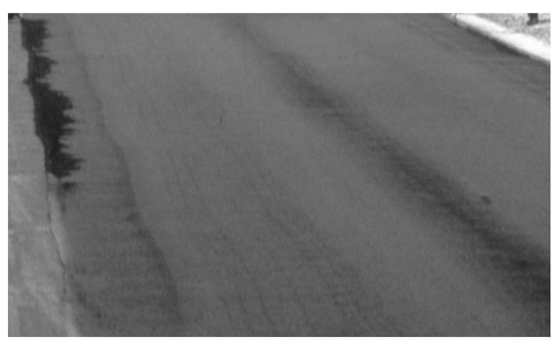
- Smoothness problems
- Density below specification
- Loss of overall mat durability
- Moisture damage & raveling
- Cracking of the pavement
- Streaky pavement surfaces

Segregation can be caused by:

- Mix designs
- Aggregate handling
- HMA plant operations
- Truck loading & unloading
- Paver operations

Pavement Segregation

End of Load Segregation



Pavement Streaking

<u>Segregation Control for HMA Materials document from the Standard Specifications Article 406.06 (g)</u>

(g) *Segregation Control. Paving operations shall be conducted in a manner to prevent medium or high segregation.*

Plant operations, hauling of the mix, paver operations, and the compacted mat shall be continually monitored for segregation.

The in-place HMA shall be evaluated daily for segregation according to the document "Segregation Control of Hot-Mix Asphalt".

The Contractor's Annual Quality Control Plan or Addendum shall identify the individual(s) responsible for performing and documenting the daily evaluations. Quality Control Plans and Addendums for subsequent projects shall reflect the corrective actions taken, whether the corrective action was initiated by the Contractor or the Engineer.

<u>Segregation Control Document from the Manual of Test Procedures</u>

Illinois Department of Transportation

Segregation Control of Hot-Mix Asphalt
Appendix B.20

Effective Date: May 1, 2007
Revised Date: December 1, 2021

1.0 SCOPE

1.1 This work shall consist of the visual identification and corrective action to prevent and/or correct segregation of hot-mix asphalt.

2.0 DEFINITIONS

2.1 Segregation. Areas with a non-uniform distribution of coarse and fine aggregate particles in a hot-mix asphalt pavement.

2.2 End-of-Load Segregation. A systematic form of segregation typically identified by chevron-shaped areas of segregation at either side of a lane of pavement, corresponding with the beginning and end of truck loads.

2.3 Longitudinal Segregation. A linear pattern of segregation that usually corresponds to a specific area of the paver.

2.4 Severity of Segregation.

2.4.1 Low. A pattern of segregation where the mastic is in place between the aggregate particles; however, there is slightly more coarse aggregate in comparison with the surrounding acceptable mat.

2.4.2 Medium. A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which exhibits some lack of mastic.

Illinois Department of Transportation

Segregation Control of Hot-Mix Asphalt
Appendix B.20

Effective Date: May 1, 2007
Revised Date: December 1, 2021

2.4.3 High. A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which contains little mastic.

3.0 PROCEDURE

3.1 When medium or high segregation of the mixture is identified by the Contractor, the Engineer, or the daily evaluation, the following specific corrective actions shall be taken as soon as possible. The corrective actions shall be reported to the Engineer before the next day's paving proceeds.

3.1.1 End of Load Segregation. When medium or high end of load segregation is identified, the following actions as a minimum shall be taken.

3.1.1.1 Trucks transporting the mixture shall be loaded in multiple dumps. The first against the front wall of the truck bed and the second against the tailgate in a manner which prevents the coarse aggregate from migrating to those locations.

3.1.1.2 The paver shall be operated so the hopper is never below 30 percent capacity between truck exchanges.

3.1.1.3 The "Head of Material" in the auger area shall be controlled to keep a constant level, with a 1 inch (25 mm) tolerance.

3.1.2 Longitudinal Segregation. When medium or high longitudinal segregation is identified, the Contractor shall make the necessary adjustment to the slats, augers or screeds to eliminate the segregation.

3.2 When the corrective actions initiated by the Contractor are insufficient in controlling medium or high segregation, the Contractor and Engineer will investigate to determine the cause of the segregation.

When an investigation indicates additional corrective action is warranted, the Contractor shall implement operational changes necessary to correct the segregation problems.

Any verification testing necessary for the investigation will be performed by the Department according to the applicable project test procedures and specification limits.

3.3 The District Construction Engineer will represent the Department in any dispute regarding the application of this procedure.

Daily Segregation Evaluation Form Example

Date	______	County	______
Job #	______	Section #	______
Plant #	______	Route	______
Material	______	District	______
Name	______	Contract #	______
HMA Mix #	______	Job #	______
Lot #	______	Project #	______
Station	______		

Check the boxes which apply the most:

Type of Segregation

☐	None	No segregation of any appreciable amount is present
☐	Segregation	Areas of non-uniform distribution of coarse and fine aggregates
☐	End of Load	Systematic form of segregation typically defined by chevron-shaped segregated areas at either side of the lane, corresponding with beginning and end of truck loads
☐	Longitudinal	A linear pattern of segregation that usually corresponds to a specific area of the paver

Remarks: ______________________________

____

____

Severity of Segregation

☐	Low	A pattern of segregation where the mastic is in place between the aggregate particles, however, there is slightly more coarse aggregate in comparison with the surrounding acceptable mat
☐	Medium	A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat which exhibits some lack of mastic
☐	High	A pattern of segregation that has significantly more coarse aggregate in comparison with the surrounding acceptable mat and which contains little mastic

If medium or high severity of segregation is present, specify corrective actions in remarks.

Remarks: ______________________________

____

____

____

______________________________ ______________________________

Contractors Representative IDOT Representative

All daily evaluations shall be stored at the mix plant where the material was produced. Copies are available upon request.

Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Jack A. Elston, P.E.
Subject:	Special Provision for Material Transfer Device
Date:	October 1, 2021

This special provision was developed by the Bureau of Materials. It has been revised to reference a new material transfer device (MTD) qualified product list (QPL) and limit the use of a Category II MTD's to lower lifts of a full-depth hot-mix asphalt (HMA) pavement where there is less than 10 in. (250 mm) of HMA binder thickness in place. It has also been revised to work with the 2022 Standard Specifications and remove the "fill in the blanks" as the required use of an MTD will now be shown in the HMA Mixture Requirements Table of the plans (see Figure 53-4.K in the BDE Manual).

This special provision shall be inserted into interstate HMA resurfacing and full-depth HMA contracts. For full-depth HMA contracts, an MTD shall be used for constructing all lifts of the pavement. It may be inserted in other HMA paving contracts at the district's discretion.

The operation or transportation of heavy equipment on pavement or structures within contract limits is governed by Article 107.16 of the Standard Specifications and implemented through Construction Memorandum No. 39. Additionally, this special provision contains specific restrictions regarding travel on structures. The designer shall submit information to the Bureau of Bridges and Structures identifying the structures that will be crossed by a Category I MTD. The Bureau of Bridges and Structures will analyze the structures to verify that they have the capacity to safely carry an emptied Category I MTD and will provide the designer with recommendations. The recommendations provided by the Bureau of Bridges and Structures will identify any structure, which due to general deterioration or insufficient load carrying capacity, cannot be crossed by an emptied Category I MTD. The plans shall include notice to the contractor of special requirements and restrictions for structures that cannot be crossed by an emptied Category I MTD. The notice shall indicate to the contractor that the emptied Category I MTD must be transported over the identified structures on a transport vehicle and that information describing axle loads and axle spacing of the transport vehicle must be provided to the Engineer for review by the Bureau of Bridges and Structures.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the January 21, 2022 and subsequent lettings. The

Project Coordination and Implementation Section will include a copy in the contract.

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MATERIAL TRANSFER DEVICE (BDE)

Effective: June 15, 1999
Revised: January 1, 2022

Add the following to Article 406.03 of the Standard Specifications:

"(n) Material Transfer Device ....1102.02"

Add the following to the end of Article 406.06(f) of the Standard Specifications:

"When required, a material transfer device (MTD) shall be used to transfer the HMA from the haul trucks to the spreading and finishing machine. The particular HMA mixtures for which an MTD is required will be specified in the plans. When not required, an MTD may still be used at the Contractor's option, subject to the requirements and restrictions herein. Use of MTDs shall be according to the following.

MTD Category	Usage
Category I	Any resurfacing application Full-Depth HMA where the in-place binder thickness is ≥ 10 in. (250 mm)
Category II	Full-Depth HMA where the in-place binder thickness is < 10 in. (250 mm)

Category I MTD's will only be allowed to travel over structures under the following conditions:

(1) Approval will be given by the Engineer.

(2) The MTD shall be emptied of HMA material prior to crossing the structure and shall travel at crawl speed across the structure.

(3) The tires of the MTD shall travel on or in close proximity and parallel to the beam and/or girder lines of the structure."

Add the following to the end of Article 406.13(b) of the Standard Specifications:

"The required use of an MTD will be measured for payment in tons (metric tons) of the HMA mixtures placed with the MTD. The use of an MTD at the Contractor's option will not be measured for payment."

Add the following between the second and third paragraphs of Article 406.14 of the Standard Specifications:

"The required use of an MTD will be paid for at the contract unit price per ton (metric ton) for MATERIAL TRANSFER DEVICE. The HMA mixtures placed with the MTD will be paid for separately according to their respective specifications."

Revise Article 1102.02 of the Standard Specifications to read:

"**1102.02 Material Transfer Device (MTD).** The MTD shall be according to the following.

(a) Requirements. The MTD shall have a minimum surge capacity of 15 tons (13.5 metric tons), shall be self-propelled and capable of moving independent of the paver, and shall be equipped with the following.

(1) Front-Dump Hopper and Conveyor. The conveyor shall provide a positive restraint along the sides of the conveyor to prevent material spillage. MTDs having paver style hoppers shall have a horizontal bar restraint placed across the foldable wings which prevents the wings from being folded.

(2) Paver Hopper Insert. The paver hopper insert shall have a minimum capacity of 14 tons (12.7 metric tons).

(3) Mixer/Agitator Mechanism. This re-mixing mechanism shall consist of a segmented, anti-segregation, re-mixing auger.

(b) Qualification and Designation. The MTD shall be on the Department's qualified product list with one of the following designations.

(1) Category I. The MTD has a documented maximum HMA carrying capacity contact pressure greater than 25 psi and has a central surge hopper of sufficient capacity to mix upstream HMA with downstream HMA.

(2) Category II. The MTD has a documented maximum HMA carrying capacity contact pressure less than or equal to 25 psi."

80045

Material Transfer Devices (Vehicles)

The following document is reprinted in this manual with permission from Astec.

Technical Paper T-117

SEGREGATION: Causes and Cures

by J. Don Brock, PhD., P.E.
and James G. May
and Greg Renegar

ASTEC encourages its engineers and executives to author articles that will be of value to members of the hot mix asphalt (HMA) industry. The company also sponsors independent research when appropriate and has coordinated joint authorship between industry competitors. Information is disbursed to any interested party in the form of technical papers. The purpose of the technical papers is to make information available within the HMA industry in order to contribute to the continued improvement process that will benefit the industry.

CONTENTS

INTRODUCTION

Hot mix asphalt mixtures that are properly designed, produced and placed provide a durable, long lasting pavement that requires very little maintenance.

However, there are a number of potentially damaging problems that can occur in the design, production and placement of hot mix paving mixtures. Of these problems, perhaps the most serious is segregation. Segregation is a frequently recurring problem that has caused concern within the paving industry for decades and receives widespread attention by contractors, state highway departments and equipment manufacturers.

When segregation is present in a mixture, there is a concentration of coarse materials in some areas of the paved mat, while other areas contain a concentration of finer materials. Segregation creates non-uniform mixes that do not conform to the original job mix formula in gradation or asphalt content. The resulting pavement exhibits poor structural and textural characteristics and has a shorter life expectancy.

Problems associated with segregation are serious. Their elimination is essential to the production of high quality paving mixtures. Elimination of segregation is the responsibility of those who produce and lay asphalt mix, those state highway departments who design the mix and inspect the final product, and those manufacturers who design and market machinery for the paving industry.

This paper was written to help designers, plant operators and paving crews be aware of the causes of segregation and known solutions. Each portion of the plant, paver and trucking operation known to cause segregation is discussed separately. In addition, a diagnostic chart accompanies this paper to help identify types of segregation and probable causes.

MIX DESIGNS

Proper mix design is important in the effort to eliminate segregation. Mixes that are uniformly designed with no gap-grading are generally very forgiving. They allow mistakes in other areas of the plant operation or laydown operation without affecting the mix performance significantly.

Gap-graded mixes are unforgiving. Consequently, any slight error in the plant, trucking or layout process can result in non-uniform surfaces. If the mix is gap-graded to a sufficient degree with a low asphalt content, it simply cannot be produced without segregation, regardless of the techniques used.

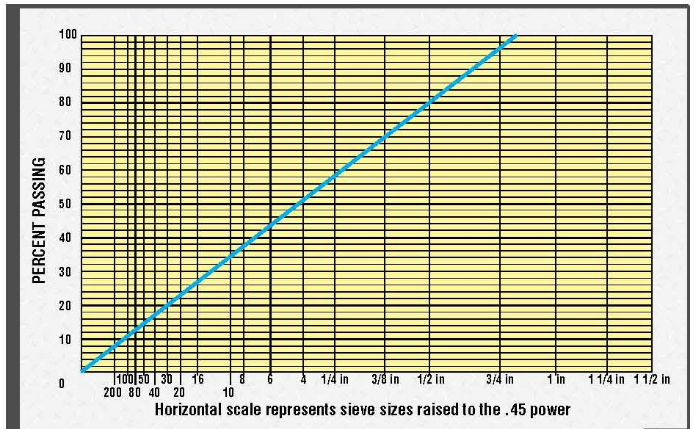
Gap graded mixes have been successfully used in England and throughout Europe. However, these mixes often have fibers or polymers, enabling the use of a higher asphalt content that makes the film thicker. In many mixes a slight increase in asphalt content (often as little as 0.2 percent) will reduce segregation significantly. Increased film thickness dampens particle-to-particle contact and reduces the tendency to separate at transfer points throughout the process. The new SMA and Superpave mixes in the U.S. are gap-graded. However, the addition of fibers and polymers make them less sensitive to segregation.

A maximum density line similar to the one shown in **Figure 1** can be utilized as a guide to uniform grading. To make a chart with a maximum density line for your operation, use a FHWA 0.45 Power Gradation Chart as shown in **Figure 1**. Draw a straight line between the lower left corner of the chart and the percent point for your largest sieve size that retains material.

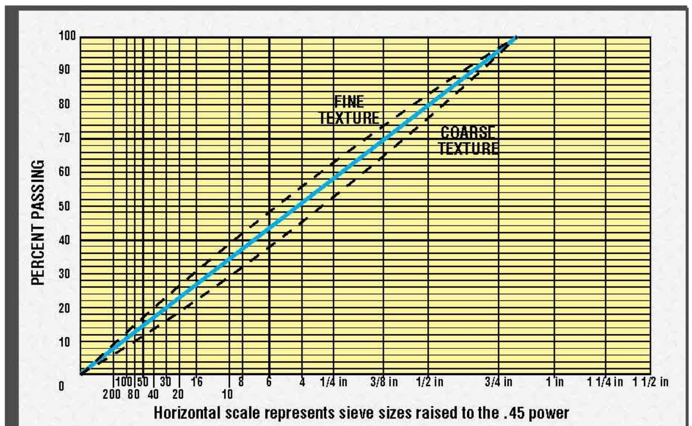
Experience dictates that mixes with gradations that fall directly on the maximum density line should not be produced. Often there is insufficient room in the mixture for the liquid asphalt, and a plastic type material results. Another problem arises when the mix design is near the maximum density line. Gradation variations in stockpile material cause the curve to vary back and forth across the maximum density line, thereby gap-grading the mix. It is suggested that the mix designer select approximately two to four percentage points above the maximum density curve if he desires a fine texture. He should select two to four points below the curve if he desires a coarse texture, see **Figure 2**. These bowed up and bowed down curves usually result in a good, forgiving mix.

Rarely does a mix that lies on the maximum density line contain sufficient *voids in the mineral aggregate* (VMA), especially if the design has a relatively high percentage of minus 200 material. A grading selected on a line approximately parallel to the maximum density line will produce a uniformly graded mix that will be very forgiving. However, the maximum density line should be used only as a guideline for uniform grading. Other criteria such as VMA, stability and other specifications must also be met.

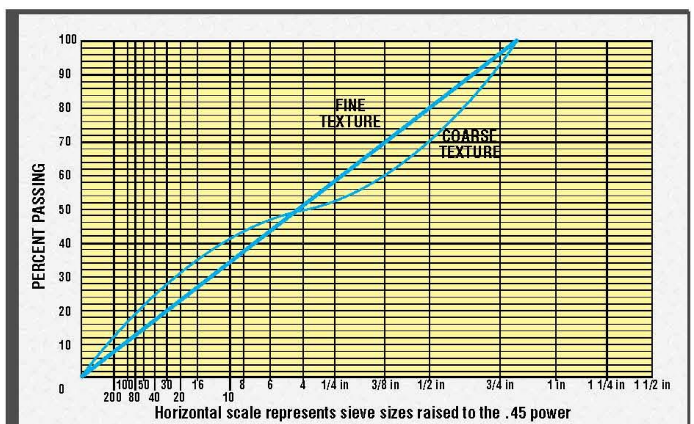
A mix design that makes an "S" across the maximum density line, as shown in **Figure 3**, can result in segregation problems.



MAXIMUM DENSITY LINE F1

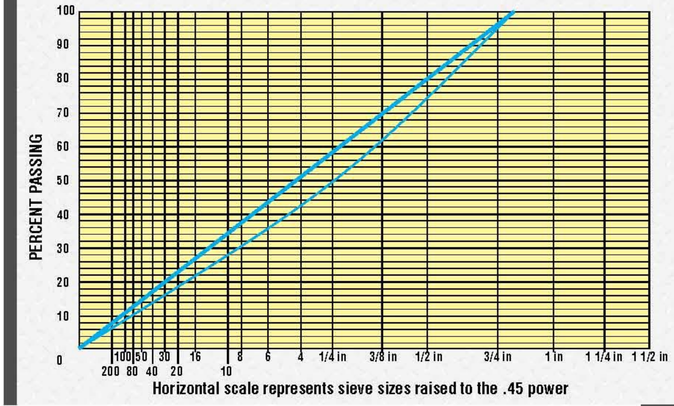


SELECTING MIXES F2

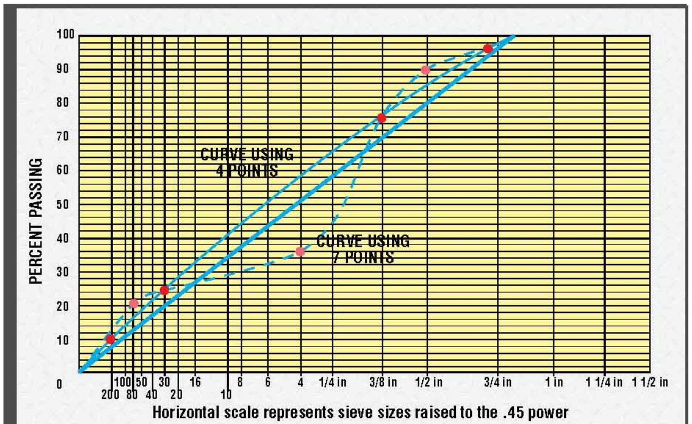


"S" CURVES TEND TO SEGREGATE F3

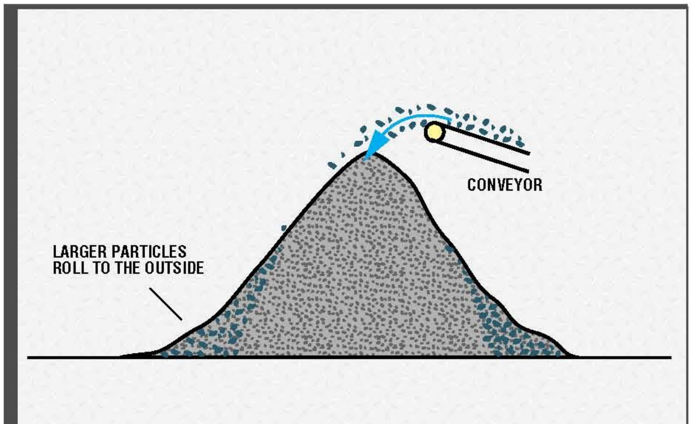
3



SLIGHTLY BOWED CURVES MAY DO WELL F4



SAME MIX 4 vs 7 POINTS F5



SEGREGATION IN A PILE F6

4

The slightly bowed curve shown in **Figure 4** could result in good performance. But the potential benefit that a designer tries to achieve by gap-grading is too often negated by segregation problems.

When plotting a mix gradation, plot as many sieve sizes as possible. **Figure 5** illustrates how plotting to only a few points can result in a misleading graph. When only 4 sieve sizes are plotted as shown in **Figure 5** the curve may indicate a "forgiving" mix. But when seven sieve sizes are plotted, also shown in **Figure 5**, it is easy to see that the mix is actually gap-graded.

STOCKPILING

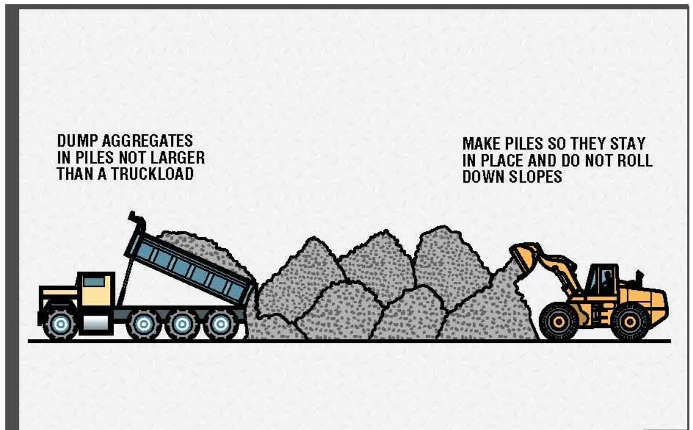
Proper stockpiling techniques are needed to insure that the material will be uniform when fed to the hot mix plant. Large stockpiles are very sensitive to single aggregate blends. **Figure 6** shows a typical example of a single aggregate stockpile. In this example, segregation has occurred because a conveying system was used to form the stockpile. Large particles have rolled to the outside of the pile thereby segregating the material. Subsequently, segregated material is fed to the plant.

Generally, different-sized materials are stockpiled separately for feeding to an asphalt plant. This makes segregation less likely because the material is more evenly sized in each pile. However, segregation can occur in smaller aggregates if a wide variation in gradation exists. Stockpile techniques shown in **Figures 7** and **8** assure uniformity of material and significantly reduce stockpile segregation. Dozer operation should be monitored to assure degradation is not occurring. Monitoring is especially critical when dealing with softer aggregates. NAPA Publication IS-69, *Stockpiling and Cold Feed For Quality,* gives good guidelines for proper stockpiling techniques.

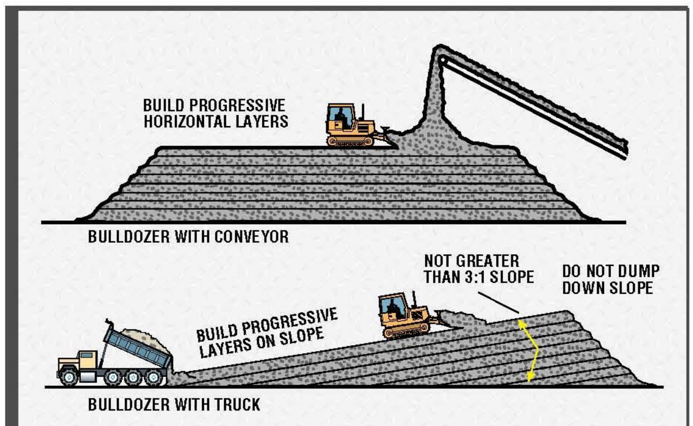
When sampling stockpile material to set up cold feed bin ratios, it is important to take several samples and use the median result as shown in **Figure 9**.

ASPHALT FACILITIES

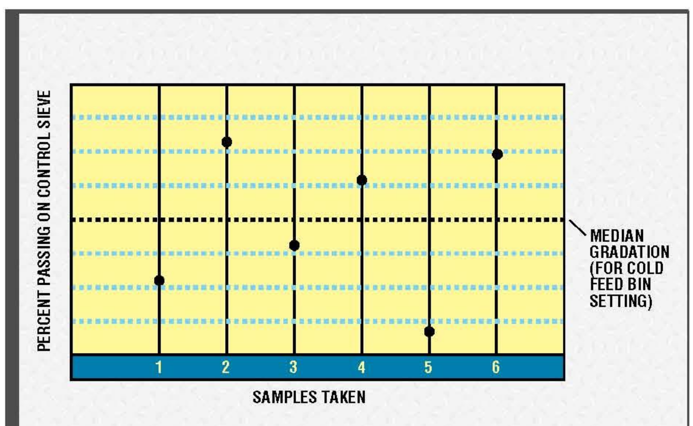
Segregation can occur at numerous points in a hot mix asphalt plant. The location at which segregation is likely to occur in a plant depends on what type of facility it is. On a batch plant, the points of most concern are cold feed bins and hot bins. On drum mix plants, surge bins and storage bins are the points of most concern.



USE NUMEROUS SMALL PILES F7

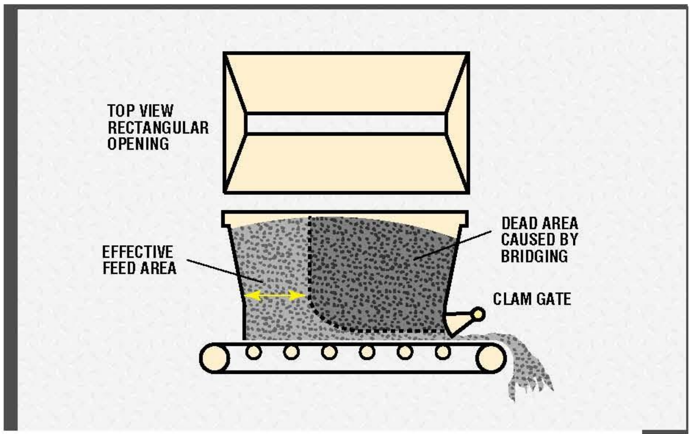


BUILD STOCKPILES IN LAYERS F8

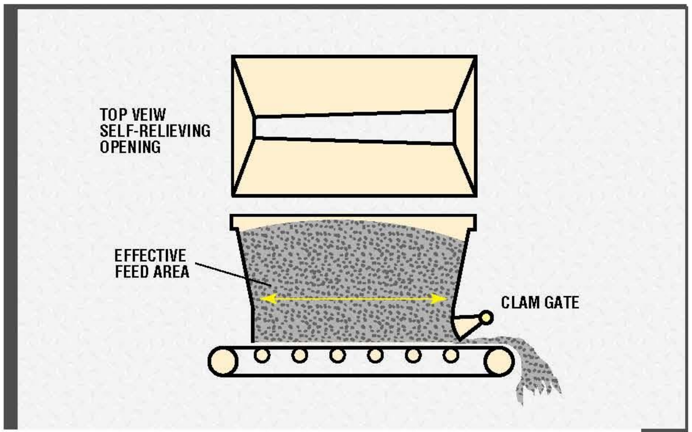


STOCKPILE SAMPLING F9

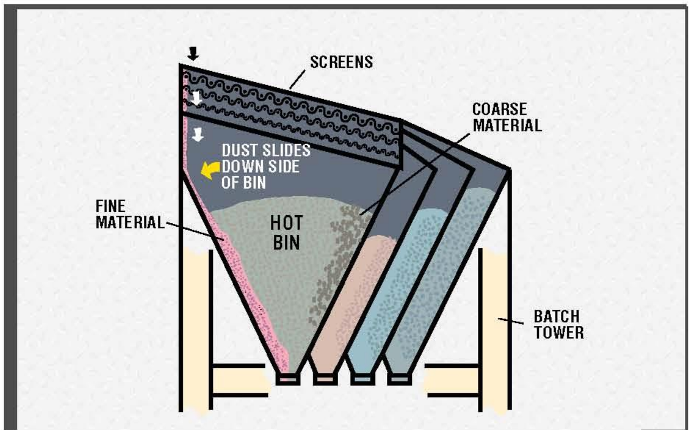
5



FEEDER BIN WITH RECTANGULAR OPENING F10



SELF-RELIEVING FEEDER BIN F11



HOT BIN SEGREGATION F12

COLD FEED BINS

Segregation in cold feed is usually not a problem unless the aggregate material consists of several sizes. Segregation should not occur when a single size of aggregate is placed in each feeder bin because there are no different sizes to segregate. However, if bridging of material occurs in the hopper, see **Figure 10**, non-uniform feeding takes place, resulting in a segregated mix.

By utilizing a self-relieving bottom shown in **Figure 11**, uniform feeding will occur all along the opening of the cold feed bin, eliminating bridging as a source of segregation.

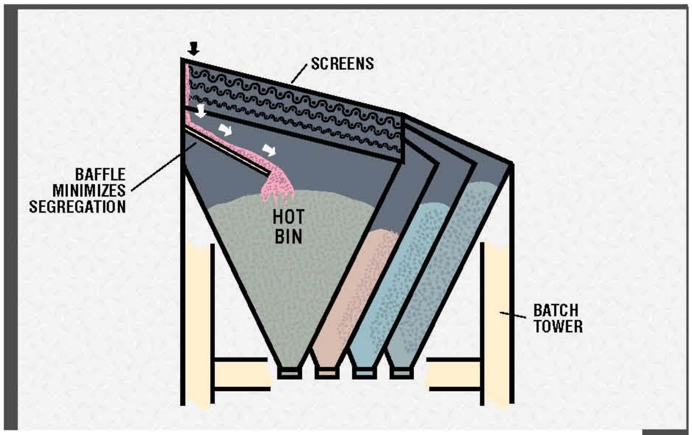
When working with a crusher-run aggregate, it can be beneficial to use two cold feed bins to feed the same material. This practice tends to minimize wide variations by feeding smaller amounts of material from two bins, thus minimizing variations in gradation.

HOT BINS ON A BATCH PLANT

As mentioned, segregation can occur with all sizes of material. Segregation often occurs in the No. 1 hot bin due to the size and shape of the large bin and the wide size range of materials in that bin. The size variation in material in Bin 1 is potentially greater than any other part of the asphalt plant because its material size varies from as large as 3/16-inch all the way down to one micron.

In recent years some have voiced concern about uniform dust return from baghouses to batch plants. Generally, material is uniformly collected in baghouses and is uniformly returned, but the material may actually be segregating in Bin 1. The ultra-fine material discharged from the bucket elevator may fall directly through the screen and lay on a sloping bin wall, **Figure 12**. It may lay there until the bin is about empty. Then a large slug of the dust may break loose and feed into the weigh hopper, producing an ultra-fine batch that is segregated, and uncoated.

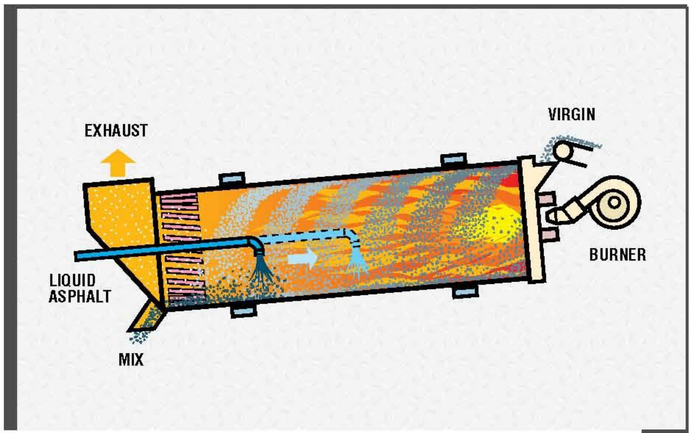
In many cases non-uniform feed from the baghouse was incorrectly suspected to be the cause of segregation in the hot bin and resulted in the addition of expensive and unnecessary equipment. There was simply an improper analysis of the problem. The proper solution should be to install a baffle as shown in **Figure 13**. The baffle causes the dust to slide to the center of the bin where it is uniformly mixed with the coarse materials.



HOT BIN WITH BAFFLE F13

The same results can be achieved by using a baffle to force the coarse material back to the sloping bin wall. There, it can be intermixed with the fine material. The method used depends on the head room and space available in the hot bins.

Utilizing a dust blower at the baghouse and a cyclone type dust receiver properly located in Bin 1 has also proved effective in eliminating segregation in this area. However, many prefer to use baffles because of relatively high maintenance costs for airlocks that handle abrasive materials such as granite.

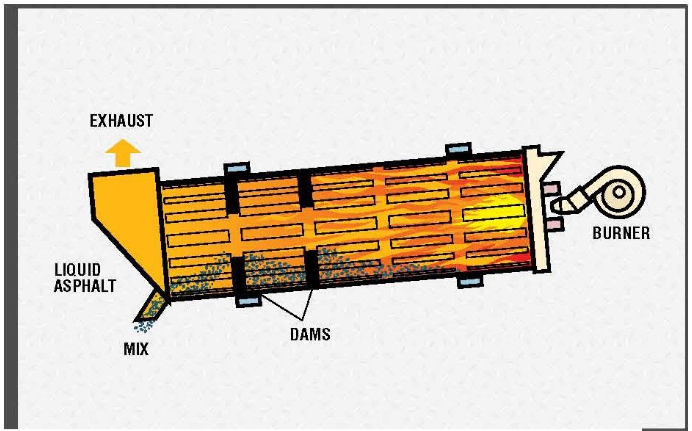


INCREASING MIXING TIME IN A DRUM MIXER F14

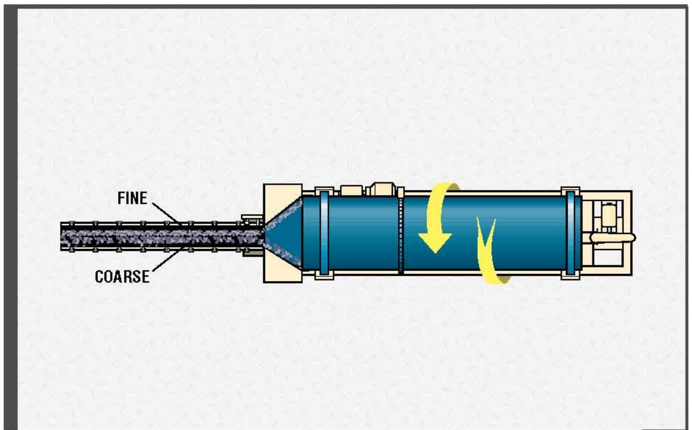
DRUM MIXER

Large particles will generally flow through a drum mixer at a slightly faster rate than small particles during initial start up and at plant shut down. Negative effects associated with this characteristic can be eliminated by adjusting the start/stop time intervals between the cold feed bins. Due to the continuous flow process that occurs after start-up, this characteristic does not produce segregation. The potential to segregate is also of little significance unless the material is gap-graded.

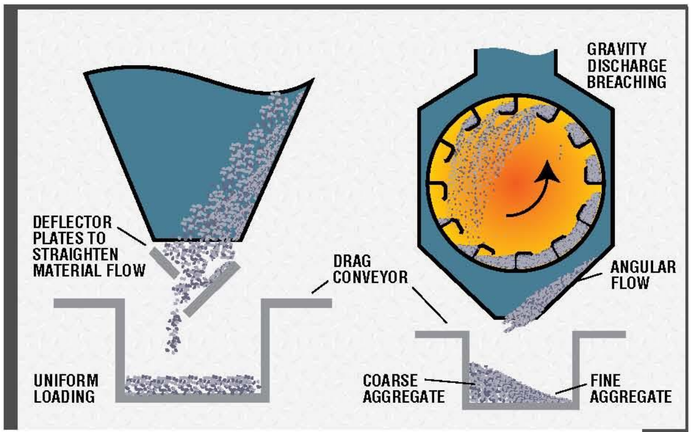
When gap-graded mixes are processed in a drum mixer, it becomes more difficult to achieve a thorough coating with a uniform thickness. The uncoated or thinly coated coarser materials are more likely to segregate. Such segregation can be reduced or eliminated through better coating. This can be accomplished by increasing the mixing time by extending the asphalt line farther up into the drum mixer as shown in **Figure 14**. For hard-to-coat materials, kick-back flights as shown in **Figure 14** can be used, or a dam (donut) can be installed in the drum to increase the mixing time, **Figure 15**.



DRUM MIXER DAMS RETARD FLOW F15



DRUM DISCHARGE SEGREGATION F16



GRAVITY DISCHARGE F17

An alternate method is to decrease the drum slope, which increases the dwell time and provides additional mixing. Increased dwell time, whether due to the addition of dams or due to decreasing the drum slope, increases the drum load. This may reduce the production rate if the drum drive motor is a limiting factor.

An often overlooked factor which can significantly affect coating quality and film thickness is the amount of minus 200 material in the mix. Coating quality will be adversely affected if the amount of minus 200 material exceeds specifications or even if it is within specifications, but on the high side of the tolerance allowed. Because of the large amount of surface area present in fine material and because of its affinity for the liquid asphalt, coarser material in the mix will have a reduced film thickness even though it may appear to be fully coated. Reduced film thickness makes the coarse material less sticky and increases its tendency to segregate. Reducing the amount of minus 200 material to the low side of the allowable tolerance will usually correct this problem. Moreover, it will be easier to produce a uniform mix and easier to handle the mix throughout the trucking and laydown operations.

INTERNAL MOISTURE

Retained internal moisture is rarely a problem while running RAP since the virgin aggregate containing the internal moisture is superheated above the mix termperature. The degree of superheat depends on the percent RAP, RAP moisture and the mix termperature. For example, with 30% RAP containing 5% moisture, the virgin aggregate is heated to 512°F to produce 300°F mix. If retained internal moisture is a problem while producing a virgin mix, one of the aggregates, not containing internal moisture, can be added into the plant process

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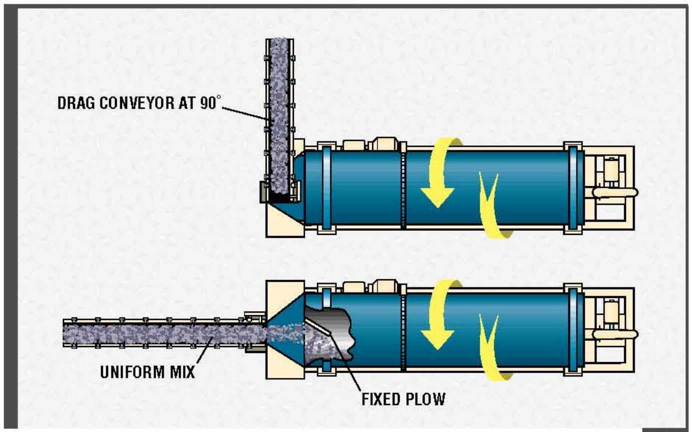


DRUM DISCHARGE FLOW F18

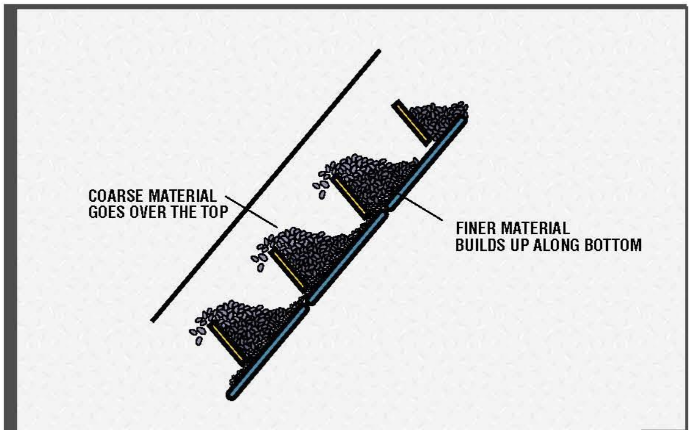
through the RAP system. This induces the plant to superheat the aggregate containing internal moisture, thus removing the internal moisture before the liquid AC is added. This helps coating and mimimizes AC absorption. An Alabama contractor reduced the moisture retained in a slag mix from 0.22% to .06% by adding 15% screenings through the RAP bin.

The coating of large stones can also be affected by internal moisture and absorption. When internal moisture is present in large aggregate its temperature tends to be cooler than finer material. Cooler stones will not coat readily until they have given up their moisture and reached a uniform elevated temperature comparable to the temperature of the rest of the mixture. Internal moisture can be eliminated by increasing drying and mixing times using the methods described above.

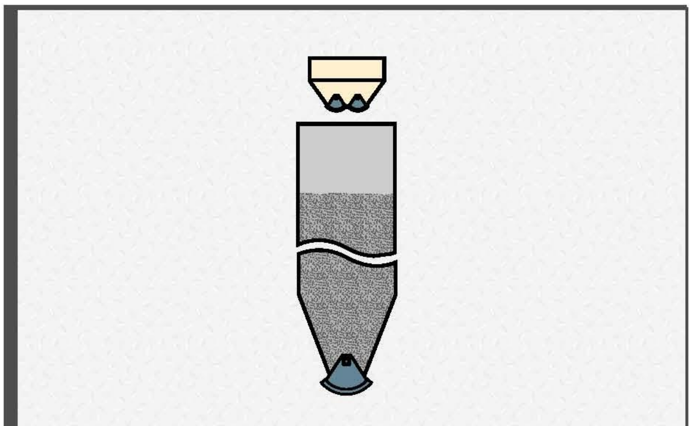
Asphalt absorption problems are related to internal moisture problems. This is because the same pores that contain the moisture in the stone will absorb a portion of the available asphalt. This absorption reduces the actual film thickness on the outside surfaces. If absorption is suspected, break open several larger stones and examine them under a magnifying glass. A dark band ranging from a few thousands of an inch to 1/32-inch wide from the surface inward indicates that absorption is occurring. The solution to attaining the film thickness originally desired is to increase the asphalt content to make up for the portion being absorbed.

Mix discharged from drums by gravity is more sensitive than mix discharged from drums with a high lift where the material is required to make a 90 degree turn prior to discharge. With gravity discharge, coarse material often discharges on one side and fine material on the other. The segregated material drops directly onto a drag conveyor and continues to segregate right on through the batcher and bin as shown in **Figure 16**. The problem can be improved by restricting the discharge chute from the drum to a smaller opening, forcing the mix into the center of the drag conveyor. Adding deflector plates or straightening vanes is also an effective way to make sure the drag conveyor is properly loaded from a gravity type discharge see **Figure 17**.

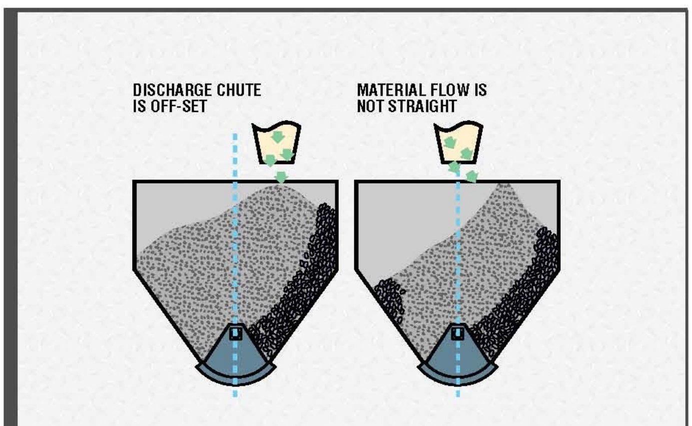
Another solution is to install a plow or single discharge point in the drum as shown in **Figure 18**, forcing all mix to come out at one point. However, experience shows it is difficult to design and install an effective plow on most drum mixers. When possible it is best to set the drag conveyor at a 90 degree angle to the drum discharge to create a right angle change in material flow. This setting reduces or eliminates drum discharge segregation.



HYDROPLANING IN A DRAG CONVEYOR F19



BIN LOADING BATCHER F20



CHUTES THAT CAUSE UNSATISFACTORY MATERIAL FLOW F21

10

SURGE AND STORAGE BINS

Drag Conveyors

Segregation will usually not occur in a drag conveyor unless it is “hydroplaning.” Hydroplaning occurs as a result of a material buildup in the bottom of the drag conveyor. Cold conveyors that do not have floating hold-downs are prone to build-up on the bottom liners. The build-up creates a high friction drag surface that results in material spilling backwards over the drag flights as shown in **Figure 19**, even at very low production rates. This condition is easily observed. Material falls backwards down the drag conveyor instead of moving uniformly in one mass with full material from flight-to flight.

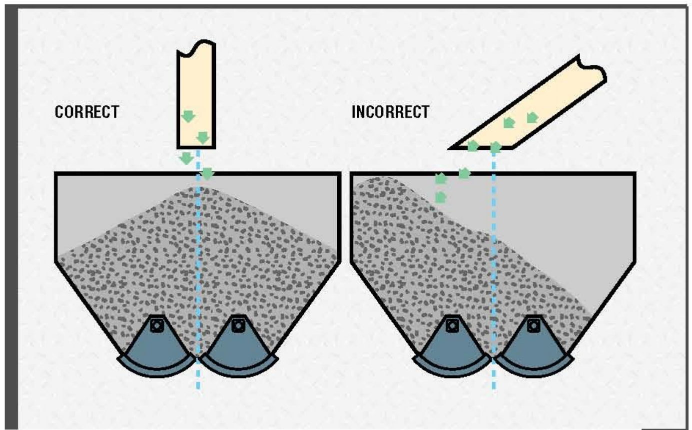
When the drag conveyor is hydroplaning, considerable segregation can occur, especially at the beginning and end of each run. Hydroplaning is more prevalent on batch plants where the segregation can be carried from batch to batch. Drag conveyors should be equipped with floating hold downs and heated bottoms for cold start-ups.

Segregation is minimized when the drag conveyor is as full as possible. When the slats are only partially filled, the larger aggregate is apt to roll to each side within the drag conveyor. So, it’s better to run at higher production rates to keep the drag conveyor full. When producing a segregation prone mix at production rates higher than the rate used by paving operations, store the extra mix and shut down production earlier than usual.

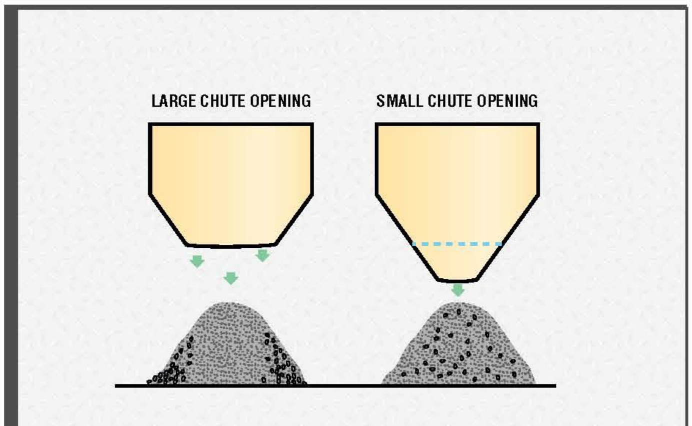
Storage Bins

The most sensitive area for segregation on a hot mix plant is in surge and storage bins. The large sizes of the bins contributes to segregation problems. Since the first surge and storage bins were developed many years ago, considerable improvement has been made on bin equipment to prevent segregation. Once of the most detailed and complete studies of hot mix surge and storage segregation was conducted by the University of Texas in the early 70's. From their investigation, various techniques were devised for eliminating segregation.

The result of the study revealed that the bin loading batcher was a good device for eliminating segregation in surge and storage bins, **Figure 20**. The study also addressed various gate openings and showed that if the bin was properly loaded with uniform mix, the gate configuration was not of significant importance. However, the batcher is not an absolute "cure all". It can create problems of its own and it's best to understand how and why.



