Aggregate Technician Course

LAKE LAND COLLEGE

2023-2024

Illinois Department of Transportation
Central Bureau of Materials

AGGREGATE TECHNICIAN COURSE

DEDICATION

This workbook is dedicated to the memory of Cyrus "Cy" McMasters, Area Supervisor, Illinois Department of Transportation, Division of Highways, District Two Bureau of Materials.

ACKNOWLEDGMENTS

The Aggregate Technician Course was developed jointly by the Illinois Department of Transportation (IDOT) and the Illinois Association of Aggregate Producers (IAAP).

IDOT Central Bureau of Materials (formally the Bureau of Materials and Physical Research):

James Gehler	Engineer of Materials and Physical Research
Bruce Neunaber	Physical Tests Engineer
William Sheftick	Geologist / Aggregate Technology Coordinator
Thomas Schutzbach	Geologist / Aggregate Testing & Field Coordinator

IDOT District Bureaus of Materials:

Charles Ward	District One, Schaumburg
Wilson (Bill) Pearce	District Three, Ottawa
Loren Bloome	District Six, Springfield

IAAP:

Ralph Vencill	Material Service Corporation
Robert Savage	Moline Consumers Company
Charles Sanders	Vulcan Materials Company

Special acknowledgment goes to Linn Tyer of IDOT for her work in the preparation of the workbook.

Additional acknowledgments are as follows:

- Information on Illinois geology was summarized from various publications of the Illinois State Geological Survey.
- Crusher details were provided by Ed Faynor of Barber-Greene Company per the Crusher and Portable Plant Association (CAPPA) booklet, "Crusher Terminology" (Appendix C herein).
- The Technical Paper T-551, "Stockpile Segregation" (Appendix D herein), was reproduced with the permission of *Superior Industries*.

AGGREGATE TECHNICIAN COURSE SCHEDULE

The following times are approximate and the schedule can be altered to accommodate the class.

Monday

8:00 am		Registration and Introduction Information
10:30 am	Ch. 1	General Geology of Illinois
12:00 pm		Lunch (1 hour)
1:00 pm	Ch. 2	Aggregate Production and Beneficiation
3:00 pm	Ch. 3	Quality and Use
5:00 pm		End of class day

Tuesday

8:00 am	Ch. 7	QC/QA Responsibilities Policy
10:00 am	Ch. 8	Aggregate Gradation Control System Policy
12:00 pm		Lunch (1 hour)
1:00 pm	Ch. 9	Aggregate Producer Control Chart Procedure Policy
5:00 pm		End of class day

Wednesday

8:00 am		Control Chart Homework
9:00 am	Ch. 4	Stockpiling and Handling
10:00 am	Ch. 5	Field Gradation Sampling
12:00 pm		Lunch (1 hour)
1:00 pm	Ch. 6	Gradation Testing Procedures & Calculations
5:00 pm		End of class day

Thursday

8:00 am	Lab	**Group 1** – Sample Splitting and Gradation Homework
	Lab	**Group 2** – Hands-on Gradation Procedure
12:00 pm		Lunch (1 hour)
1:00 pm	Lab	**Group 1** – Hands-on Gradation Procedure
	Lab	**Group 2** – Sample Splitting and Gradation Homework
5:00 pm		End of class day

Friday

8:00 am		Testing – Written, Calculation & Proficiency (See schedule for test times)

NOTE: This manual is also used for the CET 027 Mixture Aggregate Technician Upgrade class. **The above schedule does not apply to the CET 027 Mixture Aggregate Technician Upgrade class**.

<u>Attendance Policy</u>:

Students are <u>REQUIRED</u> to present photo identification on the first day of class and prior to undertaking any test (written, calculation, practical and/or retest)

<u>Students are required to attend all class sessions in their entirety in order to receive a certification</u>. The student will be required to retake any missed session **<u>or</u>** attend the class in its entirety, per the discretion of the instructor, before receiving a class certification. This includes **<u>being on time</u>** to all class sessions. **<u>No exceptions</u>** will be made to this policy!

***<u>Testing Policy</u>:**

		Aggregate Technician	**Mixture Aggregate Upgrade**
Course Prerequisite:		None	Mixture Aggregate Technician
Written Test (Part 1)	**Open** Book	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70% (Retest **<u>cannot</u>** be taken on the same day as the initial test)	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70% (Retest **<u>cannot</u>** be taken on the same day as the initial test)
Calculation Test (Part 2)	**Closed** Book	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70% (Retest **<u>can</u>** be taken on the same day as the initial test)	N/A
Practical Test (Part 3)	**Closed** Book	**<u>Time Limit</u>** – No time limit **<u>Minimum grade</u>** – Pass or Fail (Retest **<u>can</u>** be taken on the same day as the initial test)	N/A

***<u>Retest Policy</u>:**

Written Retest	**Open** Book	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70%	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70%
Calculation Retest	**Closed** Book	**<u>Time Limit</u>** – 1 1/2 hours **<u>Minimum grade</u>** – 70%	N/A
Practical Retest	**Closed** Book	**<u>Time Limit</u>** – No time limit **<u>Minimum grade</u>** – Pass or Fail	N/A

*** A current photo ID is required to be presented at the beginning of the testing.**

If the student fails **<u>any test</u>** the first time, a retest will be required to be completed for the failed test. All retests are required to be completed before the end of the current academic year. Lake Land College's academic year runs September 1st, 2023 to August 30th, 2024

<u>Example</u>: If the original failed test was taken on December 1, 2023 the last date to retest would be the last business day up until August 30, 2024.

Failure of any retest, or failure to comply with the academic year retest time limit, will result in class failure and require the student to retake the class in its entirety. The student will be required to pay all appropriate fees to retake the class.

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TABLE OF CONTENTS

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LAKE LAND COLLEGE
INSTRUCTOR AND COURSE EVALUATION

Course (circle class attended): **Agg. Tech. Course** Section ________________ Date________________________

Mix. Agg. Tech. Upgrade Section ________________

Lead Instructor Name: **Galen Altman** **Lab Instructor #1's Name:**_____________________

Lab Instructor #2's Name:_____________________

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 and the aspects in which that teaching can be improved. As a student, you are in a position to judge the quality of teaching from direct experience, and in order to help maintain the quality of instruction at Lake Land, you are asked to complete this evaluation.

DIRECTIONS: **DO NOT SIGN YOUR NAME** (to protect your anonymity). We appreciate your fairness, honesty and frankness.

For each following items, please indicate by number, on a scale from 1 to 5, with 1 being WEAK and 5 being SUPERIOR, which seems most appropriate to you for the instructors and course that you are evaluating. You are strongly encouraged to make any comments that will clarify any particular rating in the comment sections (please refer to each item you are discussing by its number).

(**1** = Weak, **2** = Needs Improvement, **3** = Average, **4** = Good, **5** = Superior)

OBJECTIVES AND APPROPRIATENESS OF THE COURSE:

1.	**Clarity of Objectives**	The objectives of the course were clearly identified and were adequately covered.	______
2.	**Selection content**	Content was relevant and met the level of the class.	______

ORGANIZATION AND CONTENT OF LESSONS:

			LEAD INSTR.	LAB INSTR. 1	LAB INSTR. 2
3.	**Teacher preparation**	Instructor was organized and knowledgeable in subject matter and prepared for each class.	______	______	______
4.	**Organization of classes**	Classroom activities were well organized and clearly related to each other.	______	______	______
5.	**Selection of materials**	Instructional materials and resources used were specific, current, and clearly related to the objectives of the course.	______	______	______
6.	**Clarity of presentation**	Content of lessons was presented so that it was understandable to the students.	______	______	______
7.	**Clarity of presentation**	Different point of view and/or methods with specific illustrations were used when appropriate.	______	______	______

Please record any general impressions and/or comments pertaining to the **course**: ______________________________________

____

____

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LAKE LAND COLLEGE
INSTRUCTOR AND COURSE EVALUATION
(PAGE 2)

		PERSONAL CHARACTERISTICS AND STUDENT RAPPORT:	**LEAD INSTR.**	**LAB INSTR. 1**	**LAB INSTR. 2**
8.	**Vocabulary**	Instructor's vocabulary level was appropriate for the class and labs.	______	______	______
9.	**Pupil participation and interest**	Instructor encouraged students to ask questions and actively participate in class and labs when practical.	______	______	______
10.	**Personal attributes**	Instructor indicated an interest and enthusiasm for teaching the subject matter.	______	______	______
11.	**Personal attributes**	Instructor was familiar with current industry practices.	______	______	______
12.	**Personal**	Instructor's mannerisms were appropriate for the class.	______	______	______
13.	**Instructor-student rapport**	Instructor indicated a willingness to help students in times of difficulty.	______	______	______
14.	**Instructor-student rapport**	Instructor was fair and impartial in dealings with students.	______	______	______

Please record any general impressions and/or comments pertaining to the **instructors**:

Lead Instructor ____

____

____

Lab Instructor #1 ____

____

____

Lab Instructor #2 ____

____

____

SUMMARY:

15. Considering everything, how would you rate each instructor? _______ _______ _______

16. Considering everything, how would you rate this course? _______

EXAMINATION:

17. **Exam** The exam correlated to the materials being covered in class. _______

INTRODUCTION

Quality Management Training Program

Quality Control / Quality Assurance (QC/QA)

The Illinois Department of Transportation (IDOT) started the Quality Management Training Program in 1991. Three segments of the construction industry were chosen to implement the QC/QA process as part of the Quality Management Training Program: Hot Mix Asphalt, Portland Cement Concrete, and the aggregates used in asphalt and concrete.

Philosophy of QC/QA:

Under the Quality Management Training Program, the contractor is responsible for Quality Control and Quality Assurance is the responsibility of IDOT. Some people feel that it is a direct conflict of interest for the contractor or aggregate producer to be doing the testing of his own product and be in charge of his own quality control. This is a major departure from the way the construction industry and IDOT have always done things in Illinois. In reality, this process is used throughout the nation, not only in the road building industry, but in other segments of industry. This movement has been encouraged by the FHWA because it provides for a significantly increased amount of testing and quality monitoring which leads to a significant improvement in the quality of the finished product. In reality, it is easier for the contractor/producer to control quality than some outside source, such as IDOT. The contractor/producer has direct control over those things that go into making up a quality product such as the personnel, the equipment, and the materials being used. When QC/QA is talked about, many people hone in on the Quality Control and forget about the Quality Assurance. The QA is IDOT's part of the program. Under this program, IDOT does not control the quality, but must take all the necessary actions to assure that the contractor is controlling quality. These assurance processes are detailed in the various special provisions and specifications. They include some parallel testing of the materials, observing the contractor's personnel performing tests to see that the tests are being run correctly, and, in general, monitoring the contractor's quality control process.

Aggregate Requirements:

One of the basic requirements in the QC/QA program is that the aggregates that are used in Hot Mix Asphalt (HMA) and Portland Cement Concrete (PCC) must be produced under the Aggregates Gradation Control System (AGCS). In this system, the aggregate producer is responsible for his gradation control and certifies that the aggregates meet the gradation and quality requirements when shipped. In addition, tighter gradation requirements are placed on the critical sieve of the coarse aggregate being produced. There are currently over 500 approved aggregate sources in the AGCS system. A current list of approved sources can be found at IDOT's following webpage:

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Specialty-Lists/Highways/Materials/Materials-&-Physical-Research/Aggregate/approvedaggregatesources.pdf

The AGCS Program was originally designed to control the production of coarse aggregates and manufactured sands used in PCC and HMA mixtures on IDOT QC/QA Projects.

The AGCS Program has since been expanded to include the following products on the date indicated:

Effective July 1, 2000

Coarse Aggregate for All PCC and Class I/Superpave HMA Projects
Manufactured Sand for All PCC and Class I/ Superpave HMA Projects
Natural Sand for All PCC and HMA Projects

Effective July 1, 2001

Coarse Aggregate and Manufactured Sand for All Non-Class I/ Superpave HMA Projects
Aggregate Surface Course
Granular Shoulders
Granular Subbase
Granular Base
Granular Embankment Special
Cover/Seal Coat

Hot Mix Asphalt

The chart below shows the progression of QC/QA in the production of hot mix asphalt. IDOT started with six projects in 1991. By August of 1994, a total of 255 jobs had been completed, which used approximately 6,000,000 tons of hot mix. Currently, all of the Districts in the state are at a 100% QC/QA implementation for hot mix production. In recent years, IDOT HMA specifications have moved to PFP and QCP type of contracts.

DISTRICT	Number of Asphalt QC/QA Contracts Let				Total # of Jobs	Estimated Total Tons
	1991	**1992**	**1993**	**As of 8/31/94**		
1	0	1	2	0	3	62,633
2	2	3	4	21	30	969,765
3	0	4	3	16	23	462,992
4	0	4	5	16	25	896,563
5	1	4	12	14	31	1,076,378
6	0	4	11	24	39	648,796
7	0	2	8	22	32	475,041
8	0	6	11	15	32	862,739
9	3	2	8	27	40	559,610
Totals	**6**	**30**	**64**	**155**	**255**	**6,013,287**

Portland Cement Concrete

The Portland Cement Concrete QC/QA program started in 1992. It is a little more complex than the Hot Mix Asphalt (HMA) program because typically the concrete mix is produced by a ready mix producer and placed by the contractor. HMA is normally produced and placed by only the contractor. Currently the QC/QA process for concrete is being used on the larger projects throughout the state, and almost 100% in District 1.

Program Training Requirements:

IDOT has mandated that the personnel involved in the QMTP program be properly trained. They have developed the following courses which are required under the Quality Management Training program. All of the following classes are available through Lake Land College except the Gradation Technician which is available through the Central Bureau of Materials (CBM).

CET 020 Mixture Aggregate Technician (3 days)

CET 021 Aggregate Technician (5 days)

CET 027 Mixture Aggregate Technician Upgrade (2 days)

CET 029 Level I Hot Mix Asphalt (5 days)

Prerequisite: CET 020 3-Day Aggregate for Mixtures **or**
CET 021 5-Day Aggregate Technician

CET 023 Level II Hot Mix Asphalt (5 days)

Prerequisite: CET 029 Level I Hot Mix Asphalt

CET 031 Level III Hot Mix Asphalt (5 days)

Prerequisite: CET 023 Level II Hot Mix Asphalt

CET 026 Half-Day Nuclear Density

CET 030 Level I Portland Cement Concrete

CET 024 * Level II Portland Cement Concrete

CET 039 ** Level III Portland Cement Concrete

Prerequisites: * ** CET 020 3-Day Aggregate for Mixtures
or * ** CET 021 5-Day Aggregate Technician
and * ** CET 030 Level I Portland Cement Concrete
and ** CET 024 Level II Portland Cement Concrete

Concrete Tester

Gradation Technician

NOTE: The CET 032 AGCS Technician Course has been eliminated. Previous CET 032 AGCS Technician training is still recognized and valid.

Wonder what IDOT QC/QA training you need? The following may help in determining what classes you should take:

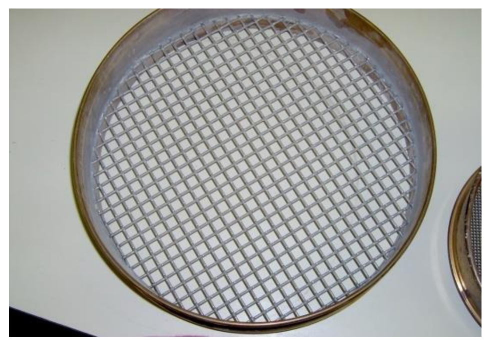
AGGREGATES	
Task	***Required Training Course for Certification***
Quality Control Manager	Aggregate Technician (CET 021) [1/]
Visual Inspections	Aggregate Technician (CET 021 [1/]
Aggregate Sampling	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020)
Splitting and Gradation Testing	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020) **or** Gradation Technician (IDOT class) [2/]
HOT MIX ASPHALT	
Quality Control Manager	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020) and Bituminous Concrete Level I (CET 029) and Bituminous Concrete Level II (CET 023)
Aggregate Sampling and Gradation Testing	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020) [2/ 4/] and/or Bituminous Concrete Level I (CET 029)
HMA Sampling and Testing	Bituminous Concrete Level I (CET 029)
HMA Mix Design	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020) and Bituminous Concrete Level I (CET 029) and Bituminous Concrete Level II (CET 023) and Bituminous Concrete Level III (CET 031)
PORTLAND CEMENT CONCRETE	
Quality Control Manager	Aggregate Technician (CET 021) **or** Mixture Aggregate Technician (CET 020) and PCC Level I Field Technician (CET 30) and PCC Level II Plant Technician (CET 24)
Job Site Mix Sampling & Testing	PCC Level I (CET 030) **or** Concrete Tester (Concrete Tester Course) [3/]
Concrete Plant Control & Testing	PCC Level I Field Technician (CET 30) and PCC Level II Plant Technician (CET 24) [2/ 3/]
PCC Mix Design	PCC Level I Field Technician (CET 30) and PCC Level II Plant Technician (CET 24) and PCC Level III (CET 039)
Precast	**Must have current A.C.I. card (no IDOT certification is required)**

Notes
1/ Combined certifications of a Mixture Aggregate Technician (CET 20) **AND** Mixture Aggregate Technician Upgrade (CET 027) meets the requirement for an Aggregate Technician (CET 021)
2/ A Gradation Technician must be supervised by a Mixtures Aggregate Technician or an Aggregate Technician. **Under supervision**, a Gradation Technician may perform gradation testing at a PCC or HMA mix plant. Contact the BMPR for information on how to attain a Gradation Technician certification.
3/ A Concrete Tester is required to be supervised by a PCC Level I or a PCC Level II Technician. Training for the Concrete Tester is available through Lake Land College.
4/ Aggregate Technicians and Mixture Aggregate Technicians may perform aggregate sampling and gradation testing at a PCC or HMA mix plant, except they **cannot** sample hot bins at a batch style HMA plant.

Metrification

After a brief try at converting to Metric units in the late 1990s, the Illinois Department of Transportation has since returned to using English units in the spring of 2000. All jobs proposed after April 2000 would be designed in English units. All manuals are published with both units of measurement, English (Metric).

Sieve Designations



The following are the English and Metric-equivalent sieve designations commonly used when testing aggregate materials:

SIEVE CONVERSIONS

ENGLISH		METRIC
3"	--------------------	75 mm
2.5"	--------------------	63 mm
2"	--------------------	50 mm
1.75"	--------------------	45 mm
1.5"	--------------------	37.5 mm
1"	--------------------	25 mm
3/4"	--------------------	19 mm
5/8"	--------------------	16 mm
1/2"	--------------------	12.5 mm
3/8"	--------------------	9.5 mm
1/4"	--------------------	6.3 mm
#4	**--------------------**	**4.75 mm**
#8	**--------------------**	**2.36 mm**
#10	--------------------	2.00 mm
#16	--------------------	1.18 mm
#30	--------------------	600 µm
#40	--------------------	425 µm
#50	--------------------	300 µm
#80	--------------------	180 µm
#100	--------------------	150 µm
#200	**--------------------**	**75 µm**

Coarse Aggregate ↕ Fine Aggregate (dividing line between #4 and #8)

Fine Aggregate ↕ Dust (-200) (dividing line at #200)

Gradation Terms & Codes:

The following terms are used to identify the gradation of an aggregate:

CA	**C**oarse **A**ggregate	Standard Specifications
CAM	**C**oarse **A**ggregate **M**etric	Standard Specifications
CM	**C**oarse **M**odified	Modified Standard Specifications
CMM	**C**oarse **M**odified **M**etric	Modified Standard Specifications
FA	**F**ine **A**ggregate	Standard Specifications
FAM	**F**ine **A**ggregate **M**etric	Standard Specifications
FM	**F**ine **M**odified	Modified Standard Specifications
FMM	**F**ine **M**odified **M**etric	Modified Standard Specifications

These terms are used in conjunction with numerical codes which indicate specific gradations and uses of material as shown in the following example. The following information is obtained in part from the Standard Specifications for Road and Bridge Construction, adopted on January 1, 2022.

The following is an example of determining material use from aggregate material codes:

Aggregate Material Codes

Inspected Material	Quality Level	Type of Material	Aggregate Type	Specification	Gradation Number	Superstructure Quality Concrete
0 = Aggregates	0 = No Quality 1 = No Quality 2 = A quality 3 = B quality 4 = C quality 5 = D quality 6 = D Quality Stabilized	0 = Gravel 1 = Crushed Gravel 2 = Crushed Stone 3 = ACBF Slag 7 = Natural Sand 8 = Stone Sand 9 = Special Aggregate	C = Coarse Aggregate F = Fine Aggregate	A = Standard Specification M = Modified Specification	Standard Specifications Article 1003.01(C) or Article 1004.01(C)	01

Example: **032CM16**

0	**3**	**2**	**C**	**M**	**16**
Aggregate	**'B' Quality**	**Crushed Stone**	**Coarse Aggregate**	**Modified Specification**	**Gradation**

A modified 'B' quality crushed stone coarse aggregate 16 gradation

Class Example:

Pages 7 & 8 are excerpts from the 2022 Standard Specifications Adopted January 1, 2022:

Art. 1003.01 (10) (c) Fine Aggregate Gradation Table

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 [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 the 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.

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

Art. 1004.01 (10) (c) Coarse Aggregate Gradation Table

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	N0. 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		
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 8, CA 11, CA 13, or CA 16 shall be 4 ± 4 percent.

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.

5/ The No. 16 (1.18 mm) requirement will be waived when CA11 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. (12.5mm) 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 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, 6, and 6 shall apply."

<u>End of excerpts from the 2022 Standard Specifications</u>

AGCS Program Highlights

Gradation of Standard Specifications versus AGCS gradations

Under the AGCS, the aggregate producer is allowed to establish their own targets for gradations, with the approval of the Department. As a part of this process, the producer must also use the master band concept. With the master band concept, a critical sieve is designated by IDOT for each required coarse aggregate gradation. The producer then sets a master band target for the critical sieve. A major factor that needs to be emphasized is that the approved gradation still needs to be compatible with other gradations to produce acceptable mix designs for asphalt and concrete mixtures.

The following is a partial summary from the AGCS Policy Memorandum:

6.2 Gradation Specifications

Sieve limits for each sieve/each product under the Aggregate Gradation Control System shall be as specified in the Department's Standard Specifications and/or as amended herein. The special critical sieve criteria for certain designated products as described in QC/QA Procedure, "Aggregate Producer Control Chart Procedure" located in the current "Manual of Test Procedures for Materials" are also required.

The midpoint/tolerance range of a designated critical sieve shall be developed from an average as shown in QC/QA Procedure, "Aggregate Producer Control Chart Procedure," noted above. The average shall be a historical average or a production average derived from start-of-production samples that is agreed to by the Department. Critical sieve limits shall take precedence over Standard Specification limits. Requests for critical sieve limits shall be submitted in writing to the District Materials Engineer for approval.

For sieves other than the top and bottom specifications sieves, sieve limits may be developed based on historical or average production values. These sieve limits may be different from those in the Standard Specifications. These modifications are also allowed for fine aggregate. Changes in the top sieve or any No. 200 sieve ranges will not be permitted. In cases where the bottom sieve is other than the No. 200 sieve, a variance in limits may be granted if the Bureau determines the minus No. 200 material to be within acceptable limits.

The Source shall request in writing to the District Materials Engineer approval of limits other than those in the Standard Specifications, but the range of the limits shall remain the same as the Standard Specifications.

Although the Department reserves the right to reject unacceptable material at any point prior to incorporation into the final product, the agreed upon gradation limits shall apply at the final point of shipping within the Source's control."

End of the partial summary from the AGCS Policy Memorandum

Development of Gradation Bands on Incoming Aggregate at Mix Plants

The aggregate user may use the gradation limits supplied by the producer or may choose to modify the gradation limits in accordance with the Department's "*Development of Gradation Bands on Incoming Aggregate at Mix Plants"* found in Appendix B of this manual. In general, this policy allows the user to shift the control limits of all sieves, except the top and bottom sieve, upwards a maximum of 3% due to the potential for degradation of some materials during shipping and handling. If the user elects to use this procedure, the new gradation limits must be approved by the District Materials Engineer. Once adopted, the new user limits are then used in place of the aggregate source limits for all gradation tests at the users' site.

Master Band/Warning Band and Critical Sieve Designations

Gradation	**Critical Sieve***	**Master Band (%)**	**Warning Band (%)**
CA/CM 5	**1" (25 mm)**	**± 8**	**± 6**
CA/CM 7	**1/2" (12.5 mm)**	**± 8**	**± 6**
CA/CM 11	**1/2" (12.5 mm)**	**± 8**	**± 6**
CA/CM 13	**No. 4 (4.75 mm)**	**± 8**	**± 6**
CA/CM 14	**3/8" (9.5 mm)**	**± 8**	**± 6**
CA/CM 16	**No. 4 (4.75 mm)**	**± 8**	**± 6**

* Master Band & Critical sieve requirements for coarse aggregate gradations are established per Specification 201 "Aggregate Gradation Sample Size Table & Quality Control Sieves" document located in the current Manual of Test Procedures.

Master Band control requirements for FA 20/21/22 aggregate gradations are established per Specification 201 "Aggregate Gradation Sample Size Table & Quality Control Sieves" document located in the current Manual of Test Procedures.

AGGREGATE GRADATION CONTROL SYSTEM

There are two methods by which aggregates can be certified for IDOT use when using the Aggregate Gradation Control System (AGCS).

<u>Method 1</u> covers aggregate producers who employ their own "trained technicians" and furnish their own "approved laboratory" to control production of aggregates under the Aggregate Gradation Control System.

Method 1 allows an aggregate producer to furnish certified aggregates on a continuing basis to any number of contractors for IDOT contracts as long as the source meets all requirements of the Aggregate Gradation Control System.

Use of Method 1 will allow the aggregate source to be listed as a Certified Source on the Approved Aggregate Source list.

<u>Method 2</u> is a variation of Method 1 where the aggregate producer utilizes the services of an engineering consultant to perform the required testing of the Aggregate Gradation Control System. The consultants must use "trained technicians" and have an "approved laboratory".

Under Method 2, the aggregate producer may furnish certified aggregates on a continuing basis to any number of contractors for IDOT contracts as long as the producer and the retained consultant continue to meet the requirements of the Aggregate Gradation Control System.

Use of Method 2 will allow the aggregate source to be listed as a Certified Source on the Approved Aggregate Source list.

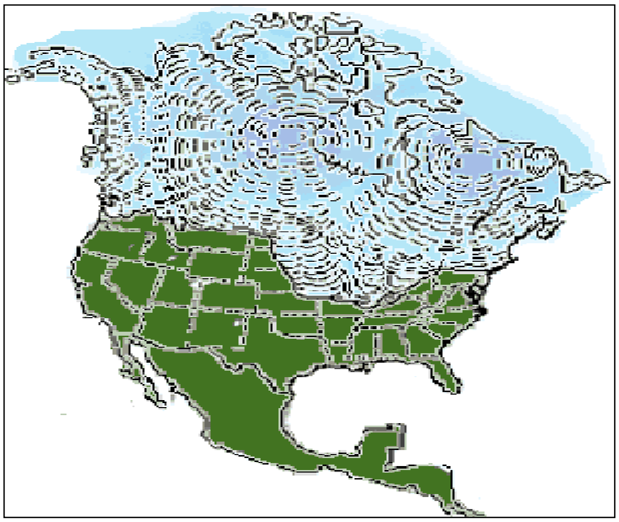
<u>NOTE</u>: "Trained technicians" indicate employees who have successfully completed the Illinois Department of Transportation "Aggregate Technician Course".

"Approved laboratory" indicates a laboratory that has been inspected and approved by the Illinois Department of Transportation District Materials office.

This Page Is Reserved

1.0 GENERAL GEOLOGY OF ILLINOIS

There 2 main aggregate products used in Illinois, **sand and gravel materials** which were created and deposited by the glaciers or water run-off and **crushed stone** which typically comes from carbonate rock formations



Glacial coverage

1.1 Sand and Gravel Geology

1.1 Sand and Gravel Geology. Sand and gravel is mined in Illinois from erosional deposits consisting of a heterogeneous mixture of igneous, metamorphic, and sedimentary rock. Most sand and gravel deposits in Illinois are related to the advance and retreat of continental glaciers that periodically moved from Canada into Illinois until approximately 10,000 years ago. Some of this material was also reworked by the processes of rivers, lakes, and winds to become our present-day sand and gravel deposits.

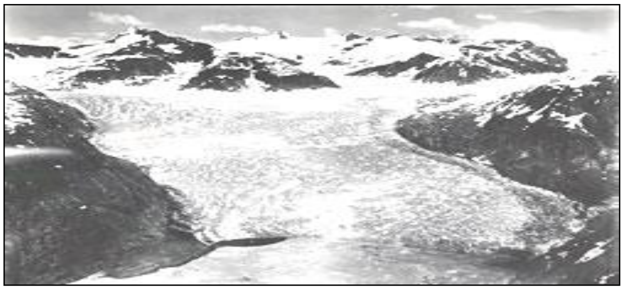
In order to provide a more extensive background, the two types of sand and gravel deposits in Illinois will be discussed in more detail:

- Glacial deposits
- Fluvial (river) deposits

1.1.1 Glacial Deposits - Although there are three types of glaciers (valley glaciers, piedmont glaciers and continental glaciers) that can produce glacial deposits, this discussion will focus on continental glaciers.

The continental glaciers were the main type of glaciation that helped to develop Illinois' sand and gravel deposits.

Continental glaciers (ice sheets) are large accumulations of ice that moved, due to the force of gravity, to cover large areas (hundreds to hundreds of thousands of square miles). They were normally thousands of feet thick. A prime example is the last continental glacier to cover Chicago (about 10,000 years ago) that was calculated to be 3,050 m (10,000 ft) thick at its maximum thickness.



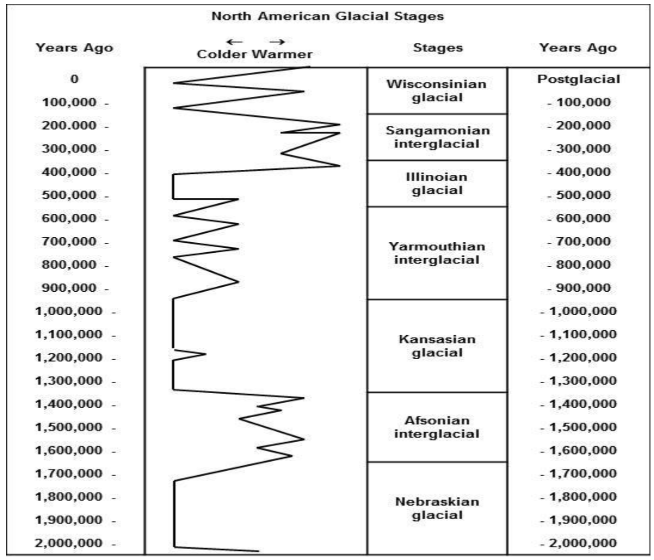
Glaciers

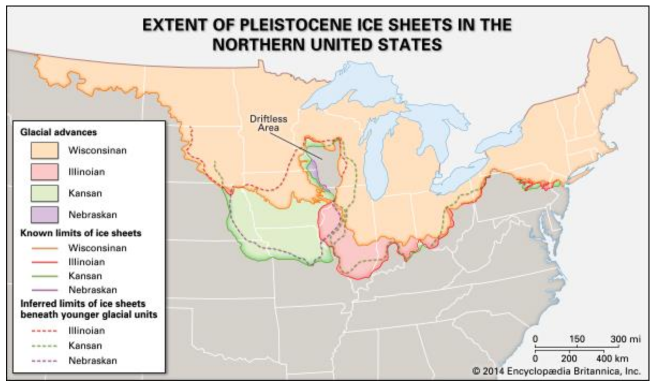
Continental glaciers, in order to grow, require low temperatures and an adequate snowfall over long periods of time (thousands of years). The continental glaciers affecting Illinois all originated in far-northern Canada.

Continental glaciers deposited sand and gravel in Illinois during at least four major advancements. During the two oldest glaciation periods, continental glaciers moved across Illinois, scouring up large amounts of deeply weathered material and various types of bedrock as they advanced as far south as the St. Louis area. However, the large amounts of material scoured up and deposited during these glacial periods were removed during subsequent glacial periods and are not generally part of current sand and gravel deposits.

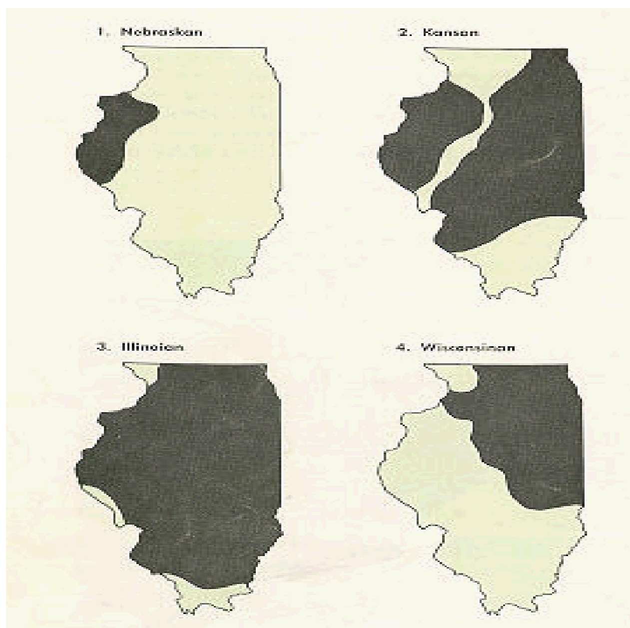
In the second youngest period, the Illinoisan, glaciers penetrated into Illinois as far south as the Shawnee Hills, at one time covering approximately 90% of the state. This time, large amounts of material were scoured and deposited across Illinois and are represented in some Illinois sand and gravel deposits.

The Wisconsinan glacier, the youngest, reached only into Central Illinois but, again, incorporated materials from the previous glacier, as well as scouring up new material, thus creating most of the current deposits presently being worked. The mechanics of glacial movement and glacial sand/gravel deposition are relatively simple. As a glacier accumulates more and more snow and ice under appropriate climatic conditions, it begins to advance or move. As the glacier advances, it plucks, scours, grinds, and pushes rock, trees, and anything else in its way (similar to a bulldozer). Even large boulders can be ground into sand and gravel-size material under the glacier as it moves.



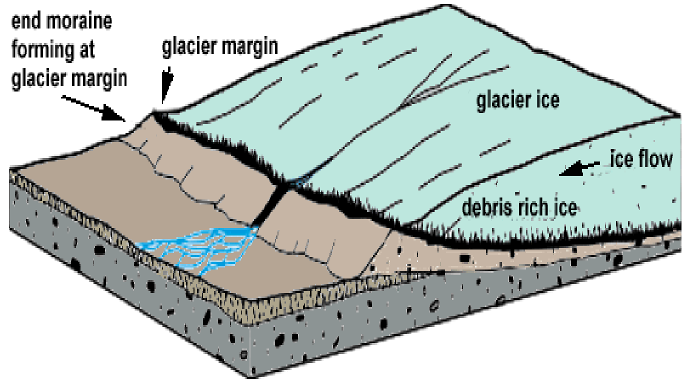


North American glacial stages



Illinois glaciation periods

This material is carried mainly in the base and sides of the glacier. The glacier continues to advance until the temperature at its leading edge is sufficiently high to cause melting to take place faster than its forward motion. When this condition occurs, it is known as "glacial retreat".



End moraine of a glacier

Sand and gravel deposition takes place as the glacier advances and retreats. A number of different types of sand and gravel deposits are left by a glacier and its melt waters. These can be divided into two main categories: (1) unstratified drift, or till, which is deposited directly by the glacier and (2) stratified drift which is deposited by the glacier's melt waters. The difference between these two is apparent in their names. Unstratified drift is a poorly sorted hodgepodge of material, whereas stratified drift is a well sorted, layered deposit.

Till deposit

Under these two general categories there are several different types of deposits. Each of these types of deposits, listed below, will be discussed in the following paragraphs.

Unstratified Drift (Glacial)	Stratified Drift (Melt Water)
Erratics	Outwash, valley trains
Moraines	Eskers
Drumlins	Kames

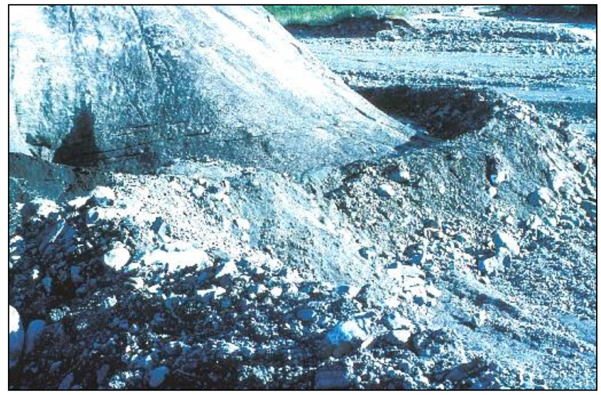
Boulder train

1.1.1.1 **Unstratified drift**

(1) Erratics and boulder trains. An erratic is a stone or boulder that has been carried from its place of origin by a glacier and left stranded on or surrounded by completely different types of material. Because of their unusually large size, most Erratics have either traveled only a short distance or are very resistant rock which makes them look out of place. A boulder train is simply a series of Erratics.

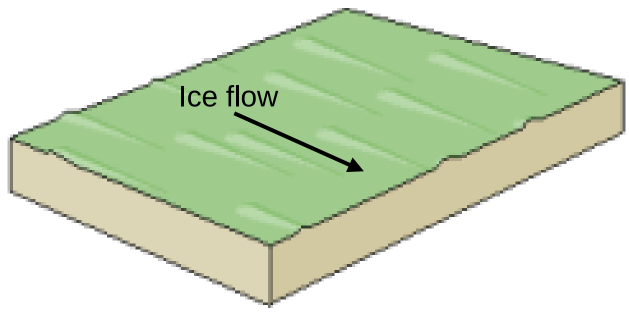
Erratics

(2) Moraines. "Moraine" is a general term that is used to describe many of the glacial landforms composed of till. A terminal or end moraine is a ridge of till that marks the limit of the glacier's advance. It forms when the glacier is melting back as fast as it advances. New ice continues to advance and melt at the glacier's front edge, providing an almost limitless supply of new debris (till). Recessional moraines are smaller ridges of till that mark places where the glacier was only temporarily in equilibrium. These lie at various locations behind the terminal moraine. Ground moraine is till that has been laid down by the main body of the glacier. It can vary in thickness from a thin layer of material on up to a thickness of hundreds of meters (feet).



Moraine

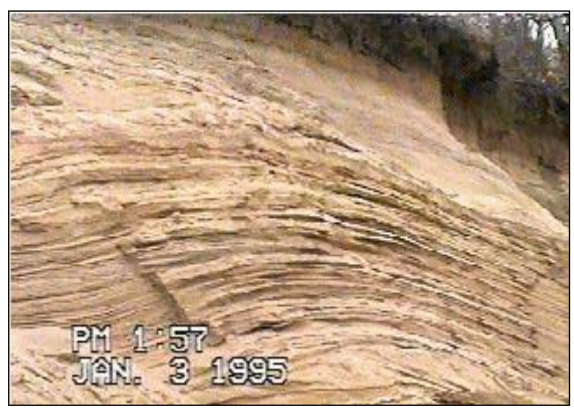
(3) Drumlins. Drumlins are smooth, elongated hills composed of till. They average approximately 30 m (100 ft) in height and are usually between 1/2 and 3/4 km (1/3 and 1/2 mile) long. Drumlins formed when till was deposited in a depression on the protected side of a rock hill. As the glacier advanced, it eroded the rock hill but was forced to glide over the drumlin. After the ice retreated, the drumlin became the high point in the area.



Drumlins

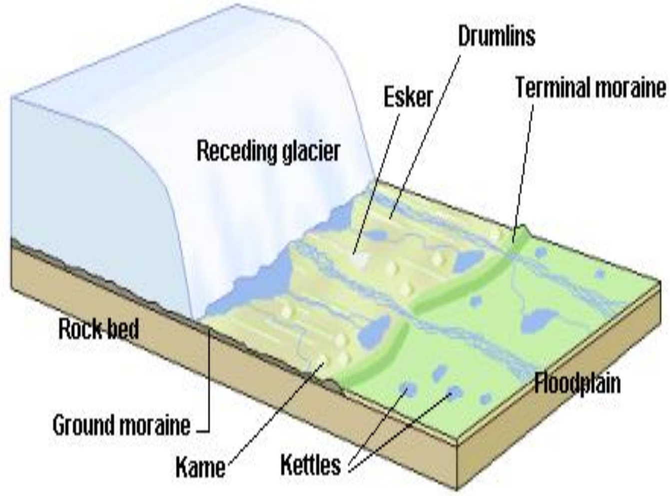
1.1.1.2 **Stratified drift**

(1) Outwash and valley trains. Outwash is the sand and gravel that is carried outward by the melt waters from the front of a glacier. As the glacier melts, it unleashes torrents of water that transport large amounts of debris. These streams of water rapidly lose their velocity and deposit their load of debris as they flow away from the ice sheet. As is usually the case, the larger particles fall out of suspension first, and as the water flow decreases, the smaller material begins to settle out. The process is known as sorting. Most of the large boulder gravel deposits in the Chicago area are outwash deposits. If the glacier happens to be melting in a valley, then this type of outwash deposit is called a "valley train".



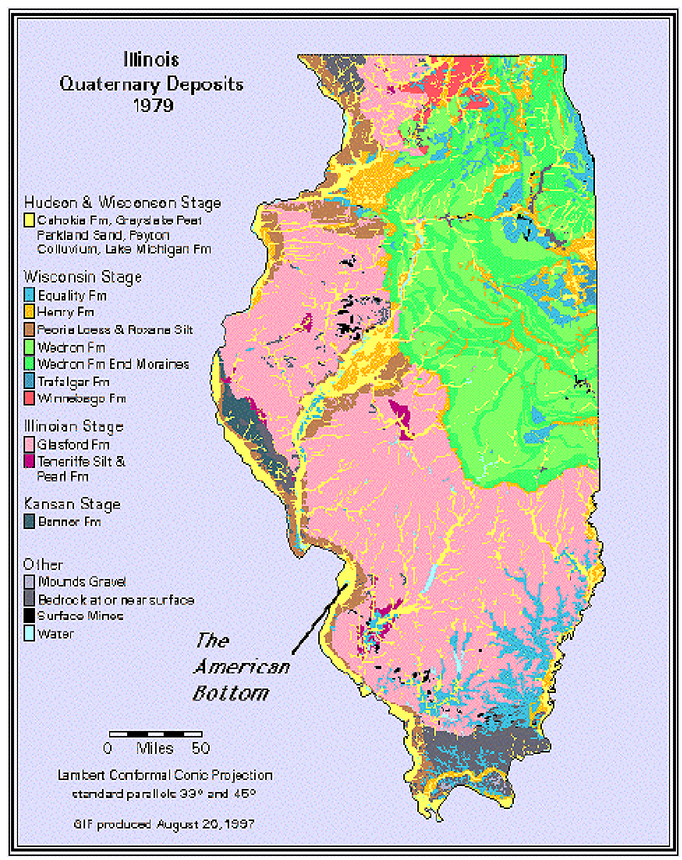
Outwash

(2) Eskers. Another stratified deposit is an esker. An esker is composed of a layer of gravel beneath a mound of sand and silt. It is a snake-shaped deposit that was formed when streams eroded a tunnel out of stagnant ice. This tunnel was then filled or partially filled with material deposited by the streams. As the glacier melted, it deposited the material in the tunnel as a steep-walled ridge of sand and gravel. Eskers range from 3 to 15 m (10 to 50 ft) in height, and 3/4 to 16 km (1/2 to 100 miles) in length but are usually only tens of meters (feet) wide.



Different components of a glacier

(3) Kames. Kames are low steep-sided hills of stratified material. They are stream deposits that are left in a hole or crevasse in a block of stagnant ice. When the ice melts, the kames become the highest point in the area.



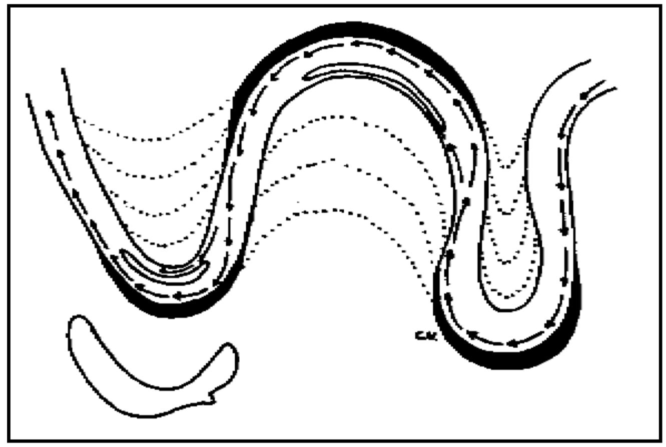
Illinois quaternary period deposits

1.1.2 **Fluvial (River) Deposits** - After the glaciers had completely retreated from Illinois, they left behind the sand and gravel deposits that have just been discussed, but they also left many rivers and streams. These rivers and streams continued to flow over and through these glacial deposits, slowly eroding them down to the bedrock. While eroding the glacial sand and gravel, the rivers and streams also reworked, resorted, transported, and then redeposit this material in new deposits downstream.

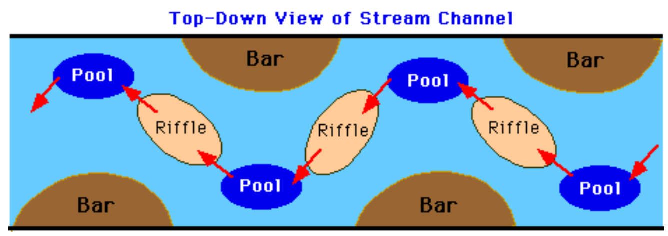
For this course, the discussion will center on two types of river deposits:

- Bar deposits
- Overbank / Flood-plain deposits

1.1.2.1 **Bar deposits**: As a river flows, it tends to erode laterally or meander back and forth across the valley. This erosion takes place on the outside of the river bends. The river then deposits this suspended material in slower moving water on the inside of the next bend. These deposits are known as "point bars". Mining can take place in one bar if it is large enough, or an operation can move up and down the river, mining multiple bars. These deposits are usually well sorted, very clean, and contain a heterogeneous mixture of glacial sand and gravel and new material eroded by the river.

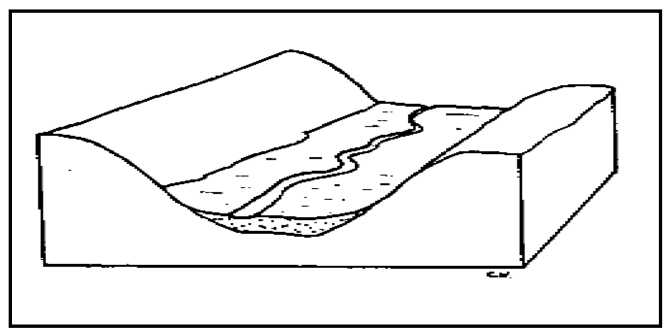


Stream Channel Deposits



Bar Deposits

1.1.2.2 **Overbank / Flood-plain deposits**: As a river overflows its banks, it loses energy, dropping its coarse particles quickly. However, large amounts of fine sand, silt, and clay remain suspended; these are deposited as the river's flow loses velocity while it extends onto the flood plain. Flood-plain deposits typically are used for backfill sand, but some are coarse enough for concrete and bituminous sand.



Flood-Plain

1.1.3 **Characteristics of a Sand and Gravel Deposit** - Now that the actual deposition of sand and gravel in certain types of deposits has been discussed, this article will focus on three characteristics that are common to all sand and gravel deposits:

- Size distribution
- Sorting
- Mineral composition

Gravel

When evaluating a potential deposit, knowledge of these characteristics can help determine whether economic mining is possible. These characteristics can also help explain quality and production problems associated with sand and gravel. Size distribution controls what products can be produced. Whether a deposit is sorted or unsorted can identify potential production problems up-front. Mineral composition plays the main role in the quality of the deposit. Each of these characteristics will be discussed in detail.

1.1.3.1 **Size distribution of a deposit**: Size distribution of a deposit simply means the amount of each different size fraction in the deposit. Material sizes range from boulders to clay. Glacial gravels, particularly the large boulder gravels in the Chicago area, tend to be considerably coarser than river deposits. Glaciers are able to carry large size material for great distances, whereas rivers, lacking the water velocity of the melting glaciers, do not have the ability to carry large boulders for long distances.

Size distribution of a deposit can also limit its uses. Some sources have enough coarse gravel to produce a full range of products, whereas others may be able to produce only pea gravel and sand. At the fine end of the spectrum, some deposits are limited entirely to fine sand production.

Size distribution can play a big part in determining the potential of a deposit. A deposit that has a size distribution that is not desirable is probably not worth opening. On the other hand, some size ranges are so valuable in certain areas of the state that a deposit may be economic to operate even though large amounts of its materials might be unusable.

Gravel Deposits

Oversize is another property that has a significant effect on the quality, physical characteristics, and size of a product. Successive crushing of oversize particles will, in general, provide quality levels exceeding that of the parent uncrushed gravel. Oversize will also provide all crushed particles (new angular fractures) in the final product. This property can be very valuable for end uses, such as hot mix asphalt.

Gravel Deposit

1.1.3.2 **Sorted / Poorly sorted deposit**: Not only is the size distribution of a deposit important, but whether each size is layered in relation to other sizes is also important. Earlier in this discussion, glacial sand and gravel was divided into unstratified and stratified deposits. Essentially, that is the same as unsorted and sorted. Glaciers, by themselves, are not able to sort material by size. When they directly deposit sand and gravel, they simply dump it all at once. All different sizes, from boulders to clay, are mixed together without any layering. On the other hand, melt waters and rivers tend to sort particles by size. As water velocity decreases, heavier or larger particles fall out first, later followed by finer material. This gives the resulting sand and gravel deposit a layered look. Most water-deposited sand and gravel deposits have numerous sequences of stratified material, grading from coarse to fine.

Boulder-train

Unsorted deposits, like moraines and other tills, can create problems when being mined. The main problem is excessive clay. This means washing is usually required to produce good aggregate. Selective mining is difficult because slugs of bad material can appear at any time. On the other hand, sorted deposits usually cause fewer problems because fine material is layered and can either be removed or processed with other material through the plant.

Poorly sorted deposit

1.1.3.3 **Mineral composition**: Sand and gravel deposits associated with glaciation contain material characteristic of the ancient bedrock that the ice sheets crossed, plus any material from older glaciers. For example, the deposits from the last part of the youngest glacier, which reached only into the Chicago area, contain mostly un-weathered material from rock located in Northeastern Illinois; the states of Wisconsin and Michigan; and Canada. These deposits consist mainly of dolomite and small amounts of igneous and metamorphic rocks.

Older glaciers which moved farther south picked up more weathered material and deleterious particles from bedrock in Central Illinois. This material was deposited in Central and Southern Illinois. The deleterious materials largely consist of chert, sandstone, siltstone, ironstone concretions, coal, wood, and some weathered limestone and igneous rocks. In addition, these older deposits have experienced more weathering in-place.