BATCHER CHARGING F22



LESS SEGREGATION WITH SMALLER CHUTE OPENING F23

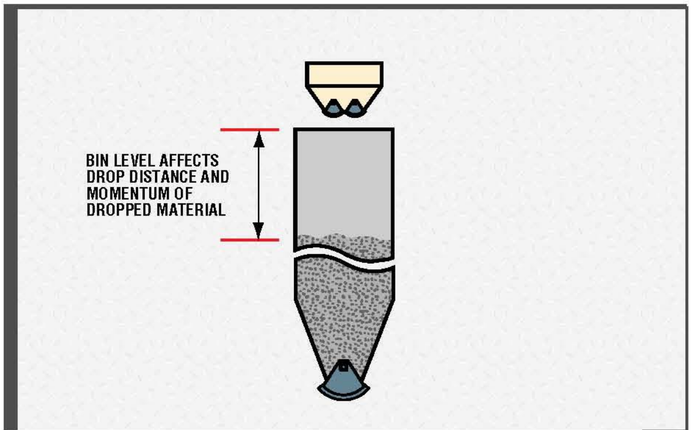
Bin Loading Batchers

Perhaps the most popular device for eliminating segregation on surge or storage bins is the bin-loading batcher. The following observations and practices should be followed when using a batcher:

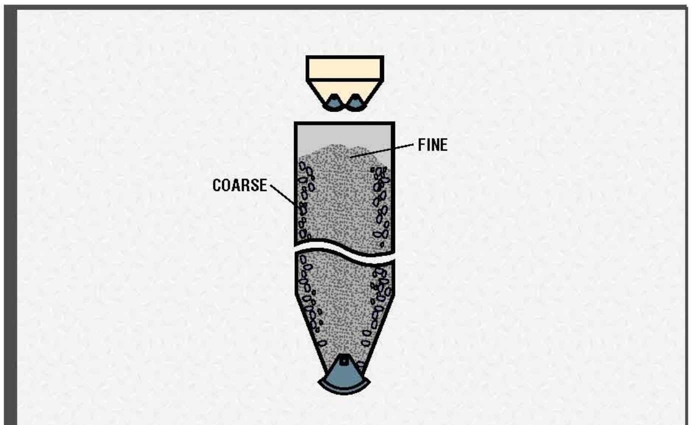
a. The batcher should be filled to its maximum capacity (at least 5,000 lbs.) And have a relatively large diameter gate opening to insure rapid discharge of material into the storage bin.

b. The batcher must be loaded directly in the center and the material from the chute loading the batcher should have no horizontal trajectory, **Figure 21** and **22**. Also, whenever mix is discharged through a chute, a small chute opening minimizes segregation, **Figure 23**. Remember, if the material segregates in the batcher, it will remain segregated throughout the bin.

c. The batcher should be filled completely before each drop. Normally, two high bin indicators are utilized. One dumps the gates and the other insures the gates will dump if the first indicator fails. When the batcher gates fail to open, mix backs up in the drag conveyor all the way into the drum. This possibility makes operators want to leave the gates open, totally defeating the batcher's purpose. If at all possible, timers should not be used on batchers except to control the gate open-time. The production rate of the plants will vary, and different amounts of time should not be used on batchers except to control the gate open-time. The production rate of plants will vary, and different times are required to fill the batcher. Remember, it is essential that the batcher be filled each time so that an adequate slug or a single mass drops into the bin.



BIN CHARGING BATCHER F24



BIN KEPT TOO FULL F25

1. Batch size should be at least 5,000 lbs. (more is better).
2. Batcher should be loaded in the center.
3. Material should flow straight down into the batcher. (no horizontal trajectory).
4. Batcher gate timers should be adjusted so that gates shut with 6-8 inches of material left in the batcher. Do not allow any free flow through the batcher.
5. Batcher should be maintained so that the mix drops out rapidly as a slug.

BATCHER RULES F26

d. The batcher should never be completely emptied. The gate-open-time should be adjusted so that a small amount of material (approximately 6 inches) remains in the batcher after the discharge cycle is completed. If the gate remains open too long, new material falls straight through the batcher and goes directly into the bin, resulting in random segregation.

e. When utilizing a bin-loading batcher, the emptier the bin, the farther the fall of the material and the more likely a level, uniform bin-loading will occur, **Figure 24**. The worst situation when operating a bin loading batcher is to have the bin material level consistently near the top, **Figure 25**. The mix drop then has insufficient momentum and results in peaks of material instead of splattering the material to form a level surface. The rules for correct batcher operation are summarized in **Figure 26**.

Loadout From Surge or Storage Bins

If the surge or storage bin is uniformly filled, loadout of hot mix asphalt from the bin is not of great concern. Pulling material below the cone is not as sensitive as with the old type center-loaded bins. This is due in part to improved bin loading with batchers and rotating chutes, but results primarily from utilizing a steep cone angle that produces a mass flow of material from the bin. With most non-gap-graded materials, the bin can be emptied without any appreciable segregation. However, with gap-graded material the bin level should still not be allowed to drop below the cone. Also, constantly running with the cone empty will accelerate cone wear.

Rapid discharge from the silo gate helps eliminate segregation in trucks. This reduces the chance of segregation in the truck bed by minimizing the rolling action of the mix as it is flowing into the truck bed.

In cold weather, bins should be insulated, at least on the cone. Could surfaces can cause the mix to stick the cone and under these conditions the material can plug flow instead of discharging in a uniform mass flow.

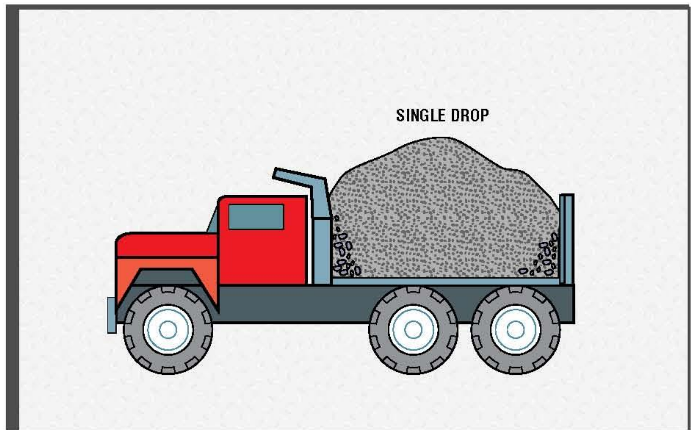
TRUCK LOADING AND UNLOADING

Due to rapid truck loading underneath surge or storage bins, truck drivers often tend to pull the truck under the bin and not move it while loading. If the mix is sensitive to segregation, larger stones will roll to the front of the truck, to the rear, and to the side, resulting in the coarse material being the first and last material to be discharged from the truck bed. The coarse material on each side will then be trapped in the wings of the paver to be discharged between truck loads. This discharging results in coarse areas of pavement between each truck load. This type of loading is shown in **Figure 27**.

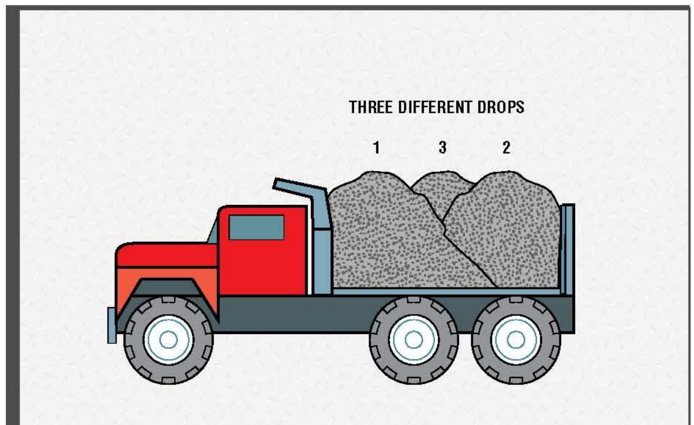
By loading the truck in at least three different drops, with the first drop being very near the front of the truck bed, the second drop extremely close to the tail gate, and the third drop in the center, segregation caused by incorrect truck loading is eliminated. This type of loading is shown in **Figure 28**.

Bins equipped with weight batchers as shown in **Figure 29** tend to batch material directly into the trucks in a manner similar to the bin loading batcher. The weigh batcher, if designed properly, greatly insures uniform loading of the truck and improves the chance of avoiding segregation with a sensitive mix.

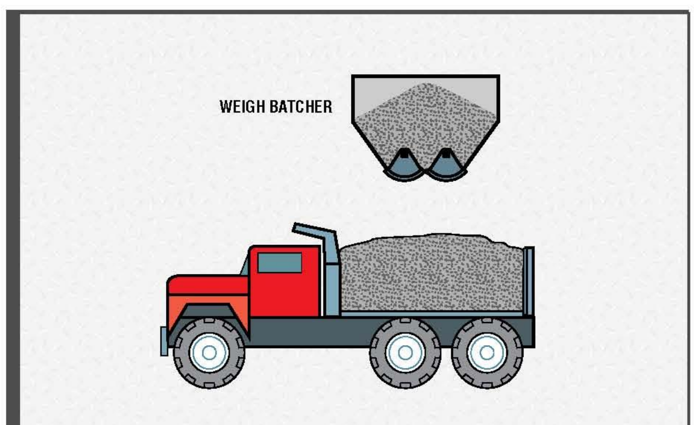
When unloading a truck into a paver hopper it is important to discharge the material as a mass instead of dribbling the material into a paver. To do this, the bottom of the truck bed needs to be in good condition and lubricated so that the entire load will slide rearward. To further assure that the material is discharged as a mass, elevate the truck bed to a large, but safe angle, **Figure 30**.



IMPROPER TRUCK LOADING F27



PROPER TRUCK LOADING F28



BIN WITH WEIGH BATCHER F29

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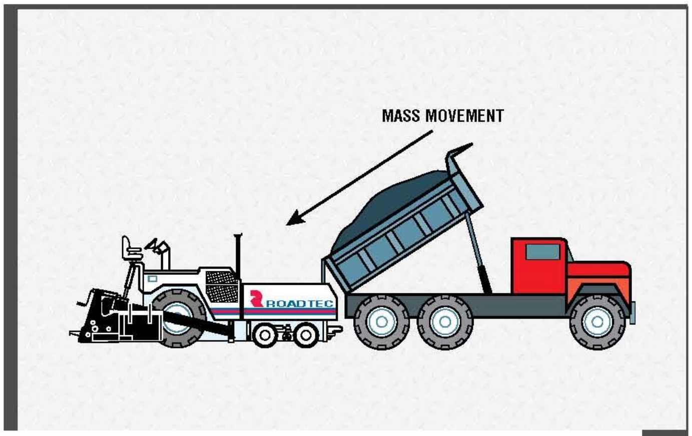
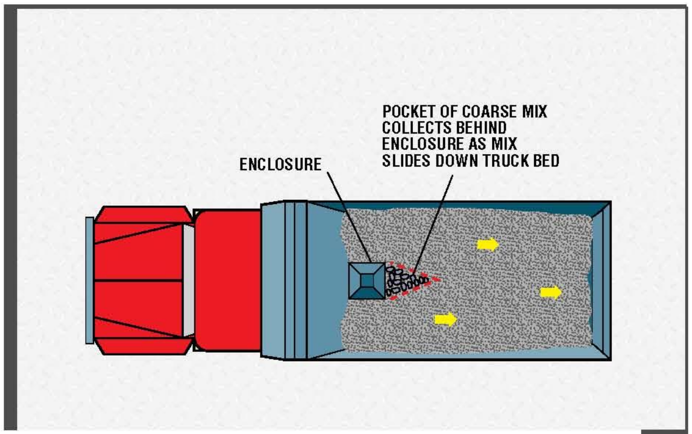


LARGER DUMPING ANGLE ASSURES MASS DISCHARGE F30



CYLINDER ENCLOSURE CAUSES "END OF LOAD" SEGREGATION F31

Rapid truck discharge floods the paver hopper and minimizes material-run-around that often occurs at the tail gate. Rapid discharge prevents an accumulation of coarse material at the outside portion of the paver wings.

With sensitive mixes it is often necessary to modify the forward portion of the truck bed to eliminate undesirable effects caused by the hydraulic cylinder enclosure. If the mix has a tendency to segregate, a pocket of coarse mix can occur as the mix slides away from the cylinder enclosure. As the load moves rearward, the mix caves in forcing large stones to accumulate in the center of the bed at the front of the truck. Then as the load moves into the paver, "end of the load" segregation occurs, **Figure 31.** Adding a plywood or light gauge metal cover across the entire front of the bed from side-to-side will mimimize this problem.

PAVER

Even though material has been successfully processed through the cold feed bin, through the plant, through the surge or storage bin, then uniformly loaded on the truck, segregation can still occur in the paver. Improper operation of a paver can cause segregation in varying degrees. Here are suggestions that should be considered when segregation occurs at the paver.

a. Do not completely empty the hopper between each truck load. Coarse material tends to roll to each side of the truck bed and thus roll directly into the wings of the hopper. By leaving material in the hopper the coarse material has a better chance of being mixed with finer material before being placed on the road.

b. Dump hopper wings only as required to level the material load in the hopper. Dumping eliminates the valleys in the material bed, thereby minimizing rolling that occurs when unloading. It allows the truck tailgate to swing open fully to flood the hopper with mix, **Figure 32**.

14

c. Dump the truck so as to flood the hopper. With the hopper as full as possible, material tends to be conveyed out from under the truck and minimizes the tendency to roll as it is dumped into the hopper.

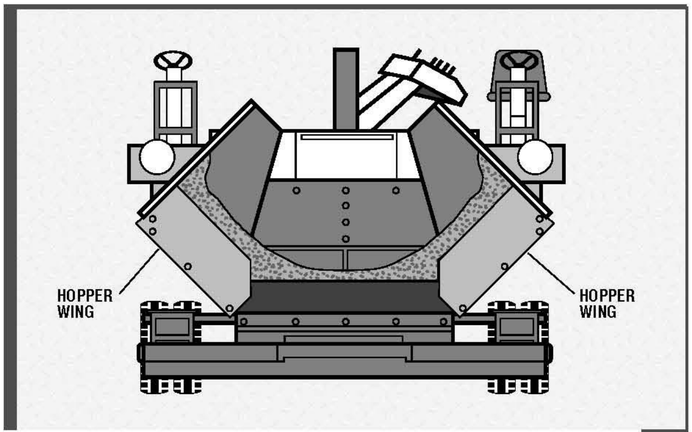
d. Open hopper gates as wide as possible to insure that the augers are full. By closing the gates and starving the augers for mix, fine material will drop directly on the ground causing coarse material to be augured to each side, **Figure 33**.

e. Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production.

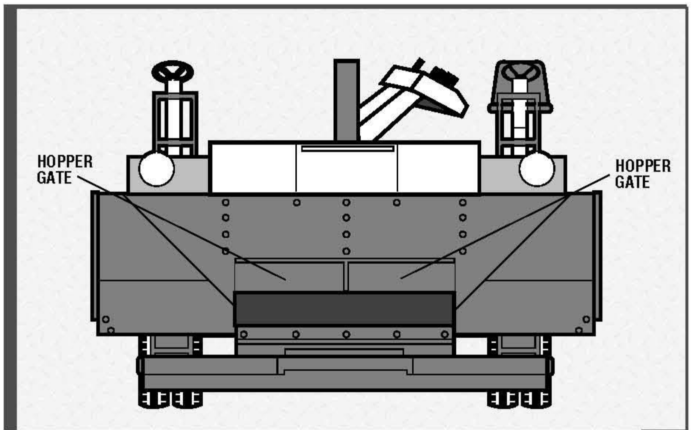
e. Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production.

f. Run augers continuously. Auger speed should be adjusted so that a continuous, slow flow of material occurs. Augers that run at high speeds are cycling on and off continuously and contribute significantly to segregation at the paver.

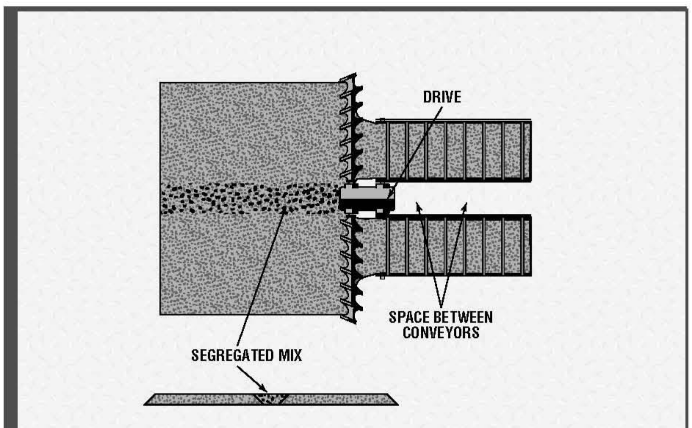
g. If augers are running too fast, the center of the mat will be deficient of material and this will generally result in a coarse strip, **Figure 34**.



PAVER HOPPER WINGS F32

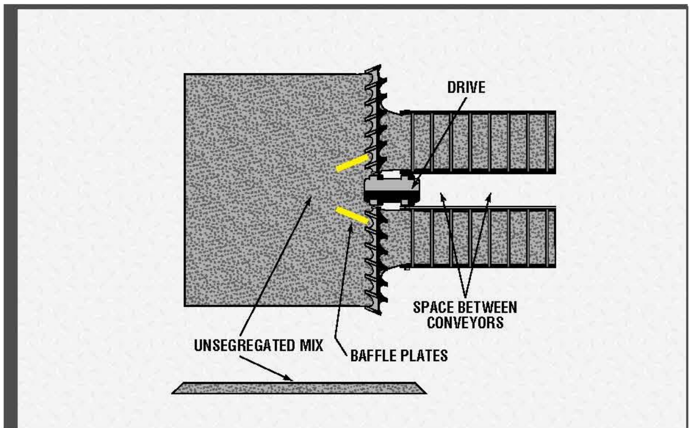


PAVER HOPPER GATES F33

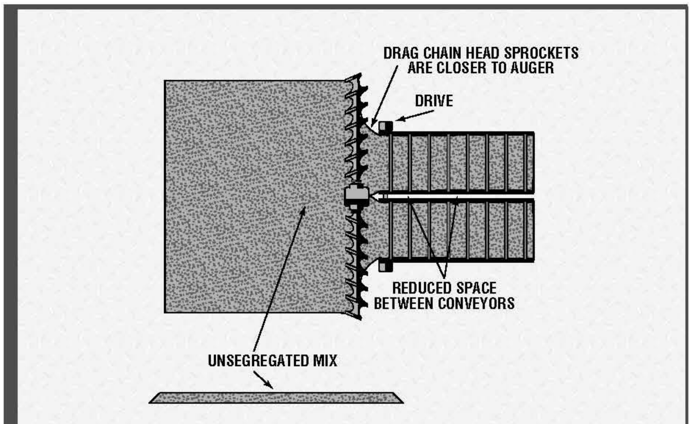


CONVENTIONAL PAVER DESIGN F34

15



CONVENTIONAL PAVER DESIGN WITH BAFFLES F35



ROADTEC PAVER DESIGN F36

SHUTTLE BUGGY MATERIAL TRANSFER VEHICLE BY GRAVITY AUGER F37

Baffle plates, as shown in **Figure 35**, will also prevent coarse materials from rolling in front of the auger gear box and causing center line segregation.

With the installation of the baffles, the augers then divert material uniformly to the center. **Figure 34** shows a conventional design where space between conveyors causes center line segregation. **Figure 36** shows the Roadtec design with two important changes made on newer Roadtec pavers to minimize segregation and eliminate the need for baffles:

1. Flight chains now have less space between them at the center of the hopper.

2. Head sprockets of the flight chains are now closer to the auger.

Another Roadtec Paver design feature which further reduces segregation is a gravity fed auger. Instead of the paver auger being fed by drag chains pulling hot mix from the bottom of the paver hopper, the hot mix in the paver hopper mass flows directly into the paver auger by gravity and is metered by hydradraulically activated clam gates. Paver maintenance is also reduced due to elimination of the drag chains, **Figure 37**.

h. If the outer edges of the paver auger are deficient of material, coarse strips along the outsides can occur as the coarse aggregate rolls to the outsides.

i. If possible, adjust paver extensions so that the paver pulls the same amount of material from each side of the hopper. If one side is pulling more material, a valley will form in that side of the paver hopper, causing segregation to occur in sensitive mixes. If correction cannot be made by adjusting the extension, offset the truck slightly towards the side requiring more material to even out the material bed in the hopper.

j. Pavers without auger extensions can cause outside edge segregation. A segregation prone mix can segregate without auger extensions as the mix piles up at the end of the auger and the larger aggregate rolls off toward the outside edge of the road.

SHUTTLE BUGGY® MATERIAL TRANSFER VEHICLE

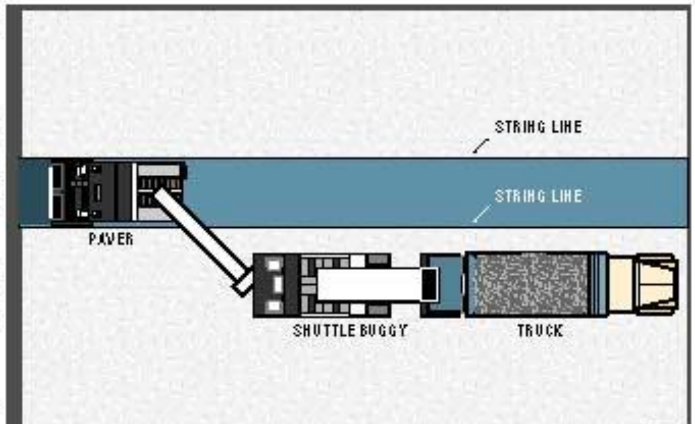
The difficulty of dumping mix from the truck into the paver while keeping the paver moving continuously should be apparent from our earlier discussion. **Figure 38** shows a Shuttle Buggy material transfer vehicle that allows the truck to stop at a suitable distance ahead of the paver, then dump its entire load without moving. The shuttle Buggy carries 30 to 35 tons of mix.

The drag conveyor on the front of the Shuttle Buggy is sufficiently wide to accept the full width of the mix load from the truck (uninterrupted) and convey it up and into the holding hopper of the Shuttle Buggy. Two variable pitch augers in the bottom of the holding hopper re-mix the material as it moves into the rear swivel discharge conveyor.

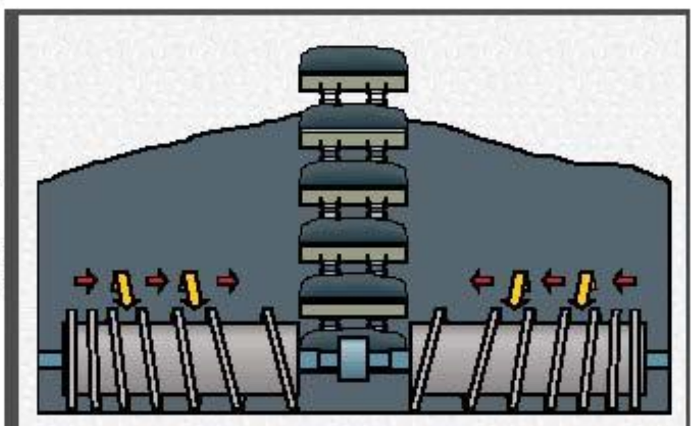
A holding hopper is installed on the paver, allowing storage of approximately 20 tons of material. The swivel conveyor from the Shuttle Buggy fills the hopper from the top. **Figure 39** shows loading from an adjacent line. This new concept allows continuous operation of the paver, re-blends the material and allows the use of large, long trailers.

Moreover, the holding hopper on the paver eliminates the accumulation of coarse material in the wings. Accumulation of coarse material and dumping of the wings is a major cause of end-of-the-load segregation.

SHUTTLE BUGGY MATERIAL TRANSFER VEHICLE F38



SHUTTLE BUGGY OPERATING IN ADJACENT LANE F39



SHUTTLE BUGGY MIXING AUGERS F40

17

These units have proven to completely eliminate end-of-load and random segregation due to three-blending of material by the mixing augers, **Figure 40**. The resulting pavement smoothness exceeds anything pre-viously accomplished on a consistent basis.

DIAGNOSTIC SYSTEM

The Segregation Diagnostic Chart accompanying this technical paper shows five different kinds of segregation. It provides a diagnostic system for analyzing the potential causes of segregation based on these types of segregation as they occur on the road. This, the most likely causes of segregation can be quickly identified in the chart. Then this paper can be consul ted for more detailed information regarding causes and remedies.

TESTING

Segregation and asphalt content go hand-in-hand. If mix uniformly produced and uniformly produced and uniformly coated and the material segregates after mixing, a sample of coarse material will reveal low asphalt content while a sample of fine material will show high asphalt content. NAPA Publication QIP109 shows methods of analyzing asphalt content and extraction problems. Refer to this publication if segregation is occurring in the sampling or in the splitting of the material prior to running extraction tests.

In summation, segregation in hot mix bituminous mixtures is a common and persistent problem. However, the problem can be controlled and even eliminated through proper mix design and through proper maintenance and operation of plants, trucks, and paving equipment. It is hoped this paper will assist in analyzing the problems and will be helpful in the selection of an effective cure.

ASTEC a subsidiary of Astec Industries, Inc.
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Astec Technical Paper T-117

Segregation: Causes and Cures
By: J. Don Brock, PhD. and Greg Renegar

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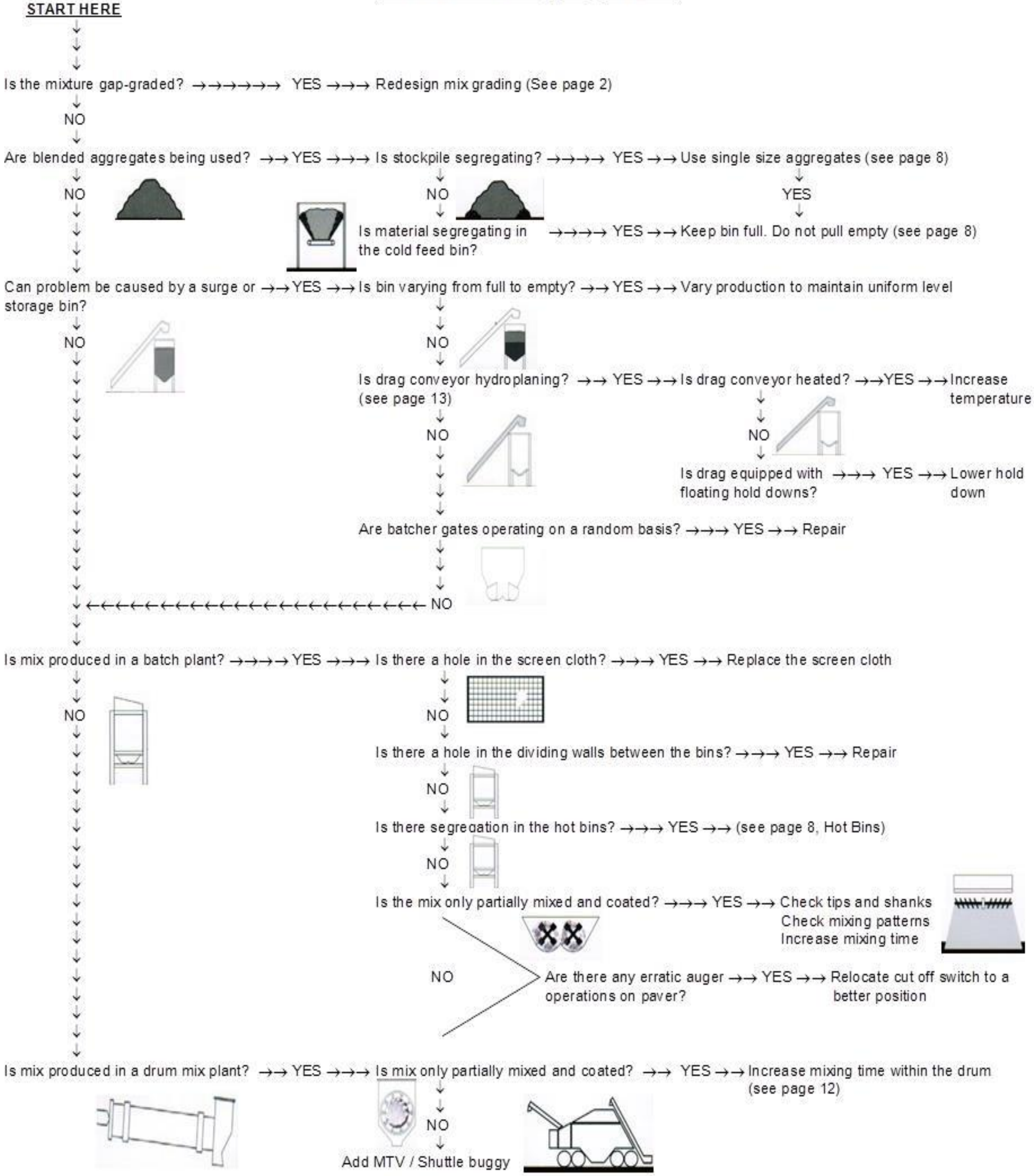
Random Segregation



Each Side Segregation (periodic)

START HERE

Is the mixture gap-graded? →→→→→→ YES →→→ Redesign mix grading (See page 2)

NO

Can problem be caused by a surge or storage bin? →→→ YES →→ Is mix coarse in front and rear of truck? →→→→→→ YES →→ Correct improper truck loading (see page 16)

NO

Are gates on batcher operating improperly? →→→→ YES →→ Repair

NO

Are gates staying open so that all material is discharged →→→→→→→→→ YES →→ Decrease batcher gate time so that some material stays in batcher

NO

Is batcher filling only partially? →→→→→→→→→→→→ YES →→ Adjust bin indicator or timer to fill batcher completely

NO

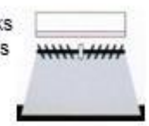
Is material dropping into the batcher at an angle? →→ YES →→ Add length to chute to divert material straight down

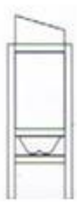
NO

Is bin operating at near full? →→→→→→→→→→→ YES →→ Operate bin at a lower level to allow batch to splatter (see page 14)

NO

Is mix produced in a batch plant? →→→ YES →→ Is mix only partially mixed and coated? →→→→→→→ YES →→ Check tips and shanks
Check mixing patterns
Increase mixing time



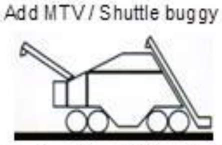


NO

Are wings of paver being dumped between each load? →→→→→→→→→ YES →→ Relocate cutoff switch into a better position

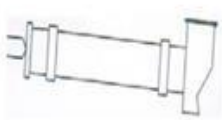
NO

Add MTV / Shuttle buggy



NO

Is mix produced in a drum mix plant? →→ YES →→ Is mix only partially mixed and coated? →→→→→→ YES →→ Check tips and shanks
Check mixing patterns
Increase mixing time

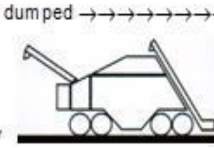


NO

Are wings of paver being dumped between each load? →→→→→→→→→ YES →→ Relocate cutoff switch into a better position

NO

Add MTV / Shuttle buggy



Centerline Segregation

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Can problem be caused by a surge →→→ YES →→ Is there a hole in the batcher? →→→→→→→ YES →→ Repair
or storage bin? ↓
↓ ↓
NO NO
↓ →→→→→→→→→→→→→←←←←←←←←←←←←← ↓

Is large material rolling in front of auger gear box as it is dumped from tunnel conveyor? →→→→→→YES →→ Slow augers. Center is deficient of mix.
↓ ↓
↓ Or, add MTV / Shuttle buggy
↓
NO →→→ If none of the above locates the problem, see random segregation, or each side segregation (evenly spaced)
↓
Or, add MTV / Shuttle buggy

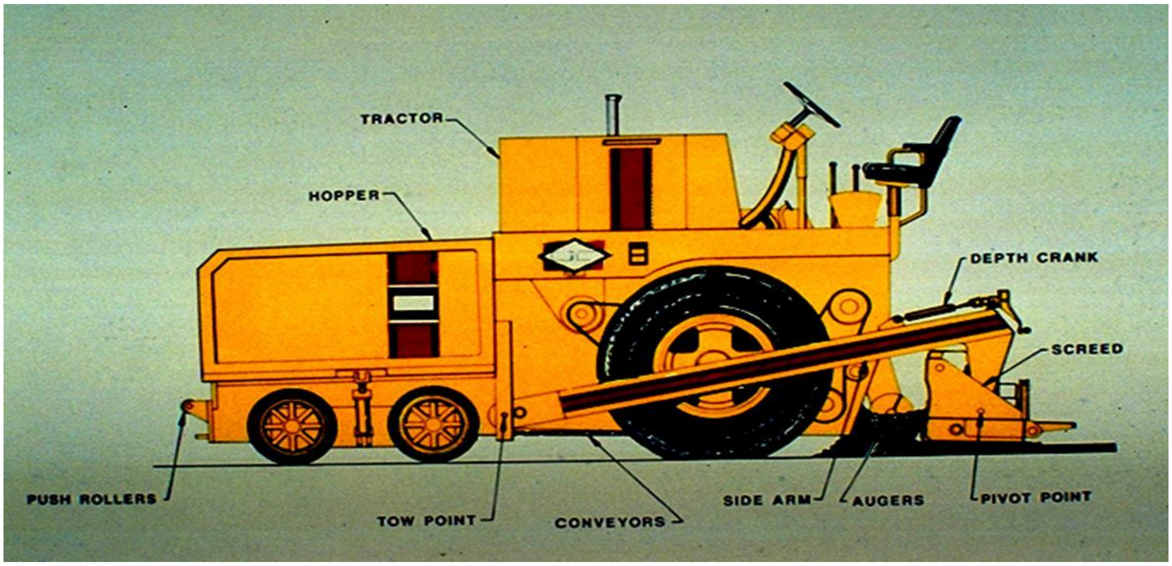
Each Side Segregation (continuous)

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Can problem be caused by a surge →→ YES →→ Is bin equipped with a batcher? →→ YES →→ Are batcher gates →→ YES →→ Repair
or storage bin? ↓ remaining open?
↓ ↓ ↓
NO NO NO
↓ →→→→→→→→→→→→→→→→→→→→→→→→ ↓ ←←←←←←←←←←←←←←←←←← ↓
↓
Are augers on paver running too slow? →→→→→→ YES →→ Speed up augers. Readjust auger unit switches.
↓ Raise hopper gates. (see page 18)
NO
↓
If none of the above locates the problem, see random segregation or each side segregation

One Side Segregation

START HERE
↓
↓
Is the mixture gap-graded? →→→→→→ YES →→→ Redesign mix grading (See page 2)
↓
NO
↓
Is mix produced in a drum mix plant? →→ YES →→ Is drum equipped with a gravity discharge? →→→→ YES →→ Install a fixed plow (see page 12)
↓ ↓
↓ ↓
NO NO
↓ ←←←←←←←←←←←←←←←←←←←←←←←←← ↓
↓
↓
Is mix loaded from a surge or storage silo? →→→→→→ YES →→→ Install a fixed plow (see page 12)
↓
NO
↓
If none of the above locates the problem, see random segregation, or each side segregation (evenly spaced)
↓
↓
Or, add MTV / Shuttle buggy

HMA LAYDOWN AND COMPACTION



Typical Paver

Old Time Pavers

New Modern Electronically Controlled Paver

The equipment has changed over the years but the paving operation principles are still the same.

When HMA is placed on the road a number of factors will determine the ability to compact the materials in order to meet density requirements. Different factors would include:

Material Properties

Aggregates	–	surface texture, particle shape, gradation
Asphalt binder	–	viscosity, VMA, percent of mix
Mixture temperature	–	optimum mix temperature, tenderness zone

Mat Thickness

Base conditions	–	Good (solid, strong, firm) or bad (soft, weak, giving)
Base thickness	–	Thick or thin mat

Weather Conditions

Ambient air temperature	–	Hot or cold
Wind speed	–	High or low, can have a cooling effect
Surface temperature	–	Hot or cold

Equipment (compaction forces)

Frequency and amplitude controls (low or high)
Maximum roller speed (fast or slow)
Matching paver speed (fast or slow)

This chapter will mainly focus on the factors pertaining to the equipment and compaction forces.

Guidelines for Selecting the Amplitude of Vibration

	Parameter Level	◄ Parameter ►	Parameter Level	
LOW Amplitude	Thin < 2” (50 mm)	Mat Thickness	Thin > 2” (50 mm)	HIGH Amplitude
	Rigid	Base Support	Flexible	
	Low	AB Viscosity	High	
	Rounded	Aggregate	Angular	
	Smooth	Aggregate Surface Texture	Rough	
	Poorly Graded	Aggregate Gradation	Dense	
	High	Temperature Mixture, Base, or Air	Low	

For very thin lifts, especially on rigid base supports, care should be exercised to avoid fracturing aggregate. It is possible to over compact a HMA mat.

LAYDOWN AND COMPACTION OUTLINE

1. BASE PREPARATION

a. Are you familiar with the base, its condition and preparation for bituminous surfacing? (Article 406.05(a))

b. Is the correct type of prime selected and applied at the proper rate? (Articles 406.02 (b, Note 1), 406.05 (b) & 1102.05)

c. Is the base dry and the air temperature in the shade at least 40° F and rising when laying leveling binder and binder courses? Is it 45° F and rising when placing surface course? (Article 406.06 (b)(1))

2. SPREADING & FINISHING MACHINE

a. Does the paver model meet requirements of Article 1102.03 per Construction Memorandum 08-11(see below)?

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

Subject:
Hot Mix Asphalt (HMA) Spreading and Finishing Machines Approved For Use in Illinois Article 1102.03

CONSTRUCTION MEMORANDUM NO. 08-11

Effective: January 1, 2008

Expires: Indefinite

This memorandum superseded Construction Memorandum No. 06-11, dated April 1, 2006.

In the past, Hot Mix Asphalt (HMA) spreading and finishing machines have been approved by the Engineer of Construction for use in Illinois. Because of the wide variety of paving and finishing machines currently available, and modifications affecting their performance can easily be made to these machines, the Engineer of Construction will no longer maintain an approved list of these machines for use on our projects.

The Resident Engineer must ensure any paving and finishing machine the contractor proposes to use meets the requirements of Article 1102.03 of the specifications prior to its use.

Under certain operating conditions, HMA spreading and finishing machines otherwise acceptable for use on IDOT projects may exceed the legal axle load. The use of these machines for resurfacing highways must be approved in accordance with the requirement of Construction Memorandum No. 39.

The Resident should also assure the factory or field installed anti-segregation kits are in good working order and not excessively worn prior to paving. The district Materials Engineer can assist the Resident with this review.

Roger Driskell, P.E.
Engineer of Construction

b. Are you familiar with the mechanical features of the paver? (Article 1102.03)

c. Are you familiar with Extensions/Augers, Electronic Grade Control, and Screed?

d. Is the spreading and finishing machine being operated at a speed that is mated with the required roller speed (special attention to the vibratory roller), which coincides with the average rate of delivery of bituminous materials to the paver? In no case shall the speed of the paver exceed 50 feet (15 m) per minute.
(Article 406.06 (f))

Beginning of the Standard Specification Article 1102.03

"1102.03 Spreading and Finishing Machine. *Hot-mix asphalt (HMA) pavers shall be self-contained, power-propelled units equipped with augers, activated screed or a strike off assembly and be capable of being heated. The augers, activated screed or strike off assembly shall be adjustable either automatically or by adding additional sections so the paver will place, compact or strike off the HMA to the full width being placed. All width extensions shall have the same placement features and equipment functions as provided on the main body of the paver. Pavers with extendible type screeds shall have a minimum 10 ft (3 m) basic screed, except on projects with 7500 sq yd (6300 sq m) or less of HMA. For these smaller projects, a minimum 8 ft (2.4 m) basic screed will be permitted. Augers shall be extended as additional sections of screed are bolted on or automatically adjustable screeds are extended. The augers need not be extended when the screed extensions on each side of the machine are 1 ft (300 mm) or less if the finished surface of the mat is uniform. Pavers used for shoulders and similar construction shall be capable of Hot-Mix Asphalt Equipment Art. 1102.04 spreading and finishing HMA in widths shown on the plans. The use of any machine obsolete in design or in poor mechanical condition will not be permitted.*

The spreading and finishing machine shall be equipped with an automatic electronic grade control device. The device shall be effective in leveling depressions in the surface of the existing pavement, the leveling course and the binder course.

The automatic electronic grade control device shall be capable of controlling the elevation of the screed relative to either a preset grade control stringline or a grade reference device traveling on the adjacent pavement surface. The traveling grade reference device shall be not less than 30 ft (9 m) in length.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to uniformly place a non-segregated mixture in front of the screed. The distribution system shall have chain curtains, deflector plates, and/or other devices designed and built by the paver manufacturer to prevent segregation during distribution of the mixture from the hopper to the paver screed. The Contractor shall submit a written certification that the devices recommended by the paver manufacturer to prevent segregation have been installed and are operational. Prior to paving, the Contractor, in the presence of the Engineer, shall visually inspect paver parts specifically identified by the manufacturer's check list for excessive wear and the need for replacement. The Contractor shall supply the completed check list to the Engineer noting the condition of the parts. Worn parts shall be replaced. The Engineer may require an additional inspection prior to placement of the surface course or at other times throughout the work.

The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

The paver shall be capable of being operated at forward speeds consistent with satisfactory placement of the mixture.

A straightedge at least 4 ft (1 m) in length and equipped with a carpenter's level shall be available at the spreading and finishing machine to check the surface of the HMA for transverse slope and longitudinal surface variations.

End of the Standard Specification Article 1102.03

3. ROLLERS

Vibratory Rollers

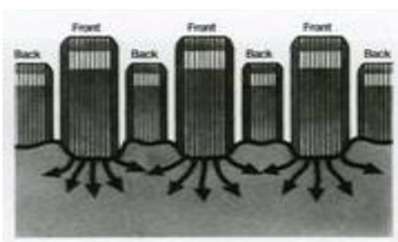
Vibratory Rollers

Steel Wheel Rollers

End of Pass

Pneumatic Tire Roller

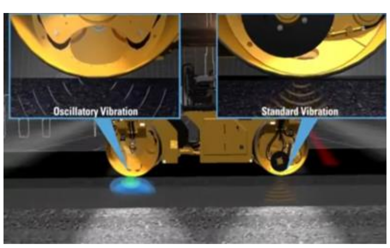
Pneumatic Roller Pass



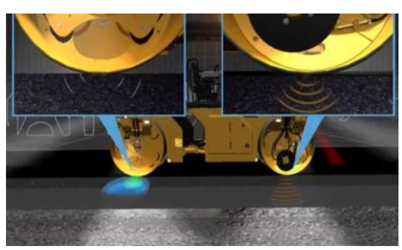
Exerted Force

Finish Roller

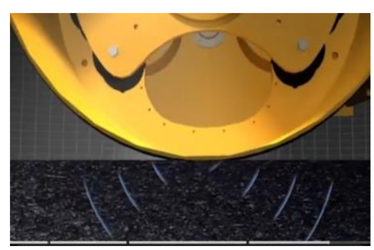
3-Wheel Roller



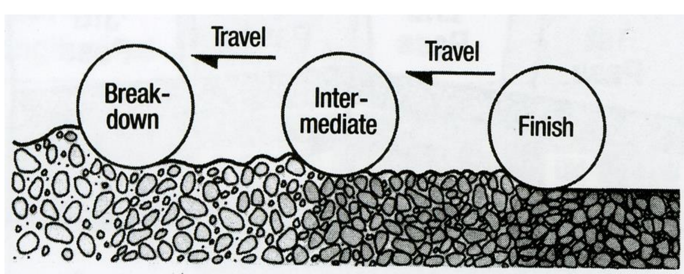
Oscillatory Roller



Oscillatory Roller



Oscillatory Roller



Compaction Phases

a. Are the required rollers on the jobsite, prior to the start of the paving operation? (Article 406.07 (a) Table 1)

b. Have the rollers been checked to meet the requirements of Article 1101.01(g) per Construction Memorandum 06-10 (see below)?

Illinois Department of Transportation
Division of Highways / Bureau of Construction
2300 South Dirksen Parkway, Springfield, Illinois 62764

"Subject:
Vibratory Rollers Approved For Use in Illinois
Article 1101.01(g)

CONSTRUCTION MEMORANDUM NO. 06-10

Effective: April 1, 2006

Expires: Indefinite

This memorandum supersedes Construction Memorandum No. 00-10 dated January 4, 2000.

Because of the wide variety of rollers currently available, and modifications which affect their performance can easily be made to these rollers, the Engineer of Construction will no longer maintain an approved list of vibratory rollers for use on IDOT projects. The Resident Engineer should ensure any vibratory roller the contractor proposes to use on IDOT projects meets the requirements of Article 1101.01(g) of the specifications prior to its use.

To accomplish this task, the Resident must check that the drum is at least 48" in diameter, at least 66" wide, minimum vibrations per minutes (VPM) of 1600, static force of 125 lbs./inch, and a total applied force of 325 lbs./inch.

If not directly shown on the contractor's specification sheet, the forces for the equipment can be calculated as follows. The static unit force is calculated by dividing the weight of the drum (in pounds) by the width of the drum (in inches). The dynamic force of each drum must be provided by the equipment specification sheet for each amplitude setting. The dynamic force (in pounds) is divided by the drum width (in inches). The total applied force is calculated by adding a dynamic force to the static force.

If the contractor's equipment satisfies the requirements of Article 1101.01(g), it may be used on IDOT projects. The project inspectors should monitor the equipment to ensure it provides the required results. Any equipment which does not provide satisfactory field performance must be removed from the project.

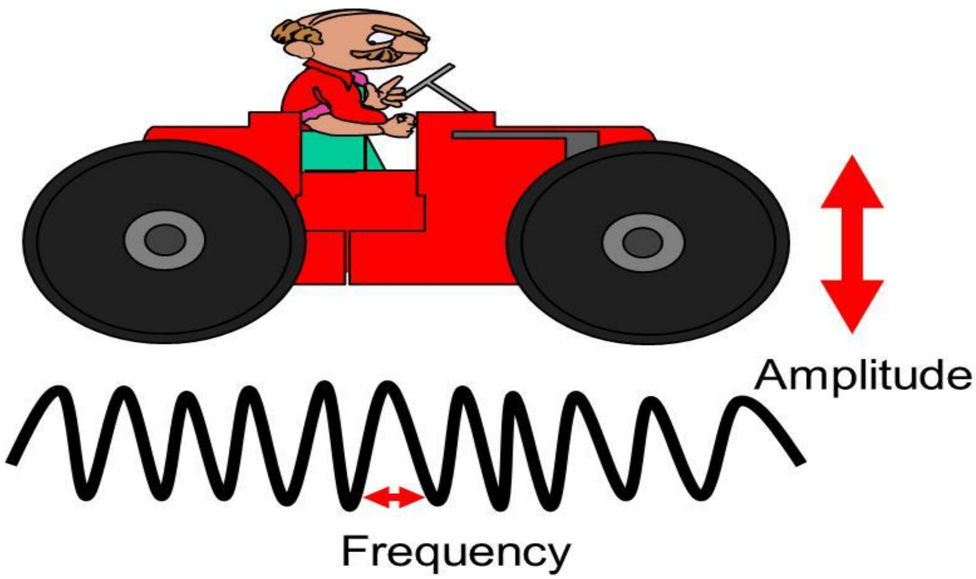
In addition to these requirements, on thin (<2.5") bituminous lifts, IDOT inspectors should restrict the total applied forces to not more than 450 lbs/linear inch. Greater applied forces tend to crush the coarse aggregate.

Roger L. Driskell

Roger L. Driskell, P.E.
Engineer of Construction"

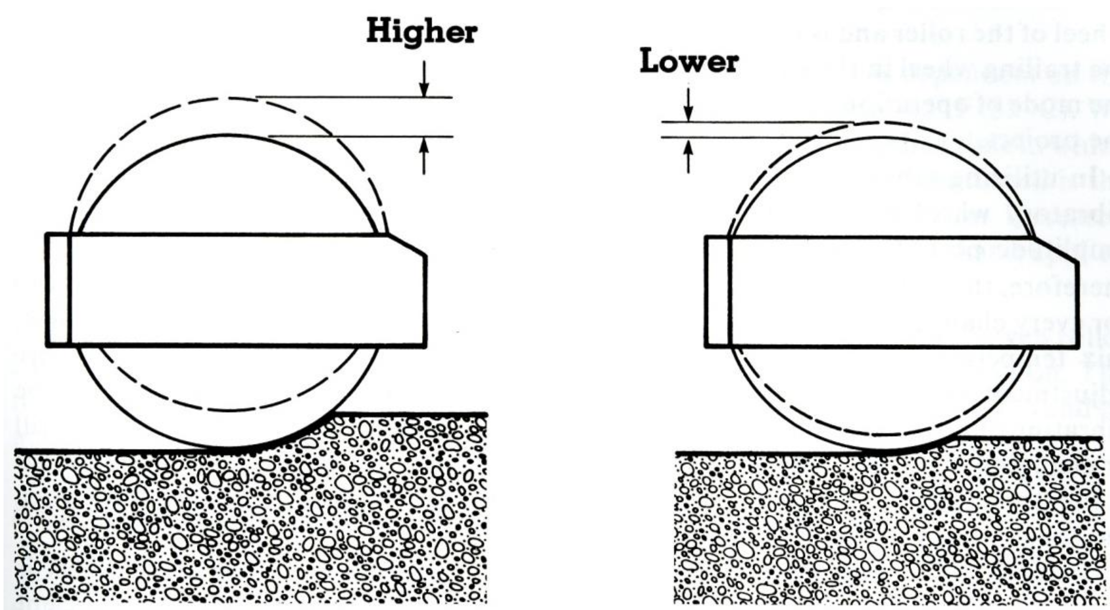
c. Have the vibratory roller settings been determined and the rollers checked to see that they are performing as desired? (Article 1101.01 (g)).

Check the roller VPMs using a reed tachometer.



Amplitude is the force (by vibrations or ballast weight) pounding on the mat.

Frequency is the distance in between the poundings.



The thickness of the mat is a major factor to determine how much amplitude is needed.

<u>Beginning of the Standard Specification Article 1101.01</u>

"1101.01 Rollers. *No roller shall be used that has in any way been thrown out of its original balance by the application of attachments. All bearings shall be tight*

.

(a) Pneumatic-Tired Rollers. The roller shall consist of not less than nine pneumatic tires revolving on two axles. The tires on the front and rear wheels shall be staggered so that they will cover the entire area over which the roller travels. Under working conditions, the roller shall develop a compression of not less than 300 lb/in. (53 N/mm) width of tire tread.

(b) Heavy Pneumatic-Tired Rollers. The roller shall have a gross weight (mass) of not less than 25 tons (23 metric tons) and shall consist of not less than four pneumatic-tired wheels revolving in one transverse line. The width of the roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is free to oscillate or move independently. Under working conditions, the roller shall develop a compression of not less than 650 lb/in. (114 N/mm) width of tire tread.

(c) Self-Propelled Pneumatic-Tired Roller. The roller shall be of the oscillating wheel type consisting of not less than seven pneumatic-tired wheels revolving on two axles, and capable of being ballasted to the weight (mass) required. The tires on the front and rear wheels shall be staggered so that the tire sidewalls will have a minimum overlap of 1/2 in. (13 mm). The roller shall provide for a smooth operation when starting, stopping or reversing direction.

The tires shall withstand inflation pressures between 60 and 120 psi (415 and 825 kPa). The roller shall be equipped with an adequate scraping or cleaning device on each tire to prevent the accumulation of material on the tires. When used for the compaction of hot-mix asphalt (HMA), the roller shall be equipped with a water system which will keep all tires uniformly wet to prevent material pickup.

The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each wheel. Ballast shall be included in determining the weight (mass).

(d) Tamping Rollers. The roller shall have a minimum weight (mass) of 90 lb/in. (16 N/mm) width of drum, and each individual tamper shall develop a compression of not less than 100 psi (690 kPa) of its tamping face area. The width of the tamping roller shall be not less than 8 ft (2.4 m), and it shall be constructed in two or more sections in such a manner that each section is free to oscillate or move independently. It shall be equipped with cleaning teeth at the rear.

(e) Steel Wheel Rollers. The roller shall be self-propelled and provide a smooth operation when starting, stopping, or reversing directions. The steering mechanism shall provide for positive control of the roller. Roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease, or gasoline drips generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.
When used on a hot-mix asphalt surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

(1) Tandem Rollers. The Contractor shall provide means for determining the weight (mass) of the roller as distributed on each axle. Ballast shall be included in determining the weight (mass).

The rear wheel may be crowned at the rate of not more than 3/16 in. in 4 1/2 ft (5 mm in 1.4 m). The front wheel shall be divided into at least two sections and shall show no noticeable crown. The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

(2) Three-Wheel Rollers. The rear wheels of three-wheel rollers may be crowned at the rate of not more than 1/16 in. in 20 in. (2 mm in 500 mm) and shall be propelled with a differential gear. The front wheel shall be divided into at least two sections, shall show no noticeable crown, and shall overlap the compression area of each rear wheel by not less than 1 1/2 in. (38 mm). The weight (mass) of the roller shall meet requirements of the specific item of work being constructed.

(f) Trench Roller. The roller shall be self-propelled, and provide a smooth operation when starting, stopping or reversing directions. The width of the compaction roller shall be not less than 20 in. (500 mm). The diameter of the compaction roller shall be not less than 60 in. (1500 mm). The roller wheels shall be smooth and free from openings or projections which will mar the surface on which the roller is operated. Motor rollers shall be equipped with drip pans to contain oil, grease or gasoline generated by the roller operation. The roller shall be provided with adjustable scrapers which shall be used when necessary to keep the surface of the wheels clean.

When used on a hot-mix asphalt (HMA) surface, the roller shall be equipped with water tanks and sprinkling devices which shall be used to wet the wheels and prevent material pickup.

The weight (mass) of the roller shall meet requirements of the specific item of work being constructed. The Contractor shall provide means for determining the weight (mass) of the roller as distributed on the compression wheel. Ballast shall be included in determining the weight (mass).

The balance wheel of the roller shall be adjustable in height to provide the slope of the surface of the specific item of work being constructed.

(g) Vibratory Roller. The vibratory roller shall be self-propelled and provide a smooth operation when starting, stopping or reversing directions. The vibrating drum(s) amplitude and frequency shall be approximately the same in each direction and meet the following minimum requirements: drum diameter 48 in. (1200 mm), length of drum 66 in. (1650 mm), vibrators 1600 vibrations per minute (VPM), unit static force on vibrating drum(s) 125 lb/in. (22 N/mm), total applied force 325 lb/in. (57 N/mm), adjustable eccentrics, and reversible eccentrics on nondriven drum(s). The total applied force for various combinations of VPM and eccentric positions shall be shown on decals on the vibrating roller or on a chart maintained with the roller.
The vibratory roller shall be equipped with water tanks and sprinkling devices, or other approved methods, which shall be used to wet the wheels to prevent material pickup.

A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating *reed tachometer shall have two rows of reeds, one ranging from 1000 to 2000 VPM and the other from 2000 to 4000 VPM."*

End of the Standard Specification Article 1101.01

d. Has the location and procedure for the test strip/growth curve been determined? (Article 1030.10 and "Hot-Mix Asphalt QC/QA Test Strip Procedures - Appendix B4" located in the Manual of Test Procedures)

e. Is the proper rolling procedure being performed following the test strip and the establishing of a rolling pattern? (Article 406.07 (a), Table 1 and "Hot-Mix Asphalt QC/QA Test Strip Procedures - Appendix B4" located in the Manual of Test Procedures)

Beginning of the Standard Specification Article 406.07

"406.07 Compaction. *The HMA shall be compacted according to the following requirements.*

(a) Rollers. Immediately after each lift of binder, or surface course mixture is placed, each lift shall be compacted with equipment meeting the requirements listed in the following Table 1.

TABLE 1 – MINIMUM ROLLER REQUIREMENTS FOR HMA

	Breakdown Roller (one of the following)	*Final Roller (one or more of the following)*	*Density Requirement*
IL-9.5, IL-9.5FG, IL-19.0 and IL-19.0L [1/]	*P* [3/]VD, P, TB, 3W, OT, OB	VS, TB, TF, OT	*As Specified in Section 1030.*
IL-4.75 and SMA [3/ 4/]	TB, 3W, OT	TF, 3W, OT	*As specified in Section 1030.*
Mixtures on Bridge Decks [2/]	T_B	T_F	*As specified in Articles: 582.05 and 582.06*

NOTE: Footnotes and definitions for Table 1 are found on the following page.

1/ If the average delivery at the job site is 85 ton/hr (75 metric ton/hr) or less, any roller combination may be used provided it includes a steel wheel roller and the required density and smoothness is obtained.

2/ One TB may be used for both breakdown and final rolling on bridge decks 300 ft (90 m) or less in length, except when the air temperature is less than 60 ºF (15 ºC).

3/ Pneumatic-tired and vibratory rollers will not be allowed.

4/ The Contractor shall provide a minimum of two steel wheel tandem rollers (TB), and/or oscillatory rollers (OT), and/or three-wheel (3W) rollers for breakdown. 3W, TB, and TF rollers shall be a minimum of 280 lb/in. (50 N/mm). The 3W, OT, and TB rollers shall be operated at a uniform speed not to exceed 3 mph (5 km/h), with the drive roll for TB rollers nearest the paver, and maintain an effective rolling distance of not more than 150 ft (45 m) behind the paver.

Equipment Definition

Vs Vibratory roller, static mode, minimum 125 lb/in. (2.2 kg/mm) of roller width. Maximum speed = 3 mph (5 km/h) or 264 ft/min (80 m/min). If the vibratory roller in static mode does not eliminate roller marks, its use shall be discontinued and a tandem roller, adequately ballasted toremove roller marks, shall be used.

VD Vibratory roller, dynamic mode, operated at a speed to produce not less than 10 impacts/ft (30 impacts/m).

P Pneumatic-tired roller, maximum speed = 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min). The pneumatic-tired roller shall have a minimum tire pressure of 80 psi (550 kPa) and shall be equipped with heat retention shields. The self-propelled pneumatic-tired roller shall develop a compression of 300 to 500 lb/in. (53 to 88 N/mm) per width of the tire tread in contact with the HMA surface.

TB Tandem roller for breakdown rolling, 8 to 12 tons (7 to 11 metric tons), 250 to 400 lb/in. (44 to 70 N/mm) of roller width, maximum speed = 3 1/2 mph (5.5 km/h) or 308 ft/min (92 m/min).

TF Tandem roller for final rolling, 200 to 400 lb/in. (35 to 70 N/mm) of roller width with minimum roller width of 50 in. (1.25 m). Ballast shall be increased if roller marks are not eliminated. Ballast shall be decrease if the mat shoves or distorts.

3W Three-wheel roller, maximum speed = 3 mph (5 km/h) or 264 ft/min (80 m/min), 300 to 400 lb/in. (53 to 70 N/mm) of roller width. The three-wheel roller shall weigh 10 to 12 tons (9 to 11 metric tons).

OT Oscillatory roller, tangential impact mode. Maximum speed = 3.0 mph (4.8 km/h) or 264 ft/min (80 m/min).

OB Oscillatory roller, tangential and vertical impact mode, operated at a speed to produce not less than 10 vertical impacts/ft (30 impacts/m).

When initial rolling causes undue displacement, hairline cracking, or checking in either the binder course or surface course, the time of rolling shall be adjusted to correct these conditions.

In all places inaccessible to the rollers, such as locations adjacent to curbs, gutters, headers, manholes, and similar structures, the required compaction shall be secured with tampers.HMA that becomes loose, broken, mixed with foreign material, or is in any way defective shall be removed and replaced with fresh HMA and compacted to conform to the surrounding area.

(b) Rolling HMA Placed Under QC/QA Criteria. Rolling of the first lane of binder and surface course shall start longitudinally at the edge having the lower elevation and progress to the other edge, overlapping on successive trips to obtain uniform coverage. The roller shall not pass over an unprotected edge of the freshly laid HMA, unless directed by the Engineer. When directed by the Engineer, the edge shall be rolled with a pneumatic-tired roller.

When laying the HMA adjacent to a previously placed lane, the first pass of the roller shall be along the longitudinal joint on the fresh mixture with the compression wheel not more than 6 in. (150 mm) from the joint. The second pass of the roller shall overlap the longitudinal joint not more than 12 in. (300 mm) on the previously placed lane, after which the rolling shall proceed from the low side of the transverse slope to the high side, overlapping uniformly. Each stop shall be regulated to prevent trapping of water on the rolled surface. The steel wheel rollers shall be operated with the compression wheels toward the direction of paving.

The speed of the roller at all times shall be slow enough to avoid displacement of the HMA. If displacement occurs, it shall be corrected at once by raking and applying fresh HMA where required. To prevent adhesion of the HMA to the roller, the wheels shall be kept properly moistened without an excess of water.

Rolling of the binder and surface courses shall be continued until all roller marks are eliminated and the HMA is satisfactorily compacted. When required by the Engineer, the surface course shall be rolled diagonally in two directions with a tandem roller, the second rolling crossing the lines of the first, and, if the width of the pavement permits, it shall also be rolled at right angles to the centerline.

End of the Standard Specification Article 406.07

4. MIXTURE DELIVER AND LAYDOWN

a. Do the trucks hauling the mixtures meet the specification requirements? (Article 1030.08).

Beginning of the Standard Specifications Article 1030.12

"1030.12 Transportation. *Vehicles used in transporting HMA shall have clean and tight beds. The beds shall be sprayed with asphalt release agents from the Department's qualified product list. In lieu of a release agent, the Contractor may use a light spray of water with a light scatter of manufactured sand (FA 20 or FA 21) evenly distributed over the bed of the vehicle. After spraying, the bed of the vehicle shall be in a completely raised position and it shall remain in this position until all excess asphalt release agent or water has been drained.*

When the air temperature is below 60 °F (15 °C), the bed, including the end, endgate, sides and bottom shall be insulated with fiberboard, plywood, or other approved insulating material and shall have a thickness of not less than 3/4 in. (19 mm). When the insulation is placed inside the bed, the insulation shall be covered with sheet steel approved by the Engineer. Each vehicle shall be equipped with a cover of canvas or other suitable material meeting the approval of the Engineer which shall be used if any one of the following conditions is present.

(a) Ambient air temperature is below 60 °F (15 °C).

(b) The weather is inclement.

(c) The temperature of the HMA immediately behind the paver screed is below 250 °F (120 °C).

The cover shall extend down over the sides and ends of the bed for a distance of approximately 12 in. (300 mm) and shall be fastened securely. The covering shall be rolled back before the load is dumped."

End of the Standard Specification Article 1030.12

b. Are occasional temperature checks being taken on the mixture and recorded? (Article 406.06 (c)(1) & (2))

c. Is there a copy of the mix design (Big "D" Notification Form) on the job and does it match what is on the delivery ticket? Is a ticket recording the net weight of material and all other required information being submitted with each load? (Article 406.13). A copy of the Big "D" Notification Form can be found in chapter 10 of this manual.

d. Are weigh checks of full truck loads being done at least once a week? (Articles 1102.01 (a)(7) & 1102.01 (b)(5) & 1102.01 (c)(3) & 1102.01 (c)(8)(b))

e. Are frequent yield test being performed to ensure mat thickness and final tonnage, not to exceed l03% of approved quantities? (Article 406.13(b))

f. Are density checks being performed in a timely manner and documented? (Article 1030.06-1030.09)

5. DOCUMENTATION

a. Are all tickets, field checks, reports and supporting documentation being recorded and submitted in a timely fashion? (Article 1030.06-1030.09)

6. Use of Self-Propelled Vibratory Rollers for Compaction of HMA

Effective use of vibratory rollers for compaction of HMA depends on the following factors:

1. Lift Thickness
2. Roller and Paver Speeds
3. Frequency
4. Amplitude
5. Condition of Equipment
6. Total Applied Force (Sum of Static and Dynamic)

To obtain optimum results of density and smoothness requires an understanding of the interaction of the above factors. For example, an improper balance of amplitude and frequency can result in a marginal density and/or a rough surface.

The total applied force required to obtain density on HMA high ESAL mixtures with a minimum number of passes should normally be between 325 and 400 pounds per inch of roller (total applied force). The total applied force is the sum of the dynamic force and the static weight force. For most rollers the static force is 125 to 150 pounds/inch and the dynamic force 200 to 400 pounds/inch. The amplitude is adjusted by changing the weight of the eccentric.

7. Frequency Control

The frequency vibration is controlled by engine speed not roller speed. Manufacturers show frequency as a function of engine rpm and is shown normally on the rpm dial. Frequency should be set at least 1,600 vpm, the specification minimum, and preferably at 2,000 to 2,400, the maximum for most rollers. High frequency is essential to provide a smooth surface and it has a secondary effect on density.

Beginning of the Standard Specifications Article 1101.01 (g), in part

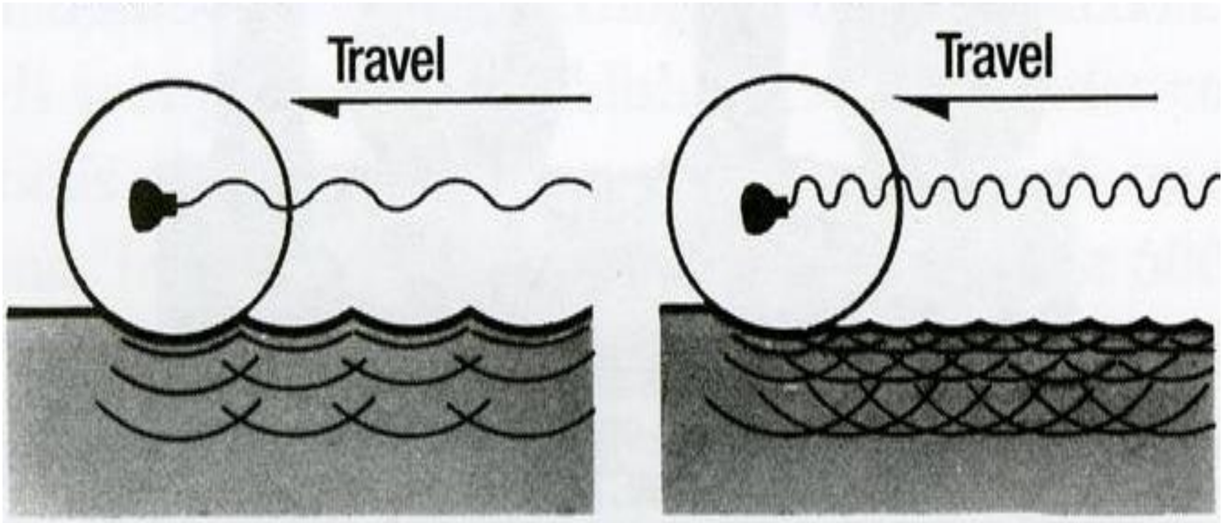
> " Vibrating Roller… *A vibrating reed tachometer (hand type) shall be furnished with each vibratory roller. The vibrating reed tachometer shall have a range of 1000 to 4000 VPM. The vibrating reed tachometer shall have two rows of reeds, one ranging from 1000 to 2000 VPM and the other from 2000 to 4000 VPM."*

End of the Standard Specifications Article 1101.01 (g), in part

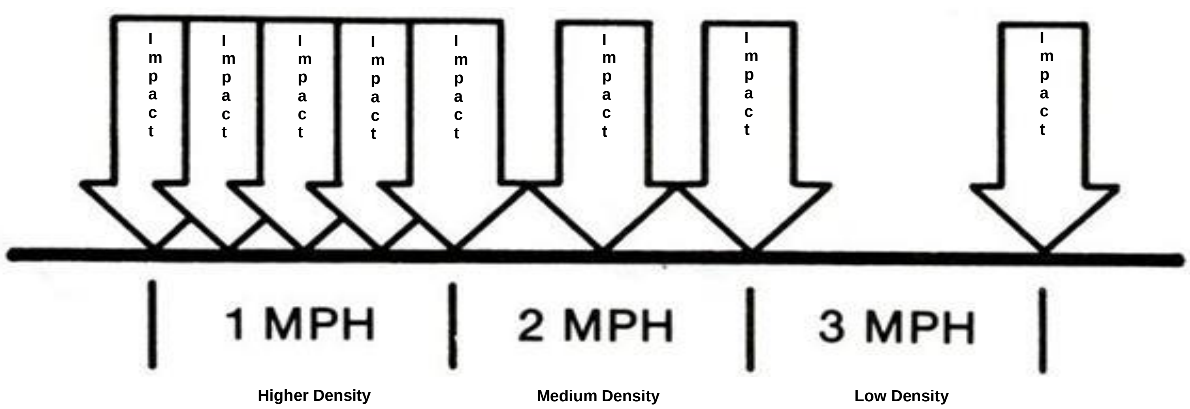
8. Maximum Vibratory Roller Speed

To determine the proper roller speed, divide the measured frequency (VPM) by 10 impacts/ft. (30 impacts/m) [Article 406.07 (a) Table 1 Equipment Definition (V_D)]

Thus, a roller with 2400vpm/10 impacts/foot could operate at a speed of 240 feet/min. So if a roller was operated at 400 feet/min with a 1600 vpm frequency, the spacing of impacts would be 4 per foot which would result in ripples and lower density because the dynamic energy into each square yard would be reduced by 2/3. This would create a 'washboard' effect on the driving surface resulting in a rough bumpy ride for the motorist.



Improper spacing Proper spacing



Increasing roller speed creates wider spacing between impacts

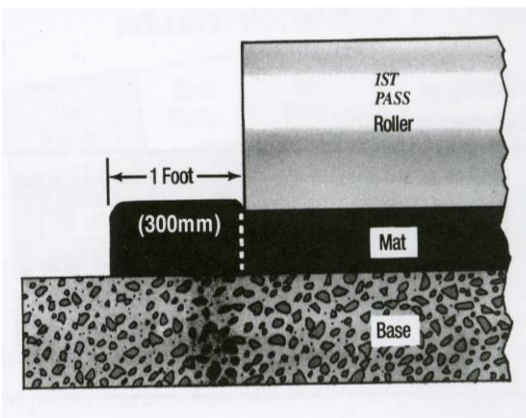
The improper spacing will create a washboard effect on the surface of the mat.

9. Maximum Paver Speed

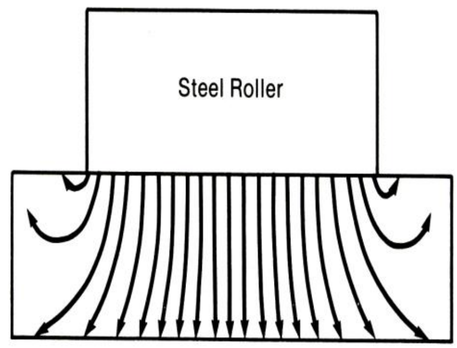
Article 406.06(f) limits the maximum speed of the paver to 50 feet per minute. The paver speed is further constrained by the maximum roller speed to the extent that the vibratory roller is able to perform the required number of passes and still keep up with the paver.

A pass of the roller is defined as one trip of the roller in one direction over any one spot.

Normally, the number of passes will normally be an odd amount to keep the roller moving forward on the mat. Each pass of the roller will be staggered across the mat to provide even coverage. The passes on the outside edges (unconfined) are usually rolled last to keep from pushing the mat outward. The Contractor is still required to achieve proper compaction on the mat edges (confined or unconfined) per the "*HMA – Density Testing of Longitudinal Joints (BMPR)*" document (located in chapter 9 in this manual).



Edge Compaction



Exerted Force

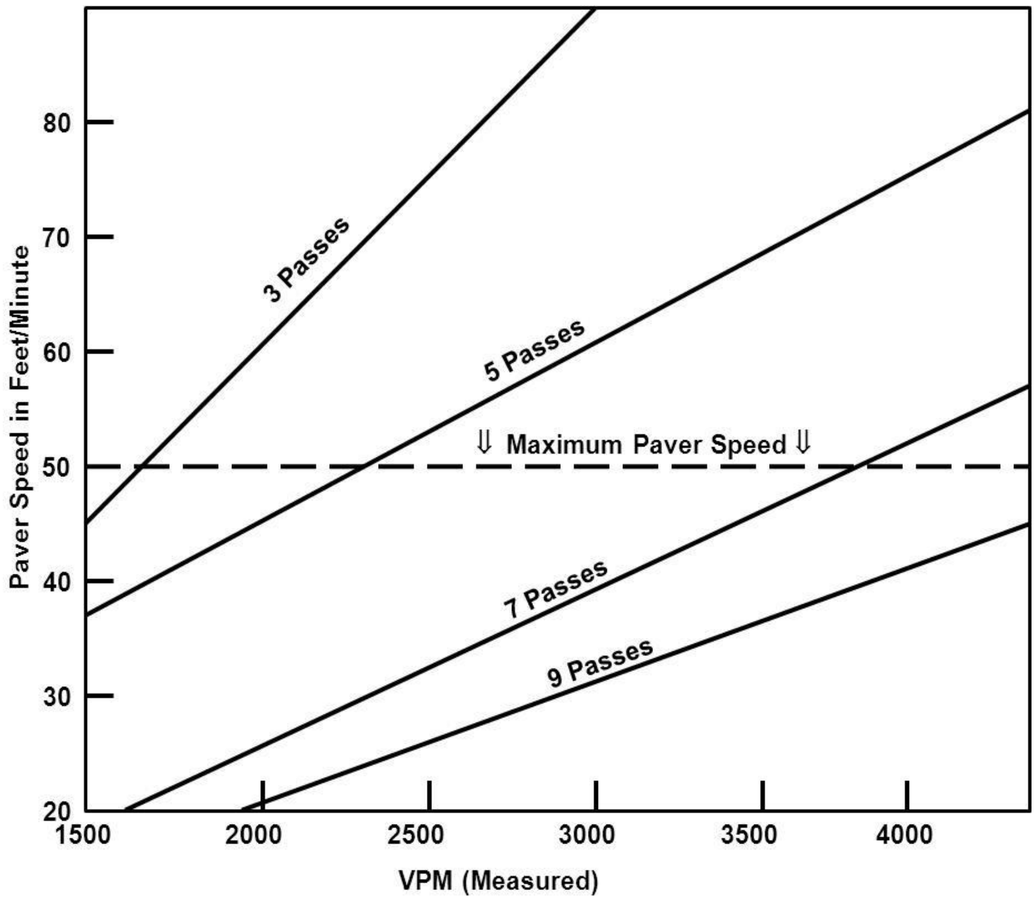
Typical number of roller passes needed to achieve density (see note below):

Type of Mixture	# of passes
High ESAL mixes	7 – 9
Low ESAL mixes	3 – 7

Appropriate mix evaluation is required to determine the actual number of passes needed to achieve the proper density of a mixture. The proper method of mixture evaluation is discussed in Chapter 8 of this manual.

NOTE: **This information only is intended to be a guideline**.

Maximum Paver Speed Permitted to Maintain at least 10 Impacts/Foot with a Vibratory Roller



Maximum Vibratory Roller Speed = $\frac{\text{Measured Frequency}}{10}$

Maximum Paver Speed = $\frac{\text{Measured Frequency}}{10(\text{\# of req. passes})} \times 0.9$

Example: Measured frequency is 2200 VPM at 5 passes

Maximum Vibratory Roller Speed (2.5 mph) = $\frac{2200}{10}$ = **220'/min**

Maximum Paver Speed = $\frac{2200}{(10 \times 5)} \times 0.9$ = **39.6'/min**

Class Example:

To determine roller and paver speed using a 7 pass pattern:

Check the VPM of the roller:

	Front Drum	Rear Drum
Forward	2200	2100
Backward	2000	2150

$$\text{Roller speed} = \frac{\text{Measured frequency}}{10 \text{ (impacts /ft.)}}$$

$$\text{Max. Paver Speed} = \frac{\text{Measured Frequency}}{10 \text{ (Number of passes)}} \times (.9)$$

10. <u>HMA Surfacing Yield Test Determination</u>

Of the many duties of the HMA surfacing inspector, the requirement of checking the rate of surfacing, or tons per station, is probably one of the most important functions he/she must perform. This check, called the yield test, is performed to help determine proper mixture quantities of ingredients which will affect the properties of the mixture.

Yields checks should be performed throughout the workday. Imagine the amount of displeasure that would be experienced by the Contractor waiting until all resurfacing is completed before discovering that the planned HMA mixture quantities had been exceeded by more than 3%. **<u>The contractor should discuss the plan quantities with the Engineer so that there are no misunderstandings.</u>**

This information on yield has been written to present to one simple calculation which should be performed throughout the day to inform the technician immediately of possible quantity issues, over or under on planned quantities.

Probing of the uncompacted HMA behind the paver is a rather inaccurate method of thickness quantity determination, the technician has to seek more reliable methods of checking quantity placement. Yield calculations should be retained in a hard back field book and should become part of the permanent project file.

Note: Use of Material Transfer Devices (MTD) restricts the ability to check yields on a truck by truck basis unless extra steps are taken to determine as to when the beginning and end of a load has passed through the MTD.

<u>Beginning of the Documentation of Contract Quantities FY 2020- page A-15 & A-16</u>

"Daily yield checks should be run on these items so that the Contractor can be notified when he/she is exceeding the maximum specified amounts of quantity. The limit of the final amount paid shall be plan quantity plus (or minus) theoretical quantities approved by authorization, multiplied by the above percentage.

YIELD CHECKS: *A yield check is a calculation to determine if the correct amount of material was used in the work:*

$$\text{Yield (\%)} = \frac{\text{Quantity of material delivered}}{\text{Theoretical quantity required}} \times 100$$

Frequent yield checks are a good engineering practice, and they may help uncover problems in the work early in the project. Yield checks documented by inspectors provide a timely and valuable source of information to the Resident.

While performing yield checks are highly recommended for all materials used in the work, they are required to be documented for the following items:

<u>Item</u>	*<u>Frequency</u>*
HMA Paving	*Frequently, each day of paving"*

<u>End of the Documentation of Contract Quantities FY 2020 - page A-15 & A-16</u>

11. Yield Calculations

A common **calculation** used to check the rate of tonnage placement is:

Theoretical Tons per Station (100 ft.)

A. Determination of Theoretical Tons per Station (100 feet):

$$T = \frac{RWN}{180}$$

WHERE:

- **T** = Theoretical tons of HMA per station (100 feet)
- **W** = Width of mat in feet
- **N** = Number of 100 foot stations
- **R** = 112***** x inches of mat thickness

***** Rate of application in lbs. per yd^2.
(One yd^2 of HMA, one inch thick is determined to be 112 lbs.)

EXAMPLE: GIVEN:

Actual mat width	=	13.5 ft	(**W**)
Theo. mat thickness	=	1.5 inches	
Actual tonnage per station	=	13.1 tons laid	

Find: **Tons per 100 ft station**

$$T = \frac{(112 \times 1.5)(13.5)(1)}{180}$$

$$T = 12.6 \text{ Tons per 100 ft station}$$

Yield using Tons per Station (100 ft)

Yield: $\frac{\text{Actual Tonnage}}{\textbf{Theoretical Tonnage (T)}} \times 100 = \%\text{ Yield} \qquad \frac{13.1}{12.6} \times 100 = 104.0\%$

NOTE: Actual tonnage greater (over yield) or less (under yield) than this figure would indicate thick or thin mat thickness and appropriate screed adjustments would be warranted.

Class Problem #1: At 1:00pm you have paved 7210 feet at a width of 14 feet (**W**), at a depth of 2 inches with 1287 tons. What is the yield?

Theoretical Tonnage (T) = $\frac{RWN}{180}$ =

% Yield = $\frac{\text{Actual Tonnage}}{\textbf{Theoretical Tonnage (T)}} \times 100$ =

<u>Beginning of the Standard Specification Article 406.13 (b), in part - 4th para.</u>

"…Mixture for cracks, joints and flangeways, binder (hand method), binder course, and surface course mixtures will be measured for payment in tons (metric tons) on approved platform scales, surge bin scales, or surge bin hopper scales equipped with automatic printers as specified in Article 1102.01(a)(7). HMA produced by a batch-type mixing plant may be measured by batch weights only when surge or storage bins are not used. An occasional check to verify the accuracy of the batch weights or automatic printers, will be made by weighing full truckloads of the HMA on an approved platform scale at the plant or on a commercial scale approved by the Engineer. If it becomes apparent that the batch weights or automatic printers are not accurate in measuring the HMA, the scales and/or printers shall be repaired immediately. Quantities of materials wasted or disposed of in a manner not called for in the contract will be deducted from the final total measured quantities. The Contractor shall furnish a load ticket which records the net weight of the HMA in each truck, as specified in Article 1102.01(a)(7). In addition, the load ticket shall have sufficient space for signatures, identification of the HMA, date of delivery, and any other data which the Engineer may require. The Contractor shall submit the load ticket to the Engineer at the work site when the truck arrives.

Mixture for cracks, joints, and flangeways, binder (hand method), and binder course in excess of 103 percent of the quantity specified by the Engineer will not be measured for payment.

Surface course mixture in excess of 103 percent of the adjusted plan quantity will not be measured for payment. The adjusted plan quantity for surface course mixtures will be calculated as follows.

Adjusted Plan Quantity = C x quantity shown on the plans or as specified by the Engineer

where C = : *English:* $C = \frac{G_{mb} \times 46.8}{U}$ *Metric:* $C = \frac{G_{mb} \times 24.99}{U}$

and where:

	G_{mb}	=	*average bulk specific gravity from approved mix design*
	U	=	*unit weight of surface course shown on the plans in lb./sq. yds./in (kg/sq. m/25 mm), used to estimate plan quantity*
	46.8	=	*English constant*
	24.99	=	*metric constant*

If project circumstances warrant a new surface course mix design, the above equations shall be used to calculate the adjusted plan quantity for each mix design using its respective average bulk specific gravity…."

<u>End of the Standard Specification Article 406.13 (b), in part - 4th para.</u>

12. Example of quantity adjustment:

Mix design G_{mb}	=	2.345 @ 4.0% air voids
Unit weight (from plan sheets)	=	112 #/sq yd/ in
Mixture	=	19534 Surface mixture
Job plan quantities	=	10,000 tons

$$C = \frac{2.345\ (46.8)}{112} = \_\_\_\_\_\_\_\_\_\_ \text{ (3 decimal places)}$$

Maximum amount before correction	=	10,000 x 103%	=
Corrected plan quantities	=	10,000 x ______ (CF)	=
Maximum amount to be laid @ 103%	=	______ x 103%	=

Class problem for quantity adjustment:

Mix design G_{mb}	=	2.517 @ 4.0% air voids
Unit weight (from plan sheets)	=	112 #/sq yd/ in
Mixture	=	19544 Surface mixture
Job plan quantities	=	24,575 tons

Corrected plan quantities	=
Maximum amount to be laid @ 103%	=

SAMPLE NOTIFICATION LETTER

Example Construction Company
101 Example Street
Example, Illinois 00000

Gentlemen:

On ____________________, the Hot Mix Asphalt (HMA) produced by your company had an asphalt content of _________ percent and/or a density of __________ percent. This does not meet the specification requirements contained in the contract.

Please bring this matter to the attention of the supervisory personnel of your company who are involved in the manufacture or placement of this material. Compliance with the contract requirements is the responsibility of your company and it is therefore important that your company take corrective action at the earliest possible moment.

Failure to take corrective action could result in suspension of the work, removal of the deficient material, or a reduction in contract price for the material in accordance with Article 105.03 of the Standard Specifications for Road and Bridge Construction.

We will cooperate with you in every way possible to eliminate this problem.

Very truly yours,

REGIONAL ENGINEER

By: ____

cc: (As applicable):
District Construction Engineer
Resident Engineer
Proportioning Technician
Supervising Field Engineer
District Materials Engineer
District Mixtures Control Engineer
District Laboratory Technician

HMA TEST STRIP GUIDELINES

I. Purpose

A. Verification of HMA Lab Design in Field

B. Determine the characteristics and density potential of the HMA

II. Test Strip

A. Growth Curve - Density Potential – on mixture quantities exceeding 3000 ton

1. HMA Mix

a. Approved mix design

b. Prior usage of mixture

c. Adjusted gradation prior to production - AJMF and Target Values

d. Selection of sites (based on tonnage)

e. Evaluate 300 tons of mixture

f. Plant production does not shut down

g. No pay item (incidental to the contract)

2. Compaction Equipment

a. Vibratory roller – 1101.01(g)

- Speed & frequency (10 impacts/ft) mated to paver

b. State checks/verification

3. Constructing Test Strip

a. Best/Ideal Conditions

- HMA temperature - 280° F minimum
- Tarped & insulated trucks
- Rollers filled with water and caught up
- Best location
- Batch plant (from pug mill)

b. Procedure

- Use of nuclear gauge/experienced operator

  1 minute readings

- Single passes of vibratory roller

- Plot results – identify a double break

- Completion

  3 tests show no upward trend

  Evidence of mat destruction

c. MF and cores after completion

4. Evaluation of Growth Curve

a. Nuclear gauge - past history

b. Density potential

- Article 1030.05(d)(4)

c. Evaluate other mix parameters (visual characteristics and plant tests)

d. Agreement of Contractor/Engineer

B. Rolling Pattern

1. Contractor determines number of passes and roller train

a. Based on agreement of AJMF and Targets

b. Engineer in agreement

c. State and Contractor spot checks for density

2. Nuclear/Core correlation location

a. 3 locations

b. Contractor & State correlations performed jointly

c. Correlation completed prior to next production day

C. Documentation

1. Contractor will provide all test strip information

III. Finalized Test Strip

A. Agreement between Contractor and State

1. Plant test results

2. Growth curve results

3. Additional adjustments = additional growth curve/testing

B. Resume production for the rest of the day at Contractor’s own risk

C. JMF adjustment limits/new mix design

- Article 1030.06 (a) paragraph 4

D. Hamburg Wheel test

E. I-FIT (Illinois Flexibility Index Test)

Beginning of Standard Specification Article 1030.10

1030.10 Start of HMA Production and Job Mix Formula (JMF) Adjustments. The start of HMA production and JMF adjustments shall be as follows.

For each contract, a 300 ton (275 metric ton) test strip will be required at the beginning of HMA production for each mixture with a quantity of 3,000 tons (2,750 metric ton) or more according to the document "Hot-Mix Asphalt Test Strip Procedures".

An off-site preliminary test strip may be required for new mixture types according to the document "Off-Site Preliminary Test Strip Procedures for Hot-Mix Asphalt".

When a test strip is constructed, the Contractor shall collect and split the mixture according to the document "Hot-Mix Asphalt Test Strip Procedures". Within two working days after sampling the mixture placed in the test strip, the Contractor shall deliver prepared samples to the District laboratory for verification testing. The Contractor shall complete mixture tests stated in Article 1030.09(a). The Department will complete testing of loose mixture samples and gyratory cylinders provided by the Contractor. Mixture sampled shall include enough material for the Department to conduct mixture tests detailed in Article 1030.09(a) and in the document "Hot-Mix Asphalt Mixture Design Verification Procedure" Section 3.3. The mixture test results shall meet the requirements of Articles 1030.05(b) and 1030.05(d), except tensile strength and TSR testing will only be conducted on the first use of a mix design for the year and Hamburg wheel tests will only be conducted on High ESAL mixtures.

"When a test strip is not required, each HMA mixture with a quantity of 3,000 tons (2,750 metric tons) or more shall still be sampled on the first day of production: I-FIT and Hamburg wheel testing for High ESAL; I-FIT testing for Low ESAL. Within two working days after sampling the mixture, the Contractor shall deliver gyratory cylinders to the District laboratory for Department verification testing. The High ESAL mixture test results shall meet the requirements of Articles 1030.05(d)(3) and 1030.05(d)(4). The Low ESAL mixture test results shall meet the requirements of Article 1030.05(d)(4)."

If the test strip mixture fails to meet the requirements for tensile strength or TSR, a resample shall be provided by the Contractor to the Department. Failure of a resampled mixture test shall result in the Contractor stopping production. The Contractor shall take corrective action and re-submit for testing according to Article 1030.05(d), substitute an approved mix design, or submit a new mix design for mix verification testing according to Article 1030.05(d).

Based on the test results from the test strip, if any JMF adjustment or plant change is needed, the JMF shall become the Adjusted Job Mix Formula (AJMF). If an adjustment/plant change is made, the Engineer may require a new test strip to be constructed. Upon completion of the first acceptable test strip, the JMF shall become the AJMF regardless of whether or not the JMF has been adjusted.

Art. 1030.10 Hot-Mix Asphalt

If the HMA placed during the initial test strip is determined to be unacceptable to remain in place by the Engineer, it shall be removed and replaced. In no case shall the target for the amount passing be outside the mixture composition limits stated in Article 1030.05(a).

The limitations between the JMF and AJMF are as follows.

Parameter	High ESAL Adjustment	Low ESAL Adjustment
1/2 in. (12.5 mm)	± 5.0 %	± 6.0 %
# 4 (4.75 mm)	± 4.0 %	± 5.0 %
# 8 (2.36 mm)	± 3.0 %	
# 30 (600 µm)	1/	
# 200 (75 µm)	1/	± 2.5 %
Asphalt Binder Content	± 0.3 %	± 0.5 %

1/ In no case shall the target for the amount passing be greater than the JMF.

Adjustments outside the above limitations will require a new mix design.

“Production is not required to stop after a test strip has been constructed.”

Upon notification by the Engineer of a failing Hamburg wheel or I-FIT test, the Contractor shall immediately resample and the Department will test. Paving may continue as long as all other mixture criteria is being met. If the second set of Hamburg wheel or I-FIT tests fail, no additional mixture shall be produced until the Engineer receives both passing Hamburg wheel and I-FIT tests.

During production, the Contractor and Engineer shall continue to evaluate test results and mixture laydown and compaction performance. Adjustments within the above requirements may be necessary to obtain the desired mixture properties. If an adjustment/plant change is made, the Engineer may request additional growth curves and supporting mixture tests.

<u>End of Standard Specification Article 1030.10</u>

Beginning of Hot Mix Asphalt Test Strip Procedures Appendix B4

“Illinois Department of Transportation

Hot Mix Asphalt Test Strip Procedures
Appendix B4

Effective: May 1, 1993
Revised: December 1, 2023

When the quantity of a mixture is greater than or equal to 3000 tons (2750 metric tons) on a contract, the Contractor and the Department shall make an evaluation of the mixture using a 300 ton (275 metric ton) test strip at the beginning of HMA production. The Contractor shall adhere to the following procedures for constructing a test strip.

A. Contractor/Department Test Strip Team

As the test strip is constructed, a team of both Contractor and Department personnel will evaluate the mix.

The test strip team may consist of the following:

1. Resident Engineer
2. District Construction Supervising Field Engineer, or representative
3. District Materials Mixtures Control Engineer, or representative
4. District Nuclear Density Gauge Tester
5. Contractor's QC Manager, required
6. Contractor’s Paving Superintendent
7. Contractor's Density Tester

Optional:

8. Central Bureau of Construction representative
9. Central Bureau of Materials representative
10. Asphalt Binder Supplier representative

B. Communications

The Contractor shall advise the team members 48 hours in advance of the anticipated start date/time of production of the test strip mix. The QC Manager shall direct the activities of the test strip team. A Department appointed representative from the test strip team will act as spokesperson for the Department.

C. Test Strip Method

The mix design shall have been approved by the Department prior to the test strip. Target values shall be provided by the Contractor and will be approved by the Department prior to constructing the test strip.

The Contractor shall produce 300 tons (275 metric tons) of mix for the test strip.

"Illinois Department of Transportation

Hot Mix Asphalt Test Strip Procedures
Appendix B4
(continued)
Effective: May 1, 1993
Revised: December 1, 2023

The procedures listed below shall be followed to construct a test strip.

1. Location of Test Strip - The test strip shall be located on a relatively flat portion of the roadway. Descending/ascending grades or ramps should be avoided.

2. Constructing the Test Strip - After the Contractor has produced and placed approximately 225 to 250 tons (200 to 225 metric tons) of mix, paving shall cease and a growth curve shall be constructed. After completion of the first growth curve, paving shall resume for the remaining 50 to 75 tons (45 to 70 metric tons), and the second growth curve shall be constructed within this area. The Contractor shall use normal rolling procedures for all portions of the test strip except for the growth curve areas which shall be compacted as directed by the QC Manager.

3. Mixture Sampling - Mixture samples shall be taken by the Contractor in the field at such a time as to represent the mixture in-between the two growth curves. The Contractor has the option to sample mixture for Department Hamburg Wheel, I-FIT, Tensile Strength, and TSR testing on the first production day after completion of an acceptable test strip. The sampling procedure shall follow the method of field sampling described in the document "Hot-Mix Asphalt QC/QA Initial Daily Plant and Random Samples" Section D. Department Random Verification Mixture Sample Determination and Collection.

   In addition to the quantity of mix the Contractor collects for their volumetric tests per Standard Specification Article 1030.09(a), the Contractor shall also collect a sufficient quantity of mix for Department tests. This shall include 50 lb (23 kg) for volumetric testing, a minimum of 150 lb (70 kg) for the Contractor to fabricate Hamburg Wheel and I-FIT gyratory cylinders, and if this test strip is the first of the year for the mix design, an additional 100 lb (45 kg) for the Contractor to fabricate gyratory cylinders for Tensile Strength and TSR testing.

D. Compaction Requirements

1. Compaction Equipment - The Contractor shall provide a roller meeting the requirements of Article 1101.01(g) for dense graded mixtures and 1101.01(e) for SMA and IL-4.75 mixtures. It shall be the responsibility of the QC manager to verify roller compliance before commencement of growth curve construction.

   a. Dense Graded Mixtures – A vibratory roller shall be used with an appropriate amplitude determined based on the roller weight and mat thickness to achieve maximum density. The vibratory roller speed shall be balanced with frequency so as to provide compaction at a rate of not less than 10 impacts per 1 ft (300 mm).

   b. SMA and IL-4.75 Mixtures – A static roller shall be used with the weight determined by the mixture composition, mat thickness, and ability to achieve maximum density.

Hot Mix Asphalt Test Strip Procedures
Appendix B4
(continued)
Effective: May 1, 1993
Revised: December 1, 2023

2. Compaction Temperature - In order to make an accurate analysis of the density potential of the mixture, the initial compaction temperature of the mixture on the pavement at the beginning of the growth curve shall be no more than 10°F (5°C) lower than the minimum mixture placement temperature specified in Article 406.06.

3. Compaction and Testing - The Contractor shall direct the roller speed and number of passes required to obtain a completed growth curve. The nuclear gauge shall be placed near the center of the hot mat and the position marked for future reference. With the bottom of the nuclear gauge and source rod clean, a 1-minute nuclear reading (without mineral filler) shall be taken after each pass of the roller. Rolling shall continue until a growth curve can be plotted, the maximum density determined, and three consecutive passes show no appreciable increase in density or evident destruction of the mat.

4. Final Testing - A core shall be taken and will be secured by the Department from each growth curve to represent the density of the in-place mixture. Additional random cores may be required as determined by the Engineer.

E. Evaluation of Growth Curves

Mixtures which exhibit density potential less than or greater than the density ranges specified in 1030.09(c) shall be considered to have a potential density problem which is sufficient cause for mix adjustment.

If an adjustment is made at the plant, the Engineer may require an additional test strip to be constructed and evaluated. This information shall then be compared to the AJMF and required design criteria for acceptance.

F. Nuclear/Core Correlation

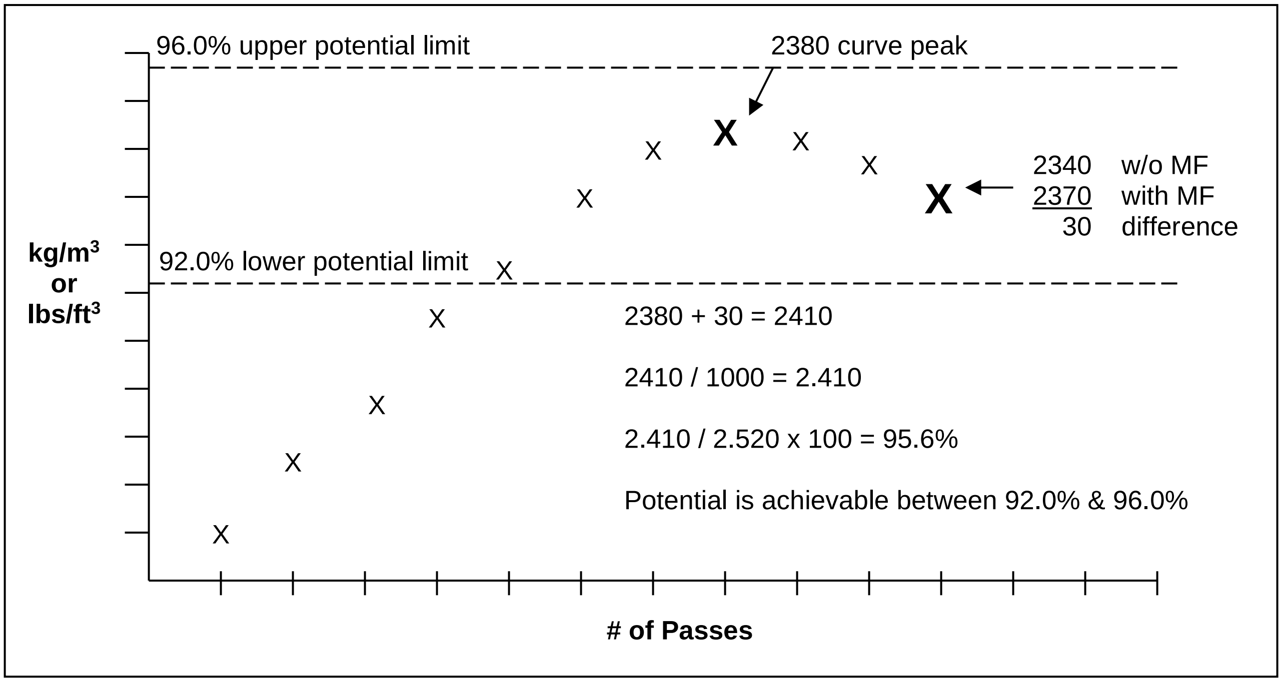
When required, a correlation of core and nuclear gauge test results shall be performed on-site as defined in the document "Procedure for Correlating Nuclear Gauge Densities with Core Densities for Hot-Mix Asphalt". This correlation shall be completed by the Contractor prior to the next day's production. Smoothness of the test strip shall be to the satisfaction of the Engineer.

G. Documentation

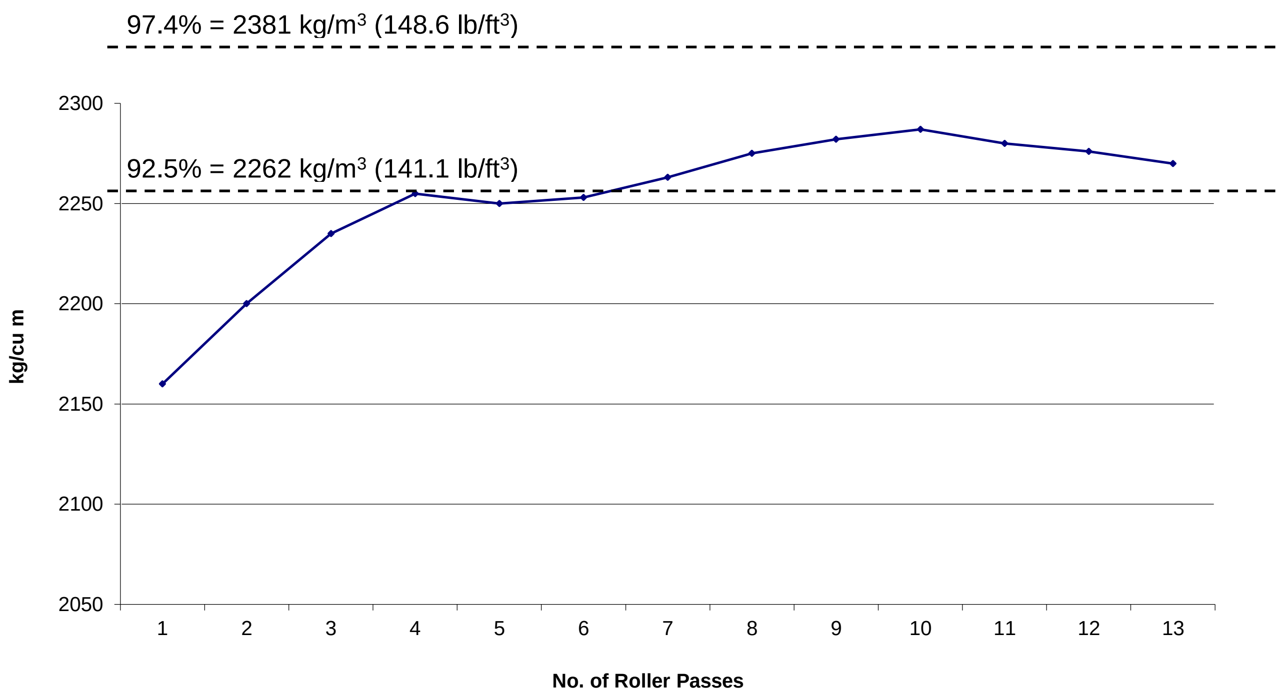
All test strip volumetric test results, rolling pattern information (including growth curves), and nuclear readings and core test results for correlating the nuclear gauge shall be tabulated by the Contractor with a copy provided to each team member and the original retained in the project files.