In general terms, sand and gravel deposits in Northeastern Illinois are better quality than those in Central and Southern Illinois. Later in the course, IDOT's quality tests will be discussed. Two of these tests highlight the quality differences between Chicago area gravels and downstate gravels. The deleterious count, a petrographic examination, actually shows that, as a whole, there are more deleterious particles in downstate gravels. Also, the freeze-thaw test, a simulation of concrete performance in a freeze-and-thaw environment, has shown that gravels from the Chicago area perform better than downstate gravels in concrete pavement. This is mainly due to the increased amounts of chert and ironstone in downstate deposits.

TYPES OF MINERALS/ROCKS FOUND IN ILLINOIS GRAVELS
Sedimentary Rocks
Dolomite Laminated dolomite Silty dolomite Pyritic dolomite Limestone Cherty carbonate Chert Weathered carbonate Ironstone Shale Sandstone-Siltstone
Igneous Rocks
Mafic Weathered mafic Coarse felsic Weathered coarse felsic Fine felsic Massive quartz
Metamorphic Rocks
Gneissic Weathered gneissic Schistose Weathered schistose Metasdimentary Weathered metasdimentary Metagraywacke Tillite Quartzite

General Classification of rocks

Class	Type	Family
Sedimentary	Calcareous	Limestone Dolomite
	Siliceous	Shale Sandstone Chert Conglomerate Braccia
Metamorphic	Foliated	Gneiss Schist Amphibolite Slate
	Nonfoliated	Quartzite Marble Serpentinite
Igneous	Intrusive (coarse-grained)	Granite Syenite Diorite Gabbro Periodotite Pyroxenite Hornblendite
	Extrusive (fine-grained)	Obsidian Pumice Tuff Rhyolite Trachyte Andesite Basalt Diabase

1.1.4 **Below-Water and Above-Water Deposits** - Sand and gravel deposits can be located above the water table and below the water table. Some deposits are operated above and below water at the same time. Each of these types of deposits has merits as well as problems.

Wind-blown sand deposit

1.1.4.1 **Below-water - wet**: Sand and gravel deposits that lie below the water table are usually gray in color and are generally less weathered than their counterparts above water. Since they are less weathered, these deposits are usually better quality aggregate than above-water gravel. The drawback of below-water mining is the expense of actually extracting the material. Costly draglines or dredges usually must be used.

Below-water deposit

1.1.4.2 **Above-water - dry**: Sand and gravel deposits above the water table commonly are brown or reddish brown in color. This color can be attributed to the oxidation of the ironstone particles in the deposits. Because the gravel has been exposed to the elements for long periods of time, it is much more weathered and contains more deleterious particles than below-water gravel. Above-water gravels are usually of lower quality than below-water material. The exception to this rule is the boulder gravels in the Chicago area that are mined above water. These gravels are relatively young, geologically speaking, and have not undergone long periods of weathering. Also, they lack large amounts of deleterious particles that cause quality problems. Dry sand and gravel is usually mined with an end loader that digs into an exposed bank.

Above-water deposit

1.4.3 **Above-water / below-water**: Mining above-water and below-water sand and gravel concurrently has one major problem: inconsistent quality. Blending above- and below-water gravels is not recommended due to their potential quality differences.

1.2 Crushed Stone Geology

1.2.1 In Illinois most of the crushed stone aggregate used is produced from carbonate rock formations. The two classes of carbonate rock involved in Illinois aggregate production are limestone and dolomite.

1.2.1.1 **Limestone** ($CaCO_3$): Limestone is deposited as a lime mud. The mud is compacted by layers of other material deposited on top of it until it is transformed into limestone. Limestone may contain fossils or may be all fossils.

The main mineral in limestone is calcite. Pure limestone would be 100% of the mineral calcite, or calcium carbonate.

1.2.1.2 **Dolomite** ($CaMg(CO_3)_2$): Very little dolomite is virgin dolomite. Most of it was originally limestone. The shallow seas that deposited the limestone sometimes became rich in the element, magnesium. The magnesium-rich water, when circulated through the lime mud, replaced some of the calcium in the limestone molecules with magnesium. This process is the same as a conventional water softener which replaces calcium in water with sodium.

The main mineral in dolomite is dolomite. Pure dolomite would be 100% of the mineral dolomite, or calcium magnesium carbonate.

1.2.1.3 In this world, very few things are pure, and rock is not one of them. There is a lot of grading between pure limestone and pure dolomite. IDOT defines limestone as carbonate rock containing less than 11.0% magnesium oxide (MgO). Dolomite is then defined as that carbonate rock containing 11.0% or more MgO. This MgO content is determined by IDOT's Chemistry Lab, using an atomic absorption spectrophotometer. IDOT differentiates between limestone and dolomite as part of its Bituminous friction policy.

CARBONATE ROCK

LIMESTONE

DOLOMITE

LIMESTONE

- $CaCO_3$
- Deposited as lime mud
- Contains fossils of plant and animal life
- Formed in shallow seas
- Calcite or calcium carbonate

Dolomite

- $CaMg(CO_3)_2$
- Originated as limestone
- Saturated with magnesium-rich water
- Formed on the reefs of shallow seas
- Dolomite is the main ingredient
- Similar to the water-softening process

Carbonate Rock Magnesium Percentage Definition
Limestone < 11.0 % magnesium oxide (MgO)
Dolomite $\geq$ 11.0 % magnesium oxide (MgO)

1.2.2 **Physical/Chemical Characteristics**

1.2.2.1 Calcite generally is white or light gray. If there is enough clay present, it might even be dark gray or black. Other impurities, such as iron, can discolor it, turning it tan or brown.

Calcite has a specific gravity of approximately 2.700, or a unit weight of 2,700 kg/m^3 (169 lbs/ft^3), and a Mohs hardness of 3. Mohs hardness is a relative scale of 1 to 10 showing the hardness of a mineral, or its resistance to scratching, where 1 is soft (talc) and 10 is hard (diamond).

1.2.2.2 Dolomite is the same colors as calcite and also may be affected by impurities, such as iron. It has a specific gravity of 2.700 to 2.800 and a Mohs hardness of 3 to 4. Dolomite can be considered slightly harder than calcite.

1.2.2.3 Distinguishing between limestone and dolomite in the field is difficult. Usually dolomite has a sugary or grainy look and is more porous or vesicular than limestone.

A standard field test for identifying limestone from dolomite involves putting a few drops of HCl (hydrochloric acid) on the unknown rock. Limestone will fizz very violently. Dolomite usually will not fizz at all unless it is scraped to produce a fine powder and then the HCl applied.

1.2.3 **Textural Characteristics** - There are several textural characteristics that are common to carbonate rocks. "Texture" is defined as the kind, size, shape, and arrangement of the component particles making up a rock, such as fossils, oolites, and crystallinity (grain size).

Limestone	
Parameter	Attribute
Color	White to light grey but can be dark grey to black
Specific Gravity	2.600 to 2.700
Hardness – Mohs scale	3
Dolomite determination	fizzing reaction

Dolomite	
Parameter	Attribute
Color	Similar to limestone
Specific Gravity	2.700 to 2.800
Hardness – Mohs scale	3 - 4
Dolomite determination	No fizzing reaction

Crushed Limestone Product

1.2.3.1 **Fossils**: Fossils are the skeletons or remains of previously living animals or plants that have been preserved in rock. Examples of fossils in Illinois rocks are carbon imprints, coral sponges, various shells, or crinoids (Indian beads).

1.2.3.2 **Oolites**: Oolites are small spherical or rounded particles usually consisting of a quartz center surrounded by multiple layers of calcite. Oolitic limestone is limestone consisting of oolites bound together in a calcite matrix or paste.

1.2.3.3 **Crystallinity**: Crystallinity is one of those words that is hard to define. It usually means the orderly arrangement or structure of mineral grains or crystals.

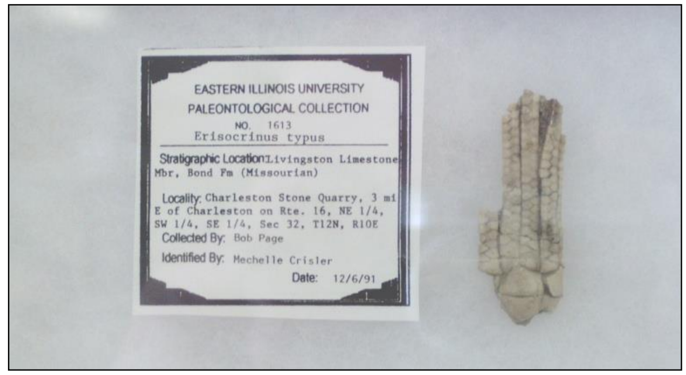
1.2.3.4 **Grain size**: Grain size is used in relation to crystallinity. There are many different sizes, but a standard classification is as follows:

(1) Lithographic limestone (less than 0.004 mm grain size diameter). This is an extremely fine crystalline rock that is of uniform character and free of coarse particles. A hand lens or microscope is needed to view these crystals.

(2) Fine-grained (0.004 mm to 1 mm grain size diameter)

(3) Medium-grained (1 mm to 5 mm grain size diameter)

(4) Coarse-grained (greater than 5 mm grain size diameter)



Fossil from Charleston Stone Co. – Coles County

Fossils from Rapatee, IL.

Oolites

1.2.4 **Impurities in Carbonate Rock** - Limestone and dolomite commonly have impurities which are usually non-carbonate minerals. Some of these are chert, clay, shale, sand, or pyrite. Most of these impurities produce quality problems when the carbonate rock is used as aggregate.

Impurities found in Carbonate Rock
Chert Clay Shale Sand Pyrite

1.2.4.1 **Chert** (silica dioxide (SiO_2)): Chert has the same chemical formula as glass or quartz. Most chert occurs as tiny pockets or nodules. When abundant, chert will appear as layers.

Chert has a Mohs hardness of 7. Due to its high Mohs hardness, it is very abrasive and damaging to crushing equipment.

The specific gravity of chert is usually less than the limestone or dolomite, somewhere between 2.050 and 2.680. Lightweight chert becomes a serious problem in P.C. concrete due to its pop-out potential. (Discussed further in Chapter 3.0 of this manual)

Chert varies in color from white to black or dark gray, even green, due to impurities in its crystalline structure. The texture of chert varies from a soft, porous, chalky material to a very glassy-looking, angular rock.

Chert – SiO_2 – Silica dioxide	
Parameter	Attribute
Color	Varies
Specific Gravity	2.050 to 2.680
Hardness – Mohs scale	7
Texture	Chalky to Glassy
Appearance	Nodules or Layers
Workability	Very abrasive
Problems	Causes pop-outs

Chert Gravel

1.2.4.2 **Clay and shale**: Clay and shale are common impurities in Illinois carbonates. Clay occurs as thin partings between the beds of carbonate rock. It also can occur as small particles scattered throughout the rock's crystalline structure.

Shale is essentially compacted and hardened clay. Normally, shale is identified by its visible laminations. It occurs in layers of variable thickness. Its color ranges from red-to-black to gray-to-green due to impurities.

Clay Balls

1.2.4.3 Some other non-carbonate impurities are sand particles, which are essentially quartz grains. Pyrite ("fool's gold") and marcasite are also found in carbonate rock.

1.2.5 **Stratigraphy** - Having covered the basic characteristics of carbonate rocks, the stratigraphy of the rock in Illinois will be discussed. Stratigraphy can be defined as the branch of geology that studies the sequence in which the rock formations were deposited.

1.2.5.1 In order to understand the stratigraphy of Illinois, a number of concepts need to be defined. These concepts or terms are often used when running a total quality control program at a quarry.

(1) Lithology. Lithology is defined as the physical characteristics of a rock, otherwise known as the structure and composition of the rock formation. In simple terms, lithology means "rock type", i.e., shale, limestone, sandstone, etc.

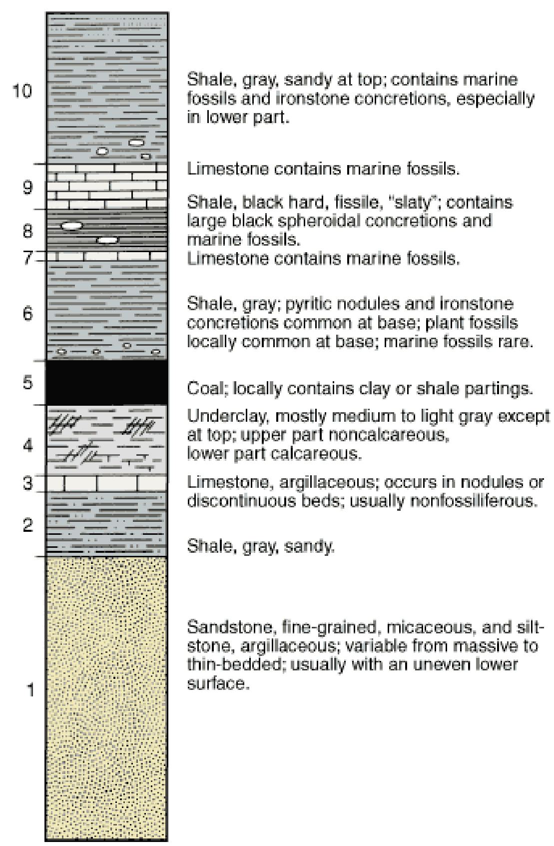
(2) Formation. A formation is a rock layer that is distinctly different than the material adjacent to it. Also, it is the primary unit used to describe rock, and it is composed of members and beds.

(3) Member. A member is a division of a formation differentiated due to its distinct lithology (physical characteristics). An example is a limestone formation that has a small shale member in it.

(4) Bed. A bed is a division in a formation or member that is a more-or-less well-defined, divisional plane between the rock above and below.

To be classified as any one of the last three, a rock type, or lithology, has to be a fairly continuous layer over considerable distance. These next several geological features have much smaller geographical boundaries.

Definitions
Stratigraphy: The study of rock formations
Lithology: The physical characteristics of a rock
Formation: A distinctively different layer of rock
Member: A physically different part of a formation
Bed: A well-defined division of a formation
Lense: A surrounded member in a formation
Tongue: A wedge of material between members
Pinch-out: Similar to the tongue
Lateral variation: Horizontal change in a formation
Joint: A fracture or crack in a formation
Fault: A fracture caused by movement
Strike: Direction of layering to a plane
Dip: The angle of layering to a plane



Pennsylvanian Geological Formation

(5) Lense. A lense is a geographically restricted member that terminates on all sides within a formation.

(6) Tongue or pinch-out. A tongue or pinch-out occurs when a certain bed, member, or formation wedges out in one direction between rock with a different lithology.

(7) Lateral variation. Lateral variation is horizontal variation in a particular rock formation. This variation can occur in mineral composition, grain size, cementation of the grains, and crystalline structure. An example would be a grading of clean limestone into a limestone containing increased amounts of clay in the crystalline structure.

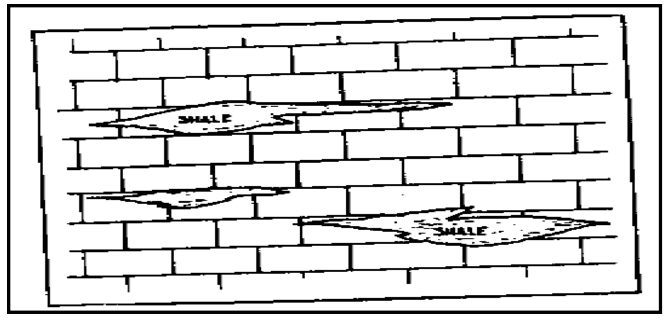
Several additional features which can be directly related to individual quarries should also be defined.

(8) Joint. A joint is a fracture or crack in rock resulting from breakage due to stress. Generally they show very little movement. Usually joints are vertical and occur in sets.

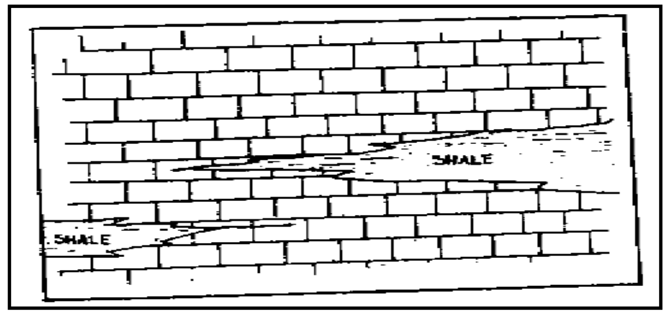
(9) Fault. A fault is a fracture or group of fractures along which there has been actual movement of rock layers -- horizontally, vertically, or both.

(10) Strike. Strike is the direction of an imaginary line formed by the intersection of the bedding and a horizontal plane.

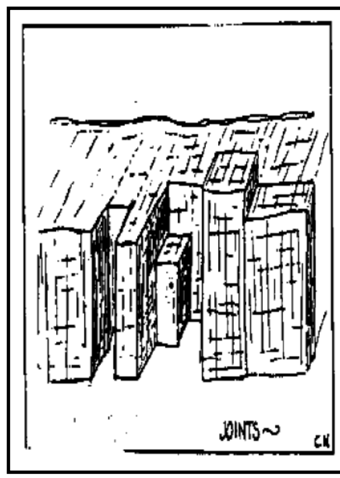
(11) Dip. Dip is the angle between the bedding and the horizontal plane. It is always measured at right angles to the strike.

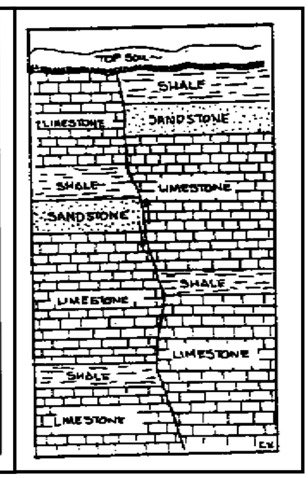


Lenses

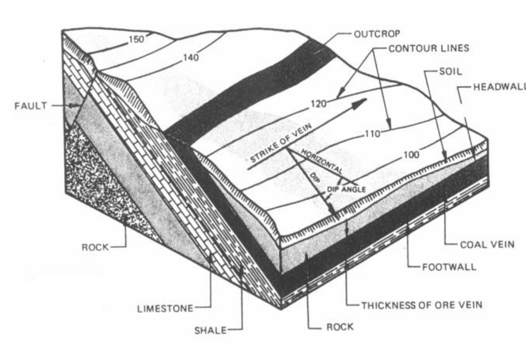


Tongues or Pinch-outs



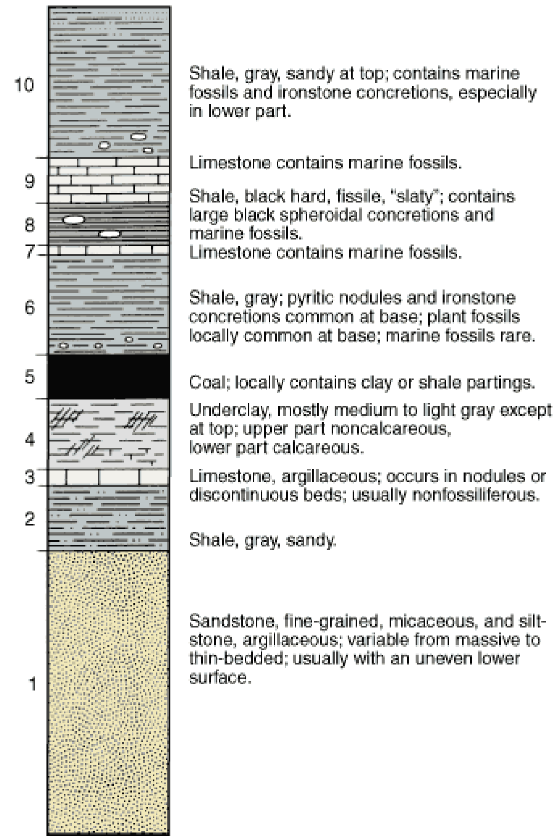


Joints Fault line



Dip and Strike

1.2.5.2 **Stratigraphy and quality** -- This section will take another look at the above-defined features but from an aggregate <u>quality</u> standpoint.

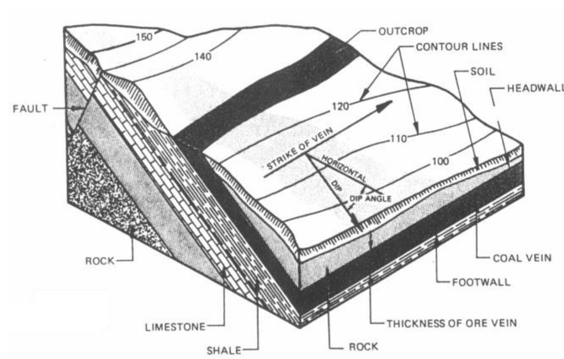


(1) <u>Lithology</u> (formations, members, and beds). Any time change in lithology occurs; a change in quality is possible.

An example could be bed thickness changes. This could mean a quality change. In addition, thinner beds mean more bedding planes which usually mean more clay.

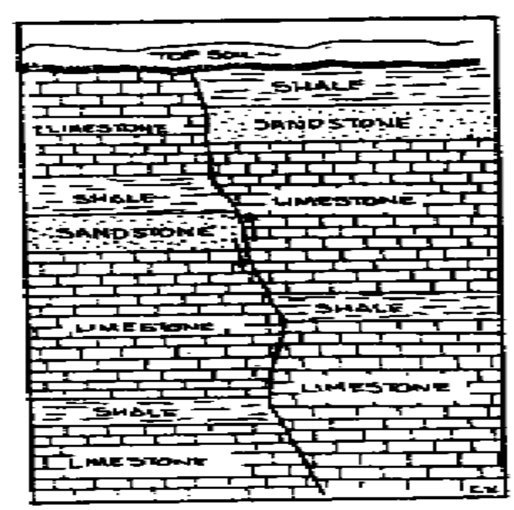
(2) <u>Lenses, tongues</u>. It is fairly obvious how these affect quality. Anytime material is added to or removed from the normal working ledge, quality problems can occur.

(3) <u>Lateral variation</u>. This is a big problem in Illinois. A gradual change in rock lithology might be missed over several years of production. However, quality tests can identify this lithology change. As an example, test results could start to rise or fall as the working ledge moves in a certain direction. The change in the physical characteristics of the face is not normally discernible. This sometimes can be seen under close observation by trained geologists.

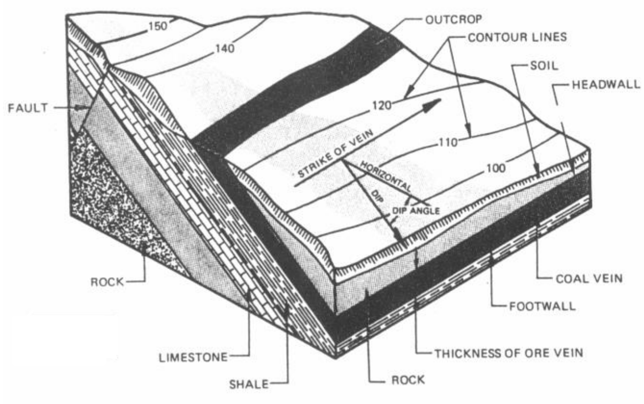


(4) <u>Joints, faults</u>. Quality problems can exist whenever these are present. Both joints and faults allow more water into the rock and allow more exposure to weathering. Also with faults, due to an extreme amount of built-up stress that causes faulting, heat is generated. This heat alters the rock and allows for more severe weathering.

Additionally with faulting, if there has been any vertical movement and subsequent erosion, then the beds are no longer lined up horizontally, and this can cause quality problems.



(5) Strike, dip. Most quarry operators try to maintain a level quarry floor. This is good mining procedure, but what if the rock is dipping? Most rock formations dip if only slightly. In this case, the operators always try to mine up dip so water flows to the sump hole. However, by mining up dip, the footage or the location in the formation changes. This can mean a serious change in quality.



Dip and Strike

1.2.6 **Classification** - Rocks are classified using many different systems that were devised by many different people. Most of the classifications are not worth memorizing. There are three general ways to classify rock:

- Rock type (lithology)
- Fossils
- Time or age

1.2.6.1 **Lithology**: Lithology has already been discussed. Basically, rock is grouped by physical characteristics.

1.2.6.2 **Fossils**: The rock is defined and given a relative age based on what fossils it contains. No concern is given to physical features. Usually as fossils grow more complex, the rock is younger. All present applications are built on earlier work.

1.2.6.3 **Time or age**: This is usually the rock's relative age based on its vertical placement in a sequence of rock. Any distinct lithologic feature is used, such as an unconformity or marker bed. For actual numerical age, radio-carbon dating or other isotopic dating is used.

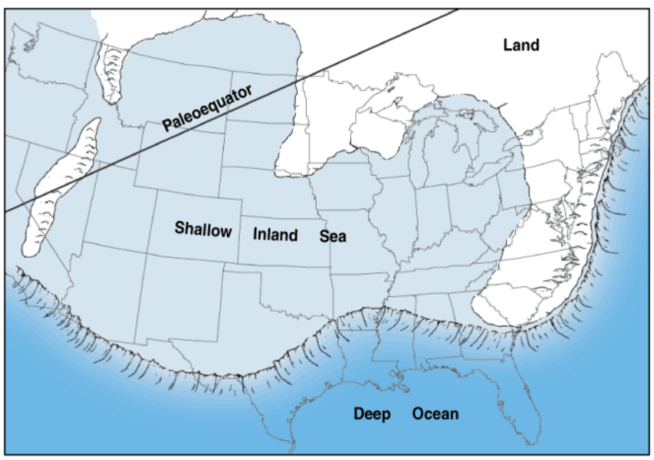
General Age Chart – Youngest to Oldest		
		Age (millions of years)
Cenozoic	Quaternary Tertiary	1 or less 1 - 63
Mesozoic	Cretaceous Jurassic Triassic	63 - 135 135 - 181 181 - 230
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian	230 - 280 280 - 310 310 - 345 345 - 405 405 - 425 425 - 500 500 - 600
Pre-Cambrian		more than 600

Geological Age Chart

Illinois Fossils

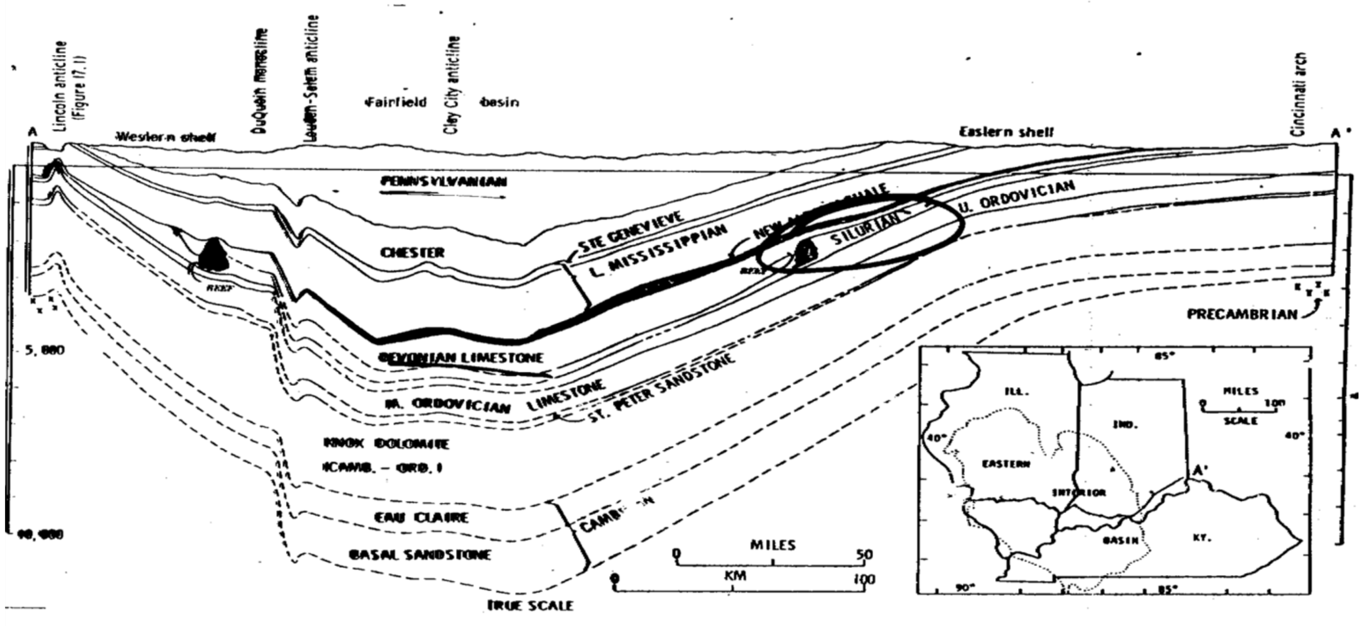
1.2.7 **General Carbonate Geology** - Illinois rock lies in a broad, oval-shaped depression, or basin, called the Illinois Basin, that is elongated north to south. This basin covers all of Illinois except the northern part. Northern Illinois geology is connected with the Michigan Basin.

In the Illinois Basin the rocks are all Paleozoic, ranging from Upper Cambrian to Pennsylvanian. The youngest rocks exist in the middle of the basin. As you progress outward, older rocks outcrop at the surface. The deepest part of the basin is located in southern Illinois and northern Kentucky. The rock is 4,600 m (15,000 ft) thick.



Mississippian Period Sea

Illinois Basin from the Pennsylvanian Period



Profile view of the Illinois Basin

1.2.8 **Production areas in Illinois.** Illinois can be divided into five general stone producing areas as follows:

(1) Northeastern Area:

Silurian dolomites from the Niagaran Series

Large-size gravel deposits

Abundance of Dolomite deposits

(2) Northwestern Area:

Ordovician, Silurian, and Devonian dolomites

Similar to the Northeastern area materials

(3) Western Area:

Mississippian limestone
Northern Part -- Lower Mississippian
Southern Part -- Upper Mississippian

Plentiful fluvial sand and gravel deposits

(4) Central Area:

Pennsylvanian limestone

Sand and small-sized gravel plentiful

(5) South Eastern:

Deeper deposits, lower qualities

Finer sand deposits with little oversize gravel

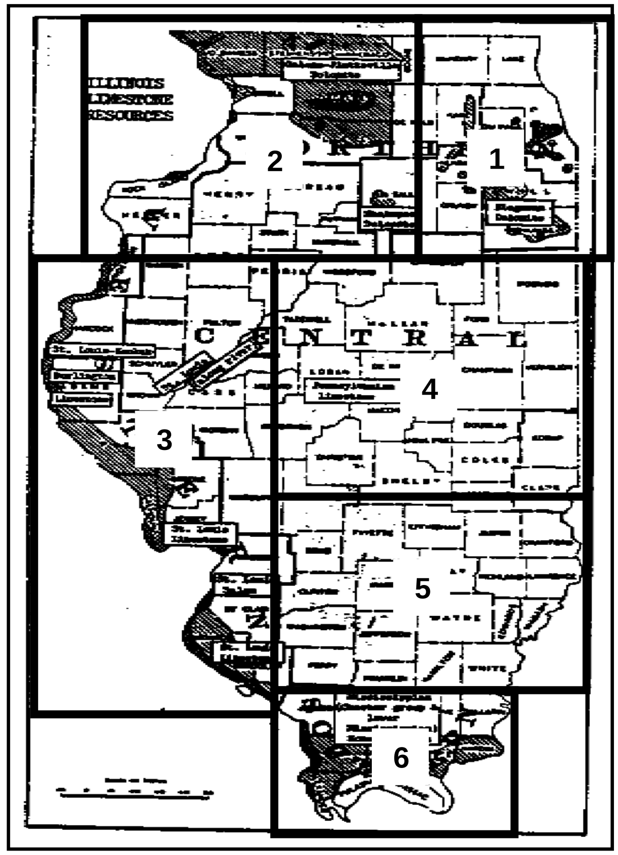
(6) Southern Area:

Upper Mississippian limestone

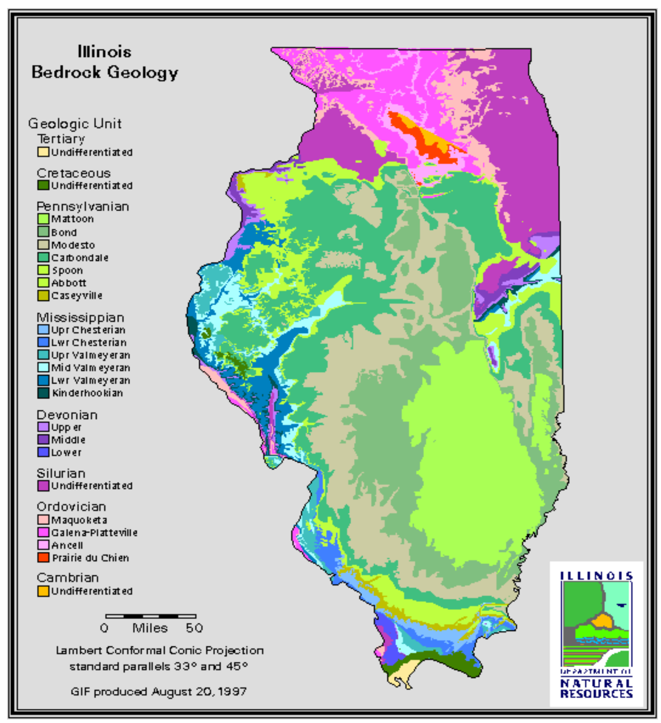
Limestone materials are usually shipped down the Mississippi River

Plentiful fluvial sand and gravel deposits

NOTE: For more detailed information, refer to the Illinois State Geological Survey (ISGS) Bulletin #95, "Handbook of Illinois Stratigraphy".



Aggregate producing areas of Illinois



Illinois Bedrock Geology

Special Aggregates used in Illinois
Crushed Sandstone
Chert Gravel
Novaculite
Trap Rock
Fly Ash
Slag
Synthetic Products
Copper Slag

1.3 **Special Aggregates**. The major aggregate types used for highway construction in Illinois are gravel, crushed gravel, limestone, and dolomite. However, there are a number of other aggregate types, both natural and manufactured, which are also used by the construction industry. The following discussion details the aggregate types, production methods, and various physical properties that affect their use. The special aggregates that will be discussed are crushed sandstone, chert gravel, novaculite, trap rock, fly ash, wet-bottom boiler slag, air-cooled blast furnace slag, steel slag, crushed concrete, synthetic products, and copper slag.

1.3.1 **Crushed Sandstone** - Sandstone is cemented sediment composed predominantly of sand-size quartz grains. The grains are cemented together by a carbonate gel which is not as strong as the quartz grains.

Sandstone deposit

Sandstone is used as a high-friction aggregate due to several special properties. The quartz particles in sandstone are continually broken out of the cementing matrix by traffic, leaving a fresh, angular quartz grain in their place. This provides a constantly renewable surface. This is why crushed sandstone is such a good friction aggregate. In contrast, when a carbonate aggregate breaks down, the particles become rounded, leaving a smooth texture and little friction potential. The rougher the texture, the higher the friction level of the aggregate.

Sandstone

The only sandstone IDOT can currently use comes from the Cave-In-Rock area in District Nine. This sandstone is called the "Rosiclare Sandstone". Crushed sandstone is used for HMA Superpave mixtures E & F, which are the two highest friction mixes currently being used in Illinois.

Manufacturing sandstone is like any regular aggregate. The ledge is shot, and the material is crushed and screened to a set gradation. The major problem in production is the high wear in the crushing and screening equipment.

1.3.2 **Chert Gravel** - Chert gravel deposits are found in very few regions of the state. The parent material for this gravel was the nodular chert found in ancient limestone formations. In the past, these chert-bearing limestones were eroded, and the chert became concentrated in gravel deposits. To be classified as chert gravel, the deposit must contain 75% chert or similar siliceous material.

Chert gravel is found basically in western Illinois and eastern Missouri. IDOT uses chert gravel from deposits at Barry, Illinois, in District Six and from the Meramec River area in Missouri, in District Eight.

Chert

Chert gravel is normally a Class B or lower quality aggregate used in HMA base mixtures and in HMA Superpave surface mixtures used at intersections, ramps, and where skid resistance is needed. When used in HMA mixtures, chert gravel must be crushed.

1.3.3 **Trap Rock** - Trap rock is defined as a dark-colored, iron-bearing igneous rock. There has been only one true trap rock previously used by IDOT. This deposit is located in Dresser, Wisconsin. IDOT's District Eight currently uses a material called trap rock which is actually mine tailings.

Trap Rock deposit

The mine tailings consist of hematite, magnetite, and granite. Another source in the area supplies an igneous rock, rhyolite, as a trap rock. These materials are Class A quality materials and are used in bituminous mixes and some bridge decks. The cost of using and shipping these materials is normally too expensive for most road work uses. These materials are good friction aggregates but, once again, the cost has to be considered.

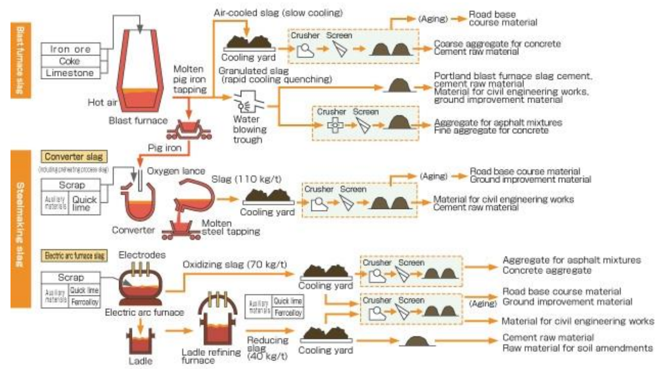
Trap Rock

1.3.4 **Fly Ash** - Fly ash is the minute burnt and unburnt particles from gases created during the combustion of ground or powdered coal. It is used as mineral filler in HMA mixtures, as a pozzolanic binder in stabilized soil subbases, and as a replacement for cement in concrete.

Fly Ash

There are two types of fly ash used in concrete: Type C and Type F. Type C is highly cementitious when used as a cement in concrete. It has a high content of calcium and has at least 50% of silicon, iron, and aluminum. Type C fly ash comes from burning western coals.

Type F has very low reactivity as a cement material. It has a lower content of calcium and at least 70% of silicon, iron, and aluminum. Type F comes from burning Illinois coals high in sulfur content.



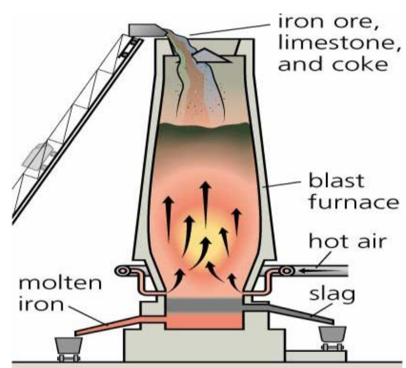
Slag Production Processes

Most of Illinois' fly ash comes from the Chicago area (District One). All fly ash is produced from coal-powered generating plants located in Illinois and surrounding states.

1.3.5 **Wet-Bottom Boiler Slag** - Wet-bottom boiler slag is a coarser, angular product from combustion of coal in wet-bottom boilers. This material is produced at the same time as fly ash. The material is mostly glassy in appearance. It can contain long and thin or teardrop-shaped particles. It is used primarily for seal coat, blotter aggregate, and as a salt extender and abrasive for snow and ice control.

Un-Processed Wet-Bottom Boiler Slag

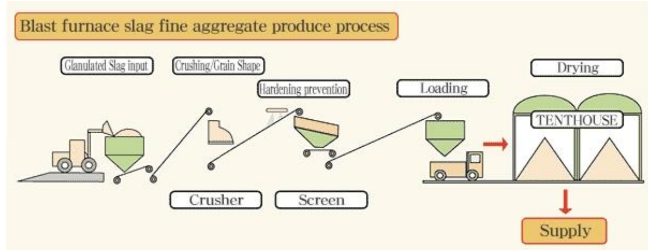
1.3.6 **Air-Cooled Blast Furnace Slag** - Air-cooled blast furnace (ACBF) slag is a nonmetallic product consisting of silicates and aluminosilicates of calcium and other bases. It develops in a molten condition simultaneously with iron in a blast furnace. The slag consists primarily of the silica and alumina from the original iron ore combined chemically with calcium and magnesium oxides from the flux stone.



The American Heritage® Dictionary of the English Language

Blast Furnace

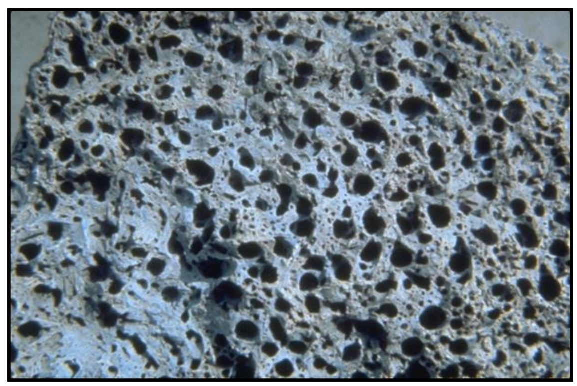
The molten slag is cooled under atmospheric conditions. Cooling may be accelerated by water sprays on the solidified mass. After it is cooled enough to be handled, the slag is dug, crushed, and screened to desired aggregate size. It is called air-cooled blast furnace, or ACBF, slag.



The solidified slag has a vesicular structure with many non-connected cells. This rough vesicular nature of slag gives it the ability to polish unevenly. This characteristic provides ACBF slag with extremely high friction potential when used in high-type bituminous surface mixtures.

Slag Pour-off

The bulk specific gravity range is 2.00 to 2.20. The smaller the size, the higher the specific gravity. The unit weight varies with size and grading of ACBF slag, method of measuring, and bulk specific gravity. The typical unit weight (compacted), graded as ordinarily used in concrete, usually ranges from 1120 kg/m^3 to 1360 kg/m^3 (70 lbs/ft^3 to 85 lbs/ft^3). Absorption is usually in the range of 1% to 6% by weight. This high and variable absorption is directly related to slag's vesicular nature. High and variable absorption, as in ACBF slag, can cause problems in producing good bituminous mixtures. A bituminous mixture's performance relies on consistent air voids and asphalt film thickness on the aggregate particles. High absorption aggregates like ACBF slag require high asphalt content in the mixture. Any variability in the absorption, different from the absorption of the aggregate used in the mix design, will cause either an excess of asphalt cement in the mixture (flushing) or a lack of asphalt cement (raveling -- not enough asphalt for the aggregate to stick together). Both conditions produce major problems in bituminous mixtures.



Air-Cooled Blast Furnace Slag

ACBF slag is used in graded aggregate bases for pavements, concrete (plain and reinforced), bituminous pavements, skid resistant surfaces, macadam surfaces and bases, railroad ballast, backfill, etc.

<u>Slag Material Properties</u>

Type	**Bulk Sp. Gr.**	**Absorption (%)**
Wet-Bottom	2.30 – 2.90	0.3 – 1.1
ACBF	2.00 – 2.20	1 – 6
Steel	3.00 – 3.40	2 – 5
Copper	3.69 – 4.04	Low – 0.5
Synthetic	Will vary with the different products	Will vary with the different products

1.3.7 **Steel Slag** - Steel slag is the nonmetallic product or slag developed in molten condition with steel in an open hearth furnace, basic oxygen furnace, or electric furnace. Its formation is very similar to that just described for ACBF slag. It is a very heavy aggregate with high absorption. Steel slag's bulk specific gravity ranges from 3.0 to 3.4, while its absorption ranges from 2.0% to 5.0%. Steel slag also has expansion potential due to the presence of possible free calcium or magnesium oxide created during its formation in the furnace. This material will hydrate and expand. Steel slag is similar to air-cooled blast furnace slag in its vesicular texture, high friction potential, and high absorption. Steel slag, however, does not have as variable absorption as ACBF slag.

Steel Slag

Steel slag used in Illinois comes from the District One area, including Indiana; District Four at Peoria; and District Eight at Granite City. Steel slag is used by IDOT only in HMA surface mixtures and seal coat. Due to its expansion potential, it is not allowed for use in any area that confines it.

A special provision covers the use of slag materials by IDOT. See the “Crushed Slag Producer Certification and Self-Testing Program (9-08.2)” and “Slag Producer Self-Testing Program (13-08.2)” Both of these documents can be found in Appendix C of this manual.

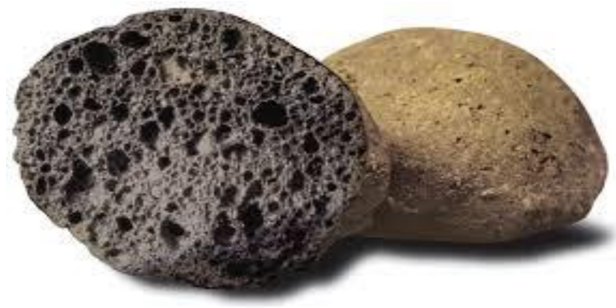
Uncrushed & Crushed Recycled Concrete

1.3.8 **Crushed Concrete** - Crushed concrete results from the process of recycling concrete by crushing concrete to the desired size and reusing the crushed concrete as a construction aggregate.

A special provision covers the use of crushed concrete by IDOT. Material produced at a central recycling plant is differentiated from material produced on a specific state project. (See “Recycling Portland Concrete Cement into Aggregate (07-08.3)” This document can be found in Appendix B of this manual.

Rubblized In-place Concrete

1.3.9 **Synthetic Products** - Synthetic products result from the recrystallization of expanded shale and clay in a kiln. This produces a lightweight aggregate, such as lakelite, Materialite, etc.



Expanded Shale Product

Lightweight synthetic aggregate is not allowed in concrete for IDOT use. A lightweight synthetic aggregate may cause some freeze-thaw problems in concrete. Synthetic products also may be no good as friction aggregates because, based on IDOT experience, the mixes do not hold together. There are problems with quality and determining what tests to run on the material. IDOT has had major problems resulting from contamination, friable mortar, and durability. There is some question whether the soundness test is valid for synthetic products.

Product Comparisons

At present, there are no synthetic products produced in Illinois.

1.3.10 **Copper Slag** - Copper slag is the nonmetallic product or slag developed in a molten state with copper in a smelter. Like steel slag, copper slag is a heavy material with a dry specific gravity (bulk) ranging from 3.69 to 4.04. Unlike steel slag, copper slag is essentially non-vesicular and has a lower absorption, averaging 0.5%.

Copper Slag Particles

The material is produced by only one company located in Hartford, Illinois, in District Eight.

Copper slag can be used in all construction uses. However, due to its high specific gravity, the economics of hauling it should be considered.

2.0 AGGREGATE PRODUCTION AND BENEFICIATION

This chapter covers the basics of how aggregate is produced. Some of these basics may not apply to all the aggregates produced in Illinois, especially some of the ones discussed in Chapter 1.0, Section 1.3 "Special Aggregates" (slag materials, crushed concrete, etc.), but will apply to most of them. While covering the basic production methods, the discussion will also cover how or if aggregate can be beneficiated by a change in the method.

The areas to be discussed are as follows:

- Stripping
- Drilling
- Blasting
- Loading and Hauling
- Scalping
- Crushers (compression and impact)
- Beneficiation Processes
- Screening
- Sand Production
- Stockpiling and Handling

Aggregate and Beneficiation Processes
Stripping Drilling Blasting Loading & Hauling Scalping Crushing Operations Beneficiation Processes Screening Sand Production Stockpiling & Handling

2.1 **Stripping**. Stripping is a basic operation in a sand and gravel pit or a quarry. The overburden material between the surface and the product (gravel or stone) must be removed before production can begin.

Stripping is a process that can affect quality and gradation from the beginning of production. Not cleaning all the overburden off, or maintaining too narrow or steep a cut which allows overburden to slide down on the production material, introduces contamination into the raw feed. Many production plants cannot handle the contamination, and acceptable materials then become unacceptable.

Stripping operations

2.2 **Drilling**. After stripping the overburden off, stone must be drilled and blasted to produce the raw feed for the production plant. Drilling is also important in quality control. Production ledges, once established, need to be maintained. Quality is directly affected by drilling control which can vary the ledge footage in an area which has unacceptable material above or below the production ledge.

Drilling a ledge

This is also where the concepts of strike and, especially, dip come into play. (See Chapter 1.0, Article 1.2.5.1 (11) or Article 1.2.5.2 (5) of this manual) Unless these concepts are taken into account when drilling and shooting, identifying a particular ledge footage as a production ledge and running quality tests on it for acceptance is meaningless.

Drilled charge hole

2.3 **Blasting**. Blasting obviously reduces solid rock to various sized pieces to provide raw feed to the production plant. Each quarry decides on the drilling pattern and blasting force to suit its crusher feed. In fact, the drilling pattern in individual ledges may vary due to differing physical characteristics of the rock.

The blasting may also be adjusted to produce riprap and other erosional protection material.

Quality may be improved by blasting finer to get more initial breakage along planes of weakness. Of course, vibration and sound from blasting can environmentally limit the use of larger charges and big shots.

Blasting

2.4 Loading and Hauling

2.4.1 **Loading** - There are several ways to load the raw feed out of the pit or quarry for hauling to the production plant. Gravel operations can have both wet and dry load-out. In the wet operation, most producers use either drag line or a dredge. Dry operations in the gravel pit normally use a front end loader to dig the material. Most quarries, also, use the front end loader to load the shot rock. Several of the biggest quarries use an electric shovel.

Quality can be affected by how loading at the face is done. If the ledge had some bad material in a horizontal seam or a pocket, digging back and forth across the front of the shot could result in the bad material being concentrated in a slug of material going through the plant and out into the stockpile.

2.4.2 **Hauling** - Hauling the material to the production plant is usually accomplished in large haul trucks. However, a number of quarries set up their primary crusher in the quarry and haul to it by front end loader. The crushed product is then belted up and out of the pit to the production plant.

Sand and gravel pumping operation

Truck hauling

2.5 **Scalping**. Scalping separates out an oversize material from smaller material somewhere in the production process and allows the oversize to be crushed and processed separately. It can be done by a grizzly before primary crushing or by a screen deck elsewhere in the process.

Grizzly scalping screen

Scalping is a definite beneficiation process that, in certain cases, removes the worst material in the smaller sizes and allows the oversize to be crushed for the better quality material.

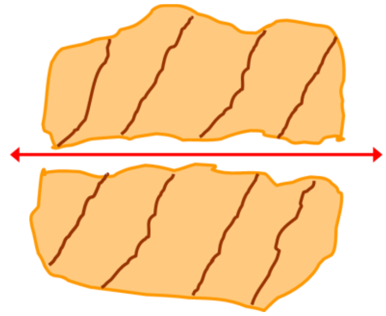
Conveyor scalping wheels

2.5.1 **Surge Piles**. A surge pile is used to even out the flow of raw feed in the plant and maintain a constant feed essential for good crushing and screening. It also allows the continued operation of separate sections of the production plant without the total plant being in operation. For example, loading and hauling to the primary crusher and crushing material into the surge pile can continue even though the secondary and tertiary plants are not operating. Also, the primary plant can be shut down while feed from the surge pile goes to the secondary and tertiary plants for processing.

The Screen Machine Ind. 107D Scalper

Surge pile

2.6 **Crushers**. Crushers are obviously important, especially in crushed stone, to reduce big rocks to small rocks so that they can be screened into a usable gradation. Crushers also upgrade the quality of the aggregate by reducing the bad rock to fines where it usually does not cause a problem. How much crushing upgrades the aggregate material is dependent upon the physical characteristics of rock and the type of crusher used.



Compression crushers break in one direction

Discussion will center on a number of different types of crushers. All fall into two categories:

- Compression crushers
- Impact crushers

Gyratory crusher

2.6.1 **Compression Crushers** - These crushers direct the rock's vertical position in the crushing chamber. Some upgrading or beneficiation occurs with this type of crusher, but not as much as can be achieved with impact crushing.

Portable Gyratory crusher

2.6.1.1 **Gyratory crusher**: This crusher is used as a primary crusher normally in the biggest quarries. It provides a large crushing capacity to service a large volume secondary plant.

The crushing action occurs as the crushing head (inverted cone shape) oscillates in a small circular path due to an eccentric. The compression crushing occurs as the crushing head progressively approaches and recedes from each point of the cone-shaped crushing chamber's inner surface.

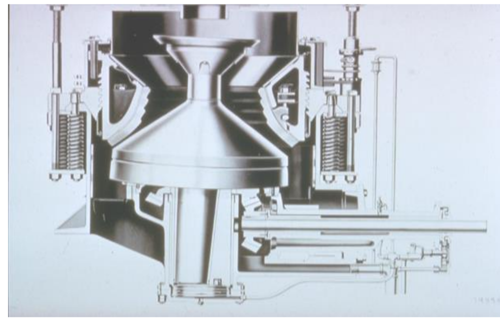
Cone crusher

The gyratory crusher is normally very large and requires a fairly large and tall infrastructure for support.

2.6.1.2 **Jaw crusher**: The jaw crusher, like the gyratory, is used mainly as a primary crusher. It is used infrequently as a secondary crusher.

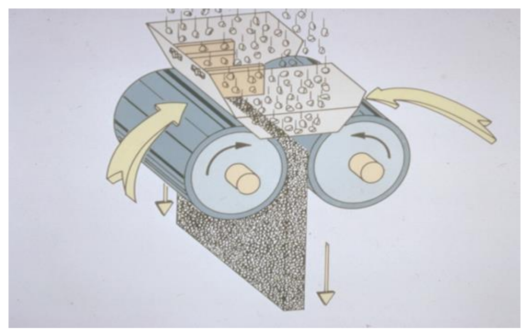
Jaw crusher

The jaw crusher employs the same crushing principle as the gyratory, that is, reciprocating pressure-crushing. This is achieved through the use of an eccentric which oscillates a flat swing-jaw against a stationary plate. The motion of the swing-jaw is greatest at the discharge opening and gradually decreases toward the upper part of the crushing chamber. The crusher is made in portable models and also with a double jaw configuration.



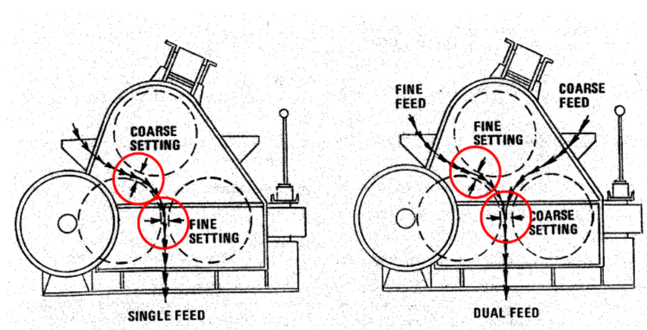
Cone crusher

2.6.1.3 **Cone crusher**: The Cone crusher is a relatively high-speed gyratory crusher incorporating a flatter head angle. The number of gyrations employed in crushing is approximately twice that used in a primary gyratory crusher. Cone crushers are normally used as secondary, tertiary, or quaternary crushers in the production plant.

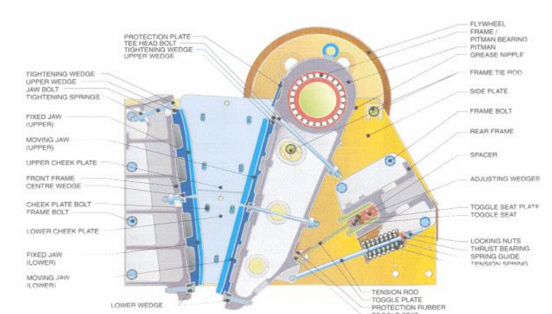


Double roll crusher

2.6.1.4 **Roll crusher**: The last of the major compression crushers is the roll crusher. A double roll crusher has two rolls mounted in the same plane which revolve toward each other, thus crushing the material between them. A triple roll crusher has a third roll added to create two separate crushing chambers, increasing the crusher's ratio of reduction. The crusher is usually used as a secondary, tertiary, or quaternary crusher.

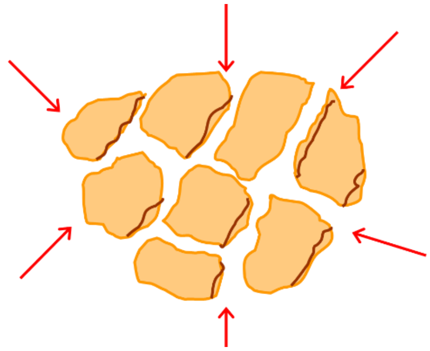


Triple Roll crusher



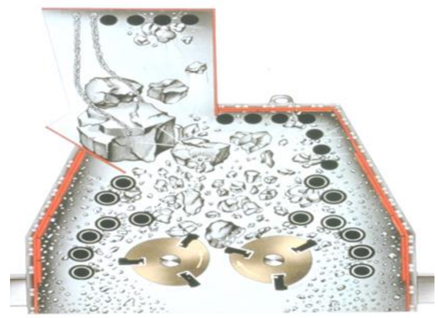
Single jaw crusher

2.6.2 **Impact Crushers** - This type of crusher obviously uses impact rather than compression to crush material. Impact crushers do beneficiate most materials. Whereas compression crushing normally causes breakage parallel to the compression force, impact crushing normally causes breakage across zones of weakness in the material, no matter at what orientation the material comes through the crusher. One unfortunate aspect of impact crushing is the increased production of fines. There are four types of impact crushers that will be discussed.



Better beneficiation
Impact crusher

2.6.2.1 **Horizontal Impactor**: A horizontal impact crusher contains a horizontal rotor with impeller bars which rotates at extremely high rpm's. Material is fed into the crushing chamber and falls onto the high-speed rotor. The impeller bars both impact and hurl the material against breaker bars and plates lining the crushing chamber. Breakage occurs from both the impact of the impeller bars and the impact against the breaker bars/plates. Some rock-on-rock breakage may also occur.



Horizontal shaft impact crusher

The horizontal impactor can perform as a primary, secondary, tertiary, or quaternary crusher.

Vertical shaft impact crusher

2.6.2.2 **Vertical Shaft Impactor**: The vertical shaft impactor (VSI) contains a vertical rotor, instead of a horizontal rotor, on which a feed plate is mounted. The rotor is turned at high rpm's and the material is dropped on top of the rotating feed plate. The feed plate flings the rock outward against breaker plates. Breakage occurs against the plates and possibly some rock-on-rock breakage. There are also several strictly rock-on-rock VSI crushers currently on the market. The VSI does not give the double impact breakage as in the horizontal impactor.

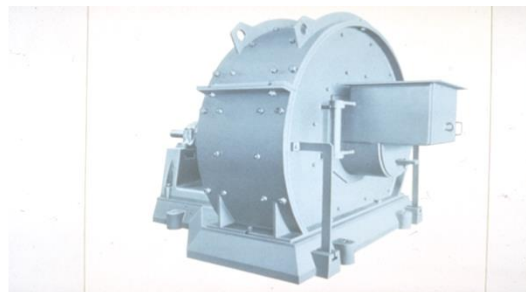
The VSI is usually a secondary, tertiary, or quaternary crusher.

Vertical shaft impact crusher

2.6.2.3 **Hammermill**: The hammermill contains a horizontal rotor, rotated at high rpm's, on which are mounted hammers, normally free-swinging. The crushing chamber is equipped with grates at the bottom. Crushing is achieved by impact from the hammers and by shear and attrition from the hammers forcing the rock through the grates.

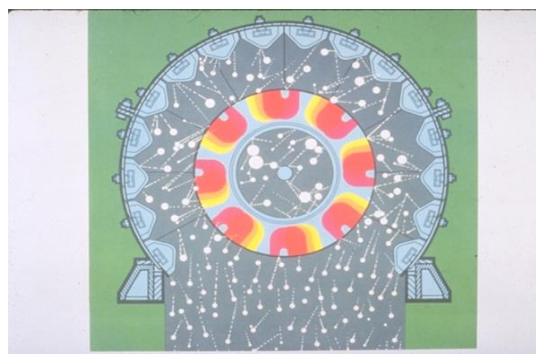
Hammermill impact crusher

The hammermill is usually considered a tertiary or quaternary crusher (maybe a secondary in certain situations). The hammermill is sometimes used to make Ag lime.



Cage mill impact crusher

2.6.2.4 **Cage mill**: The cage mill contains a high-rpm, vertically rotating cage which has breaker bars mounted in it. Material is fed into the center of the cage, and the material is then hit and broken by the breaker bars. It is also thrown against breaker plates lining the outside of the crushing chamber.



Cage mill impact crusher

The cage mill is normally used as a secondary, tertiary, or quaternary crusher. Do to the potential to create excessive fines; the cage mill crusher is not used very much in Illinois except to produce sand products or AG lime material.

2.6.3 Crusher Advantages vs. Disadvantages

Crusher type	Compression	Impact
Advantages	Less dust	Better beneficiation
	Lower cost to operate	Better particle shape
		More portable
Disadvantages	Elongated particles	More fines
	Deposits will crush differently	Higher cost to operate

2.7 **Beneficiation Processes**.
Beneficiation of rock by impact crushing is one proven method. Several other proven beneficiation processes should also be discussed.

2.7.1 **Heavy Media** - The heavy media process involves dropping the production feed into a conical tank containing a slurry of water and iron-based particles. The slurry is continually agitated in the tank by paddles thus keeping the particles suspended. This creates a slurry of a known specific gravity that can be adjusted. The material dropped into the slurry either sinks or floats due to its difference in specific gravity from that of the slurry. The float, or deleterious material, is skimmed off the top while the good material is drawn off the bottom of the tank. The iron particles are washed off the rock and recovered for use.

There is at least one heavy media plant operating in Illinois at the present time.

Heavy media process

2.7.2 **Logwasher** - Use of a logwasher, preferably a double logwasher, is also a beneficiation process. The production material and water is introduced into the bottom end of the logwasher, and large horizontal shafts with paddles agitate, grind, and auger the material up and out the logwasher. Soft material, especially clay and soft shale, is broken down and washed away with the water.

The logwasher will not, unfortunately, eliminate excessive amounts of the hard, unsound rock.

Twin-shaft logwasher

Logwasher unit

2.7.3 **Attrition Mill** – Attrition mills perform similarly to logwashers except usually on sand. Paddles agitate the material, allowing attrition, or breakdown, by particle grinding against particle.

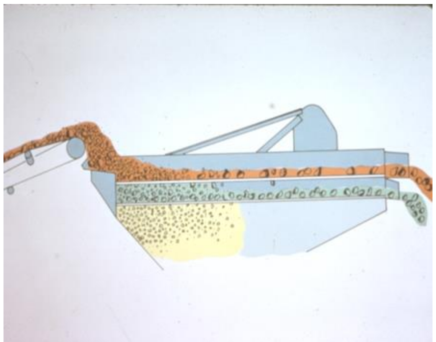
Magnetic Belt Screening Unit

2.7.4 **Magnet** – Magnets perform a beneficiation process in the production of ACBF and steel slags. Iron and steel particles are removed from the slags before their sale for aggregate.

2.8 **Screening**. Screening obviously separates the material into separate sizes for a gradation or for recombining into a gradation. Screen decks (either double or triple decks) allow different sized screen wire to be mounted to separate the material into sizes. Some decks even have spray bars mounted to facilitate fines or clay removal.

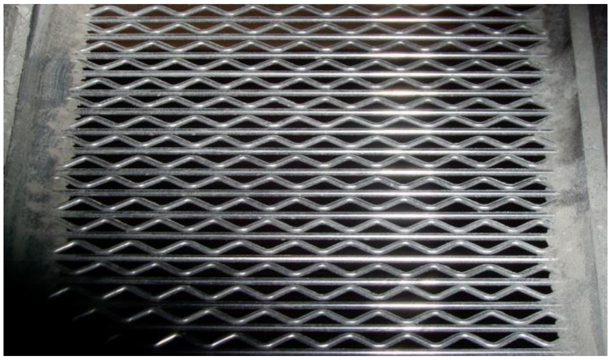
Dual Screening Unit

The adjacent figure provides a good illustration of how the eccentric vibration applied to the decks helps separate into sizes. Then, these individual sizes can be either recombined and crushed further, or otherwise processed into specific aggregate gradations. Some sand, both natural and manufactured, can be produced without screening.



Screening unit Operation

Inclined Vibrating Screening Unit



Self-cleaning screen

2.9 **Sand Production**. Sand classifiers, using rising currents of water and gravity separation of various size ranges, can be used to produce a sand gradation.

Classifier

Sometimes a producer does not need equipment as elaborate as a classifier. There are some sand deposits that need only the fines removed. Most producers use a simple sand screw to float out the fines; most manufactured sand is produced this way. Of course, the sand screw is also used to dewater the sand prior to stockpiling.

2.10 **Stockpiling and Handling**. Stockpiling and handling are the last processes in the production of aggregate. Stockpiling and handling then become very important because all the effort prior to stockpiling can be for nil if the material becomes segregated. This is discussed in greater detail in Chapter 4.0 “Stockpile and Handling” of this manual.

Flooded classifier

Sand & gravel production plant

Sand screw

This page is reserved

3.0 QUALITY AND USE

The Central Bureau of Materials (CBM) will perform the required quality testing on the aggregate used for on IDOT projects throughout Illinois. Quality samples are taken at each source by District inspectors and then transported to the CBM in Springfield for testing.

There are four main quality classes of aggregate used by IDOT. These classes are listed below with typical examples of their use. Actual classification is determined by the Standard Specifications and aggregate usage.

NOTE: Aggregate used for a specific quality class has to meet quality specification requirements for that particular class.

Common Aggregate Uses	
Quality Class	**Use**
"A" **Highest Quality**	Portland Cement Concrete (PCC)
"B"	HMA – High ESAL D, E & F Surface mixtures
"C"	HMA – High & Low ESAL C Surface & Binder mixtures Seal/cover coat (oil & chip)
"D" **Lowest Quality**	Stabilized subbase & shoulders including HMA usage

Aggregate materials cannot be sold and/or used in applications that demand a higher quality requirement than what the material has been approved.

Aggregate quality tests used to evaluate aggregate properties for a quality determination are as follows:

- **Sodium Sulfate Soundness***
- **Los Angeles Abrasion***
- **Deleterious Count / Heavy Media***

* Main quality tests performed on most aggregates used for IDOT purposes.

Other tests ran for material-specific purposes include:

- Freeze-Thaw Expansion Test (PCC)
- Hydrometer (HMA and PCC)
- Colorimetric/Mortar Strength (PCC)
- Dolomite Determination (Friction)

In addition to the three main quality tests, IDOT has implemented the Micro Duval testing system.

The Micro Duval test is being used to further evaluate the main aggregate properties of materials used for HMA and PCC materials. The test helps to complement the Sodium Sulfate Soundness and Los Angeles Abrasion tests.

Micro Duval Test

A number of tests are run simply to provide physical characteristics of aggregate used in the concrete/HMA mixture design process. Two of these tests are:

- Friction Characteristics
- Specific Gravity and Absorption

All the tests listed previously are used for either coarse aggregate, fine aggregate, or both. The following discussion will cover the importance of each test, the procedure, and whether it applies to coarse or fine aggregate.

All the tests start in a breakdown room at IDOT's central aggregate laboratory where the field samples are reduced down to test size samples.

IDOT CBM breakdown room

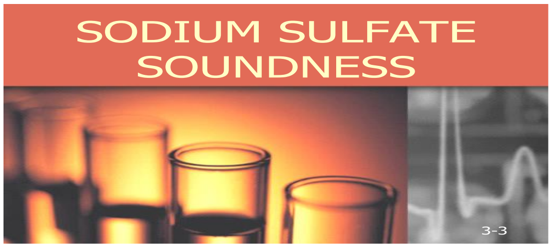
Material is mixed into a sample pad

The field technician acquires the samples

The material is reduced to test sample size

A coarse aggregate mechanical splitter for reducing aggregates to sample size

Material is fractionalized



3.1 **Sodium Sulfate Soundness**. The sodium sulfate soundness test is run on both coarse and fine aggregate. The soundness test is designed to measure an aggregate's resistance to weathering.

Over the course of the 5-cycle test, sodium sulfate crystals are built up in the pore structure of the aggregate particles. The stress caused by the formation of these salt crystals breaks the weaker particles. This breakdown is calculated as percent loss.

IDOT follows the ITP 104 test procedure.

3.1.1 A generalized version of the sodium sulfate soundness test method is as follows (pictures are shown on the following page of this manual):

3.1.1.1 Each sample is washed, dried back to a constant weight, and sieved into individual sizes.

3.1.1.2 A specified amount of sized material is placed in bread pans for testing. The amount of material and the number of bread pans used depend on the gradation of the sample. It should be noted that IDOT uses pans instead of the 8” (200 mm) diameter sieves prescribed in T 104.

3.1.1.3 To start the first cycle, the samples and pans are put in the environmental chamber and covered with sodium sulfate solution to at least 1/2” (12.5 mm) above the sample. Lids are applied to keep any moisture inside the cabinet from dripping into the pans and diluting the saturated solution. The temperature maintained inside the cabinet is 70° ± 1° F (21° ± 0.5° C), and the relative humidity is approximately 100%. The soaking temperature is considered critical. The samples are left soaking in the chamber for 16 to 18 hours.

3.1.1.4 After the samples have soaked for at least 16 hours, the solution is poured off, and the pans are put in the oven to dry at a temperature of 230° ± 9° F (110° ± 5° C) to a constant weight. After cooling, the samples have completed one cycle in the test. The samples are ready to start another cycle. Since this is a 5-cycle test, 4 more cycles, as just described, are run on the sample.

3.1.1.5 After the fifth cycle, the samples are washed free of the sodium sulfate crystals. After drying to constant weight, the coarse aggregate samples are sieved over the next size smaller sieve than the one on which they were made up. Fine aggregate is sieved over the same sieve on which it was made up. Any particles that fall through the sieves are considered "loss".

3.1.1.6 The total percent loss for the sample is calculated by taking a percentage of each pan loss and adding them together.

3.1.2 The Standard Specifications for the soundness test are as follows:

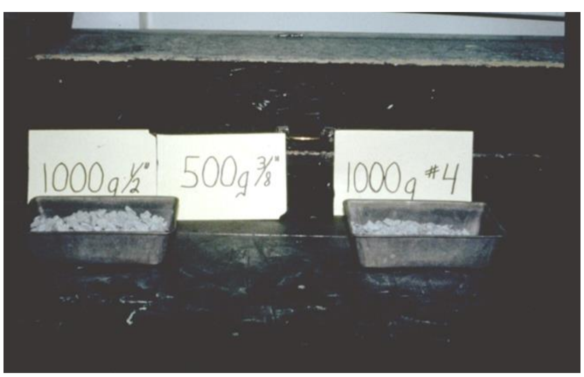
Quality Test	Class	Maximum Loss
Coarse Aggregate:	“A”	15%
	“B”	15%
	“C”	20%
	“D”	25% [2/]
Fine Aggregate:	“A”	10%
	“B”	15%
	“C”	20%

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

1) Sample is washed

2) Sample is dried to a constant weight

3) Sample is sieved into individual fractions



4) Sample size is based on the gradation

5) Solution is added & sample is put into a controlled temperature environment

6) Sample is rinsed of the solution & dried

7) The process is repeated 4 more times

8) A gradation test is performed

3.2 **Los Angeles Abrasion**. The Los Angeles abrasion test is run only on coarse aggregate according to AASHTO T 96. It measures the aggregate's ability to resist wear and gives an indication of the degradation potential of the aggregate. It is not a true abrasion test. The Los Angeles abrasion test is more of an impact test.

Abrasions are not run on large aggregate gradations such as CA01, CA03 and CA05 because the results on the large stone [(+1 1/2" (+37.5 mm)] do not correlate well with tests run on the smaller sized gradations.

3.2.1 The Los Angeles abrasion test is run as follows (pictures are shown on the following page of this manual):

3.2.1.1 The test sample is initially washed, dried back to a constant weight, and sieved into separate sizes.

3.2.1.2 The test sample of 5,000 grams is made up according to the gradation of the material. The gradation also determines the number of steel balls (abrasive charge) that are added to the test sample. The number of steel balls used for the test is determined by the quality level being tested (12 for “A” quality, 11 for “B” quality and 8 for “C” quality aggregate)

3.2.1.3 The sample and the balls are put in the Los Angeles machine. The machine is then mechanically rotated at 30 rpm to 33 rpm for a total of 500 revolutions.

The machine is a cylindrical steel drum that is 28” (710 mm) in diameter and 20” (508 mm) wide. A steel shelf sticks perpendicular to the wall inside the machine. The shelf dimensions are 3 1/2" x 1" x 20" (90 mm x 25 mm x 508 mm).

3.2.1.4 After 500 revolutions the sample is dumped from the machine and sieved over a No. 12 (1.70-mm) sieve. The material passing the No. 12 (1.70-mm) sieve is considered loss and is calculated as a direct percentage of the original test sample's weight.

Los Angeles Abrasion Machine

3.2.2 The Standard Specifications for the Los Angeles abrasion test are as follows:

Quality Test	Class	Maximum Loss
Coarse Aggregate:	“A”	40 [3/]
	“B”	40 [4/]
	“C”	40 [5/]
	“D”	45

[3/] For PCC – maximum loss is 45
[4/] Doesn’t apply to steel or crushed slag
[5/] For HMA binder mixtures except as surface mixtures – maximum loss is 45


1) Sample is washed


2) Sample is dried to a constant weight


3) Sample is sieved into individual fractions

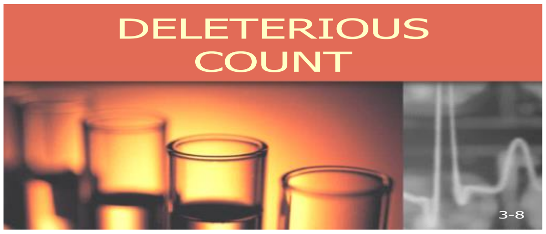

4) Material is weighed based on size


5) Steel balls are added based on quality


6) Material is placed in the LA Abrasion machine


7) Removed after 500 revolutions


8) A gradation test is performed



3.3 **Deleterious Count**. This test is a petrographic examination of an aggregate sample to identify material that has been determined to be deleterious in highway construction use. It applies to both natural sand fine aggregate (only) and coarse aggregate.

3.3.1 For coarse aggregate, the deleterious count test procedure is as follows:

3.3.1.1 The material is split and screened over a No. 4 (4.75-mm) sieve. Each test sample ranges from 1,000 grams to 5,000 grams, depending on the size of the aggregate.

3.3.1.2 Lab personnel hand-examine each particle to determine if it is deleterious. The deleterious particles of different composition are kept in separate pans. A tool is used to detect the soft particles and chert.

Maximum limits have been established by specification for several different types of deleterious particles. These limits will change for Classes “A” through “C” quality.

For Class “A” quality coarse aggregate, the following maximum limits have been set:

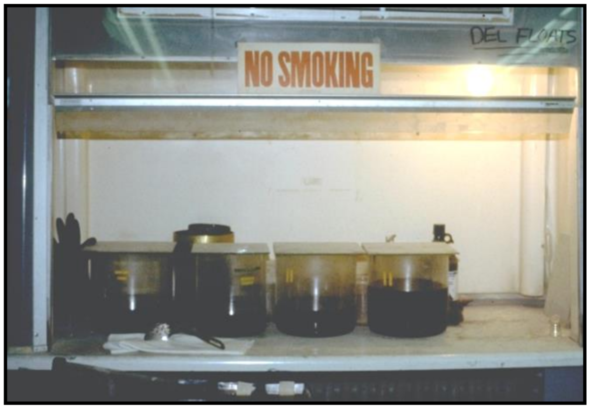
Quality Test	% Maximum
Shale	1.0
Clay lumps	0.25
Coal and Lignite	0.25
Soft and unsound	4.0
Other deleterious	4.0 [9/]
Total deleterious	5.0

[9/] Includes deleterious chert

Each piece of material is hand-inspected

Material is classified by deleterious type

In Class “A” quality samples, deleterious chert is picked out as "other deleterious". Since not all chert is considered deleterious, all the chert picked out is soaked for 16 hours and run in a heavy media set-up. The heavy media is a solution of zinc bromide and water. Two stainless steel tanks contain this mixture -- one set at a specific gravity of 2.350 for identifying deleterious chert in gravel, and one set at 2.550 for deleterious chert in crushed stone. If the chert is lighter than the gravity of the solution in which it is placed, it will float and is considered deleterious.



Heavy media test

<u>For Classes “B” and “C” quality coarse aggregate</u>, the main emphasis is on shale, clay lumps, and soft and unsound particles.

Classes “B” and “C” quality samples are not checked for deleterious chert because chert does not cause problems in HMA mixtures like it does in concrete. Chert gravel is required to be crushed when used in HMA mixtures.

Quality Test	Class “B” Quality % Maximum	Class “C” Quality % Maximum
Shale	2.0	4.0
Clay lumps	0.5	0.5
Soft and	6.0	8.0
Other	2.0	2.0
Total	6.0	10.0

Material specification % Max limits

3.3.1.3 Three other counts done on coarse aggregate, for informational purposes only, are as follows:

(1) <u>Carbonate count</u> (for Variable Speed Friction Testing). All carbonate rock is picked out of gravel samples.

(2) <u>Siliceous count</u> (District Six Special Provision). All siliceous rock (chert, quartzite, etc.) is counted out of a chert gravel sample.

(3) <u>Crushed particle count</u>. Particles having a fresh, mechanically fractured face are counted out.

Note: See the Policy Memorandum “Crushed Gravel Producer Self-Testing Program” (12-08.2). This document can be found in Appendix B of this manual.

Crushed particle count test

3.3.2 The deleterious count on fine aggregate is run only for Classes A and B qualities. A sample is split out, dried, and sieved over a 600-µm (No. 30) sieve. Next, the sample is split or quartered down to 100 grams. The sample is then examined either under a microscope or with the naked eye. Deleterious particles that are picked for Classes A and B quality sands include the following:

Quality Test	**Class "A" Quality % Maximum**	**Class "B" Quality % Maximum**
Shale	3.0	3.0
Clay lumps	1.0	3.0
Coal, Lignite, and shells	1.0	1.0
Conglomerate	3.0	3.0
Other deleterious	3.0	3.0
Total deleterious	3.0	5.0

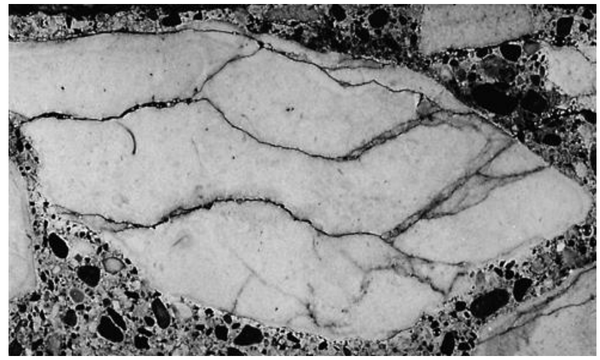
By far, the most common deleterious particle in natural sand is shale.

The deleterious particles that are removed are weighed, and a percentage of the total sample is calculated.

Fine aggregate deleterious count

3.4 Freeze-Thaw Expansion Test

3.4.1 The freeze-thaw expansion test is used to identify aggregate that causes D-cracking in P.C. concrete. "D-cracking" is defined as "the disintegration cracking of P.C. concrete due to freeze-thaw failures of its aggregate particles and surrounding mortar". The term also refers to the crack pattern which forms on the surface.



Aggregate D-cracking

D-cracking is initiated in the lower levels of a pavement slab and at any cracks or joints where moisture readily accumulates and saturates exposed aggregate particles. Water can exert 10,000 psi of pressure by expanding 9% of its volume when frozen. The cycle of freezing and thawing breaks the rock particles and surrounding mortar. This distress progresses upward and outward, destroying the pavement. Thus the concrete is reduced to rubble.

Pavement damage from D-cracking

IDOT has identified three conditions necessary to cause D-cracking. If one of these conditions is eliminated then D-cracking can be eliminated in concrete pavements:

- Freeze-thaw environment
- Water
- Susceptible aggregate

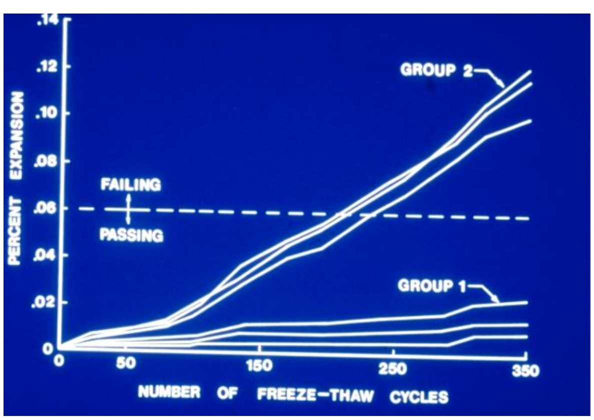
Pavement damage from D-cracking

Nothing can be done about the freeze-thaw environment. While IDOT is working on eliminating water, the majority of water is still not removed from under the pavement. IDOT decided in 1979 that the best approach and only approach was to identify D-cracking aggregates and eliminate their use in P.C. concrete pavements.

3.4.2 To identify D-cracking aggregates, IDOT has tested and continues to test all concrete aggregates in three different sizes in the Rapid Freeze-Thaw Test, ASTM C 666, Method B (rapid freezing in air -- thawing in water). This test consists of separating the coarse aggregate into individual sieve sizes and soaking the material for 18 hours; then combining the sizes in specific amounts with standard sand, cement, and admixtures; and making up a concrete mix. Keeping everything standard allows the evaluation of only the coarse aggregate for D-cracking.

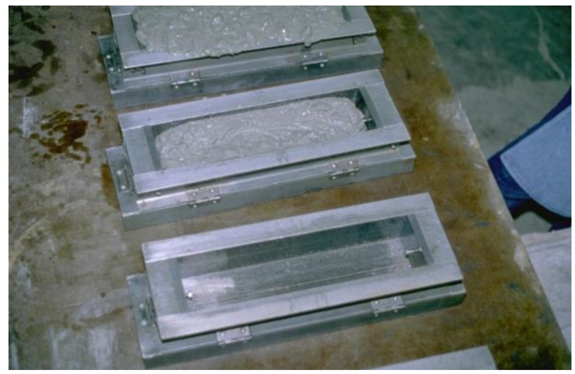
Three (3) beams are made up which have steel bolts embedded in the ends of the beams. After a 14-day cure, the initial length of each beam is read on the comparator, and the beams are run through 350 cycles of rapid freeze-thaw. Approximately once per week (25 to 50 cycles) the beams are removed from the cabinets and measured for length change. These length changes are plotted on a graph. The IDOT failure criterion is no more than 0.06% length change.

A list of what each producer can supply size-wise, or if the source is totally rejected for use in P.C. concrete pavements, is available at each IDOT District Materials office. This is strictly limited to aggregates for on-grade concrete pavements, concrete base course, and concrete base course widening.



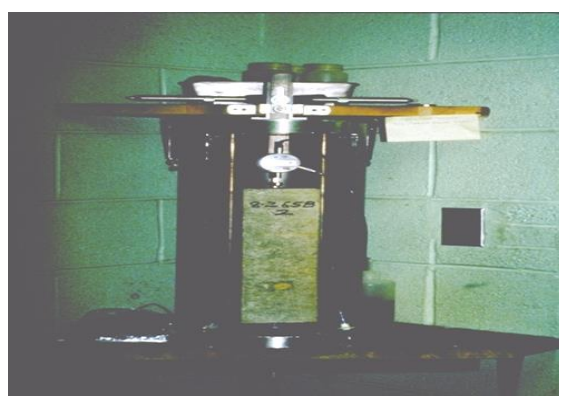
Freeze-Thaw Test Results

Materials are mixed together

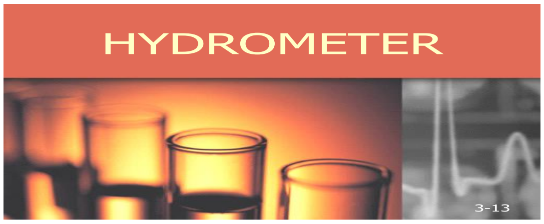


Test beams are produced & cured

Test beams are run through 350 cycles



Test beams are evaluated



3.5 **Hydrometer**. As part of IDOT's acceptance program for fine aggregate, products with high amounts of fines, 12% or more. The hydrometer test is run to determine the percentage of clay-sized particles. Clay-size content is checked because excessive minus No. 200 (minus 75-µm) material, especially clay, is detrimental to concrete and bituminous mixes.

3.5.1 The procedure for the hydrometer test is as follows:

3.5.1.1 A sample is split out, oven-dried, and dry-sieved over a No. 10 (2.00-mm) sieve.

It should be pointed out that a separate gradation is run on the sample, and the hydrometer sample is made up and tested only if the gradation is in-spec.

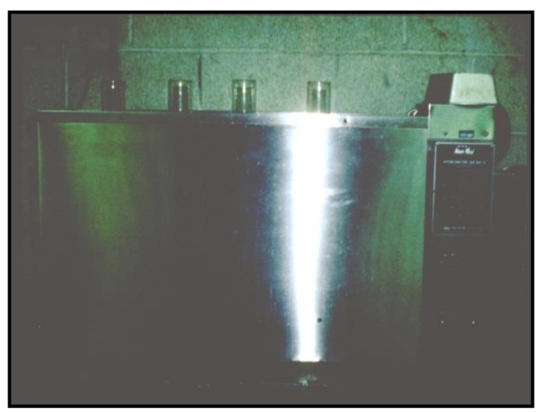
3.5.1.2 A sodium hexametaphosphate solution is added to 100 grams of the fine aggregate. This mixture is allowed to sit overnight. The sodium hexametaphosphate is a dispersing agent that acts to break apart any clay lumps.

3.5.1.3 The sample is added with distilled water to a graduated cylinder. The cylinder is placed in a temperature-regulated bath and allowed to reach 68° F (20° C). The cylinder is removed, hand-shaken for one minute, and returned to the bath.

Readings as the sample settles out and temperatures of the bath are taken at the 1, 5, 15, 30, 60, 90, 120, 250 and 1,440 minute intervals.

Sample is split & dried

Sample is mixed with sodium hexametaphosphate solution and sits overnight



Readings are taken at intervals while in a controlled environment

3.5.1.4 The readings are plotted on logarithmic graph paper, adjusting the results for moisture content and temperature. Part of the original sample was oven-dried to determine the correction for moisture. A curve is drawn through the readings. On the graph, the percentage of clay is the point on the curve at 540 minutes. The percentage of clay is adjusted for the percentage passing the No. 10 (2.00-mm) sieve in the original gradation and reported.

3.5.2 The Standard Specifications restrict the hydrometer test to Classes “A” and “B” quality fine aggregate. A maximum of 3% clay as determined by the test is allowed.

3.6 **Colorimetric / Mortar Strength**

3.6.1 The colorimetric, or color, test is used to determine the amount of organic particles in Class “A” quality sands because organics reduce concrete strengths.

IDOT uses the AASHTO T 21 test procedure. A sample is soaked for 24 hours in a 3% sodium hydroxide solution. The solution is then compared to a standard color chart. The sodium hydroxide solution will dissolve any organic material, therefore coloring the solution. If the color exceeds the color test standard of 11, the mortar strength test has to be run.

3.6.2 The mortar strength test (AASHTO T 71 as revised by IDOT) is designed to actually test the strength of the suspect sand by comparing it in mortar to a standard sand mortar. The test consists of making up cubes of cement and a sample sand. Standard sand cubes are also made up. After curing in a moist room for 14 days, the cubes are crushed to determine their strength. The sample cube's strength must be at least 95% of the standard sand cube.

This test determines whether the organic particles in the sand will cause any strength loss in the concrete.

3.7 **Dolomite Determination**. This test looks at the chemical properties of carbonate rock.

3.7.1 The dolomite determination is run using the following procedure:

3.7.1.1 Several grams of a pulverized crushed stone sample are dissolved in hydrochloric acid. The liquid is filtered. Any solids are dried and become insoluble residue.

3.7.1.2 The liquid is put in a test tube and tested on the atomic absorption spectrophotometer. This machine determines the percentage of magnesium oxide in the sample.

Dolomite Determination

3.7.1.3 The Standard Specifications define limestone and dolomite as follows:

- Limestone -- < 11.0% MgO
- Dolomite -- $\geq$ 11.0% MgO

This test is used for IDOT's friction specifications and the Variable Speed Friction Testing program to differentiate carbonate crushed stone as limestone or dolomite materials.

3.8 Friction Specifications and Tests

3.8.1 Friction Tests

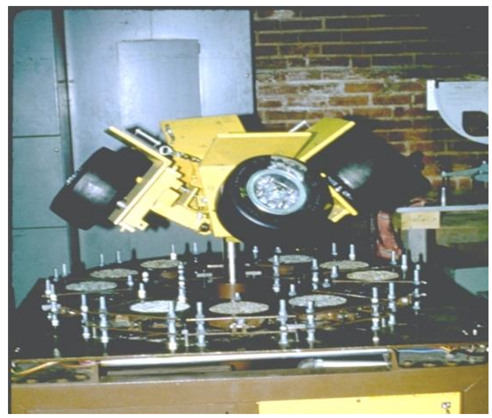
3.8.1.1 **Friction Trailer**: Many overlays (both new and old) are continually checked in the field by IDOT's ASTM friction trailer. This device is pulled at 40 mph (64 km/hr) on the pavement and uses water and a locked, full-size tire procedure to measure the pavement's friction potential. This friction potential is expressed as a Friction Number (FN).

3.8.1.2 **Variable Speed Friction Test**: IDOT can also evaluate the friction potential of the raw aggregates and combinations of aggregates in the laboratory by using its Small-Wheeled Circular Track and Variable Speed Friction Tester (VST). These devices, developed by North Carolina State University in the late 1970's, consist of a polishing track and a pendulum friction tester.

The Small-Wheeled Circular Track consists of four go-cart tires that revolve around on the aggregate samples at 30 rpm. The tires on the track are alternately toed in and toed out to provide a scrubbing or polishing action on aggregate samples.

These aggregate samples consist of aggregate particles placed in a steel mold with cement paste added, and a retarder on the mold surface. The cement paste hardens, holding the particles in place, except for the cement paste at the surface. The surface is scrubbed clean of the cement paste, leaving exposed only the aggregate to be tested.

Portable friction testing trailer



Small-wheeled circular track

Preparing a sample for the circular track

The VST drops a pendulum and tire across a wet sample and measures the energy lost. The measurement is run after 8 hours of polishing on the Small-Wheeled Circular Track and is called the Variable Speed Number (VSN).

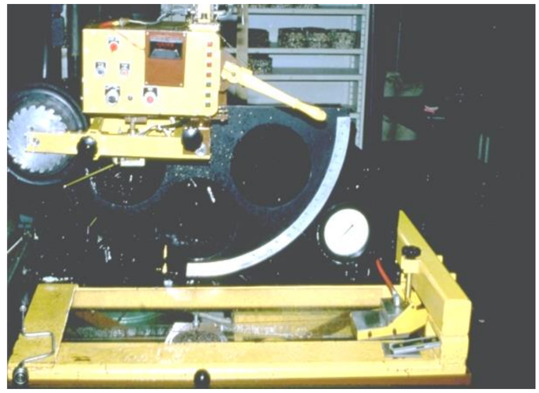
The Department has run every Class “B” quality aggregate in the VST and determined its VSN. Aggregates in Illinois are now ranked by their VSN. The adjacent graph shows that the slags, novaculite chert, and sandstone are among the best friction aggregates.

It also shows that the decision made in 1975 that limestone polishes too easily was, on the average, correct. It substantiates the aggregates required for HMA Mixture classes C, D, E and F.

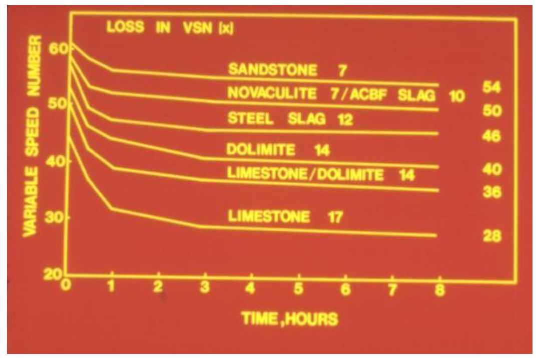
3.8.2 **Friction Specifications** - The coarse aggregate portion of any bituminous mixture provides the major friction characteristics for that mixture. Both the macro-texture (the overall surface texture of the bituminous mat) and the micro-texture (the wear pattern of the individual rock particles) are largely controlled by the coarse aggregate. In 1975, IDOT established its first special provision on high-friction pavements. In that special provision, the Department identified which aggregates could be used in the surface bituminous mix to provide a certain level of friction on the highway.

IDOT's current friction program is called the "Skid Accident Reduction Program". This program, or policy, looks at two specific procedures when overlaying a section of highway.

<u>First</u>, all spot locations or high-accident sites are identified, and specific remedies are selected to improve these sites. This may include changes in signing, geometrics of the roadway, or use of special high-friction mixes, such as open-graded friction course or sand seals



VST Testing Equipment



VSN Graph

<u>Second</u>, the normally scheduled rehabilitation of the rest of the section of highway is decided. Here, IDOT decides what level of high-friction HMA mixture is required. One of three HMA surface mixtures can be used based on the average daily traffic (ADT) of the road.

In 2000 IDOT made significant changes in the friction specifications. The new specification is on the following pages.

Skid Accident Reduction Program looks at two areas:
1. Spot locations including high accident areas
2. Normally scheduled highway rehabilitation

<u>Beginning of the Standard Specification Article 1004.01 (a) (4) in part</u>

"(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 not limited to, quartzite, granite, rhyolite and diabase."

<u>End of the Standard Specification Article 1004.01 (a) (4) in part</u>

<u>Beginning of the Standard Specification Article 1004.03 (a)</u>

"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.

Use	*Mixture*	*Aggregates Percent (%) Allowed by Volume*
Class A	*Seal or Cover*	*<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*
HMA *Low ESAL*	*Stabilized Subbase or Shoulders*	*<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*

<table>
<tr><th>Use</th><th>Mixture</th><th colspan="2">Aggregates Percent (%) Allowed by Volume</th></tr>
<tr><td>HMA
High ESAL
Low ESAL</td><td>Binder
IL-19.0
or IL-19.0L

SMA Binder</td><td colspan="2">Allowed Alone or in Combination [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
IL-9.5L

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

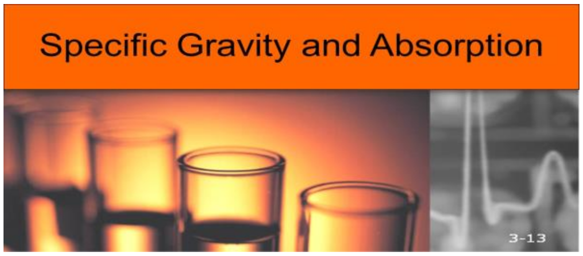
SMA
Ndesign 50
Surface</td><td colspan="2">Allowed Alone or in Combination [5/]:

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">Other Combinations Allowed:</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>

Use	Mixture	Aggregates Percent (%) Allowed by Volume	
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 SMA Surface.
3/ Crushed concrete will not be allowed in SMA mixes.
4/ Crushed steel slag shall not be used as binder.
5/ When combinations of aggregates are used, the blend percent measurements listed shall be by volume."

<u>End of the Standard Specification Article 1004.03 (a)</u>



3.9 **Specific Gravity and Absorption**. Specific gravity and absorption tests are run on both coarse and fine aggregates. While specific gravity and absorption are not used for acceptance, both the CBM and the District Material Offices will use the information in the design process for HMA and Portland Cement Concrete mixtures.

Gravity and absorption also can be <u>indications</u> of quality and durability. Low specific gravities and a high absorption usually indicate an unsound or low quality aggregate. An aggregate with a high absorption can be expected to undergo a large volume change when saturated and dried, or frozen and thawed.

General rules for specific gravity and absorption for aggregates:

- with a specific gravity over 2.60 and an absorption under 2.0% is considered good.
- with a specific gravity between 2.60 to 2.54, inclusive, and an absorption between 2.0% and 3.0%, inclusive, is considered borderline.
- with a specific gravity under 2.54 and an absorption over 3.0% can indicate a poor aggregate.

<u>General Specific Gravity and Absorption Rules</u>

	Specific Gravity	Absorption
Good	over 2.600	under 2.0%
Borderline	2.600 - 2.540	2.0% to 3.0%
Poor	under 2.540	over 3.0%

There are exceptions to these rules:

Air-cooled blast furnace slag is very light, 2.00 to 2.25 specific gravity, and has a high absorption but has good strength and friction properties that are desirable as a building material.

Another exception would be a shale-laminated stone that has a high gravity and low absorption. This type of stone is considered deleterious due to the shale laminations. When exposed to the weather this material will breakdown easily making it very undesirable for use as a building material.

The procedures to determine specific gravity and absorption for coarse and fine aggregate are basically the same with the exception of determining the saturated surface dry condition. IDOT follows procedures ITP 84 for coarse aggregate and ITP 85 for fine aggregate.

Aggregate specific gravities and absorption tests have:

a. A direct correlation with certain mixture attributes that could potentially affect specification requirements when controlling the production and placement of asphalt and/or concrete products.

b. A potential for variability in testing procedures and results.

Because of this, the BMPR will perform all official aggregate specific gravity and absorption tests on aggregate materials used on Illinois contracts. The BMPR issues a statewide listing of the established specific gravity and absorption values for all aggregates used in Illinois. These listings are available on the IDOT website. A contractor can also contact their local IDOT District Materials office to obtain this information.

Aggregate producers and asphalt/concrete contractors are encouraged learn the process of running specific gravity and absorption tests on aggregates in order to perform checks from time to time when producing or using aggregate materials. These results will not replace the CBM's established listing of aggregate specific gravities and absorption values.

There are certain times where producers and asphalt/concrete contractors are required to perform specific gravity and absorption tests. When using crushed slag products (ACBF and steel slag) to produce HMA or PCC mixtures, the slag producer and asphalt/concrete contractor is required to perform daily production control tests on slag samples to determine current specific gravity and absorption of these materials in order to make adjustments on mixtures using the slag materials.

Slag materials, especially steel slag materials, tend to have daily variations and inconsistency issues that can be detrimental to asphalt and/or concrete products. By performing these daily tests and being aware of these variations, the asphalt/concrete contractor can make adjustments to their mixtures in order to maintain mix compliance to the specifications.

When slag materials are being used in mixtures used for IDOT purposes, the IDOT CBM or District Materials office will give instructions to producers and contractors instructing how to properly perform these tests. District Material technicians will monitor these testing procedures performed by producers and contractors in order to verify test results when producing mixtures for IDOT use.

The current Policy Memorandum detailing the "Crushed Slag Producer Certification and Self-Testing Program" (13-08.2) can be found in Appendix 'B' of this manual.

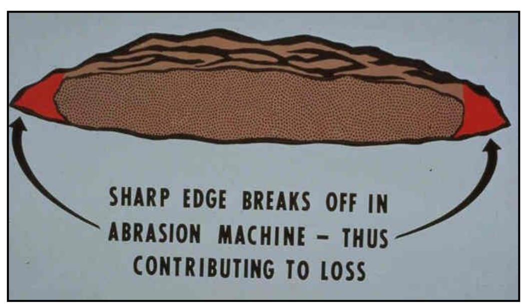
4.0 STOCKPILING AND HANDLING

Stockpiling and handling are two of the most important aspects in the aggregate production process. Material being produced to a uniform in-specification gradation can become out-of-specification material through poor stockpiling and handling. Several factors affecting aggregate gradation in this manner are segregation and degradation.

Segregation and degradation can be defined as follows:

- Segregation is the separation of a well graded production aggregate into individual sizes due to gravity. An example is large particles rolling down an inclined pile (cone) farther than smaller particles. This leads to almost all the large particles concentrated at the bottom and a fines pipe formed in the center of the pile.

- Degradation is the actual breakdown of the individual aggregate particles due to abrasion and attrition during stockpiling and handling. This is extremely detrimental since the amount of minus 75 µm (minus No. 200) fines can be increased greatly. Increased fines create problems in most uses.

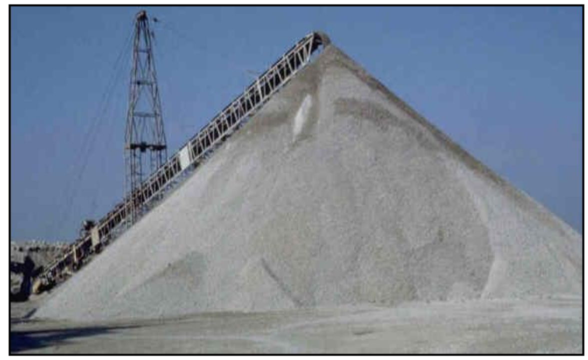


The following discussion will cover the types of stockpiling/handling, the effect of segregation and degradation on each type, and the methods normally used to eliminate or reduce their effects.

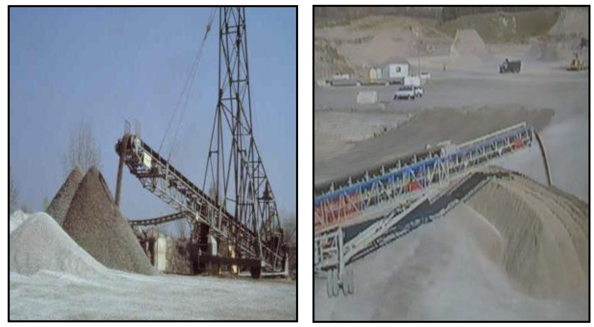
All stockpiling and handling for the Aggregate Gradation Control System shall conform to *Policy Memorandum 11-08.7 Aggregate Gradion Control System (AGCS)* (see Appendix A, page A-77 herein).

4.1 **Conveyor Stockpiles**. One of the two most common stockpiling methods in Illinois is material being discharged from a conveyor belt to form a stockpile. There are two kinds of conveyor stockpiles:

- Cone - formed under a fixed or adjustable conveyor belt
- Elongated Cone (tent-shaped) - built by a radial (or movable) stacker or a telescopic portable radial stacker



Cone Stockpile



Elongated Cone Stockpiles

4.1.1 These two types of stockpiles create a high degree of segregation. A simple explanation can show the reason for segregation. As the aggregate stream is conveyed up the belt **(Figure A)**, vibration of the belt tends to layer the individual sizes and causes the fines to move to the bottom of the belt. When the material comes off the belt into the cone stockpile, the fine material clings to the belt longer and therefore drops straight down or toward the backside of the pile. The larger material falls or is thrown slightly away from the center top point of the pile. Belt speed can also be a large factor. As a result, the large particles have a tendency to roll down the front and sides of the pile and accumulate at the bottom **(Figure B)**.