End of Hot Mix Asphalt Test Strip Procedures Appendix B4

HMA Growth Curve Example **19535 mixture** (‘D’ = 2.520)



HMA Growth Curve Example **19523 mixture** (‘D’ = 2.445)



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Typical Test Strip Sequence

Once the test strip has been completed, the contractor can continue paving the rest of the day **at their own risk**

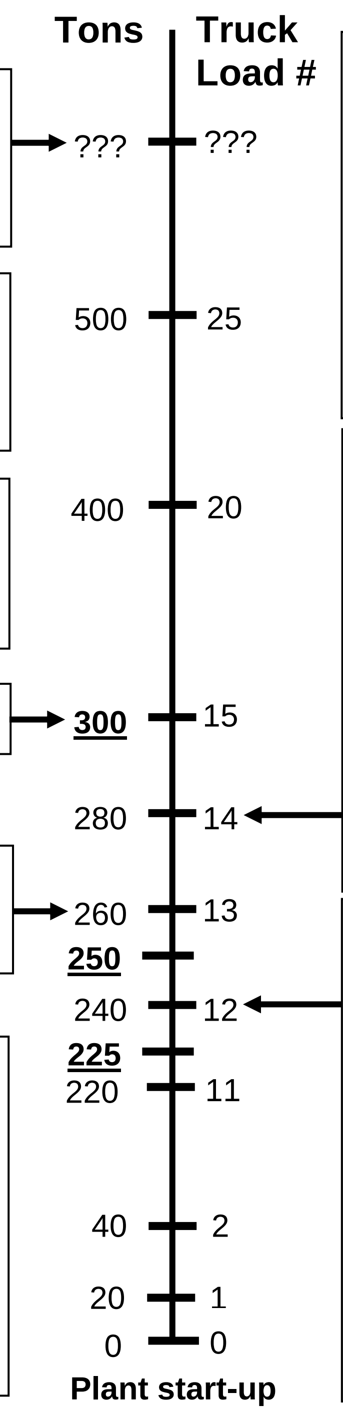
If mixture adjustments are needed, after the initial test strip, an additional test strip(s) may be ordered by the Engineer

Each plant sample will include enough material to run all test parameters including the Hamburg Wheel test & IDT

End of test strip

The **1st mixture sample** will be taken at the plant from truck load #13

Prior to start of test strip:
1) Approved design in place
2) Targets established for JMF
3) Corrections factors applied to JMF targets
4) Locate a good location for test strip
5) Normal roller procedures except in the growth curve areas



If things are good, a roller pattern will be established and a **2nd plant sample** will be taken

If a nuclear core correlation is performed, the **3rd set of cores** will be cut from the location corresponding to the truck load from which the 2nd plant sample was taken

The **2nd growth curve** is to be performed in the area represented by truck load #14 (250 - 300 T) (Paving can continue from this point)

A core will be cut to determine if the density potential has been met

If a nuclear core correlation is performed, the **2nd set of cores** will be cut from this growth curve

The **1st growth curve** is to be performed in the area represented by truck load #12 (225 - 250 T)

Paving will cease until the growth curve has been completed

A core will be cut to determine if the density potential has been met

If a nuclear core correlation is performed, the **1st set of cores** will be cut from this growth curve

On this example, a truckload is equivalent to 20 tons

NOTE: When different truck load sizes are utilized, the load sequence will have to be adjusted accordingly to the tonnage requirements

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Bituminous Mixture Design

Date: 12/07/16

Design Number:----->	84Bit1234	cer Name & Number>	2251-05	Asphalt Products
n Lab ?(PP,PL,IL ect.)	PP	erial Code Number--->	19523	BIT CONC SURF CSE N70 C

Agg No.	#1	#2	#3	#4	#5	#6	#7	ASPHALT	
Size		032CM16D	032CM16C	038FA20	037FA01	004MF01		10127	ACPG 64-22
(PROD#)		50912-02	51352-03	51352-03	50510-04	52102-07		2260-01	
(NAME)		Vulcan	Nokomis	Nokomis	C I M	Blom. Cr. St.		Aspt Mts	
(LOC)		Kankakee	Nokomis	Nokomis	Vandalia	Blom. , Ind		Urbana	
Agg Blend %	0.0	48.8	16.2	14.2	19.5	1.3	0.0	100.0	

Agg No. Sieve Size	#1	#2	#3	#4	#5	#6	#7	Blend	Mix Spec.	Formula	Range Min	Range Max
1		100.0	100.0	100.0	100.0	100.0		100.0	100	100		
3/4		100.0	100.0	100.0	100.0	100.0		100.0	100	100		
1/2		100.0	100.0	100.0	100.0	100.0		100.0	90-100	100		
3/8		98.0	97.0	100.0	100.0	100.0		98.5	66-100	99		
#4		37.0	34.0	100.0	100.0	100.0		58.6	24-65	59	52	62
#8		9.0	7.0	74.0	87.0	100.0		34.3	16-48	34	28	38
#16		5.4	4.8	46.0	64.0	100.0		23.7	10-32	24		
#30		5.2	4.0	28.0	40.0	100.0		16.3	0	16	12	20
#50		4.0	3.5	16.0	15.0	100.0		9.0	4-15	9		
#100		3.8	3.3	9.0	3.0	98.0		5.5	3-10	6		
#200		3.5	3.0	5.9	1.6	88.0		4.5	2-6	4.5	3.2	6.2
					Rap AC ==========>		0					

	#1	#2	#3	#4	#5	#6	#7	Blend	
Bulk Sp Gr	2.618	2.635	2.614	2.595	2.48	2.8	2.8	2.588	Bulk Sp Gr
pparent Sp	1	1	1	1	1	1	1		Apparent Sp Gr
bsorption, %	2.4	1.1	1.4	1.6	2.4	1	1	1.5	Absorption, %
								1.030	AC Specific Gravity
								0.87	Dust/AC Ratio

BITUMINOUS MIXTURE AGED HOW LO 1 HOURS @ 154 C

SUMMARY OF SUPERPAVE GYRATORY TEST DATA

	N-initial			10	N-design			70	Adjusted Gse			
PB:	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9	4.4	4.9	5.4	5.9
mb (corr):	2.079	2.083	2.099	2.110	2.317	2.318	2.340	2.353	2.317	2.318	2.340	2.353
Gmm:	2.473	2.455	2.437	2.420	2.473	2.455	2.437	2.420	2.473	2.455	2.438	2.420
Pa:	15.9	15.2	13.9	12.8	6.3	5.6	4.0	2.8	6.3	5.6	4.0	2.8
VMA:	23.2	23.5	23.3	23.3	14.4	14.8	14.5	14.4	14.4	14.8	14.5	14.4
ELD VMA:	24.8	25.1	24.9	24.9	16.2	16.6	16.3	16.3	16.2	16.6	16.3	16.3
VFA:	31.4	35.4	40.4	44.9	56.4	62.3	72.4	80.8	56.2	62.3	72.4	80.8
Vbe:	7.3	8.3	9.4	10.5	8.1	9.2	10.5	11.7	8.1	9.2	10.5	11.7
Pbe:	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1	3.6	4.1	4.6	5.1
Gse:	2.643	2.644	2.644	2.644	2.643	2.644	2.644	2.644	2.644	2.644	2.644	2.644
Pba:	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Slope: 9.9 Does Design Require Anti-Strip Additive (Yes No Material Code for Anti-Strip---

IBER OF REVOLUTIO	70			Voids		Design Field					TSR
	% AC	Gmm	Gmb	Pa	VMA	VMA	VFA	Gse	Gsb	TSR	W/Anti
PTIMUM DESIGN DAT	5.4	2.438	2.340	4.0	14.5	16.3	72.2	2.644	2.588	0.75	
Adjusted Design Data:	5.4	2.438	2.340	4.0	14.5	16.3	72.4	2.644	2.588		
Minimum Requirements				4.0	14.5		65-75			0.75	0.75
State Results:											

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MATERIAL CODES

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19504	BINDER	19.0L	N30	93.0 [1/]- 97.4 %-
19504R	BINDER	19.0L (REC)	N30	93.0 [1/]- 97.4 %-
19505	SURFACE	C - 9.5L	N30	92.5 – 97.4 %
19505R	SURFACE	C - 9.5L (Rec)	N30	92.5 – 97.4 %
19510		4.75	N50	93.0 - 97.4 %
19510R		4.75 (Rec)	N50	93.0 - 97.4 %
19512	BINDER	19.0	N50	93.0 [1/]- 97.4 %-
19512R	BINDER	19.0 (Rec)	N50	93.0 [1/]- 97.4 %-
19513	SURFACE	C	N50	92.5 – 97.4 %
19513F	SURFACE	C FG	N50	93.0 – 97.4 %
19513FR	SURFACE	C FG (Rec)	N50	93.0 – 97.4 %
19513R	SURFACE	C (Rec)	N50	92.5 – 97.4 %
19514	SURFACE	D	N50	92.5 – 97.4 %
19514F	SURFACE	D - FG	N50	93.0 – 97.4 %
19514FR	SURFACE	D - FG (Rec)	N50	93.0 – 97.4 %
19514R	SURFACE	D (Rec)	N50	92.5 – 97.4 %
19515	SURFACE	E	N50	92.5 – 97.4 %
19515R	SURFACE	E (Rec)	N50	92.5 – 97.4 %
19516	SURFACE	F	N50	92.5 – 97.4 %
19516R	SURFACE	F (Rec)	N50	92.5 – 97.4 %
19522	BINDER	19.0	N70	93.0 [1/]- 97.4 %-
19522R	BINDER	19.0 (Rec)	N70	93.0 [1/]- 97.4 %-
19523	SURFACE,	C	N70	92.5 – 97.4 %
19523F	SURFACE	C-FG	N70	93.0 – 97.4 %
19523FR	SURFACE,	C-FG (Rec)	N70	93.0 – 97.4 %
19523R	SURFACE	C (Rec)	N70	92.5 – 97.4 %
19524	SURFACE,	D	N70	92.5 – 97.4 %
19524F	SURFACE	D-FG	N70	93.0 – 97.4 %
19524FR	SURFACE	D FG (Rec)	N70	93.0 – 97.4 %
19524R	SURFACE	D (Rec)	N70	92.5 – 97.4 %
19525	SURFACE	E	N70	92.5 – 97.4 %
19525R	SURFACE	E (Rec)	N70	92.5 – 97.4 %
19526	SURFACE	F	N70	92.5 – 97.4 %
19526R	SURFACE	F (Rec)	N70	92.5 – 97.4 %
19532	BINDER	19.0	N90	93.0 – 96.0 %
19532R	BINDER	19.0 (Rec)	N90	93.0 – 96.0 %
19533	SURFACE	C	N90	92.0 – 96.0 %
19533R	SURFACE	C (Rec)	N90	92.0 – 96.0 %
19534	SURFACE	D	N90	92.0 – 96.0 %
19534F	SURFACE	D-FG	N90	92.0 – 96.0 %

[1/] 92.0 percent when placed as first lift on an unimproved subgrade

MATERIAL CODES (Continued)

CODE	MIX TYPE	GRADATION/ FRICTION	# GYRATIONS	INDIVIDUAL SPECIFICATION
19534FR	SURFACE	D-FG (Rec)	N90	93.0 – 97.4 %
19534R	SURFACE	D (Rec)	N90	92.0 – 96.0 %
19535	SURFACE	E	N90	92.0 – 96.0 %
19535R	SURFACE	E (Rec)	N90	92.0 – 96.0 %
19536	SURFACE	F	N90	92.0 – 96.0 %
19536R	SURFACE	F (Rec)	N90	92.0 – 96.0 %
19604	BINDER	9.5	N50	92.5 – 97.4 %
19604F	BINDER	9.5-FG	N50	93.0 – 97.4 %
19604FR	BINDER	9.5-FG (Rec)	N50	93.0 – 97.4 %
19604R	BINDER	9.5 (Rec)	N50	92.5 – 97.4 %
19605	BINDER	9.5	N70	92.5 – 97.4 %
19605F	BINDER	9.5-FG	N70	93.0 – 97.4 %
19605FR	BINDER	9.5-FG (Rec)	N70	93.0 – 97.4 %
19605R	BINDER	9.5-(Rec)	N70	92.5 – 97.4 %
19606	BINDER	9.5	N90	92.0 – 96.0 %
19606F	BINDER	9.5-FG	N90	93.0 – 97.4 %
19606FR	BINDER	9.5-FG (Rec)	N90	93.0 – 97.4 %
19606R	BINDER	9.5 R	N90	92.0 – 96.0 %
19647	SMA SURFACE	9.5 D	N50	93.5 -97.4 %
19647R	SMA SURFACE	9.5-D (Rec)	N50	93.5 -97.4 %
19650	SMA BINDER	12.5	N50	93.5 -97.4 %
19650R	SMA BINDER	12.5 (Rec)	N50	93.5 -97.4 %
19651	SMA SURFACE	12.5 C	N50	93.5 -97.4 %
19651R	SMA SURFACE	12.5-C (Rec)	N50	93.5 -97.4 %
19652	SMA SURFACE	12.5 D	N50	93.5 -97.4 %
19652R	SMA SURFACE	12.5-D (Rec)	N50	93.5 -97.4 %
19653	SMA BINDER	12.5	N80	93.5 -97.4 %
19653R	SMA BINDER	12.5 (Rec)	N80	93.5 -97.4 %
19654	SMA SURFACE	12.5 E	N80	93.5 -97.4 %
19654R	SMA SURFACE	12.5-E (Rec)	N80	93.5 -97.4 %
19655	SMA SURFACE	12.5-F	N80	93.5 -97.4 %
19655R	SMA SURFACE	12.5-F (Rec)	N80	93.5 -97.4 %
19664	SMA SURFACE	9.5-E	N80	93.5 -97.4 %
19664R	SMA SURFACE	9.5-E (Rec)	N80	93.5 -97.4 %
19665	SMA SURFACE	9.5-F	N80	93.5 -97.4 %
19665R	SMA SURFACE	9.5-F (Rec)	N80	93.5 -97.4 %

Notes:
For recycled mixes add an "R" after 5-digit code. - Example: 19534R
For Fine Graded Recycled mixes add an “FR” after 5-digit code – Example: 19534FR

Code number breakdown:

195 indicates a HMA mixture
The 4th digit indicates the number of N_{des} gyrations (1 = 50 gyrations, etc.)
The 5th digit indicates the type of mixture (IL-19.0 or a surface mixture)

HMA – Hot-Mix Asphalt
SMA – Stone Matrix Asphalt

HMA Material Code Break Down

The mix code for a 19523 HMA mixture breaks down as:

195 = HMA mixture

2 = _____ gyrations

3 = _______________ mixture

Type of mixture* = _______________ mixture

Number of Gyrations* = _____ gyrations

* See page 8-18 for type of mixture and gyrations

Density requirements = _______________

Class Problem

Determine the mixture, gyrations and the density requirements for a 19532 HMA mixture:

Type of mixture = _______________ mixture

Number of Gyrations = _____ gyrations

Density requirements = _______________

HMA Mix Correlation Problems

Determine the following for the two class problems below:

1. The required percent density by specification of the mixture
2. The percent density of the random test location
3. The theoretical air voids of the mixture at the random test location
4. Determine if the percent density is within specification

Problem #1: When placing a 19514 mixture at a random test location, with the given information, determine the following:

Given: 'r' = 0.9423 m = 0.8252
b = 423.078 kg/m^3 "D" = 2.450

X = 2358 kg/m^3 (the individual test result (average of readings) at a random density test site location)

Adjusted Density formula: Y = mX + b

Final % density = ________________ Theo. Air Voids = _________

Required % density = ________________ Meets Density = YES NO

Problem #2: Use the following given data and determine the following for a 19535 HMA mix.

Given: 'r' = 0.7154 m = 0.8977
b = –199.234 kg/m^3 "D" = 2.510

X = 2917 kg/m^3 (the individual test result (average of readings) at a random density test site location)

Final % density = ________________ Theo. Air Voids = _________

Required % density = ________________ Meets Density = YES NO

Extra Blank Worksheets

Worksheets **Page**

Homework

NOTE: Use the given information from Chapter 4 for each homework problem

In-Class Problems

NOTE: If applicable, all proportioning problems in this section have been adjusted for windage.

Homework Sheets

Dryer-drum plant set-up HW problem #1

Feeder	RAP	#1	#2	#3	#4	MF	-----			
Agg							**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 700**		
Agg%								**= 100%**		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AC										

Recycle dryer-drum plant set-up HW problem #2

Recycle Dryer-Drum <u>Set-up</u> Homework Problem #2										
Feeder		**R1**	**#1**	**#3**	**#3**	**MF**	**New Bit**			
Agg		**RAP**	**CM11**	**CM16**	**FM02**	**MF**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%								**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2										
3/8										
#4										
#8										
#16										
#30										
#50										
#100										
#200										
AC										

Batch plant set-up HW problem #3

Bin # Size	Bin #4 **+ 1/2**	Bin #3 **-1/2 +#4**	Bin #2 **-4 +#8**	Bin #1 **- #8**	MF **- #200**	New Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** =		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1									
3/4									
1/2									
3/8									
#4									
#8									
#16									
#30									
#50									
#100									
#200									
AC									

Dryer-drum plant adjustment HW problem #4

Feeder	RAP	#1	#2	#3	MF	------			
Agg		**CM11**	**CM16**	**FM20**	**MF**	**New Bit**			
Mix%							= 100%		
TPH							**Prod Rate - TPH =** 300		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1		100	100	100	100		**100**		
3/4		91	100	100	100		**96**		
1/2		34	100	100	100		**74**		
3/8		14	97	100	100		**64**		
#4		3	32	99	100		**43**		
#8		2	9	96	100		**36**		
#16		1	8	56	100		**23**		
#30		1	8	42	100		**17**		
#50		1	7	16	100		**10**		
#100		1	6	6	100		**5**		
#200		1.0	5.5	3.8	85.0		**3.1**		
AC							**4.4**		

Dryer-drum Plant Set-up In-Class Problems

Dryer-Drum Set-up Class Example #1										
Feeder	RAP	#1	#2	#3	#4	------	**New Bit**			
Size			**CM16**		**FM02**	**MF01**				
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**	[redacted]	**= 100%**		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			**100**		**100**	**100**		**100**		
3/8			**96**		**100**	**100**		**98**		
#4			**39**		**100**	**100**		**59**		
#8			**9**		**86**	**100**		**34**		
#16			**7**		**59**	**100**		**24**		
#30			**5**		**35**	**100**		**16**		
#50			**5**		**14**	**100**		**9**		
#100			**5**		**9**	**97**		**7**		
#200			**4.2**		**2.1**	**91.0**		**5.2**		
AC								**5.2**		

Dryer-Drum Set-up Class Example #2										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%								**= 100%**		
TPH								**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2			**100**	**100**		**100**		**100**		
3/8			**95**	**100**		**100**		**97**		
#4			**37**	**99**		**100**		**57**		
#8			**8**	**78**		**100**		**33**		
#16			**6**	**54**		**100**		**23**		
#30			**5**	**32**		**100**		**16**		
#50			**4**	**16**		**100**		**10**		
#100			**3**	**11**		**98**		**8**		
#200			**2.2**	**7.1**		**94.0**		**5.7**		
AC								**6.1**		

Recycle Dyer-drum Plant Set-up In-Class Problems

Recycle Dryer-Drum Set-up Problem #1										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%			53.5	20.0		1.2		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100		100	100		100		100		
3/8	96		95	100		100		96		
#4	70		37	100		100		60		
#8	46		17	91		100		40		
#16	33		6	64		100		24		
#30	20		5	43		100		17		
#50	15		3	21		100		11		
#100	10		2	5		100		7		
#200	7.9		1.7	4.0		90.0		4.8		
AC	4.5							5.7		

Recycle Dryer-Drum Set-up using RAP & RAS - Problem #2										
Feeder	R1	R2	#1	#2	#3	MF	New Bit			
Size	RAS	RAP		CM16	FM20					
Mix%								= 100%		
TPH								Prod Rate - 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2	100	100		100	100			100		
3/8	100	93		97	100			98		
#4	100	67		38	100			59		
#8	94	46		9	80			36		
#16	75	34		5	60			25		
#30	48	27		4	38			17		
#50	40	18		4	15			10		
#100	34	12		3	4			6		
#200	27.4	9.4		3.0	3.9			5.0		
AC	27.0	4.5						5.4		

Batch Plant Set-up In-Class Problems

Batch Plant Set-up Example 1							**Surface Mixture**		
Bin # Size	Bin #4 + 1/2	Bin #3 -1/2 +#4	Bin #2 -4 +#8	Bin #1 - #8	MF - #200	New Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs. = 2000**		
Agg%							= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1									
3/4									
1/2		100	100	100	100		**100**		
3/8		96	100	100	100		**99**		
#4		6	90	100	100		**57**		
#8		1	6	95	100		**33**		
#16		1	1	70	100		**23**		
#30		1	1	54	100		**19**		
#50		1	1	30	100		**10**		
#100		1	1	18	99		**7**		
#200		1.0	1.0	10.0	88.8		**4.7**		
AC							**6.1**		

Batch Plant Set-up Example 2							**Binder Mixture**		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%							= 100%		
#'s							**Batch Size - Lbs.** = **10000**		
Agg%							= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1	100	100	100	100	100		**100**		
3/4	90	100	100	100	100		**95**		
1/2	20	80	100	100	100		**71**		
3/8	18	39	95	100	100		**59**		
#4	1	5	82	100	100		**40**		
#8	1	1	11	93	100		**27**		
#16	1	1	1	50	100		**16**		
#30	1	1	1	35	100		**11**		
#50	1	1	1	17	100		**7**		
#100	1	1	1	11	99		**5**		
#200	0.3	0.3	0.2	6.9	87.7		**3.1**		
AC							**5.9**		

Dryer-drum Adjustment In-Class Problems

Dryer-Drum Adjustment Problem #1 Coarse Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 600 TPH		
Agg%		51.3	17.0		29.4	2.3		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		41	100		100	100	70	73		
		21.0	17.0		29.4	2.3				
3/8										
#4		3	32		99	100	38	43		
		1.5	5.4		29.1	2.3				
#8		2	8		92	100	32	36		
		1.0	1.4		27.0	2.3				
#16										
#30		2	3		57	100	21	23		
		1.0	0.5		16.8	2.3				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.4	3.5		
		0.8	0.4		0.1	2.1				
AC								4.0		

Dryer-Drum Adjustment Problem #1 Coarse Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 600 TPH		
Agg%								= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		41	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		2	8		92	100		36		
#16										
#30		2	3		57	100		23		
#50										
#100										
#200		1.5	2.4		0.5	90.0		3.5		
AC								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%		40.0	18.0		39.0	3.0		= 100%		
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits	
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max
1										
3/4										
1/2		40	100		100	100	76	73		
		16.0	18.0		39.0	3.0				
3/8										
#4		3	32		99	100	49	43		
		1.2	5.8		38.6	3.0				
#8		3	7		92	100	41	36		
		1.2	1.3		35.9	3.0				
#16										
#30		2	3		58	100	27	23		
		0.8	0.5		22.6	3.0				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.9	3.5		
		0.6	0.4		0.2	2.7				
AC								4.0		

Dryer-Drum Adjustment Problem #2 Fine Example

Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16		FM01	MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 300 TPH		
Agg%								= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		40	100		100	100		73		
3/8										
#4		3	32		99	100		43		
#8		3	7		92	100		36		
#16										
#30		2	3		58	100		23		
#50										
#100										
#200		1.5	2.2		0.5	90.0		3.5		
AC								4.0		

Dryer-Drum Adjustment Problem #3 Class Example											
Feeder	RAP	#1	#2	#3	#4	------	-----				
Size		CM11	CM16	FM20		MF01	New Bit				
Mix%								= 100%			
TPH								Production Rate 200 TPH			
Agg%		37.0	25.0	38.0				= 100%			
Sieve Size	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb Grad	Target	Control Limits		
	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin			Min	Max	
1											
3/4											
1/2		36	100	100		100	76	80			
		13.3	25.0	38.0							
3/8											
#4		3	49	80		100	44	47			
		1.1	12.3	30.4							
#8		1	16	75		100	33	35			
		0.4	4.0	28.5							
#16											
#30		1	3	30		100	13	13			
		0.4	0.8	11.4							
#50											
#100											
#200		0.5	2.5	7.9		90.0	3.8	4.1			
		0.2	0.6	3.0							
AC								4.7			

Dryer-Drum Adjustment Problem #3 Class Example										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size		CM11	CM16	FM20		MF01	New Bit			
Mix%								= 100%		
TPH								Production Rate 200 TPH		
Agg%								= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2		36	100	100		100		80		
3/8										
#4		3	49	80		100		47		
#8		1	16	75		100		35		
#16										
#30		1	3	30		100		13		
#50										
#100										
#200		0.5	2.5	7.9		90.0		4.1		
AC								4.7		

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Proportioning Solutions

Problem # **Homework solutions** **Page**

In-Class proportioning problem solutions

*** The solutions provided for the adjustment problems are shown only for the critical sieves. The test for this class and the real world requires calculations for the entire worksheet to be completed <u>including</u> non-critical sieves.**

NOTE: **<u>Adjustment problems</u> can have more than one solution due to rounding of the combined gradation results (in order to meet the target gradation values). Your solution(s) should be close, normally no more than 1 or 2 percent difference. When working on the adjustment problems, your answer(s) do not have to match these solutions exactly in order to be correct as long as your calculations have been performed correctly. Always check your answers, especially during the written test. The solutions provided here are not considered to be more accurate or more correct, they are just different solutions.**

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Chapter 4 Homework Answers

Dryer-Drum Set-up Homework Problem #1

Dryer-Drum Set-up Homework Problem #1										
Bin #		#1	#2	#3	#4	MF	New Bit			
Size		CM 11	CM 16	FM 20	FM 02	MF 01				
Mix %		**47.0**	**22.6**	**12.5**	**12.5**	**1.4**	**4.0**	= 100%	100.0	
#'s		**329.0**	**158.2**	**87.5**	**87.5**	**9.8**	**28.0**	Batch Size Tons		700
Agg %		**49.0**	**23.5**	**13.0**	**13.0**	**1.5**		= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"		100	100	100	100	100	100	100		
		49.0	23.5	13.0	13.0	1.5				
3/4"		85	100	100	100	100	93	94		
		41.7	23.5	13.0	13.0	1.5				
1/2"		44	100	100	100	100	**73**	**73**		
		21.6	23.5	13.0	13.0	1.5				
3/8"		19	97	100	100	100	60	60		
		9.3	22.8	13.0	13.0	1.5				
#4		10	34	100	100	100	**40**	**39**		
		4.9	8.0	13.0	13.0	1.5				
#8		7	9	75	92	100	**29**	**27**		
		3.4	2.1	9.8	12.0	1.5				
#16		4	6	42	65	100	19	18		
		2.0	1.4	5.5	8.5	1.5				
#30		3	5	29	40	100	**13**	**13**		
		1.5	1.2	3.8	5.2	1.5				
#50		2	4	16	14	100	7	7		
		1.0	0.9	2.1	1.8	1.5				
#100		2	3	8	3	97	5	5		
		1.0	0.7	1.0	0.4	1.5				
#200		1.8	1.9	5.8	1.7	90.0	**3.7**	**3.7**		
		0.9	0.4	0.8	0.2	1.4				
AC								4.0		

Recycle Dryer-Drum Plant Set-up Homework Problem #2

Dryer-Drum Recycle Set-up Homework Example #2										
Feeder		R2	#1	#2	#3	MF	New Bit			
Size		RAP	CM11	CM16	FM02	MF01				
Mix%		25.1	31.7	19.2	20.2	1.0	2.8	= 100%		
TPH		175.7	221.9	134.4	141.4	7.0	19.6	Prod Rate = 700 TPH		
Agg%		25.0	33.0	20.0	21.0	1.0		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	Max
1		100	100	100	100	100.0	100	100		
		25.0	33.0	20.0	21.0	1.0				
3/4		94	91	100	100	100	96	96		
		23.5	30.0	20.0	21.0	1.0				
1/2		85	40	100	100	100	77	75		
		21.3	13.2	20.0	21.0	1.0				
3/8		79	15	92	100	100	65	66		
		19.8	5.0	18.4	21.0	1.0				
#4		63	3	40	99	100	47	47		
		15.8	1.0	8.0	20.8	1.0				
#8		46	2	15	92	100	36	36		
		11.5	0.7	3.0	19.3	1.0				
#16		37	2	6	60	100	25	24		
		9.3	0.7	1.2	12.6	1.0				
#30		31	2	4	45	100	20	19		
		7.8	0.7	0.8	9.5	1.0				
#50		23	1	4	14	100	11	10		
		5.8	0.3	0.8	2.9	1.				
#100		13	1	4	3	98	6	6		
		3.3	0.3	0.8	0.6	1.0				
#200		7.6	1.0	4.0	2.2	88.0	4.4	4.3		
		1.9	0.3	0.8	0.5	0.9				
AC		4.5						4.0		

Batch Plant Set-up Homework Problem #3

Batch Plant Set-up Homework Probblem #3										
Bin #	Rap	Bin # 4	Bin # 3	Bin # 2	Bin # 1	MF	New Bit			
Size		+ 1/2	1/2-#4	4-#8	- #8	- #200				
Mix %			**42.7**	**20.8**	**29.5**	**1.7**	**5.3**	= 100%	100.0	
#'s			**3416**	**1664**	**2360**	**136**	**424**	lbs/Batch		8000
Agg %			**45.0**	**22.0**	**31.2**	**1.8**		= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			100	100	100	100	**100**	**100**		
			45.0	22.0	31.2	1.8				
3/8"			93	100	100	100	**97**	**97**		
			41.9	22.0	31.2	1.8				
#4			4	94	100	100	**56**	**55**		
			1.8	20.7	31.2	1.8				
#8			2	6	92	100	**33**	**33**		
			0.9	1.3	28.7	1.8				
#16			2	1	74	100	**26**	**27**		
			0.9	0.2	23.1	1.8				
#30			1	1	45	100	**17**	**17**		
			0.5	0.2	14.0	1.8				
#50			1	1	23	100	**10**	**10**		
			0.5	0.2	7.2	1.8				
#100			1	1	14	99	**7**	**7**		
			0.5	0.2	4.4	1.8				
#200			0.5	0.4	5.9	88.0	**3.7**	**3.7**		
			0.2	0.1	1.8	1.6				
AC								**5.3**		

Dryer-Drum Adjustment Homework Problem #4

Drier-Drum Adjustment Homework Problem #4									
Feeder		#1	#2	#3	MF	**New Bit**			
Agg		**CM 11**	**CM 16**	**FM 20**	**MF 01**				
Mix%		**38.2**	**24.9**	**32.5**	**0.0**	**4.4**	= 100%		
TPH		**114.6**	**74.7**	**97.5**	**0.0**	**13.2**	**Prod Rate - TPH =** **300**		
Agg%		**40.0**	**26.0**	**34.0**	**0.0**		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1		100	100	100	100	**100**	**100**		
		40.0	26.0	34.0	0.0				
3/4		91	100	100	100	**96**	**96**		
		36.4	26.0	34.0	0.0				
1/2		**34**	**100**	**100**	**100**	**74**	**74**		
		13.6	**26.0**	**34.0**	**0.0**				
3/8		14	97	100	100	**65**	**64**		
		5.6	25.2	34.0	0.0				
#4		**3**	**32**	**99**	**100**	**43**	**43**		
		1.2	**8.3**	**33.7**	**0.0**				
#8		**2**	**9**	**96**	**100**	**36**	**36**		
		0.8	**2.3**	**32.6**	**0.0**				
#16		1	8	56	100	**22**	**23**		
		0.4	2.1	19.0	0.0				
#30		**1**	**8**	**42**	**100**	**17**	**17**		
		0.4	**2.1**	**14.3**	**0.0**				
#50		1	7	16	100	**8**	**10**		
		0.4	1.8	5.4	0.0				
#100		1	6	6	100	**4**	**5**		
		0.4	1.6	2.0	0.0				
#200		**1.0**	**5.5**	**3.8**	**85.0**	**3.1**	**3.1**		
		0.4	**1.4**	**1.3**	**0.0**				
AB							**4.4**		

Class Problem Solutions

Dryer-drum Set-up #1

Dryer-Drum Set-up Class Example #1										
Feeder	RAP	#1	#2	#3	#4	------	New Bit			
Size			**CM16**		**FM02**	**MF01**				
Mix%			**63.5**		**29.4**	**1.9**	**5.2**	**= 100%**		
TPH			**317.5**		**147.0**	**9.5**	**26.0**	**Prod Rate TPH = 500**		
Agg%			**67.0**		**31.0**	**2.0**		**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Control Limits Max
1										
3/4										
1/2			**100** / **67.0**		**100** / **31.0**	**100** / **2.0**	**100**	**100**		
3/8			**96** / **64.3**		**100** / **31.0**	**100** / **2.0**	**97**	**98**		
#4			**39** / **26.1**		**100** / **31.0**	**100** / **2.0**	**59**	**59**		
#8			**9** / **6.0**		**86** / **26.7**	**100** / **2.0**	**35**	**34**		
#16			**7** / **4.7**		**59** / **18.3**	**100** / **2.0**	**25**	**24**		
#30			**5** / **3.4**		**35** / **10.9**	**100** / **2.0**	**16**	**16**		
#50			**5** / **3.4**		**14** / **4.3**	**100** / **2.0**	**10**	**9**		
#100			**5** / **3.4**		**9** / **2.8**	**97** / **1.9**	**8**	**7**		
#200			**4.2** / **2.8**		**2.1** / **0.7**	**91.0** / **1.8**	**5.3**	**5.2**		
AC								**5.2**		

Dryer-drum Set-up #2

Drier-Dryer-Drum Set-up Class Example #2										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size			**CM16**	**FM20**		**MF01**	**New Bit**			
Mix%			**62.2**	**29.6**		**2.1**	**6.1**	**= 100%**		
TPH			**311.0**	**148.0**		**10.5**	**30.5**	**Prod Rate TPH = 500**		
Agg%			**66.3**	**31.5**		**2.2**		**= 100%**		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Max
1										
3/4										
1/2			**100**	**100**		**100**	**100**	**100**		
			66.3	**31.5**		**2.2**				
3/8			**95**	**100**		**100**	**97**	**97**		
			63.0	**31.5**		**2.2**				
#4			**37**	**99**		**100**	**58**	**57**		
			24.5	**31.2**		**2.2**				
#8			**8**	**78**		**100**	**32**	**33**		
			5.3	**24.6**		**2.2**				
#16			**6**	**54**		**100**	**23**	**23**		
			4.0	**17.0**		**2.2**				
#30			**5**	**32**		**100**	**16**	**16**		
			3.3	**10.1**		**2.2**				
#50			**4**	**16**		**100**	**10**	**10**		
			2.7	**5.0**		**2.2**				
#100			**3**	**11**		**98**	**8**	**8**		
			2.0	**3.5**		**2.2**				
#200			**2.2**	**7.1**		**94.0**	**5.8**	**5.7**		
			1.5	**2.2**		**2.1**				
AC								**6.1**		

Recycle Dryer-Drum Set-up using RAP Problem #1

Recycle Dryer-Drum Set-up using RAP - Problem #1										
Feeder	RAP	#1	#2	#3	#4	------	-----			
Size	RAP	CM11	CM16	FM20	FM02	MF01	New Bit			
Mix%	24.7		50.0	19.6		1.1	4.6	= 100%		
TPH	74.1		150.0	58.8		3.3	13.8	Prod Rate <u>300 TPH</u>		
Agg%	25.0		53.0	20.8		1.2	[redacted]	= 100%		
Sieve Size	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	% Pass / % Bin	Comb Grad	Target	Control Limits Min	Max
1										
3/4										
1/2	100		100	100		100	100	100		
	25.0		53.0	20.8		1.2				
3/8	96		95	100		100	96	96		
	24.0		50.4	20.8		1.2				
#4	70		37	100		100	59	60		
	17.5		19.6	20.8		1.2				
#8	46		17	91		100	41	40		
	11.5		9.0	18.9		1.2				
#16	33		6	64		100	26	24		
	8.3		3.2	13.3		1.2				
#30	20		5	43		100	18	17		
	5.0		2.7	8.9		1.2				
#50	15		3	21		100	11	11		
	3.8		1.6	4.4		1.2				
#100	10		2	5		100	6	7		
	2.5		1.1	1.0		1.2				
#200	7.9		1.7	4.0		90.0	4.8	4.8		
	2.0		0.9	0.8		1.1				
AC	4.5							5.7		

Recycle Dryer-Drum Set-up using Rap & RAS Problem #2

Recycle Dryer-Drum Set-up Problem #2										
Feeder	R1	R2	#1	#2	#3	MF	New			
Size	RAS	RAP		CM16	FM20		Bit			
Mix%	3.9	14.9		53.0	24.6		3.6	= 100%		
TPH	19.5	74.5		265.0	123.0		18.0	Prod Rate = 500 TPH		
Agg%	3.0	15.0		56.0	26.0			= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass		% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin		% Bin	Grad	Target	Min	Max
1										
3/4										
1/2	100	100		100	100		100	100		
	3.0	15.0		56.0	26.0					
3/8	100	93		97	100		97	98		
	3.0	14.0		54.3	26.0					
#4	100	67		38	100		60	59		
	3.0	10.1		21.3	26.0					
#8	94	46		9	80		36	36		
	2.8	6.9		5.0	20.8					
#16	75	34		5	60		26	25		
	2.3	5.1		2.8	15.6					
#30	48	27		4	38		18	17		
	1.4	4.1		2.2	9.9					
#50	40	18		4	15		10	10		
	1.2	2.7		2.2	3.9					
#100	34	12		3	4		6	6		
	1.0	1.8		1.7	1.0					
#200	27.4	9.4		3.0	3.9		4.9	5.0		
	0.8	1.4		1.7	1.0					
AC	27.0	4.5						5.4		

Batch Plant Set-up #1

Batch Plant Set-up Example #1								**Surface Mixture**		
Bin #		Bin #4	Bin #3	Bin #2	Bin #1	MF	**New Bit**			
Size		**+ 1/2**	**- 1/2 + #4**	**- #4 + #8**	**- #8**	**- #200**				
Mix%			**40.5**	**22.5**	**30.0**	**0.9**	**6.1**	**= 100%**		
#'s			**810**	**450**	**600**	**18**	**122**	**Batch Size = 2000**		
Agg%			**43.0**	**24.0**	**32.0**	**1.0**		**= 100%**		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2			**100**	**100**	**100**	**100**	**100**	**100**		
			43.0	**24.0**	**32.0**	**1.0**				
3/8			**96**	**100**	**100**	**100**	**98**	**99**		
			41.3	**24.0**	**32.0**	**1.0**				
#4			**6**	**90**	**100**	**100**	**57**	**57**		
			2.6	**21.6**	**32.0**	**1.0**				
#8			**1**	**6**	**95**	**100**	**33**	**33**		
			0.4	**1.4**	**30.4**	**1.0**				
#16			**1**	**1**	**70**	**100**	**24**	**23**		
			0.4	**0.2**	**22.4**	**1.0**				
#30			**1**	**1**	**54**	**100**	**19**	**19**		
			0.4	**0.2**	**17.3**	**1.0**				
#50			**1**	**1**	**30**	**100**	**11**	**10**		
			0.4	**0.2**	**9.6**	**1.0**				
#100			**1**	**1**	**18**	**99**	**7**	**7**		
			0.4	**0.2**	**5.8**	**1.0**				
#200			**1.0**	**1.0**	**10.0**	**88.8**	**4.7**	**4.7**		
			0.4	**0.2**	**3.2**	**0.9**				
AC								**6.1**		

Batch Plant Set-up #2

Batch Plant Set-up Example 2						Binder Mixture			
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ ½	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%	**27.3**	**29.2**	**12.2**	**24.3**	**1.1**	**5.9**	**= 100%**		
#s	**2730**	**2920**	**1220**	**2430**	**110**	**590**	**Batch Size - Lbs. = 10,000**		
Agg%	**29.0**	**31.0**	**13.0**	**25.8**	**1.2**		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1	100	100	100	100	100	100	100		
	29.0	31.0	13.0	25.8	1.2				
3/4	90	100	100	100	100	97	95		
	26.1	31.0	13.0	25.8	1.2				
1/2	20	80	100	100	100	71	71		
	5.8	24.8	13.0	25.8	1.2				
3/8	18	39	95	100	100	57	59		
	5.2	12.1	12.4	25.8	1.2				
#4	1	5	82	100	100	40	40		
	0.3	1.6	10.7	25.8	1.2				
#8	1	1	11	93	100	27	27		
	0.3	0.3	1.4	24.0	1.2				
#16	1	1	1	50	100	15	16		
	0.3	0.3	0.1	12.9	1.2				
#30	1	1	1	35	100	11	11		
	0.3	0.3	0.1	9.0	1.2				
#50	1	1	1	17	100	6	7		
	0.3	0.3	0.1	4.4	1.2				
#100	1	1	1	11	99	5	5		
	0.3	0.3	0.1	2.8	1.2				
#200	0.3	0.3	0.2	6.9	87.7	3.1	3.1		
	0.1	0.1	0.0	1.8	1.1				
AC							5.9		

Adjustment #1 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Agg%		46.4	17.5		33.7	2.4		= 100.0%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1										
3/4										
1/2		41	100		100	100	72.6	73		
		19.0	17.5		33.7	2.4				
3/8										
#4		3	32		99	100	42.8	43		
		1.4	5.6		33.4	2.4				
#8		2	8		92	100	35.7	36		
		0.9	1.4		31.0	2.4				
#16										
#30		2	3		57	100	23.0	23		
		0.9	0.5		19.2	2.4				
#50										
#100										
#200		1.5	2.4		0.5	90.0	3.5	3.5		
		0.7	0.4		0.2	2.2				
AC								4.0		

Adjustment #2 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Agg%		45.7	18.8		33.1	2.4		= 100%		
Sieve Size	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	% Pass % Bin	Comb Grad	Target	Control Limits Min	 Max
1										
3/4										
1/2		40	100		100	100	73	73		
		18.3	18.8		33.1	2.4				
3/8										
#4		3	32		99	100	43	43		
		1.4	6.0		32.8	2.4				
#8		3	7		92	100	36	36		
		1.4	1.3		30.5	2.4				
#16										
#30		2	3		58	100	23	23		
		0.9	0.6		19.2	2.4				
#50										
#100										
#200		1.5	2.2		0.5	90.0	3.5	3.5		
		0.7	0.4		0.2	2.2				
AC								4.0		

Adjustment #3 - Dryer-drum Plant

<u>Critical Sieves only</u>!

Dryer-drum Adjustment Class Problem #3										
Bin #			#1	#2	#3	MF	New Bit			
Size			**CM11**	**CM16**	**FM20**	**MF 01**				
Mix %								= 100%		
#'s								Prod. Rate TPH		200
Agg %			**32.0**	**27.2**	**40.8**			= 100%	100.0%	
Sieve	%Pass	%Pass	%Pass	%Pass	%Pass	%Pass	Comb		Control Limits	
Size	%Bin	%Bin	%Bin	%Bin	%Bin	%Bin	Grad	Target	Min	Max
1"										
3/4"										
1/2"			**36**	**100**	**100**	**100**	**80**	**80**		
			11.5	**27.2**	**40.8**					
3/8"										
#4			**3**	**49**	**80**	**100**	**47**	**47**		
			1.0	**13.3**	**32.6**					
#8			**1**	**16**	**75**	**100**	**35**	**35**		
			0.3	**4.4**	**30.6**					
#16										
#30			**1**	**3**	**28**	**100**	**13**	**13**		
			0.3	**0.8**	**11.4**					
#50										
#100										
#200			**0.5**	**2.3**	**8.2**	**90.0**	**4.1**	**4.1**		
			0.2	**0.6**	**3.3**					
AC								**4.7**		

Adjustment #4 - Batch Plant

Batch Plant Adjustment Example Answer							Surface Mixture		
Bin #	Bin #4	Bin #3	Bin #2	Bin #1	MF	New			
Size	+ 1/2	-1/2 +#4	-4 +#8	- #8	- #200	Bit			
Mix%		**33.9**	**24.6**	**34.8**	**1.2**	**5.5**	= 100%		
#'s		**3390**	**2460**	**3480**	**120**	**550**	**Batch Size - Lbs. =** **10000**		
Agg%		**35.9**	**26.0**	**36.9**	**1.2**		= 100%		
Sieve	% Pass	% Pass	% Pass	% Pass	% Pass	Comb		Control Limits	
Size	% Bin	% Bin	% Bin	% Bin	% Bin	Grad	Target	Min	Max
1									
3/4									
1/2		100	100	100	100	**100**	**100**		
		35.9	26.0	36.9	1.2				
3/8		88	100	100	100	**96**	**96**		
		31.6	26.0	36.9	1.2				
#4		8	92	100	100	**65**	**65**		
		2.9	23.9	36.9	1.2				
#8		1	2	98	100	**38**	**38**		
		0.4	0.5	36.2	1.2				
#16		1	1	70	100	**28**	**27**		
		0.4	0.3	25.8	1.2				
#30		1	1	49	100	**20**	**20**		
		0.4	0.3	18.1	1.2				
#50		1	1	25	100	**11**	**10**		
		0.4	0.3	9.2	1.2				
#100		1	1	12	100	**6**	**7**		
		0.4	0.3	4.4	1.2				
#200		0.2	0.4	8.9	87.7	**4.6**	**4.6**		
		0.1	0.1	3.3	1.1				
AC							**5.5**		

HMA MIXTURE EVALUATION

Defining a "Good" HMA Mix

A "Good" HMA mix is defined as an economical blend of aggregates and asphalt binder which produce the following results:

Asphalt Binder

The HMA mix has sufficient asphalt binder to thoroughly coat all the aggregate particles and ensure a durable pavement.

Stability

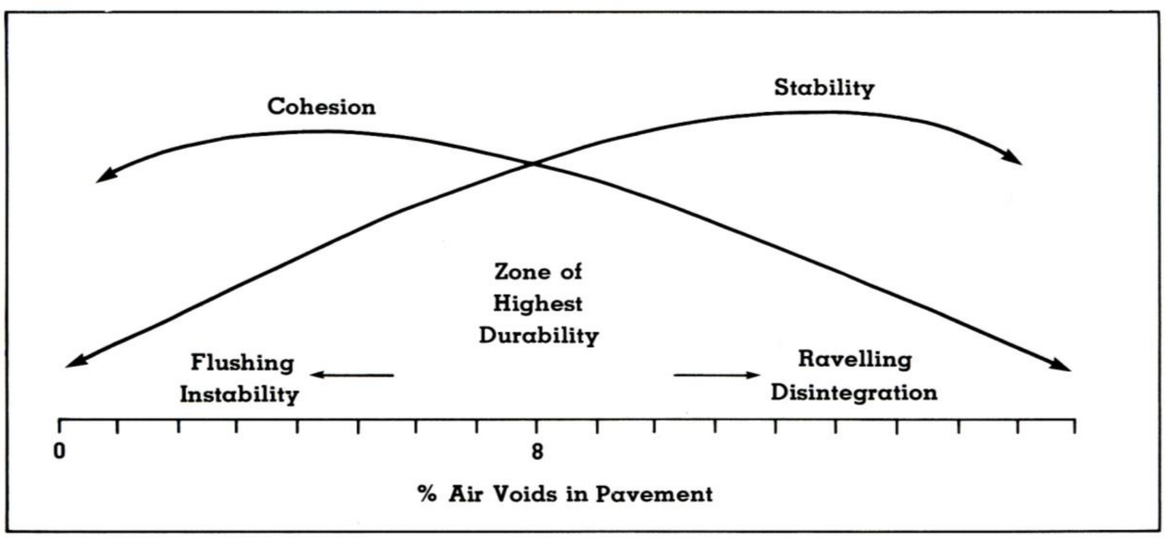
The HMA mix has sufficient stability to satisfy the demands of traffic without distortion or displacement (refers to rutting, shoving, etc.).

Voids

There has to be sufficient air voids in the compacted HMA mix to allow for a slight amount of additional compaction under traffic without flushing, bleeding or loss of stability, but low enough to keep out harmful effects like air and moisture, which cause premature aging and stripping.

a. Below 3% causes rutting. There is no place for the asphalt binder and aggregate to move except outward.

b. Above 7% - 8% the HMA mix is permeable. Water easily runs through the compacted HMA causing oxidation, cracking and raveling of the mixture.



Workability

The HMA mix needs sufficient workability to permit efficient placement of the HMA mix without segregation or other placement problems.