FIGURE A

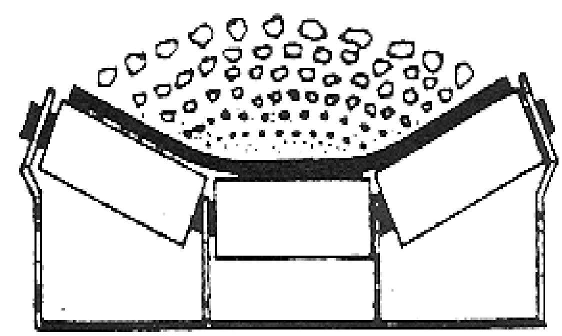
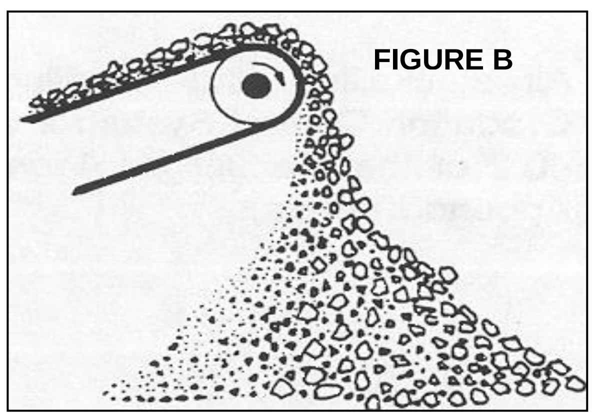


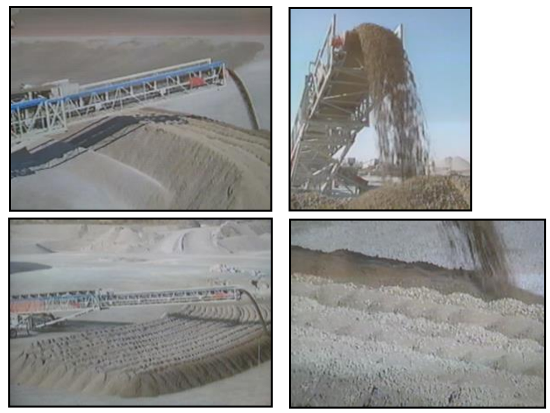
FIGURE B



Several factors determine the amount of segregation in a pile. These are: belt speed, the distance of fall from the conveyor, the amount of moisture in the aggregate, the wind conditions, and the height of the pile. The distance of fall is one advantage where an adjustable stacker can produce a less segregated stockpile than a fixed belt by keeping the distance between the discharge end of the belt and the top of the pile to a minimum.

An adjustable radial stacker or an adjustable telescopic portable radial stacker can be used to build elongated tent-shaped piles. The adjustable radial stacker moves horizontally as well as vertically. The telescopic radial stacker not only moves horizonally and vertically, but also moves telescopically in and out creating a flat, instead of coned, surface. Although stockpiles using these two types of stackers also tend to segregate, they are superior to simple cone piles when built and loaded from properly. With either of these two types of stackers, the top of the pile must always be close to the end of the belt, and the stacker must be continually moved to keep the pile uniform without indentations. Load-out must be done across the end opposite the conveyor. Mixing during load-out should be done to incorporate the coarse edges with the finer center.

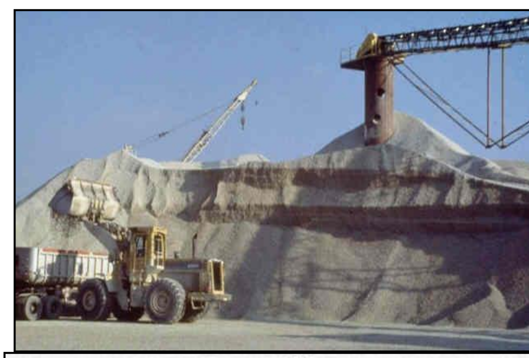
Adjustable Radial Stacker

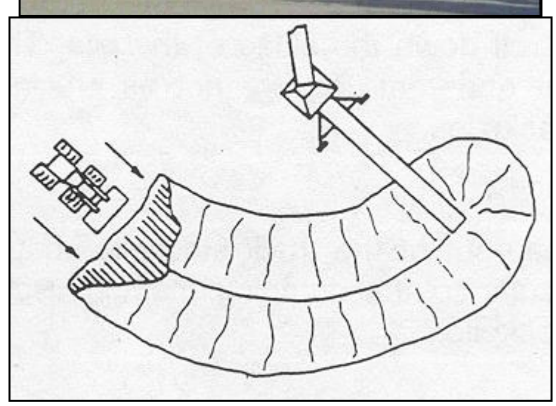


Telescopic Portable Radial Stacker

It should be pointed out that the fall distance from the conveyor/stacker to stockpile cannot be greater than 15 feet unless a change is approved by the Central Bureau of Materials, as specified in Section 5.1.2 of *Policy Memorandum 11-08.7* (See Appendix A, herein).

The source's handling/load-out procedures must adequately remix the material into an acceptable gradation when loading from cones/elongated cone piles. This explains why the endloader operator is so vitally important in most aggregate plants. A poor job of remixing means out-of-specification material being shipped.





The endloader must load perpendicular to the belt flow when loading out of fixed belt cones (see figure on cone stockpile in Section 4.1). Elongated cone stockpiles must be worked from either end rather than from points along the banana-shaped sides (see figure on elongated cone stockpiles in Section 4.1). The endloader must also remix the material when loading out. Buckets from both the center fines pipe and the fine backside of the pile must be reworked or alternated with buckets of coarse particles at the front, sides, and bottom of the pile. This remixing will help to bring the material back into gradation.

4.1.2 Degradation in cone/elongated cone stockpiles normally does not become a major problem. The main abrading action, which is minimum, is in the load-out of the stockpile.

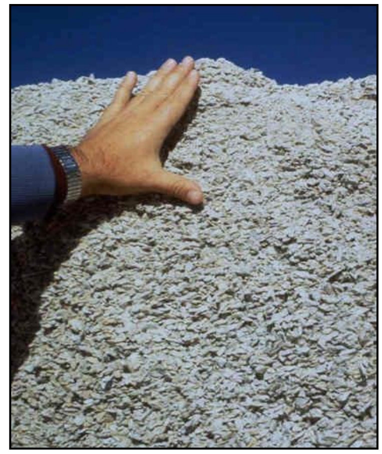
4.2 **Truck Stockpiles**. The second of the two most common stockpiling methods is using large off-road trucks. These trucks normally carry 25 to 100 metric tons per load. The method requires truck dumps to be placed next to each other, effectively building a layer of material. Material can be placed alongside the layer and pushed up by an endloader. This is considered a **single-layer/pushed stockpile.**

Most sources choose to build **multilayered truck stockpiles**. In this case, a ramp of material is constructed to allow the trucks to drive up on the just-completed layer. An endloader or a bulldozer has to level the layer before the trucks can drive on it. The trucks proceed to dump loads across the top of the layer, making sure not to dump closer than 2 to 4 feet (0.6 to 1.3 m) from the layer edge. No material dumped on the second or subsequent layers should roll down the sides of the pile. This process can be continued to build a multilayered stockpile.

4.2.1 Stockpiles built in this manner have very little segregation as long as material is not allowed to roll down the sides of the pile. Therefore, load-out and remixing are not as crucial as in coned stockpiles.

Load-out of the truck stockpile should be perpendicular to the dumping method used to build the stockpile.

4.2.2 Degradation does become a factor when building a multilayered truck stockpile. The movement of trucks on the layered material can cause sufficient abrading and attrition of the aggregate particles to produce an unacceptable amount of minus minus No. 200 (75 µm) fines.

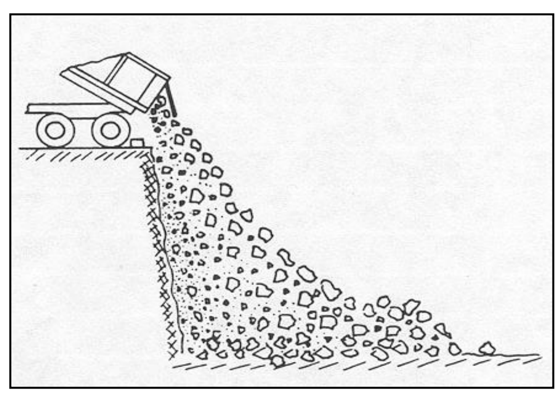


Care must be exercised when permitting trucks on a stockpile. Aggregate used where excessive fines can cause problems should not be truck-stockpiled. Stockpiles should be constantly monitored for a fines problem and, if necessary, corrective action initiated, even to the extent of halting truck-stockpiling.

4.3 **Clam Shell Stockpiles**. Very few aggregate sources use a clam shell to build a stockpile. It is used mainly to unload material from river barges. A few Illinois sources and suppliers use this method to build their stockpiles. The clam shell method casts the material that is picked up from the barge in thin layers, building one upon the other. If correctly constructed, very little material rolls down the sides of the pile.

Segregation and degradation are minimal in a clam shell stockpile. The main problem associated with this type of stockpile is the high expense in building it.

4.4 **Other Methods**. Some sources stockpile material by dumping truckloads over a quarry or pit face. (See adjacent figure.) This method, like conveyor-stockpiling, allows the material to segregate when the larger particles roll down the sloped pile. This is not a recommended stockpiling method because reclaiming normally cannot be done correctly to remix the aggregate.



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5.0 **FIELD GRADATION SAMPLING**

This chapter is designed to detail the correct sampling procedure to be used when taking gradation samples under the Aggregate Gradation Control System. Sampling shall conform to current Illinois Modified AASHTO R90 Test Prodecure. **No other sampling procedures will be allowed**. Both production and stockpile sampling methods will be covered in this chapter.

5.1 **Importance of Sampling**. The *Aggregate Technician Course Manual* discusses the importance of correctly sampling aggregate for testing. Therefore, it should be sufficient to say in this chapter that knowing what is actually being produced is of prime importance in the production and utilization of aggregate. Unless gradation samples are truly **representative** of the material being produced and shipped, the test results are worthless for plant control or material acceptance.

5.2 **Production Gradation Sampling**. Production sampling is generally acknowledged as the best sampling method for plant gradation control. It also is noted for providing the most representative samples. Following is a listing of four production sampling methods. Each will be described and any limitations discussed.

- On-belt sampling
- Belt-stream sampling
- Bin-discharge sampling
  (requires IDOT approval)
- Truck-dump sampling

5.2.1 **On-Belt Sampling** - This production sampling method (illustrated on page 5-3) requires the producer to stop the production belt containing the finished product. A template (as illustrated) is inserted into the material on the belt. All the material between the template shall be removed and shall represent one of three increments making up the field sample. Extreme care shall be taken, including the use of a brush, to remove all fines on the belt between the template for inclusion into the increment. The belt shall be stopped at least three times (three increments) during approximately 10 to 15 minutes of operation to obtain a field sample. If additional material is needed beyond three increments due to the amount of material on the belt, additional template cuts may be taken during the three belt stoppages.

Automatic samplers may be used as long as the gradations compare to samples taken with the sample template.

Samples shall be taken only during normal plant operation and when the belt is under normal load.

5.2.2 **Belt-Stream Sampling** - The sample shall be taken by cutting the stream of aggregate as it leaves the end of the production belt (see page 5-3). A sampling device is passed uniformly through the entire (width and depth) stream flow during normal production and belt load. Each sampling pass (increment) is combined with others to make up the field sample. A minimum of three increments shall be taken during a 10 to 15 minute sampling period. Enough increments shall be taken to provide the correct field sample size.

Extreme care shall be taken to make sure the sampling device passes completely and uniformly through the entire stream flow (from outside the stream on one side to outside the stream on the other side) and to ensure the device does not overflow.

On-Belt Sampling

Step 1

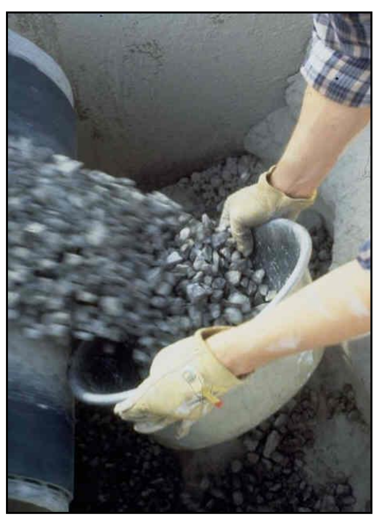
Step 2

Step 3

Step 4

Belt-Stream Sampling

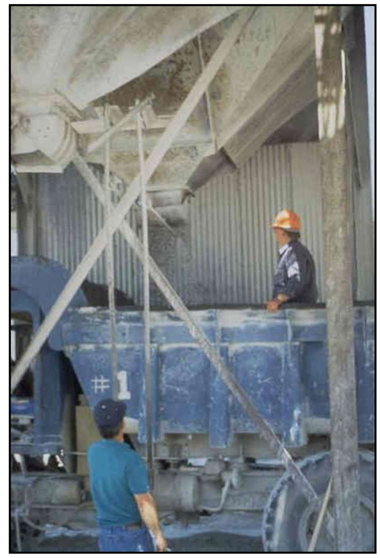
Step 1



Step 2

Step 3

5.2.3 **Bin-Discharge Sampling** - Bin discharge shall be sampled in a manner similar to belt-stream sampling to get a production sample. A sampling device is passed through the entire bin discharge stream. A minimum of three increments shall be taken during a 10- to 15-minute sampling period and combined to form the field sample.



Before cutting the bin discharge stream, the bin must be emptied until such time that the stream of material entering the bin is the stream of material exiting the bin. Sampling may take place at that time.

Samples shall be taken only during normal plant operation and when the bin is being fed under normal load

The major problems associated with bin-discharge sampling involve segregated material clinging to the sides of the bin. This material can and does break loose which alters the gradation of the bin-discharge stream. This sampling procedure shall therefore be used only when approved by the District Engineer. (This technique of sampling may also be considered as another method for end-point sampling.)

5.2.4 **Truck-Dump Sampling** – Sampling from inside of transportation units is not permitted. The transportation unit shall be off-loaded and sampled by any of the sampling procedures under Illinois Test Procedure 2.

This sampling method requires taking a field sample from one or two truck dumps which are placed during the building of a stockpile or feeding of a plant. The truck dump(s) shall be cut with an endloader and two or more bucketsloads extracted. The bucketloads shall be dumped on one another to form a small pile. **The small pile shall then be mixed from two directions perpendicular to each other.** To mix the pile, the endloader shall cut into the pile along its base until approximately its midpoint. The loader bucket shall be lifted, the loader moved 1 to 2 feet forward, and the bucket dumped on the other half of the pile.

Care shall be exercised to avoid cutting below the base of the truckdumps or small pile and contaminating the material to be sampled.

After mixing twice, the endloader shall drop and angle its bucket downward on one side of the pile into a layer not less the 1 foot thick

The layer shall be sampled using a required shovel to take increments in a random “X” pattern over the layer. The shovel shall be forced vertically to its full depth when sampling each increment except that care shall be used to not dig completely through the layer. This would contaminate the sample being obtained. The equipment wheel paths and the edges of the sample layer should be avoided. Sufficient increments shall be taken to make up a correct field sample. Care shall also be exercised to retain as much material on the shovel when taking increments. Sufficient increments shall be taken to make up a correct field sample.

5.3 **Stockpile Sampling**. Stockpile sampling is needed to confirm that the material in the stockpile meets a specified gradation or can be remixed during load-out to meet a specified gradation. Care has to be taken to obtain a representative sample.

5.3.1 There are two general rules for getting samples (especially coarse aggregate) from a stockpile.

5.3.1.1 The sample shall be taken from the working face of the stockpile. The working face shall be perpendicular to the direction of flow used to build the stockpile. Stockpiles having no working face shall have one established prior to sampling. The working face shall have the interior of the pile exposed to permit proper reblending of the pile to eliminate segregated aggregate. If necessary, material may be brought out of the main pile’s working face into a substockpile for sampling.

5.3.1.2 Take several bucketloads across the opened face of the main stockpile or substockpile with an endloader and combine them in a small pile. Care shall be exercised to avoid having the endloader cut below the base of the existing stockpile. This prevents contamination of the sample.

5.3.2 **Stockpile Sampling Procedure** – As for the actual sampling procedure (see page 5.7). The stockpile sampling procedure shall follow the truck-dump sampling procedure using an endloader. The endloader shall cut across the working face as detailed in "Truck-Dump Sampling." Any special mixing procedure used during loading shall be used when taking any samples.

Stockpile Sampling Procedure

Step 1 – Take several bucketloads across the opened face of the main stockpile or substockpile with an endloader and combine them in a small pile.

Step 2 – The small pile shall then be mixed from two directions perpendicular to each other, always dumping back on tip of the pile.

Step 3 – After mixing, the endloader shall backdrag the pile into a layer not less than one foot thick.

Step 4 – The layer shall be sampled using a shovel to take a minimum of five increments in "X" pattern. Increments should be taken to the full depth of the shovel and care should be exercised to retain as much material as possible.

5.4 **Sampling Equipment**. Several pieces of sampling equipment are mentioned in the preceding parts of this chapter. This equipment - template, sampling device, and shovel - must meet certain requirements to be used for sampling. The following paragraphs describe the requirements for each piece.

5.4.1 **Template** - The template shall consist of two endplates and shall be designed to be adjustable. The distance between the end plates may therefore be changed to gather more material from the belt for each increment. The end plates shall also be machined or cut to the approximate belt size and shape.

A single template end plate may be used in the sampling procedure, if care is exercised.

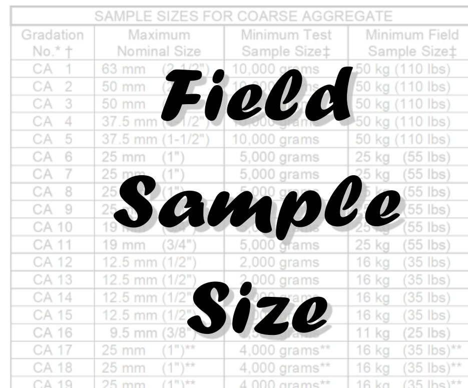
5.4.2 **Sampling Device** - The sampling device used to cut the flow stream from the end of the belt or the bin discharge must be strong enough to handle the force of the flow stream. The device must also be large and deep enough to cut the <u>entire</u> flow stream and not overflow when passing through the stream. The device may be a bucket, a pan, or a specifically manufactured sampling container.

****Shelby tubes are not allowed as sampling devices.**

5.4.3 **Shovel** - The shovel shall be square-nosed and of a size easily handled. It shall also have built-up sides and back ***(approximately 1 1/2 inch [37.5mm])*** to facilitate the retention of material on the shovel when sampling.

5.5 **<u>Sampling Frequency / Field Sample Size</u>**

5.5.1 **Sampling Frequency** - The frequency of gradation sampling is listed in the "Aggregate Gradation Control System". This program is covered in Chapter 8.0 of the *Aggregate Technician Course Manual.*



5.5.2 **Field Sample Size** - The field sample size is detailed in the Aggregate Gradation Sample Size Table & Quality Control Sieves, effective December 1, 2021. A copy of the Aggregate Sample Size Table is located on pages 6-18 & 6-19 herein.

5.6 **Safety**. Gradation sampling can pose one of the greatest risks to the safety of the aggregate technician/inspector. <u>Extreme care</u> should be used whenever around the aggregate plant and mobile equipment.

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6.0 GRADATION TESTING

The procedure for determining the gradation or particle size distribution of an aggregate is divided into five parts:

- Reduction of field sample
(Illinois Modified AASHTO R 76)
- Drying of the sample
(Illinois Modified AASHTO T 255)
- Wash test
(Illinois Modified AASHTO T 11)
- Dry sieve analysis
(Illinois Modified AASHTO T 27)
- Calculation / Reporting

The following sections will describe each part of the gradation test procedure, in detail, as it is performed on a field sample brought into the laboratory.

In addition, aggregate moisture content may be run on the gradation sample prior to gradation testing or on a separate test sample, both as detailed in Article 6.6 herein.

The necessary laboratory equipment to run a gradation or aggregate moisture content shall be approved by the Bureau specified in the Appendix D3 “Aggregate Laboratory Equipment” in the Manual of Test Procedures for Materials (See Appendix A, herein). This equipment shall be continually monitored and frequently checked by the aggregate technician for compliance to the required Illinois Test Procedures. The producer laboratory will also be checked by the Department during initial source certification and on a biennial basis thereafter.

6.1 Reduction of Field Samples. Field samples must be reduced to test sample size before testing. The test sample size for gradation testing shall conform to the Illinois Specification 201, Aggregate Gradation Sample Size Table & Quality Control Sieves. The test sample size shall be as stated in Illinois Specification 201.

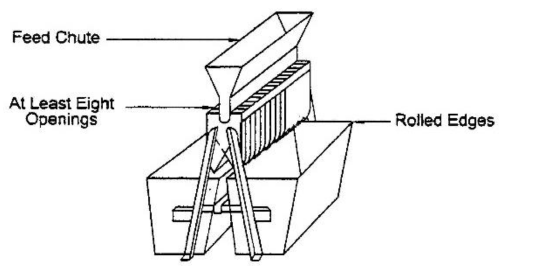
Reduction of field samples shall conform to AASHTO R 76 (see Appendix A, herein). Selection during splitting of an exact predetermined mass for the sample is not permitted.

The required splitting method for coarse aggregate in the program shall be mechanical splitters as detailed in Article 6.1.1 (following). The preferred splitting method for fine aggregate shall be mechanical splitters; however, quartering and miniature stockpile sample may be used. If a mechanical splitter is used, it shall conform to AASHTO R 76, Method ‘A’ (see Appendix A herein).

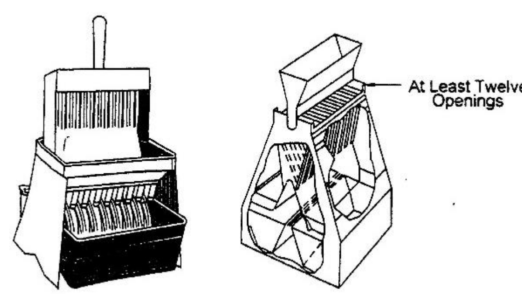
6.1.1 Method ‘A’ - Mechanical Splitters - As stated in the specification, the mechanical splitter shall have an even number of same-width chutes, directed alternately to different sides. There shall be a minimum of eight chutes for coarse aggregate and twelve chutes for fine aggregate. All chutes shall be at least 50% larger than the largest particle in the field sample. Two pans, each of which covers the entire width of the chute area, shall be used to catch the two split halves. The splitter shall be equipped with a hopper (preferred type) or a straight edged pan, either of which shall give a width equal to or slightly less than the overall width of the chutes. The splitter and accessory equipment shall be designed and operated so that the sample will flow smoothly without restriction or loss of material and can be fed at a slow, controlled rate during the splitting process.

Mechanical Splitters
Hopper Style

Mechanical Splitters
Straightedge Pan Style



Riffle Sample Splitter
(a) Large Sample Splitter for Coarse Aggregate



(b) Small Sample Splitters for Fine Aggregate

All aggregate splitters used must conform to AASHTO R 76.

The actual splitting procedure requires the field sample be placed in the hopper or pour pan and evenly distributed from edge to edge. This allows the material to be divided into approximately equal amounts by flowing through the chutes. The sample shall be introduced into the chutes in an even flow. A fast discharge or "shot-gunning" the sample into the chutes may cause material to bridge over a chute, creating a non-representative sample. One of the two splits may then be reintroduced into the hopper or pour pan for further splitting. This procedure should be done the appropriate number of times to result in the correct test sample size.

On the final split, the masses of the two halves (after splitting) shall be within +/- 10% of each other. This is determined adding 10% of the mass of the smaller split to the mass of the smaller split; the larger split cannot exceed this calculated mass. If it does, both split halves shall be recombined and split until the mass comparison requirement is met.

Example problem of final split calculation:

Weight of 1st half is 2020 g
Weight of 2nd half is 1853 g

(Smaller split) _______ g x 10% = _________ g

(Add to smaller split) _______g + _________g = _________g

The mass of the larger split half (2020 g) cannot be larger than the calculated mass in order to be a valid split.

If the larger half exceeds the calculated mass, recombine the two halves and split again.

Mechanical Splitting

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

6.1.2 Method 'B' - Quartering - Quartering, as described in AASHTO R 76, requires the fine aggregate field sample be placed on a hard, clean, level surface or on a canvas blanket. (See page 6-6.) The sample is then thoroughly mixed by turning over the entire samples four times with a shovel, forming a small conical pile. If the canvas blanket is used, mixing may also be accomplished by alternately lifting each corner of the canvas and pulling it over the sample diagonally toward the opposite corner. This causes the material to be rolled and mixed. The mixing procedure, whether by shove or canvas, shall be repeated three times, resulting with the formation of a small conical pile. Care shall be taken not to lose material or add foreign material in either mixing procedure.

The small conical pile shall be flattened to a uniform thickness and diameter by applying the shovel to the apex of the pile. The diameter should be approximately four to eight times the thickness.

The flattened pile shall then be divided into four equal quarters with a shovel or trowel. Two diagonally opposite quarters shall be removed, including all fine material. A brush may be used to clean the cleared spaces. Remix and quarter the remaining material as many times as necessary following the above-described method to achieve the required test sample size.

On the final split, both split halves shall conform to the +/- 10% mass requirement detailed in Article 6.1.1 herein.

Quartering

Step 1

Step 2

Step 3

Step 4

6.1.3 Method 'C' - Miniature Stockpile – Miniature stockpile sampling may be used on only damp, fine aggregate. The material is mixed using the same procedure as just described in quartering. The small conical pile is flattened to a sampling pad of uniform thickness and diameter by applying the shovel to the apex of the pile. Each quarter section of the resulting pad will contain the material originally in it. The test sample is then obtained by selecting at least five increments in a random "X" pattern over the miniature sampling pad using a sampling thief, small scoop, or spoon. The number of increments should be sufficient to provide a sample slightly larger than the required minimum test sample size when dried to constant weight.

For all State monitor splits, the number of increments, as described above, shall be doubled to provide a sample twice the required size. This material shall then be dried to constant weight and split in accordance to Method 'A' (mechanical splitter), or, instead of drying and mechanically splitting, the material may be split in accordance to Method 'B' (quartering) of IL Modified AASHTO R 76. Both split halves shall conform to the +/- 10% weight requirement detailed in Article 6.1.1 herein.

6.2 Drying of Test Sample – The test sample shall be dried back to constant weight in conformance to the AASHTO T 255 utilizing an oven, specifically designed for drying, set at and capable of maintaining a uniform temperature of 230 +/- 9˚F (110 +/- 5˚C). Constant weight is defined as "The sample weight, at which there has not been more than a 0.5-gram weight loss during an additional 1 hour of drying". This shall be verified occasionally.

The sample may also be dried in a pan on an electric hot plate or gas burner in lieu of using an oven. Since this method can create drying temperatures greatly exceeding the allowed oven temperatures, extreme care must be used when using this drying method. The technician shall continually attend the sample on the electric hot plate or gas burner. While microwave ovens are not permitted for drying aggregate gradation samples, microwave ovens can be used when drying non-gradation test samples used for moisture determination only.

The electric hot plate and/or gas burner should be operated on a low-as-needed heat during drying. This will eliminate the popping, crackling, and/or sizzling noise which indicates potential aggregate breakdown. The heat must be turned down if these noises persist, or the sample must be constantly stirred to prevent this potential aggregate particle disintegration.

After the test sample has been dried back to constant weight, the sample shall be cooled down to room temperature. The sample shall then have its weight determined to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate on scales or a balance conforming to the *AASHTO Standard M 231, Weighing Devices Used in the Testing of Materials*. All scales or balances shall be tared before being used to determine any weight required in this chapter. This procedure provides the Total Dry Weight of the original test sample.

6.3 Wash Test – The wash test, AASHTO T 11, “Amount of Material Finer than No. 200 [75um] Sieve in Aggregate”, requires the sample be placed in a sufficiently sized pan and covered with water. If necessary, a wetting agent, such as a detergent or dispersing solution, may be added to assure thorough separation of the fines from the coarse particles. (Note: There should be enough wetting agent to produce only a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry some material with them.) The sample shall be agitated by the use of a **large spoon or similar instrument** to bring the fines into suspension in the water. The water is then immediately poured into a nested set of sieves. The nested set of sieves must consist of the No. 200 [75µm] sieve with an additional sieve placed directly on top. The sieve placed on top of the No. 200 (75µm) is used as a protectant sieve and can be any sieve from the #8 (2.36mm) through the No. 16 (1.18mm). Care shall be taken to avoid pouring many of the coarse particles onto the sieves. This procedure is repeated as many times as necessary until the wash water is clear. At this time, all material retained on the wash sieves is then carefully washed back into the sample.

Manual Wash Method

Mechanical Wash Method

A mechanical device, such as a Ploog washer, may be used for **coarse aggregate samples** providing its results match the manual procedure. If using a mechanical washing device, the protectant sieve needs to be an extra tall sieve (at least 6-8”) to avoid loss of material due to splashing. A loss of fines due to the dripping of water from the outside edge will not be allowed and can be prevented by applying a coating of wax around the outside edge of the drum lip. If sample degradation occurs, then mechanical washing method will not be allowed. After completing the washing, the test sample is dried back to constant weight and its weight determined. This weight is recorded as the Total Wash Weight to the nearest 1 gram for coarse aggregate and the nearest 0.1 gram for fine aggregate.

If the wash test is not required, Section 6.3 may be eliminated.

Wash Test

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

STEP 6

6.4 Dry Sieve Test – The test sample, after drying back to constant mass and having its mass determined, shall be run in the dry sieve test conforming AASHTO T 27, "Sieve Analysis of Fine and Coarse Aggregates". All equipment used shall conform to AASHTO T 27

The first step in the test procedure requires a nested set of 12" [300mm] sieves (8" [200mm] are acceptable for fine aggregate samples), be gathered and stacked. As the sieves are being stacked, they should be inspected for cracks, breaks, or any other problem which would exclude their continued use or alter test results in any way. The size of the sieves used shall conform to the gradation specifications of the aggregated tested. The No. 200 (75um) sieve is required to be part of all nested sets when running a gradation test. It is also required, when using 12" (300mm) sieves, the use of additional cutter sieves beyond the specified gradation sieves for all coarse aggregate gradations is required per Illinois Specification 201. Cutter sieves may be required for any aggregate gradation if it is determined that overloading of individual sieves occurs. Please refer to the current Illinois Specification 201-Aggregate Gradation Sample Size Table & Quality Control Sieves (See Appendix A herein) for the listing of required cutter sieves by gradation.

The sample is then introduced into the nested set of sieves and placed on or into a mechanical shaker. The shaker shall impart a vertical, or lateral and vertical, motion to the nested set. This causes the aggregate particles to bounce and turn so as to present different particle chance for a particle to pass a certain sized
orientations to the sieves. This allows every
sieve.

The shaker shall be run for a minimum of 7 minutes, controlled by an automatic shut-off timer. Seven (7) minutes of shaking shall be considered the standard unless reduced shaker efficiency is demonstrated through finish hand-shaking as described in Paragraph 8.4 of AASHTO T 27 (See Appendix B herein). Shaking time shall be increased if necessary to comply with AASHTO T 27. Shaking time shall not exceed 10 minutes.

Extreme care shall be taken not to overload individual sieves or even approach the overload limits. An **overload** is defined as **several layers of particles, one on top of the other, which do not permit the top layers of particles access to the sieve openings**. Sample results which show overloading or a borderline situation are immediately suspect. If samples continually overload a sieve or sieves, then future samples shall be run in the appropriate number of portions to prevent overloading, or additional cutter sieves shall be added to the nested set to correct the problem.

After mechanical shaking, all sieves shall be finished off by hand-shaking. For hand-shaking, the largest sieve that contains material shall be removed from the stack, visually inspected for an overload, and inverted over an empty pan. While inverted, all particles shall be cleaned from the sieve. The material shall then be placed back on the same sieve and hand-shaken over an empty pan. Any amount of material that is considered to be an overload or to be approaching and overload shall be hand-shaken in at least two increments. Any appreciably large amount of particles passing a sieve may indicate poor mechanical shaking or overloading. The finish hand-shaking noted in Paragraph 8.4 of AASHTO T 27 shall then be initiated.

After hand-shaking, any retained material shall be removed from the sieve. Particles shall not be forced through the sieves. The sieve shall be inverted and lightly tapped on the sides to facilitate removal for weighing. A dowel rod or putty knife may be used to gently remove wedged particles from all sieves down through and including the No. 10 (2.00mm). A soft brass-wired brush shall be used on the No. 16 (1.18mm) through the No. 40 (425 µm) sieves, while a soft china brush shall be used the No. 50 (300 µm) sieve through the No. 200 (75µm) sieve.

Dry Sieve Test

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

STEP 6

STEP 7

STEP 8

After hand-shaking and cleaning, the material retained on each sieve shall have its mass determined and the mass recorded. All determination of mass shall start with the largest sieve in the nested set and proceed down to the pan. Determination of mass shall be to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. Any material that passed the sieve during hand-shaking shall be placed on the next smaller sieve.

After use, all sieves shall be inspected for cracks, breaks, or any other problem which would exclude their continued use.

6.5 **Calculation / Reporting** - All recording/ calculation and report shall be done on the Department's gradation form. Individual source forms may be used if approved by the District Materials Engineer. The procedure for test calculation and reporting is as follows:

6.5.1 **Calculation of Test Results** – Calculation of test results shall follow the procedure described below. Refer to the Department's gradation form herein.

6.5.1.1 The DIFF. – No. 200 (-0.075) shall be determined by subtracting the Washed Mass (weight) from the Total Dry Mass (weight).

6.5.1.2 The "Minus" 75um (No. 200) by Washing" shall be determined by using the following formula:

$$\textbf{\% -200 (-75µm) by Washing} = \frac{\textbf{TDW-TWW}}{\textbf{TDW}} \textbf{ X 100}$$

where TDM= Total Dry Mass (weight)

and TWM = Total Wash Mass (weight)

This result shall be rounded to the nearest 0.1% and recorded on the gradation form.

6.5.1.3 Calculate the "Cumulative Mass (weight) Retained" for each sieve by adding its "Individual Mass (weight) Retained" and the "Individual Mass (weight) Retained" for each larger sieve in the nested set of sieves. Record the "Cumulative Mass (weight) Retained".

6.5.1.4 Calculate the "Maximum Gain-Loss" of the mass (weight) allowed for acceptance by using the following formula; rounding the result to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate:

$$\textbf{Maximum Gain-Loss} = \textbf{0.3\% x TDW}$$

where TDM = Total Dry Mass (weight)

6.5.1.5 Calculate the "Cumulative Percent Retained" for each sieve by using the following formula and record it by rounding to the nearest 0.1%.

$$\textbf{Cumulative \% Retained} = \frac{\textbf{CWR}}{\textbf{TDW}} \textbf{ X 100}$$

where CMR = Cumulative Mass (weight) Retained

and TDM = Total Dry Mass (weight)

6.5.1.6 Calculate the percent passing each sieve by using the following formula:

% passing = 100 – Cumulative % Retained

These results shall be recorded to the nearest 0.1%.

6.5.2 **Reporting** - All percent passing results except the washed minus 75um (minus No. 200) shall be reported on the gradation form as whole numbers. The washed minus No. 200 (75um) result's shall be reported to the nearest 0.1%. The gradation forms shall be completed with all required information. All forms shall be sent to the District office on a weekly basis for entry into the MISTIC system.

Rounding of values will be according to ASTM E 29.

For all sieves treated as an overload, an "S" will be notated on the worksheet next to the sieve size designation.

6.6 Aggregate Moisture Content - Aggregate moisture content may be run on the gradation sample prior to gradation testing or on a separate test sample. Field samples must be reduced to test sample size before testing according to Section 6.1 herein (according to AASHTO R 76 and shall meet the minimum sample size requirements of Illinois Specification 201, Aggregate Gradation Sample Size Table and Quality Control Sieves (See Appendix A, herein).

Both field and test samples must be stored in sealable, non-absorbing plastic bags and/or plastic containers to prevent moisture loss, prior to determining the mass (weight) of the sample.

The Aggregate Technician may be required, by the source, to perform this test on an infrequent basis for information on aggregate being shipped. The Aggregate Moisture Content test is commonly required to be run at both HMA and P.C. concrete plants per QC/QA specifications. When run, all test results shall be reported on the appropriate report forms and documented in a plant diary.

6.6.1 Test Procedure - Aggregate moisture content test procedure shall conform to AASHTO T 255.

The test sample shall be initially weighed to the nearest gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate on scales or a balance conforming to AASHTO M 231. All scales shall be tared before being used for any weighing. This weighing procedure provides the "Original Sample Mass (weight), g" .The test sample shall be dried back to constant mass according to Section 6.2 herein (according to AASHTO T 255). When performing an aggregate moisture content test only, a microwave oven or heat lamp may also be used for drying purposes on a non-gradation test samples.

After the test sample has been dried to constant mass and cooled sufficiently, so as not to damage the balance or scale, the mass of the test sample will be determined as required above in this Section (6.6.1). The test sample shall have its mass determined as soon as the container can be safely handled to prevent additional moisture from being pulled from the air into the aggregate structure. This procedure provides the "Total Dry Mass (weight) g".

Calculation / Reporting - The "Aggregate Moisture Content" shall be determined by using the following formula:

$$P = \frac{(OSW - TDW)}{TDW} \times 100$$

Where P = Aggregate Moisture Content (%),

OSM = Original Sample Mass (weight), g,

and TDM = Dried Sample Mass (weight), g

Test results shall be rounded to the nearest 0.1%.

Example:

With the following given information calculate the percent moisture for a sample of CM11 material:

OSW = 5,165 g
TDW = 5,045 g

$$P = \frac{(5{,}165 - 5{,}045)}{5{,}045} \times 100$$

P = ____________

Illinois Specification 201

Illinois Department of Transportation (IDOT)

AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

COARSE AGGREGATE GRADATION TABLE

CA(CM)[1, 2]	Minimum Field Sample Size[3]	Minimum Test Sample Size[3]	3”	2 1/2”	2”	1 3/4”	1 1/2”	1”	3/4”	5/8”	1/2”	3/8”	1/4”	#4	#8	#16	#40	#50	#200
CA01	110 lbs (50 kg)	10,000 g	X	X^{MN}	X		X	X											X
CA02	110 lbs (50 kg)	10,000 g		X	X^{MN}		XC	X	XC		X			X		X	X		X
CA03	110 lbs (50 kg)	10,000 g		X	X^{MN}		X	X			X								X
CA04	110 lbs (50 kg)	10,000 g			X		X^{MN}	X	XC		X	XC		X		X	X		X
CA05[5]	110 lbs (50 kg)	10,000 g				X	X^{MN}	$X^{MB,6}$	XC		X			X^{6}					X
CA06	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC		X	XC		X		X	X		X
CA07[5]	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	$X^{MB,6}$	XC	XC	X^{6}					X
CA08	55 lbs (25 kg)	5,000 g					X	X^{MN}	X	XC	X	XC	XC	X		X			X
CA09	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X	XC	XC	X		X			X
CA10	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X	XC	XC	X		X	X		X
CA11[5]	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	$X^{MB,6}$	XC	XC	X		X^{6}			X
CA12	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X	XC	X	X		X
CA13[5]	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	$X^{MB,6}$	XC	X^{6}			X
CA14[5]	35 lbs (16 kg)	2,000 g								X	X^{MN}	$X^{MB,6}$	XC	X^{6}					X
CA15	35 lbs (16 kg)	2,000 g									X	X^{MN}	XC	X	XC	X			X
CA16[5]	25 lbs (11 kg)	1,500 g									X	X^{MN}	XC	$X^{MB,6}$	XC	X^{6}			X
CA17	35 lbs (16 kg)[4]	4,000 g[4]	X		XC			XC			XC	XC		$X^{MN, 4}$		X		X	X
CA18	35 lbs (16 kg)[4]	4,000 g[4]	X					$X^{MN, 4}$			XC	XC		X		X		X	X
CA19	35 lbs (16 kg)[4]	4,000 g[4]	X					$X^{MN, 4}$			XC	XC		X		X	X	X	X
CA20	25 lbs (11 kg)	2,000 g									X	X^{MN}	XC	X	X	X			X

Note: See footnotes below Fine Aggregate Gradation Table for explanation of symbols

Illinois Specification 201

Illinois Department of Transportation (IDOT)

AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

FINE AGGREGATE GRADATION TABLE															
FA(FM)[1, 2]	**Minimum Field Sample Size[3]**	**Minimum Test Sample Size[3]**	**1”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**
FA01	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA02	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA03	25 lbs (11 kg)	500 g			X	X^{MN}		X			X		X		X
FA04	25 lbs (11 kg)	500 g			X				X^{MN}						
FA05	25 lbs (11 kg)	500 g			X	X^{MN}								X	X
FA06	25 lbs (11 kg)	500 g	X	X	X	X^{MN}								X	X
FA07	25 lbs (11 kg)	100 g				X		X^{MN}			X		X		X
FA08	25 lbs (11 kg)	100 g					X				X^{MN}			X	X
FA09	25 lbs (11 kg)	100 g					X					X^{MN}		X	X
FA10	25 lbs (11 kg)	100 g						X			X^{MN}		X		X
FA20[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA21[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA22[5]	25 lbs (11 kg)	500 g			X	X^{MB}	$X^{MB, 6}$		X						X^{6}
FA23[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA24[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}

Notes below apply to Fine and Coarse Aggregate Gradation Tables Only

X = Required Gradation Specification Sieves

XC = Required Cutter Sieves

MB = Master Band Sieves for Category I Coarse Aggregate for PCC and HMA Mixes; Bituminous use only for fine aggregate.

MN = Maximum Nominal Sieve for Crushed Gravels – Maximum Nominal Size is defined as the first specification sieve in the product gradation on which material may be retained.

1 = CA = Coarse Aggregate; CM = Coarse Aggregate, Modified; FA = Fine Aggregate; FM = Fine Aggregate, Modified

2 = CM and FM gradations shall be sampled and tested the same as the corresponding CA and FA gradations.

3 = Slag should be adjusted accordingly due to its lighter or heavier mass.

4 = Will vary with the gradation of the material being used

5 = Control Charts Required

6 = Required Sieve for Control Charts

Illinois Specification 201

Illinois Department of Transportation (IDOT)

AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

LARGE SIZED AGGREGATE GRADATION TABLE										
CS/RR[1,2]	**Minimum Test Sample Size[3]**	**8”**	**6”**	**4”**	**3”**	**2”**	**1 ½”**	**1”**	**½”**	**#4**
CS01	50,000 g	X	X	X	XC	X		XC	XC	X
CS02	50,000 g		X	X	XC	X		XC	XC	X
RR01	20,000 g				X	XC	X	XC	XC	X
RR02	20,000 g			X	XC	X	XC	XC	XC	X

Notes below apply to Large Sized Aggregate Gradation Table Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
1 = CS = Coarse Aggregate Subgrade; RR/RRM = Rip Rap
2 = Dry Gradations Only
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = A round nosed shovel may be used for sampling
5 = Metal plates with precisely sized square holes may be used for the gradation
6 = Test sample size shall be taken in the field. No splitting is required.

AGGREGATE GRADATION REPORT

MISTIC ID: ____

Inspector No.: ____ Name: ____ Date Sampled: ____ Seq No: ____
Mix Plant No.: ____ Name: ____ Contract No: ____ Job No.: ____
Responsible Loc: ____ Lab: ____ Lab Name: ____ Source Name: ____

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5								
3/8	9.5								
1/4	6.3								
#4	4.75								
#8	2.36								
#10	2.0								
#16	1.18								
#30	0.6								
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075								
Pan									
Tot Dry Wt.				% Washed - 200					
Tot Wash Wt.									
Diff (-.075)				#200 / #40					

Orig. Wet Weight: ____ Moisture %: ____

(Mix Plant Only)

Lot: ____

Bin: ____

Tech/Insp: ____

Tested By: ____

Agency: ____

Copies to: ____

Report Date: ____

/FOR DTY03504

MI504QC

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AGGREGATE GRADATION REPORT

MISTIC ID: ____

Inspector No.: ____ Name: ____ Date Sampled: ____ Seq No: ____
Mix Plant No.: ____ Name: ____ Contract No: ____ Job No.: ____
Responsible Loc: ____ Lab: ____ Lab Name: ____ Source Name: ____

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5								
3/8	9.5								
1/4	6.3								
#4	4.75								
#8	2.36								
#10	2.0								
#16	1.18								
#30	0.6								
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075								
Pan									

Tot Dry Wt. ____ % Washed - 200 ____
Tot Wash Wt. ____
Diff (-.075) ____ #200 / #40 ____

Orig. Wet Weight: ____ Moisture %: ____

(Mix Plant Only)

Lot: ____

Bin: ____

Tech/Insp: ____

Tested By: ____

Agency: ____

Copies to: ____

Report Date: ____

/FOR DTY03504
MI504QC

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AGGREGATE GRADATION REPORT

MISTIC ID: (1)

Inspector No.:	(2)	Name:	(3)	Date Sampled:	(4)	Seq No:	(5)
Mix Plant No.:	(6)	Name:	(7)	Contract No:	(8)	Job No.:	(9)
Responsible Loc:	(10)	Lab:	(11)	Lab Name:	(12)	Source Name:	(13)

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge
(14)	(15)	(16)	(17)	(19)	(21)	(23)	(22)	(20)

SIEVE IN / MM	3 75	2.5 63	2 50	1.75 45	1.5 37.5	1 25	3/4 19	5/8 15.9	1/2 12.5	3/8 9.5	#4 4.75	#8 2.36	#16 1.18	#30 0.6	#40 0.425	#50 0.3	#100 0.15	#200 0.075
PASS %	(24)																	

%WASH - 200	PI RATIO	RESULT	REMARK
(25)	(26)	(27)	(28)

Insp. Quantity (tons)
(18)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0	(29)	(30)	(31)	(32)	(33)	(34)		
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5								
3/8	9.5								
1/4	6.3								
#4	4.75								
#8	2.36								
#10	2.0								
#16	1.18								
#30	0.6								
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075								
Pan									

Tot Dry Wt.	(35)	% Washed - 200	(38)
Tot Wash Wt.	(36)		
Diff (-.075)	(37)	#200 / #40	(39)

Orig. Wet Weight: (40) Moisture %: (41)

(Mix Plant Only)

Lot: (42)

Bin: (43)

Tech/Insp: (44)

Tested By: (45)

Agency: (46)

Copies to: (47)

Report Date: (48)

/FOR DTY03504

MI504QC

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FIELD/LAB GRADATIONS

MI 504M

(Revised 11/9/22)

1. **MISTIC ID:** MISTIC test identification number. Leave blank, the MISTIC system will generate the test identification number.

2. **INSPECTOR NO.:** Identify the individual who took the sample. For split samples, the same inspector number should be used for both halves of the sample.

   a) IDOT personnel should enter their MISTIC inspector number.

   b) Contractor, Subcontractor, Producer, should use a "9", the District Number, and seven zeroes (0's). Example: (960000000) for District 6

   c) Consultant personnel enter their company's MISTIC inspector number.

   d) Local agency personnel are to enter a "9"; followed by the District number, which is repeated until the field is filled.
   Example: (966666666) for District 6 local agency.

3. **INSPECTOR NAME:** Enter the name of the inspector who took the sample.

4. **DATE SAMPLED:** Enter the date the sample was taken as month, day, and year in mmddyy format. Example: (103112)

5. **SEQ. NO.:** Sequence number. May be any combination of letters and/or numbers up to 6 characters in length. It is used to differentiate multiple samples of the same gradation, taken on the same day. For a split sample, both halves of the split shall have "**SPLIT**" in this field.

6. **MIX PLANT NO.:** The MISTIC code number for the P.C. Concrete or Hot Mix Asphalt Producer. Only one plant may be shown on one report.

7. **MIX PLANT NAME:** Name of mix plant.

8. **CONTRACT NO.:** Leave blank unless the gradation has been sampled at a jobsite for a specific contract. Enter the 5 digit contract number. If it is a local agency contract without a 5 digit number, then enter the 16 or 17 character MFT (Motor Fuel Tax) contract number.

9. **JOB NO.:** Leave blank unless gradation sampled at the jobsite for a specific contract. Enter the 8 character number that corresponds with the 5 digit contract number. If the contract number is not 5 digits, leave this field blank.

10. **RESPONSIBLE LOC.:** Enter the District identification number as a "9" followed by the District.
    Example: 96 for District 6

11. LAB: Enter the 2 letter MISTIC lab code.

Laboratory Locations	MISTIC Lab Codes
Producer Plant Site Laboratory	PP
Producer Non-Plant Site Laboratory	PL
Producer Construction Site	PC
Producer Quarry Laboratory	PQ
Independent Plant Site Laboratory	IP
Independent Non-Plant Site Laboratory	IL
Independent Construction Site	IC
Independent Quarry Laboratory	IQ
Independent Laboratory	IN
IDOT/Local Agency Plant Site Laboratory	FP
IDOT/Local Agency Construction Site	FC
IDOT/Local Agency Quarry Laboratory	FQ
DISTRICT LABORATORY	DI
DISTRICT SATELLITE LABORATORY	DS

NOTE: A Contractor, Subcontractor, and Producer are to use one of the “Producer” lab codes. An IDOT Consultant, Contractor Consultant, Subcontractor Consultant, and Producer Consultant are to use one of the “Independent” lab codes.

12. LAB NAME: Enter the name of the company which cannot exceed 20 characters.

13. SOURCE NAME: Enter the name of the aggregate producer.

14. SOURCE: Enter the MISTIC code number of the aggregate producer. Example: 50912-02

15. MAT. CODE NO.: Material code for the aggregate product. Enter the 8 to 10 character code number of the material being tested.

The following information will help you determine if you have the correct material code number.

- The first space is a “0” to indicate the material is an aggregate.
- The second space indicates the QUALITY LEVEL of the aggregate. Coarse and fine aggregates

used in concrete are always "A" quality. Hot mix asphalt surface course and fine aggregates are generally "B" quality. Hot mix asphalt binder course aggregates are generally "C" quality and fine aggregate are "B" quality (see below)

- The third space indicates the Type of Material (see below).
- The fourth space indicates the Aggregate Type (see below).
- The fifth space indicates the SPECIFICATION of the aggregate (see below).
- The sixth space is always a "M" to **Metric**.
- The seventh and eighth spaces are the Gradation Number of the aggregate. See Articles 1003.01(c) and 1004.01(c) of the Standard Specifications.
- The ninth and tenth spaces indicate superstructure quality aggregate for concrete use. Always enter "01" if testing superstructure quality aggregate.