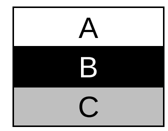
Level I Asphalt Calculation Review

Terms from Level I:

A. Gmb ("d") Bulk Specific Gravity of the mixture — Volume = 0.3 m³ (1 ft.³)

Gmb ("d") Involves A, B, & C

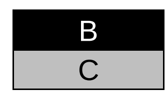
Where: A = Volume of Air
B = Volume of Asphalt Binder
C = Volume of Aggregate



B. Gmm ("D") Maximum Theoretical Gravity — Volume = 0.3m³ (1 ft.³)

Gmm ("D") Involves only B & C

Where: B = Volume of Asphalt Binder
C = Volume of Aggregate



The volume of air (A) is removed

Conversion factors: **EXAMPLE**:

Metric - Convert G_{mm} ("D") or G_{mb} ("d") to a metric unit weight (kg/m³) by multiplying by 1000.0 — 2.541 x 1000 = 2541 kg/m^3

English - Convert G_{mm} ("D") or G_{mb} ("d") to an English unit weight (lbs./ft³) by multiplying by 62.4 — 2.541 x 62.4 = 158.6 lb/ft^3

Review of Calculations: **EXAMPLE**:

% Density = (G_{mb}/G_{mm}) x 100 or ("d" / "D") x 100 — (2.434 ÷ 2.572) x 100 = 94.6%

A. % Density is the measurement of compactive effort by:

1) Lab – Using gyratory samples at N_{des} (30 – 90 gyrations which correlates to expected traffic levels for 20 years)
2) Field - Developed by a rolling pattern measured by:
   (a) Cores
   (b) Adjusted nuclear density gauge

EXAMPLE:

% Voids = (1 – (G_{mb}/G_{mm})) x 100 — (1 – (2.434 ÷ 2.572)) x 100 = 5.4%
or (1 – ("d"/"D")) x 100

or

(100% - % Density) — 100.0% – 94.6% = 5.4%

B. Voids is the measurement of the volume of air in:

1) Compacted briquette (In lab by gyratory method)
2) Cores (In-Place mat density)

NOTE: "% Density" will refer to the In-Place Roadway Density; "% Voids" will refer to lab voids.

Standardized Nomenclature for Asphalt Mixture Parameters

Illinois Department of Transportation has adopted standardized nomenclature for asphalt mixture related parameters in reference to the terms used to describe different Superpave mixture attributes. The following terms will assist the technician when referring to documents that have been revised to reflect this new format:

G	=	Bulk specific gravity of an aggregate
G_b	=	Specific gravity of asphalt binder
G_{sb}	=	Bulk specific gravity of combined aggregates
G_{se}	=	Effective specific gravity of an aggregate
G_{sa}	=	Apparent specific gravity of combined aggregate
G_{mb}	=	(“d”) Bulk specific gravity of compacted mixture
G_{mm}	=	(“D”) Maximum theoretical specific gravity of mixture
P	=	Percentage by weight of aggregates
P_b	=	Asphalt, percent by total weight of mixture
P_s	=	Aggregate, percent by total weight of mixture
P_{mm}	=	Loose mix, percent by total weight of mixture (=100%)
P_{be}	=	Effective asphalt binder, percent by total weight of mix
P_a	=	Air voids in compacted mix, percent of total volume
P_{ba}	=	Absorbed asphalt binder, percent by total weight of aggregates

NOTE: The first letter denotes the following:

G = gravity P = percent

The first letter of the subscript denotes the following:

m = mix s = stone (aggregate) b = binder (asphalt) a = air voids

The second letter of the subscript denotes the following:

b = bulk m = maximum a = apparent e = effective

The following is common terms, conversions and sieve designations:

Common English and Metric Terms

Type	English	Metric (SI)
Length	Inches, feet yards	millimeters, meter, kilometer
Area	Inches^2 , feet^2 , yards^2	millimeters^2 , meter^2 , kilometer^2
Volume	Ounces, quarts, gallons	Liters, meters^3
Mass	Ounces, pounds, tons	Grams, kilograms, metric tons
Energy	Foot pounds	Joules (J)
Force	pounds, kips	Newtons (N), kilo Newtons (kN)
Pressure, stress	pounds per inch^2 , #/ft^2	Pascal (Pa), kilo Pascal (kPa)
Speed, velocity	Feet/second, miles/hour	meter/second, kilometers/hour
Acceleration	(Feet/second)^2 , (miles/hour)^2	(meter/second)^2 , (kilometers/hour)^2
Density	Pounds per ft^3	kg/meter^3
Temperature	Fahrenheit	Celsius

English Sieve Designations with Metric Equivalent

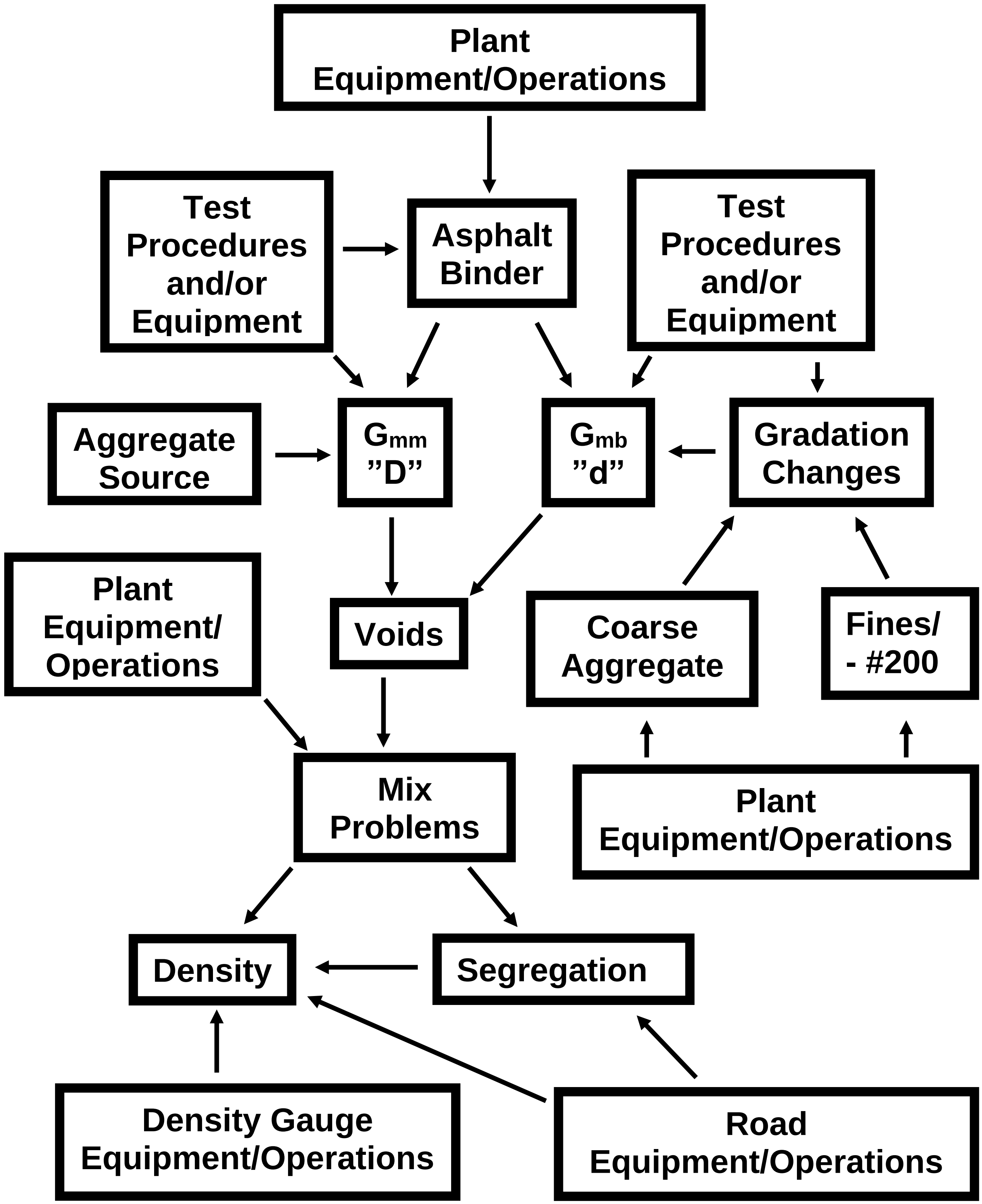
English	Metric	English	Metric
2 in.	50 mm	**No. 8**	**2.36 mm**
1 3/4 in.	45 mm	No. 10	2.00 mm
1 1/2 in.	**37.5 mm**	No. 12	1.70 mm
1 1/4 in.	31.5 mm	No. 14	1.40 mm
1.06 in.	26.5 mm	**No. 16**	**1.18 mm**
1 in.	**25.0 mm**	No. 18	1.00 mm
7/8 in.	22.4 mm	No. 20	850 µm
3/4 in.	**19.0 mm**	No. 25	710 µm
5/8 in.	**16.0 mm**	**No. 30**	**600 µm**
0.530 in.	13.2 mm	No. 35	500 µm
1/2 in.	**12.5 mm**	No. 40	425 µm
7/16 in.	11.2 mm	No. 45	355 µm
3/8 in.	**9.5 mm**	**No. 50**	**300 µm**
5/16 in.	8.0 mm	No. 60	250 µm
0.265 in.	6.7 mm	No. 70	212 µm
1/4 in.	**6.3 mm**	No. 80	180 µm
No. 3 1/2	5.6 mm	**No. 100**	**150 µm**
No. 4	**4.75 mm**	No. 120	125 µm
No. 5	4.00 mm	No. 140	106 µm
No. 6	3.35 mm	No. 170	90 µm
No. 7	2.80 mm	**No. 200**	**75 µm**

NOTE: Sieve designations in **underlined bold type** are commonly used for testing of HMA mixtures.

Common English to Metric Conversions

Type	From English	To Metric	Multiply by
Lengths	Inch	millimeter (mm)	25.4
	Feet	millimeter (mm)	304.8
	Feet	meter (m)	0.3048
	Yard	meter (m)	0.9144
	Mile	kilometer km	1.609344
	Mile	meter (m)	1609.344
	Inches/mile	mm/km	15.7828
Areas	$Inch^2$	mm^2	645.16
	$Feet^2$	m^2	0.092903
	$Yard^2$	m^2	0.836127
	Acre	m^2	4046.856
	Acre	hector acre (ha)	0.404685
	$Mile^2$	km^2	2.59
Volume	$Inch^3$	mm^3	16387.06
	$Feet^3$	m^3	0.028316
	$Yard^3$	m^3	0.764555
	Gallon	Liter (L)	3.78541
	Gallon/Yard	L/m	4.1398
	$Gallon/Yard^2$	L/m^2	4.5273
	$Gallon/Yard^3$	L/m^3	4.9511
	Gallon/Acre	L/ha	9.354
	Gallon/Ton	L/metric ton	4.1726
Mass	Ounces	gram (g)	28.349523
	Pound	kilogram (kg)	0.453592
	kip (1000 lbs.)	metric ton	0.453592
	Ton	metric ton	0.9072
Force	Pound	Newton (N)	4.44822
	kip	kilo Newton (kN)	4.44822
Force/Unit Length	Pound/Foot	N/m	14.5939
	Pound/Inch	N/mm	0.1751
Pressure, Stress	$Pound/Feet^2$	Pascals (Pa)	47.8803
	$kips/Feet^2$	kPa	47.8803
	$Pound/Inch^2$	kPa	6.89476
	$Pound/Inch^2$	Mega Pascals (MPa)	
	$kips/Inch^2$	MPa	
Energy	Foot Pound	Joules (J)	1.35582
Mass/Length	$Ounces/Yard^2$	kg/m^2	0.0339057
	$Pounds/Feet^2$	kg/m^2	4.8824
	$Pounds/Yard^2$	kg/m^2	0.5425
	$Pounds/Feet^3$	kg/m^3	16.01894
	$Pounds/Yard^3$	kg/m^3	0.5933
	Pounds/Acre	kg/ha	1.1208
	Ton/Acre	metric ton/ha	2.2417
Temperature	Fahrenheit (F)	Celsius (C)	(F- 32)/1.8 = C

Troubleshooting Flow Chart



Proportionality Rules

General

α **Proportional** - Each variable reacts in the same direction. One increases the other increases, etc.

$1/\alpha$ **Inversely Proportional** - Each variable reacts in the opposite direction. One increases the other decreases, etc.

Proportionality Rules of H.M.A.

a) Voids $1/\alpha$ Density

b) Voids α G_{mm} ("D")

c) Voids $1/\alpha$ G_{mb} ("d")

d) Voids $1/\alpha$ Asphalt Binder Content

e) Voids $1/\alpha$ Minus #200 material

f) Voids α Coarseness of mix (except sand mix)

g) Voids $1/\alpha$ Temperature

h) Voids α Manufactured sand / Natural sand blend

Additional Rules

a) 1% change in minus #200 material generally creates about 1% change in voids.

b) Too much or not enough minus #200 material can create a tender mix.

c) A sandy mix [very fine on the # 4 or # 8 sieves] can create a tender mix.

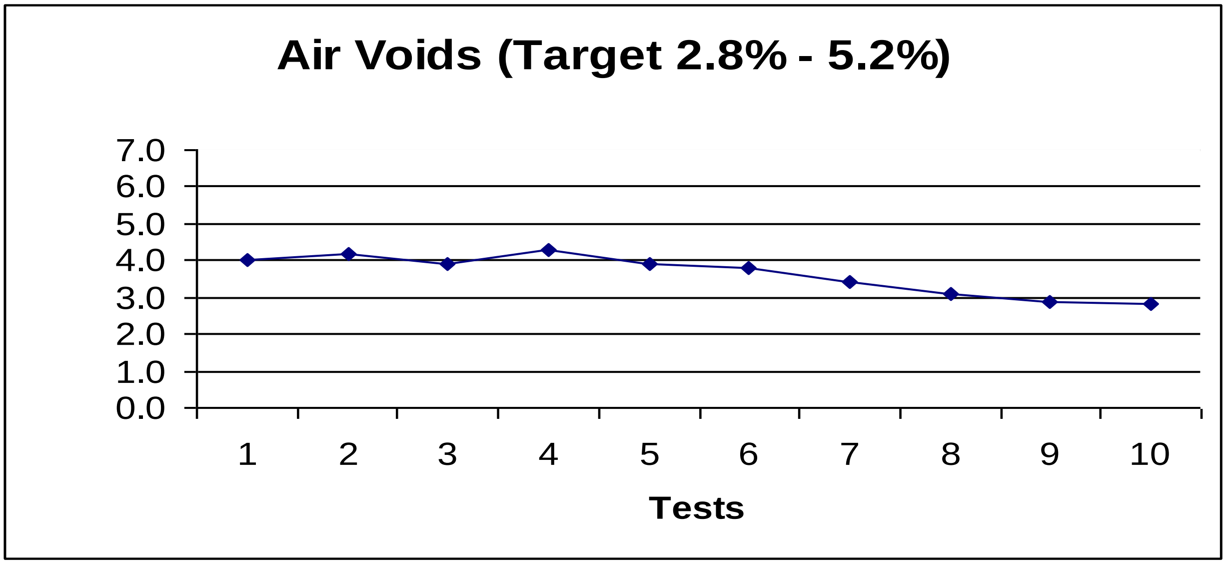
d) The manufactured sand / natural sand blend controls the #30 sieve. If the #30 material is too high this can create a tender mix.

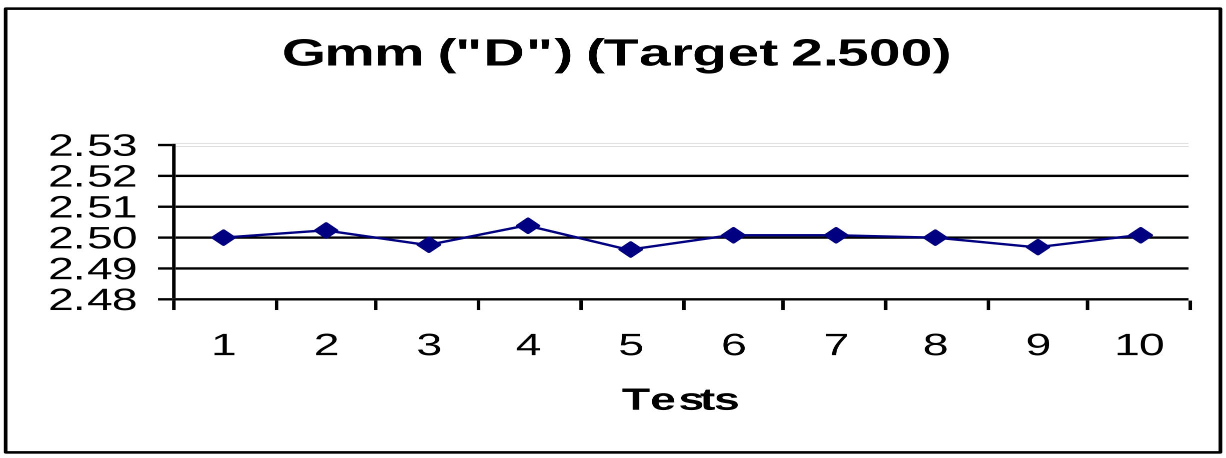
e) Segregation of a sample (coarse or fine) can correlate to the asphalt binder content, air voids or density being low or high for an individual sample.

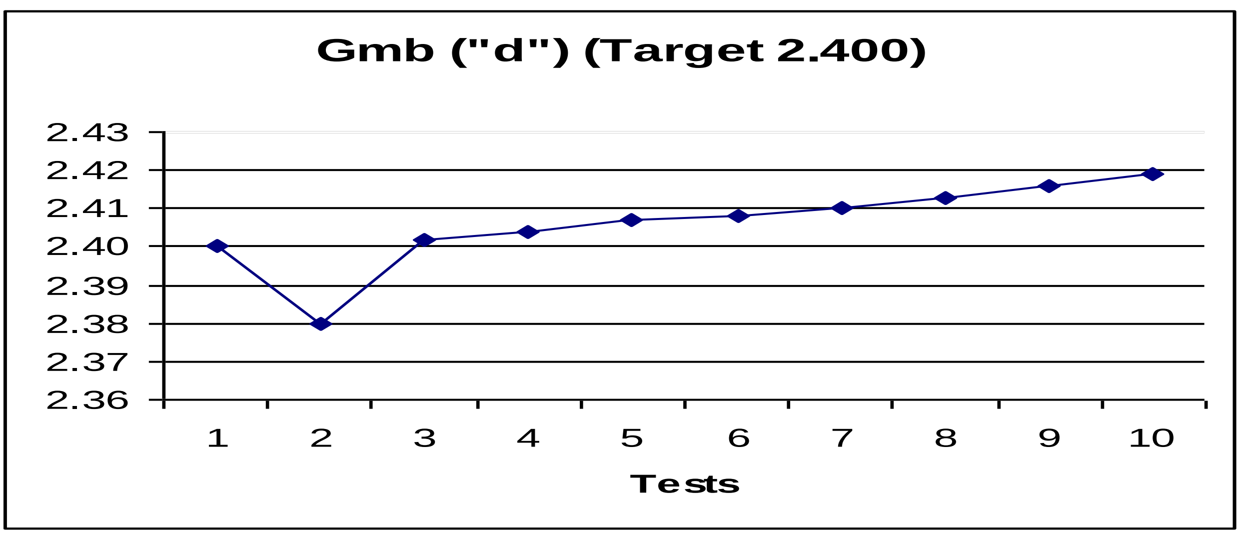
f) HMA mixture compaction temperature for the breakdown and pneumatic (rubber tired) rollers should be 285°F ± 15° F. The mat temperature for a finish roller should be about 120° F or cool enough to place your hand on the mat and leave it.

Problem #1Control Charts

Is there a problem according to these control charts?







MOVING AVERAGE TREND PROBLEMS

Problem 1

A) Is there a problem according to the 3 charts shown? (Page 6-8)

B) Are we required to take corrective action?

C) What or where is the Problem?

D) What influences G_{mb} ("d")?

Problem 1 Investigation

Define the problem:

a) Test Procedure/Equipment?

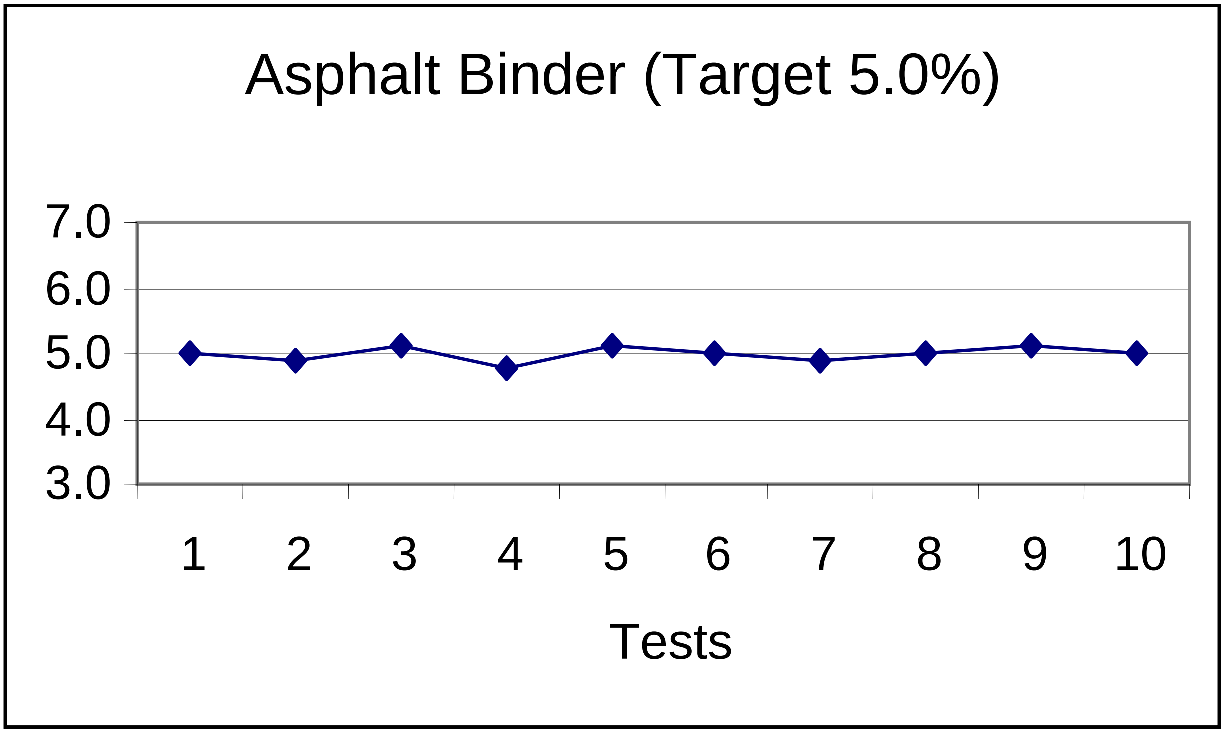
b) Asphalt Binder Content?

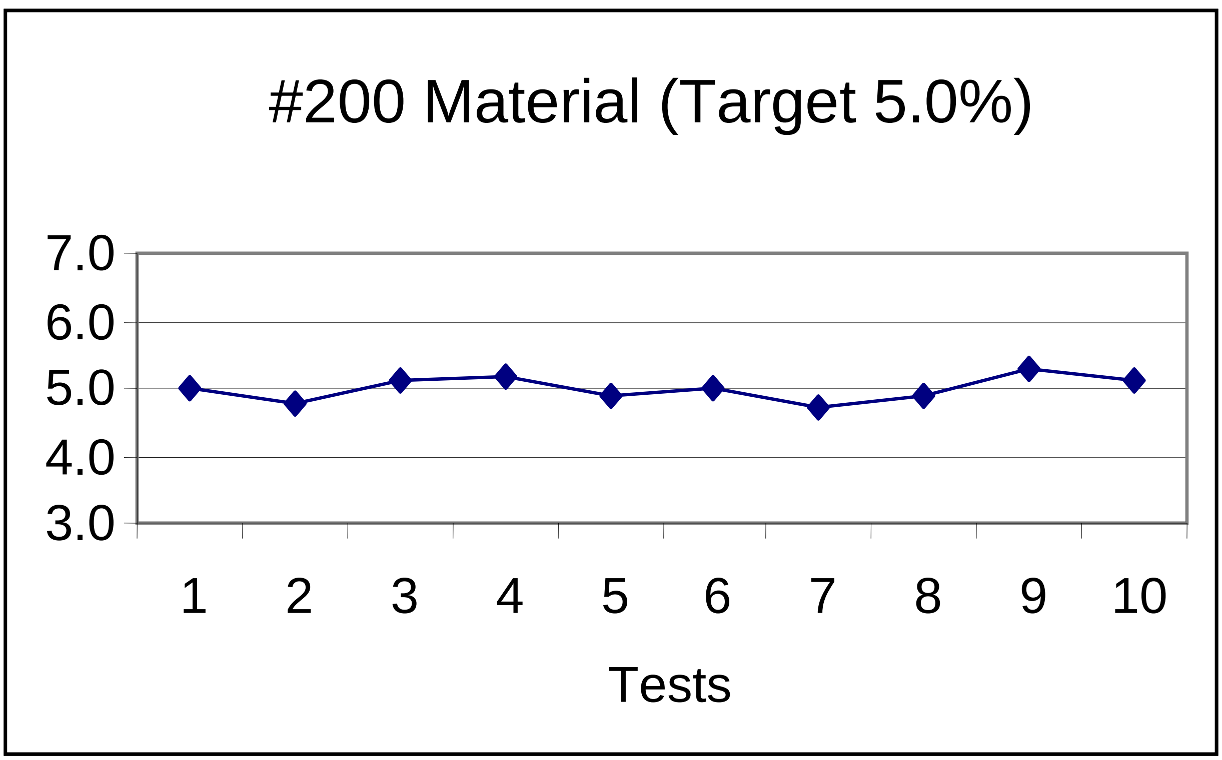
c) Minus #200 Content?

d) Aggregate Gradation? (coarse or fine)

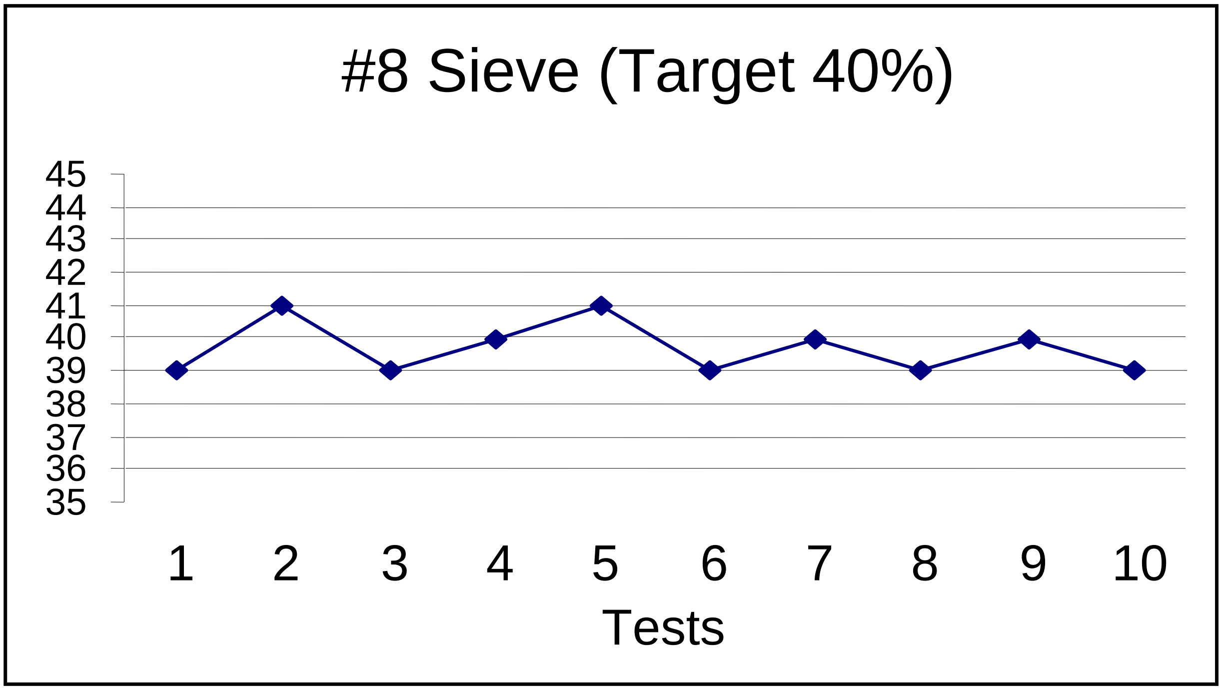
Based on what information given, is there enough information to make a decision?

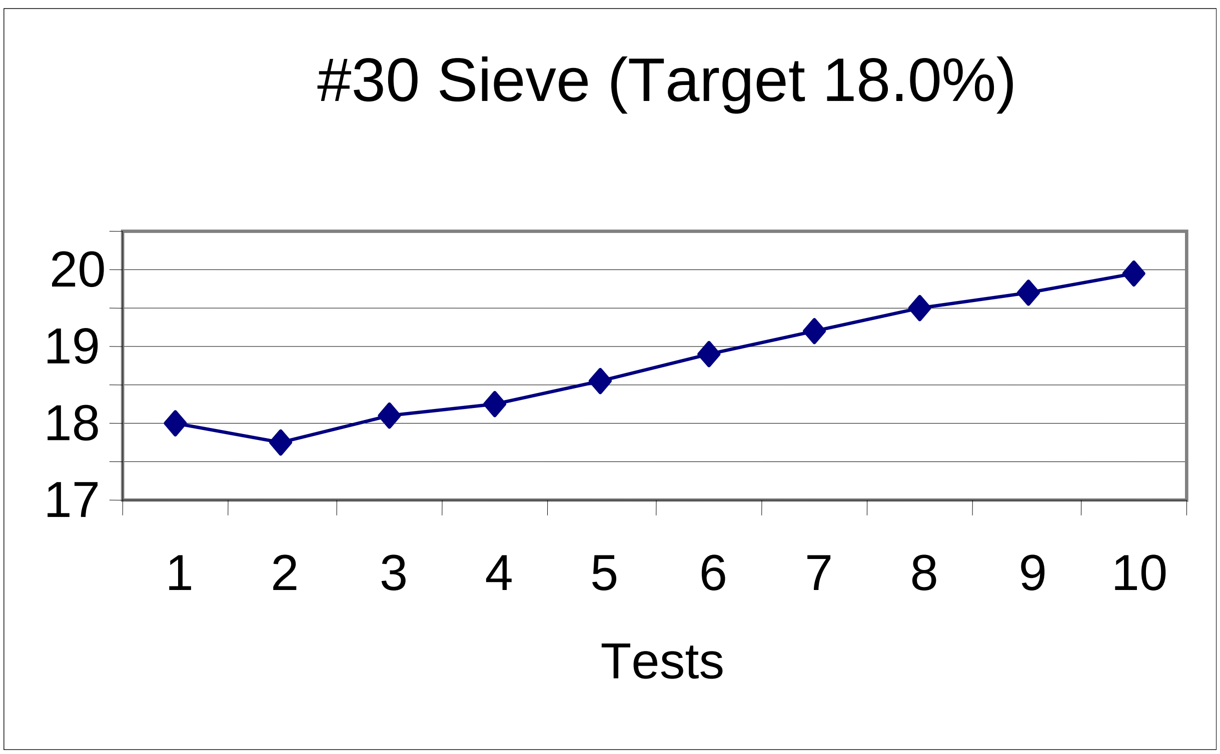
Problem #1 Control Charts





Problem #1 Control Charts





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Problem 1- Solution

Eleven different control charts need to be created based on the test results to the mixture.

By analyzing all of the test results, certain mixture controls can be eliminated, such as the asphalt binder and #200 dust content, in this case.

Since the evidence points to a mixture problem, and because there are a number of different test procedures and testing equipment being used, this will help to rule out individual test procedures and/or equipment. Test procedures normally can only be responsible for an immediate cause of a problem and will not carry to different areas (stockpiles, road, etc.) or influence other mixture aspects. Incorrect calculations could indicate problems throughout production but the influence would only be seen in the results not the actual mixture performance.

Examples:

a) A hole in a sieve will only affect the test results for that gradation and will/can have no effect on the air voids, asphalt binder content, density, etc. of the actual mixture. Only if there is an actual material problem can it effect other mixture attributes (too much actual #200 material in the mixture will affect the air voids, asphalt binder content, density, etc.).

b) If the G_{mb} or G_{mm} test was performed incorrectly or the test equipment was used incorrectly or malfunctioned during the test, the results would show the air voids to be affected but the actual mixture would/could still be good. The density test on the road would/could corroborate that the air voids were actually good (as long as that test was performed correctly).

   In other words, if two or more different test results show problems with the mixture, this should indicate something **is wrong with the mixture**, not the testing equipment or test procedures.

   In order for the test procedures and/or test equipment to be faulty for numerous mixture aspects, **at the same time**, everything would have to match up and happen at the same exact time; gradation (plant), air voids (plant) and density (road).

So proper investigation should include analyzing all of the control charts and information for the mixture, which in this case, will show that the #4 material is at fault and needs to be checked out further.

Where does the #30 material come from?

The # 30 size of material generally comes from the FM20 and FM01 aggregate materials.

This is where we should start our investigation.

Prior to a proportioning change we should check a number of items to determine the cause of the problem.

a) Drier Drum Plant - Is the cold feed belt for the FM 20 sand slipping, blocked, or plugged? Is the material being fed correctly as determined by a weigh belt sample or cold feed calibration? Is the sand being introduced at the proper feed rate? Properly proportioned material at the cold feeds is necessary to meet the mixture gradation.

b) Batch or Continuous Plant - Is carry-over being experienced in Bins #1 and/or #2. This can be due to a blinded sand screen or feeding the plant at too high of a production rate? Does the plant need to be slowed down or the screens cleaned or replaced? Is material leaking between bins (plugged waste chute, hole in the bin partition walls, etc.)? Are the proper individual aggregate weights being met during the batching process?

c) Has the stockpile gradations changed (weekly stockpile or incoming gradation samples)? Has the loader operator gotten into a fine area of the stockpiles (ramp areas, scrapping into the base material, etc.)? Is the loader operator feeding the right products into the plant or 'cleaning up' around the stockpile areas?

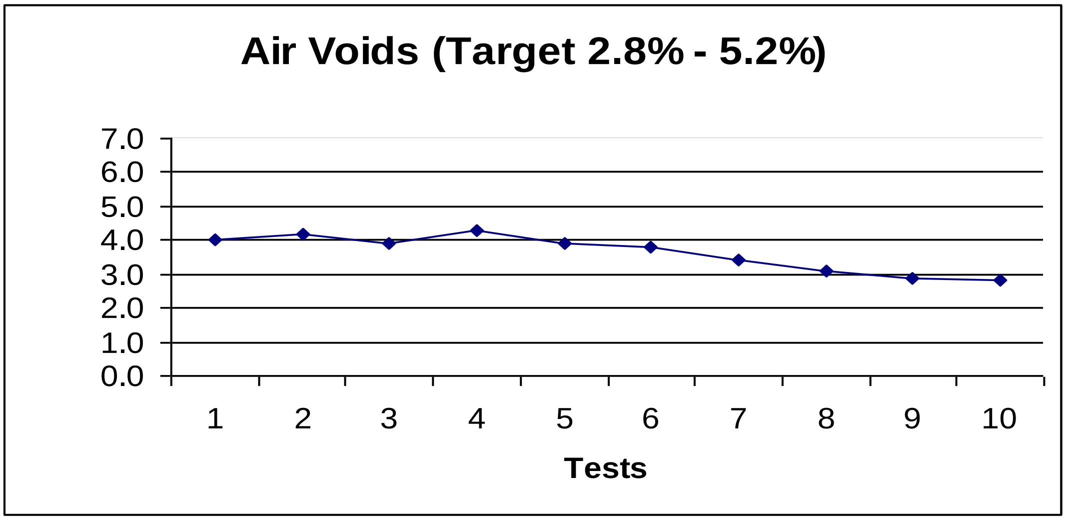
d) Are the plant scales in proper adjustment and working correctly?

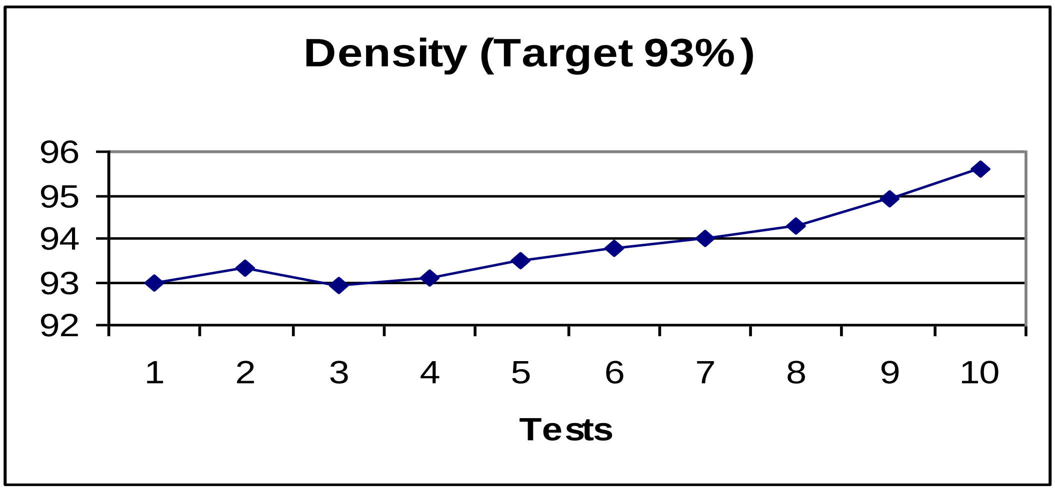
e) Are the cold feed gates set at the proper openings? Are the cold feeds motors set at the correct settings (based on the cold feed calibrations)? Are the cold feed calibrations still usable or has something changed (motor replacement, cold feed repair, etc.)? Do the cold feeds have the proper dividers preventing contamination?

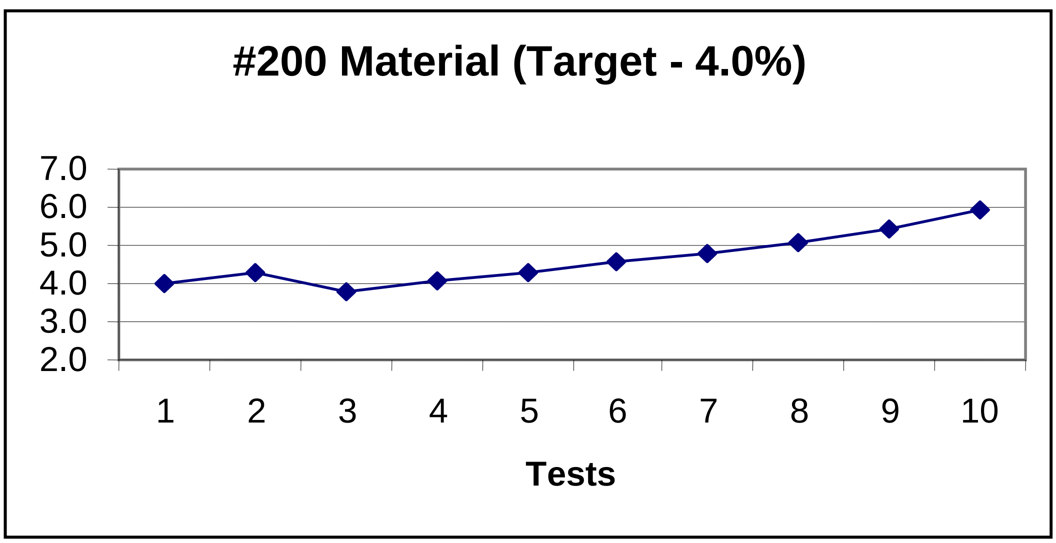
f) Are the plants settings for the mixture being produced correct and for the right mixture?

Problem #2 Control Charts

Is there a problem according to these control charts?







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Problem #2

A. Is there a problem according to the 3 charts shown? (Page 9-15)

B. Are we required to take corrective action?

C. What or where is the problem?

D. What influences minus # 200 material?

1) Test procedure/equipment/calculation?

2) Poor sampling technique?

3) Minus # 200 material change in any of the stockpiles?

4) Dust slide occurred in the #1 hot bin?

5) Cold feeders for the sands have changed?

a) Gate opening has been changed?

b) Belt speed/tachometer working improperly?

6) Mineral filler system not working properly?

7) Bag house (secondary collector system) not working properly?

Problem 2 – Solution

Where does the dust come from that is going into the mixture? There are normally three sources for dust at a HMA plant:

1) Mixture ingredients

2) Plant generated

3) Purchased material

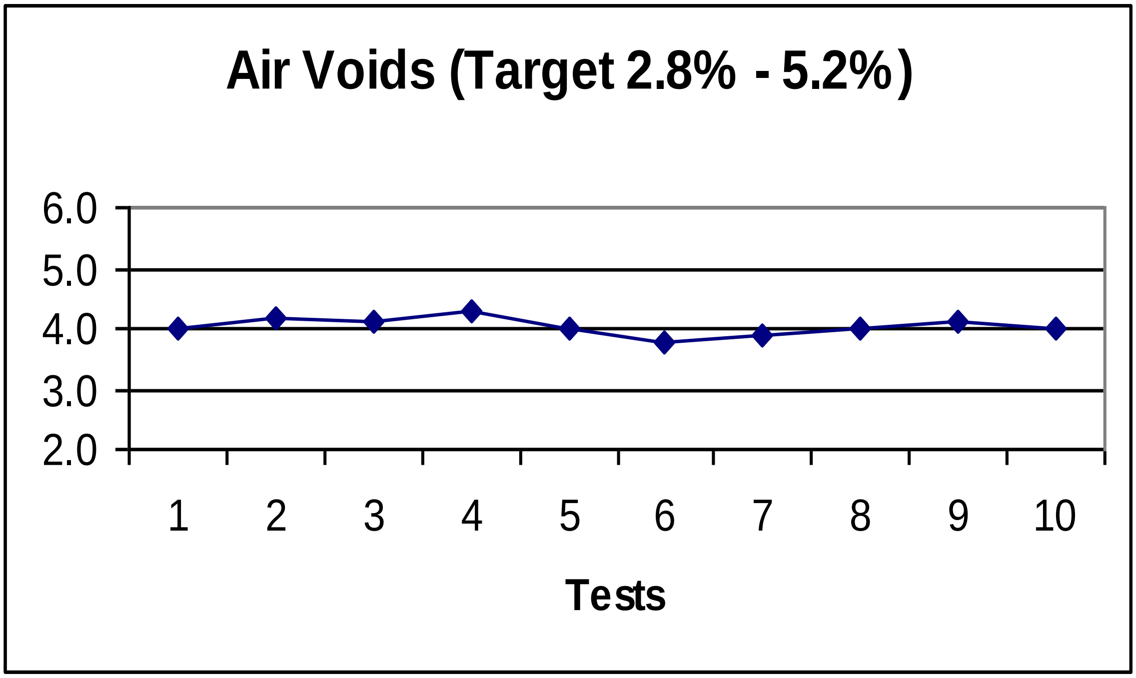
Checks should be done on the incoming material, existing stockpiles, cold feeds, mineral filler system, baghouse, as well as, the speed and efficiency of the plant.

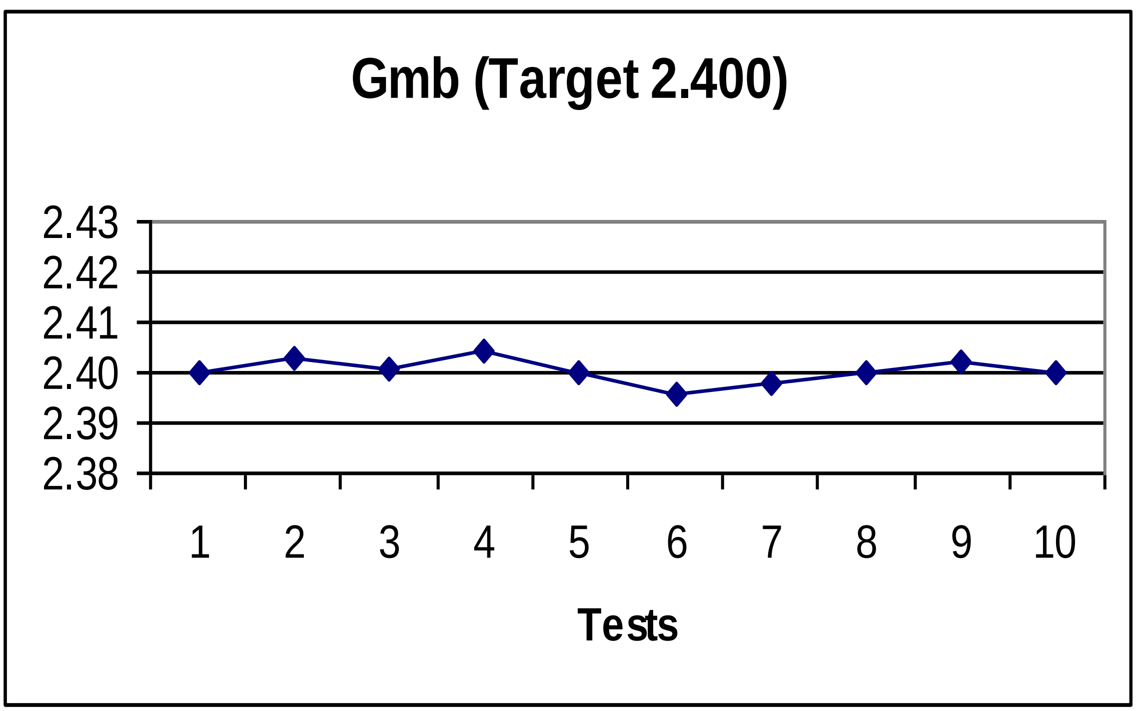
This particular mixture issue is probably not related to sampling and/or test procedures since the effects are showing up in the plant mixture test results and in the density tests from the road.

NOTE: Solutions based on the percentage of minus #200 material is to be determined by washed ignition burn gradation samples or washed hot bin gradation samples and/or combined belt gradation samples. Stockpile samples can be used to determine minus 200 material but isn't effective for plant control.

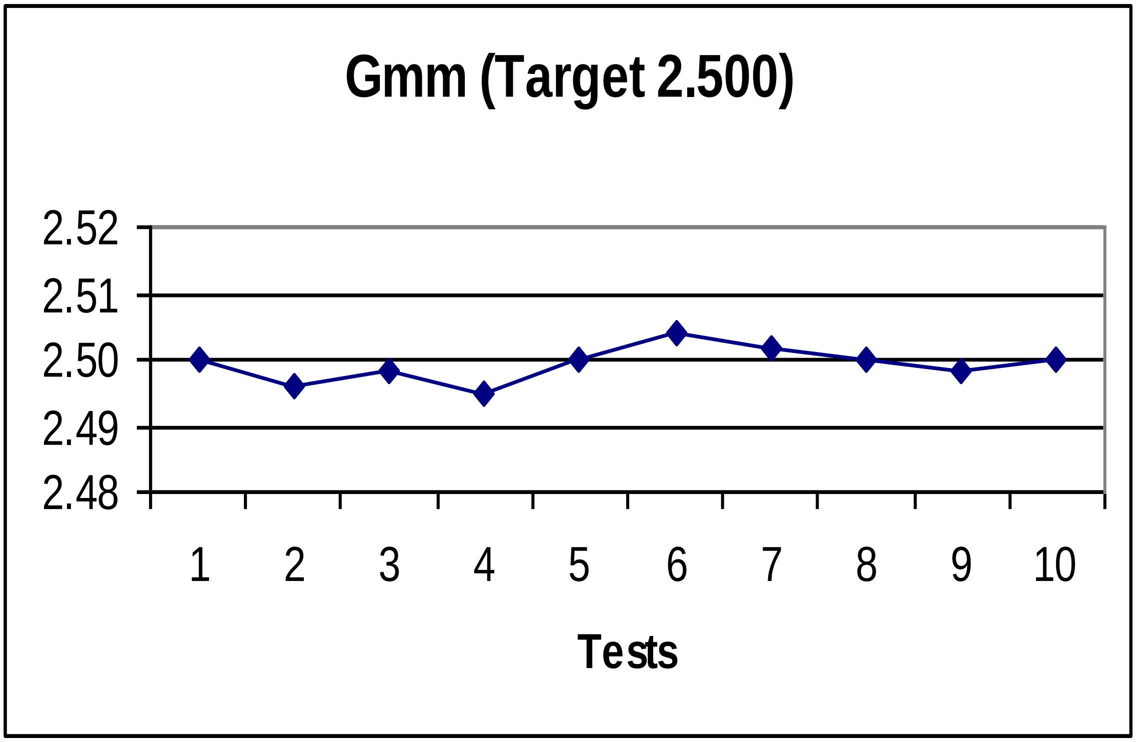
Problem #3 Control Charts

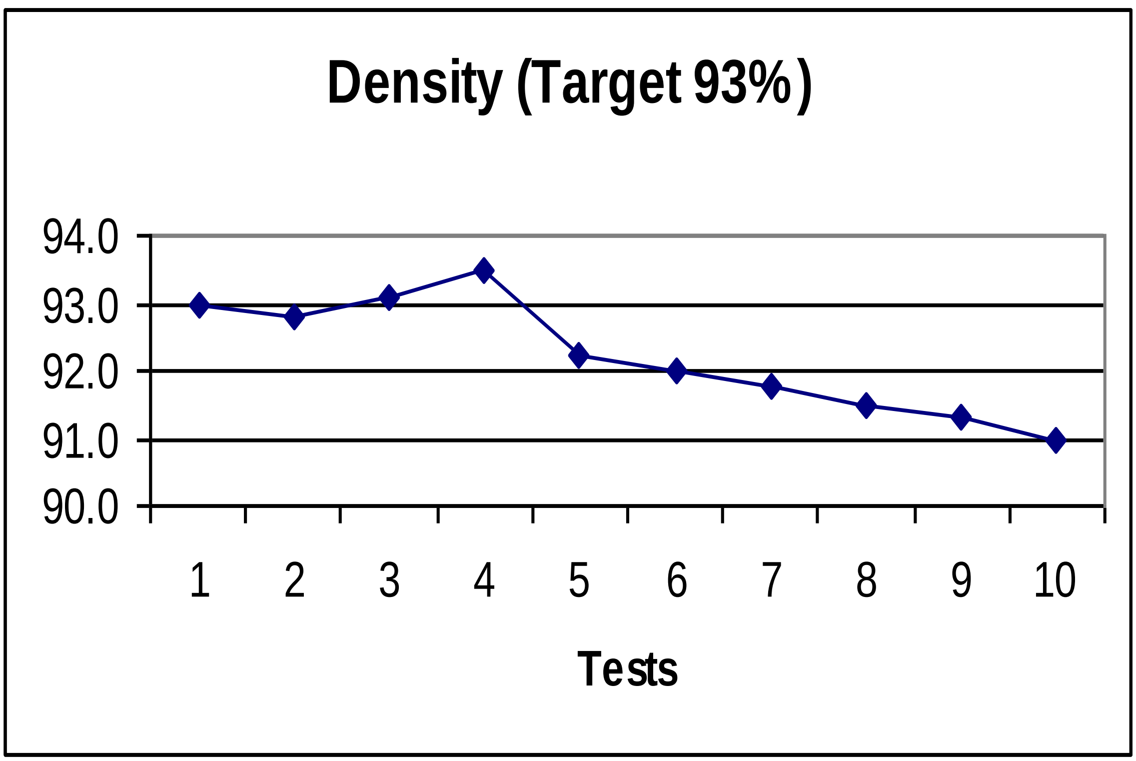
Is there a problem according to these 4 control charts?