QUALITY LEVEL	**TYPE OF MATERIAL**	**AGGREGATE TYPE**
0 & 1 Have No Quality	0 = Gravel	C = Coarse Aggregate
2 = A Quality	1 = Crushed Gravel	F = Fine Aggregate
3 = B Quality	2 = Crushed Stone	
4 = C Quality	3 = ACBF Slag	
5 = D Quality	7 = Natural Sand	
6 = D Quality Stabilized	8 = Stone Sand	
	9 = Special Aggregate	

SPECIFICATION

A = Standard Specification
M = Modified or QC/QA Specification

16. TYPE INSP: Type of inspection (see below). For additional information see Attachment 4 in the Project Procedures Guide.

AGENCY	**QC/QA**	**NON QC/QA**
Contractor/Producer/ Consultant	PRO	-----
IDOT/Consultant at Aggregate Source	IND (split), INV	PRO
IDOT/Consultant at Mix Plant	IND (split), INV	IND (split-share), INV

17. ORIG. I.D. #: Original identification number. Use for resample tests only. Enter the original MISTIC test identification number of the failing test.

18. INSP. QTY.: Inspected Quantity. Leave blank. IDOT personnel may enter the quantity that is represented by the gradation test but it is not required.

19. **<u>SPEC.:</u>** Specification. Leave blank. IDOT aggregate personnel should enter the master band ranges under a "PRE" test at the beginning of each production season.

Example: MB2036

20. **<u>LEDGE:</u>** A five-digit code, provided by the District that correlates to the production method of the sampled material. Enter "99999" for all stockpile samples and material sampled at a Terminal or Supply Yard.

21. **<u>SAMPLED FROM</u>:** Enter the 2 character designation in the first two spaces. Refer to "Sampled From Codes".

Sample From	Sampled From Codes
Barge	BR
Belt End (Stream)	BE
Cold Feed	CF
Hot Bin	HB
On Belt (Stopped)	OB
Production	PR
Rail Car	CR
Road	RD
Silo / Bin	SI
Stockpile	SP
Truck Dump	TD
Truck	TK
Weigh Belt	WB

22. **<u>LOADOUT / TERMINAL:</u>** Enter name of site for multiple samples from the same source

23. **<u>WASH/DRY:</u>** Enter "W" if the test was a washed gradation, or a "D" if it was a dry gradation.

24. **<u>GRADATION RESULTS INPUT TABLE:</u>** Enter the percent passing test results, "percent % passing", from the calculation table for all sieves. All test results shall be reported to the nearest 1%, except for the 0.075 mm (#200) sieve, which shall be reported to the nearest 0.1%.

25. **<u>WASH - 0.075 (-#200):</u>** Enter the washed minus 0.075 mm (#200) value from the calculation table to the nearest 0.1%.

26. **<u>PI RATIO:</u>** Plasticity index ratio. Leave blank. IDOT personnel, when appropriate, should enter the PI ratio value.

27. **<u>TEST RESULTS</u>:** Enter "APPR" for results meeting specifications or "FAIL" for failure to meet specifications. Show under "Remarks" action taken for samples not meeting specifications. For example, retest, checked equipment, test method incorrect, will monitor.

28. <u>REMARKS:</u> This space should be used to record any comments about the aggregates, or the stockpiling and handling methods used.

For "IND" inspection, a comparison remark is required, because the assurance test is from a split sample. For an acceptable comparison, enter the following:

- Enter "C" when tests compare within acceptable limits of precision.
- Enter date of comparison
- Enter initials for "IND" inspector
- Enter "ws" if the sample was witnessed by the "IND"

Example: C – 100197 TCS ws

For an unacceptable comparison, enter the following:

- Enter "X" when tests do not compare within acceptable limits of precision.
- Enter date of comparison.
- Enter initials for "IND" inspector.
- Enter "ws" if the sample was witnessed by the "IND"
- Explain reason for unacceptable comparison.

  Examples: Contractor obtained sample incorrectly; IDOT equipment required repair; Contractor performed test method incorrectly; problem was not identified, will investigate further if problem continues.
- Enter "ws" if the sample was witnessed by the "IND"

Example: X - 100297 TCS ws. Contractor obtained sample incorrectly.

29. <u>INDIV. WT. RETAINED:</u> Enter the weight of aggregate on each sieve individually, starting with the largest sieve first. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram. If the **sieve was overloaded** and split into two or more portions to hand sieve, then write a "S" outside the table on that row (right or left side).

30. <u>CUMUL. WT. RETAINED:</u> Cumulative Weight Retained. Add the weight on each sieve, to the weight on any larger sieve(s), and enter that value.

31. <u>CUMUL. % RETAINED:</u> Cumulative Percent Retained. Divide the cumulative weight retained by the total dry weight, and multiply by 100, for each sieve. Round to the nearest 0.1%, and enter that value.

32. <u>PERCENT % PASSING:</u> Subtract the cumulative percent retained, from 100, for each sieve. Record to nearest 0.1%, and enter that value

33. <u>MINIMUM % PASSING:</u> Enter the specification minimum for all appropriate sieves. These may be Standard Specifications, or modified Standard Specification, or master band limits.

34. **<u>MAXIMUM % PASSING:</u>** Enter the specification maximum for all appropriate sieves. These may be Standard Specifications, or modified Standard Specification, or master band limits

35. **<u>TOTAL DRY Wt.:</u>** Enter the weight of the sample after it has been dried to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.

36. **<u>TOTAL WASHED WT.:</u>** Enter the weight of the sample after it has been washed, and dried back to a constant weight. Weigh coarse aggregate to the nearest 1 gram, and fine aggregate to the nearest 0.1 gram.

37. **<u>DIFF. -0.075 (-200):</u>** Subtract total washed weight from the total dry weight, and enter that value.

38. <u>% WASHED -0.075:</u> Divide the "Diff. -0.075" by the "Total Dry Wt." and multiply by 100. Round to the nearest 0.1%, and enter that value.

39. **<u>0.075 / 0.425:</u>** Leave blank. IDOT personnel, when appropriate, enter the ratio of the percent passing the 0.075 mm (#200) sieve and the 0.425 mm (#40) sieve.

40. **<u>ORIGINAL WET WT.</u>:** Enter weight of the "as received" material before drying.

41. **<u>MOISTURE %:</u>** Percent difference between the "Original Wet Wt." and "Total Dry Wt."

42. **<u>LOT:</u>** Leave blank. IDOT mix plant personnel use if performing individual hot bin "IND" tests. Enter the lot corresponding to the Daily Plant Output (MI 305). Also, enter this in the remarks.

43. **<u>BIN:</u>** Leave blank. IDOT mix plant personnel use if performing individual hot bin "IND" tests. Enter the appropriate hot bin number. Also, enter this in remarks.

44. **<u>TECH / INSP.:</u>** Leave blank. IDOT will enter initials of the person entering the test results into MISTIC.

45. **<u>TESTED BY:</u>** Print the name of the individual who tested the aggregate. The individual's signature is also required. If the test is run by a Gradation Technician, then the supervisor should sign here also.

46. **<u>AGENCY:</u>** Enter testers employer

47. **<u>COPIES TO:</u>** Enter the distribution of this report. The normal distribution for mix plant results is the **original** goes to the District Engineer, a copy goes to the Resident Engineer(s), and a copy goes to the QC Manager(s). The distribution for aggregate source tests is the original goes to the District Engineer and a copy goes to the Source's QC manager. Non-QC/QA – Same as above, except that the file copy stays with the tester or the individual who completed the report.

48. **<u>REPORT DATE:</u>** Leave blank. IDOT will enter the date the results are entered into MISTIC as month, day, and year n mmddyy format.

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Effective: November 1, 1995
Revised: December 1, 2021

7.0 QUALITY CONTROL (QC) MANAGER / AGGREGATE TECHNICIAN / AGCS TECHNICIAN / MIXTURE AGGREGATE TECHNICIAN / IDOT INSPECTOR / GRADATION TECHNICIAN RESPONSIBILITIES

The Quality Control (QC) Manager, Aggregate Technician, AGCS Technician, Mixture Aggregate Technician, IDOT Aggregate Inspector, and the Gradation Technician have specific responsibilities under the Aggregate Gradation Control System. Many of these responsibilities are similar, including gradation sampling/testing and visual inspection of production. Several are limited to the QC Manager, the Aggregate Technician, or the IDOT Aggregate Inspector. It should be noted that only the Aggregate Technician or the AGCS Technician may also be the QC Manager.

The following table denotes the responsibilities and the person responsible.

	QC Manager	**Aggregate Tech.**	**AGCS Tech.**	**Mixture Agg. Tech.**	**IDOT Inspector**	**Gradation Tech.**
▪ Knowledge of Specs	X	X	X		X	
▪ Quality Sampling					X	
▪ Visual Inspection	X	X	X		X	
▪ Gradation Sampling	X	X	X	X	X	
▪ Gradation Testing	X Note 2	X		X	X	X **Note 1**
▪ Plant Diary	X	X	X	X		
▪ Aggregate Certification	X					
▪ Safety	X	X	X	X	X	X

Note 1: Only under direct supervision of Aggregate Technician or Mixture Aggregate Technician
Note 2: Not allowed for AGCS Technician

Each responsibility is discussed below.

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7.1 **Knowledge of Current Specifications.** The QC Manager, the Aggregate Technician, the AGCS Technician, and the IDOT Aggregate Inspector must maintain up-to-date knowledge of the specifications that apply to the aggregate products currently being produced at the Source. The Aggregate Technician and the AGCS Technician shall have available at the Source a copy of the current Standard Specification, any applicable supplemental specifications, and the *Manual of Test Procedures for Materials*. All four individuals shall be aware of any special provisions which change current aggregate specifications. This applies to both quality and gradation specifications. A copy of the current Standard Specifications, Sections 1003 and 1004, and the supplemental specifications to Sections 1003 and 1004 are located in the Appendix.

7.2 **Quality Sampling / Testing.** IDOT will continue to sample and test all aggregates for quality. The IDOT Aggregate Inspector shall sample any certified stockpile at the frequency designated in the *Manual for Aggregate Inspection*. All quality samples are sent to the Central Bureau of Materials for testing. The tests run were discussed previously in Chapter 3.0 herein. Any certified stockpile must meet the designated quality before shipment. Willful shipment of out-of-specification material shall be handled according to Section 11.2 of the Department's current Policy Memorandum, "Aggregate Gradation Control System (AGCS)", in Chapter 8.0.

Although the Aggregate Technician/AGCS Technician will not be sampling or testing for quality, he will be notified when sampling occurs and may witness the sampling. The Aggregate Technician/AGCS Technician should obtain and maintain quality information on specific ledges, production methods, and the certified stockpiles. Shipment of approved material remains the responsibility of the Source.

A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

7.3 **Visual Inspection.** The responsibility of visually inspecting an aggregate Source's process on a frequent basis falls on the Aggregate Technician, the AGCS Technician, and the IDOT Aggregate Inspector. Visual inspection can be defined as observing the processing or production area, the stockpiling methods, and the loading/handling operation, as well as the condition of the aggregate in the flow stream or stockpiles.

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7.3.1 For the Aggregate Technician/AGCS Technician, visual inspections shall be a daily occurrence—**several** (three or more) inspections spread uniformly through-out the production day—while producing certified aggregate. Visual inspections by the IDOT Aggregate Inspector may be at a reduced frequency. Most Aggregate/AGCS Technicians/Inspectors will establish an inspection route when they enter the Source. As an example, the inspection route will take them past the ledge face to verify from where the raw feed is coming. This also allows for visual examination of the face for contamination or the intrusion of poor quality material into the ledge.

The production plant, from the primary crusher to the final screening/log washing, is visited next. This stop verifies that the correct production method is being used to produce the required quality and gradation. Problems with equipment, such as screen cloth, etc., can be observed and corrected.

Finally, the stockpiling/load-out area can be observed. Segregation, degradation, or contamination can be readily identified and proper steps taken to eliminate the problems.

7.3.2 This quick type of inspection helps the Aggregate Technician/AGCS Technician/ Inspector "keep a handle on" the aggregate being produced. It does not take away from actual testing of the aggregate but enhances the inspection to ensure quality aggregate.

Remember, it is an Aggregate/AGCS Technician's/Inspector's responsibility to observe the overall aggregate operation to detect segregation, degradation, and contamination that is detrimental to the quality of the aggregate product. These observations should be communicated immediately to the QC Manager for corrective action if necessary.

7.4 **Gradation Sampling.** Quality or gradation sampling involves taking a small, representative portion of a finished product for quality/gradation control or compliance testing. The word "representative" is perhaps the most important word in that definition, especially in conjunction with gradation testing. It is imperative that the sample accurately represents the material being produced. Inaccurate samples can lead to acceptable material being rejected or to non-acceptable material being used. In either case, non-representative sampling often results in higher construction/maintenance costs.

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7.4.1 Under the Aggregate Gradation Control System, the Aggregate Technician, the AGCS Technician, the Mixture Aggregate Technician, and the IDOT Aggregate Inspector must know how to correctly sample aggregate for gradation testing. The Aggregate Technician/AGCS Technician/Mixture Aggregate Technician will have to sample at a specified frequency from both production and stockpiles. They may choose one of the approved production sampling methods described in Illinois Modified AASHTO R 90, (Chapter 5.0 of the AGCS). The stockpile sampling method noted in Chapter 5.0 is the only method allowed for sampling a stockpile. The IDOT Aggregate Inspector will sample on a very infrequent basis. Most of the IDOT monitor samples will be split samples taken and split by the Aggregate Technician/AGCS Technician/Mixture Aggregate Technician. However, the IDOT Aggregate Inspector may take a sample at any time under the program.

7.4.2 The frequency of sampling for the Aggregate Technician/AGCS Technician/Mixture Aggregate Technician, and the IDOT Aggregate Inspector is covered in the Department's current Policy Memorandum, "Aggregate Gradation Control System (AGCS)", in Chapter 8.0. The high number of samples required, especially by the Aggregate Technician/AGCS Technician/Mixture Aggregate Technician, makes it imperative that the technician/ inspector takes the time and has the knowledge to accurately sample for gradation testing. The overall program relies on accurate results to supply in-gradation aggregate to IDOT construction projects.

7.5 **Gradation Testing.** Illinois Modified AASHTO T 11 / Illinois Modified AASHTO T 27 (Chapter 6.0 of the AGCS) describes the correct and acceptable method to run a gradation test. As with gradation sampling, inaccurate results hurt both the aggregate producer as well as IDOT. It is therefore the responsibility of the Aggregate Technician, the Mixture Aggregate Technician, the Gradation Technician, and the IDOT Aggregate Inspector to correctly run the gradation test. The AGCS Technician is not allowed to split or run gradation tests under the AGCS.

7.6 **Plant Diary.** The Aggregate Technician/AGCS Technician is required to maintain a plant diary when producing under the program. This diary shall detail samples taken, pass/fail results, corrective action, plant/ledge changes, etc., daily. The diary must be kept at the Source for periodic checking by the IDOT Aggregate Inspector. See Example on [following page (page 7-6 of Aggregate Technician Course Manual)].

The IDOT Aggregate Inspector is required to keep a personal diary on his daily inspection trips. Much of the same information required for the Aggregate Technician/AGCS Technician diary is noted by the IDOT Aggregate Inspector.

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7.7 **Aggregate Certification.** The previous discussions on numerous individual responsibilities focus attention on the QC Manager's/Aggregate Technician's/AGCS Technician's/Inspector's overall responsibilities. The Source's QC Manager has the overall responsibility of certifying that material being placed on the certified stockpile is produced under and conforms to the Aggregate Gradation Control System. The production or quarry supervisor, if not the QC Manager, also assumes some of the responsibility for assuring that in-specification material is being made and shipped to IDOT projects.

The IDOT Aggregate Inspector, through his monitoring activities (sampling/ testing, visual inspection, etc.), must verify the continued compliance to the Aggregate Gradation Control System. Any lack of compliance, as noted by the IDOT Aggregate Inspector, will be grounds for Source decertification under the program and shall be communicated to the QC Manager as expediently as possible for correction.

7.8 **Safety.** It is the responsibility of the QC Manager, the Aggregate Technician, the AGCS Technician, the Mixture Aggregate Technician, the IDOT Aggregate Inspector, and the Gradation Technician to perform their respective duties in a safe manner. To assure that this condition is met, the QC Manager, the Aggregate Technician, the AGCS Technician, the Mixture Aggregate Technician, and the IDOT Aggregate Inspector should be familiar with any and all safety regulations in force. Great care should be taken when sampling around moving equipment, e.g., conveyor belts, screen decks, hopper grates, etc. Due to poor visibility and large truck/equipment traffic, caution should also be used when driving around the plants and stockpiles.

The QC Manager, the Aggregate Technician, the AGCS Technician, the Mixture Aggregate Technician, and the IDOT Aggregate Inspector must have a knowledge of applicable Mine Safety and Health Administration (MSHA) regulations. The IDOT Aggregate Inspector is also regulated by Departmental policies covered in the "Employee Safety Code" handbook.

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EXAMPLE

Company Name: ______________________________

Aggregate / AGCS Technician Plant Diary

Date:	
Plant Name:	
Weather:	
Ledge Information:	
Material Being Produced:	

VISUAL INSPECTION:	**1ST VISIT**	**2ND VISIT**	**3RD VISIT**	**ADDITIONAL VISITS**
Time:				
Stockpile/Loadout:				
Degradation	YES/NO	YES/NO	YES/NO	YES/NO
Segregation	YES/NO	YES/NO	YES/NO	YES/NO
Contamination	YES/NO	YES/NO	YES/NO	YES/NO
Plant:				
Pit Area:				
Graph(s):				
Samples Taken:				
Production				
Loadout:				
Resample:				
SIGNATURE:				

Problems: (Init./Time)	
Action Taken: (Init./Time)	
Comments:	

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022 11-08.7
This Policy Memorandum supersedes number 11-08.6 dated December 4, 2018

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

This program shall apply to all Sources that supply certified aggregate for uses identified in this program to projects let under the jurisdiction of the Illinois Department of Transportation (includes local agency projects with state/federal funding). All aggregate shipped for program-designated uses on these projects shall be from a Certified Source.

2.0 PURPOSE

2.1 To establish a procedure of certification whereby Sources shall supply aggregate for designated use meeting test properties cited by the Bureau.

2.2 To set forth the conditions for Source certification and revocation of certification.

3.0 DEFINITIONS

AGCS Technician – A technician at the Source who has successfully completed the Department's AGCS Technician Course. The AGCS training course is no longer available; however, there are still individuals that hold this title. This individual may perform all duties of the Aggregate Technician under the Gradation Control Program except gradation testing. Gradation testing (including splitting) must be performed by an Aggregate Technician or a Mixture Aggregate Technician.

Aggregate Inspector – District materials inspector who has successfully completed the Department's Aggregate Technician Course and is responsible for inspection at an aggregate Source. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

Aggregate Technician – Sampling and testing technician at the Source who has successfully completed the Department's Aggregate Technician Course and is responsible for the Gradation Control Program at the Source. The Aggregate Technician course (CET 021) is a 5-day course, offered as a part of the IDOT Quality Management Training Program administered through Lake Land College in Mattoon, IL. https://www.lakelandcollege.edu/idot/idot-training-schedule/

Bureau – Bureau of Materials, Illinois Department of Transportation, Springfield, Illinois.

Department – Illinois Department of Transportation.

District – Materials Office located at each Illinois Department of Transportation highway district office.

Failing Gradation Sample – A gradation sample which, when tested, exceeds the established Master Band on the critical sieve and/or exceeds the specification ranges on the other sieves for that gradation.

Gradation Technician – A technician who has successfully completed the Department's Gradation Technician Course and is responsible only for splitting and testing gradation samples. The Gradation Technician shall be monitored on a daily basis by the Aggregate Technician. To become a Gradation Technician, contact the local IDOT Aggregate Inspector. The Gradation Technician Course is a ½ day course that is taught by IDOT District personnel and is not administered by Lake Land College.

Mechanical Blending – Blending for gradation or of different types of materials shall be through interlocked feeders or a blending plant such that the prescribed blending percentage is maintained throughout the blending process.

Mixture Aggregate Technician – A technician who has successfully completed the Department's Mixture Aggregate Technician course (CET 020) and is responsible only for gradation sampling and gradation testing. The Mixture Aggregate Technician course (CET 020) is a 3-day course, offered as a part of the IDOT Quality Management Training Program administered through Lake Land College in Mattoon, IL. https://www.lakelandcollege.edu/idot/idot-training-schedule/

Monitor Sample – Gradation sample taken from the Source, Terminal, Supplier Yard, or mix plant and tested by the Department to monitor the gradation being produced by the Source under its Gradation Control Program. This sample shall also be used to evaluate the adequacy of procedures and equipment used by the Source in its Gradation Control Program.

Outlying (OS) Source – A certified aggregate source located out-of-state which is specifically designated by the inspecting District and the Bureau and required to follow the requirements listed in Section 8.0 herein.

Qualified Products List (QPL) – The current Approved/Qualified Producer List of Aggregate Sources, maintained by the Department identifying aggregate sources certified to supply aggregate to Department/Local Agency projects.

Quality Control (QC) Manager – The Aggregate Technician or the AGCS Technician designated by the Source who shall be responsible for compliance with the requirements of the Aggregate Gradation Control System. The QC Manager shall have successfully completed the Department's Aggregate Technician Course or the AGCS Technician Course.

Source – Individual aggregate source, i.e., a specific quarry or pit location supplying a specific product or products.

Source Classification – Under this program, a **Source** will be classified as Certified, De-Certified, or Non-Certified.

Certified Source – A **Source** that has met the requirements for certification and is allowed to supply aggregate for Department/Local Agency projects.

De-Certified Source – A **Source** that has had its **Certified Source** status revoked because requirements warranting certification have not been maintained. A De-Certified Source shall not be allowed to supply aggregate to Department/Local Agency projects.

Non-Certified Source – A **Source** that does not initially meet certification requirements or has not applied for certification.

Source QC Plan – A QC Plan detailing how an **Outlying Source** will comply with the AGCS.

Standard Specifications – Current edition of the Illinois Department of Transportation Standard Specifications for Road and Bridge Construction.

Supplier Yard – A Yard which buys aggregate from an AGCS or IDOT-inspected source and resells the aggregate from the yard for use on IDOT contracts (includes local agency projects with state and or federal funding).

Terminal – A location owned by, leased to, or provided to an AGCS or IDOT-inspected source from which the source ships aggregate for use on IDOT contracts (includes local agency projects with state and/or federal funding).

4.0 GENERAL RESPONSIBILITIES

4.1 The Bureau shall maintain a **QPL** identifying **certified sources**. Only **Certified Sources** shall supply material to Department/Local Agency projects. Each **Certified Source** shall maintain its own Gradation Control Program unless producing Category IV aggregate only. Aggregate shipped from a **Certified Source** shall be certified to meet the quality and gradation requirements in the **Standard Specifications**. However, if approved by the District, the **Source** may choose to certify and supply other than standard **Department** gradations as established by the criteria in Article 6.2 herein.

4.2 A **Supplier Yard** shall meet the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived. The incoming aggregate sampling/testing shall be according to the current Department QC/QA document, Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production, Section B. Materials, 1. Aggregates, b. Incoming Aggregate Gradation Samples.

4.3 A **Terminal** shall meet all the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived.

5.0 REQUIREMENTS FOR SOURCE CERTIFICATION

5.1 A Certified Source shall have been checked using the procedures set forth in Section 10.0 herein and found to meet the requirements for Source certification. Any Source subsequently found not meeting these or any other requirements of this program shall be removed from the **QPL** based on the procedure detailed in Section 11.0.

The requirements for Source certification are as follows:

5.1.1 Gradation Control Program - Gradation samples shall be taken and tested as per Section 6.0 herein. Gradations and their ranges established per Article 6.2 herein which do not meet the Standard Specifications shall be submitted to the District for approval prior to production.

5.1.2 Stockpiling and Handling - Degradation is of primary concern in handling aggregates. Steel-tracked equipment shall not be operated on stockpiles. Free-fall from conveyor equipment onto load-out stockpiles shall be held to a maximum of 15 feet. The fall height requirement may be waived if the aggregate source uses special remixing procedures or a device approved by the Bureau. A comparison of a series of samples taken during the reclaiming or loading-out operation to those taken from the production belt should be made to estimate the effect of the aggregate-handling method on degradation.

5.1.2.1 Stockpiling and handling of aggregate should be designed to hold segregation to a minimum. Coned stockpiles shall not be built with stationary or movable conveyor equipment unless the reclaiming method is such that the loaded-out material visually shows minimal segregation. Radial and longitudinal conveyors or stackers shall be kept in motion to reduce coning. Where possible, a spreader chute on the stacker shall be used to broaden or flatten the wedge shape of the pile. Cascading down the sides of the pile should be held to a minimum. Material shall be reclaimed from wedge-shaped piles with an end-loader or equipment having similar type loading action working from the end of the pile, with care taken to work the entire width of the pile to remix the material as much as possible. Aggregate-handling methods using tunnel conveyor systems to reclaim aggregate from coned surge piles shall be checked for consistency of gradation. The method of aggregate-handling and stockpiling currently in use at a particular Source shall be considered satisfactory provided that the product, when checked at a load-out point, meets the gradation requirements.

5.1.2.2 Materials certified under this program shall be stockpiled separately and identified by signs. Signs shall have a minimum of 3" lettering. Each individual sign shall be free-standing and moveable. Any changes made to signing must be pre-approved by the District.

5.1.3 Approved Laboratory - Laboratory facilities and equipment shall conform to Section 7.0 herein. Laboratories shall be checked by District personnel and reapproved on a biennial basis. One (1) laboratory may be used as an approved laboratory for more than one (1) Source as long as no problems occur in maintaining each Source's Gradation Control Program.

5.1.4 Sampling and Testing Personnel - Sampling and testing personnel overseeing the Source's control processes (including consultants and contractors) at the Source shall be Aggregate Technicians.

5.1.4.1 The Source may use an AGCS Technician to perform all duties of an Aggregate Technician except when splitting and gradation testing. When an AGCS Technician is used, splitting and gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician.

5.1.4.2 The Source may use Gradation Technicians for splitting and gradation testing only. The Gradation Technician shall be under the direct supervision of the Aggregate Technician when testing gradation samples. The Source may also use Mixture Aggregate Technicians for sampling and gradation testing only. The Mixture Aggregate Technician shall be under the supervision of the Aggregate Technician or the AGCS Technician.

5.1.4.3 The Aggregate Technician, Gradation Technician or Mixture Aggregate Technician, shall demonstrate gradation testing proficiency to the Aggregate Inspector on a quarterly basis.

5.1.4.4 Any Mixture Aggregate Technician qualified personnel, when performing sampling and testing for a HMA or PCC Contractor, shall not concurrently perform the duties of an Aggregate Technician, an AGCS Technician, or a Mixture Aggregate Technician in the AGCS.

6.0 GRADATION CONTROL PROGRAM

6.1 The Gradation Control Program shall be run by an Aggregate Technician or an AGCS Technician as defined in Section 3.0 herein. The QC Manager shall assume responsibility for compliance with the Aggregate Gradation Control System and specifically shall ensure that the Aggregate Technician, AGCS Technician, or Mixture Aggregate Technician is performing all the required duties under the Aggregate Gradation Control System.

6.2 All communication concerning the Aggregate Gradation Control System shall be directed to the QC Manager.

6.3 Primary duties of the Aggregate Technician shall include frequent visual inspection, gradation sampling and testing, documentation, etc., as detailed herein and in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities", located in the current Manual of Test Procedures for Materials.

6.4 The AGCS Technician may perform the same duties as the Aggregate Technician except splitting and gradation testing. Splitting and gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician or a Mixture Aggregate Technician.

6.5 **Gradation Specifications.** Sieve limits for each sieve/each product under the Aggregate Gradation Control System shall be as specified in the Department's Standard Specifications and/or as amended herein. The special critical sieve criteria applies to designated products as described in QC/QA Procedure, "Aggregate Producer Control Chart Procedure" located in the current Manual of Test Procedures for Materials.

6.5.1 The midpoint/tolerance range of a designated critical sieve shall be developed from an average as shown in QC/QA Procedure, "Aggregate Producer Control Chart Procedure". The average shall be a historical average, or a start of production average derived from 5 start-of-production samples agreed to by the Department. All 5 start of production samples must pass the established critical sieve limit. Critical sieve limits will take precedence over Standard Specification limits. Requests for critical sieve limits shall be submitted in writing to the District Materials Engineer for approval.

6.5.2 The top and bottom sieves shall not be altered. For all other sieves, limits may be developed based on historical or start of production values. These sieve limits may be different from those in the Standard Specifications. These modifications are also allowed for fine aggregate. Changes in the top sieve or any No. 200 sieve ranges will not be permitted. In cases where the bottom sieve is other than the No. 200 sieve, a variance in limits may be granted if the Bureau determines the minus No. 200 material to be within acceptable limits. The Source shall request in writing to the District Materials Engineer approval of limits other than those in the Standard Specifications, but the range of the limits shall remain the same as the Standard Specifications except on critical sieves where critical sieve limits will take precedence. The agreed upon gradation limits shall apply at the final point of shipping within the Source's control.

6.5.3 The Department reserves the right to reject unacceptable material at any point prior to incorporation into the final product.

6.6 **Sampling and Testing**. Gradation samples shall be reduced to testing size by Illinois Modified AASHTO R 76. Minimum Field Sample Size and Minimum Test Sample Size shall be as noted in the Sample Size table, Illinois Specification 201. All sampling and gradation testing shall conform to Illinois Modified AASHTO R 90, Illinois Modified AASHTO R 76, Illinois Modified AASHTO T 11, and Illinois Modified AASHTO T 27. The Illinois Test Procedures noted above are located in the current Manual of Test Procedures for Materials.

6.6.1 Sampling and testing frequencies (including washed tests) by category/use shall be as noted in Table 1 herein.

Definitions of each frequency are as follows:

6.6.1.1 **Start-of-Production Frequency**. After a seasonal shutdown of production or when first producing a new product, the sampling and testing of start-up production or of the new product shall be at start-of-production frequencies/requirements noted in Table 1.

6.6.1.2 **Normal-Production Frequency**. During normal production, the minimum production sampling and testing frequency/requirements as noted in Table 1 shall be maintained.

6.6.1.3 **Stockpile Frequency**. During loadout of stockpiles, the minimum stockpile sampling and testing frequency/requirements as noted in Table 1 shall be maintained for each stockpile.

6.6.1.4 **Production Changes (Short-Term Shutdowns for Screen Changes, Crusher Modifications, Different Feed Rates, New Products, etc.)**. If a production change is made, a washed gradation sample shall immediately be run on all affected products. The start-of-production sampling frequency shall be implemented if the result on any critical sieve in that sample exceeds the warning bands on the critical sieve or if any results fail any specified sieve limits.

6.7 **Documentation**. Gradation results shall be charted on control charts, if required in Table 1, according to QC/QA Procedure, "Aggregate Producer Control Chart Procedure", located in the current Manual of Test Procedures for Materials. Within one (1) working day of sampling, all gradation results shall be charted, posted, or entered into a Source computer, each of which shall be located at the Source and/or approved laboratory, at the District's option. Computer-maintained charting must be approved by the Department and accessible in a timely manner during any Department inspection. Computer-maintained charts shall be printed and displayed once per week or at the request of the Department. Control charts are the property of the Department and shall not be removed or altered in any manner. The Aggregate Inspector will check the control charts on a regular basis. Source gradation computation sheets will be maintained by the Department for a minimum of three (3) years after the date run.

6.7.1 A Source diary shall be maintained by the Aggregate Technician or the AGCS Technician. The Aggregate Technician or the AGCS Technician shall log all actions taken during the production day, such as new product production, sampling, resampling, screen changes, separate stockpiling, visual inspections, etc., as noted in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities" in the current Manual of Test Procedures for Materials.

6.7.2 The Source shall immediately notify the District whenever new products are being produced at the Source under its Gradation Control Program.

6.8 **Failing Gradation Samples**. Any Failing Gradation Sample (start-of-production, normal-production, or stockpile) shall be evaluated according to the following procedure and, if necessary, immediate action taken to correct a failing gradation.

6.8.1 If a gradation sample fails, one (1) resample from the same sampling location shall immediately be taken and tested. If the resample passes, the testing frequency being run prior to the failure shall be resumed. If the resample fails, a second resample shall immediately be taken.

6.8.2 If the second resample passes, the start-of-production sampling frequency shall be initiated. All samples in the series must pass before the normal production or stockpile sampling frequency for that location can be restarted.

6.8.3 If the second production resample fails, production of that specified aggregate shall not be incorporated in the approved stock, or, in the case of the second stockpile resample failing, shipment from that stockpile shall cease. Corrective action shall be initiated by the Source. No material shall be placed on or, in the case of stockpile problems, shipped from the certified stock until a passing gradation sample is taken and tested. The start-of-production frequency shall then be run at that location. All samples in the series must pass before the normal-production or stockpile sampling frequency for that location can be restarted.

6.8.4 All resamples shall be washed gradation tests except as stated under Note 2 in Table 1.

6.8.5 Any action taken, such as resampling, screen changes, separate stockpiling, etc., shall be noted in the remarks area of the failing test computation sheet and in the Source diary.

6.8.6 The Aggregate Technician or the AGCS Technician shall monitor the corrective action. Failure to comply with Section 6.8 herein shall cause the **Source** to be removed from the **QPL** as per Section 11.0 herein.

6.9 **Failing Monitor Gradation Samples**. Any **Source**'s failing Monitor gradation sample taken and tested by the Department and determined to be a Source problem per Section 9.6 will be considered a Failing Gradation Sample under the Source's Gradation Control Program and shall cause the Source to enact Section 6.8 herein.

7.0 APPROVED LABORATORY

7.1 An approved Source laboratory shall have the required equipment or alternatives approved by the Bureau specified in the Appendix D3 "Aggregate Laboratory Equipment" in the current Manual of Test Procedures for Materials.

7.2 If a mixture QC laboratory is used for AGCS testing, the following additional equipment is required for use only on AGCS aggregate samples:

- One set of nested sieves for coarse and/or fine aggregate.
- One set of wash sieves.
- One coarse and/or fine aggregate splitter.

8.0 OUTLYING (OS) SOURCE REQUIREMENTS

8.1 Each district may designate a certified aggregate Source located out-of-state which shall follow specific requirements in running the AGCS, listed herein. The District shall detail the criteria used to qualify the Source for the Outlying designation. The Source QC plan tentatively approved by the District shall accompany the District request.

8.1.1 The **Bureau** shall notify the District Materials Engineer in writing as to whether the aggregate **Source** has met the Outlying criteria, the **Source QC Plan** is acceptable, and the **Source** will be designated as an **Outlying (OS) Source** and placed on the **QPL**.

8.2 The **OS Source** shall follow all requirements of the AGCS program unless otherwise noted within this section. A **Source QC Plan** shall be submitted for department approval to the inspecting **District**. Other states' QC/QA programs or parts thereof may be substituted for the Illinois AGCS program, if approved by the **Bureau**. All substitutions/ changes shall be noted in the **Source QC Plan**. The minimum sampling frequencies noted in the Illinois AGCS program shall be met regardless of frequencies listed in the other state programs.

8.3 The **District** will, at least annually, visit each Source to obtain quality and gradation samples, observe program procedures, and inspect the AGCS laboratory. Laboratory inspections conducted under other states' programs may be used if the **OS Source** has been approved to use the other states' QC/QA program.

8.3.1 These inspections may be unannounced.

8.4 The **District** will inspect, sample, and test incoming aggregate according to the specified AGCS monitor frequency at Illinois sites (job sites, mix plants, terminals, or supplier yards). Split sample, load-out, and comparison requirements noted in Section 9 herein will be waived.

8.4.1 The **District** will communicate the test results to the **QC Manager** at the aggregate **Outlying Source** (OS) for appropriate action, including any needed corrective action. In addition, the District will communicate the test results to any **QC Manager** or Resident Engineer at the jobsite, mix plant, terminal, or supplier yard, for appropriate action, including the need for corrective action.

8.5 **Outlying Sources** shall notify their inspecting **District** of all scheduled AGCS shipments/ production (including shipments to mix plants, terminals, and supplier yards) prior to the shipment/production.

8.6 Once designated as an **Outlying Source** (OS), all aggregate, including Category I, III, and IV, shipped to Illinois Department of Transportation projects (including all Local Agency projects) shall be produced under the AGCS program. Category IV shall be run at the Category III frequency.

9.0 DEPARTMENT RESPONSIBILITIES

9.1 Sampling and testing for quality shall remain the responsibility of the Department. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, will not be allowed to take any quality or Freeze-thaw samples at an aggregate **Source**.

9.2 Monitor gradation samples at the **Source** shall be taken, by or in the presence of an Aggregate Inspector, from each aggregate being produced for designated use at each Certified **Source**. All Monitor samples shall be split samples of a **Source's** gradation sample taken as per the **Source's** Gradation Control Program. Additionally, the Department reserves the right to sample Monitor samples at any time. At least two (2) out of every five (5) Monitor samples shall be taken from the stockpile's loadout face once loadout procedures have started. The Monitor samples will be tested by District personnel on Department testing equipment according to the first paragraph of Section 6.3 herein. All Monitor samples shall be washed gradation tests unless Note 2 in Table 1 is applicable. Each Monitor sample shall be identified as to sampling location.

9.3 Sampling and testing frequency for the Monitor gradation samples shall be a minimum of one (1) sample per every twenty (20) production days for each gradation being produced for designated use.

9.4 All Monitor gradations run will be reported in the MISTIC system. Computation sheets will be retained for a minimum of three (3) years in the Department's **Source** file.

9.5 The Inspector will compare both the Monitor sample and the Source's split sample for validity as defined by the Department's "Guideline for Sample Comparison" (see Appendix A of the current Manual of Test Procedures for Materials). The reason for any significant difference between the two (2) samples shall be identified and corrected.

9.6 All Monitor gradations will be communicated to the **QC Manager**. All failing monitor gradations will be investigated by the Department. Any failing gradations, which are determined to be a **Source** problem not already corrected by the Producer, shall cause Article 6.6 herein to be enacted by the **Source**. The Aggregate Inspector will compare the failing gradation to the **Source's** control charts and/or split sample computation sheet. If the control chart indicates that the **Source** is aware of the problem and is taking corrective action, normal Monitor sampling may resume. The Aggregate Inspector will continue to visually monitor the problem and the **Source's** corrective action. If the control chart indicates the **Source** is not aware of the problem, a split sample of the **Source's** next sample as specified in Article 6.5 shall be tested. Failure of the **Source** to follow Article 6.6 shall result in the **Source** being removed from the **QPL** per Section 11.0 herein.

10.0 SOURCE CERTIFICATION PROCEDURE

10.1 An aggregate **Source** wishing to become certified shall verbally contact the **District**. A preliminary meeting may be held to discuss requirements of the program. After the initial contact or the preliminary meeting, a written request for certification shall be submitted to the District Materials Engineer.

10.2 An evaluation team composed of two (2) **District** personnel shall conduct an inspection of the **Source** for compliance to the certification checklist for all **Sources** producing Category I and III aggregate. A formal meeting with the **Source's** management, **QC Manager**, and quality control personnel shall be held to discuss the **Source's** Gradation Control Program requirements. The **Source** shall submit a certification letter and an Aggregate Shipping Tickets Information Form for Producers (BMPR AGG01) as designated by the **Department**. Each **Source** shall provide and maintain their own quality-on-tickets form and a listing of current certified gradations being produced under the Aggregate Gradation Control System. The certification letter and the Aggregate Shipping Tickets Information Form for Producers Form (BMPR AGG01), shall be forwarded to the **Bureau** before the **Source** will be added to the **QPL**.

10.3 Each **Certified Source** will be reevaluated on a biennial basis by **District** personnel. The reevaluation shall be a complete evaluation of the **Source's** laboratory and technician(s). A copy of the reevaluation checklist and comments shall be forwarded to the **Bureau**. Failure to comply with the certification criteria will result in the **Source's** certification being revoked as per the procedure detailed in Section 11.0 and the **Source** will be classified as De-Certified and removed from the **QPL**.

10.4 If at any time a **Certified Source** does not maintain the proper QC personnel, the **Source** will be given thirty (30) days to comply by either hiring a new QC person, training existing personnel or by contracting with a qualified consultant. If after thirty (30) days the source does not have the proper QC personnel; the **Source's** Certification will be revoked by the **Bureau**. Section 11.0 will not apply to this type of Revocation. The **Source** will be reinstated on the **QPL** once the proper QC personnel are acquired.

10.4.1 As an option to this type of Revocation, a **Source** may utilize a Gradation Technician for gradation testing as long as the following criteria are met:

- The **Source** shall inform the district, in writing, of the QC personnel change.

- The **Source** shall have an **Aggregate Technician** visit the **Source** a minimum of three (3) times a day to oversee the **Gradation Technician**.
- The **Source** shall have the proper personnel trained and in place in a timeframe acceptable to the **Bureau**.

11.0 REVOCATION OF A SOURCE'S CERTIFICATION

11.1 The **Department** may revoke a **Source's** Certification for any of the following reasons:

- Failing to follow the procedures and requirements of the Aggregate Gradation Control System (AGCS) Policy Memorandum.
- Misrepresentation of materials or products.
- Failing to follow the approved **Quality Control Plan**.

11.2 Before removal, the District Materials Engineer will detail, in a non-conformance letter to the **Source's QC Manager**, reason/s the **Department** is seeking to revoke the **Source's** Certification. The **Source** will have two weeks to reply. The **Source** shall not place materials in question on certified stockpiles during the two-week period. If the **Department's** reasons warrant, the **Source** may be required to stop shipment of any and all products to **Department** and/or Local Agency projects.

11.3 Within this two-week period, the **Source's QC Manager** shall reply provide a written response outlining the steps the Source is taking to address the issues outlined in the **Department's** non-conformance letter.

11.4 After receipt of the **Source's** letter, the **District** will schedule a meeting with the **Source** to discuss the proposed revocation and the **Source's** response. Based on this meeting, the District Materials Engineer will either (1) conclude the steps taken by the **Source's QC Manager** are adequate and terminate the revocation process, or (2) conclude the **Source's** response does not adequately address the issues outlined in the **Department's** non-conformance letter and recommend in writing to the **Bureau** that the **Source** be taken off the **QPL**. The recommendations shall include details and **District/Source** comments concerning the proposed revocation. Copies of all correspondence, including meeting minutes, shall be sent to the **Bureau** and the **Source**.

11.5 If requested by the **Source** within seven days of the **District's** recommendation to revoke the Certification, the **Bureau** will schedule a meeting with the **Source's QC Manager** and the **District**. Based on this meeting, the **Bureau** will either terminate the revocation process or proceed with removing the **Source** from the **QPL**.

11.6 The **Bureau's** decision to revoke the **Source's** Certification is a final agency decision of the Illinois Department of Transportation.

11.7 The **Bureau** will notify the District Materials Engineer and **Source** in writing when a **Source's Certification** has been revoked and that the **Source** has been removed from the QPL and has been listed as a **De-Certified Source**. The **Source** shall not supply aggregate materials or products for **Department** and/or Local Agency projects until the **Source's Certification** has been reinstated on the **QPL**.

11.8 If the revocation process is not based on misrepresentation of materials or products, and/or failure to follow the overall general requirements of this policy, the **QC Manager**, at any time, may inform the **District** in writing that the **Source** is no longer producing or shipping a specific gradation. This action will terminate any revocation process against the **Source** concerning the materials in question. Production of that gradation for the AGCS shall not be restarted unless the **District** concurs that corrective action has been completed by the **Source**.

12.0 REINSTATEMENT OF A SOURCE'S CERTIFICATION

The **Source** may re-apply for reinstatement of its certification at the end of the revocation period. Re-application shall be in writing to the **Bureau** and include the specific steps to be taken to correct the cause for loss of certification.

13.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the **Bureau**.

TABLE 1

Category	Use	Start of Production	Normal Production	Stockpile/ Loadout	Control Charts	Master Band
I (Notes 1 & 5)	Coarse Aggregate and Manufactured Sand Used in HMA and PCC Coarse Aggregate for Pavement Drainage	1 per 1,000 T (907 metric tons) for the first 5,000 T (4,536 metric tons) (all wash)	1 per 2,000 T (1,814 metric tons) 2 per day max (wash 1/3 coarse agg.) (wash all manufactured sand)	2/week (all wash) (Note 3)	Yes	Yes (Note 8)
III (Notes 1 & 5)	Natural Sand for All PCC and HMA Projects Aggregate Surface Course Granular Shoulders Granular Sub-base Granular Base Granular Embankment Special Cover/Seal Coat Sand Bedding Porous Granular Embankment and Bedding, Sand Backfill for Underdrains French Drains Membrane Waterproofing Mortar Sand Blotter Granular Embankment Aggregate Subgrade (Note 9)	1 per 2,000 T (1,814 metric tons) for the first 4,000 T (3,629 metric tons) (all wash) (Note 2)	1 per 10,000 T 2 per day max 1 per week min (all wash) (Notes 2 & 6)	1/week (all wash) (Notes 2 & 7)	No	No

Table 1 (cont.)

Category	Use	Start of Production	Normal Production	Stockpile/ Loadout	Control Charts	Master Band
IV (Note 4)	Rock Fill Erosion and Sediment Control Rip-Rap Bedding Ice Control Abrasives Trench Backfill	Department Testing				

Note 1: A producer may adjust gradation bands for any product in accordance with Article 6.2 of the AGCS.

Note 2: Wash only products used for HMA, PCC, Seal/cover coat and products with # 200 sieve requirements.

Note 3: No loadout tests for quantities under 500 tons (454 metric tons) or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 500 tons (454 metric tons), a loadout sample shall be run.

Note 4: Testing to be performed by IDOT personnel.

Note 5: Testing frequency may be reduced based on conformance to QC requirements, consistency in meeting sieves' midpoints, statistical consistency, etc.

Note 6: Minimum of 1 per week after the first 10,000 tons (9,072 metric tons) of production per week for aggregate surface course, granular shoulders, granular subbase, granular base, and granular embankment special; minimum of 1 every 2 weeks if production less than 10,000 tons (9,072 metric tons) per 2-week period.

Note 7: No loadout tests for quantities under 1,000 tons (907 metric tons) or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 1,000 tons (907 metric tons), a loadout sample shall be run.

Note 8: Refer to current QC/QA Procedure, "Aggregate Producer Control Chart Procedure" for required gradation.

Note 9: Only Normal Production testing shall apply. No Wash.

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Aggregate Producer Control Chart Procedure
(Chapter 9, Aggregate Technician Course Manual)
Appendix A3

Effective: November 1, 1995
Revised: December 1, 2017

9.0 AGGREGATE PRODUCER CONTROL CHART PROCEDURE

Gradation control charts provide an effective way to monitor the aggregate production process and can present a graphical record of aggregate gradation during continuous production and stockpiling. Specific changes or gradual trends in a product's gradation can be readily identified before major trouble occurs. Other benefits may also be realized by using control charts including but not limited to:

- Decreased product variability
- Established production capabilities
- Permanent record of gradation quality
- Increased sense of "quality awareness" at the Source

For these reasons, an Aggregate Producer Control Chart Procedure is an important requirement in the Gradation Control Program at certified aggregate Sources in Illinois.

Under the Illinois Aggregate Producer Control Chart Procedure, all gradation test results (percent passing) for each required gradation/production point tested shall be recorded on a control chart within one working day of sampling. The control chart/s for any gradation in the program must therefore have each required sieve represented on the chart.

The gradation control charts are to be readily accessible at the source and/or approved laboratory and available for inspection upon request by the Aggregate Inspector or a representative of the Department. Computer-maintained charts are the property of the Department and shall not be removed or altered in any manner. The Aggregate Inspector shall check the control charts on a regular basis.

The "Illinois Specification 201 Aggregate Gradation Sample Size Table & Quality Control Sieves" document from the "Manual of Test Procedures for Materials" designates the required sieves for coarse and fine aggregate gradations.

9.1 Definitions

9.1.1 **Average**: The sum of a series of test results or measurements divided by the number of values or measurements included in the sum, also, known as the arithmetic mean.

9.1.2 **Check Samples**: Samples taken for a specific purpose, other than required by Table 1. This information may be used to verify an observation or conclusion, or as a means of confirmation of corrective action, other than required by Table 1. Such samples are permitted under any circumstances except to replace samples required by Table 1.

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Effective: November 1, 1995
Revised: December 1, 2017

9.1.3 **Control Charts**: A visual representation of test results, observations, or measurements arranged in an orderly sequence in respect to time. Control charts provide the means of measuring the effectiveness of process control, detecting lack of control, directing a course of action to restore control, and increased sense of “quality awareness”.

9.1.4 **“Master Band” or Control Limits**: Mathematical limits placed on gradations, based on established Master Band limits, which when exceeded initiate action by those responsible for process control, and/or acceptance of aggregate products. These limits may be established on the basis of previous historical experience or by start of production results.

9.1.5 **Sample Testing Frequency**: As per Table 1.

9.1.6 **Table 1**: Table 1 of the current Central Bureau of Materials’ Policy Memorandum, “Aggregate Gradation Control System (AGCS)” found in the “Manual of Test Procedures for Materials”.

9.1.7 **Trend**: When two or more points move away from the mid-point target values in either direction (±), thus producing either a steep angled line or three points moving with a gradual angle. This is usually associated with the moving average points but can also be determined from individual test points. Trends are indications that a problem(s) are or will be present if corrective action is not taken.

9.1.8 **“Warning Band” or Moving Average**: The average of 5 consecutive values (sample results) obtained per Table 1 requirements, based on established Warning Band limits. Such values always represent the most recently obtained test results or measurements within the prescribed group of observations. These limits may be established on the basis of previous historical experience or by start of production results.

9.2 **Control Chart Paper / Size**: Control Charts for the Gradation Control Program, when created by hand, must be placed on 10x10 cross-sectional graph paper measuring 420 mm x 280 mm (16-1/2” x 11”) or 216 mm x 280 mm (8-1/2” x 11”). Graph paper used for this purpose, can be ordered through office supply specialty stores, companies dealing in drafting materials or ordered through the internet. An example of a control chart is found on the last page of this document.

9.3 **Chart Preparation**: At the top of the control chart, the aggregate product material code and the Master Band (when known) will be noted.

Lines corresponding to the upper and lower percent-passing Standard Specification limits for each required sieve/gradation shall be drawn horizontally across the graph.

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The vertical distance between these lines must accurately represent the difference between the upper and lower limits for each sieve using a vertical scale of one division (square) which will equal one percent (1%) passing on all sieves except the 75-µm (No. 200), see Article 9.3.1.

On the left side of the control chart, the upper and lower specification lines of each sieve shall be connected by a drawn vertical double arrow.

The specification limits for the each sieve, e.g., 45% for upper limit and 15% for lower limit, must be indicated at the top (for upper limit) and bottom (for lower limit) of the arrow. The sieve size, e.g., 4.75 mm (No. 4), shall also be indicated between the limits on the far left side of the chart.

The vertical scale [(1% = 1 division (square) or 0.1% = 1 division (square)] shall be noted below each required sieve.

Each test value will be spaced horizontally every 1/2" or 5 horizontal divisions (squares).

9.3.1 The 75-µm (No. 200) sieve, when plotted, shall be plotted for washed tests only.

9.3.2 Master Bands and Warning Bands shall be drawn across the graph for the critical sieve, when required, as defined in Article 9.5.1 herein. Master Band limits, once known, shall be represented by a solid line and the Warning Band limits shall be represented by a broken line.

9.4 **Plotting of Test Values**. The Gradation Control Program allows the producer to run both washed and dry gradation tests. The percent passing results for each different kind of gradation test run shall be plotted on the control chart using specific symbols. All symbols must measure approximately 2.5 mm (1/10") on each side/diameter.

9.4.1 The symbols to be used for each test type are as follows:

Type of Gradation Test	Symbol	
Washed Production	Open Circle	O
Dry Production	Circled X	⊗
Stockpile (can be plotted on separate chart)	Asterisk	✱
Moving Average	Open Square	□

9.4.2 In addition to the required symbols, line-types are used to further facilitate proper interpretation of the plotted information. Washed production test results will be connected with a broken line while moving average results are to be connected with a solid line.

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9.4.3 The moving average will be calculated and plotted on the last five consecutive washed production test values on each critical sieve and is only plotted when a new washed production test is ran.

The moving average will be started by taking the fifth test value after the start of yearly production, or production restarted after a protracted shutdown, and averaging it with the four preceding test values. Once the moving average is established, the moving average will be calculated and plotted each time a new washed production test value is ran and plotted.

9.4.4 Each individual test result that is ran and plotted will have the following information located at the bottom of the chart below the respective plotted test result.

- Date the sample was taken (e.g. 07/15/11)
- Time the sample was taken (e.g. 10:15 am)
- Every resample was taken (An ‘R’ shall be placed under the test result that it represents)
- Initials of the Aggregate technician plotting the test results
- All individual test symbols shall have the numerical value written just below the symbol.

9.4.5 Stockpile load out test results may be plotted or summarized on a separate control chart, graph, or table. The reporting format may be developed by the Source. The reporting format shall include the information required in this article (sample type, time, and date).

The control limits and deviation from the established Master Band shall be identified.

9.5 **Master Band/Warning Band**. During Start of Production, Master Bands/Warning Bands must be developed and placed on the control chart after five tests or within the first 9,100 metric tons (10,000 tons), whichever occurs first, for each product's critical sieve, when required. Any production or equipment change after development of a Master Band may necessitate the development of a new Master Band.

Historical data from washed production samples may also be used, at the Source's request, to establish Master Band targets. The average, rounded to the nearest whole number, used to establish the Master Band shall be based only on washed production critical sieve test results.

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Revised: December 1, 2017

9.5.1 Master Bands/Warning Bands will be drawn plus/minus using the below-listed percentages from a rounded average for each listed coarse aggregate sieve/gradation.

If the critical sieve and the plus/minus percentages for coarse aggregates is not listed, this information will be assigned by the Central Bureau of Materials on an as-needed basis.

Gradation	Sieve	Master Band (%)	Warning Band (%)
CA/CM 5	25 mm (1")	± 8	± 6
CA/CM 7	12.5 mm (1/2")	± 8	± 6
CA/CM 11	12.5 mm (1/2")	± 8	± 6
CA/CM 13	4.75 mm (No. 4)	± 8	± 6
CA/CM 14	9.5 mm (3/8")	± 8	± 6
CA/CM 16	4.75 mm (No. 4)	± 8	± 6

Sand Producers – Refer to Illinois Specification 201 for gradation requirements.

9.5.2 When a production change is made, a vertical line shall be drawn through the Master Band. The change shall be noted on the chart and documented in the Source plant diary.

9.5.3 A Master Band, when established, shall take precedence over the Standard Specification limits set for that sieve/gradation.

9.6 **Test Values at Master Band/Warning Band Limits**. When an individual test value on a Master Band **exceeds** the Master Band limits, the producer must treat that test result as a failure. Article 6.5 of the current Aggregate Gradation Control System Department Policy Memorandum shall be enacted. Article 6.5 of the AGCS requires resamples/corrective action be taken in response to the initial failing test.

The situation of the moving average hitting or exceeding a Warning Band is different than a failing individual test and Master Bands. When the moving average **hits or exceeds** the Warning Bands, the Source must decide whether to take corrective action to bring the gradation back within the Warning Bands or to develop a new Master Band.

The Source must notify the District what action was taken.

If a new Master Band is developed, the material shall be stockpiled separately from the previous production.

The development of a new Master Band may necessitate new HMA or PCC mix designs.

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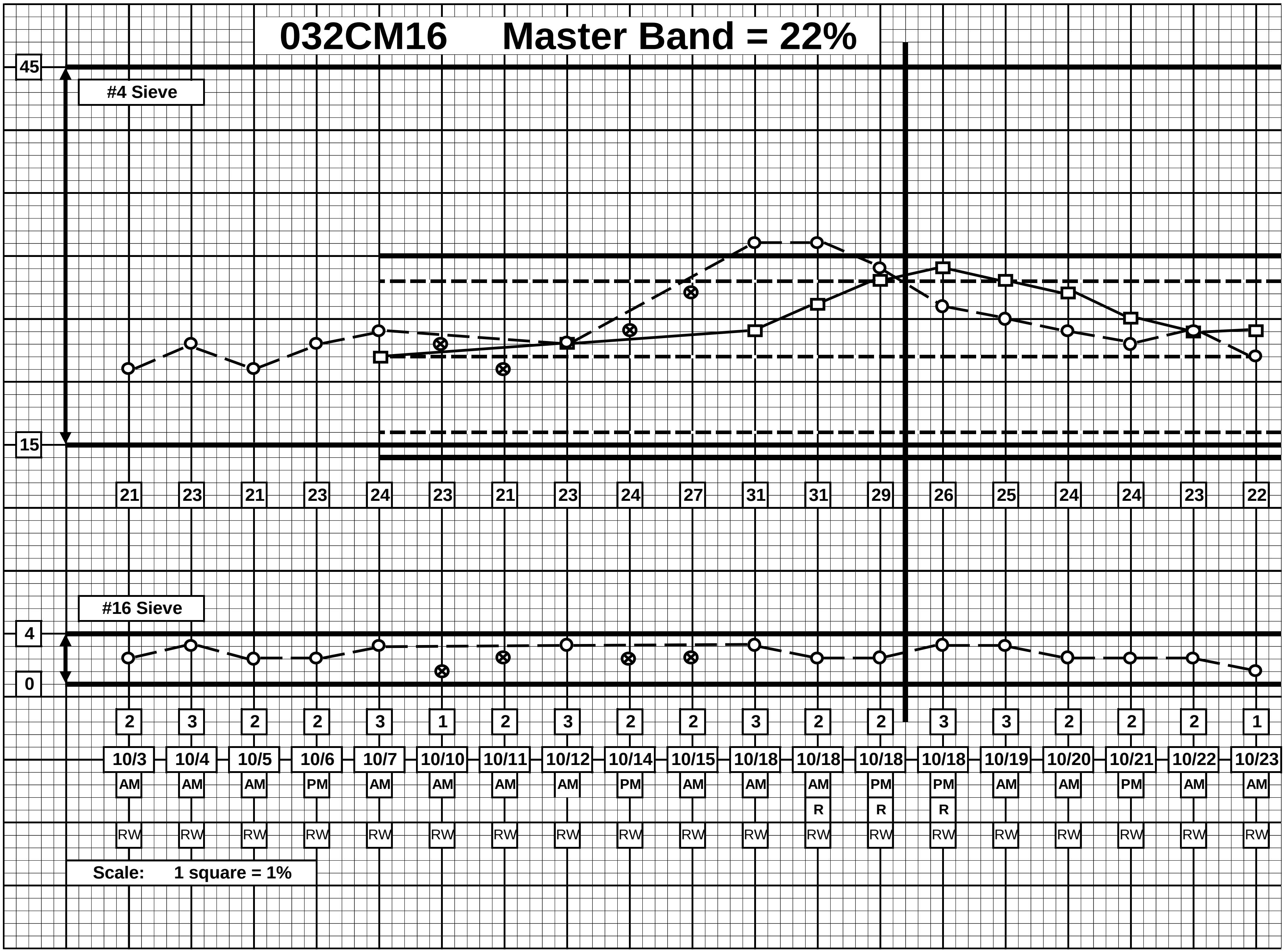
032CM16 Master Band = 22%
#4 Sieve
45
15
21 23 21 23 24 23 21 23 24 27 31 31 29 26 25 24 24 23 22
#16 Sieve
4
0
2 3 2 2 3 1 2 3 2 2 3 2 2 3 3 2 2 2 1
10/3 10/4 10/5 10/6 10/7 10/10 10/11 10/12 10/14 10/15 10/18 10/18 10/18 10/18 10/19 10/20 10/21 10/22 10/23
AM AM AM PM AM AM AM AM PM AM AM AM PM PM AM AM PM AM AM
R R R
RW RW RW RW RW RW RW RW RW RW RW RW RW RW RW RW RW RW RW
Scale: 1 square = 1%

<u>Note</u>: The following has been added to this manual to better facilitate and understand the concepts of control charts in this class. **<u>This information is not part of the official document nor will it be found in the "Aggregate Producer Control Chart Procedure" document</u>** located in the current Manual of Test Procedures.

<u>Calculating Averages</u>

A technician obtains "n" (5) consecutive test values: 59 61 58 55 60

<u>What is the average of these five test values?</u>

Solution: The sum of the data values: 61 + 55 + 58 + 59 + 60 = 293

The average is: $\frac{\text{Sum of Data}}{\text{Number of Data}} = \frac{293}{5} = 58.6$ or 59

The value of 59 would then be the average for these five test values. (Answers should always reflect the required precision based on the given information).

<u>Example</u>: All reported aggregate **<u>percent</u>** values are rounded to the nearest whole percent except the 75-µm (No. 200 material). The 75-µm (No. 200) **<u>percent</u>** values are rounded to the nearest tenth of a percent. This applies to percent only and is not to be confused when working with **<u>weights</u>** **(**coarse and fine aggregate materials).

<u>"Moving" Average Calculation</u>

A technician obtains 15 consecutive test values (n):

5l 46 50 53 49 48 56 47 49 48 43 52 56 44 49

Determine the moving average for the 5th, 7th, 10th and the 15th tests?

<u>Solution for the 5th test value</u>: **<u>5l 46 50 53 49</u>** 48 56 47 49 48 43 52 56 44 49

5l + 46 + 50 + 53 + 49 = 249

249 ÷ 5 = **49.8** = **50** (50 would then be plotted for the 5th test moving average value)

<u>Solution for the 6th test value</u>: 5l **<u>46 50 53 49 48</u>** 56 47 49 48 43 52 56 44 49

46 + 50 + 53 + 49 + 48 = 246

246 ÷ 5 = **49.2** = **49** (49 would then be plotted for the 6th test moving average value)

<u>Solve</u> for the 10th test value: 5l 46 50 53 49 48 56 47 49 48 43 52 56 44 49

<u>Solve</u> for the 15th test value: 5l 46 50 53 49 48 56 47 49 48 43 52 56 44 49

<u>Note</u>: The following Illinois Specification 201 "Aggregate Gradation Sample Size Table & Quality Control Sieves" 3-page document is officially found in the current "Manual of Test Procedures" and **<u>is not part of</u>** the "Aggregate Producer Control Chart Procedure" document. The Illinois Specification 201 document is placed here as an aid to help facilitate the discussion of Control Charts.

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

COARSE AGGREGATE GRADATION TABLE																				
CA(CM)[1,2]	**Minimum Field Sample Size [3]**	**Minimum Test Sample Size[3]**	**3"**	**2 1/2"**	**2"**	**1 3/4"**	**1 1/2"**	**1"**	**3/4"**	**5/8"**	**1/2"**	**3/8"**	**1/4"**	**#4**	**#8**	**#16**	**#40**	**#50**	**#200**
CA01	110 lbs (50 kg)	10,000 g	X	X^{MN}	X		X	X											X
CA02	110 lbs (50 kg)	10,000 g		X	X^{MN}		XC	X	XC		X			X		X	X		X
CA03	110 lbs (50 kg)	10,000 g		X	X^{MN}		X	X			X								X
CA04	110 lbs (50 kg)	10,000 g			X		X^{MN}	X	XC		X	XC		X		X	X		X
CA05[5]	110 lbs (50 kg)	10,000 g				X	X^{MN}	$X^{MB,6}$	XC		X			X^{6}					X
CA06	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC		X	XC		X		X	X		X
CA07[5]	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	$X^{MB,6}$	XC	XC	X^{6}					X
CA08	55 lbs (25 kg)	5,000 g					X	X^{MN}	X	XC	X	XC	XC	X		X			X
CA09	55 lbs (25 kg)	5,000 g					X	X^{MN}	XC	XC	X	XC	XC	X		X			X
CA10	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	X	XC	XC	X		X	X		X
CA11[5]	55 lbs (25 kg)	5,000 g						X	X^{MN}	XC	$X^{MB,6}$	XC	XC	X		X^{6}			X
CA12	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	X	XC	X	X		X
CA13[5]	35 lbs (16 kg)	2,000 g							X		X^{MN}	X	XC	$X^{MB,6}$	XC	X^{6}			X
CA14[5]	35 lbs (16 kg)	2,000 g								X	X^{MN}	$X^{MB,6}$	XC	X^{6}					X
CA15	35 lbs (16 kg)	2,000 g									X	X^{MN}	XC	X	XC	X			X
CA16[5]	25 lbs (11 kg)	1,500 g									X	X^{MN}	XC	$X^{MB,6}$	XC	X^{6}			X
CA17	35 lbs (16 kg)[4]	4,000 g[4]	X		XC			XC			XC	XC		$X^{MN,4}$		X		X	X
CA18	35 lbs (16 kg)[4]	4,000 g[4]	X					$X^{MN,4}$			XC	XC		X		X		X	X
CA19	35 lbs (16 kg)[4]	4,000 g[4]	X					$X^{MN,4}$			XC	XC		X		X	X	X	X
CA20	25 lbs (11 kg)	2,000 g									X	X^{MN}	XC	X	X	X			X

Note: See footnotes below Fine Aggregate Gradation Table for explanation of symbols

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES
Effective: December 1, 2021

FINE AGGREGATE GRADATION TABLE															
FA(FM)[1,2]	**Minimum Field Sample Size [3]**	**Minimum Test Sample Size[3]**	**1”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**
FA01	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA02	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	X^{MB}		X		X	X
FA03	25 lbs (11 kg)	500 g			X	X^{MN}		X			X		X		X
FA04	25 lbs (11 kg)	500 g			X				X^{MN}						
FA05	25 lbs (11 kg)	500 g			X	X^{MN}								X	X
FA06	25 lbs (11 kg)	500 g	X	X	X	X^{MN}								X	X
FA07	25 lbs (11 kg)	100 g				X		X^{MN}			X		X		X
FA08	25 lbs (11 kg)	100 g					X				X^{MN}			X	X
FA09	25 lbs (11 kg)	100 g					X					X^{MN}		X	X
FA10	25 lbs (11 kg)	100 g						X			X^{MN}		X		X
FA20[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA21[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA22[5]	25 lbs (11 kg)	500 g			X	X^{MB}	$X^{MB, 6}$		X						X^{6}
FA23[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}
FA24[5]	25 lbs (11 kg)	500 g			X	X^{MN}	X^{MB}		X	$X^{MB, 6}$		X		X	X^{6}

Notes below apply to Fine and Coarse Aggregate Gradation Tables Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
MB = Master Band Sieves for Category I Coarse Aggregate for PCC and HMA Mixes; Bituminous use only for fine aggregate.
MN = Maximum Nominal Sieve for Crushed Gravels – Maximum Nominal Size is defined as the first specification sieve in the product gradation on which material may be retained.
1 = CA = Coarse Aggregate; CM = Coarse Aggregate, Modified; FA = Fine Aggregate; FM = Fine Aggregate, Modified
2 = CM and FM gradations shall be sampled and tested the same as the corresponding CA and FA gradations.
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = Will vary with the gradation of the material being used
5 = Control Charts Required
6 = Required Sieve for Control Charts

Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES
Effective: December 1, 2021

LARGE SIZED AGGREGATE GRADATION TABLE										
CS/RR[1,2]	**Minimum Test Sample Size[3]**	**8”**	**6”**	**4”**	**3”**	**2”**	**1 ½”**	**1”**	**½”**	**#4**
CS01	50,000 g	X	X	X	XC	X		XC	XC	X
CS02	50,000 g		X	X	XC	X		XC	XC	X
RR01	20,000 g				X	XC	X	XC	XC	X
RR02	20,000 g			X	XC	X	XC	XC	XC	X

Notes below apply to Large Sized Aggregate Gradation Table Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
1 = CS = Coarse Aggregate Subgrade; RR/RRM = Rip Rap
2 = Dry Gradations Only
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = A round nosed shovel may be used for sampling.
5 = Metal plates with precisely sized square holes by be used for the gradation
6 = Test sample size shall be taken in the field. No splitting is required

<u>The following are the gradation tables taken from the 2022 Standard Specifications</u>:

Art. 1004.01 (10) (c) Coarse Aggregate Gradation Table

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		

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.

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.

Article 1003.01 (10) (c) Fine Aggregate Gradation Table

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 [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 the 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:

This Page Is Reserved

CHAPTER 6 – HOMEWORK

READ ALL OF THE FOLLOWING INSTRUCTIONS ON PAGES HM-1 AND HM-2, BEFORE COMPLETING THE HOMEWORK. THE INSTRUCTIONS ARE FOR THE CALCULATIONS HOMEWORK PROBLEMS 1 THRU 6, WHICH ARE LOCATED ON PAGES HM-3 TO HM-13.

Problem No. 1

- Calculate the Percent Passing.
- Show all weights and percents calculated.
- Report Percent % passing on the Report line.
- Calculate Max Loss.
- Calculate % Moisture.

Problem No. 2

- Calculate the Percent Passing.
- Show all weights and percents calculated.
- Report Percent % passing on the Report line.
- Calculate the % Washed -200.
- Calculate Max Loss.
- Calculate % Moisture

Problem No. 3

- Calculate the Percent Passing.
- Show all weights and percents calculated.
- Report Percent % passing on the Report line.
- Calculate the % Washed -200.
- Calculate Max Loss.
- Calculate % Moisture

OVER – (HOMEWORK CONTINUED)

CHAPTER 6 – HOMEWORK (Cont'd)

Problem No. 4

- Calculate the percent passing
- Show all weights and percents calculated.
- Report Percent % passing on the Report line.
- Calculate the % Washed -200.
- Calculate Max Loss.
- Calculate % Moisture.
- Use given information below and complete as much of the form as possible. (Directions for filling out the form are located in Chapter 6 on pages 6-27 thru 6-32.)

GIVEN: **Sam Jones is the Quality Control Manager for Maine Construction Company (918-02). Sam took a sample of 022CM16 from a stockpile located at Maine Construction's asphalt plant site on June 20, 2023. Joyce Walker, a Mixture Aggregate Technician, who also works for Maine Construction, ran a washed gradation (Seq. No. 005) on this material the same day. The testing took place on site in the Maine Construction's laboratory. The stone came from Alta Materials. (50587-03). Maine Construction's plant and laboratory is located in District 3.**

Problem No. 5

- Calculate the Percent Passing.
- Show all weights and percents calculated.
- Report Percent % passing on the Report line.
- Calculate the % Washed -200.
- Calculate Max Loss.
- Calculate % Moisture.

Problem 6 - Sample Comparison Problem

- Transfer the producer rounded passing from each sieve to this worksheet. (from Problem No. 5)
- Calculate the monitor's and producer's fraction, fraction difference, and write in the applicable tolerance.
- Specify the proper disposition (ok or out)

AGGREGATE GRADATION REPORT

MISTIC ID: ______

Inspector No.: ______ Name: ______ Date Sampled: ______ Seq No: ______
Mix Plant No.: ______ Name: ______ Contract No: ______ Job No.: ______
Responsible Loc: ______ Lab: ______ Lab Name: ______ Source Name: ______

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge
	022CM11					D		

SIEVE IN	3	2.5	2	1.75	1.5	1	3/4	5/8	1/2	3/8	#4	#8	#16	#30	#40	#50	#100	#200
MM	75	63	50	45	37.5	25	19	15.9	12.5	9.5	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0	0					100		
3/4	19.0	570				80	96		
5/8	15.9	1001							
1/2	12.5	1508				34	50		
3/8	9.5	1305							
1/4	6.3	916							
#4	4.75	243				0	12		
#8	2.36								
#10	2.0								
#16	1.18	227				0	8		
#30	0.6	15							
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075	33				0	2.5		
Pan		21							
Tot Dry Wt.		5842	% Washed - 200						
Tot Wash Wt.									
Diff (-.075)			#200 / #40						

Orig. Wet Weight: 5929 Moisture %: ______

(Mix Plant Only)

Lot: ______

Bin: ______

Homework #1

Tech/Insp: ______

Tested By: ______

Agency: ______

Copies to: ______

Report Date: ______

/FOR DTY03504

MI504QC

Is this a valid test? ______

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AGGREGATE GRADATION REPORT

MISTIC ID: ________

Inspector No.: ________ Name: ________ Date Sampled: ________ Seq No: ________
Mix Plant No.: ________ Name: ________ Contract No: ________ Job No.: ________
Responsible Loc: ________ Lab: ________ Lab Name: ________ Source Name: ________

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge
	038FM20					W		

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5								
3/8	9.5	0.0					100		
1/4	6.3								
#4	4.75								
#8	2.36	131.2				67	97		
#10	2.0								
#16	1.18	237.4				36	66		
#30	0.6	133.6				20	46		
#40	0.425								
#50	0.3	101.9				7	29		
#80	0.18								
#100	0.15	74.5				2	16		
#200	0.075	52.1				0	8		
Pan		3.0							
Tot Dry Wt.		760.2	% Washed - 200						
Tot Wash Wt.		734.9							
Diff (-.075)			#200 / #40						

Orig. Wet Weight: 778.9 Moisture %: ________

(Mix Plant Only)

Lot: ________

Bin: ________

Homework #2

Tech/Insp: ________

Tested By: ________

Agency: ________

Copies to: ________

Report Date: ________

/FOR DTY03504
MI504QC

Is this a valid test? ________

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AGGREGATE GRADATION REPORT

MISTIC ID: ______

Inspector No.: ______ Name: ______ Date Sampled: ______ Seq No: ______
Mix Plant No.: ______ Name: ______ Contract No: ______ Job No.: ______
Responsible Loc: ______ Lab: ______ Lab Name: ______ Source Name: ______

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge
	027FM02					W		

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5								
3/8	9.5	0.0					100		
1/4	6.3								
#4	4.75	31.0				94	100		
#8	2.36	95.8				70	100		
#10	2.0								
#16	1.18	104.6				45	85		
#30	0.6	156.7				41	67		
#40	0.425								
#50	0.3	294.5							
#80	0.18								
#100	0.15	119.0				0	10		
#200	0.075	7.6				0	6		
Pan		0.4							
Tot Dry Wt.		823.4							
Tot Wash Wt.		811.1							
Diff (-.075)									

% Washed - 200: ______

#200 / #40: ______

Orig. Wet Weight: 842.6 Moisture %: ______

(Mix Plant Only)

Lot: ______

Bin: ______

Homework #3

Tech/Insp: ______

Tested By: ______

Agency: ______

Copies to: ______

Report Date: ______

/FOR DTY03504

MI504QC

Is this a valid test? ________

This Page Is Reserved

AGGREGATE GRADATION REPORT

MISTIC ID: ____

Inspector No.: ____ Name: ____ Date Sampled: ____ Seq No: ____

Mix Plant No.: ____ Name: ____ Contract No: ____ Job No.: ____

Responsible Loc: ____ Lab: ____ Lab Name: ____ Source Name: ____

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5	0					100		
3/8	9.5	32				94	100		
1/4	6.3	763							
#4	4.75	567				32	48		
#8	2.36	739							
#10	2.0								
#16	1.18	30				0	8		
#30	0.6								
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075	27				0	2.5		
Pan		3							
Tot Dry Wt.		2206	% Washed - 200						
Tot Wash Wt.		2169							
Diff (-.075)			#200 / #40						

Orig. Wet Weight: 2265 Moisture %: ____

(Mix Plant Only)

Lot: ____

Bin: ____

Homework #4

Tech/Insp: ____

Tested By: ____

Agency: ____

Copies to: ____

Report Date: ____

/FOR DTY03504

MI504QC

Is this a valid test? ________

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AGGREGATE GRADATION REPORT

MISTIC ID: ________

Inspector No.: ________ Name: ________ Date Sampled: ________ Seq No: ________
Mix Plant No.: ________ Name: ________ Contract No: ________ Job No.: ________
Responsible Loc: ________ Lab: ________ Lab Name: ________ Source Name: ________

SOURCE	MATL CODE	TYPE INSP	ORIGINAL ID	SPECIFICATION	SAMPLED FROM	WASH DRY	Load Out / Terminal	Ledge
	022CM16					W		

SIEVE IN / MM	3 / 75	2.5 / 63	2 / 50	1.75 / 45	1.5 / 37.5	1 / 25	3/4 / 19	5/8 / 15.9	1/2 / 12.5	3/8 / 9.5	#4 / 4.75	#8 / 2.36	#16 / 1.18	#30 / 0.6	#40 / 0.425	#50 / 0.3	#100 / 0.15	#200 / 0.075
PASS %																		

%WASH - 200	PI RATIO	RESULT	REMARK

Insp. Quantity (tons)

SIEVE English	SIEVE Metric	Ind. Wt. Retain	Accum Wt.	Accum % Retain	% Passing	Spec Min	Spec Max	Out Flag	Rounded Passing
3	75.0								
2.5	63.0								
2	50.0								
1.75	45.0								
1.5	37.5								
1	25.0								
3/4	19.0								
5/8	15.9								
1/2	12.5	0					100		
3/8	9.5	89				94	100		
1/4	6.3	460							
#4	4.75	920				34	48		
#8	2.36	737							
#10	2.0								
#16	1.18	80				0	8		
#30	0.6								
#40	0.425								
#50	0.3								
#80	0.18								
#100	0.15								
#200	0.075	36				0	2.5		
Pan		2							

Tot Dry Wt.	2380	% Washed - 200	
Tot Wash Wt.	2322		
Diff (-.075)		#200 / #40	

Orig. Wet Weight: 2451 Moisture %: ________

(Mix Plant Only)

Lot: ________

Bin: ________

Homework #5

Tech/Insp: ________

Tested By: ________

Agency: ________

Copies to: ________

Report Date: ________

/FOR DTY03504

MI504QC

Is this a valid test? ________

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HOMEWORK PROBLEM 6

SAMPLE COMPARISON DATA

If the comparison has no out-of-tolerance fractions, both sample results are considered valid. If an out-of-tolerance situation has been identified, both the producer certified technician and the State inspector shall immediately investigate the splitting procedure, test equipment, test method, and calculations for possible equipment failure or procedure errors. The State Monitor Sample shall always take precedence unless shown to be invalid during investigation.

022CM16	1/2" (12.5 mm)	3/8" (9.5 mm)	1/4" (6.3 mm)	#4 (4.75 mm)	#8 (2.36 mm)	#16 (1.18 mm)	#200 (75 µm)
Monitor, % Passing	100	97	73	33	10	5	2.0
Producer, % Passing							

Comparison Data

Consecutive Sieve Sizes	Monitor Fraction	Producer Fraction	Fraction Difference	Applicable Tolerance	Disposition
1/2" and 3/8" (12.5 mm and 9.5 mm)					
3/8" and 1/4" (9.5 mm and 6.3 mm)					
1/4" and #4 (6.3 mm and 4.75 mm)					
#4 and #8 (4.75 mm and 2.36 mm)					
#8 and #16 (2.36 mm and 1.18mm)					
#16 and #200 (1.18 mm and 75 µm)					
#200 and Pan (75 µm and Pan)					

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5-Day Aggregate Technician Chapter 9 Control Chart Homework

Create a control chart for a Category I 042CM11 aggregate product with a Master Band set at 47%, then:

A) Plot the following information on the control chart
B) Identify all required retest and/or corrective action situations

Sampling Frequency	Date	Time	Critical Sieve	Bottom Sieve	Gradations Wash	Gradations Dry
Start of Production Frequency	06/05	am	45	4	X	
	06/05	pm	44	6	X	
	06/06	am	45	3	X	
	06/06	pm	49	4	X	
	06/07	am	45	4	X	
Normal Production Frequency	06/10	am	42	2		X
	06/10	pm	41	1		X
	06/11	am	35	2	X	
	06/12	am	38	1	X	
	06/12	am	41	3	X	
	06/12	pm	39	2	X	
	06/13	am	49	3	X	
	06/13	pm	45	5	X	
	06/14	am	47	4	X	
	06/14	pm	48	7	X	
	06/14	pm	46	3	X	
	06/17	am	48	4	X	
	06/17	pm	45	3	X	
	06/18	am	45	2	X	

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APPENDIX A – TABLE OF CONTENTS

PAGE

MTP = Manual of Test Procedures for Materials
IDOT = Illinois Department of Transportation

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Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

COARSE AGGREGATE GRADATION TABLE

CA(CM)[1, 2]	Minimum Field Sample Size[3]	Minimum Test Sample Size[3]	3”	2 1/2”	2”	1 3/4”	1 1/2”	1”	3/4”	5/8”	1/2”	3/8”	1/4”	#4	#8	#16	#40	#50	#200
CA01	110 lbs (50 kg)	10,000 g	X	X[MN]	X		X	X											X
CA02	110 lbs (50 kg)	10,000 g		X	X[MN]		XC	X	XC		X			X		X	X		X
CA03	110 lbs (50 kg)	10,000 g		X	X[MN]		X	X			X								X
CA04	110 lbs (50 kg)	10,000 g			X		X[MN]	X	XC		X	XC		X		X	X		X
CA05[5]	110 lbs (50 kg)	10,000 g				X	X[MN]	X[MB,6]	XC		X			X[6]					X
CA06	55 lbs (25 kg)	5,000 g					X	X[MN]	XC		X	XC		X		X	X		X
CA07[5]	55 lbs (25 kg)	5,000 g					X	X[MN]	XC	XC	X[MB,6]	XC	XC	X[6]					X
CA08	55 lbs (25 kg)	5,000 g					X	X[MN]	X	XC	X	XC	XC	X		X			X
CA09	55 lbs (25 kg)	5,000 g					X	X[MN]	XC	XC	X	XC	XC	X		X			X
CA10	55 lbs (25 kg)	5,000 g						X	X[MN]	XC	X	XC	XC	X		X	X		X
CA11[5]	55 lbs (25 kg)	5,000 g						X	X[MN]	XC	X[MB,6]	XC	XC	X		X[6]			X
CA12	35 lbs (16 kg)	2,000 g							X		X[MN]	X	XC	X	XC	X	X		X
CA13[5]	35 lbs (16 kg)	2,000 g							X		X[MN]	X	XC	X[MB,6]	XC	X[6]			X
CA14[5]	35 lbs (16 kg)	2,000 g								X	X[MN]	X[MB,6]	XC	X[6]					X
CA15	35 lbs (16 kg)	2,000 g									X	X[MN]	XC	X	XC	X			X
CA16[5]	25 lbs (11 kg)	1,500 g									X	X[MN]	XC	X[MB,6]	XC	X[6]			X
CA17	35 lbs (16 kg)[4]	4,000 g[4]	X		XC			XC			XC	XC		X[MN, 4]		X		X	X
CA18	35 lbs (16 kg)[4]	4,000 g[4]	X					X[MN, 4]			XC	XC		X		X		X	X
CA19	35 lbs (16 kg)[4]	4,000 g[4]	X					X[MN, 4]			XC	XC		X		X	X	X	X
CA20	25 lbs (11 kg)	2,000 g									X	X[MN]	XC	X	X	X			X

Note: See footnotes below Fine Aggregate Gradation Table for explanation of symbols

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Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES
Effective: December 1, 2021

FINE AGGREGATE GRADATION TABLE															
FA(FM)[1, 2]	**Minimum Field Sample Size[3]**	**Minimum Test Sample Size[3]**	**1”**	**1/2”**	**3/8”**	**#4**	**#8**	**#10**	**#16**	**#30**	**#40**	**#50**	**#80**	**#100**	**#200**
FA01	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB]		X		X	X
FA02	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB]		X		X	X
FA03	25 lbs (11 kg)	500 g			X	X[MN]		X			X		X		X
FA04	25 lbs (11 kg)	500 g			X				X[MN]						
FA05	25 lbs (11 kg)	500 g			X	X[MN]								X	X
FA06	25 lbs (11 kg)	500 g	X	X	X	X[MN]								X	X
FA07	25 lbs (11 kg)	100 g				X		X[MN]			X		X		X
FA08	25 lbs (11 kg)	100 g					X				X[MN]			X	X
FA09	25 lbs (11 kg)	100 g					X					X[MN]		X	X
FA10	25 lbs (11 kg)	100 g						X			X[MN]		X		X
FA20[5]	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB, 6]		X		X	X[6]
FA21[5]	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB, 6]		X		X	X[6]
FA22[5]	25 lbs (11 kg)	500 g			X	X[MB]	X[MB, 6]		X						X[6]
FA23[5]	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB, 6]		X		X	X[6]
FA24[5]	25 lbs (11 kg)	500 g			X	X[MN]	X[MB]		X	X[MB, 6]		X		X	X[6]

Notes below apply to Fine and Coarse Aggregate Gradation Tables Only

X = Required Gradation Specification Sieves

XC = Required Cutter Sieves

MB = Master Band Sieves for Category I Coarse Aggregate for PCC and HMA Mixes; Bituminous use only for fine aggregate.

MN = Maximum Nominal Sieve for Crushed Gravels – Maximum Nominal Size is defined as the first specification sieve in the product gradation on which material may be retained.

1 = CA = Coarse Aggregate; CM = Coarse Aggregate, Modified; FA = Fine Aggregate; FM = Fine Aggregate, Modified

2 = CM and FM gradations shall be sampled and tested the same as the corresponding CA and FA gradations.

3 = Slag should be adjusted accordingly due to its lighter or heavier mass.

4 = Will vary with the gradation of the material being used

5 = Control Charts Required

6 = Required Sieve for Control Charts

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Illinois Specification 201
Illinois Department of Transportation (IDOT)
AGGREGATE GRADATION SAMPLE SIZE TABLE & QUALITY CONTROL SIEVES

Effective: December 1, 2021

LARGE SIZED AGGREGATE GRADATION TABLE										
CS/RR[1,2]	**Minimum Test Sample Size[3]**	**8”**	**6”**	**4”**	**3”**	**2”**	**1 ½”**	**1”**	**½”**	**#4**
CS01	50,000 g	X	X	X	XC	X		XC	XC	X
CS02	50,000 g		X	X	XC	X		XC	XC	X
RR01	20,000 g				X	XC	X	XC	XC	X
RR02	20,000 g			X	XC	X	XC	XC	XC	X

Notes below apply to Large Sized Aggregate Gradation Table Only

X = Required Gradation Specification Sieves
XC = Required Cutter Sieves
1 = CS = Coarse Aggregate Subgrade; RR/RRM = Rip Rap
2 = Dry Gradations Only
3 = Slag should be adjusted accordingly due to its lighter or heavier mass.
4 = A round nosed shovel may be used for sampling
5 = Metal plates with precisely sized square holes may be used for the gradation
6 = Test sample size shall be taken in the field. No splitting is required.

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Illinois Modified Test Procedure
Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
1.1	Remove "of coarse, fine, or combinations" in the first paragraph. Remove "which the aggregate is furnished" and replace with "the AGCS Policy" in the first paragraph. Add "for the following purposes" to the end of the last sentence of the first paragraph.
1.1.1	Add: "Preliminary investigation of the potential source of supply."
1.1.2	Add: "Control of the product at the source of supply."
1.1.3	Add: "Control of the operations at the site of use."
1.1.4	Add: "Acceptance or rejection of the materials."
1.1.4 Note1	Add: "Sampling plans and acceptance and control tests vary with the type of construction in which the material is used."
1.2	Replace with the following: "The text of this standard references notes which provide explanatory material. These notes (excluding those in tables and figures) shall not be considered as requirements of the procedure."
1.3	Replace with the following: "The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents. Therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the procedure."
1.4	Replace with the following: "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 procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use."
1.4 Note 2	Replace with the following: "The quality of the results produced by this procedure are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used."
2.1	Replace with the following: Illinois Modified AASHTO Standards • T11, Materials Finer Than No. 200 (75µm) Sieve in Mineral Aggregates by Washing • T27, Sieve Analysis of Fine and Coarse Aggregates
2.3	Insert the following: Illinois Specification: • Illinois Specification 201 Aggregate Gradation Sample Size Table
3	Replace with the following: "**3 TERMINOLOGY**"
3.1	Add: "Definitions:"
3.1.1	Add: "Maximum size of aggregate, n—in specifications for, or descriptions of aggregate—the smallest sieve opening through which the entire amount of aggregate is required to pass."
3.1.2	Add: "Maximum aggregate size, (Superpave) n—in specifications for, or descriptions of aggregate—one size larger than the nominal maximum aggregate size."

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Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
3.1.3	Add: “Nominal maximum aggregate size (of aggregate), n—in specifications for, or descriptions of aggregate—smallest sieve opening through which the entire amount of the aggregate is permitted to pass.”
3.1.4	Add: “Nominal maximum aggregate size (Superpave), n—in specifications for, or descriptions of aggregate—one size larger than the first sieve that retains more than 10% aggregate.”
3.1.4.1	Add: Discussion – These definitions in 3.1.2 and 3.1.4 apply to hot mix asphalt (HMA) mixtures designed using the Superpave system only.
3.1.4.2	Add: Discussion – Specifications on aggregates usually stipulate a sieve opening through which all the aggregate may, but need not, pass so that a slated maximum portion of the aggregate may be retained on that sieve. A sieve opening so designated is the nominal maximum size.
4	Replace with the following: “**4 SIGNIFICANCE AND USE**”
4.1	Add: “Sampling is a critical step in determining the quality of the material being evaluated. Care shall be exercised to ensure that samples are representative of the material being evaluated.”
4.2	Add: “This practice is intended to provide standard requirements and procedures for sampling coarse and fine aggregate products. The detailed requirements as to materials, interpretation of results, and precision and bias are described in specific test methods.”
4.3	Add: “For sampling of potential aggregate sources and preliminary site investigation, refer to Central Bureau of Materials AGCS Policy Memo.”
5	Replace with the following: “**5 APPARATUS**”
5.1	Add: Template – The template shall be designed with two end plates and shall be adjustable. The distance between the two end plates may therefore be changed to gather more material from the belt for each increment. The end plates shall also be machined or cut to the approximate belt size and shape. A template with a single end plate may be used in the sampling method, if care is exercised.
5.2	Add: Sampling Device – The sample device used to cut the flow stream from the end of the belt, or the bin discharge, must be strong enough to handle the force of the flow stream. The device must also be large and deep enough to cut the entire flow stream and not overflow when passing through the stream. The device may be a bucket, a pan, or a manufactured sampling container.

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Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
5.2 Note 3	Add: “Shelby tubes are not allowed as sampling devices.”
5.3	Add: Shovel – The shovel shall be square-nosed and of a size easily handled. It shall also have built-up sides and back (approximately 1 ½” [37.5mm]) to facilitate the retention of material on the shovel when sampling.
5.4	Add: Sampling Containers – Bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment. For moisture content samples, containers must prevent moisture loss.
6	Replace with the following: “**6 PROCEDURE**”
6.1	Add: General – Samples to be tested for quality shall be obtained from the finished product. Samples from the finished product to be tested for abrasion loss shall not be subject to further crushing or manual reduction in particle size in preparation for the abrasion test unless the size of the finished product is such that it requires further reduction for the testing purposes.
6.2	Add: Inspection – The material shall be inspected to determine discernible variations. The seller shall provide suitable equipment needed for proper inspection and sampling.
6.3	Add: Sampling – Aggregate production sampling shall be accomplished by one of the following methods: 1. Belt-stream sampling 2. Bin-discharge sampling (requires IDOT approval) 3. On-belt sampling 4. Truck-dump or stockpile sampling
6.3 Note 4	Add: “No other sampling methods will be permitted.”

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Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
6.3.1	Add: Sampling from Belt-Stream Discharge or from Bins: Belt-Stream Sampling – The sample shall be taken by cutting the stream of aggregate as it leaves the end of the production belt. A sampling device is passed uniformly through the entire width and depth stream flow during normal production and belt load. Each sampling pass (increment) is combined with others to make up the field sample. A minimum of three increments shall be taken during a 10 to 15-minute sampling period. Enough increments shall be taken and combined to provide the correct field sample size. Extreme care shall be taken to make sure the sampling device passes completely and uniformly through the entire stream flow (from outside the stream on one side to outside the stream on the other side) and to ensure the device does not overflow. Bin Sampling – Bin discharge shall be sampled in a manner similar to belt-stream sampling. A sampling device is passed through the entire bin discharge stream. A minimum of three increments shall be taken during a 10 to 15-minute sampling period and combined to form the field sample. Before cutting the bin discharge stream, the bin must be emptied until such time that the stream of material entering the bin is the stream of material exiting the bin. Sampling may take place at that time. Extreme care shall be taken to make sure the sampling device passes completely and uniformly through the entire stream flow (from outside the stream on one side to outside the stream on the other side) and to ensure the device does not overflow. Samples shall be taken only during normal plant operation and when the bin is being fed under normal load. The major problems associated with bin-discharge sampling involve segregated material clinging to the sides of the bin. This material can and does break loose, altering the bin-discharge stream gradation. The sampling method therefore shall be used only when approved by the District Engineer.

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Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
6.3.2	Add: On-Belt Sampling – The sample shall be taken by stopping the belt containing the finished product. A template shall be inserted into the material on the belt. All the material between the template shall be removed and shall represent one of the three increments (minimum) making up the field sample. Extreme care shall be taken, including the use of a brush, to remove all fines on the belt between the template for inclusion in the increment. The belt shall be stopped at least three times (three increments) during approximately 10 to 15 minutes of operation to obtain a field sample. If additional material is needed beyond three increments due to the amount of material on the belt, additional template cuts may be taken during the three belt stoppages. Automatic samplers may be used as long as the gradations compare to samples taken with the sample template. Contact the Central Bureau of Materials for further guidance. Samples shall be taken only during normal plant operation and when the belt is under normal load.
6.3.3	Add: Sampling from Truck-Dumps or from Stockpiles: **Sampling from inside of transportation units is not permitted.** The transportation unit shall be off-loaded and sampled only by the sampling methods listed, herein. Truck-Dump Sampling – The sample shall be taken by placing one or two truck dumps together. This may occur during the building of a stockpile or feeding of a plant. The truck dump(s) shall be cut with an end loader and two or more bucket loads extracted. The bucket loads shall be dumped on one another to form a small pile. The small pile shall then be mixed from two directions perpendicular to each other. To mix the pile, the end loader shall cut into the pile along its base until approximately its midpoint. The loader bucket shall be lifted, the loader moved 1 to 2 feet forward, and the bucket dumped on the other half of the pile. Care shall be exercised to avoid cutting below the base of the truck dumps or small pile and contaminating the material to be sampled. After mixing twice, the end loader shall drop the angle of its bucket downward on one side of the pile and back drag the pile into a layer not less than 1 foot thick.

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Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
6.3.3 (cont'd)	The layer shall be sampled using a required shovel to take increments in a random "X" pattern over the layer. The shovel shall be forced vertically to its full depth when sampling each increment except that care shall be used to not dig completely through the layer. This would contaminate the sample being obtained. Care shall also be exercised to retain as much material on the shovel as possible when taking increments. Sufficient increments shall be taken to make up a correct field sample. CS01, CS02, RR1 and RR2 Sampling – The preparation of the sample pile shall be in accordance with section 6.3.3 on truck-dump sampling except after mixing twice, the end loader shall not back drag or strike off the top of the pile. The sample pile shall then be split in half by the end loader dragging away one half of the pile leaving a vertical slope. Spanning the breadth of the vertical face the sample shall be taken from higher and lower points in a "W" fashion. Sufficient increments shall be taken to obtain the correct field sample size. Stockpile Sampling – The sample shall be taken from the working face of the stockpile. The working face shall be perpendicular to the direction of flow used to build the stockpile. Stockpiles having no working face shall have one established prior to sampling. The working face shall have the interior of the pile exposed to permit proper re-blending of the pile to eliminate segregated aggregate. If necessary, material may be brought out of the main pile's working face into the sub-stockpile for sampling. The stockpile sampling method shall follow the truck-dump sampling method using an end loader. The end loader shall cut across the working face as detailed in "Truck-Dump Sampling." Any special mixing procedure used during loading shall be used when taking any samples. This is the only acceptable method for acquiring quality samples.
6.4	Add: "Masses of Field Samples:"
6.4.1	Add: Field Sample Sizes – The field sample size shall meet the minimum requirements as detailed in the Illinois Specification 201.
7	Replace with the following: "**7 SHIPPING SAMPLES**"
7.1	Add: "Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment."

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Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method for
Sampling Aggregate Products

Reference AASHTO R 90-18 (2022)

AASHTO Section	***Illinois Modification***
7.2	Add: “Shipping containers for aggregate samples shall have a LM-5 envelope attached to the container. Written on the outside of the LM-5 shall be the following information: producer number, test id# (including suffix), material code, ledge description. The required information to be written on the outside of the LM-5 shall also be written on the outside of the sample container. Inside the LM-5 shall contain a fully completed LM-6 form. The LM-6 form shall be the most recent version of the Central Bureau of Materials online template.”
7.3	Add: “Red Tag Samples – Used for Quality Samples only”
7.3.1	Add: “The Central Bureau of Materials has established a procedure which allows the producer the opportunity to deliver their quality samples directly to the Central Bureau of Materials, located at 126 E. Ash Street in Springfield. The sample, taken by the District, will be sampled following the procedures outlined in 6.3.3. Upon completion of the sampling the District shall “Red Tag” the sample containers. During the tagging process the District shall write the “Red Tag” serial number on the LM-6 form. If the serial number is not indicated on the LM-6 form the samples will not be accepted. Once the sample containers are tagged and documentation has been completed the producer will then be allowed to deliver the samples to the Central Bureau of Materials.

Standard Practice for

Sampling Aggregate Products

AASHTO Designation: R 90-18 (2022)[1]

AASHTO

Reclassified: 2018 **Reviewed but Not Updated: 2022**

Technical Subcommittee: 1c, Aggregates

1. SCOPE

1.1. This practice covers the procedures for obtaining representative samples of coarse, fine, or combinations of coarse and fine aggregate (CA and FA) products to determine compliance with requirements of the specifications under which the aggregate is furnished. The method includes sampling from conveyor belts, transport units, roadways, and stockpiles.

1.2. *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 appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED STANDARDS

2.1. *AASHTO Standards*:

- M 323, Superpave Volumetric Mix Design
- T 11, Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
- T 27, Sieve Analysis of Fine and Coarse Aggregates

2.2. *ASTM Standard*:

- D75/D75M, Standard Practice for Sampling Aggregates

3. SIGNIFICANCE AND USE

3.1. Sampling is a critical step in determining the quality of the material being evaluated. Care shall be exercised to ensure that samples are representative of the material being evaluated.

3.2. This practice is intended to provide standard requirements and procedures for sampling coarse, fine and combinations of coarse and fine aggregate products. The detailed requirements as to materials, interpretation of results, and precision and bias are described in specific test methods.

3.3. For sampling of potential aggregate sources and preliminary site investigation, refer to ASTM D75/D75M.

4. APPARATUS

4.1. *Shovels or Scoops, or Both*—Tools with which to gather the sample.

4.2. *Brooms, Brushes, and Scraping Tools*—Tools to assist in collecting the sample.

4.3. *Sampling Tube*—Plastic, aluminum, or similar tube whose diameter is at least three times the nominal maximum aggregate size; the end of the tube may be angled to assist in sampling.

4.4. *Mechanical Sampling Systems*—Normally, a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.

4.5. *Belt Template*—A pair of templates, either joined to each other or separate, which are the shape and width of the aggregate stream belt. If the two templates are joined, enough space must be allowed between the templates to yield an increment of the required weight.

4.6. *Sampling Containers*—Bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment. For moisture content samples, containers must prevent moisture loss.

5. PROCEDURE

5.1. Sampling is as important as testing. The technician shall use every precaution to obtain samples that are representative of the material. Record the sampling time or location, or both. When samples will be used as part of a statistical quality control or acceptance program, determine the time or location for sampling using a random sampling procedure.

5.1.1. Ensure sampling equipment and containers are clean and dry before sampling.

5.2. The field samples should meet or exceed the minimum mass in Table 1. The amounts specified in Table 1 will generally provide adequate material for routine grading and quality analysis (Note 1).

Note 1—Sample size is based upon the test(s) required. Generally, the field sample size should be such that, when split twice, it will provide a testing sample of proper size. For example, the sample size may be four times that shown in T 27, or in T 11 if that mass is more appropriate.

Table 1—Recommended Sample Sizes

Nominal Maximum Size		Minimum Mass	
mm	(in.)	kg	(lb)
90	(3 1/2)	175	(385)
75	(3)	150	(330)
63	(2 1/2)	125	(275)
50	(2)	100	(220)
37.5	(1 1/2)	75	(165)
25.0	(1)	50	(110)
19.0	(3/4)	25	(55)
12.5	(1/2)	15	(35)
9.5	(3/8)	10	(25)
4.75	(No. 4)	10	(25)
2.36	(No. 8)	10	(25)

Note 2—Nominal maximum size may be defined by aggregate type or usage; for example, as defined by M 323.

5.3. *Sampling from Conveyor Belt Using a Sampling Template*—Avoid sampling at the beginning or end of the aggregate run due to the potential for segregation. Be careful when sampling in the rain. Make sure to capture material that may stick to the belt or that the rain tends to wash away.

5.3.1. Stop the belt.

5.8. *Sampling from Stockpile for Coarse Aggregate and Mixtures of Coarse and Fine Aggregate Products*:

5.8.1. *Sampling from a Flat Surface Created by a Loader*:

5.8.1.1. Direct the loader operator to enter the stockpile with the bucket at least 0.3 m (1 ft) above ground level without contaminating the stockpile.

5.8.1.2. Discard the first bucketful.

5.8.1.3. Have the loader re-enter the stockpile, obtain a full loader bucket of the material, and tilt the bucket back and up.

5.8.1.4. Form a small sampling pile at the base of the stockpile by gently rolling the material out of the bucket with the bucket just high enough to permit free flow of the material. Repeat as necessary.

5.8.1.5. Create a flat surface by having the loader back drag the small pile.

5.8.1.6. Obtain increments from at least three randomly selected locations on the flat surface at least 1 ft (300 mm) from the edge.

5.8.1.7. Fully insert the shovel, exclude the underlying material, roll back the shovel, and lift the material slowly out of the pile to avoid material rolling off the shovel.

5.8.1.8. Combine the increments to form a sample.

5.8.2. *Sampling from a Horizontal Surface on the Stockpile Face*:

5.8.2.1. Create horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile with a shovel, or with a loader if one is available.

5.8.2.2. Shove a flat board against the vertical face behind sampling location to prevent sloughing. Discard sloughed material to create the horizontal surface.

5.8.2.3. Obtain sample from the horizontal surface as close as possible to the intersection of the horizontal and vertical faces.