Problem #3 Control Charts





Problem #3

A. Is there a problem with the 4 charts shown on pages 9-18 & 9-19?

B. Are we required to take corrective action?

C. What or where is the problem?

1) Road
2) Plant
3) HMA Mixture

D. What influences density?

1) Plant operations
2) Mixture
3) Road operations
4) Mat temperature
5) Compaction effort
    a) Rollers
    b) # of passes, etc.
6) Segregation
7) Underlying road conditions
    a) Correlation still valid
8) Nuclear density gauge?
    a) Gauge operator
    b) Gauge malfunctioning
    c) Inaccurate calculations

Problem 3 – Solution

First impressions indicate that this is a road density problem and all plant aspects can be ignored but looking at the flow chart on page 9-6 shows that plant operations/mixture aspects have a direct relationship with the road.

Problems from the plant can be carried out to the road, such as temperature or segregation, which will affect the ability to obtain proper mat density. Good communication between the plant and road is imperative and can help to expose potential problems.

Proper investigation will include verifying both proper plant and road operations to solve this situation. Testing procedures will probably not be the solution to this problem since the test results indicate a trending problem.

INDIVIDUAL TEST RESULTS

Isolated Tests

How a technician should respond to a "failed" individual test.

A. Don't take a knee-jerk reaction to a single test.

B. Always make sure all of the sampled material is completely and correctly blended before obtaining or running any test specimens.

The test samples must be representative of the material being tested! This starts with proper blending of plant and/or road samples.

C. Encountering defective material, you should:

a) Be able to visually see defective or poorly sampled material with practice and experience.

b) Need to take corrective action right away.

c) Still need to obtain samples and perform the test(s).

d) Be able to recognize when the test/sample is going to fail prior to completing the test (experience and practice).

e) Should immediately resample when encountering failing test results.

f) Monitor the material and/or operations.

C. Test termed as "flyers"

1) Typically doesn't match or correlate with other results (stands out like a sore thumb).

2) Could be a failed test due to incorrect test procedures, defective equipment or poor sampling methods.

3) A quick check of the equipment and calculations should be performed prior to resampling to determine possible equipment/operation or calculation errors.

4) Arrangements should be in place to replace any inoperable or malfunctioning equipment. Production shall stop or any lots of material produced and placed can be subject to rejection.

5) Resamples should be taken to verify mixture compliance whenever an adjustment or mixture change has been made.

Specialized Testing

"HMA testing for control (biased or check)."

A. If a potential problem is noticed, corrective action should be taken.

Example: If segregated stockpiles are found then additional gradation tests should be ran to determine the extent of the segregation.

Corrective action, as addressed per the AGCS program, will be needed to properly re-blend the material.

B. Prior to the start of production, run a few split samples with the District and/or another company to determine/help resolve differences in test results to identify and correct potential problems to avoid possible plant/job shutdown.

Participate in the BMPR round robin testing.

C. When test results are bouncing from top to bottom of the control limits, additional testing should be performed and the problem(s) identified and resolved.

D. In situations of improper quantities of materials, determine the cause of the shortages or overflow. Don't just tweak or change settings on the cold feeds or plant controls, as this will change the characteristics of the mix (gradations, air voids, density, etc.). Determine the cause and then fix the actual problem(s).

Resample Tests

A technician's response to a failed test:

A. Immediate resampling for a failed test.

B. Immediate resampling when obviously defective material is observed.

C. Immediate resampling after determination of a failed test for any unknown reason.

D. Samples should not be taken during the first 1/2 hour of start of mix production or within the last 1/2 hour of mixture shipment.

E. Do not wait to resample, a failed test should be resampled immediately to determine the cause of the failure.

Exception, if mixture production has been discontinued due to the suspension of operations (rain, production ended for the day, etc.) before a resample can be taken.

In this case, upon restarting of the mixture the next time, tests should be performed to determine any potential problems.

F. If a specific failed test parameter can be easily determined as to the cause of the test failure then a resample/retest can/should be taken only for that failed test parameter.

1) Only the G_{mm} ("D"), G_{mb} ("d") for failed air voids.

2) Only asphalt binder content for failed asphalt binder content.

3) Only failed gradation test for individual hot bin(s), combined belt, cold feeds or stockpiles.

It is still good practice to keep an eye on all aspects of the mixture.

G. The resample test result(s) should be placed on the respective control chart(s) immediately to the right the failed test result(s) from which the resample test result originated. The retest results should be included when plotting the moving average.

Control Chart Documentation

A. Only randomly generated test results and resample test results should be placed on control charts.

1) Individual test results are to be identified by an open circle symbol and connected by dashed lines.
2) Moving average results are to be identified by an open square symbol and connected with solid lines.

B. State assurance test results and resample test results, can be posted on the contractors control charts, utilizing an open triangle symbol. State assurance test results and resample test results should be obtained from the state inspector within a reasonable time frame.

C. Control charts should be kept up to date.

D. It is good practice to make the control chart information available to the state inspector or other state representatives (DE, RE, etc.)

E. Check or bias test results or other extra test results obtained by the contractor should be kept in some type of filing system as determined by the contractor. Normally, these types of test are not included on control charts. Electronic data storage is highly recommended.

These types of tests are very important and are an effective tool used for the control process.

F. With practice and proficiency of testing and proportioning, the contractor should be able to keep the test results within 1 - 2% of the target. As stated at the beginning of this class, experience is vital for success and being able to control production and placement of HMA materials.

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What-If Problems

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Chapter 2-What If

Problem #1

Problem: While observing plant operations at a batch plant, the plant technician notice that two of the hot bin gate cylinders are in the open position at the same time during the batching operation.

Why is this happening?

What will this do to the mix?

What can/should be done to fix the problem?

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Chapter 2-What If

Problem #2

Problem: During the performance of the 6-minute check at a dryer-drum plant, the following information is generated. If the target value from the weigh-belt calibration is 15.2 accumulated tons and the allowable range is ± 2%, determine if the plant is 'OK' to begin production. If not, what are the possible avenues that the plant technician would take to investigation of the problem? What could be causing the issue?

Print #	Time	Accumulation of Aggregate in TPH	6-Minute Check
Start	5:05:12 am	----------	----------
1st check	5:10:12 am	12.4	
2nd check	5:16:12 am	26.7	
3rd check	5:22:12 am	41.2	

Cause(s):

Solution(s):

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Chapter 2-What If

Problem #3

Problem: While monitoring production at a dryer-drum plant the plant technician noticed that the material exiting the drum into the slat conveyor is not entirely coated with asphalt binder, particularly on the knock-out box side (far end of the drum) of the discharge chute.

What could be the causing this?

What can be done to alleviate the problem?

Cause(s):

Solution(s):

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Chapter 2-What If

Problem #4

Problem: While monitoring operations at a dryer drum plant, the plant technician notices that the plant operator has the bag house dust transferred directly to the dryer drum.

Why is the operator doing this?

How will this affect the mixture performance?

What should be done to correct the situation?

Cause:

Effects on the mixture performance:

Correction:

Chapter 4-What If

Problem #1

Problem: A plant technician, when setting up the initial aggregate percentages at a dryer-drum plant, was using individual stockpile gradations but the projected combined gradations do not match the JMF targets.

What could be causing this?

What should the plant technician do to correct the situation?

The gradations (design & stockpile) in question are on the following page.

Causes:

Solutions:

Chapter 4

Problem #1

Design vs. Field Gradations

Sieve Sizes	Design Gradation			Field Gradation		
	CM11	CM16	FM20	CM11	CM16	FM20
1”	100			100		
3/4”	84			93		
1/2”	**34**	**100**		**45**	**100**	
3/8”	11	95	100	22	98	100
#4	**2**	**24**	**99**	**5**	**41**	**98**
#8	**2**	**4**	**85**	**3**	**13**	**75**
#16	2	2	53	2	8	50
#30	**1**	**2**	**30**	**2**	**7**	**32**
#50	1	2	17	2	6	21
#100	1	2	10	2	5	15
#200	**1**	**1.4**	**7.3**	**1.3**	**4.9**	**11.9**

This Page Is Reserved

Chapter 4 What-If Problem #2

After checking the setting of the cold feeds for tons per hour being delivered, you have determined the percent of aggregate are as follows:

CM 16 Limestone 25%
CM 16 Dolomite.............. 40%
FM 20............................... 14%
FM 01........................... 19.5%
MF 01............................. 1.5%

Are the settings correct for a N90 D Surface Mixture?

If not why?

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Chapter 9-What If

Problem #1

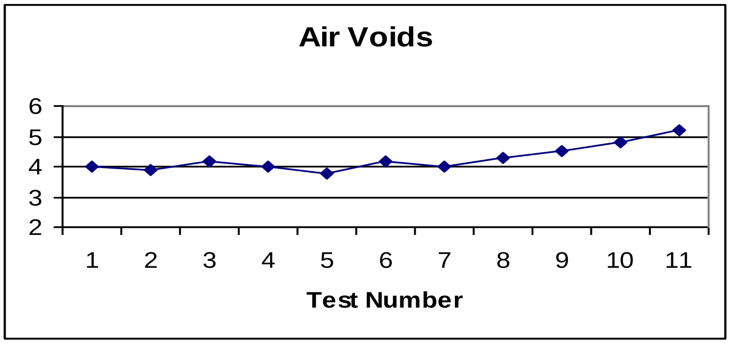
Problem: Using the control charts on page 10-20, determine where or what the problem(s) is/are and what corrective action should be taken?

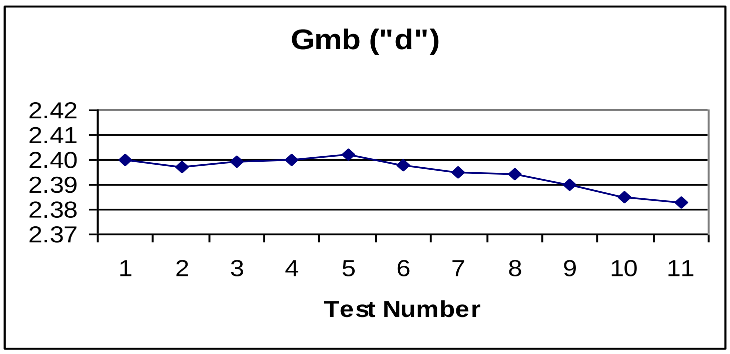
Problems:

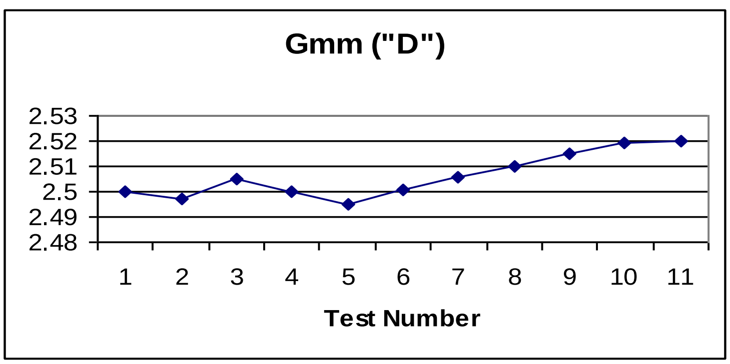
Corrective action:

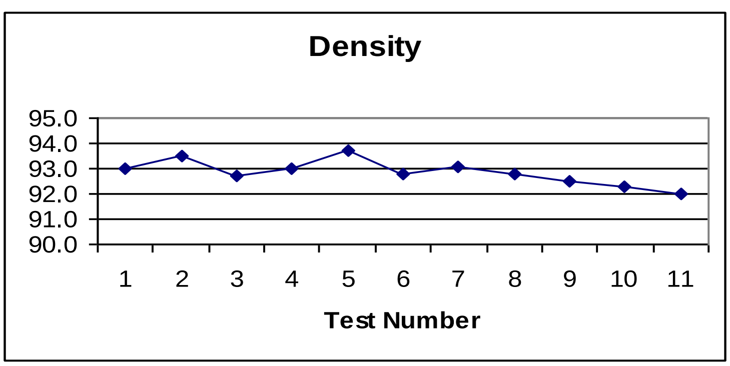
Chapter 9-What If

Problem #1









Chapter 9-What If

Problem #2

Problem: A dryer-drum plant is producing an IL-19.0 N_{des} 90 binder mixture (19532). The samples taken at the plant is showing high air voids and the density tests from the road is showing high density on the compacted mixture.

What could be causing this problem?

What can be done to correct the problem?

Causes:

Corrective action:

This Page Is Reserved

Chapter 9-What If

Problem #3

Problem: A contractor's technician noticed that the HMA mixture arriving at the job appears to have "**free asphalt**", commonly referred to as **drain-down**, in the bed of some of the trucks. The drain-down is located mostly in the back one third of the truck beds.

The plant producing the HMA mixture is a dryer-drum and the haul time to the job is 40 minutes.

What are some causes for this to happen?

Causes:

This Page Is Reserved

Chapter 9-What If

Problem #4

Problem: A sample of 042CM11 aggregate was taken from a cold feed at a dryer-drum plant utilizing the belt-stream sampling method. The test results show that the percent passing on the critical sieve was 10%-15% coarser than what the corresponding stockpile sample test results were showing.

What could cause this problem?

What will it do to the mix?

What can/should be done to correct the problem?

Cause:

Possible mixture problems:

Corrective action:

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Chapter 11 Contents

MoTP = Manual of Test Procedures
CBM* = Central Bureau of Materials

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Illinois Department of Transportation

Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5

Effective Date: May 1, 1993
Revised Date: December 1, 2021

The following checklists detail the required minimum duties of Contractor Quality Control (QC) personnel. The QC Manager has overall responsibility to ensure that the listed duties are performed and documented. The QC Manager shall not perform sampling and/or testing except in emergency situations or in any other situation approved by the Engineer. Additional tasks or duties, as necessary, may be required to control the quality of production and placement of the Hot-Mix Asphalt (HMA) mixtures. An HMA Level II Technician may be used to perform any HMA Level I Technician duties.

Note: Testing frequency denoted as "P" = "Prior to Test Strip" and as "D" = "Daily".

A. Level I Technician Checklist

1. Production/Placement Tasks

a. Perform incoming aggregate gradations before start-up time. (PD) ___

b. Ensure lab equipment is on hand and in working order. (PD) ___

c. Run moisture samples daily (drum only). (PD) ___

d. Determine random sampling times one day in advance and inform the QC Manager and the Engineer of the sampling times. (D) ___

e. Take required samples when required using proper procedures. (D) ___

f. Run required tests as soon as possible using proper procedures. (D) ___

g. Take resamples as required. (D) ___

h. Plot all random and resample results on control charts as soon as test results are available. (D) ___

i. Take check samples when necessary. (D) ___

j. Contact QC Manager immediately when tests fail or any time problems occur. (D) ___

k. Test cores for Nuclear/Core Correlation when applicable (After Test Strip). ___

2. Required Tests. The minimum test frequency shall be according to Section 1030 of the Standard Specifications. However, additional tests may be required by the Engineer.

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5
(continued)
Effective Date: May 1, 1993
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a. Stockpiles
(washed gradations minimum one per week for each material used) ___

b. Moisture samples (drum only) ___

c. Washed Gradations ___

d. Asphalt Content

e. G_{mb} ___

f. G_{mm} ___

B. <u>QC Manager and/or Level II Technician Checklist</u>

Complete and submit Annual QC Plan prior to construction season. ___

1. <u>Preliminary Inspection Tasks</u>

a. Check for the approved sources of the materials:

(1) Aggregates — ensure it is from Certified Source ___

(2) Mineral filler ___

(3) Asphalt binder (See d. below.) ___

(4) Other additives

(5) Truck Bed Release Agent – ensure it is on the QPL ___

b. Check the aggregate stockpiling and handling procedures:

(1) Observe stockpiling procedures to ensure they are built correctly. ___

(2) Discuss loadout and sampling procedures with endloader operator. ___

(3) Sample aggregate stockpiles, in conjunction with District inspectors, and submit for Mix Designs. ___

c. Check the gradation of the aggregates:

(1) Obtain average gradation of each aggregate

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
Appendix B.5
(continued)
Effective Date: May 1, 1993
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(including Master Bands) from the aggregate source. ___

(1) Compare aggregate source information to stockpile samples at the mix plant and with the design gradation. ___

(2) Test the gradation of each aggregate stockpile.

d. Check asphalt binder:

(1) Source ___

(2) Grade ___

(3) Incoming temperatures ___

(4) Specific Gravity (drum only) ___

e. Verify that the laboratory and laboratory equipment have been inspected and approved by the Department and are in good working order. ___

f. Review Hot-Mix Asphalt Level I and Level II Technician Course manuals. ___

2. <u>Production/Placement Tasks</u>

a. Complete and submit Quality Control Addendum (P) ___

b. Check the mix plant for the following:

(1) Approval and calibration (P) ___

(2) Asphalt binder storage temperature (PD) ___

(3) Stockpiles (PD)

(a) Correct loadout ___

(b) Place in proper cold-feed bins

(4) Cold-feed bins or bulkheads and feeders (PD) ___

(5) Dust collecting systems (D) ___

(6) Screens and screening requirements (P) ___

(7) Hot-bin sampler (P) and hot-bin overflow (PD) ___

(8) Weigh belt 6-minute check (drum only) (D) ___

(9) Temperature recorders and thermometers (PD) ___

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
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(continued)
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(10) Mixing timers (batch plant only) (PD) ___

(11) Surge and storage bins (PD) ___

(12) Platform scales or suspended weigh hopper (PD) ___

(13) Additive system(s) (when required) (PD) ___

(14) Ticket printer (P) ___

(15) Computer and control systems (PD) ___

c. RAP/FRAP/RAS from appropriate approved sealed stockpile (PD) ___

d. Check trucks for the following (QC Manager may assign these duties to a Level I Technician):

(1) Truck bed release agents (PD) ___

(2) Insulation (D) ___

(3) Tarps (D) ___

(4) Clean beds (D) ___

e. Coordinate any test strip per Department guidelines (QC Manager only). ___

f. Monitor sampling and testing procedures, density test, and laydown operations. (D) ___

g. Check the mixtures for the following:

(1) Gradation test performed and bin percentages determined before start-up (P) ___

(2) Correct Job Mix Formula is being used (P) ___

(3) Moisture check (PD) ___

(4) Temperature (D) ___

(5) Coating and segregation (D) ___

(6) Additives (D) ___

(7) Draindown (D) ___

h. Laydown operation (QC Manager only)

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Hot-Mix Asphalt QC/QA
QC Personnel Responsibilities and Duties Checklist
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(continued)
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Monitor the following field checks:

(1) Check for obvious defects in truck (segregation, uncoated, temperature, etc.) (D) ___

(2) Monitor paver operations (equipment, laydown procedures, etc) (PD) ___

(3) Rollers and operations (equipment, pattern, procedure, etc.) (PD) ___

(4) Mix characteristics on road (appearance, mat temperature, etc.) (D) ___

(5) Monitor densities as required (D) ___

i. Monitor all test results and make any adjustments necessary (QC Manager only) (D). ___

j. Perform scale checks (minimum one per week per scale). Follow procedure in Construction Manual Documentation Section. ___

k. Ensure following records are kept and reports are submitted in a timely manner as required (QC Manager only):

(1) Daily plant output (D) ___

(2) Field gradation (D) ___

(3) Density (D) ___

(4) Control charts (D) ___

(5) Additives (D) ___

(6) Scale checks (D) ___

(7) Plant diary (D) ___

C. <u>HMA Level I Technician, HMA Level II Technician, and Quality Control Manager Duties</u>

1. <u>Material Source</u>

It is necessary to identify the source of the ingredients to ensure that they have been inspected and the correct quality of aggregate, grade of asphalt binder, and anti-strip additive are being used in the specified mix. Sources shall be verified.

2. <u>Aggregate Quality</u>

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QC Personnel Responsibilities and Duties Checklist
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(continued)
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The HMA Level II Technician may confirm the quality of the aggregate by requesting current quality information from the District Materials office.

3. Stockpiling

Sites for stockpiles shall be grubbed and cleaned prior to storing the aggregates.

Separate stockpiles shall be provided for the various sources and kinds of aggregates. Stockpiles shall be separated to prevent intermingling at the base (width of endloader bucket). If partitions are used, they shall be of sufficient heights to prevent intermingling. Aggregates for HMA mixtures shall be handled, in and out of the stockpiles, in such a manner that will prevent contamination and degradation.

Coarse aggregate stockpiles shall be built in layers not exceeding 1.5 m (5 ft) in height and each layer shall be completely in-place before the next layer is started. A stockpile may be expanded by again starting the expansion from the ground and building layers as before. End-dumping over the sides will not be permitted. Use of steel track equipment on Class B Quality, Class C Quality and all blast furnace slag aggregate stockpiles shall not be permitted where degradation is detected. When loading out of stockpiles, vertical faces shall be limited to reasonable heights to eliminate segregation due to tumbling. Segregation or degradation due to improper stockpiling or loading out of stockpiles shall be just cause for rejecting the material.

RAP/FRAP stockpiles shall be according to Article 1031.02(a).

RAS stockpiles shall be according to Article 1031.02(b).

4. Gradations

The HMA Level II Technician shall obtain the average gradations as well as the Master Bands from the aggregate source. The HMA Level II Technician shall run the required gradation's test frequency on incoming aggregate as required in Section 1030 of the Standard Specifications.

5. Asphalt Binder

a. Incoming Asphalt Binder: The HMA Level II Technician shall periodically check the grade and temperature of asphalt binder as received at the plant. If the asphalt binder is shipped by truck, the driver should have in their possession a numbered ticket showing the name and location of the refinery, the name of the material, date shipped, loading temperature, quantity, specific gravity or weight/L (weight/gal), and the number of the tank from which the asphalt was loaded. It is the responsibility of the refinery to load trucks only from tanks that have been tested and approved by the Department. If

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QC Personnel Responsibilities and Duties Checklist
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shipment is made by rail, a tag usually will be found on the top of the dome of the tank car indicating that it has been sampled at the refinery.

b. Asphalt Binder Storage: The HMA Level II Technician shall check the temperature of the asphalt binder in storage. The temperatures shall be maintained in accordance with the Standard Specifications. The HMA Level II Technician should be aware of the grade of asphalt binder in each storage tank. Asphalt binders of different sources and grades shall not be intermixed in storage, and the tanks shall be identified.

6. Testing Equipment

Care of the laboratory testing equipment is the responsibility of the HMA Level I Technician. Equipment shall be furnished by the Contractor or Consultant, kept clean, and kept in good working condition. The furnished equipment shall meet the minimum private laboratory requirements stated in the Central Bureau of Materials Policy Memorandum Number 6-08.4. At the start of the project, the HMA Level I technician shall check that all equipment required to be furnished is available and in good condition. Acceptance and, ultimately, performance of a mixture may be dependent on the accuracy of the tests. Defective equipment could result in erroneous, as well as untimely, results.

7. Hot-Mix Asphalt Plant

a. Plant Approval: Plant must be approved and calibrated prior to production each construction season. The QC Manager shall review this information. If it is not available or current, the District Hot-Mix Asphalt Supervisor shall be notified.

b. Cold Aggregate Bins: The cold aggregate bins or bulkheads shall be checked for aggregate intermingling. Each bin or compartment in a bin shall contain only one source and type of aggregate. The bins should be checked each day to ensure the charging of the compartments remains the same as it was for previous operations for the same mix. The QC Manager shall notify the state inspector of changes in aggregate source and gradation and/or gate settings.

c. Batch Plant Dust Collector: The Level II Technician shall check that the dust from the primary collector is returned to the boot of the hot elevator by a metering system as required by Article 1102.01(b)(3) of the Standard Specifications. This metering system should be such as to require a few adjustments in maintaining a uniform rate of collected dust returned to the hot elevator. The primary dust-feed shall occur only when aggregate is being discharged from the drier.

Plants having dry secondary collectors shall return this material to a storage silo or the mineral filler bin if it will meet the requirements of the mineral filler specifications (Section 1011 of the Standard Specifications).

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QC Personnel Responsibilities and Duties Checklist
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d. Screens: Samples from the hot-bins shall be inspected for contamination. An excess of coarse aggregate in the sand bin or sand in the coarse aggregate bins may indicate broken or clogged screens and/or a hole between the bins. The screens shall separate aggregate into sizes to produce a uniform gradation. If fluctuations in gradation occur, a change in screen size and/or aggregate flow rate may be required. Article 1102.01(b)(10) of the Standard Specifications shall be applied.

e. Hot-Bins: The HMA Level II Technician is to ensure that each hot-bin overflow pipe is working to prevent back-up of material into other compartments or bins. An overflow or sudden shortage of material in a bin may indicate a broken or clogged screen, a change in feeding rate, or a change in gradation of the aggregate being used. Overflow pipes shall not be discharged into the hot elevator.

f. Temperature Recording Device: The temperature recording devices shall be checked for compliance with Article 1102.01 of the Standard Specifications. A new chart shall be used each day.

g. Timers: The timers used for recycling the wet and dry mixing times for a batch plant shall be checked and set at the required mixing times. The required times are in the appropriate articles of the Standard Specifications.

h. Batching: The HMA Level II Technician shall observe the batching operation to ensure the approved batch weights are being met. Manually operated batch plants shall have markers on the scales to indicate the approved batch weight of each ingredient material. Automatic batching plants shall have posted near the scales the approved weights per bin. It is recommended that batch counters and/or ton counters be set at "zero" or initial and final readings be taken and recorded each day.

i. Surge and Storage Bins: When a surge and storage bin are used, approval and scale calibration information should be available. They shall be inspected for compliance with Article 1102.01(a)(5) of the Standard Specifications. Trucks shall be loaded in such a manner as to minimize segregation.

j. The platform and/or suspended weigh hopper scale shall be checked for proper zero. The scales shall be cleaned off before starting each day.

k. The additive system(s) calibration shall be checked and the proper flow rate determined.

l. The weigh ticket printer shall be checked for information required by the appropriate articles of the Standard Specifications.

m. The computer and/or control system shall be checked to see if the correct percentages of materials have been entered. The automatic printer for the computer of the drier drum should be turned on and working.

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QC Personnel Responsibilities and Duties Checklist
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8. Trucks

A HMA Level I Technician, under the direct supervision of the QC Manager, or the HMA Level II Technician shall inspect the trucks used to transport the HMA mix. The technician shall see that each truck is provided with a cover and is properly insulated, if specified, before it is permitted to be used in the transportation of the mixture from the plant to the job. The truck bed shall be observed for foreign material before the bed is lubricated. The HMA Level II Technician shall observe the spraying of the inside of the trucks with a release agent and shall see that no pools of release agent remain in the truck beds before loading.

9. Mixture Inspection

The HMA Level II Technician shall inspect the mixture at the plant, which includes observing the weighing of the materials; checking the temperature of the mixture; and visually inspecting for coating of the aggregates, segregation, and moisture in the mixture. The HMA Level I Technician shall sample and determine the gradation of the hot-bins and/or cold-feeds and the proper amount of asphalt binder being used to ensure conformity to the mix formula. The HMA Level II Technician shall also verify and document the addition rates of the anti-strip additives.

In addition, the HMA Level I Technician shall perform the required core density tests and, when required, extraction tests at the field laboratory.

The QC Manager shall furnish the Contractor with the mixing formulas which have been established for a specific combination of sources of ingredients. The formulas shall state the percentage of aggregate for each sieve fraction and the percentage of asphalt binder. These formulas are to be used in proportioning the ingredient materials for HMA mixtures within the specified tolerances. Changes in the mix formulas are to be made only by the QC Manager.

It is important that the QC Manager observe the laying and compaction of the mixture.

Mixture variations are noticeable in the completed work, and variations that are not apparent in the mixture at the plant sometimes show up as defects in the texture and uniformity of the surface. Flushing of the mixture is a defect that can be detected only on the road.

It is the duty of both the HMA Level I and HMA Level II Technicians to establish and maintain an open line of communications.

Timely and appropriate actions can be instituted by early detection of defects or mixture variations.

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10. Scale Checks

When measurement of mixtures is on the basis of weights obtained from batch weights or platform scales, occasional scale checks shall be made by weighing full truckloads of the mixture on an approved platform scale at the plant site or on a commercial scale approved by the Engineer. The procedure is described in the Department's Documentation of Contract Quantities Manual. The tests will be performed by the Level II Technician and reported on form BIC 2367, as needed, and the "Daily Plant Report".

11. Samples

The HMA Level I Technician shall take check samples of the mixture in addition to the required samples. Section 1030 of the Standard Specifications discusses sampling procedures and sampling frequency.

12. Reports

The Quality Control Manager is responsible for completion of a "Daily Plant Report" for each day of production for each type of mix. Other reports, when required, are "Sample Identification" (LM-6), and Scale Checks.

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Model Annual Quality Control Plan for Hot-Mix Asphalt Production
Appendix B.1

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Producer Name: ______________________________

Producer/Supplier No.*: ______________________________

Producer Main Office Mailing Address: ______________________________

City/State/ZIP: ______________________________

Plant(s) City/State/ZIP: ______________________________

*If the location includes more than one plant, this Annual Quality Control (QC) Plan may apply to the other facilities. Include relevant IDOT P/S Numbers under "Plant(s)".

A. <u>Producer Responsibilities</u>

The Producer is responsible for controlling the equipment, component materials, and production methods to ensure the specified product is obtained. All requirements of the Standard Specifications, the Manual of Test Procedures for Materials, contract-specific documents, Hot-Mix Asphalt (HMA) Level I and II Technician Manuals, and this Annual QC Plan will be adhered to. A Quality Control Addendum shall be completed for each contract and submitted prior to the preconstruction conference.

Where one Contractor is producing the mix and another is responsible for the laydown, the Quality Control Manager, from either party, who is ultimately responsible for the Quality Control should be identified in the Quality Control Addendum.

B. <u>Quality Control Personnel</u>

The QC Manager will assign duties in accordance with the "QC Personnel Responsibilities and Duties Checklist". The QC Manager will assure the listed duties are performed and documented. Additional duties, when necessary, will be assigned and monitored by the QC Manager. Sufficient QC personnel will be provided to comply with the QC Plan. Additional QC personnel will be added when necessary.

Quality Control Manager Name:
Phone Number:
e-mail Address:
Mailing Address (if different than above):

Backup Quality Control Manager Name:
Phone Number:
e-mail Address:

Owner or Individual Supervising QC Personnel Listed Above:

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
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Phone Number:
e-mail Address:

Additional contract-specific personnel will be included on the QC Addendum.

C. Plant(s)

IDOT Producer Number: ______________________________

Manufacturer: ______________________________

Model Number: ______________________________

Serial Number: ______________________________

Approved Batch Size or TPH as applicable:________________

Plant Survey Re/Approval Date:__________________________

(If more than one plant at location - Repeat for the additional plant)

D. Quality Control Laboratory

Quality Control Laboratory Location:
Quality Control Laboratory Approval Date:
Qualified for Method 2 Dispute Testing Complete (Y/N):
Use of Central Lab AC (Y/N):
Laboratory Manager:
Laboratory Phone Number:

Backup Quality Control Laboratory Location:
Backup Quality Control Laboratory Approval Date:
Qualified for Method 2 Dispute Testing Complete (Y/N):
Laboratory Manager:
Laboratory Phone Number:

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
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E. Materials

All materials proposed for use are from approved sources. Material sources are identified below for coarse aggregate, fine aggregate, mineral filler, RAP/FRAP/RAS, asphalt binder, tack coat, longitudinal joint sealant, anti-strip additive, and asphalt release agent.

1. Coarse Aggregates

Coarse aggregate materials are shown in the following table:

Material Code	Producer/Supplier Number	Producer Name	Location	Delivery Method [1/]

Note: 1/ Truck / Rail / On-Site Quarry

Coarse aggregate stockpile method: (Conveyor Cone, Conveyor Elongated Cone, Single Layer Truck, Multi-Layer Truck):

Procedures utilized to replenish and test stockpiles:

Procedures utilized to prevent intermingling of stockpiles:

List and attach any approved mix plant gradation adjustments according to Appendix A.1 of the Manual of Test Procedures.

2. Fine Aggregates

Fine aggregate materials are shown in the following table:

Material Code	Producer/Supplier Number	Producer Name	Location	Delivery Method [1/]

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Note: 1/ Truck / Rail / On-Site Quarry

Procedures utilized to replenish and test stockpiles:

Procedures utilized to prevent intermingling of stockpiles:

List and attach any approved mix plant gradation adjustments according to Appendix A.1 of the Manual of Test Procedures.

3. RAP/FRAP/RAS Materials

RAS materials incorporated into mixtures are shown in the following table:

Material Code	Producer Supplier Number	Producer Name	Producer Location

RAS stockpiling method

RAP/FRAP materials incorporated into mixtures will be described in the project QC Addendum.

RAP/FRAP Procedures:

- Delivery and stockpiling method:
- Method of Processing (Crushing / Screening / Fractionation method):
- Maintaining source and/or quality stockpile seal:

4. Liquid Asphalt

Liquid asphalt grades and sources are shown in the following table:

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Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
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(continued)
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PG Grade	Producer/Supplier Number	Producer Name	Producer Location

Procedures for preventing mixing liquid asphalt grades:

5. Mineral Filler, Anti-Strip, WMA and SMA Stabilizing Additives, Asphalt Release Agents, Longitudinal Joint Sealant & Tack Coat Materials

Material	Producer Supplier Number	Producer Name	Producer Location

F. Aggregate Stockpile Procedures

All aggregate stockpiles will be built using procedures that will minimize segregation and degradation.

G. Incoming Aggregate Gradation Samples

A washed gradation test will be performed for each 500 tons (450 metric tons) for the first 1,000 tons (900 metric tons) for each aggregate received. Additional gradation tests (every third test will be a washed gradation test) will be run on the frequency of one test per 2,000 tons (1,800 metric tons) for each aggregate received while the stockpiles are being built or aggregate is being shipped in. Gradation correction factors will be developed from washed gradation test results and applied to all dry gradation results. All aggregate (correction factors applied) will meet the mix plant gradation bands as developed according to the current Department policy, "Development of Gradation Bands on Incoming Aggregate at Mix Plants", before being used in mix production at the mix plant. All incoming aggregate gradation results shall be recorded in the plant diary. If a failing sample is encountered, the following resample procedure will be followed:

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1. Immediately resample the aggregate represented by the failing test.

2. If the first resample passes, the required frequency will be continued.

3. If the first resample fails, shipment of the aggregate will be halted, and corrective action will be taken. Corrective action may be rejection of the material, remixing or addition of material by feeder/conveyor system, or any other action approved by the Engineer. The aggregate producer will be notified of the problem. A second resample will be taken immediately after corrective action.

4. If the second resample passes, the aggregate represented will be used, and aggregate shipment into the plant will be resumed.

5. If the second resample fails, the aggregate represented will not be used in HMA mixtures. The material will be removed from the certified aggregate stockpile.

H. Required Gradation Sample

After mix production has started, all aggregate stockpiles will be checked with a required washed gradation sample on a weekly basis. This testing will be waived if the mixture is classified as a small tonnage item. The test results shall be compared to the mix plant gradation bands for compliance. These gradation results will be noted in the Plant Diary, and a copy will be provided to the Engineer.

If a weekly required stockpile sample fails, the following resample procedure will be followed:

1. Immediately resample and test the new stockpile sample.

2. If the first resample passes, mix production may continue. Several additional check samples will be taken to monitor the stockpile.

3. If the first resample fails, mix production will be halted, and corrective action will be taken on the stockpile. Corrective action may include rejection of the material, remixing or addition of material by feeder/conveyor system before use in the plant. The Aggregate Producer will be notified of the problem. A second resample will be obtained immediately after corrective action.

4. If the second resample passes, mix production will begin. Several additional check samples will be taken to monitor the stockpile.

5. If the second resample fails, the stockpile will not be used in HMA mixtures.

Illinois Department of Transportation

Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production
Appendix B.1
(continued)
Effective Date: May 1, 1993
Revised Date: December 1, 2021

Aggregate not meeting the mix plant gradation bands shall not be used in HMA mixtures.

I. Reporting of Test Results

All test results will be reported daily either electronically using the Department QMP Package, or by submission of the following forms to the Resident Engineer and other designated personnel as requested by the Department.

MI 504M	Field/Lab Gradations (stockpile gradations)
MI 305	Bituminous Daily Plant Report (front) Plant Settings and Scale Checks (back)
MI 303C	Bituminous Core Density Testing QC/QA
MI 303N	Nuclear Density Report QC/QA
MI 308	Asphalt Content and Volumetric Testing
LM-6	Sample Identification (for liquid asphalt)

The completed forms will be forwarded to the Engineer within three days of test completion.

J. Control Charts

In addition, when control charts are required as part of the Quality Management Program they will either be posted at the laboratory or readily available electronically upon request in accordance with the Department's current document "Hot-Mix Asphalt QC/QA Control Charts".

Primary QC Manager Signature ______________________ Date ___________________

(Please type or print name) ________________________________ Title _____________

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Illinois Department of Transportation

Model Quality Control (QC) Addendum for Hot-Mix Asphalt Production
Appendix B.2

Effective Date: July 1, 1995
Revised Date: December 1, 2021

Contract No.: ______________________________
Marked Route: ______________________________
County: ______________________________
Prime Contractor: ______________________________
HMA Producer: ______________________________
Contractor Performing Laydown: ______________________________

This Quality Control (QC) Addendum provides contract specific information to supplement the Hot-Mix Asphalt (HMA) Annual QC Plan. If multiple HMA producers will be utilized for specific items of work on a single contract (Example: one for mainline and another for shoulder), a separate QC Addendum shall be submitted for each producer.

A. HMA Production Location

	Producer Name	Location	IDOT P/S Number
Primary			
Backup			

B. Mix Designs

The following mix designs will be utilized:

Pay Item	Material Code	Lift (if applicable)	Mix Description	Department Mix Design Number	Annual Verification Completed (Y/N)

The table may include a primary and a secondary mixture for each item.

Illinois Department of Transportation

Model Quality Control (QC) Addendum for Hot-Mix Asphalt Production
Appendix B.2
(continued)
Effective Date: July 1, 1995
Revised Date: December 1, 2021

C. Reclaimed Asphalt Pavement (RAP/FRAP)

RAP/FRAP material incorporated into mixtures originated from the following sources:

Material Code	Material Description	Quality	Source (Marked Route, Location & Lift)	Mix Design # Utilizing the Material

D. Quality Control Personnel

Overall (Production & Laydown) Project Quality Control Manager Name:
Company:
Phone Number:

The QC personnel are shown in the table below:

Name	Task(s) Performed	Employed By	Training Level

E. Project Specific Issues:

HMA Producer Signature: ____________________________________

Title: ____________________________________

(Type or print name): ______________________________ Date: ____________

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: January 4, 2023	4-08.3
This Policy Memorandum supersedes number 4-08.2 dated January 21, 2020	

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS

SUBJECT: APPROVAL OF HOT-MIX ASPHALT PLANTS AND EQUIPMENT

1.0 SCOPE

This policy governs the approval of **Hot-Mix Asphalt (HMA) Plants** for both prequalification and production purposes.

2.0 REFERENCES

2.1 *Standard Specifications for Road and Bridge Construction*, edition current at the time of the advertisement for bids, Illinois Department of Transportation

2.2 *Supplemental Specifications and Recurring Special Provisions*, edition current at the time of the advertisement for bids, Illinois Department of Transportation

2.3 Prequalification Rules (Manual), Illinois Department of Transportation

2.4 "The Fundamentals of the Operation and Maintenance of the Exhaust Gas System in a Hot Mix Asphalt Facility", IS-52, National Asphalt Pavement Association

2.5 "The Uniform Burner Rating Method for Aggregate Dryers", IS-76, National Asphalt Pavement Association

2.6 Illinois-Modified AASHTO T 11 (Washed Gradations)

2.7 Illinois-Modified AASHTO T 2 (Aggregate Sampling)

2.8 Illinois-Modified AASHTO T 27 (Sieve Analysis)

2.9 Illinois-Modified AASHTO T 30 (Sieve Analysis of Extracted Aggregate)

2.10 Illinois-Modified AASHTO T 164 (Extraction Method)

2.11 Illinois-Modified AASHTO T 308 (Ignition Oven Method)

3.0 DEFINITIONS

BUREAU - Central Bureau of Materials (CBM), Illinois Department of Transportation.

CONTRACTOR – The individual, firm, partnership, joint venture, or corporation contracting with the **Department** for performance of prescribed work.

High ESAL and Low ESAL APPROVAL – Successful completion of an evaluation process administered by the **Bureau** to determine the capability of an **HMA plant** to produce consistent mix within the **Department's** specifications. This approval is a prerequisite to production of High ESAL or Low ESAL mixtures for the **Department**. It may be conducted concurrent with the start of a contract. It is not a prerequisite for initial Prequalification. (Section 7 of this Policy describes the procedure in detail.)

DEPARTMENT – Illinois Department of Transportation (IDOT), including its **Districts** and Central Bureau offices.

DISTRICT - District office, Illinois Department of Transportation.

ENGINEER – Chief Engineer of the Department of Transportation of the State of Illinois, or authorized representative as defined in Section 101 of the Standard Specifications.

EQUIPMENT FACTOR - A Prequalification factor that is a measure of the annual dollar value of production capacity for selected equipment and plant facilities. For **HMA Plants**, the Work Category and **Production Rating** are used to determine the **Equipment Factor**.

HOT-MIX ASPHALT (HMA) PLANT - A plant intended to produce High ESAL or Low ESAL mixtures for the **Department**. For the purposes of Prequalification, an **HMA Plant** includes equipment specified in the **Department's** Prequalification Rules and the *Standard Specifications for Road and Bridge Construction*.

POSITIVE DUST CONTROL EQUIPMENT (PDCE) - PDCE shall consist of a system that is an integral part of the production process. The system shall accurately weigh all of the secondary dust collected in the baghouse, transfer the material to a storage silo, accurately weigh the required amount of fines to be returned from the storage silo, and transfer them back to the mixture. The positive dust control weighing devices shall have an accuracy of 0.5 percent of the actual weight of material. The system shall be capable of automatically monitoring the dust collection process and adjusting the amount of asphalt cement added to the mixture. The entire system shall be interlocked with the plant controls to respond to production rate changes, start up, and shut down situations. The weighing process shall be displayed and recorded in 0.1 units. The **PDCE** shall be capable of accurately wasting dust without having any adverse effects on the mixture.

PREQUALIFICATION APPROVAL STATUS - A rating process established by the **Department** which requires all prospective bidders to obtain a Certificate of Eligibility prior to being considered for issuance of bidding proposal forms and plans for any contract awarded by the **Department**, as well as contracts awarded by local agencies requiring approval of award by the **Department**.

PREQUALIFICATION SECTION – The section within the Bureau of Construction of the **Department** responsible for determining responsibility, financial ratings, **Work Ratings** and the issuance of bidding proposals.

PRODUCTION RATING - A nominal **Production Rating** for an **HMA Plant**. It is calculated by the **Bureau** and is one factor used to determine the Prequalification **Equipment Factor**. It is also the maximum field production rate approved for **Department** work. (Section 5 of this Policy describes this rating in detail.)

WORK RATING - A dollar value of work of a particular category of construction that an applicant can perform with his/her organization and equipment in one construction season.

4.0 GENERAL

4.1 **Prequalification.**

4.1.1 Prior to Prequalification, the **Contractor** shall complete a plant survey on forms furnished by the **Department**. The **Contractor** shall submit the forms to the **District** in which the plant is located or the nearest **District** if the plant is located out-of-state. The **District** shall forward the submittal to the **Bureau**.

4.1.2 During the Prequalification process, each **HMA Plant** will be evaluated by the **Bureau**. The **Bureau** will determine the **Production Rating** used in determining the **Contractor's Work Rating**.

4.1.3 The **Bureau** will evaluate the submittal and conduct investigations as necessary.

4.1.4 The **Bureau** will provide the **Production Rating** to the **Prequalification Section**. The **Production Rating** will be used by the **Prequalification Section** to establish a **Work Rating** for the **Contractor** according to the Prequalification Rules.

4.1.5 An **HMA Plant** will be evaluated for a single owner only. The prequalification rating for a leased plant will apply to a single **Contractor** only.

4.2 **Plant Approval for High ESAL and Low ESAL Mixtures. HMA Plants** intending to produce High ESAL and/or Low ESAL for the **Department** shall be evaluated by the **Department** for **High ESAL and Low ESAL Approval** as specified herein.

4.3 **Re-approval.** All plants will be re-surveyed for consideration for continued approval every 5 years. The **Department** will notify the **Contractor** to resubmit the survey forms.

4.4 **Plant Modifications.** The **Bureau** shall be notified of all plant modifications for previously approved HMA plants.

4.5 **Revocation of Plant Approval.** If the **Department** determines the **HMA Plant** is unable to consistently produce HMA within the specification tolerances as defined in the contract, the **Prequalification Approval Status** may be revoked by the **Bureau** which would require the **Contractor** to repeat the plant approval process. The **Bureau** will notify the **Prequalification Section** of any and all plant approval revocations.

4.6 **Reinstatement Process.** If the **HMA Plant** approval is revoked, the **Contractor** shall provide the **Bureau** a written plan of corrective action. Once the **Bureau** reviews and finds the plan acceptable, the plant approval process may begin. If the **Bureau** requires the installation of the **Positive Dust Control Equipment (PDCE)**, the installation shall comply with the definition above. If **PDCE** or any other plant modifications are required, the equipment shall be installed and/or modifications made prior to the production of any HMA for the **Department**. With approval of the **Bureau**, the installation may be performed prior to the start of the next construction season. The **Bureau** may stipulate operational conditions or restrictions on the plant until all required modifications are completed.

5.0 PRODUCTION RATES

All **HMA Plants** will be evaluated by the **Bureau** and assigned a nominal **Production Rating**. **Production Ratings** will be based on this policy and the industry standards, as applicable, in the referenced NAPA publications (NAPA Procedure). **Production Ratings** will be given in tons (metric tons) of HMA mixture per hour.

5.1 **Assumed Criteria.** Ratings will be based on the conventions described in the referenced NAPA publications. Variables included in the NAPA algorithm are assigned the following values:

5.1.1 Assumed gas flow velocity of 1,000 feet (300 meters) per minute for all dryers.

5.1.2 Radius is calculated at the exhaust end chamber of the dryer.

5.1.3 Assume 147 ft^3 (4.2 m^3) per minute of air required per ton (metric ton) of aggregate.

5.1.4 HMA mixture is assumed to contain 5% asphalt binder.

5.1.5 Combined aggregate contains 5% moisture.

5.2 **Exceptions to NAPA Procedure.**

5.2.1 The **Contractor** may request a temporary increase in **Production Rating** if the incoming aggregate contains less than 5% moisture. The **Contractor** shall (1) provide moisture analysis of the aggregate stockpiles, (2) demonstrate to the **Engineer** that increased production does not affect the quality of the HMA mix, and (3) provide testing requested by the **Engineer** during the analysis and production.

5.2.2 The **Contractor** may request a permanent modification to the **Production Rating** if the design of the plant is not consistent with the schematics and standards contained in the NAPA Procedure. The **Contractor** shall provide the Manufacturer's certification and all calculations supporting the exception. For plants modified by the **Contractor**, the **Contractor** shall provide engineering justification for any request.