5.8.2.4. Obtain at least one increment of equal size from each of the top, middle, and bottom thirds of the pile.

5.8.2.5. Combine the increments to form a single sample.

5.9. *Sampling from a Stockpile for Fine Aggregate (Alternate Tube Method)*:

5.9.1. Remove the outer layer of material.

5.9.2. Using a sampling tube, obtain increments of equal size from a minimum of five random locations on the pile.

5.9.3. Combine the increments to form a single sample.

5.3.2. Set the sampling template in place on the belt avoiding intrusion by adjacent material.

5.3.3. Remove the material from inside the template; include all of the material adhering to the belt.

5.3.4. Obtain equal increments when one increment is insufficient for the required testing.

5.3.5. Combine the increments to form a single sample.

5.4. *Sampling from Conveyor Belt Discharge*—Avoid sampling from the beginning or end of an aggregate run due to the potential for segregation. To collect a representative sample the sampling device must pass through the full stream of material as it runs off the conveyor belt. A manually, semi-automatic, or automatically operated sampling device may be used to collect the sample.

5.4.1. Pass a sampling device, at a constant speed and perpendicular to the flow of material, through the full stream once in each direction without overfilling; include all material that may adhere to the sampling device when emptying into the container, or divert the full stream of material into container.

5.4.2. Obtain multiple equal increments when one increment is insufficient for the required testing.

5.4.3. Combine the increments to form a single sample.

5.5. *Sampling from Transport Units*:

5.5.1. Visually divide the unit into four quadrants.

5.5.2. Identify one sampling location in each quadrant.

5.5.3. Remove approximately 0.3 m (1 ft) of material from the sampling area. Obtain an increment from the exposed surface. Repeat in each of the remaining quadrants.

5.5.4. Combine the increments to form a single sample.

5.6. *Sampling from Roadway—Berm or Windrow*:

5.6.1. Do not take the sample or any increment from the beginning or end of the windrow or berm.

5.6.2. Remove the top one third of the windrow or berm before taking an increment.

5.6.3. Obtain a minimum of three approximately equal increments from random locations along the windrow or berm.

5.6.3.1. Fully insert the shovel into the location, exclude the underlying material, roll back the shovel, and lift the material slowly out of the pile to avoid material rolling off the shovel.

5.6.4. Combine the increments to form one single sample.

5.7. *Sampling from Roadway—In Place*:

5.7.1. Obtain representative sample after spreading and before compacting.

5.7.2. Insert the shovel to the full depth of the material, exclude the underlying material, roll back the shovel, and lift the material slowly to avoid material rolling off the shovel. Repeat as necessary.

6. SHIPPING SAMPLES

6.1. Use bags or containers to transport aggregate samples. Make sure the bags and containers are clean and undamaged to avoid contamination or loss of sample.

6.2. *Label each sample with unique identification labels that contain the following information*:

6.2.1. Date and time the sample was obtained;

6.2.2. Sampling location;

6.2.3. Quantity of material represented by the sample, if applicable;

6.2.4. Material type; and

6.2.5. Supplier.

7. KEYWORDS

7.1. Coarse aggregate; fine aggregate; samples.

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[1] Formerly T 2. First published as a practice in 2018.

Illinois Modified Test Procedure
Effective Date: December 1, 2022
Revised Date: December 1, 2023

Standard Test Method
for
Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

Reference AASHTO T 11-23

AASHTO Section	***Illinois Modification***
1.1	Replace "method" with "procedure" in the first sentence of paragraph.
1.2	Replace with the following: "There are two methods allowed for this procedure. The first method uses only water for the operation. The second allows the use of a wetting agent to assist in the loosening of the material finer than the No. 200 (75-µm) sieve from the coarser material. A wetting agent such as detergent or dispersing solution is recommended."
1.4	Delete the first sentence of paragraph
2.1	Replace with "Illinois Modified AASHTO Standards": • R 76, Standard Practice for Reducing Samples of Aggregate to Testing Size • R 90, Sampling Aggregate Products • T 27, Sieve Analysis of Fine and Coarse Aggregates • T 30, Mechanical Analysis of Extracted Aggregate
2.2	Replace with the following: Illinois Specifications: ▪ Illinois Specifications 201, Aggregate Gradation Sample Size Table
2.3	Replace with the following: ASTM Standards: ▪ E 11, Woven Wire Test Sieve Cloth and Test Sieves ▪ E 29 (Illinois Modified), Using Significant Digits in Test Data to Determine Conformance with Specifications C 125, Standard Terminology Relating to Concrete and Concrete Aggregates
2.4	Delete
3.1	Delete "or water containing a wetting agent, as specified" from the first sentence of paragraph.
4.2	Replace "in" with "with" in the first sentence of paragraph. Revise the second sentence to read: "In some cases, the finer material is adhering to the larger particles, such as some clay coatings and coatings on aggregates that have been extracted from bituminous mixtures."
5.2	Add sentence to end of paragraph: "The sieve cloth shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving."
5.5	Add sentences to end of paragraph: "The oven shall be specifically designed for drying. In addition, a gas burner or electric hot plate may be used. Microwave ovens are <u>not</u> permitted for drying aggregate gradations samples."
5.7 Note 1	Revise with the following: "A mechanical device, such as a Ploog Washer, may be used for coarse aggregate samples providing its results match the manual procedure. When using a mechanical washing device, loss of fines from damage to the drum or dripping water will not be allowed. Applying wax to the rim of the drum will help prevent water from dripping down the outside of the drum."
6.1	Replace with the following: "Field samples of aggregate shall be taken according to Illinois Modified AASHTO R90. The field sample size shall meet the minimum requirements in the Illinois Specifications 201."

Illinois Modified Test Procedure
Effective Date: December 1, 2022
Revised Date: December 1, 2023

Standard Test Method
for
Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

Reference AASHTO T 11-23

AASHTO Section	***Illinois Modification***
6.2	Replace with the following: "Field samples of aggregate shall be reduced to test sample size before testing according to Illinois Modified AASHTO R76." Add and insert: "Test sample size for aggregate gradation samples shall meet the minimum requirements found in Illinois Specifications 201." to the end of the paragraph.
8.1	Replace with the following: The test sample shall be dried back to constant mass in an oven specifically designed for drying, set at and capable of maintaining a uniform temperature of 230±9˚F(110±5˚C). Constant mass is defined as the sample mass at which there has not been more than a 0.5-gram mass loss during an additional 1 hour of drying. This should be verified occasionally. The sample may also be dried to constant mass in a pan on an electric hot plate or gas burner. The technician shall <u>continually attend</u> the sample when drying on the electric hot plate or gas burner. The electric hot plate or gas burner should be operated on a low-as-needed heat to prevent popping, crackling, and/or sizzling noise from the aggregate during drying. If these noises occur, the heat must be turned down and/or the sample must be constantly stirred during drying to prevent potential aggregate particle breakdown. After the test sample has been dried to constant mass and cooled down to room temperature, the sample shall have its mass determined to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. All balances or scales shall be tared before being used to determination of mass required by this test procedure. This procedure provides the "Total Dry Mass, g" (TDM) of the original test sample.
8.2	Replace with the following: After drying and determining the mass, place the test sample in the container and add sufficient water to cover it. If a wetting agent is warranted as stated in 4.2, add the wetting agent to the water (Note 2). Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the No. 200 (75µm) sieve from the coarser particles, and to bring the fine material into suspension. The use of a large spoon or other similar tool shall be used to stir and agitate the aggregate in the wash water. Once the wash water becomes clear pour the wash water containing the suspended and dissolved solids over the nested sieves, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample.
8.2 Note 3	Add: There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity will depend on the hardness of the water and the quality of the detergent. Excessive suds may overflow the sieves and carry some material with them.

Illinois Modified Test Procedure
Effective Date: December 1, 2022
Revised Date: December 1, 2023

Standard Test Method
for
Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

Reference AASHTO T 11-23

AASHTO Section	***Illinois Modification***
7.3	Replace with the following: Add a second charge of water to the sample in the container, agitate, and decant as before. Repeat this operation until the wash water is clear.
7.3 Note 4	Add: If mechanical washing equipment is used, the charging of water, agitating, and decanting may be a continuous operation.
7.3 Note 5	Add: A spray nozzle or a piece of rubber tubing attached to a water faucet may be used to rinse any of the material that may have fallen onto the sieves. The velocity of water, which may be increased by pinching the tubing or by use of a nozzle, should not be sufficient to cause any splashing of the sample over the sides of the sieve.
8.4	Replace with the following: Return all material retained on the nested sieves by flushing per note 5. Dry the washed test sample to constant mass and determine the mass of the test sample in the same manner as detailed in 8.1 herein. This procedure provides the "Total Wash Mass, g" (TWM).
8.4 Note 6	Add: Following the washing of the sample and flushing any material retained on the No. 200 (75µm) sieve back into the container by washing from the back of the sieve. No water should be decanted from the container except through the No. 200 (75µm) sieve, to avoid loss of material. Excess water from flushing should be evaporated from the sample in the drying process."
9	Delete
	"
10.1	Replace with the following: The "Percent Minus 75µm (No. 200) by Washing" shall be determined by using the following formula: % - No. 200 (-75µm) by Washing = $\frac{TDM-TW}{TDM} * 100$ TDM = Total Dry Mass, g. TWM = Total Wash Mass, g."
11.1	Replace with the following: The test results shall be rounded to the nearest 0.1 percent and recorded on the Illinois Department of Transportation (IDOT) gradation form. All rounding shall be according to ASTM E 29 (Illinois Modified)."
12	Delete
13	Delete

This Page Is Reserved

Standard Method of Test for

Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

AASHTO Designation: T 11-23[1]

Technically Revised: 2023

Technical Subcommittee: 1c, Aggregates

ASTM Designation: C117-17

1. SCOPE

1.1. This test method covers determination of the amount of material finer than a 75-μm (No. 200) sieve in aggregate by washing. Clay particles and other aggregate particles that are dispersed by the wash water, as well as water-soluble materials, will be removed from the aggregate during the test.

1.2. Two procedures are included, one using only water for the washing operation, and the other including a wetting agent to assist the loosening of the material finer than the 75-μm (No. 200) sieve from the coarser material. Unless otherwise specified, Procedure A (water only) shall be used. Analysis of aggregate extracted from asphalt mixtures is conducted in accordance with T 30.

1.3. The values stated in SI units are to be regarded as the standard.

1.4. *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 procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.*

1.5. *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 231, Weighing Devices Used in the Testing of Materials
- 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 76, Reducing Samples of Aggregate to Testing Size

- R 90, Sampling Aggregate Products
- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 30, Mechanical Analysis of Extracted Aggregate

2.2. *ASTM Standards*:
- C117, Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standard*:
- IEC 60584-1:2013, Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Other Document*:
- NCHRP Research Results Digest 389, Precision Estimates of AASHTO T 304, AASHTO T 96, and AASHTO T 11 and Investigation of the Effect of Manual and Mechanical Methods of Washing on Sieve Analysis of Aggregates, Transportation Research Board, National Research Council, Washington, DC, 2014.

3. SUMMARY OF METHOD

3.1. A sample of the aggregate is washed in a prescribed manner, using either plain water or water containing a wetting agent, as specified. The decanted wash water, containing suspended and dissolved material, is passed through a 75-µm (No. 200) sieve. The loss in mass resulting from the wash treatment is calculated as mass percent of the original sample and is reported as the percentage of material finer than a 75-µm (No. 200) sieve by washing.

4. SIGNIFICANCE AND USE

4.1. Material finer than the 75-µm (No. 200) sieve can be separated from larger particles much more efficiently and completely by wet sieving than through the use of dry sieving. Therefore, when accurate determinations of material finer than 75 µm in fine or coarse aggregate are desired, this test method is used on the sample prior to dry sieving in accordance with T 27. The results of this test method are included in the calculation in T 27, and the total amount of material finer than 75 µm by washing, plus that obtained by dry sieving the same sample, is reported with the results of T 27. Usually the additional amount of material finer than 75 µm obtained in the dry-sieving process is a small amount. If it is large, the efficiency of the washing operation should be checked. A large amount of material could also be an indication of the degradation of the aggregate.

4.2. Plain water is adequate to separate the material finer than 75 µm from the coarser material in most aggregates. In some cases, the finer material is adhered to the larger particles, such as in some clay coatings and coatings on aggregates that have been extracted from bituminous mixtures. In these cases, the fine material will be separated more readily with a wetting agent in the water.

5. APPARATUS AND MATERIALS

5.1. *Balance*—The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass or better, and conform to the requirements of M 231.

5.2. *Sieves*—A nest of two sieves, the lower being a 75-µm (No. 200) sieve and the upper being a sieve with openings in the range of 2.36 mm (No. 8) to 1.18 mm (No. 16), both conforming to the requirement of ASTM E11.

5.3. *Container*—A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.

5.4. *Spoon or Mixing Utensil*—Or similar device for agitating the sample during the washing procedure.

5.5. *Oven*—An oven of sufficient size, capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F). Oven(s) for heating and drying shall be capable of operation at the temperatures required, between 100 to 120°C (212 to 248°F), within ±5°C (±9°F), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.

5.6. *Wetting Agent (Procedure B only)*—Any dispersing agent, such as liquid dishwashing detergent, powdered dishwashing detergent, or sodium hexametaphosphate that will promote separation of the fine materials without degrading the aggregate.

5.7. *Mechanical Washing Apparatus (Optional)*—A mechanical apparatus that aids in the washing process.

Note 2—A sample shall not be washed for more than 10 minutes when using a mechanical washing apparatus. Wash intervals greater than 10 minutes have been shown to cause significant amounts of degradation depending upon aggregate type (NCHRP RR Digest 389).

6. SAMPLING

6.1. Sample the aggregate in accordance with R 90. If the same test sample is to be tested for sieve analysis according to T 27, comply with the applicable requirements of that method.

6.2. Thoroughly mix the sample of aggregate to be tested and reduce the quantity to an amount suitable for testing using the applicable methods described in R 76. If the same test sample is to be tested according to T 27, the minimum mass shall be as described in the applicable sections of that method. Otherwise, the mass of the test sample, after drying, shall conform with the following:

Nominal Maximum Size	Minimum Mass, g
4.75 mm (No. 4) or smaller	300
9.5 mm ($^3/_8$ in.)	1000
19.0 mm ($^3/_4$ in.)	2500
37.5 mm ($1^1/_2$ in.) or larger	5000

temperature of 110 ± 5°C (230 ± 9°F). Determine and record the mass to the nearest 0.1 percent of the original mass of the sample.

9. PROCEDURE B—WASHING USING A WETTING AGENT

9.1. Prepare the sample in the same manner as for Procedure A.

9.2. After drying and determining the mass, place the test sample in the container. Add sufficient water to cover the sample, and add wetting agent to the water (Note 6). Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the 75-µm (No. 200) sieve from the coarser particles, and to bring the fine material into suspension. The use of a large spoon or other similar tool to stir and agitate the aggregate in the wash water has been found satisfactory. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves described in Section 5.2, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample. Do not overflow or overload the 75-µm (No. 200) sieve.

Note 6—There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity will depend on the hardness of the water and the quality of the detergent. Excessive suds may overflow the sieves and carry some material with them.

9.3. Add a second charge of water (without wetting agent) to the sample in the container, agitate, and decant as before. Repeat this operation until the wash water is clear.

9.4. Complete the test as for Procedure A.

10. CALCULATION

10.1. Calculate the amount of material passing a 75-µm (No. 200) sieve by washing as follows:

$$A = \left[(B - C) / B \right] \times 100 \qquad (1)$$

where:

A = percentage of material finer than a 75-µm (No. 200) sieve by washing;

B = original dry mass of sample, g; and

C = dry mass of sample after washing, g.

11. REPORT

11.1. Report the percentage of material finer than the 75-µm (No. 200) sieve by washing to the nearest 0.1 percent, except if the result is 10 percent or more, report the percentage to the nearest whole number.

11.2. Include a statement as to which procedure was used.

12. PRECISION AND BIAS

12.1. *Precision*—The estimates of precision of this test method listed in Table 1 are based on results from the AASHTO re:source Proficiency Sample Program, with testing conducted by this test method and ASTM C117. The significant differences between the methods at the time the data were acquired is that T 11 required, and ASTM C117 prohibited, the use of a wetting agent. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

The test sample shall be the end result of the reduction. Reduction to an exact predetermined mass shall not be permitted. If the nominal maximum size of the aggregate to be tested is not listed above, the next larger size listed shall be used to determine sample size.

7. SELECTION OF PROCEDURE

7.1. Procedure A shall be used, unless otherwise specified by the specification with which the test results are to be compared, or when directed by the agency for which the work is performed.

8. PROCEDURE A—WASHING WITH PLAIN WATER

8.1. Dry the test sample to constant mass at a temperature of 110 ± 5°C (230 ± 9°F). Determine the mass to the nearest 0.1 percent of the mass of the test sample.

8.2. If the applicable specification requires that the amount passing the 75-µm (No. 200) sieve shall be determined on a portion of the sample passing a sieve smaller than the nominal maximum size of the aggregate, separate the sample on the designated sieve and determine the mass of the material passing the designated sieve to 0.1 percent of the mass of this portion of the test sample. Use this mass as the original dry mass of the test sample in Section 10.1.

Note 3—Some specifications for aggregates with a nominal maximum size of 50 mm (2 in.) or greater, for example, provide a limit for material passing the 75-µm (No. 200) sieve determined on that portion of the sample passing the 25.0-mm (1-in.) sieve. Such procedures are necessary because it is impractical to wash samples of the size required when the same test sample is to be used for sieve analysis by T 27.

8.3. After drying and determining the mass, place the test sample in the container and add sufficient water to cover it. No detergent, dispersing agent, or other substance shall be added to the water. Agitate the sample with sufficient vigor to result in complete separation of all particles finer than the 75-µm (No. 200) sieve from the coarser particles, and to bring the fine material into suspension. The use of a large spoon or other similar tool to stir and agitate the aggregate in the wash water has been found satisfactory. Immediately pour the wash water containing the suspended and dissolved solids over the nested sieves described in Section 5.2, arranged with the coarser sieve on top. Take care to avoid, as much as feasible, the decantation of coarser particles of the sample.

8.4. Add a second charge of water to the sample in the container, agitate, and decant as before. Repeat this operation until the wash water is clear. Do not overflow or overload the 75-µm (No. 200) sieve. Limit agitation by mechanical washing equipment to a maximum of 10 min. Following the washing of the sample and the flushing of any materials retained on the 75-µm (No. 200) sieve back into the container, no water shall be decanted from the container except through the 75-µm (No. 200) sieve to avoid loss of material. Excess water from flushing should be evaporated from the sample in the drying process.

Note 4—If mechanical washing equipment is used, the charging of water, agitating, and decanting may be a continuous operation.

Note 5—A spray nozzle or a piece of rubber tubing attached to a water faucet may be used to rinse any of the material that may have fallen onto the sieves. The velocity of water, which may be increased by pinching the tubing or by use of a nozzle, should not be sufficient to cause any splashing of the sample over the sides of the sieve.

8.5. Return all material retained on the nested sieves by flushing into the container containing the washed sample. If a mechanical washing apparatus is used, transfer material on the nest of sieves and the washing apparatus to a drying container. Dry the washed aggregate to constant mass at a

Table 1—Precision

	Standard Deviation (1s),[a] %	Acceptable Range of Two Results (d2s),[a] %
Coarse aggregate:[b]		
Single-operator precision	0.10	0.28
Multilaboratory precision	0.22	0.62
Fine aggregate:[c]		
Single-operator precision	0.15	0.43
Multilaboratory precision	0.29	0.82

[a] These numbers represent the (1s) and (d2s) limits as described in ASTM C670.

[b] Precision estimates are based on aggregates having a nominal maximum size of 19.0 mm (3/4 in.) with less than 1.5 percent finer than the 75-µm (No. 200) sieve.

[c] Precision estimates are based on fine aggregates having 1.0 to 3.0 percent finer than the 75-µm (No. 200) sieve.

12.1.1. The precision values for fine aggregate in Table 1 are based on nominal 500-g test samples. Revision of this test method in 1996 permits the fine aggregate test sample size to be 300 g minimum. Analysis of results of testing of 300-g and 500-g test samples from Aggregate Proficiency Test Samples 99 and 100 (Samples 99 and 100 were essentially identical) produced the precision values in Table 2, which indicates only minor differences due to test sample size.

Table 2—Precision Data for 300-g and 500-g Test Samples

Fine Aggregate Proficiency Sample				Within Laboratory		Between Laboratory	
Test Result	Sample Size	No. Labs	Avg	1s	d2s	1s	d2s
AASHTO T 11/ASTM C117 (Total material passing the No. 200 sieve by washing, %)	500 g	270	1.23	0.08	0.24	0.23	0.66
	300 g	264	1.20	0.10	0.29	0.24	0.68

Note 7—The values for fine aggregate in Table 1 will be revised to reflect the 300-g test sample size when a sufficient number of Aggregate Proficiency Tests have been conducted using that sample size to provide reliable data.

12.2. *Bias*—Because there is no accepted reference material suitable for determining the bias for the procedure in this test method, no statement on bias is made.

13. KEYWORDS

13.1. Aggregate; size analysis; wash loss; 75-µm (No. 200) sieve.

[1] Similar but not identical to ASTM C117-17.

Illinois Modified Test Procedure
Effective Date: December 1, 2022

Standard Test Method
for
Sieve Analysis of Fine and Coarse Aggregates

Reference AASHTO T 27-23

AASHTO Section	***Illinois Modification***
2.1	Replace "AASHTO Standards" with "Illinois Modified AASHTO Standards"
2.2	Replace with the following: Illinois Specifications: • Illinois Specifications 201, Aggregate Gradation Sample Size Table
2.3	Add and insert the following: ASTM Standards: • E 11, Woven Wire Test Sieve Cloth and Test Sieves • E 29 (Illinois Modified), Using Significant Digits in Test Data to Determine Conformance with Specifications • C 125, Standard Terminology Relating to Concrete and Concrete Aggregates
3.1	Replace "method" with "procedure" in the first sentence of paragraph.
4.2	Replace "T 11" with "T 11 (Illinois Modified)" in the second sentence of the paragraph.
5.2 Note 1	Replace with the following: "When running Coarse Aggregate samples 12in (305mm) are required, if running Fine Aggregate samples 12in (305mm) or 8in (203mm) sieves are acceptable." Delete.
5.3	Delete: Note 2
5.4	Add sentences to end of paragraph: "The oven shall be specifically designed for drying. In addition, a gas burner or electric hot plate may be used. Microwave ovens are <u>not</u> permitted for drying aggregate gradations samples."
6.1	Replace with the following: "Field samples of aggregate shall be taken according to Illinois Modified AASHTO Standards R90. The field sample size shall meet the minimum requirements in the Illinois Specifications 201."
6.2	Replace with the following: "Field samples of aggregate shall be reduced to test sample size before testing according to Illinois Modified AASHTO Standards R76." "Test sample size for aggregate gradation samples shall meet the minimum requirements found in Illinois Specifications 201."

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for
Sieve Analysis of Fine and Coarse Aggregates

Reference AASHTO T 27-23

AASHTO Section	***Illinois Modification***
6.3	Replace with the following: "In the event that the amount of material finer than No. 200 (75µm) sieve is to be determined by Illinois Modified AASHTO Standards T11, proceed as follows: use the procedure described in Section 7.3.1 or 7.3.2, whichever is applicable."
6.3.1	Add and insert the following: "Use the same test sample for testing by AASHTO Standards T 11 (Illinois Modified) and by this method. First test the sample according to T 11 (Illinois Modified) through the final drying operation, and then dry-sieve the sample as stipulated in Sections 8.2 through 8.6 of this method."
6.3.2	Add and insert the following: "If the test sample is not to be tested by Illinois Modified AASHTO Standards T 11, follow Section 8, "Procedure"."
6.4	Delete.
6.5	Delete.
6.6	Delete.
6.7	Delete.
6.7.1	Delete.
6.7.2	Delete.
6.7.3	Delete.
7.1	Replace with the following: "If the test sample has not been subject to testing by T 11 (Illinois Modified), the test sample shall be dried back to constant mass in an oven specifically designed for drying, set at and capable of maintaining a uniform temperature of 230±9˚F (110±5˚C). Constant mass is defined as the sample mass at which there has not been more than a 0.5-gram mass loss during an additional 1 hour of drying. This should be verified occasionally. The sample may also be dried to constant mass in a pan on an electric hot plate or gas burner. The technician shall continually attend the sample when drying on the electric hot plate or gas burner. Microwave ovens are not permitted for drying gradation samples.

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Reference AASHTO T 27-23

AASHTO Section	***Illinois Modification***
7.1 (cont'd)	The electric hot plate or gas burner should be operated on a low-as-needed heat to prevent popping, crackling, and/or sizzling noise from the aggregate during drying. If these noises occur, the heat must be turned down and/or the sample must be constantly stirred during drying to prevent potential aggregate particle breakdown. After the test sample has been dried to constant mass and cooled down to room temperature, the sample shall have its mass determined to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. All balances or scales shall be tared before being used for determination of mass required by this test procedure. This procedure provides the "Total Dry Mass", g (TDM) of the original test sample. When testing Recycled Asphalt Pavement (RAP) samples shall be air dried to a constant mass."
7.2	Replace with the following: "A nested set of sieves (8 inch [203mm] or 12 inch [305mm]) shall be gathered and stacked. As the sieves are being stacked, they should be inspected for cracks, breaks, or any other problem which would exclude their continued use. The size of the sieves used shall conform to the gradation specifications of the aggregate tested. The No. 200 (75μm) sieve is required to be part of all nested sets when running a gradation test. It is also required that 8-inch (203mm) and 12-inch (305mm) round sieves use additional cutter sieves beyond the specified gradation sieves for all coarse aggregate gradations. Some cutter sieves may be required for fine aggregate gradations if overloading of individual sieves occurs. Gradations CA/CM 7 and 11 require the 5/8-inch (16.0mm), 3/8-inch (9.5mm), and 1/4-inch (6.3mm) sieves as cutter sieves, while the gradations CA/CM 13, 14, and 16 require the 1/4-inch (6.3mm) and the No. 8 (2.38mm) sieves. Cutter sieves for other gradations can be found in Illinois Specification 201.

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Reference AASHTO T 27-23

AASHTO Section	***Illinois Modification***
7.2 (cont'd)	The sample shall then be introduced into the nested set of sieves and placed in a mechanical shaker. The shaker shall impart a vertical, or lateral and vertical, motion to the nested set. This causes the aggregate particles to bounce and turn so as to present different particle orientations to the sieves. This allows every chance for the particle to pass a certain sized sieve. The shaker shall be run for 7 minutes, controlled by an automatic shut-off timer. Seven (7) minutes of shaking shall be considered the standard unless reduced shaker efficiency can be demonstrated through finish hand-shaking as described in Section 8.4. Shaking time shall be increased, if necessary, to comply with the finish hand-shaking procedure in Section 8.4. Shaking time shall not exceed 10 minutes."
7.3	Replace with the following: "Extreme care shall be taken not to overload individual sieves or even approach the overload limits. An overload is defined as several layers of particles, one on top of the other, which do not permit the top layers of particles access to the sieve openings. Sample results which show overloading, or a borderline situation are immediately suspect. If samples continually overload a sieve or sieves, then future samples shall be run in the appropriate number of portions to prevent overloading, or additional cutter sieves shall be added to the nested set to correct the problem."
7.3.1	Delete.
7.3.1.1	Delete.
7.3.1.2	Delete.
7.3.1.3	Delete.
7.3.1.4	Delete.
7.3.1.5	Delete.
7.4	Add paragraph to beginning: "After mechanical shaking, all sieves shall be finished off by hand-shaking. When hand-shaking, the largest sieve that contains material shall be removed from the stack, visually inspected for overload, and inverted over an empty pan. While inverted, all particles shall be cleaned from the sieve. The material shall then be placed back on the same sieve and hand-shaken over an empty pan. Any amount of material that is considered to be an overload or to be approaching an overload shall be hand-shaken in a least two increments. Any appreciable amount of particles passing a sieve may indicate poor mechanical shaking or overloading. The finish hand-shaking described in the following paragraph shall then be initiated."

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AASHTO Section	***Illinois Modification***
7.5	Replace with the following: “After hand-shaking, material shall be removed from the sieve. Particles shall not be forced through the sieves. The sieve shall be inverted and lightly tapped on the sides to facilitate removal for weighing. A dowel rod or putty knife may be used to gently remove wedged particles from all sieves down through the No. 10 (2.00mm). A soft brass-wired brush shall be used on the No. 16 (1.18mm) through the No. 40 (425µm) sieve. A soft china brush shall be used on the No. 50 (300µm) through the No. 200 (75µm) sieve. Any material that passed the sieve during hand-shaking shall be placed on the next smaller sieve. After use, all sieves shall be inspected for cracks, breaks, or any other problem which would exclude their continued use.”
7.5 Note	Add: “The dowel rod can be made of any material that will not deposit foreign material into the test sample or cause damage to the sieves during the removal of wedged particles.”
7.6	Add and insert the following: “After hand-shaking and cleaning, the material retained on each sieve shall have its mass determined and the mass recorded. All determination of mass shall start with the largest sieve in the nested set and proceed down to the pan. Determination of mass shall be to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. The total mass of the material after sieving should check closely with original mass of samples placed on the sieves. If the amounts differ by more than 0.3 percent, based on the original dry sample mass, the results should not be used for acceptance purposes.”

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Effective Date: December 1, 2022

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Reference AASHTO T 27-23

AASHTO Section	***Illinois Modification***
8.1	Replace with the following: "Calculation of test results shall follow the procedure described below: Calculated the "Cumulative Mass Retained" for each sieve by adding its "Individual Mass Retained" and the "Individual Mass Retained" for each larger sieve in the nested set of sieves. Record the "Cumulative Mass Retained". Calculated the "Cumulative Percent Retained" for each sieve by using the following formula and record it by rounding to the nearest 0.1 percent: Cumulative % Retained = $\frac{CMR}{TDM} * 100$ where CMR = Cumulative Mass Retained and TDM = Total Dry Mass Calculated the percent passing each sieve by using the following formula: % = 100 – Cumulative % Retained These results shall be recorded to the nearest 0.1 percent."
8.1.1	Delete.
9.2	Replace with the following: "All percent passing results except the washed minus No. 200 (75µm) and minus No. 200 (75µm) shall be reported on the gradation form as whole numbers. The washed minus No. 200 (75µm) and minus No. 200 (75µm) results shall be reported to the nearest 0.1 percent. Illinois Department of Transportation (IDOT) gradation forms or forms approved by IDOT shall be used. These forms shall be competed with all required information."
9.3	Delete
9.4	Add and insert the following: "For all sieves that are considered overloaded and split in more than one increment. An "S" next to the sieve must be notated on the worksheet."
10	Replace **PRECISION AND BIAS** with the following: "**COMPARISON PROCEDURE**"
10.1	Replace with the following: "All comparison testing shall be conducted in accordance with the most current version of the Illinois Department of Transportation Manual of Test Procedures for Materials (Appendix A7)."
10.2	Delete
12	Delete.

Standard Method of Test for

Sieve Analysis of Fine and Coarse Aggregates

AASHTO Designation: T 27-23[1]

Technically Revised: 2023

Technical Subcommittee: 1c, Aggregates

ASTM Designation: C136/C136M-19

1. SCOPE

1.1. This method covers the determination of the particle size distribution of fine and coarse aggregates by sieving.

1.2. Some specifications for aggregates, which reference this method, contain grading requirements including both coarse and fine fractions. Instructions are included for sieve analysis of such aggregates. Analysis of aggregate extracted from asphalt mixtures is conducted in accordance with T 30.

1.3. The values stated in SI units are to be regarded as the standard. The values in parentheses are provided for information purposes only.

1.4. *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 procedure to consult and establish appropriate safety and health practices and to determine the applicability of regulatory regulations prior to its use.*

1.5. *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 231, Weighing Devices Used in the Testing of Materials
- 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 76, Reducing Samples of Aggregate to Testing Size
- R 90, Sampling Aggregate Products
- T 11, Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- T 30, Mechanical Analysis of Extracted Aggregate

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standard*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances

3. SUMMARY OF METHOD

3.1. A sample of dry aggregate of known mass is separated through a series of sieves of progressively smaller openings for determination of particle size distribution.

4. SIGNIFICANCE AND USE

4.1. This method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregates. The results are used to determine compliance of the particle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products and mixtures containing aggregates. The data may also be useful in developing relationships concerning porosity and packing.

4.2. Accurate determination of material finer than the 75-µm (No. 200) sieve cannot be achieved by use of this method alone. T 11 for material finer than the 75-µm (No. 200) sieve by washing should be employed.

5. APPARATUS

5.1. *Balance*—The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

5.2. *Sieves*—The sieve cloth shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. The sieve cloth and standard sieve frames shall conform to the requirements of ASTM E11. Nonstandard sieve frames shall conform to the requirements of ASTM E11 as applicable.

Note 1—It is recommended that sieves mounted in frames larger than standard 203.2 mm (8 in.) diameter be used for testing coarse aggregate to reduce the possibility of overloading the sieves. See Section 7.3.

5.3. *Mechanical Sieve Shaker*—A mechanical sieving device, if used, shall create motion of the sieves to cause the particles to bounce, tumble, or otherwise turn so as to present different orientations to the sieving surface. The sieving action shall be such that the criterion for adequacy of sieving described in Section A2 is met in a reasonable time period.

Note 2—Use of a mechanical sieve shaker is recommended when the size of the sample is 20 kg (44 lb) or greater, and may be used for smaller samples, including fine aggregate. Excessive time (more than approximately 10 min) to achieve adequate sieving may result in degradation of the sample. The same mechanical sieve shaker may not be practical for all sizes of samples because the large sieving area needed for practical sieving of a large nominal size coarse aggregate very likely could result in loss of a portion of the sample if used for a smaller sample of coarse aggregate or fine aggregate.

5.4. *Oven*—An oven of appropriate size capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F). Oven(s) for heating and drying shall be capable of operation at the temperatures required, between 100 to 120°C (212 to 248°F), within ±5°C (±9°F), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature, regardless of drying apparatus used, shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.

6. SAMPLING

6.1. Sample the aggregate in accordance with R 90. The mass of the field sample shall be the mass shown in R 90 or four times the mass required in Sections 6.4 and 6.5 (except as modified in Section 6.6), whichever is greater.

6.2. Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in R 76. The sample for test shall be the approximate mass desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined mass shall not be permitted.

Note 4—Where sieve analysis, including determination of material finer than the 75-µm (No. 200) sieve, is the only testing proposed, the size of the sample may be reduced in the field to avoid shipping excessive quantities of extra material to the laboratory.

6.3. *Fine Aggregate*—The size of the test sample of aggregate, after drying, shall be 300 g minimum (Note 5).

6.4. *Coarse Aggregate*—The mass of the test sample of coarse aggregate shall conform with the following (Note 5):

Nominal Maximum Size Square Openings, mm (in.)	Minimum Mass of Test Sample, kg (lb)
9.5 (3/8)	1 (2)
12.5 (1/2)	2 (4)
19.0 (3/4)	5 (11)
25.0 (1)	10 (22)
37.5 (1 1/2)	15 (33)
50 (2)	20 (44)
63 (2 1/2)	35 (77)
75 (3)	60 (130)
90 (3 1/2)	100 (220)
100 (4)	150 (330)
125 (5)	300 (660)

Note 5—If washing is performed in accordance with T 11 prior to sieve analysis by this test method, it is acceptable for the sample to be less than the minimum required mass after washing,

as long as the minimum sample mass is met prior to performing the washing procedure. The initial sample mass for analysis by this method should be the same as the final sample mass for T 11.

6.5. *Coarse and Fine Aggregates Mixtures*—The mass of the test sample of coarse and fine aggregate mixtures shall be the same as for coarse aggregate in Section 6.4.

6.6. *Samples of Large-Size Coarse Aggregate*—The size of sample required for aggregate with 50-mm (2-in.) nominal maximum size or larger is such as to preclude convenient sample reduction and testing as a unit except with large mechanical splitters and sieve shakers. As an option when such equipment is not available, instead of combining and mixing sample increments and then reducing the field sample to testing size, conduct the sieve analysis on a number of approximately equal sample increments such that the total mass tested conforms to the requirements of Section 6.4.

6.7. In the event that the amount of material finer than the 75-µm (No. 200) sieve is to be determined by T 11, use the procedure described in Section 6.7.1 or 6.7.2, whichever is applicable.

6.7.1. For aggregates with a nominal maximum size of 12.5 mm ($^1/_2$ in.) or less, use the same test sample for testing by T 11 and this method. First test the sample in accordance with T 11 through the final drying operation, then dry sieve the sample as stipulated in Sections 7.2 through 7.5 of this method.

6.7.2. For aggregates with a nominal maximum size greater than 12.5 mm ($^1/_2$ in.), a single test sample may be used as described in Section 6.7.1 or separate test samples may be used for T 11 and this method.

6.7.3. Where the specification requires determination of the total amount of material finer than the 75-µm (No. 200) sieve by washing and dry sieving, use the procedure described in Section 6.7.1.

7. PROCEDURE

7.1. If the test sample has not been subjected to testing by T 11, dry it to constant mass at a temperature of 110 ± 5°C (230 ± 9°F). Determine and record the mass of material that will be placed on the sieves to the accuracy of the balance as defined in Section 5.1.

Note 6—For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate for the sieve analysis test. The results are little affected by the moisture content unless (1) the nominal maximum size is smaller than about 12.5 mm ($^1/_2$ in.), (2) the coarse aggregate contains appreciable material finer than 4.75 mm (No. 4), or (3) the coarse aggregate is highly absorptive (a lightweight aggregate, for example). Also, samples may be dried at the higher temperature associated with the use of hot plates without affecting results, provided steam escapes without generating pressures sufficient to fracture the particles, and temperatures are not so great as to cause chemical breakdown of the aggregate.

7.2. Select sieves with suitable openings to furnish the information required by the specifications covering the material to be tested. Use additional sieves as desired or necessary to provide other information, such as fineness modulus, or to regulate the amount of material on a sieve to meet the requirements of Annex A1. If the sample was washed in accordance with T 11, the 75-µm (No. 200) sieve shall be included in the sieve set. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample, or portion of the sample if it is to be sieved in more than one increment, on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy of sieving described in Annex A2.

7.3. Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation.

7.3.1. *Prevent an overload of material on an individual sieve as described in Table A1 by one or a combination of the following methods*:

7.3.1.1. Insert an additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve immediately above that sieve in the original set of sieves.

7.3.1.2. Split the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.

7.3.1.3. Use sieves having a larger frame size and providing greater sieving area.

7.3.1.4. In the case of coarse and fine aggregate mixtures, the portion of the sample finer than the 4.75-mm (No. 4) sieve may be distributed among two or more sets of sieves to prevent overloading of individual sieves.

7.3.1.5. Alternatively, the portion finer than the 4.75-mm (No. 4) sieve may be reduced in size using a mechanical splitter according to R 76. If this procedure is followed, compute the mass of each size increment of the original sample as follows:

$$A = \frac{W_1}{W_2} \times B \qquad (1)$$

where:

A = mass of size increment on total sample basis;

W_1 = mass of fraction finer than 4.75-mm (No. 4) sieve in total sample;

W_2 = mass of reduced portion of material finer than 4.75-mm (No. 4) sieve actually sieved; and

B = mass of size increment in reduced portion sieved.

7.4. Unless a mechanical sieve shaker is used, hand sieve particles retained on the 75 mm (3 in.) by determining the smallest sieve opening through which each particle will pass by rotating the particles, if necessary, in order to determine whether they will pass through a particular opening; however, do not force particles to pass through an opening.

7.5. Determine the mass of each size increment on a scale or balance conforming to the requirements specified in Section 5.1 to the nearest 0.1 percent of the total original dry sample mass. The total mass of the material after sieving should check closely with the total original dry mass of the sample placed on the sieves. If the two amounts differ by more than 0.3 percent, based on the total original dry sample mass placed on the sieves, the results should not be used for acceptance purposes.

8. CALCULATION

8.1. Calculate percentages passing, total percentages retained, or percentages in various size fractions to the nearest 0.1 percent on the basis of the total mass of the initial dry sample. If the same test sample was first tested by T 11, include the mass of material finer than 75-µm (No. 200) sieve by washing in the sieve analysis calculation; and use the total dry sample mass prior to washing in T 11 as the basis for calculating all the percentages.

8.1.1. When sample increments are tested as provided in Section 6.6, total the masses of the portion of the increments retained on each sieve, and use these masses to calculate the percentage as in Section 8.1.

8.2. Calculate the fineness modulus, when required, by adding the total percentages of material in the sample that are coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100; 150 µm (No. 100), 300 µm (No. 50), 600 µm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), 4.75 mm (No. 4), 9.5 mm ($^3/_8$ in.), 19.0 mm ($^3/_4$ in.), 37.5 mm ($1^1/_2$ in.), and larger, increasing the ratio of 2 to 1.

9. REPORT

9.1. *Depending on the form of the specifications for use of the material under test, the report shall include one of the following*:

9.1.1. Total percentage of material passing each sieve, or

9.1.2. Total percentage of material retained on each sieve, or

9.1.3. Percentage of material retained between consecutive sieves.

9.2. Report percentages to the nearest whole number, except if the percentage passing the 75-µm (No. 200) sieve is less than 10 percent, it shall be reported to the nearest 0.1 percent.

9.3. Report the fineness modulus, when required, to the nearest 0.01.

10. PRECISION AND BIAS

10.1. *Precision*—The estimates of precision for this test method are listed in Table 1. The estimates are based on the results from the AASHTO re:source Proficiency Sample Program, with testing conducted by T 27 and ASTM C136/C136M. The data are based on the analyses of test results from 65 to 233 laboratories that tested 18 pairs of coarse aggregate proficiency test samples, and test results from 74 to 222 laboratories that tested 17 pairs of fine aggregate proficiency test samples (Samples No. 21 through 90). The values in the table are given for different ranges of total percentage of aggregate passing a sieve.

Table 2—Precision Data for 300-g and 500-g Fine Aggregate Test Samples

Fine Aggregate Proficiency Sample Test Result	Sample Size	Number of Labs	Average	Within Laboratory 1s	Within Laboratory d2s	Among Laboratories 1s	Among Laboratories d2s
AASHTO T 27/ASTM C136/C136M:							
Total material passing the 4.75-mm (No. 4) sieve (%)	500 g	285	99.992	0.027	0.066	0.037	0.104
	300 g	276	99.990	0.021	0.060	0.042	0.117
Total material passing the 2.36-mm (No. 8) sieve (%)	500 g	281	84.10	0.43	1.21	0.63	1.76
	300 g	274	84.32	0.39	1.09	0.69	1.92
Total material passing the 1.18-mm (No. 16) sieve (%)	500 g	286	70.11	0.53	1.49	0.75	2.10
	300 g	272	70.00	0.62	1.74	0.76	2.12
Total material passing the 600-µm (No. 30) sieve (%)	500 g	287	48.54	0.75	2.10	1.33	3.73
	300 g	276	48.44	0.87	2.44	1.36	3.79
Total material passing the 300-µm (No. 50) sieve (%)	500 g	286	13.52	0.42	1.17	0.98	2.73
	300 g	275	13.51	0.45	1.25	0.99	2.76
Total material passing the 150-µm (No. 100) sieve (%)	500 g	287	2.55	0.15	0.42	0.37	1.03
	300 g	270	2.52	0.18	0.52	0.32	0.89
Total material passing the 75-µm (No. 200) sieve (%)	500 g	278	1.32	0.11	0.32	0.31	0.85
	300 g	266	1.30	0.14	0.39	0.31	0.85

10.2. *Bias*—Because there is no accepted reference material suitable for determining the bias in this test method, no statement on bias is made.

11. KEYWORDS

11.1. Aggregate gradation; fineness modulus.

ANNEX A

(Mandatory Information)

A1. OVERLOAD DETERMINATION

A1.1. Do not exceed a mass of 7 kg/m^2 (4 g/in^2) of sieving surface for sieves with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation.

A1.2. Do not exceed a mass in kilograms of the product of 2.5 × (sieve opening in mm) × (effective sieving area) for sieves with openings 4.75 mm (No. 4) and larger. This mass is shown in Table A1.1 for five sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note A1—The 7 kg/m^2 (4 g/in.^{2}) amounts to 200 g for the usual 203-mm (8-in.) diameter sieve [with effective or clear sieving surface diameter of 190.5 mm (7 $^1/_2$ in.)] or 450 g for a 305-mm (12-in.) diameter sieve [with effective or clear sieving surface diameter of 292.1 mm (11 $^1/_2$ in.)].

Table 1—Estimates of Precision

	Total Percentage of Material Passing		Standard Deviation (1s),[a] %	Acceptable Range of Two Results (d2s),[a] %
Coarse Aggregate:[b]	100	≥95	0.32	0.9
Single-operator precision	<95	≥85	0.81	2.3
	<85	≥80	1.34	3.8
	<80	≥60	2.25	6.4
	<60	≥20	1.32	3.7
	<20	≥15	0.95	2.7
	<15	≥10	1.00	2.8
	<10	≥5	0.75	2.1
	<5	≥2	0.53	1.5
	<2	0	0.27	0.8
Multilaboratory precision	100	≥95	0.35	1.0
	<95	≥85	1.37	3.9
	<85	≥80	1.92	5.4
	<80	≥60	2.82	8.0
	<60	≥20	1.97	5.6
	<20	≥15	1.60	4.5
	<15	≥10	1.48	4.2
	<10	≥5	1.22	3.4
	<5	≥2	1.04	3.0
	<2	0	0.45	1.3
Fine Aggregate:				
Single-operator precision	100	≥95	0.26	0.7
	<95	≥60	0.55	1.6
	<60	≥20	0.83	2.4
	<20	≥15	0.54	1.5
	<15	≥10	0.36	1.0
	<10	≥2	0.37	1.1
	<2	0	0.14	0.4
Multilaboratory precision	100	≥95	0.23	0.6
	<95	≥60	0.77	2.2
	<60	≥20	1.41	4.0
	<20	≥15	1.10	3.1
	<15	≥10	0.73	2.1
	<10	≥2	0.65	1.8
	<2	0	0.31	0.9

[a] These numbers represent, respectively, the (1s) and (d2s) limits as described in ASTM C670.

[b] The precision estimates are based on aggregates with nominal maximum size of 19.0 mm (3/4 in.).

10.1.1. The precision values for Fine Aggregate in Table 2 are based on nominal 500-g test samples. Revision of ASTM C136 in 1994 permitted the fine aggregate test sample size to be 300 g minimum. Analysis of results of testing of 300-g and 500-g test samples from Aggregate Proficiency Test Samples 99 and 100 (Samples 99 and 100 were essentially identical) produced the precision values in Table 2, which indicate only minor differences due to test sample size.

Note 7—The values for Fine Aggregate in Table 1 will be revised to reflect the 300-g test sample size when a sufficient number of Aggregate Proficiency Tests have been conducted using that sample size to provide reliable data.

Table 2—Precision Data for 300-g and 500-g Fine Aggregate Test Samples

Fine Aggregate Proficiency Sample Test Result	Sample Size	Number of Labs	Average	Within Laboratory 1s	Within Laboratory d2s	Among Laboratories 1s	Among Laboratories d2s
AASHTO T 27/ASTM C136/C136M:							
Total material passing the 4.75-mm (No. 4) sieve (%)	500 g	285	99.992	0.027	0.066	0.037	0.104
	300 g	276	99.990	0.021	0.060	0.042	0.117
Total material passing the 2.36-mm (No. 8) sieve (%)	500 g	281	84.10	0.43	1.21	0.63	1.76
	300 g	274	84.32	0.39	1.09	0.69	1.92
Total material passing the 1.18-mm (No. 16) sieve (%)	500 g	286	70.11	0.53	1.49	0.75	2.10
	300 g	272	70.00	0.62	1.74	0.76	2.12
Total material passing the 600-µm (No. 30) sieve (%)	500 g	287	48.54	0.75	2.10	1.33	3.73
	300 g	276	48.44	0.87	2.44	1.36	3.79
Total material passing the 300-µm (No. 50) sieve (%)	500 g	286	13.52	0.42	1.17	0.98	2.73
	300 g	275	13.51	0.45	1.25	0.99	2.76
Total material passing the 150-µm (No. 100) sieve (%)	500 g	287	2.55	0.15	0.42	0.37	1.03
	300 g	270	2.52	0.18	0.52	0.32	0.89
Total material passing the 75-µm (No. 200) sieve (%)	500 g	278	1.32	0.11	0.32	0.31	0.85
	300 g	266	1.30	0.14	0.39	0.31	0.85

10.2. *Bias*—Because there is no accepted reference material suitable for determining the bias in this test method, no statement on bias is made.

11. KEYWORDS

11.1. Aggregate gradation; fineness modulus.

ANNEX A

(Mandatory Information)

A1. OVERLOAD DETERMINATION

A1.1. Do not exceed a mass of 7 kg/m^2 (4 g/in^2) of sieving surface for sieves with openings smaller than 4.75 mm (No. 4) at the completion of the sieving operation.

A1.2. Do not exceed a mass in kilograms of the product of 2.5 × (sieve opening in mm) × (effective sieving area) for sieves with openings 4.75 mm (No. 4) and larger. This mass is shown in Table A1.1 for five sieve-frame dimensions in common use. Do not cause permanent deformation of the sieve cloth due to overloading.

Note A1—The 7 kg/m^2 (4 g/in.^{2}) amounts to 200 g for the usual 203-mm (8-in.) diameter sieve [with effective or clear sieving surface diameter of 190.5 mm (7 $^1/_2$ in.)] or 450 g for a 305-mm (12-in.) diameter sieve [with effective or clear sieving surface diameter of 292.1 mm (11 $^1/_2$ in.)].

A1.3. As provided below, the amount of material retained on a sieve may be regulated by (1) the introduction of a sieve with larger openings immediately above the given sieve, (2) testing the sample in multiple increments, or (3) testing the sample over a nest of sieves with a larger sieve-frame dimension.

A1.3.1. Insert an additional sieve with opening size intermediate between the sieve that may be overloaded and the sieve immediately above that sieve in the original set of sieves.

A1.3.2. Split the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.

A1.3.2.1. Alternatively, the portion finer than the 4.75-mm (No. 4) sieve may be reduced in size using a mechanical splitter according to R 76. If this procedure is followed, compute the mass of each size increment of the original sample as follows:

$$A = \frac{W_1}{W_2} \times B \tag{1}$$

where:

A = mass of size increment on total sample basis;

W_1 = mass of fraction finer than 4.75-mm (No. 4) sieve in total sample;

W_2 = mass of reduced portion of material finer than 4.75-mm (No. 4) sieve actually sieved; and

B = mass of size increment in reduced portion sieved.

A1.4. Use sieves having a larger frame size and providing greater sieving area.