5.2.3 For all exceptions, the responsibility for supporting data rests with the **Contractor**. The **Department** may reject requests that, in the sole opinion of the **Engineer**, are not adequately supported.

5.3 **Other Limiting Factors.** The NAPA Procedure may not be applicable in all cases. The plant may include equipment that restricts production capacity below that calculated by the NAPA Procedure. In these instances, the **Bureau** will calculate the **Production Rating** based on these restrictions. The **Department** will provide the **Contractor** with written notification of any such determination, along with the calculations used to determine the **Production Rating**. Examples follow:

5.3.1 <u>Sand Screens – Criteria</u>.

5.3.1.1 Maximum production rate = R = 1.5 tons per hour per ft^2 of 1/8-inch screen (15 metric tons per hour per m^2 of 3.2 mm screen).

5.3.1.2 Sand is 1/3 of aggregate blend.

5.3.1.3 Total aggregate rate = sand screen area x R x 3

5.3.2 Pugmill – Criteria.

5.3.2.1 Capacity based on charts supplied by manufacturer, or

5.3.2.2 Alternate formula: Capacity = Net volume below centerline of shaft x 1.15 x 100 lbs/ft^3 (1,600 kg/m^3).

5.3.2.3 Conversion factor from lbs/batch to tons per hour [TPH] = 0.0325 (kg/batch to metric tons per hour = 0.065). This equation assumes 65 batches per hour.

5.3.3 Aggregate Scale/Hopper Capacities.

5.3.4 Asphalt Binder Scale/Bucket Capacities.

5.3.5 The **Contractor** may request a recalculation of the **Production Rating** when plant modifications change the conditions on which the Limiting Factor was calculated.

6.0 HIGH ESAL AND LOW ESAL APPROVAL

The following will be used to evaluate the consistency of mixtures produced by **HMA Plants** seeking approval to produce High ESAL and Low ESAL mixtures. This includes the sampling, testing, and acceptance requirements for an accelerated gradation and asphalt binder content testing program. It allows for rapid and early determination of reliable target values for gradation and asphalt content.

6.1 The test shall be performed on a High ESAL IL-19.0 binder mix prior to use of the plant for binder production. It may be conducted concurrent with the start of a contract. It may be carried over into an additional contract only with the approval of the **Bureau**.

6.2 The **Contractor** shall proportion the binder mixture to meet the job mix formula (JMF). The **Engineer** may consent to the use of a High ESAL surface mixture for the test if binder is not included in the initial project. If the evaluation is performed on a surface mixture, a restriction of "Surface Mixture Only" approval will apply. An additional evaluation on a binder mixture will be required in order for full **High ESAL and Low ESAL Approval** to be granted.

6.3 The **Bureau** will designate the plant as either Type 1 or Type 2 prior to the start of the **High ESAL and Low ESAL Approval** process.

6.3.1 Type 1 Plants are defined as those which have a prequalification rating of 250 tons (180 metric tons) per hour or greater of mixture.

6.3.2 Type 2 Plants are defined as those which have a prequalification rating of less than 250 tons (180 metric tons) per hour of mixture.

6.4 **Procedure.** Test production specifications are as follows:

6.4.1 Lot Sizes.

6.4.1.1 Plant Type 1. The quantity shall be 5,000 tons (4,500 metric tons) of approved JMF mixture. The evaluation will include 5 lots of approximately 1,000 tons (900 metric tons) each. Each of the 5 lots will be further divided into 5 sublots (for a total of 25 tests).

6.4.1.2 Plant Type 2. The quantity shall be 3,000 tons (4,500 metric tons) of approved JMF mixture. The evaluation will include 5 lots of approximately 600 tons (545 metric tons) each. Each of the 5 lots will be further divided into 5 sublots (for a total of 25 tests).

6.4.2 The procedure will be run over a period of not less than 3 production days.

6.4.3 No more than 2 lots in any day may be included in the evaluation (to allow for lab testing between days).

6.4.4 One lot may be produced before the start of this evaluation process to determine preliminary target values. With approval of the **Engineer**, this lot may be used to establish preliminary target values and rolling patterns per the specified start-up procedures.

6.4.5 The **Contractor** will not be required to cease production between lots. Mixture produced between lots will be evaluated according to the contract specifications.

6.5 **Sampling.** Sampling shall follow the referenced methods:

6.5.1 HMA Mixture. The **Contractor** shall take random samples, with back up splits reserved for the **Department's** use, from each sublot (25 total) from randomly selected trucks. Approximate sample size shall be ± 2,000 g for binder mixtures and ± 1,000 g for surface mixtures.

6.6 **Testing.**

6.6.1 Following the referenced test methods, the **Contractor** shall perform gradation and asphalt binder content analysis for each sublot. Testing will be performed on each hot-mix asphalt sample. Asphalt binder content (AC) control limits and limits on control sieves will be as follows:

Specification Control Limits

PARAMETER	CONTROL LIMIT (INDIVIDUAL TEST)	CONTROL LIMIT (MOVING AVERAGE OF 4)
% Passing		
12.5 mm (1/2 inch)	± 6%	± 4%
4.75 mm (No. 4)	± 5%	± 4%
2.36 mm (No. 8)	± 5%	± 3%
600 µm (No. 30)	± 4%	± 2.5%
75 µm (No. 200)	± 1.5%	± 1.0%
Asphalt Binder Content	± 0.3%	± 0.2%

6.6.2 Results for each test will be evaluated for conformance with the specified control limits. Note: "Moving average" is the average of the results of the current test and the previous 3 individual tests (4 total).

The **Department** will test a minimum of one sample per lot for verification purposes.

6.7 **Adjustments.** On the basis of visual analysis and test results, the **Contractor** may make plant adjustments to improve consistency of the mix. The **Engineer** will cooperate and assist in this effort when requested.

6.8 **Acceptance.** The **Bureau** may approve the plant for normal production when the evaluation shows that the plant can produce mixture that consistently complies with the project specifications. This will generally be defined as when the moving average of each test (all sieves and asphalt binder content) for a single lot remains within the specified moving average control limits. Each successive lot should also show improving and consistent results. However, the individual test results will also be evaluated for consistency. The final two lots will have no individual test results outside the individual control limits.

6.9 **Non-compliance.**

6.9.1 In the case of non-compliance, the **Bureau** may authorize the production of one or more additional lots for testing. Before any such additional production, the **Bureau** will require the **Contractor** to submit a plan of corrective action for approval. The **Contractor** shall demonstrate contract compliance of all material produced.

6.9.2 The **Contractor** shall be responsible for performing all additional testing beyond the 25 tests included in this procedure, and providing back up samples for use by the **Department**. No additional HMA mixture shall be produced for **Department** contracts until all testing is completed.

6.9.3 The **Engineer** may direct or carry out any other corrective action available through the Standard Specifications or other contract documents.

6.9.4 Repeating Plant Approval Process. A **Contractor** failing to produce consistent mixture as defined herein may only continue producing mix if the plant approval process is repeated. In order to repeat the approval process the **Contractor** shall provide a written plan of corrective action to the **Bureau**. Permission to repeat the plant approval process will only be granted if the **Bureau** finds the plan of corrective action to be acceptable

6.9.5 Plant Deficiencies. If the **Bureau** determines that the plant, as configured, is not capable of meeting the conditions for plant approval, the installation of **Positive Dust Control Equipment** or other modifications may be required. Approval and scheduling shall proceed per section 4.6 above.

6.10 **Compensation.** The **Contractor** shall be responsible for all costs, including additional laboratory testing due to non-compliance. These costs will be considered as included in the contract unit price for the HMA item involved.

7.0 CLOSING NOTICE

Archived versions of this policy memorandum may be examined by contacting the **Bureau**.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the **Bureau.**

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Current PFP & QCP Specifications

PFP = Payment for Performance
QCP = Quality Control for Performance
I-FIT = Illinois Flexibility Index Test

MoTP = Manual of Test Procedures
BDE = Bureau of Design and Environment

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Illinois Department of Transportation

Hot-Mix Asphalt PFP Pay Adjustments
Appendix E.1

Effective Date: December 12, 2003
Revised Date: December 1, 2021

This document explains the statistical analysis and procedures used to determine pay adjustments for a hot-mix asphalt (HMA) mixture and a HMA full-depth pavement when Pay for Performance (PFP) is specified as the Quality Management Program (QMP).

Pay parameters are evaluated using percent within limits (PWL) analyzed collectively and statistically by the Quality Level Analysis method to determine the total estimated percent of the lot that is within specification limits. Quality Level Analysis is a statistical procedure for estimating the percent compliance to a specification and is affected by shifts in the arithmetic mean and the sample standard deviation.

Additionally, for a full-depth pavement the adjusted pay and pay adjustment will be calculated using the combined composite pay factors for mixtures used in its construction.

Note: Monetary deductions will be applied separately for both dust/AB ratio using the Dust/AB Ratio Deduction Table and unconfined edge density using the Unconfined Edge Density Deduction Table found in the Standard Specifications Article 406.14.

(a) PAY ADJUSTMENT PROCEDURES

Items 1 through 8 of the following procedure will be repeated for each of the pay parameters (air voids, field VMA and core density) for each lot.

(1) Determine the arithmetic mean ($\bar{x}$) of the test results:

$$\bar{x} = \frac{\sum x}{n}$$

Where:

$\sum$ = summation of
x = individual test value
n = total number of test values

(2) Calculate the sample standard deviation (s):

$$s = \sqrt{\frac{n \cdot \Sigma (x)^2 - (\Sigma x)^2}{n(n-1)}}$$

Where:

$\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

(3) Calculate the upper quality index (Q_U):

$$Q_U = \frac{UL - \bar{x}}{s}$$

Where:

UL = upper specification limit (target value (*TV*) plus allowable deviation)

(4) Calculate the lower quality index (Q_L):

$$Q_L = \frac{\bar{x} - LL}{s}$$

Where:

LL = lower specification limit (target value (*TV*) minus allowable deviation)

(5) Determine P_U (percent within the upper specification limit which corresponds to a given Q_U) from Table 2. (Note: Round up to nearest Q_U in Table 2.)

Note: If a *UL* is not specified, P_U will be 100.

(6) Determine P_L (percent within the lower specification limit which corresponds to a given Q_L) from Table 2. (Note: Round up to nearest Q_L in Table 2.)

Note: If a *LL* is not specified, P_L will be 100.

(7) Determine the Quality Level or *PWL* (the total percent within specification limits).

$$PWL = (P_U + P_L) - 100$$

(8) To determine the pay factor for each individual parameter lot:

Pay Factor (PF) = 55 + 0.5 (PWL)

(9) Once the project is complete determine the Total Pay Factor (*TPF*) for each parameter by using a weighted lot average by tons (mix) or distance (density) of all lots for a given parameter.

TPF = W1PFlot1 + W2PFlot(n+1) + etc.

Where:

W1,W2… = weighted percentage of material evaluated
PF = Pay factor for the various lots
TPF = Total pay factor for the given parameter

(10) Determine the Composite Pay Factor (*CPF*) for each mixture. The *CPF* shall be rounded to 3 decimal places.

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PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

$$CPF = [f_{Voids}(TPF_{Voids}) + f_{VMA}(TPF_{VMA}) + f_{Density}(TPF_{Density})] / 100$$

Substituting from Table 1:

$$CPF = [0.3(TPF_{Voids}) + 0.3(TPF_{VMA}) + 0.4(TPF_{Density})] / 100$$

Where:

f_{Voids}, f_{VMA}, *and* $f_{Density}$ = Parameter Weights listed in Table 1

TPF_{Voids}, TPF_{VMA}, *and* $TPF_{Density}$ = *Total Pay Factor for the designated measured attribute from (9)*

(11) Determine the adjusted pay and pay adjustment for a given mixture.

Plan Unit Pay = Mixture Unit Price x Quantity

Adjusted Pay = Plan Unit Pay x CPF

Pay Adjustment = Adjusted Pay – Plan Unit Pay

(12) To determine the adjusted pay and pay adjustment for a full-depth pavement, first combine the composite pay factors for all mixtures to arrive at the combined composite pay factor. Each mixture composite pay factor will be weighted equally. Mixtures placed having the same gyration values but with and without polymer will be treated as two separate mixtures. For example, one surface mix and one binder mix will be weighted 50/50 regardless of tonnage. Additionally, one surface mix, one polymer binder mix and one non-polymer binder mix will be treated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts. The full-depth adjusted pay is determined by multiplying the plan unit pay by the combined composite pay factor. The pay adjustment is then determined by subtracting the plan unit pay from the adjusted pay.

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

Table 1

<table>
<tr><th colspan="5">Pay Parameters, Parameter Weights “f” and Quality Levels</th></tr>
<tr><th colspan="2">Pay Parameter</th><th>Parameter Weight “f”</th><th>UL</th><th>LL</th></tr>
<tr><td colspan="2">Air Voids</td><td>0.3</td><td>Design Voids + 1.35</td><td>Design Voids – 1.35</td></tr>
<tr><td colspan="2">Field VMA</td><td>0.3</td><td>MDR[/1] + 3.0</td><td>MDR[/1] – 0.7</td></tr>
<tr><td rowspan="4">In-Place Density</td><td>IL-4.75</td><td rowspan="4">0.4</td><td>97.5</td><td>92.5</td></tr>
<tr><td>IL-9.5, IL-9.5FG</td><td>97.5</td><td>91.5</td></tr>
<tr><td>IL-19.0</td><td>97.5</td><td>92.2</td></tr>
<tr><td>SMA</td><td>98.0</td><td>93.0</td></tr>
</table>

1. MDR = Minimum Design Requirement (VMA)

Illinois Department of Transportation

PFP Quality Level Analysis
Appendix E.1
(continued)

Effective: December 12, 2003
Revised: December 1, 2021

TABLE 2: QUALITY LEVELS
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58

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Appendix E.1
(continued)

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TABLE 2: QUALITY LEVELS (continued)
QUALITY LEVEL ANALYSIS BY STANDARD DEVIATION METHOD

P_U OR P_L PERCENT WITHIN LIMITS FOR POSITIVE VALUES OF Q_U OR Q_L	UPPER QUALITY INDEX Q_U OR LOWER QUALITY INDEX Q_L														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to infinity
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.53
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: For negative values of Q_U or Q_L, P_U or P_L is equal to 100 minus the table P_U or P_L. If the value of Q_U or Q_L does not correspond exactly to a figure in the table, use the next higher value.

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(continued)

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(b) Examples

Example 1 – One Lift Overlay:

Determine the adjusted pay and pay adjustment for the given lot of a N90 IL-9.5 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 27,840 tons over 16.7 miles.

Note that mix sample and density lots are independent of each other.

In this example the first mix sample lot represents 10,000 tons while the first density lot represents 6 miles (N=30). The project would have two additional mix and density lots following the same calculations as the first mix and density lots, respectively. All three lots are combined as per step (9).

Mix sample: Each sublot represents 1000 tons

Lot #	Sublot #	Air Voids TV = 4.0	Field VMA Design Min. = 15.0
1	1	4.2	15.4
	2	4.5	15.7
	3	3.3	14.9
	4	5.0	15.0
	5	5.4	15.2
	6	2.5	15.5
	7	3.8	15.2
	8	4.1	15.3
	9	4.3	15.4
	10	4.5	15.6
	Average:	4.16	15.32
	Standard Deviation:	0.825	0.253

Density: Each density test interval represents 0.2 mile (5 cores are taken per mile) along the 6 miles of paving resulting in an N=30.

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Lot #	Density Test Interval	Density
1	1	91.5
	2	93.0
	3	92.9
	4	93.5
	5	93.0
	6	94.0
	7	92.8
	8	93.5
	9	91.0
	⋮	⋮
	30	92.7
Average:		92.79
Standard Deviation:		0.910

Determine the pay factor for each parameter.

Air Voids:

Lot: Average = 4.16
Standard Deviation = 0.825

$$Q_U = \frac{(4.0 + 1.35) - 4.16}{0.825} = 1.44$$

$$Q_L = \frac{4.16 - (4.0 - 1.35)}{0.825} = 1.83$$

N = 10 sublots (from Table 2)

P_U = 94

P_L = 98

PWL = (94 + 98) - 100

PWL = 92

PF = 55 + 0.5 (92)

PF = 101.0

Determine the pay factor for Air Voids.

PF_{Voids} = 101.0

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Field VMA:

Lot : Average = 15.32
Standard Deviation = 0.253

$$Q_U = \frac{(15.0+3.0)-15.32}{0.253} = 10.59$$

$$Q_L = \frac{15.32-(15.0-0.7)}{0.253} = 4.03$$

N = 10 sublots (from Table 2)

P_U = 100

P_L = 100

PWL = (100 + 100) - 100

PWL = 100

PF = 55 + 0.5 (100)

PF = 105.0

Determine the pay factor for Field VMA.

PF_{VMA} = 105.0

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Density:

Lot: Average = 92.79
Standard Deviation = 0.910

$$Q_U = \frac{97.0 - 92.79}{0.910} = 4.63$$

$$Q_L = \frac{92.79 - 91.5}{0.910} = 1.42$$

N = 30 Density measurements (from table)

P_U = 100

P_L = 93

PWL = (100 + 93) - 100

PWL = 93

PF = 55 + 0.5 (93)

PF = 100.5

Determine the pay factor for Density.

$PF_{Density}$ = 101.5

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Determine the total pay factors for each parameter. In this example the Air Voids PF and Field VMA PF for the second and third lots are given to be equal to the Air Voids PF and Field VMA PF for the first lot, respectively. The total pay factor for density ($TPF_{Density}$) is calculated as shown below.

Lot #	Mix Tons	Air Voids PF	Field VMA PF	Density Distance	Density PF
1	10,000	101.0	105.0	31680 ft	101.5
2	10,000	101.0	105.0	31680 ft	101.4
3	7,840	101.0	105.0	24640 ft	97.3
Total	27,840			88000 ft	
TPF		**101.0**	**105.0**		**100.3**

$TPF_{Density} = W1PF_{lot1} + W2PF_{lot2} + W3PF_{lot3}$

$TPF_{Density}$= (31680/88000)(101.5)+(31680/88000)(101.4)+(24640/88000)(97.3)

$TPF_{Density}$= 100.3

Combine the three Total Pay Factors to determine the Composite Pay Factor for the mix.

CPF = [0.3(101.0) + 0.3(105.0) + 0.4(100.3)] / 100

CPF = 1.019

Determine the adjusted pay for the given mixture.

Given that the mixture bid price per ton = $65.00 and 27,840 tons were placed.

Plan Unit Pay = $65.00/ton x 27,840 tons = $1,809,600.00

Adjusted Pay = $65.00/ ton x 27,840 tons x 1.019 = $1,843,982.40

The pay adjustment is the difference between the adjusted pay and the plan unit pay.

Pay Adjustment = $1,843,982.40 – $1,809,600.00 = $34,382.40

If the difference is a positive value this will be the incentive paid. If the difference is a negative value this will be the disincentive applied. In this case a $34,382.40 incentive would be paid as per Construction Memorandum #4.

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Example 2 – Full Depth:

Given: a 14,000 sq yd full-depth project bid at $40/sq yd with two mixtures whose composite pay factors were determined to be 101.5% and 99.2%. The full-depth combined composite pay factor will be calculated as follows:

101.5(1/2) + 99.2(1/2) = 100.4%

Determine the adjusted pay and pay adjustment for the full-depth pavement.

Given that the bid price per square yard = $40.00 and 14,000 sq yd were placed.

Plan Unit Pay = $40.00/ sq yd x 14,000 sq yd = $560,000

Adjusted Pay = $40.00/ sq yd x 14,000 sq yd x 1.004 = $562,240

Pay Adjustment = $562,240 – $560,000 = $2,240 (Positive value = Incentive)

Example 3 – Full Depth:

Given: a 43,000 sq yd full-depth project bid at $40/sq yd with three mixtures whose composite pay factors were determined to be 98.9%, 101.5% and 99.2%. The full-depth combined composite pay factor will be calculated as follows:

98.9(1/3) + 101.5(1/3) + 99.2(1/3) = 99.9%

Determine the adjusted pay and pay adjustment for the full-depth pavement.

Given that the bid price per square yard = $40.00 and 43,000 sq yd were placed.

Plan Unit Pay = $40.00/ sq yd x 43,000 sq yd = $1,720,000

Adjusted Pay = $40.00/ sq yd x 43,000 sq yd x 0.999 = $1,718,280

Pay Adjustment = $1,718,280 – $1,720,000 = -$1,720 (Negative value = Disincentive)

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2

Effective Date: May 1, 2008
Revised Date: December 1, 2021

Samples shall be obtained at the frequencies specified in the Standard Specification Articles 1030.07 and 1030.08 for PFP and QCP, respectively.

A. The samples shall be taken at the randomly selected tonnage within a sublot. The random tonnage will be determined by the Engineer using the “Random Numbers” table as specified herein or the Department’s Quality Management Program (QMP) Package software. The tonnage shall be calculated according to the following:

1. Unless otherwise known, determine the random locations for a tonnage in excess of five percent over plan quantity by multiplying the plan quantity tonnage by 1.05 to determine an over-projected final quantity. If the over-projected final quantity is not achieved, disregard the additional random values.

2. Determine the maximum number of sublots needed for the given mixture by dividing the over-projected tonnage calculated above by the sublot size in tons (metric tons) (typically 1,000 tons). Round this number to the next whole value. This will determine the maximum number of sublots for the given mixture.

3. Multiply the sublot tonnage by a three-digit random number, expressed as a decimal. The number obtained (rounded to a whole number) shall be the random sampling tonnage within the given sublot.

4. The individual sublot random tonnages shall then be converted to cumulative random tonnages. This is accomplished by using the following equation for each sublot.

$$\mathrm{CT}_n = [(\mathrm{ST}) \text{ x } (n-1)] + \mathrm{RT}_n$$

Where: n = the sublot number
CT = Cumulative tonnage
RT = Random tonnage as determined in #3 above
ST = Sublot tonnage

B. If paving is completed for a particular mixture before the specified sampling tonnage for the last sublot is achieved, the last sublot shall be omitted.

C. Samples shall be taken out of trucks at the plant. The truck containing the random tonnages will be determined by the Engineer following the procedure described herein. Two sampling platforms (one on each side of the truck) shall be provided for sampling of the mix. In order to obtain a representative sample of the entire truck load, an equal amount of material shall be taken from each quarter point around the circumference of each pile in the truck to obtain a composite sample weighing approximately 200lb (95 kg). All material shall be obtained by using a "D"-handled, square-ended shovel with built-up sides and back (1 to 1.5 in. [25 to 38 mm]). The sample tonnage will be disclosed no more than 30 minutes prior to sampling. Sampling shall be performed by the Contractor under the supervision of the Engineer.

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2
(continued)
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D. The truck sample shall be divided into three approximately equal size (split) samples by the use of an approved mechanical sample splitter. The Engineer will witness all splitting. Two split samples for Department testing shall be placed in Department-approved sample containers provided by the Contractor and identified as per the Engineer's direction. The Engineer will gain immediate possession of both Department split samples. The Contractor may store, discard, or test the remaining split sample as described in Section 1030 of the Standard Specifications. However, the Contractor must test and provide the sample results in order to initiate the dispute resolution process as described in the Hot-Mix Asphalt Pay for Performance Special Provision.

Example:

Given: Plan quantity = 10,000 tons for a given mixture. Sublot = 1,000 tons.

1. Determine the over-projected final tonnage.

   10,000 tons x 1.05 = 10,500 tons

2. Determine the maximum number of sublots needed for the project based on the over-projected tonnage.

   10,500 tons/1,000 tons = 10.5 (Note: Always round up)
   Therefore, a maximum of 11 sublots

3. Obtain random numbers from the table and apply a different random number to each sublot.

   1000 x 0.546 = 546
   1000 x 0.123 = 123

   Repeat for **each** sublot.

4. Convert **individual** tonnages to cumulative job tonnage.

   [1,000 x (1-1)] + 546 = 546
   [1,000 x (2-1)] + 123 = 1,123

   Repeat for each sublot.

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
Appendix E.2
(continued)
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The following contains a completed table for the 11 plant random samples:

Lot Number	Sublot Number	Random Number	Tonnage within Sublot	Cumulative Job Tonnage
1	1	0.546	1000 x 0.546 = 546	[1000 x (1-1)] + 546 = 546
	2	0.123	1000 x 0.123 = 123	[1000 x (2-1)] + 123 = 1123
	3	0.789	1000 x 0.789 = 789	[1000 x (3-1)] + 789 = 2789
	4	0.372	1000 x 0.372 = 372	[1000 x (4-1)] + 372 = 3372
	5	0.865	1000 x 0.865 = 865	[1000 x (5-1)] + 865 = 4865
	6	0.921	1000 x 0.921 = 921	[1000 x (6-1)] + 921 = 5921
	7	0.037	1000 x 0.037 = 37	[1000 x (7-1)] + 37 = 6037
	8	0.405	1000 x 0.405 = 405	[1000 x (8-1)] + 405 = 7405
	9	0.214	1000 x 0.214 = 214	[1000 x (9-1)] + 214 = 8214
	10	0.698	1000 x 0.698 = 698	[1000 x (10-1)] + 698 = 9698
	11	0.711	1000 x 0.711 = 711	[1000 x (11-1)] + 711 = 10711

If paving is completed prior to production of the 10,711 ton of mixture, the 11^{th} sublot is omitted.

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Hot-Mix Asphalt PFP and QCP Random Plant Samples
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(continued)
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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations Appendix E.3

Effective Date: April 1, 2009
Revised Date: December 1, 2021

Random density test locations will be determined at the frequency specified in the Standard Specification Articles 1030.07 and 1030.08. Cores shall be collected by the Contractor at these locations and secured by the Department for testing. The test locations will be determined as follows:

A) Prior to paving, the test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's Quality Management Program (QMP) Package software. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department until finish rolling is complete. Disclosing the information prior to finish rolling would be in direct violation of federal regulations. Once random test locations are determined by the Engineer, it may be necessary to alter these locations due to quantity adjustments, sequencing changes, or other alterations made by the Department or Contractor. The Engineer will document any changes to the random test locations and provide documentation to the Contractor upon completion of the project.

Each test location will be randomly located both longitudinally and transversely within each density interval by using two random numbers. The first random number is used to determine the longitudinal distance to the nearest 1 ft (300 mm) into the density testing interval. The second random number is used to determine the transverse offset to the nearest 0.1 ft (30 mm) from the left edge of the **paving lane**. The direction of the **paving lane** will be the same as the direction of traffic.

Longitudinal Location: Determine the random longitudinal location by multiplying the length of the prescribed density interval by the random number selected from the Random Numbers table.

Transverse Offset to Center of Core: Determine the random transverse offset as follows:

1. PFP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each unconfined edge from the entire paved lane width (i.e. If a 12.0 ft (3.7 m) wide paved lane has two unconfined edges, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 1.0 ft (300 mm) for each confined longitudinal joint with longitudinal joint sealant (LJS) (i.e. If a 12.0 ft (3.7 m) wide paved lane has one unconfined edge without LJS and one confined edge with LJS, the effective lane width would be 10.0 ft (3.0 m).) The effective lane width is reduced by 4.0 in. (100 mm) for each confined edge without LJS. The effective lane width is further reduced 4.0 in. (100 mm) for the diameter of the core barrel.

   Effective lane width of PFP pavement = pavement lane width – 1.0 ft (300 mm) for each unconfined/LJS edge – 4.0 in. (100 mm) for each confined non LJS edge – 4.0 in. (100 mm) for core barrel

   The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is unconfined or located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

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Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge is unconfined/LJS edge + 4.0 in. (100 mm) if left edge is confined non LJS edge + 2.0 in. (50 mm) for core barrel

Areas outside the mainline pavement that are paved concurrently with the mainline pavement (i.e. 3 ft (1 m) wide shoulders, driveways, etc.) are not considered part of the paved mainline mat. See the PFP example calculation herein.

Additionally, the longitudinal joint density test locations of a paved lane with one or both unconfined edges without LJS will be determined by multiplying each sublot length for each unconfined, non-LJS edge by a random number. The transverse locations of the longitudinal joint density coring will be centered at a distance of 4.0 in. (150 mm) plus 2.0 in. (50 mm) (to account for the distance from the edge of the core barrel to the center of core) from each unconfined, non-LJS edge. See the PFP example calculation herein.

2. QCP. The effective lane width of the paving lane will be used in calculating the transverse offset. The effective lane width is determined by first subtracting 1.0 ft (300 mm) for each longitudinal joint with LJS from the entire lane width. The effective lane width is then reduced 4.0 in. (100 mm) for each joint that does not have LJS. The effective lane width is further reduced by 4.0 in. (100 mm) for the diameter of the core barrel.

   Effective lane width of QCP pavement = pavement lane width – 1.0 ft (300 mm) for each edge with LJS – 4.0 in. (100 mm) for each edge without LJS – 4.0 in. (100 mm) for core barrel

   The transverse offset is determined by first multiplying the effective lane width by the selected random number. If the left edge is located immediately above LJS, 1.0 ft (300 mm) will be added to the calculated transverse offset measurement. If the left edge is confined but without LJS, 4.0 in. (100 mm) will be added to the calculated transverse offset measurement. An additional 2 in. (50 mm) will be added to the calculated transverse offset measurement to account for the distance from the edge of the core barrel to the center of core. The transverse offset is measured from the left physical edge of the paved lane to locate the center of the core on the pavement.

   Transverse Offset to Center of Core = effective lane width x random number + 1.0 ft (300 mm) if left edge has LJS + 4.0 in. (100 mm) if left edge does not have LJS + 2.0 in. (50 mm) for core barrel. Cores taken within 1.0 ft (300 mm) of an unconfined edge without LJS will have 2.0% density added for pay adjustment calculation purposes. See the QCP example calculation herein.

B) This process will be repeated for all density intervals on a given project.

C) Moving Test Locations.

There are two scenarios in which random test locations may be moved longitudinally using the same random transverse offset. The first scenario is to avoid only the obstacles listed under Case 1 below. The second scenario is to avoid pavement defects in the surface being overlaid as described in Case 2 below.

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1) Case 1. In the event the random test location will not allow the necessary compactive effort to be applied, the Engineer will adjust the longitudinal location of the test location in order to avoid the obstacle. Using the same random transverse offset, the test location will be moved longitudinally, ± 15 ft (4.6 m) to avoid the following obstacles only:

   a) Structures or Bridge Decks
   b) Detection loop or other pavement sensors
   c) Manholes or other utility appurtenances

2) Case 2. In the event there are pavement defects in the surface being overlaid, the Contractor may place temporary markings on the shoulder prior to paving to represent longitudinal locations where a defect is present. These pavement defect locations will be approved by the Engineer. If a random test location lands at the same longitudinal location as a temporary mark, the test location will be moved 5 ft (1.5 m) past the temporary mark in the direction toward the paver at the same transverse offset. In the case of an asphalt scab (i.e. thin layer of less than 0.5 in. (13 mm) of asphalt pavement remaining after milling) the temporary markings shall show the extent or length of the defect. The test location will then be moved to a longitudinal distance 5 ft (1.5 m) past the end of the defect toward the paver.

D) Example Calculations.

<u>PFP Example.</u>

This **PFP** example illustrates the determination of the random test locations within the first mile of a lot.

Given: The HMA pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined without LJS and the right edge unconfined without LJS.

This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.917, 0.289, 0.654, 0.347, and 0.777. The random numbers for the transverse direction are: 0.890, 0.317, 0.428, 0.998, and 0.003.

The individual longitudinal density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = random distance within the given density testing interval

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The longitudinal test locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile). The transverse core locations are determined by multiplying the transverse random number by the effective width of the paved mat.

Determine the effective lane width by subtracting 1.0 ft for each unconfined edge and 4.0 in. (0.33 ft) for each confined edge without LJS from the 13.0 ft paved lane width. In this case the right edge is unconfined, so subtract 1.0 ft (1.0 ft), and the left edge is confined without LJS so subtract 4.0 in. (0.33 ft). Then subtract 4.0 in. (0.33 ft) for the width of the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width of 11.34 ft by the random numbers and adding 4.0 in. (0.33 ft) for the left confined edge plus 2.0 in. (0.17 ft) for the core barrel (0.33 ft + 0.17 ft = 0.5 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows (See Figure 1):

Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location1/
1	1056 x 0.917 = 968 ft	1056 x (1-1) + 968 = 968 ft	(11.34 x 0.890) + 0.5 = 10.6 ft
2	1056 x 0.289 = 305 ft	1056 x (2-1) + 305 = 1361 ft	(11.34 x 0.317) + 0.5 = 4.1 ft
3	1056 x 0.654 = 691 ft	1056 x (3-1) + 691 = 2803 ft	(11.34 x 0.428) + 0.5 = 5.4 ft
4	1056 x 0.347 = 366 ft	1056 x (4-1) + 366 = 3534 ft	(11.34 x 0.998) + 0.5 = 11.8 ft
5	1056 x 0.777 = 821 ft	1056 x (5-1) + 821 = 5045 ft	(11.34 x 0.003) + 0.5 = 0.5 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

Additionally, there will be two longitudinal joint density sublots in the unconfined right edge within the mile section, each sublot 0.5 mile (2640 ft). The random numbers to determine the locations for coring are: 0.822 and 0.317.

Sublot #	Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location1/
1	1	2640 x 0.822 = 2170 ft	2640 x (1-1) + 2170 = 2170 ft	6.0 in.
2	2	2640 x 0.317 = 837 ft	2640 x (2-1) + 837 = 3477 ft	6.0 in.

1/ Transverse location of the center of the core measured from the right physical edge of the paved lane.

QCP Example.

This **QCP** example illustrates the determination of the core locations within the first mile of a project.

Given: The pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined with LJS and the right edge unconfined without LJS.

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This will require a density testing interval of 0.2 miles. The random numbers for the longitudinal direction are: 0.904, 0.231, 0.517, 0.253, and 0.040. The random numbers for the transverse direction are: 0.007, 0.059, 0.996, 0.515, and 0.101.

The individual density test interval distances can be converted to the cumulative random distance using the following equation:

$$CD_n = [D \times (n-1)] + R_n$$

Where:

n = the density interval number
CD = cumulative distance
D = density testing interval length (typically 1056 ft (0.2 mile))
R = Random distance within the given density testing interval

The longitudinal core locations are determined by multiplying the longitudinal random numbers by 1056 ft (0.2 mile).

The transverse core locations are determined by multiplying the transverse random numbers by the effective lane width. The effective lane width is the width of the paved lane minus 1.0 ft for the left edge confined with LJS, 4.0 in (0.33 ft) for the right edge without LJS, and 4.0 in. (0.33 ft) for the core barrel.

Effective Lane Width = 13.0 ft - 1.0 ft - 0.33 ft – 0.33 ft = 11.34 ft

The calculated transverse offset distances are determined by multiplying the effective lane width by the random numbers and adding 1.0 ft for the left confined edge with LJS plus 2.0 in. (0.17 ft) for the core barrel (1.0 ft + 0.17 ft = 1.17 ft). The random locations for the first mile measured from the beginning of the lot and the left (confined) edge of the paved mat to the center of the core barrel are as follows:

Core #	Longitudinal Location	Cumulative Distance	Center of Core Transverse Location[1/]
1	1056 x 0.904 = 955 ft	1056 x (1-1) + 955 = 955 ft	(11.34 x 0.007) + 1.17 = 1.2 ft
2	1056 x 0.231 = 244 ft	1056 x (2-1) + 244 = 1300 ft	(11.34 x 0.059) + 1.17 = 1.8 ft
3	1056 x 0.517 = 546 ft	1056 x (3-1) + 546 = 2658 ft	(11.34 x 0.996) + 1.17 = 12.5 ft
4	1056 x 0.253 = 267 ft	1056 x (4-1) + 267 = 3435 ft	(11.34 x 0.515) + 1.17 = 7.0 ft
5	1056 x 0.040 = 42 ft	1056 x (5-1) + 42 = 4266 ft	(11.34 x 0.101) + 1.17 = 2.3 ft

1/ Transverse location of the center of the core measured from the left physical edge of the paved lane.

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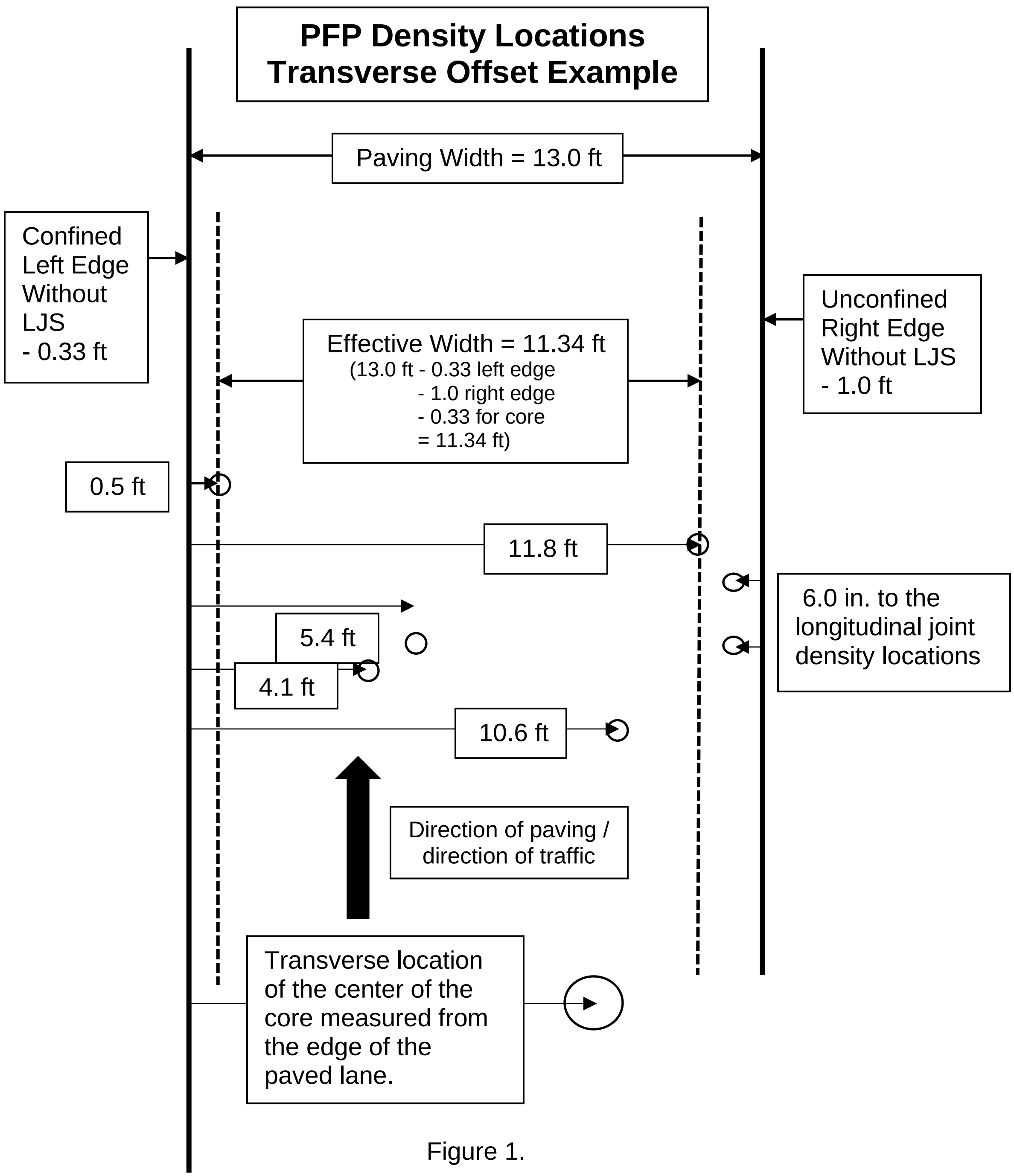

Figure 1.

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
Appendix E.4

Effective Date: April 1, 2008
Revised Date: December 1, 2021

Hot-mix asphalt (HMA) samples shall be obtained at the frequency specified in the Standard Specification Article 1030.07 for mixtures using Pay for Performance (PFP) criteria and 1030.08 for mixtures using Quality Control for Performance (QCP) criteria.

The jobsite mixture samples shall be taken at randomly selected test locations within each sublot. Prior to paving, the random test locations will be determined by the Engineer using the "Random Numbers" table as specified herein or the Department's Quality Management Program (QMP) Package software. The values are to be considered confidential and are not to be disclosed to anyone outside of the Department prior to the truck containing the random tonnage arriving at the jobsite. Disclosing the information would violate the intent of this procedure and federal regulations.

The sample location will be determined by calculating the longitudinal distance the truck delivering the random sample tonnage would travel to discharge the random sample tonnage. The starting station for the longitudinal distance measurement is the location of the paver where the truck begins to unload the mixture into the paver or Material Transfer Device (MTD). Computations are made to the nearest 1 ft (300 mm) (see examples in the appendix herein). In the event the job site conditions pose a safety risk, the Engineer will adjust the random test location to the nearest safe location. Unsafe conditions include: intersections, narrow or restricted areas such as underpasses, on interchange ramps within 100 ft (30 m) of an access controlled highway, or any other situation deemed unsafe.

If the paving is completed for a mixture before the specified sampling test location for the last mixture sublot is completed, a sample will not be taken and the tonnage will be added to the previous lot.

The Contractor may select either sampling behind the paver or sampling from the MTD discharge chute. The Contractor shall provide the necessary equipment and HMA Level I personnel to obtain the required samples, for whatever method is chosen, as specified herein.

A. Behind the Paver Sampling.

   This method covers the procedures for sampling HMA mixtures at the point of delivery immediately behind the paver and before initial compaction. This method is intended to provide a single composite sample that is representative of the mixture as produced (i.e. excludes paver effects).

   1. Equipment.

      1. IDOT Approved Sampling Shovel (Figure 1).

      2. Sample Containers (4 each). Metal sample buckets with a minimum capacity of 3.5 gal (13 L).

      3. IDOT Approved HMA Sample Splitter.

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Effective Date: April 1, 2008
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4. Plate/Shovel Sampling. The following additional equipment is needed when sampling HMA placed directly over a milled surface, rubblized concrete or an aggregate base.

   1) Sampling Plates (4 each). The sampling plates shall be rectangular and have a minimum size of 14 x 28 in. (360 x 720 mm). Plates shall have a hole approximately 0.25 in. (6 mm) in diameter drilled through each of the four corners.

   2) Lifting Handles and Wire Lead. A 24 in. (600 mm) length of wire shall be attached to the two holes on one side of the plate to serve as a lifting handle. An additional wire lead shall be attached to one of the lifting handles for locating the buried plate in the pavement. This wire shall extend to the edge of the pavement.

   3) Hammer and masonry nails for securing plates and wire lead.

Overall Length = 5 ft (1.5 m)
Shovel Width = 10 in. (255 mm)
Shovel Length = 12 in. (305 mm)
Shovel Sides = 4 in. (100 mm)

Figure 1. Aluminum Sampling Shovel & Dimensions

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Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
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Effective Date: April 1, 2008
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1. Shovel Sample Sampling Procedure (Without Plates). This method shall be used when sampling over smooth HMA and concrete surfaces.

   a) The sampling shovel shall be used at each of the four offsets illustrated in Figure 2. to dig directly downward into the HMA behind the paver until it comes into contact with the previous pavement surface. When in contact, the shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

2. Shovel/Plate Sampling Procedure (With Plates). This method shall be used when sampling HMA directly over aggregate base, stabilized subbase, rubblized concrete, or a milled surface. This method may not be appropriate for a 3/4 in. (19 mm) binder lift over a milled surface. In the case of IL-4.75 or IL-9.5 FG mixtures, if approved by the Engineer, these mixtures may be shovel sampled from the auger area at the designated random location. Intentions of sampling IL-4.75 or IL-9.5 FG mixtures in this manner shall be listed in the approved QC Plan.

   a) Each plate with the wire lead attached to the handle shall be placed at one of four positions at the designated location ahead of the paver according for Figure 2. If conditions on the project require restricting movement of the plate, a nail shall be driven through one of the holes in the plate and into the pavement.

   b) The wire lead shall be extended beyond the edge of the pavement. Trucks, pavers, and/or material transfer devices will be allowed to cross over the plate and/or wire lead.

   c) After the HMA is placed, the wire lead shall be used to locate the plate. Once located, the wire handles shall be lifted out of the pavement. This will locate the four corners of the plate.

   d) Once the plate edges are defined, the shovel shall be used to dig downward through the thickness of the HMA behind the paver until it is in contact with the plate. The shovel shall be pushed forward until it is full. The shovel shall be lifted up slowly. The mix shall be carefully placed into the sample container in order to prevent any loss of HMA.

   e) Remove the sampling plates from the pavement.

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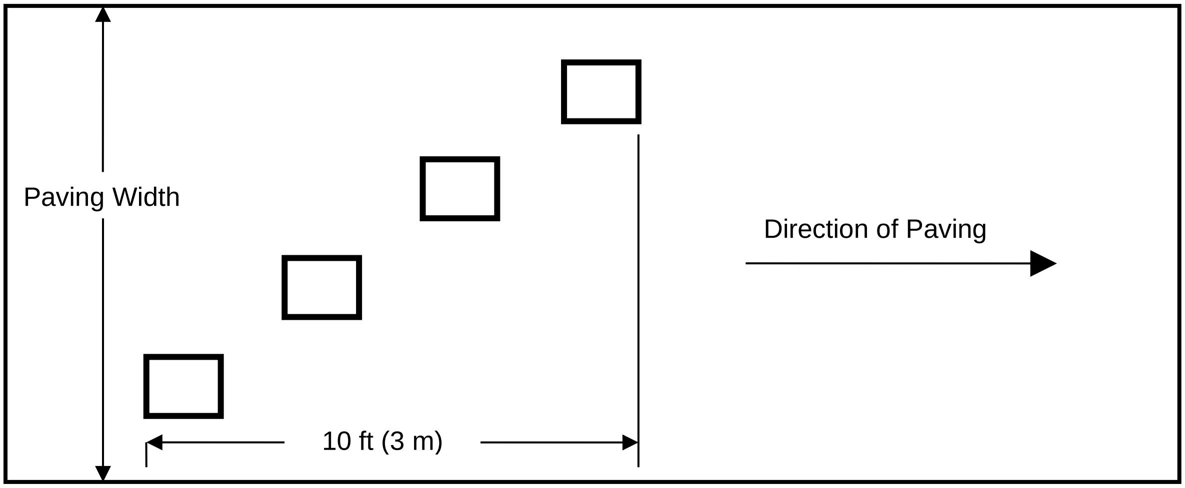

Figure 2. Behind the Paver Sampling Layout

2. Composite/Lab Samples.

   1. HMA samples shall be taken, blended and split, using an IDOT approved HMA splitter, onsite by the Contractor and witnessed by the Engineer. The sample shall be taken immediately behind the paver and before initial roller compaction. One composite sample consists of four increments collected within 10 ft (3 m) longitudinally and diagonally across the width of the paving operation (Fig. 2). The four increments shall be blended according to HMA Level I procedures to provide a single composite sample.

   2. Composite Sample.

      PFP and QCP. A composite sample size shall be a minimum of 200 lb (90 kg).

   3. Lab Sample.

      PFP and QCP. The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

3. Sample Site Repair.

   a) HMA from the paver auger system shall be used to fill the voids left in the pavement from sampling. To reduce segregation and low density in the finished mat, buckets shall be used to fill the voids left by the samples.

Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
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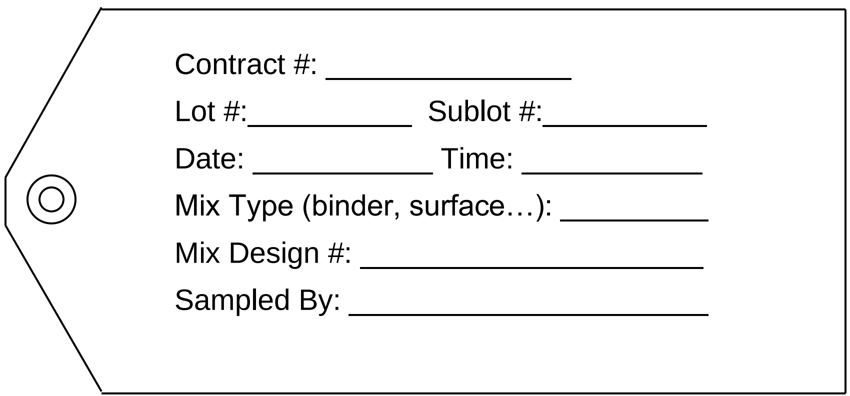
PFP and QCP. The minimum lab sample size of 50 lb (23 kg) shall be obtained by splitting the composite samples into four equal lab samples using an IDOT approved HMA splitter. The Engineer will secure three Department lab samples for the Contractor to transport to the District Materials Laboratory.

C. Documentation – After the sample has been obtained, the following information shall be written on each sample bag or box with a felt tip marker.



D. Sample Security – Each sample bag will be secured by the Engineer using a locking ID tag. Sample boxes will be sealed/taped using a security ID label.

E. Sample Transportation – The Contractor shall deliver the secured sample to the District Laboratory, during regular working hours, within two days of sampling.

F. Examples:

1. Behind Paver Sampling. Determination of random sample locations for behind the paver sampling.

   This example illustrates the determination of the random behind the paver test location within a sublot:

   Given: A surface mix with a design G_{mb} of 2.400 is being placed 12 feet wide and 1.5 inches thick. The Engineer has determined all the undisclosed random tonnages prior to production. The plan quantity on the project was 10,000 tons and enough random values were determined to allow for a 5% overrun assuring enough random tonnages were generated. Discard any overrun random tonnages if the placed tonnage on the project is less than the calculated tonnage.

Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling
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Sublot Number	Random Number	Sublot Tonnage	Cumulative Job Tonnage
1	0.1669	167	167
2	0.5202	520	1520
3	0.3000	300	2300
4	0.6952	695	3695
5	0.4472	447	4447
6	0.2697	270	5270
7	0.5367	537	6537
8	0.7356	736	7736
9	0.4045	405	8405
10	0.3356	336	9336
11	0.0899	90	10090

The truck containing the mix representing the 167 ton shall be the first sublot tested. The truck in question contains 12 tons of mix, the 160 to 172 cumulative tons to be placed on the project. Determine the random location by dividing the value of the selected truck tonnage to determine the random distance value to 3 decimal places.

167 – 160 = 7 (where the random ton falls within the truck)

7/(172-160) = 7/12 = 0.583 (random distance value)

Determine the distance using 58.3% of the distance the mix in the truck will pave out using the following formula:

$$Longitudinal\ Distance = \frac{384.6 \times Tons \times RD}{Gmb \times width \times thickness}$$

Where:

Longitudinal Distance = random distance from starting station (ft)
Tons = total tons within the sample truck
RD = random distance value as calculated above
G_{mb} = design G_{mb} for the mix being placed
Width = width of mat being paved (ft)
Thickness = thickness of mat being paved (in.)

$$Longitudinal\ Distance = \frac{384.6 \times 12 \times .583}{2.400 \times 12 \times 1.5}$$

Longitudinal Distance = 62.3 ft = 62 ft

Measure the calculated longitudinal distance from the starting station where the truck began to unload. Determine and document the random sample station and obtain the random mix sample as outlined herein.

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Starting Station = 105+00
Random Sample Location = 105+00 + 62 = 105+62

This process shall be repeated for the subsequent sublots.

2. Examples of MTD Sampling Devices.

Figure 3. Example of MTD Sampling Device

Figure 4. Additional Examples of MTD Sampling Devices

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Figure 5. Additional Examples of MTD Sampling Devices

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Figure 6. Additional Examples of MTD Sampling Devices

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RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.301	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.146
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.281	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

Note: Always select a new set of numbers in a systematic manner, either horizontally or vertically. Once used, the set should be crossed out.

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RANDOM NUMBERS

PFP/QCP Jobsite Sampling Location Determination

Date:	______	Contract #:	______	Route:	______
HMA Mix #:	______	HMA Mix Code:	______	HMA Desc.:	______
Design G_{mb}:	______	Pvt width(w):	______	Pvt thickness(t):	______

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

Lot #:		Sublot #:		Sampling Tonnage (st):	

Begin Truck Tons (b):		Longitudinal Distance(d): *(d)=[384.6(q)(rd)] / [G_{mb}(w)(t)]*	
End Truck Tons (e):		Starting Station(ss):	
Tons in Truck (q): *(q)=(e)-(b)*		Random sample location(rl): *(rl)=(ss)+/-(d)* *{add or subtract if up/down sta.}*	
Random Truck distance(rd): *(rd)=[(st)-(b)]/(q)*			

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Hot-Mix Asphalt PFP Dispute Resolution
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A. Scope

This document describes the two methods for disputing Pay for Performance (PFP) test results and the requirements for each. It also provides cost information for dispute testing and instructions for submitting dispute resolution samples to the Central Bureau of Materials (CBM). All participating Contractor Labs shall meet all the requirements of an Approved QC Laboratory by the Department.

B. Dispute Resolution

Dispute resolution testing will be permitted when the Contractor submits their split sample test results prior to receiving Department split sample test results. Dispute resolution testing shall be according to Method 1 (pay parameter dispute) or Method 2 (individual parameter dispute). When dispute resolution is chosen, the Contractor shall submit a request in writing within four working days of receipt of the Department's results of the Quality Level Analysis for the lot in question. The Engineer will document receipt of the request. The request shall specify Method 1 or Method 2 dispute resolution. The CBM laboratory will be used for dispute resolution testing.

1. Method 1:

Method 1 dispute resolution will be allowed when Contractor and Department split test results exceed the precision limits shown in Table 1. Dispute resolution test results for G_{mm}, G_{mb}, and asphalt binder content will replace the original Department G_{mm}, G_{mb}, and asphalt binder content test results. Method 1 shall be used in cases where Department test results are outside the acceptable limits shown in the Standard Specifications Article 1030.07.

Table 1

Test Parameter	Limits of Precision
Voids	1.0 %
Field VMA	1.0 %
Dust/AB Ratio	0.2
Core Density	1.0 %

2. Method 2:

Method 2 dispute resolution will be allowed when both: 1) the Contractor participates and complies with the AASHTO re:source Proficiency Sample Program testing protocol as specified herein and 2) the Contractor and Department **adjusted** split test results, as described herein, exceed the precision limits shown in Table 2. The dispute resolution test/s will only be performed for the parameter/s (G_{mm}, G_{mb}, or asphalt binder content) exceeding precision limits. Both solvent extraction and ignition oven procedures may be used for determining asphalt binder content. The dispute resolution test result(s) will replace the original Department result(s) for the disputed parameters.

Table 2

Test Parameter	Limits of Precision
G_{mm}	0.008
G_{mb}	0.012
Asphalt Binder Content	0.2

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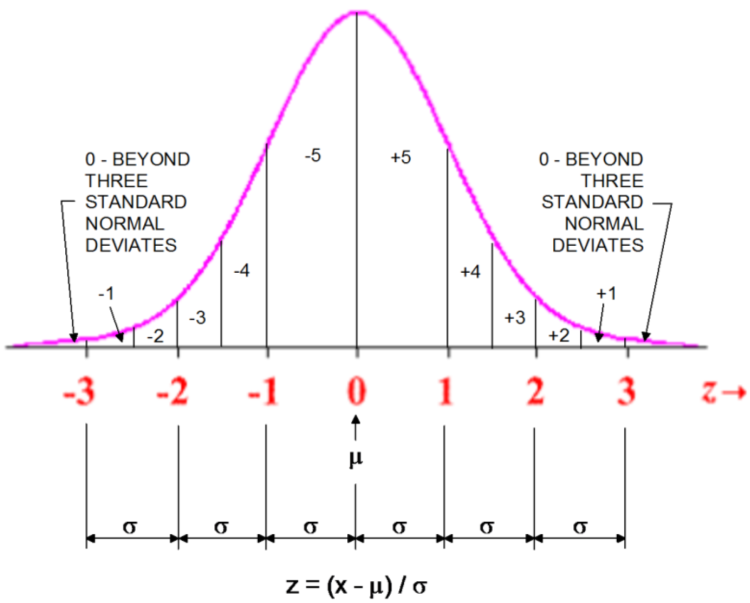
a. Proficiency Sample Testing

To qualify for dispute resolution using Method 2, a QC laboratory must participate in the AASHTO re:source's (formerly AMRL) Proficiency Sample Program (PSP). PSP samples are distributed annually to federal, state, independent, commercial, and research testing laboratories. AASHTO re:source scores proficiency test samples by fitting a standard normal distribution to the data from all laboratories (with outliers eliminated). Laboratories whose results fall within one standard normal deviation from the mean are assigned a numerical score of "5." Laboratories whose results fall between 1 and 1½ standard normal deviations from the mean are assigned a score of "4," and the ratings are further decreased one point for each half standard normal deviate thereafter. A positive sign (+) indicates the lab result is above the population mean, and a negative sign (-) indicates the lab result is below the population mean. This system can be depicted graphically, as follows:



For the Contractor to dispute individual test results, G_{mm}, G_{mb}, and/or asphalt binder content, all of the following shall be met:

1. The Contractor's laboratory that conducts the Quality Control testing for the project in question participates annually in the appropriate AASHTO re:source PSP.
2. The Contractor has submitted the laboratory's proficiency sample report(s) to the Department with the documentation of the data results submission to AASHTO re:source dated no later than December 31 for G_{mm} and G_{mb} and June 7 for asphalt content. The results will be evaluated as follows:
   a) If the Contractor's laboratory that conducts Quality Control testing received a proficiency score of 3 or better on all individual tests (G_{mm}, G_{mb}, and asphalt binder content), the Contractor will be approved for Method 2.

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b) If the Contractor's laboratory that conducts Quality Control testing for the project in question received a proficiency score of 2 or lower on an individual test, the Contractor shall complete the following to remain on the Method 2 approved list:

i) Conduct an investigation and perform a root cause analysis to determine the possible reason(s) for the results;
ii) Correct any issues that are uncovered in the investigation;
iii) Document the investigation and corrective actions;
iv) Submit the AASHTO Accreditation Program (AAP) proficiency sample corrective action report to CBM; and
v) Purchase and test a blind proficiency sample from AASHTO re:source.

Note: Blind extra proficiency samples are surplus samples that were produced for a regularly scheduled round of testing and are available for purchase by contacting AASHTO re:source. The blind extra proficiency sample should be randomly selected by AASHTO re:source.

vi) Submit the laboratory's proficiency sample report for the blind proficiency sample to the Department with the documentation of the data results submission to AASHTO re:source dated no later than December 31 for G_{mm} and G_{mb} and June 7 for asphalt content. Failure to show that these results were submitted to AASHTO re:source by these deadlines will result in removal from the Method 2 approved list.

vii) A proficiency score of 3 or better shall be received for the test parameter in question on the blind proficiency sample.

viii) Failure to achieve a score of 3 or better on each of the three test parameters in two attempts within each annual testing period will result in removal from the Method 2 approved list until a score of 3 or better on all test parameters is achieved through scheduled AASHTO re:source PSP testing.

c) Use of Contractor Central Lab for asphalt binder content disputes:

i) All labs shall conduct daily asphalt binder content testing for quality control.

ii) Any lab that participates in the PSP program and earns ratings of 3 or better on respective G_{mm}, G_{mb}, and asphalt binder content tests is eligible to dispute any of the three parameters according to Method 2.

iii) A Contractor's Lab that has earned PSP ratings of 3 or better in all three parameters can be used as a Central Lab to dispute asphalt binder content according to Method 2 for any of the labs operated by that Contractor. To be eligible to be a Central Lab, that specific lab must perform all the asphalt binder content testing that is reported to the Department for all of that Contractor's PFP projects for that calendar year including the asphalt binder content sample result that is being disputed. In addition, for any lab to use a Central Lab for asphalt binder content disputes according to Method 2, the originating lab where daily quality control is conducted shall have earned ratings of 3 or better on both G_{mm} and G_{mb} testing.

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3. The adjusted split test results, as defined below, for the individual test, G_{mm}, G_{mb}, or asphalt binder content, exceed the precision limits listed in Table 2. The adjusted split test results account for any offset between the Department and Contractor test results. The adjusted split test results will be determined for each lot by:
   a) For each sublot, subtract the Department's result from the Contractor's result to determine the initial split;
   b) For each lot, calculate the average initial split test result;
   c) For each sublot, subtract the average initial split test result for the lot from the initial split result to determine the adjusted split sublot test result.
   d) Compare the adjusted split with the precision limits listed in Table 2 to determine whether the sample qualifies for dispute testing (Example is shown in Table 3).

Table 3.

EXAMPLE ADJUSTED SPLIT RESULTS CALCULATION

G_{mm}				
Sublot	Contractor	IDOT	Initial Split	Adjusted Split
1-1	2.456	2.454	0.002	-0.001
1-2	2.458	2.455	0.003	0.000
1-3	2.462	2.466	-0.004	-0.007
1-4	2.471	2.463	0.008	0.005
1-5	2.459	2.461	-0.002	-0.005
1-6	2.474	2.462	0.012	0.009
1-7	2.463	2.465	-0.002	-0.005
1-8	2.463	2.461	0.002	-0.001
1-9	2.472	2.468	0.004	0.001
1-10	2.466	2.464	0.002	-0.001
Average Initial Split			0.003	

Density cores for dispute resolution testing shall be taken at the same time as the random density core. The density core for dispute resolution testing shall be taken within 1 ft (300 mm) longitudinally of the random density core and at the same transverse offset. Density dispute resolution will replace the original density test results. For density disputes, the Contractor shall use the Department's running average for G_{mm} when determining compliance with the limits of precision.

If three or more consecutive mixture sublots or G_{mm} results are contested, corresponding density results will be recalculated with the new G_{mm}.

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C. Dispute Testing Pay Schedule

The final pay factor for the lot under dispute resolution will be recalculated using the results from all disputed mix sublots and density intervals. If the recalculated average lot pay factor for any single disputed mix sublot or density interval is less than or equal to the original lot pay factor, the laboratory costs for that sublot (Table 4) will be borne by the Contractor.

Table 4

Test	Cost
Method 1 Mix Testing	$1000 / sublot
Core Density	$300 / core
G_{mm}	$200
G_{mb}	$500
Asphalt Binder Content	$500

1. Mix Dispute Cost Calculation Examples:

Given: This example mix is an N50 SMA with an updated G_{SB} of 2.650 and a design G_{MM} of 2.500. Examples 1 and 2 will use the data provided in Tables 5 and 6.

Table 5

Example Contractor Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	2.369	2.501	6.1	5.3	16.1
1-2	2.367	2.498	6.0	5.2	16.0
1-3	2.372	2.502	5.9	5.2	15.8
1-4	2.371	2.503	6.2	5.3	16.1
1-5	2.368	2.503	6.0	5.4	16.0
1-6	2.369	2.497	6.1	5.1	16.1
1-7	2.368	2.501	6.0	5.3	16.0
1-8	2.384	2.498	6.0	4.6	15.4
1-9	2.375	2.495	5.9	4.8	15.7
1-10	2.368	2.496	6.0	5.1	16.0

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Table 6

Example IDOT District Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	2.355	2.494	6.1	5.6	16.6
1-2	2.370	2.510	6.1	5.6	16.0
1-3	2.375	2.504	6.3	5.2	16.0
1-4	2.378	2.502	5.3	5.0	15.0
1-5	2.377	2.485	5.9	4.3	15.6
1-6	2.354	2.500	6.0	5.8	16.5
1-7	2.370	2.497	6.0	5.1	15.9
1-8	2.381	2.503	6.1	4.9	15.6
1-9	2.377	2.493	6.0	4.7	15.7
1-10	2.367	2.494	6.1	5.1	16.1

Example 1 – Method 1 Mix Disputes:

Sublots 1-4 and 1-5 qualify for dispute resolution based on the limits for Method 1 in Table 1. The Contractor has chosen to dispute these two mix sublots. The CBM dispute resolution results are shown Table 7. These results will replace the District results.

Table 7

Example IDOT CBM Dispute Resolution Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-4	2.372	2.498	6.2	5.0	16.0
1-5	2.374	2.495	6.0	4.9	15.8

Replacing the results for the mix sublots generates the pay factor changes shown in Table 8. The effect of each sublot on the pay factor is evaluated independently of other disputed sublots when determining if the sublot lab costs are to be borne by the Contractor.

Table 8

Method 1 Pay Factors				
Sublot	Air Voids	VMA	Average	Cost Responsibility
Initial Pay Factors	89.5	100.5	97.3	
1-4 Only	89.5	105.0	95.8	IDOT
1-5 Only	89.0	101.0	95.0	Contractor
Final Pay Factors	89.0	105.0	97.0	

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Sublot 1-4 caused an increase in the VMA pay factor, and no change in the air voids pay factor. The average pay factor increased, so the cost for sublot 1-4 will be borne by IDOT. Sublot 1-5 caused an increase in the VMA pay factor, but a decrease in the air voids pay factor. The average pay factor did not change, so the cost for sublot 1-5 will be borne by the Contractor.

Example 2 – Method 2 Mix Disputes

Based on the adjusted splits, sublots 1-1 through 1-6 qualify for Method 2 dispute resolution. The adjusted splits are shown in Table 9, with the highlighted splits being outside of the precision limits from Table 2. For this example, the Contractor is qualified to use Method 2, and has chosen to dispute all the possible sublots using Method 2. The CBM results for the disputed volumetrics are shown in Table 10. Those results then replace the District results from Table 6, and the combined results are shown in Table 11 with the new values highlighted.

Table 9

Method 2 Splits						
Sublot	Initial G_{MB}	Adjusted G_{MB}	Initial G_{MM}	Adjusted G_{MM}	Initial AB	Adjusted AB
1-1	0.014	**0.013**	0.007	0.006	0.00	-0.00
1-2	-0.003	-0.004	-0.012	**-0.013**	-0.10	-0.10
1-3	-0.003	-0.004	-0.002	-0.003	-0.40	**-0.40**
1-4	-0.007	-0.008	0.001	0.000	0.90	**0.90**
1-5	-0.009	-0.010	0.018	**0.017**	0.10	0.10
1-6	0.015	**0.014**	-0.003	-0.004	0.10	0.10
1-7	-0.002	-0.003	0.004	0.003	0.00	0.00
1-8	0.003	0.003	-0.005	-0.006	-0.10	-0.10
1-9	-0.002	-0.002	0.002	0.001	-0.10	-0.10
1-10	0.001	0.000	0.002	0.001	-0.10	-0.10
Average Initial split	0.001		0.001		0.00	

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Table 10

Example IDOT CBM Dispute Resolution Results			
Sublot	G_{MB}	G_{MM}	AB
1-1	2.362	X	X
1-2	X	2.505	X
1-3	X	X	6.2
1-4	X	X	6.2
1-5	X	2.495	X
1-6	2.356	X	X

Table 11

Example IDOT Combined Dispute Resolution Results					
Sublot	G_{MB}	G_{MM}	AB	Air Voids	VMA
1-1	**2.362**	2.494	6.1	**5.3**	**16.3**
1-2	2.370	**2.505**	6.1	**5.4**	**16.0**
1-3	2.375	2.504	**6.2**	**5.2**	**15.9**
1-4	2.378	2.502	**6.2**	**5.0**	**15.8**
1-5	2.377	**2.495**	5.9	**4.7**	**15.6**
1-6	**2.356**	2.500	6.0	**5.8**	**16.4**

Replacing the results for the mix sublots generates the pay factor changes shown in Table 12. The effect of changing each sublot on the pay factor is evaluated independently of other disputed sublots when determining if the lab costs are to be borne by the Contractor.

Table 12

Method 2 Pay Factors				
Sublot	Air Voids	VMA	Average	Cost Responsibility
Initial Pay Factors	89.5	100.5	95.0	
1-1 Only	91.0	101.0	96.0	IDOT
1-2 Only	90.5	100.5	95.5	IDOT
1-3 Only	89.5	100.5	95.0	Contractor
1-4 Only	89.5	104.5	97.0	IDOT
1-5 Only	89.0	100.5	94.8	Contractor
1-6 Only	89.5	100.5	95.0	Contractor
Final Pay Factors	92.5	105.0	98.8	

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Hot-Mix Asphalt PFP Dispute Resolution
Appendix E.5

Effective Date: April 1, 2010
Revised Date: December 1, 2023

Disputing sublot 1-5 caused the pay factor to decrease, resulting in the Contractor bearing the cost. Disputing sublots 1-1, 1-2, and 1-4 caused the pay factor to increase, resulting in IDOT bearing the cost.

Disputing sublots 1-3 and 1-6 did not cause the pay factor to increase, resulting in the Contractor bearing the cost.

Example 3 – Method 1 Core Disputes:

Given: This example mix is an N50 SMA with an updated G_{SB} of 2.650 and a design G_{MM} of 2.500. The sublot core G_{MB} results from the Department and Contractor are shown in table 13. The Department's running average G_{MM} for this sublot is 2.487, and it has been used to calculate the Density in Table 13.

Table 13

Sublot	Contractor Results		IDOT District Results		Δ Density
	G_{MB}	Air Voids	G_{MB}	Density	
1-1	2.315	93.1	2.305	92.7	0.4
1-2	2.324	93.4	2.295	92.3	**1.1**
1-3	2.320	93.3	2.301	92.5	0.8
1-4	2.328	93.6	2.309	92.8	0.8
1-5	2.329	93.6	2.355	94.7	**1.1**
1-6	2.338	94.0	2.320	93.3	0.7
1-7	2.335	93.9	2.322	93.4	0.5
1-8	2.338	94.0	2.335	93.9	0.1
1-9	2.360	94.9	2.333	93.8	**1.1**
1-10	2.340	94.1	2.320	93.9	0.2

Sublots 1-2, 1-5, and 1-9 are outside the limits of precision from Table 1 and can be disputed using Method 1. The Contractor has decided to dispute all the sublots. The CBM G_{MM} and air void results are shown in Table 14. Table 15 shows the effect of each of the CBM results on the pay factor. The effect of each sublot is evaluated independently for determining the cost responsibility.

Table 14

CBM Results		
Sublot	G_{MB}	Density
1-2	2.315	93.1
1-5	2.328	93.6
1-9	2.329	93.6

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Table 15

Method 1 Core Pay Factors		
Sublot	Density	Cost Responsibility
Initial Pay Factor	87.0	
1-2	90.0	IDOT
1-5	85.5	Contractor
1-9	87.0	Contractor
Final Pay Factor	89.5	

Sublot 1-2 caused the pay factor to increase, so IDOT bears the cost. Sublot 1-5 caused the pay factor to decrease, so the Contractor bears the cost. Sublot 1-9 did not change the pay factor, so the Contractor bears the cost.

D. Dispute Submittal Instructions

When submitting HMA mix and/or core samples to CBM for dispute testing, the District will include the following:

1. All District and Contractor split sample test results on the attached "PFP Dispute Resolution Form",
2. The dispute resolution HMA mix split sample with the contract number and sublot clearly marked on each sample bag,
3. Cores must be split or sawed by the Contractor to the appropriate lift thickness for testing,
4. Quality Management Program (QMP) Package template and Daily Plant Reports sent electronically for mix being tested.

Send sample and requested documentation to:

Illinois Department of Transportation
Central Bureau of Materials
Hot-Mix Asphalt Laboratory
126 E. Ash Street
Springfield, Illinois 62704-4766
Attention: HMA Lab Supervisor

Any sample sent to CBM without the above listed information will not be processed until all requested information is received.

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PFP DISPUTE RESOLUTION

Method 1 ☐ Parameter Disputed: VMA ☐ Voids ☐ D/AB ☐

Method 2 ☐ Parameter Disputed: G_{mb} ☐ G_{mm} ☐ AB ☐

Contract # : ______________________

Dist. Lab ID # : ______________________

Mix Design # : ______________________

Mix Code #: ______________________

Producer #: ______________________

CBM Lab #: ______________________

Wt. for G_{mb}: ______________________

Sampled From: Truck ☐ MTD ☐ Road ☐

Sample Date: ______________________

Date Received: ______________________

Mix Lot ______ Sublot ______

Sieve Size	**District** % Passing	**Contractor** % Passing	**CBM** % Passing
1 ½ in. (37.5 mm)			
1 in. (25 mm)			
¾ in. (19 mm)			
½ in. (12.5 mm)			
3/8 in. (9.5 mm)			
No. 4 (4.75 mm)			
No. 8 (2.36 mm)			
No. 16 (1.18 mm)			
No. 30 (600 µm)			
No. 50 (300 µm)			
No. 100 (150 µm)			
No. 200 (75 µm)			
Asphalt Binder %			
Dust/AB Ratio			
G_{mm}			
G_{mb}			
% Air Voids			
G_{sb}			
Field VMA			

CORES

	District	**Contractor**	**CBM**
Core #	G_{mm}†	G_{mm}	G_{mm}
Core #	G_{mb}	G_{mb}	G_{mb}
Core #	Density %	Density %	Density %

† This shall be the G_{mm} used for Density Calculation.

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Hot-Mix Asphalt QCP Pay Adjustments
Appendix E.6

Effective Date: January 1, 2012
Revised Date: December 1, 2021

This document explains the procedures used to determine the pay adjustment for a hot-mix asphalt (HMA) mixture and a hot-mix asphalt full-depth pavement when Quality Control for Performance (QCP) is specified as the Quality Management Program (QMP).

The following steps are used to determine the pay adjustment for a QCP mixture:

1. Determine sublot deviation from target for each pay parameter.

   A. If intelligent compaction was successfully implemented, there will be no deviations from target for density.

   B. A density sublot will either be based upon intelligent compaction or density tests using cores. The two methods will not be mixed.

2. Determine the sublot pay factor (PF) for each sublot using Table 1 and the deviation from target.

   A. For mixtures, the 105% column only applies when the District conducts testing of all the sublots within a given lot and all the test results are within the Acceptable Limits.

   B. For density, the 105% column also applies to density sublots where no individual density test is less than 90.0% or greater than 98.0% density.

   C. If intelligent compaction was successfully implemented, the density pay factor will be 100%.

3. Determine the average sublot PF for each pay parameter. The average sublot PF for each pay parameter will be capped at 100.0%.

4. Calculate the composite pay factor (CPF) using the average sublot PFs and Equation 1.

5. Determine the plan unit pay, adjusted pay, and pay adjustment for the mixture using Equations 2, 3, and 4.

Additionally, for a full-depth pavement the adjusted pay and pay adjustment will be calculated using the combined composite pay factors for mixtures used in its construction. Each mixture composite pay factor will be weighted equally. Mixtures placed having the same gyration values but with and without polymer will be treated as two separate mixtures. For example, one surface mix and one binder mix will be weighted 50/50 regardless of tonnage. Additionally, one surface mix, one polymer binder mix and one non-polymer binder mix will be treated as three equally (1/3) weighted mixtures even if the polymer binder is the only difference between binder lifts. The full-depth adjusted pay is determined by multiplying the plan unit pay by the combined composite pay factor. The pay adjustment is then determined by subtracting the plan unit pay from the adjusted pay.

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Note: Monetary deductions for dust/AB ratio will be applied separately using the Dust/AB Ratio Deduction Table found in the Standard Specifications Article 406.14.

Table 1

Pay Parameter		Pay Factor			
		105%	100%	95%	90%
Air Voids 1/2/3/		± 0.5%	± 1.2%	± 1.6%	± 2.0%
Field VMA 1/2/		0% to +1.0% above minimum specified	-0.5% to +2.0%	-0.7% to +2.5%	-1.0% to +3.0%
In-Place Density 4/5/	SMA	94.0% to 95.0%	93.5% to 96.5%	92.5% to 97.0%	92.0% to 98.0%
	HMA	93.5% to 94.5%	92.5% to 96.5%	91.5% to 97.0%	90.0% to 98.0%

1/ Mixture targets specified in 1030.05(b).
2/ If mixture testing is waived for small tonnage, the Contractor will receive 100% for Air Voids and Field VMA pay factors in Equation 1.
3/ Ranges based on deviation from specified design percent Air Voids.
4/ If no density requirement applies, the Contractor will receive 100% for the Density pay factor in Equation 1.
5/ A density test where the core thickness is less than 0.75 in. will not be used in the Density pay factor calculation.

Equation 1: $CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$

Where:

CPF = Composite Pay Factor

PF_{Voids}, PF_{VMA}, and $PF_{Density}$ = Average sublot pay factors for the pay parameters

The pay adjustment for a given mixture is calculated by multiplying the Mixture Unit Price by the Quantity and the CPF, and then subtracting the Mixture Unit Price multiplied by the Unit Price according to Equations 2, 3, and 4 below.

Equation 2: Plan Unit Pay = Mixture Unit Price x Mixture Quantity

Equation 3: Adjusted Pay = (Mixture Unit Price x Mixture Quantity x CPF/100)

Equation 4: Pay Adjustment = Adjusted Pay – Plan Unit Pay

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Overlay Example:

Determine the adjusted pay and pay adjustment for a N70 HMA IL-9.5 surface mixture being placed at 1.5 inches thick as an overlay with QCP specified as the Quality Management Program. The project consists of 6,900 tons placed over a distance of 12 lane miles. From the mix requirements table in the contract plans and 1030.05(b) the target air voids are 4.0% and the target minimum field VMA is 15.0%, respectively.

Note: The mix sample lots and density lots are independent of one another.

In this example, the first mix lot represents 4,000 tons while the second lot represents 2,900 tons. There are 12 density sublots representing 12 lane-miles (N=12).

Mix samples: Each sublot represents 1,000 tons except for lot 2, sublot 3 which represents 900 tons. (Note: All sublots are weighted the same.)

Mixture Sample		Air Voids		Field VMA	
Lot	Sublot	Contractor	District	Contractor	District
1	1	4.1	***3.2***	14.9	***14.6***
	2	3.9		14.5	
	3	2.5		14.0	
	4	3.0		14.8	
2	1	2.3	***2.5***	14.3	***14.5***
	2	2.1	2.2	14.0	14.1
	3	3.8	3.6	14.7	14.6

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Density: Since this pavement is < 3 inches thick, cores are taken randomly every 0.2 miles which is 5 cores per mile (60 cores for the 12 lane-mile project). With each density sublot the average of 5 consecutive cores represents 1 mile of paving.

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Hot-Mix Asphalt QCP Pay Adjustments
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Density Sublot	Density Intervals (cores)				
	1	2	3	4	5
1	90.4	90.8	91.6	92.4	92.1
2	93.8	94.1	92.3	92.1	92.6
3	91.8	93.5	93.9	92.8	92.5
4	93.7	94.2	93.5	93.3	92.8
5	92.1	94.1	92.6	93.8	92.3
6	94.1	94.3	93.2	94.5	93.9
7	93.6	93.3	92.5	91.9	92.7
8	92.8	93.3	94.2	93.5	93.7
9	91.5	91.2	91.9	91.8	90.9
10	93.0	92.6	92.1	92.3	94.1
11	92.3	93.0	93.8	92.6	94.1
12	91.5	93.5	92.7	93.8	92.1

Determine the average sublot pay factor for each parameter:

Air Voids:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Air Void results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire lot receives a pay factor of 100%.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District Air Void results were not within the 100% pay factor tolerance, the District had to test all of the remaining sublot splits. (see completed table below):

Calculate the Air Void deviation from the target for each of the District sublot split results.

Lot 1:

Sublot 2: Deviation = 3.2% - 4.0% = -0.8%

Lot 2:

Sublot 1: Deviation = 2.5% - 4.0% = -1.5%
Sublot 2: Deviation = 2.2% - 4.0% = -1.8%
Sublot 3: Deviation = 3.6% - 4.0% = -0.4%

Using Table 1 and the deviation from the Target, determine the corresponding Air Voids sublot pay factor for each District test result.

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Lot 1:
Sublot 2: Pay Factor associated with -0.8% in Table 1 is 100%

Lot 2:
Sublot 1: Pay Factor associated with -1.5% in Table 1 is 95%
Sublot 2: Pay Factor associated with -1.8% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 105%

Air Voids					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1 2 3 4	4.1 3.9 2.8 3.0	***3.2***	***-0.8***	***100***
2	1 2 3	2.3 2.1 3.8	***2.5*** 2.2 3.6	***-1.5*** -1.8 -0.4	***95*** 90 105

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot pay factor for Air Voids. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four.)

Average sublot Pay Factor (PF_{Voids}) = ((100% x 4) + 95% + 90% + 105%) / 7 sublots = **98.6%**

Field VMA:

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Field VMA results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, the District does not need to test the remaining sublots in Lot 1 and the entire lot receives a pay factor of 100%.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District results were not within the 100% pay factor tolerance **for Air Voids**, the District had to test all of the remaining sublot splits. (see completed table below):

Calculate the Field VMA deviation from the target for each of the District sublot split results.

Lot 1:
Sublot 2: Deviation = 14.6% - 15.0% = -0.4%

Lot 2:
Sublot 1: Deviation = 14.5% - 15.0% = -0.5%
Sublot 2: Deviation = 14.1% - 15.0% = -0.9%
Sublot 3: Deviation = 14.6% - 15.0% = -0.4%

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Using Table 1 and the deviation from Target, determine the corresponding Field VMA sublot pay factor for each District test result.

Lot 1:

Sublot 2: Pay Factor associated with -0.4% in Table 1 is 100%

Lot 2:

Sublot 1: Pay Factor associated with -0.5% in Table 1 is 100%
Sublot 2: Pay Factor associated with -0.9% in Table 1 is 90%
Sublot 3: Pay Factor associated with -0.4% in Table 1 is 100%

Minimum Field VMA = 15.0%					
Lot	Sublot	Contractor	District	Deviation	Sublot PF
1	1 2 3 4	14.9 14.5 14.4 14.8	***14.6***	***-0.4***	***100***
2	1	14.3	***14.5***	***-0.5***	***100***
	2	14.0	14.1	-0.9	90
	3	14.7	14.6	-0.4	100

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

Calculate the average sublot pay factor for Field VMA. (Note: The 100% in Lot 1 represents four sublots and therefore is multiplied by four)

Average sublot Pay Factor (PF_{VMA}) = ((100% x 4) + 100% + 90% + 100%) / 7 sublots = **98.6%**

Density:

Determine the average Density for each sublot.

Determine the sublot pay factor using the average sublot Density and Table 1 (see completed table below).

Determine the Density pay factor by averaging the sublot pay factors.

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Density Sublot	Density Intervals (cores)						
	1	2	3	4	5	Sublot Ave.	Sublot PF
1	90.4	90.8	91.6	92.4	92.1	91.5	95
2	93.8	94.1	92.3	92.1	92.6	93.0	100
3	91.8	93.5	93.9	92.8	92.5	92.9	100
4	93.7	94.2	93.5	93.3	92.8	93.5	105
5	92.1	94.1	92.6	93.8	92.3	93.0	100
6	94.1	94.3	93.2	94.5	93.9	94.0	105
7	93.6	93.3	92.5	91.9	92.7	92.8	100
8	92.8	93.3	94.2	93.5	93.7	93.5	105
9	91.5	91.2	91.9	91.8	90.9	91.5	95
10	93.0	92.6	92.1	92.3	94.1	93.8	100
11	92.3	93.0	93.8	92.6	94.1	92.1	100
12	91.5	93.5	92.7	93.8	92.1	92.7	100
PF / 12 Sublots = 100.5							
Average Density Sublot PF = 100 (capped at 100)							

Composite Pay Factor:

Determine the Composite Pay Factor using Equation 1.

$$CPF = 0.30(PF_{Voids}) + 0.30(PF_{VMA}) + 0.40(PF_{Density})$$

$$= 0.30(98.6) + 0.30(98.6) + 0.40(100.0)$$

$$CPF = 99.2\%$$

QCP Adjusted Pay and Pay Adjustment:

Determine the adjusted pay and pay adjustment for the given mixture using Equations 2, 3, and 4.

Where: Mixture Unit Price = $65.00/ton

Mixture Quantity = 6,900 tons placed.

Plan Unit Pay = $65.00/ton x 6,900 tons = $448,500

Adjusted Pay = $448,500 x 99.2/100 = $444,912

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Pay Adjustment = ($65.00/ton x 6,900 tons x 99.2 / 100) – ($65.00/ton x 6,900 tons)
= - $3,588

In this case a $3,588 disincentive would be applied as per Construction Memorandum #4.

Full Depth Example 1:

Given: a full-depth project with two mixtures whose composite pay factors were determined to be 100.0% and 98.2%. The bid price per square yard = $40.00 and 1,400 sq yd were placed.

The full-depth combined composite pay factor will be calculated as follows:

100.0(1/2) + 98.2(1/2) = 99.1%

Determine the full-depth adjusted pay and pay adjustment.

Plan Unit Pay = $40.00/ sq yd x 1,400 sq yd = $56,000

Adjusted Pay = $40.00/ sq yd x 1,400 sq yd x 0.991 = $55,496

Pay Adjustment = $55,496 – $56,000 = - $504

Full Depth Example 2:

Given: a full-depth project with three mixtures whose composite pay factors were determined to be 98.9%, 100.0% and 99.2%. The bid price per square yard = $40.00 and 1,400 sq yd were placed.

The full-depth combined composite pay factor is calculated as follows:

98.9(1/3) + 100.0(1/3) + 99.2(1/3) = 99.4%

Determine the full-depth adjusted pay and pay adjustment.

Plan Unit Pay = $40.00/ sq yd x 1,400 sq yd = $56,000

Adjusted Pay = $40.00/ sq yd x 1,400 sq yd x 0.994 = $55,664

Pay Adjustment = $55,664 – $56,000 = - $336

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Best Practices
for
Hot-Mix Asphalt PFP and QCP
Appendix E.7
Effective Date: April 1, 2012
Revised Date: December 1, 2021

Purpose

This document is intended to aid District personnel in successfully supporting the Pay-For-Performance (PFP) and Quality Control for Performance (QCP) Quality Management Programs. Following these guidelines will lower risk to both the Department and Contractor, which should result in lower bid prices.

Lab

Since payment on PFP and QCP projects is based on Department test results, attention to laboratory equipment, qualified lab personnel and laboratory efficiency becomes paramount. Review of results from recent "Annual HMA Uniformity Studies" (aka Round Robins), dispute resolutions, and addressing any District lab issues resulting in poor comparisons will prove beneficial.

1) Equipment

It is imperative to inspect and calibrate all laboratory testing equipment according to frequencies listed in Policy Memorandum 21-08 "Minimum Department And Local Agency Laboratory Requirements For Construction Materials Testing Or Mix Design" at a minimum. Inspection and calibration immediately prior to PFP and QCP testing is highly recommended. Always use the same gyratory compactor for an individual PFP or QCP contract.

Assessment of existing and needed equipment should be performed to determine possible benefits of purchasing additional equipment to optimize productivity. Each district should also develop an action plan in the event key equipment breaks down.

2) Personnel

It is also imperative that all laboratory personnel intended to be involved in PFP and QCP testing be qualified with successful completion of HMA Level I as a minimum. It is also important to keep technician assignments as consistent as possible. It is highly recommended to conduct in-house round robins with the above-mentioned laboratory personnel to ensure repeatability.

3) Sample Treatment

Inconsistent treatment of samples prior to testing has been identified as the leading reason for differences in test results between the contractor and the state. It is recommended that samples, for all parties involved, be allowed to cool to room temperature immediately after blending and splitting. The samples should then be reheated and compacted as soon as the samples reach compaction temperature. In each sublot, it is recommended to maintain mixture bulk specific gravity (G_{mb}) specimen dry weights within 10 grams for HMA and 15 grams for SMA. This would the entail the QC lab communicating the dry G_{mb} sample weight being used to the District Lab by writing it on the sample bag or some other means.

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4)
5) Laboratory Efficiency

The PFP and QCP QMP's are based heavily on Department testing which involves higher testing frequencies for the for the District laboratories when compared to the QC/QA QMP Timely QA test completion has been proven to reduce risk for Contractors and, if done consistently, should reduce bid prices. An internal audit of your District laboratory for efficiency may help identify ways to improve productivity. This activity should be conducted by District materials staff that are not involved in day-to-day testing or CBM staff if requested.

While the PFP and QCP specifications allow a 10 day turnaround, the District should attempt to reduce the turnaround time as much as possible. Nationally recognized successful programs have test turnaround results within 5 days.

Project Personnel

Key components of PFP and QCP which provide the necessary compliance with the Code of Federal Regulations (CFR) are 1) undisclosed random mix and density sample locations, 2) samples witnessed by the Engineer, and 3) sample security. The CFR is intended to assure that samples are under control of the Engineer at all times to verify the quality of the product. Most Districts will need to rely on project staff to determine random mix sample and density core locations. It will be important for project personnel to understand their role in witnessing and securing the sample. District Materials and Construction staff should meet prior to the start of a PFP or QCP project to discuss:

1) Responsibilities

   a) Who will be responsible for generating random mix samples and random density locations according to the Manual of Test Procedures for Materials documents "**Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling" and "Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations".**
   b) Who will be responsible for identifying undisclosed sample locations and sample layout.
   c) How will samples be secured; discuss who will transport and / or store samples.
   d) Who will be responsible for entering data in QMP Package software, calculating pay and how communication regarding pay factors will occur.

2) Communication

   a) Random mix sample locations
      i) Discuss when to disclose sampling locations.
      ii) Discuss how to move mix sampling locations due to unsafe conditions according to the Manual of Test Procedures for Materials documents "**Hot-Mix Asphalt PFP and QCP Random Jobsite Sampling".**

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b) Density Locations
   i) Discuss whether there will be obstacles that will warrant moving random core locations according to the Manual of Test Procedures for Materials document "**Hot-Mix Asphalt PFP and QCP Procedure for Determining Random Density Locations".**
   ii) Discuss how to handle coring locations that need to be opened immediately to traffic.

Also, it will be important to make sure Construction personnel have copies of all the necessary supporting documents.

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Hot-Mix Asphalt PFP and QCP Calculations of Monetary Deductions
Appendix E.8
Effective Date: December 1, 2021
Revised Date: May 13, 2022

This document explains the procedures used to determine the unconfined edge density sublot monetary deduction for Pay for Performance (PFP), and the dust/AB ratio sublot deduction for hot-mix asphalt (HMA) mixtures and full-depth pavements when PFP or Quality Control for Performance (QCP) is selected as the Quality Management Program.

A. Determining and Applying an Unconfined Edge Density Monetary Deduction

The following steps are used to determine the unconfined edge density for a PFP mixture or full-depth pavement and calculate any monetary deductions. The Unconfined Edge Density Deduction Table in Standard Specification Article 406.14 will be used to determine the monetary deductions.

1. Test all sublots for unconfined edge density.

2. Determine the monetary deductions using the Unconfined Edge Density Deduction Table.

3. Total all unconfined edge density monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.

4. If the total unconfined edge density monetary deductions are not $0,

   a) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.

   b) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

B. Determining and Applying a Dust/AB Ratio Deduction

The following steps are used to determine the dust/AB ratio for PFP and QCP mixtures or full-depth pavements and to determine any monetary deduction. The Dust/AB Ratio Deduction Table in 406.14 will be used to determine sublot monetary deductions for both PFP and QCP Quality Management Programs.

Note: The dust/AB ratio monetary deduction procedure is not applicable to Stone Matrix Asphalt (SMA) mixtures.

1. PFP:

a) Test all sublots for minus No. 200 (75 µm) (dust) content and asphalt binder (AB) content.

b) Determine the sublot deductions using the Dust/AB Ratio Deduction Table.

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c) Total all dust/AB ratio monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.

d) If the total dust/AB ratio monetary deductions are not $0,

1) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.

2) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

<u>2. QCP:</u>

a) Test for the sublot dust/AB ratio for the randomly selected sublot of each lot.

1) If the air voids and field VMA meet the 100% pay factor limits of Table 1 of the document "Hot-Mix Asphalt QCP Pay Adjustments" and compare within the precision limits table of the 1030.08.

i. And the dust/AB ratio range is within the $0 Deduct/Sublot using the Dust/AB Ratio Deduction Table, the entire lot will have a $0 monetary deduction.

ii. If the dust/AB ratio range is within any monetary deduction other than $0 Deduct/Sublot, all sublots will be tested for dust and AB and the dust/AB ratio monetary deduction will be calculated for each sublot.

2) If the air voids or field VMA do not meet the 100% pay factor limits of Table 1 of the document "Hot-Mix Asphalt QCP Pay Adjustments" or do not compare within the precision limits table of the 1030.08.

i. All sublots will be tested for dust and AB and the dust/AB ratio monetary deduction will be calculated for each sublot.

b) Total all dust/AB ratio monetary deductions. For full-depth pavements, total all monetary deductions for all mixtures comprising the pavement.

c) If the total dust/AB ratio monetary deductions are not $0,

1) For full-depth pavements, apply the total monetary deductions to the adjusted full-depth pay.

2) For all other HMA mixtures, apply the total monetary deductions for the mixture to the adjusted mixture pay.

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PFP Unconfined Edge Density Mixture Example

Given: The HMA pavement consists of a 13.0 ft wide mat 1.5 in. thick with the left edge confined without LJS and the right edge unconfined without LJS. Calculate the unconfined edge density sublot monetary deductions within the first mile.

There will be two unconfined edge density sublots along the right edge within the first mile.

Sublot #	Core #	Density	Deduct/Sublot[1/]
1	1	90.5%	$0
2	2	89.3%	$1,000
Total Monetary Deduction for Unconfined Edge Density = $1,000			

1/ From the Unconfined Edge Density Deduction Table

In addition to any PFP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; and any dust/AB ratio monetary deductions, a monetary deduction for unconfined edge density of $1,000 would be applied to this mixture.

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PFP Unconfined Edge Density Full-Depth Example

Given: A 75,000 sq yd full-depth pavement with a surface 24 ft wide is constructed with three mixtures. The contractor used two passes to achieve the width of the pavement. Each mixture was placed in one lift. The first pass of the first two mixtures had both edges unconfined. The second adjacent passes had one unconfined edge (centerline confined). The surface mixture was placed on LJS on all longitudinal joints. Calculate the unconfined edge density monetary deductions for the last 0.3 miles.

The first mix, first pass will have one random core taken in the last 0.3 miles from both unconfined edges. The second pass will have one random core taken in the last 0.3 miles from the unconfined edge. The second mix will be sampled the same way as the first mix. The third mix, the surface, will have no cores because LJS was used.

			Sublot #	Core #	Density	Deduct/Sublot[1/]
Mix 1	Pass 1	Left Edge	1	1	90.5%	$0
		Right Edge	2	2	90.2%	$0
	Pass 2	Left Edge	3	3	89.2%	$1,000
		Right Edge		-	-	-
Mix 2	Pass 1	Left Edge	4	4	90.3%	$0
		Right Edge	5	5	90.1%	$0
	Pass 2	Left Edge	6	6	88.5%	$3,000
		Right Edge		-	-	-
Mix 3	Pass 1	-		-	-	-
	Pass 2	-		-	-	-
Total Monetary Deduction for Unconfined Edge Density = $4,000						

1/ From the Unconfined Edge Density Deduction Table

In addition to the PFP combined pay adjustments calculated from the three mixtures; based upon the air voids, field VMA and density tests; and any dust/AB ratio monetary deductions, a monetary deduction for unconfined edge density of $4,000 would be applied to this full-depth pavement.

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PFP Dust/AB Ratio Example

Given: A N90 IL-9.5 HMA surface being placed at 1.5 inches thick as an overlay. The project consists of 10,000 tons over 16 miles.

Note: The mix sample and density lots are independent of each other.

In this example the mix sample lot represents 10,000 tons.

Note: All PFP sublots are tested for dust/AB ratio.

Lot #	Sublot #	Dust	AB	Dust/AB Ratio	Deduct/Sublot[1/]
1	1	5.1	6.0	0.8	$0
	2	4.9	6.0	0.8	$0
	3	4.8	5.9	0.8	$0
	4	5.3	5.9	0.9	$0
	5	5.8	5.8	1.0	$0
	6	7.4	5.8	1.3	$1,000
	7	7.3	5.7	1.3	$1,000
	8	5.2	6.1	0.8	$0
	9	5.3	5.9	0.9	$0
	10	5.1	5.8	0.9	$0
Total Monetary Deduction for Dust/AB Ratio = $2,000					

1/ From the Dust/AB Deduction Table

In addition to any PFP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; and any unconfined edge monetary deductions, a monetary deduction for dust/AB ratio of $2,000 would be applied to this mixture.

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QCP Dust/AB Ratio Example

Given: A N70 IL-9.5 HMA surface mixture being placed at 1.5 inches thick as an overlay with QCP specified as the Quality Management Program. The project consists of 6,900 tons placed over a distance of 12 lane miles. From the mix requirements table in the contract plans and 1030.05(b) the target air voids are 4.0% and the target minimum field VMA is 15.0%, respectively.

Note: The mix sample lots and density lots are independent of one another.
In this example, the first mix lot represents 4,000 tons while the second lot represents 2,900 tons.

Mix samples: Each sublot represents 1,000 tons except for Lot 2, Sublot 3 which represents 900 tons. (Note: All sublots are weighted the same.)

Mixture Sample		Air Voids		Field VMA		District			Deduct/ Sublot1/
Lot	Sublot	Contractor	District	Contractor	District	Dust	AB	Dust/AB Ratio	
1	1	4.1	***3.2***	14.9	***14.6***				-
	2	3.9		14.5		4.8	5.9	0.8	$0 2/
	3	2.5		14.0					-
	4	3.0		14.8					-
2	1	2.3	***2.5***	14.3	***14.5***	7.3	5.6	1.3	$1,000
	2	2.1	2.2	14.0	14.1	7.4	5.5	1.3	$1,000
	3	3.8	3.6	14.7	14.6	5.6	5.8	1.0	$0
Total Monetary Deduction for Dust/AB Ratio = $2,000									

Note: Bolded and italicized test results denote the sublot split that was randomly selected by the District for testing.

1/ From the Dust/AB Ratio Deduction Table

2/ If the tested mixture sublot is outside of the $0 deduction range, the District will test the remaining sublots for dust/AB ratio monetary deductions. This in itself will not trigger testing the other sublots for air voids or field VMA.

Since the District randomly selected and tested the split from Sublot 2 in Lot 1, and the Air Void and Field VMA results were 1) within the 100% pay factor tolerance **and** 2) within Precision Limits of the Contractor's results, and the District Dust/AB Ratio test result is in the range of no monetary deduction, the District does not need to test the remaining sublots in Lot 1 for Dust/AB Ratio and the entire lot receives no Dust/AB Ratio monetary deduction.

For the second lot, the District randomly selected and tested the split from Sublot 1. Since the District Air Void results were not within the 100% pay factor tolerance, the District had to test all of the remaining sublots, including Dust/AB Ratio. The Dust/AB Ratio test results for Sublot 1 and Sublot 2 were both in the range of a $1,000/sublot monetary deduction. The Dust/AB Ratio test result for Sublot 3 is in the range of no monetary deduction.

In addition to any QCP pay adjustments calculated for the mixture; based upon the air voids, field VMA and density tests; a monetary deduction for Dust/AB Ratio of $2,000 would be applied to this mixture.

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