Table A3.1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve[a]				
	203.2 mm, dia[b]	254 mm, dia[b]	304.8 mm, dia[b]	350 by 350, mm	372 by 580, mm
	Sieving Area, m^2				
	0.0285	0.0457	0.0670	0.1225	0.2158
125 mm (5 in.)	[c]	[c]	[c]	[c]	67.4
100 mm (4 in.)	[c]	[c]	[c]	30.6	53.9
90 mm (3$^1/_2$ in.)	[c]	[c]	15.1	27.6	48.5
75 mm (3 in.)	[c]	8.6	12.6	23.0	40.5
63 mm (2$^1/_2$ in.)	[c]	7.2	10.6	19.3	34.0
50 mm (2 in.)	3.6	5.7	8.4	15.3	27.0
37.5 mm (1$^1/_2$ in.)	2.7	4.3	6.3	11.5	20.2
25.0 mm (1 in.)	1.8	2.9	4.2	7.7	13.5
19.0 mm ($^3/_4$ in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm ($^1/_2$ in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm ($^3/_8$ in.)	0.67	1.1	1.6	2.9	5.1
4.75 mm (No. 4)	0.33	0.54	0.80	1.5	2.6

[a] Sieve-frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

[b] The sieve area for round sieves is based on an effective or clear diameter of 12.7 mm ($^1/_2$ in.) less than the nominal frame diameter because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm ($^1/_4$ in.) over the sieve cloth. Thus, the effective or clear sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm (7$^1/_2$ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm ($^1/_4$ in.).

[c] Sieves indicated have less than five full openings and should not be used for sieve testing.

A2. TIME EVALUATION

A2.1. The minimum time requirement shall be evaluated for each shaker at least annually by the following method:

A2.1.1. Shake the sample over nested sieves for approximately 10 min.

Note A2—If the sample material may be prone to degradation, reduce the initial shaking time in Section A2.1.1 to 5 min, and begin each recheck with a new sample.

A2.1.2. Provide a snug-fitting pan and cover for each sieve and hold the items in a slightly inclined position in one hand.

A2.1.3. Hand-shake each sieve continuously for 60 s by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per min, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

A2.2. If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving, adjust the shaker time and repeat Section A2.1.

A2.3. In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

A2.4. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm (8-in.) diameter sieves to verify the adequacy of sieving.

A2.5. If the mass retained on any sieve exceeds the maximum allowable mass per Table A1.1, select a different sample and repeat Section A2.

[1] Similar but not identical to ASTM C136/C136M-19.

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Illinois Modified Test Procedure
Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method
for
Reducing Samples of Aggregate to Testing Size

Reference AASH
TO R 76-23

AASHTO Section	***Illinois Modification***
2.1	Replace with the following: Illinois Modified AASHTO Standards: • R90, Sampling Aggregate Products • T11, Materials Finer Than No. 200 (75µm) Sieve in Mineral Aggregates by Washing
2.2	Replace with the following: Illinois Specification: • Illinois Specification 201 Aggregate Gradation Sample Size Table.
2.3	Insert the following: ASTM Standard: • C125, Standard Terminology Relating to Concrete and Concrete Aggregates
5.1	Replace with the following: “Fine Aggregate – The preferred splitting method for fine aggregate shall be a fine aggregate mechanical splitter (Method A). However, quartering (Method B) and miniature stockpile sampling (Method C) may be used.”
5.1.1 Note 1	Replace with the following: “As a quick approximation of free moisture; if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated surface-dry.”
5.1.2	Replace “38 mm (1 ½ in.)” with “1 1/2in. (37.5mm)” in the second sentence of the paragraph
5.2	Replace with the following: “Coarse Aggregate and Mixtures of Coarse and Fine Aggregate – The required splitting method for coarse aggregate and mixtures of coarse and fine aggregate shall be a coarse aggregate mechanical splitter (Method A). However, quartering (Method B) may be used for coarse aggregate moisture tests to proportion Portland cement concrete, cement aggregate mixture II, and controlled low-strength material mixtures.”
5.3	Delete
6.1	Replace with the following: “Field samples of aggregate shall be taken according to Illinois Modified AASHTO R90. The field sample size shall meet the minimum requirements in the Illinois Specifications 201.”

Illinois Modified Test Procedure
Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method
for
Reducing Samples of Aggregate to Testing Size

Reference AASHTO R 76-23

AASHTO Section	***Illinois Modification***
7.1	Replace with the following: "Sample Splitter – Sample splitters shall have an even number of equal width chutes, but not less than a total of eight for coarse aggregate, or twelve for fine aggregate, which discharge alternatively to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50 percent larger than the largest particles in the sample to be split (Note 2). For dry fine aggregate in which the entire sample will pass the 3/8in. (9.5mm) sieve, the minimum width of the individual chutes shall be at least 50 percent larger than the largest particles in the sample and the maximum width shall be 3/4in. (19mm). The splitter shall be equipped with two receptacles to hold the two halves of the sample following splitting. It shall also be equipped with a hopper or straight-edged pan, which has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (see Figure 1).
7.1 Note 2	Replace with the following: "Mechanical splitters are commonly available in sizes adequate for coarse aggregate having the largest particles not larger than 1 1/2in. (37.5mm)."
7.1 Note 3	Delete
8.1	Replace with the following: "Place the original sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced in the chutes, approximately equal amounts will flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the receptacles below. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other receptacle may be reserved for reduction in size for other tests. Upon the final split, the mass of the two halves (after splitting) shall be within ±10 percent of each other. This is determined by multiplying mass of the smaller split by (1.10 or 110%); the larger split cannot exceed this calculated mass. If it does, both split halves shall be recombined and split until the mass comparison requirement is met."
9.1	Replace "2 by 2.5 m (6 by 8 ft.)" with "6 by 8ft (2 by 2.5m)"

Illinois Modified Test Procedure
Effective Date: December 1, 2021
Revised Date: December 1, 2023

Standard Test Method
for
Reducing Samples of Aggregate to Testing Size

Reference AASHTO R 76-23

AASHTO Section	***Illinois Modification***
10.1.1	Replace with the following: "Mix the material thoroughly on a hard, clean, level surface by turning the entire sample over four times using a shovel. Each shovel full shall be deposited on top of the preceding one. This procedure shall be done three times, resulting in the formation of a small conical pile. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately four to eight times the thickness. Divide the flattened mass into four equal quarters with a shovel or trowel. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. The two unused quarters may be set aside for later use and/or testing if desired. Successively mix and quarter the remaining material until the sample is reduced to the desired size (see Figure 2). Both halves of the final split shall meet the 10 percent comparison requirement of section 8.1 herein."
10.1.2	Replace with the following: "As an alternative to the procedure in Section 10.1.1, the field sample may be placed on a canvas blanket. Mixing may be accomplished by the shovel method listed in 10.1.1 herein or by alternately lifting each corner of the canvas and pulling over the sample diagonally toward the opposite corner. This causes the material to be rolled and mixed. The material shall then be flattened and divided as required in 10.1.1. (see Figure 3) Both halves of the final split shall meet the 10 percent comparison requirement of section 8.1 herein."
12.1	Revise with the following: "Mix the material thoroughly on a hard, clean, level surface as required in 10.1.1 or 10.1.2. The test sample shall be obtained by selecting at least five increments in a random "X" pattern over the resultant miniature sample pad using a sampling thief, small scoop, or spoon. A sufficient number of increments shall be obtained to provide a test sample slightly larger than the minimum test sample size when dried to a constant mass. For all samples from which a state monitor split will also be obtained, the number of increments shall be doubled to provide a sample twice the minimum required test size. This material shall then be dried to constant mass, as specified in Illinois Modified AASHTO T11, and split in a fine aggregate mechanical splitter according to Method A – Mechanical Splitter. Alternately, the material may also be quartered according to Method B – Quartering. Both halves of the final split shall meet the 10 percent comparison requirement of section 8.1 herein."
13	Delete

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Standard Practice for

Reducing Samples of Aggregate to Testing Size

AASHTO Designation: R 76-23[1]

Technically Revised: 2023

Technical Subcommittee: 1c, Aggregates

ASTM Designation: C702/C702M-18

1. SCOPE

1.1. These methods cover the reduction of large samples of aggregate to the appropriate size for testing, employing techniques that are intended to minimize variations in measured characteristics between the test samples so selected and the large sample.

1.2. The values stated in SI units are to be regarded as the standard.

1.3. *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 procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- R 90, Sampling Aggregate Products
- T 84, Specific Gravity and Absorption of Fine Aggregate

2.2. *ASTM Standard*:
- C125, Standard Terminology Relating to Concrete and Concrete Aggregates

3. TERMINOLOGY

3.1. *Definitions*—the terms used in this standard are defined in ASTM C125.

4. SIGNIFICANCE AND USE

4.1. Specifications for aggregates require sampling portions of the material for testing. Other factors being equal, larger samples will tend to be more representative of the total supply. The methods described in this standard provide for reducing the large sample obtained in the field or produced in the laboratory to a convenient size for conducting a number of tests to describe the material and measure its quality. These methods are conducted in such a manner that the smaller test sample portion will be representative of the larger sample and, thus, of the total supply. The individual test methods provide for minimum masses of material to be tested.

4.2. Under certain circumstances, reduction in size of the large sample prior to testing is not recommended. Substantial differences between the selected test samples sometimes cannot be avoided, as, for example, in the case of an aggregate having relatively few large-sized particles in the sample. The laws of chance dictate that these few particles may be unequally distributed among the reduced-size test samples. Similarly, if the test sample is being examined for certain contaminants occurring as a few discrete fragments in only small percentages, use caution in interpreting results from the reduced-size test sample. Chance inclusion or exclusion of only one or two particles in the selected test sample may importantly influence interpretation of the characteristics of the original sample. In these cases, test the entire original sample.

4.3. Failure to carefully follow the procedures in these methods could result in providing a nonrepresentative sample to be used in subsequent testing.

5. SELECTION OF METHOD

5.1. *Fine Aggregate*—Reduce samples of fine aggregate that are drier than the saturated surface-dry condition (Note 1) using a mechanical splitter according to Method A. Samples having free moisture on the particle surfaces may be reduced in size by quartering according to Method B, or by treating as a miniature stockpile as described in Method C.

5.1.1. If the use of Method B or Method C is desired, and the sample does not have free moisture on the particle surfaces, the sample may be moistened to achieve this condition, thoroughly mixed, and then the sample reduction performed.

Note 1—The method of determining the saturated surface-dry condition is described in T 84. As a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated surface-dry.

5.1.2. If use of Method A is desired and the sample has free moisture on the particle surfaces, the entire sample may be dried to at least the surface-dry condition, using temperatures that do not exceed those specified for any of the tests contemplated, and then the sample reduction performed. Alternatively, if the moist sample is very large, a preliminary split may be made using a mechanical splitter having wide chute openings 38 mm ($1^1/_2$ in.) or more to reduce the sample to not less than 5000 g. The portion so obtained is then dried, and reduction to test sample size is completed using Method A.

5.2. *Coarse Aggregates*—Reduce the sample using a mechanical splitter in accordance with Method A (preferred method) in Section 8 or by quartering in accordance with Method B in Sections 10.1.1 or 10.1.2. Do not use the sectoring Method B in Section 10.1.3 or the miniature stockpile Method C in Section 12 for coarse aggregates.

5.3. *Combined Coarse and Fine Aggregate*—Samples that are in a dry condition may be reduced in size by either Method A in Section 8 or Method B in Sections 10.1.1 or 10.1.2. Samples having free moisture on the particle surfaces may be reduced in size by quartering according to Method B Sections 10.1.1 or 10.1.2. When Method A is desired and the sample is damp or shows free water, dry the sample until it appears dry or until clumps can be easily broken by hand (Note 2). Dry the entire sample to this condition, using temperatures that do not exceed those specified for any of the tests contemplated, and then reduce the sample. Do not use the sectoring Method B in Section 10.1.3 or the miniature stockpile Method C in Section 12 for combined aggregates.

Note 2—The dryness of the sample can be tested by tightly squeezing a small portion of the sample in the palm of the hand. If the cast crumbles readily, the correct moisture range has been obtained.

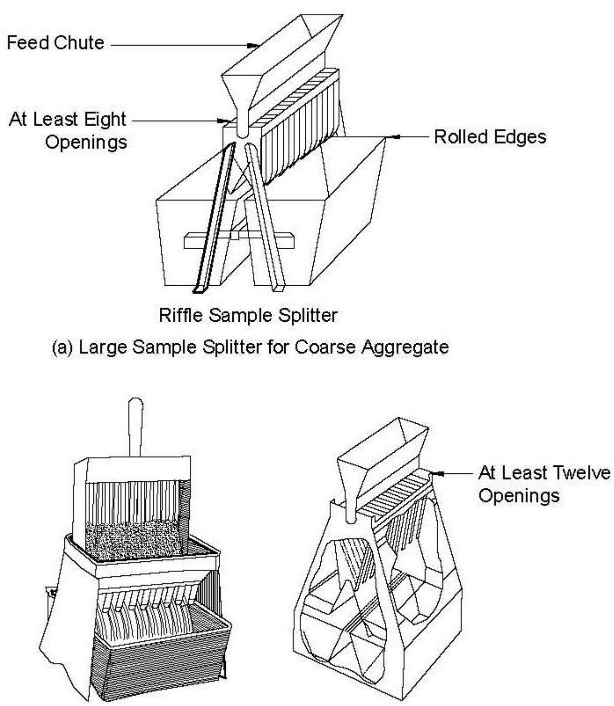
6. SAMPLING

6.1. Obtain samples of aggregate in accordance with R 90, or as required by individual test methods.

METHOD A—MECHANICAL SPLITTER

7. APPARATUS

7.1. *Sample Splitter*—Sample splitters shall have an even number of equal-width chutes, but not less than a total of eight for coarse aggregate, or twelve for fine aggregate, which discharge alternatively to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50 percent larger than the largest particles in the sample to be split (Note 3). For dry fine aggregate in which the entire sample will pass the 9.5-mm ($^3/_8$-in.) sieve, the minimum width of the individual chutes shall be at least 50 percent larger than the largest particles in the sample and the maximum width shall be 19 mm ($^3/_4$ in.). The splitter shall be equipped with two receptacles to hold the two halves of the sample following splitting. It shall also be equipped with a hopper or straightedged pan, which has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (see Figures 1 and 2).



(a) Large Sample Splitter for Coarse Aggregate

(b) Small Sample Splitters for Fine Aggregate

Note: (a) may be constructed as either closed or open type. Closed type is preferred.

Figure 1—Sample Splitters (Riffles)

(a) Side View (b) Top View

Figure 2—Sample Splitter (Adjustable)

Note 3—Mechanical splitters are commonly available in sizes adequate for coarse aggregate having the largest particle not over 37.5 mm ($1^1/_2$ in.).

8. PROCEDURE

8.1. Place the original sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced into the chutes, approximately equal amounts will flow through each chute. Introduce the sample at a rate that allows the material to flow freely through the chutes into the receptacles below.

8.2. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other receptacle may be reserved for reduction in size for other tests.

METHOD B—QUARTERING

9. APPARATUS

9.1. Straightedge; straightedged scoop or shovel.

9.2. Spatulas, trowels, or drywall taping knives.

9.3. Stick or pipe.

9.4. Broom or brush.

9.5. Tear-resistant rectangular tarp, appropriate for the amount and size of the material being reduced.

9.6. *Quartering Template*—Formed in the shape of a 90-degree cross with equal length sides that exceed the diameter of the flattened cone of material sufficient to allow complete separation of the quartered sample. The height of the sides must be sufficient to extend above the thickness of the flattened cone of the sample to be quartered (see Figure 3).

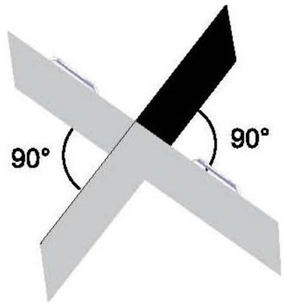


Figure 3—Quartering Template

10. PROCEDURE

10.1. Use the procedure described in Section 10.1.1, 10.1.2, 10.1.3, or a combination thereof.

10.1.1. *Quartering on a Clean, Hard, Level Surface*:

10.1.1.1. Place the original sample on a clean, hard, level surface where there will be neither loss of material nor the accidental addition of foreign material.

10.1.1.2. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift.

10.1.1.3. Carefully flatten the conical pile to a uniform thickness with a diameter approximately four to eight times the thickness by pressing down the top with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it.

10.1.1.4. Divide the flattened mass into four approximately equal quarters with a quartering template, shovel, or trowel.

10.1.1.5. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. The two unused quarters may be set aside for later use or testing.

10.1.1.6. If necessary, repeat Sections 10.1.1.2 through 10.1.1.5 until the required sample size is obtained (see Figure 4).

10.1.1.7. The reduced sample consists of two diagonally opposite quarters.

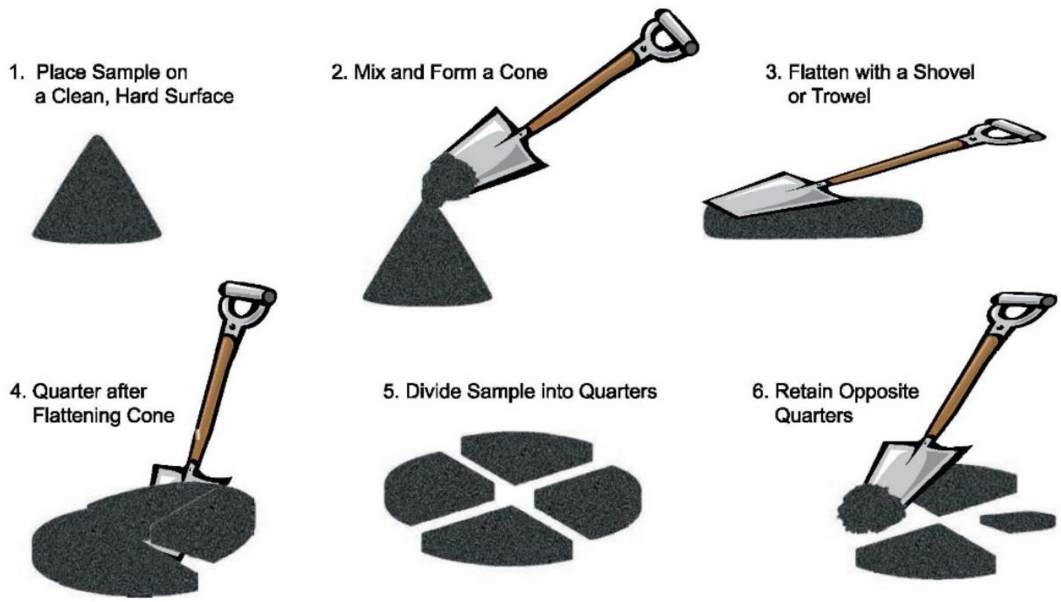


Figure 4—Quartering on a Hard, Clean, Level Surface

10.1.2. *Quartering on a Tarp*:

10.1.2.1. As an alternative to the procedure in Section 10.1.1 or when the floor surface is uneven, place the sample on a tarp and mix with a shovel or trowel as described in Section 10.1.1.2, leaving the sample in a conical pile.

10.1.2.2. As an alternative to mixing with the shovel or trowel, lift each corner of the tarp and pull it over the sample toward the diagonally opposite corner, causing the material to be rolled. Roll the material at least four times until it is thoroughly mixed.

10.1.2.3. Pull each corner of the tarp toward the center of the pile so the material will be left in a conical pile.

10.1.2.4. Flatten the pile as described in Section 10.1.1.3.

10.1.2.5. Divide the sample as described in Section 10.1.1.4 or insert a stick or pipe beneath the tarp and under the center of the pile, then lift both ends of the stick or pipe, dividing the sample into two approximately equal parts.

10.1.2.6. Remove the stick or pipe, leaving a fold of the tarp between the divided portions.

10.1.2.7. Insert the stick or pipe under the center of the pile at right angles to the first division and again lift both ends of the stick or pipe, dividing the sample into four approximately equal parts.

10.1.2.8. Remove two diagonally opposite quarters, being careful to clean the fines from the tarp. The two unused quarters may be set aside for later use or testing.

10.1.2.9. If necessary, repeat Sections 10.1.2.1 through 10.1.2.8 until the required sample size is obtained (see Figure 5).

10.1.2.10. The reduced sample consists of two diagonally opposite quarters.

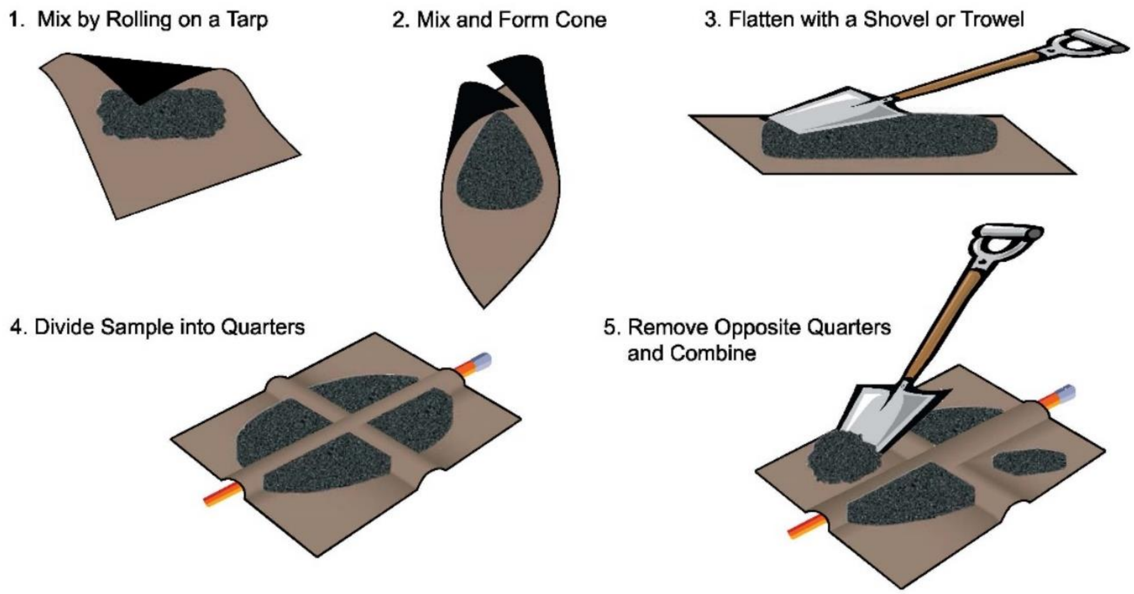


Figure 5—Quartering on a Tarp

10.1.3. *Sectoring*:

10.1.3.1. This method may be used in conjunction with Section 10.1.1, 10.1.2, or a combination of both.

Note 4—The sectoring method may be used for reducing samples of fine aggregate to a target sample size with minimal manipulation.

10.1.3.2. Mix the material as described in Section 10.1.1.2.

10.1.3.3. Flatten the conical pile as described in Section 10.1.1.3.

10.1.3.4. Divide the flattened cone into four approximately equal quarters using a quartering template, straightedge, shovel, or trowel, assuring complete separation.

10.1.3.5. Using a straightedge, obtain a sector by slicing through a quarter of the material from the center point to the outer edge of the quarter.

10.1.3.6. Pull or drag the sector from the quarter with two straightedges or hold one edge of the straightedge in contact with a quartering device.

10.1.3.7. Remove an approximately equal sector from the diagonally opposite quarter and combine.

10.1.3.8. If necessary, repeat Sections 10.1.3.5 through 10.1.3.7 until the required sample size is obtained (see Figure 6).

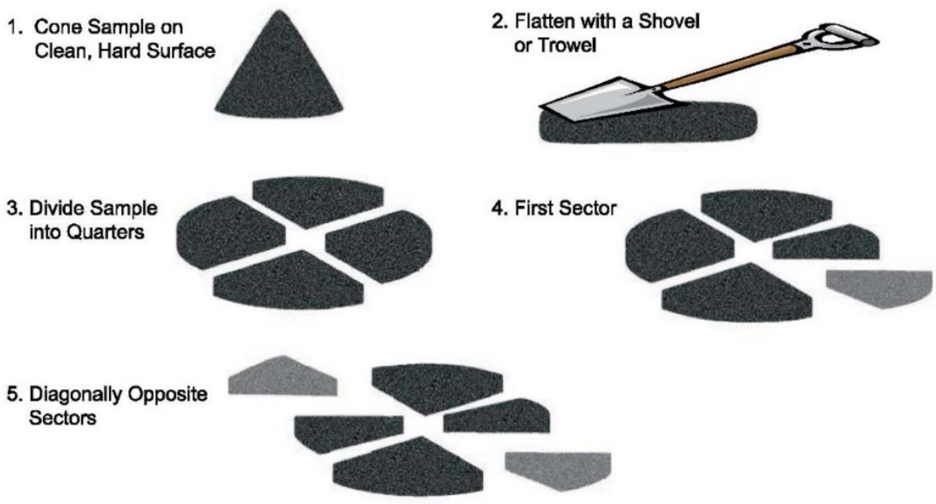


Figure 6—Reduction by Sectoring

METHOD C—MINIATURE STOCKPILE SAMPLING (DAMP FINE AGGREGATE ONLY)

11. APPARATUS

11.1. Straightedge, flat bottom scoop, square point shovel, or trowel for mixing the aggregate.

11.2. A small sampling thief, small scoop, or spoon for sampling.

12. PROCEDURE

12.1. Place the original sample of damp fine aggregate on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material.

12.2. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed.

12.3. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. If desired, the conical pile may be flattened to a uniform thickness and diameter by pressing the top with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it.

12.4. Obtain a sample for each test by selecting at least five increments of material at random locations from the miniature stockpile, using any of the sampling devices described in Section 11.2.

13. KEYWORDS

13.1. Aggregate; aggregate sample; mechanical splitter; quartering.

[1] Formerly T 248. First published as a practice in 2016. Similar but not identical to ASTM C702/C702M-18.

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Illinois Modified Test Procedure
Effective Date: December 1, 2023

Standard Method of Test
For
Total Evaporable Moisture Content of Aggregates by Drying

Reference AASHTO T 255-22

AASHTO Section	***Illinois Modification***
1.1	Add the following: Aggregate moisture content may be run on a gradation sample prior to gradation testing or on a separate test sample.
2.1	Revise the individual Standards as follows: AASHTO R 76 (Illinois Modified) AASHTO R 90 (Illinois Modified) AASHTO T 19/T 19M (Illinois Modified) AASHTO T 84 (Illinois Modified) AASHTO T 85 (Illinois Modified)
2.2	Delete the individual Standard as follows: ASTM C 670
5.2	Add the following: The oven shall be specifically designed for drying. All the other specified sources of heat may be used for drying except for a microwave oven or an electric heat lamp. A microwave oven or an electric heat lamp may be used only when drying a non-gradation test sample.
6.1	Replace with the following: Field samples of aggregate shall be taken according to AASHTO R 90 (Illinois Modified). The field sample size shall meet the minimum requirements in the IDOT Aggregate Gradation Sample Size Table. Field samples shall be stored in sealable, nonabsorbent bags or containers prior to splitting to prevent moisture loss.
6.2	Replace with the following: Field samples of aggregate shall be reduced to test sample size before testing according to AASHTO R 76 (Illinois Modified). Test sample size for non-gradation samples shall meet the minimum test sample size in Table 1. Test sample size for gradation samples also having aggregate moisture content performed shall meet the minimum requirements in the IDOT Aggregate Gradation Sample Size Table. Test samples shall be stored in sealable, nonabsorbent bags or containers prior to determining mass to start the test.
7.1	Replace with the following: The test sample shall have its mass determined to the nearest 1 gram for coarse aggregate and to the nearest 0.1 gram for fine aggregate. This procedure provides the “Original Sample Mass, g” (OSM).
7.2	Replace with the following: The test sample shall be dried back to constant mass by the selected source of heat as specified herein.

Illinois Modified Test Procedure
Effective Date: December 1, 2021

Standard Method of Test
For
Total Evaporable Moisture Content of Aggregates by Drying
(continued)
Reference AASHTO T 255-00 (2021)

AASHTO Section	***Illinois Modification***
7.2.1	Add the following: When a gas burner or electric hot plate is used for drying, the technician shall continually attend the sample. The gas burner or electric hot plate should be operated on a low-as-needed heat to prevent popping, crackling, and/or sizzling noise from the aggregate during drying. If these noises occur, the heat must be turned down and/or the sample must be constantly stirred during drying to prevent potential aggregate particle breakdown.
7.3	Delete.
7.3.1	Delete.
7.4	Replace with the following: Constant mass is defined as the sample mass at which there has not been more than a 0.5-gram mass loss during 1 hour of drying.
7.5	Replace with the following: After the test sample has been dried to constant mass and cooled sufficiently so as not to damage the balance or scale, determine the mass of the test sample to the nearest 0.1 gram for fine aggregate. The test sample shall have its mass determined as soon as the pan or container can safely be handled to prevent additional moisture from being pulled from the air into the aggregate structure. This procedure provides the “Total Dry Mass, g” (TDM). The TDM will also be used for calculation of gradation samples.
8.1	Replace with the following: The “Aggregate Moisture Content” shall be determined by using the following formula: $P = \frac{100(OSM - TDM)}{TDM}$ where P = Aggregate Moisture Content (%) OSM = Original Sample Mass, g. and TDM = Dried Sample Mass, g. Results shall be reported as required and in the appropriate plant diary. Test results shall be rounded to the nearest 0.1 percent. All rounding shall be according to ASTM E 29 (Illinois Modified).

Standard Method of Test for

Total Evaporable Moisture Content of Aggregate by Drying

AASHTO Designation: T 255-22[1]

Technically Revised: 2022

Technical Subcommittee: 1c, Aggregates

ASTM Designation: C566-13

1. SCOPE

1.1. This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this test method.

1.2. The values stated in SI units are to be regarded as the standard. The values stated in parentheses are provided for information only.

1.3. *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 procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.* For specific precautionary statements, see Sections 5.3.1, 7.2.1, and 7.3.1.

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 231, Weighing Devices Used in the Testing of Materials
- 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 90, Sampling Aggregate Products
- T 19M/T 19, Bulk Density ("Unit Weight") and Voids in Aggregate
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate

2.2. *ASTM Standards*:

- C125, Standard Terminology Relating to Concrete and Concrete Aggregates
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission* Standard:

- IEC 60584-1:2013, Thermocouples - Part 1: EMF Specifications and Tolerances

2.4. *Other Document*:

- Strategic Highway Research Program. National Research Council Report SHRP-P-619, Soil Moisture Proficiency Sample Program, 1993. Available from https://onlinepubs.trb.org/onlinepubs/shrp/SHRP-P-619.pdf

3. TERMINOLOGY

3.1. *Definitions*—For definitions of terms used in this test method, refer to ASTM C125.

4. SIGNIFICANCE AND USE

4.1. This test method is sufficiently accurate for usual purposes such as adjusting batch quantities of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In rare cases where aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled-temperature oven.

4.2. Large particles of coarse aggregate, especially those larger than 50 mm (2 in.), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large-size particles.

5. APPARATUS

5.1. *Balance*—The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

5.2. *Source of Heat*—A ventilated oven capable of maintaining the temperature surrounding the sample at 110 ± 5°C (230 ± 9°F). Oven(s) for heating and drying shall be capable of operation at the temperatures required, between 100 to 120°C (212 to 248°F), within ±5°C (±9°F), as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range. The thermometer for measuring the temperature, regardless of drying apparatus used, shall meet the requirements of M 339M/M 339 with a temperature range of at least 90 to 130°C (194 to 266°F), and an accuracy of ±1.25°C (±2.25°F) (see Note 1). Where close control of the temperature is not required (see Section 4.1), other suitable sources of heat may be used, such as an electric or gas hot plate, electric heat lamps, or a ventilated microwave oven.

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type J or K, Special Class, Type T any Class; IEC 60584 thermocouple thermometer, Type J or K, Class 1, Type T any Class; or dial gauge metal stem (bi-metal) thermometer.

5.3. *Sample Container*—A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one-fifth of the least lateral dimension.

5.3.1. **Precaution**—When a microwave oven is used, the container shall be nonmetallic.

Note 2—Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan with heat lamps or oven. Note precaution in Section 5.3.1.

5.4. *Stirrer*—A metal spoon or spatula of convenient size.

6. SAMPLE

6.1. Sampling shall generally be accomplished in accordance with R 90, except the sample size may be as stated in Table 1.

Table 1—Sample Size for Aggregate

Nominal Maximum Size of Aggregate, mm (in.)[a]	Mass of Normal Weight Aggregate Sample, Min., kg[b]
4.75 (0.187) (No. 4)	0.5
9.5 (3/8)	1.5
12.5 (1/2)	2
19.0 (3/4)	3
25.0 (1)	4
37.5 (1 1/2)	6
50 (2)	8
63 (2 1/2)	10
75 (3)	13
90 (3 1/2)	16
100 (4)	25
150 (6)	50

[a] Based on sieves meeting ASTM E11.

[b] Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry–loose unit mass of the aggregate in kg/m^3 (determined using T 19M/T 19) and dividing by 1600.

6.2. Secure a sample of the aggregate representative of the moisture content in the supply being tested and having a mass not less than the amount listed in Table 1. Protect the sample against loss of moisture prior to determining the mass.

7. PROCEDURE

7.1. Determine the mass of the sample to the nearest 0.1 percent.

7.2. Dry the sample thoroughly in the sample container by means of the selected source of heat, exercising care to avoid loss of any particles. Very rapid heating may cause some particles to explode, resulting in loss of particles. Use a controlled temperature oven when excessive heat may alter the character of the aggregate, or where more precise measurement is required. If a source of heat other than the controlled temperature oven is used, stir the sample during drying to accelerate the operation and avoid localized overheating. When using a microwave oven, stirring of the sample is optional.

7.2.1. **Caution**: When using a microwave oven, occasionally minerals are present in aggregates that may cause the material to overheat and explode. If this occurs, it can damage the microwave oven.

7.3. When a hot plate is used, drying can be expedited by the following procedure. Add sufficient anhydrous denatured alcohol to cover the moist sample. Stir and allow suspended material to settle. Decant as much of the alcohol as possible without losing any of the sample. Ignite the remaining alcohol and allow it to burn off during drying over the hot plate.

7.3.1. **Warning**: Exercise care to control the ignition operation to prevent injury or damage from the burning alcohol.

7.4. The sample is thoroughly dry when further heating causes, or would cause, less than 0.1 percent additional loss in mass.

7.5. Determine the mass of the dried sample to the nearest 0.1 percent after it has cooled sufficiently not to damage the balance.

8. CALCULATION

8.1. Calculate total evaporable moisture content as follows:

$$p = 100(W - D)/D \quad (1)$$

where:

p = total evaporable moisture content of sample, percent;

W = mass of original sample, g; and

D = mass of dried sample, g.

8.2. Surface moisture content is equal to the difference between the total evaporable moisture content and the absorption, with all values based on the mass of a dry sample. Absorption may be determined in accordance with T 85, Test for Specific Gravity and Absorption of Coarse Aggregate, or T 84, Test for Specific Gravity and Absorption of Fine Aggregate.

9. PRECISION AND BIAS

9.1. *Precision*:

9.1.1. The within-laboratory single-operator standard deviation for moisture content of aggregates has been found to be 0.28 percent (Note 3). Therefore, results of two properly conducted tests by the same operator in the same laboratory on the same type of aggregate sample should not differ by more than 0.79 percent (Note 3) from each other.

9.1.2. The between-laboratory standard deviation for moisture content of aggregates has been found to be 0.28 percent (Note 3). Therefore, results of properly conducted tests from two laboratories on the same aggregate sample should not differ by more than 0.79 percent (Note 3) from each other.

9.1.3. Test data used to derive the above precision indices were obtained from samples dried to a constant mass in a drying oven maintained at 110 ± 5°C. When other drying procedures are used, the precision of the results may be significantly different than that indicated above.

Note 3—These numbers represent, respectively, the 1s and d2s limits as described in ASTM C670.

9.2. *Bias*:

9.2.1. When experimental results are compared with known values from accurately compounded specimens, the following has been derived.

9.2.1.1. The bias of moisture tests on one aggregate material has been found to have a mean of +0.06 percent. The bias of individual test values from the same aggregate material has been found with 95 percent confidence to lie between –0.07 percent and +0.20 percent.

9.2.1.2. The bias of moisture tests on a second aggregate material has been found to have a mean of less than +0.01 percent. The bias of individual test values from the same aggregate material has been found with 95 percent confidence to lie between –0.14 percent and +0.14 percent.

9.2.1.3. The bias of moisture tests overall on both aggregate materials has been found to have a mean of +0.03 percent. The bias of individual test values overall from both aggregate materials has been found with 95 percent confidence to lie between –0.12 percent and +0.18 percent.

9.2.2. Test data used to derive the above bias statement were obtained from samples dried to a constant mass in a drying oven maintained at 110 ± 5°C. When other drying procedures are used, the bias of the results may be significantly different than that indicated above.

Note 4—These precision and bias statements were derived from aggregate moisture data provided by 17 laboratories participating in the SHRP Soil Moisture Proficiency Sample Program, which is fully described in the National Research Council Report SHRP-P-619. The samples tested that relate to these statements were well-graded mixtures of fine and coarse aggregate with moisture contents ranging from air dry to saturated surface-dry.

10. KEYWORDS

10.1. Aggregate; drying; moisture content.

[1] This method is technically equivalent to ASTM C566-13, except for the balance statement in Section 5.1.

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Illinois Modified Test Procedure
Effective Date: December 1, 2019

Standard Method of Test
for
Using Significant Digits in Test Data to Determine Conformance with Specifications

Reference ASTM E 29-13 (2019)

Note: Several test procedures reference either ASTM E 29 for rounding of test results. Results for Illinois Department of Transportation tests shall follow the “round up from five” rule, i.e.:

When the digit beyond the last place to be retained (or reported) is equal to or greater than 5, increase by 1 the digit in the last place retained.

The following modification to ASTM shall apply:

ASTM Section	***Illinois Modification***
6.4.2	Revise as follows: When the digit next beyond the last place to be retained (or reported) is equal to or greater than 5, increase by 1 the digit in the last place retained.
6.4.3	Delete.
6.4.4	Delete.

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Designation: E29 – 13 (Reapproved 2019) An American National Standard

Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[1]

This standard is issued under the fixed designation E29; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice is intended to assist the various technical committees in the use of uniform methods of indicating the number of digits which are to be considered significant in specification limits, for example, specified maximum values and specified minimum values. Its aim is to outline methods which should aid in clarifying the intended meaning of specification limits with which observed values or calculated test results are compared in determining conformance with specifications.

1.2 This practice is intended to be used in determining conformance with specifications when the applicable ASTM specifications or standards make direct reference to this practice.

1.3 Reference to this practice is valid only when a choice of method has been indicated, that is, either *absolute method or rounding method*.

1.4 The system of units for this practice is not specified. Dimensional quantities in the practice are presented only as illustrations of calculation methods. The examples are not binding on products or test methods treated.

1.5 *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 appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E2282 Guide for Defining the Test Result of a Test Method
IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 *Definitions*—Terminology E456 provides a more extensive list of terms in E11 standards.

3.1.1 *observed value, n*—the value obtained by making an observation. **E2282**

3.1.2 *repeatability conditions, n*—conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time. **E177**

3.1.3 *repeatability standard deviation (s_r), n*—the standard deviation of test results obtained under repeatability conditions. **E177**

3.1.4 *significant digit*—any of the figures 0 through 9 that is used with its place value to denote a numerical quantity to some desired approximation, excepting all leading zeros and some trailing zeros in numbers not represented with a decimal point.

3.1.4.1 *Discussion*—This definition of significant digits relates to how the number is represented as a decimal. It should not be inferred that a measurement value is precise to the number of significant digits used to represent it.

3.1.4.2 *Discussion*—The digit zero may either indicate a specific value or indicate place only. Zeros leading the first nonzero digit of a number indicate order of magnitude only and are not significant digits. For example, the number 0.0034 has two significant digits. Zeros trailing the last nonzero digit for

[1] This practice is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.30 on Statistical Quality Control.

Current edition approved Jan. 1, 2019. Published January 2019. Originally approved in 1940. Last previous edition approved in 2013 as E29 – 13. DOI: 10.1520/E0029-13R19.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

numbers represented with a decimal point are significant digits. For example, the numbers 1270. and 32.00 each have four significant digits. The significance of trailing zeros for numbers represented without use of a decimal point can only be identified from knowledge of the source of the value. For example, a modulus strength, stated as 140 000 Pa, may have as few as two or as many as six significant digits.

3.1.4.3 *Discussion*—To eliminate ambiguity, the exponential notation may be used. Thus, 1.40×10^5 indicates that the modulus is reported to the nearest 0.01×10^5 or 1000 Pa.

3.1.4.4 *Discussion*—Use of appropriate SI prefixes is recommended for metric units to reduce the need for trailing zeros of uncertain significance. Thus, 140 kPa (without the decimal point) indicates that the modulus is reported either to the nearest 10 or 1 kPa, which is ambiguous with respect to the number of significant digits. However, 0.140 MPa clearly indicates that the modulus is reported to the nearest 1 kPa, and 0.14 MPa clearly indicates that the modulus is reported to the nearest 10 kPa.

3.1.5 *test result, n*—the value of a characteristic obtained by carrying out a specified test method. **E2282**

4. Significance and Use

4.1 This practice describes two commonly accepted methods of rounding data, identified as the Absolute Method and the Rounding Method. In the applications of this practice to a specific material or materials it is essential to specify which method is intended to apply. In the absence of such specification, reference to this practice, which expresses no preference as to which method should apply, would be meaningless. The choice of method depends upon the current practice of the particular branch of industry or technology concerned, and should therefore be specified in the prime publication.

4.1.1 The unqualified statement of a numerical limit, such as "2.50 in. max," cannot, in view of different established practices and customs, be regarded as carrying a definite operational meaning concerning the number of digits to be retained in an observed or a calculated value for purposes of determining conformance with specifications.

4.1.2 *Absolute Method*—In some fields, specification limits of 2.5 in. max, 2.50 in. max, and 2.500 in. max are all taken to imply the same absolute limit of exactly two and a half inches and for purposes of determining conformance with specifications, an observed value or a calculated value is to be compared directly with the specified limit. Thus, any deviation, however small, outside the specification limit signifies nonconformance with the specifications. This will be referred to as the *absolute method*, which is discussed in Section 5.

4.1.3 *Rounding Method*—In other fields, specification limits of 2.5 in. max, 2.50 in. max, 2.500 in. max are taken to imply that, for the purposes of determining conformance with specifications, an observed value or a calculated value should be rounded to the nearest 0.1 in., 0.01 in., 0.001 in., respectively, and then compared with the specification limit. This will be referred to as the *rounding method*, which is discussed in Section 6.

4.2 Section 7 of this practice gives guidelines for use in recording, calculating, and reporting the final result for test data.

5. Absolute Method

5.1 *Where Applicable*—The absolute method applies where it is the intent that all digits in an observed value or a calculated value are to be considered significant for purposes of determining conformance with specifications. Under these conditions, the specified limits are referred to as absolute limits.

5.2 *How Applied*—With the absolute method, an observed value or a calculated value is not to be rounded, but is to be compared directly with the specified limiting value. Conformance or nonconformance with the specification is based on this comparison.

5.3 *How Expressed*—This intent may be expressed in the standard in one of the following forms:

5.3.1 If the absolute method is to apply to all specified limits in the standard, this may be indicated by including the following sentence in the standard:

For purposes of determining conformance with these specifications, all specified limits in this standard are absolute limits, as defined in ASTM Practice E29, for Using Significant Digits in Test Data to Determine Conformance with Specifications.

5.3.2 If the absolute method is to apply to all specified limits of some general type in the standard (such as dimensional tolerance limits), this may be indicated by including the following sentence in the standard:

For purposes of determining conformance with these specifications, all specified (dimensional tolerance) limits are absolute limits, as defined in ASTM Practice E29, for Using Significant Digits in Test Data to Determine Conformance with Specifications.

5.3.3 If the absolute method is to apply to all specified limits given in a table, this may be indicated by including a footnote with the table as follows:

Capacity mL	Volumetric Tolerance[A] ± mL
10	0.02
25	0.03
50	0.05
100	0.10

[A] Tolerance limits specified are absolute limits as defined in Practice E29, for Using Significant Digits in Test Data to Determine Conformance with Specifications.

6. Rounding Method

6.1 *Where Applicable*—The rounding method applies where it is the intent that a limited number of digits in an observed value or a calculated value are to be considered significant for purposes of determining conformance with specifications.

6.2 *How Applied*—With the rounding method, an observed value or a calculated value should be rounded by the procedure prescribed in 4.1.3 to the nearest unit in the designated place of figures stated in the standard, as, for example, "to the nearest kPa," "to the nearest 10 ohms," "to the nearest 0.1 percent," etc. The rounded value should then be compared with the specified limit, and conformance or nonconformance with the specification based on this comparison.

6.3 *How Expressed*—This intent may be expressed in the standard in one of the following forms:

6.3.1 If the rounding method is to apply to all specified limits in the standard, and if all digits expressed in the specification limit are to be considered significant, this may be indicated by including the following statement in the standard:

The following applies to all specified limits in this standard: For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding method of ASTM Practice E29, for Using Significant Digits in Test Data to Determine Conformance with Specifications.

6.3.2 If the rounding method is to apply only to the specified limits for certain selected requirements, this may be indicated by including the following statement in the standard:

The following applies to specified limits for requirements on (tensile strength), (elongation), and (...) given in ..., (applicable section number and title) and (...) of this standard: For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded to the nearest 1 kPa for (tensile strength), to the nearest (1 percent) for (elongation), and to the nearest (...) for (...) in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

6.3.3 If the rounding method is to apply to all specified limits in a table, this may be indicated by a note in the manner shown in the following examples:

6.3.3.1 *Example 1*—Same significant digits for all items:

	Chemical Composition, % mass
Copper	4.5 ± 0.5
Iron	1.0 max
Silicon	2.5 ± 0.5
Other constituents (magnesium + zinc + manganese)	0.5 max
Aluminum	remainder

For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded to the nearest 0.1 percent, in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

6.3.3.2 *Example 2*—Significant digits not the same for all items; similar requirements:

	Chemical Composition, % mass min	max
Nickel	57	...
Chromium	14	18
Manganese	...	3
Silicon	...	0.40
Carbon	...	0.25
Sulfur	...	0.03
Iron	remainder	

For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded "to the nearest unit" in the last right-hand significant digit used in expressing the limiting value, in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

6.3.3.3 *Example 3*—Significant digits not the same for all items; dissimilar requirements:

	Tensile Requirements
Tensile strength, psi	60 000 to 72 000
Yield point, min, psi	33 000
Elongation in 2 in., min %	22

For purposes of determination of conformance with these specifications, an observed value or a calculated value shall be rounded to the nearest 1000 psi for tensile strength and yield point and to the nearest 1 percent for elongation, in accordance with the rounding method of ASTM Practice E29 Using Significant Digits in Test Data to Determine Conformance with Specifications.

6.4 *Rounding Procedure*—The actual rounding procedure[3] shall be as follows:

6.4.1 When the digit next beyond the last place to be retained is less than 5, retain unchanged the digit in the last place retained.

6.4.2 When the digit next beyond the last place to be retained is greater than 5, increase by 1 the digit in the last place retained.

6.4.3 When the digit next beyond the last place to be retained is 5, and there are no digits beyond this 5, or only zeros, increase by 1 the digit in the last place retained if it is odd, leave the digit unchanged if it is even. Increase by 1 the digit in the last place retained, if there are non-zero digits beyond this 5.

NOTE 1—This method for rounding 5's is not universally used by software packages.

6.4.4 This rounding procedure may be restated simply as follows: When rounding a number to one having a specified number of significant digits, choose that which is nearest. If two choices are possible, as when the digits dropped are exactly a 5 or a 5 followed only by zeros, choose that ending in an even digit. Table 1 gives examples of applying this rounding procedure.

6.5 The rounded value should be obtained in one step by direct rounding of the most precise value available and not in two or more successive roundings. For example: 89 490 rounded to the nearest 1000 is at once 89 000; it would be incorrect to round first to the nearest 100, giving 89 500 and then to the nearest 1000, giving 90 000.

6.6 *Special Case, Rounding to the Nearest 50, 5, 0.5, 0.05, etc.*—If in special cases it is desired to specify rounding to the nearest 50, 5, 0.5, 0.05, etc., this may be done by so indicating

[3] The rounding procedure given in this practice is the same as the one given in the *ASTM Manual 7 on Presentation of Data and Control Chart Analysis.*

TABLE 1 Examples[A] of Rounding

Specified Limit	Observed Value or Calculated Value	To Be Rounded to Nearest	Rounded Value to be Used for Purposes of Determining Conformance	Conforms with Specified Limit
Yield point, 36 000 psi, min	35 940	100 psi	35 900	no
	35 950	100 psi	36 000	yes
	35 960	100 psi	36 000	yes
Nickel, 57 %, mass, min	56.4	1 %	56	no
	56.5	1 %	56	no
	56.6	1 %	57	yes
Water extract conductivity, 40 ms/m, max	40.4	1 ms/m	40	yes
	40.5	1 ms/m	40	yes
	40.6	1 ms/m	41	no
Sodium bicarbonate 0.5 %, max, dry mass basis	0.54	0.1 %	0.5	yes
	0.55	0.1 %	0.6	no
	0.56	0.1 %	0.6	no

[A] These examples are meant to illustrate rounding rules and do not necessarily reflect the usual number of digits associated with these test methods.

in the standard. In order to round to the nearest 50, 5, 0.5, 0.05, etc., double the observed or calculated value, round to the nearest 100, 10, 1.0, 0.10, etc., in accordance with the procedure in 6.4, and divide by 2. For example, in rounding 6025 to the nearest 50, 6 025 is doubled giving 12 050 which becomes 12 000 when rounded to the nearest 100 (6.4.3). When 12 000 is divided by 2, the resulting number, 6000, is the rounded value of 6025. In rounding 6075 to the nearest 50, 6075 is doubled giving 12 150 which becomes 12 200 when rounded to the nearest 100 (6.4.3). When 12 200 is divided by 2, the resulting number, 6100, is the rounded value of 6075.

6.7 *Special Case, Rounding to the Nearest Interval Not Covered in 6.4 or 6.6*—In some test methods, there may be a requirement to round a value to an interval that does not align with the specific requirements in 6.4 or 6.6, such as to the nearest 0.02, 0.25, 0.3, etc. In such cases, the following procedure can be used for rounding to any interval:

NOTE 2—Using a calculation subroutine that has been programmed to perform the rounding procedure described in 6.7.1, 6.7.2, and 6.7.3 can be advantageous in evaluating laboratory data.

6.7.1 Divide the result by the desired rounding increment or interval.

6.7.2 Round the result obtained in 6.7.1 to the nearest whole number following the conventions in 6.4, 6.4.1, 6.4.2, and 6.4.3 as appropriate.

6.7.3 Multiply the result obtained in 6.7.2 by the desired rounding increment or interval.

6.7.4 For example, in rounding 0.07 to the nearest 0.02, dividing 0.07 by 0.02 gives a value of 3.5. Rounding this value to the nearest whole number gives a value of 4, based on the information in 6.4.3. Multiplying 4 by 0.02 yields 0.08. In rounding 0.09 to the nearest 0.02, dividing 0.09 by 0.02 gives a value of 4.5. Rounding this value to the nearest whole number gives a value of 4, based on the information in 6.4.3. Multiplying 4 by 0.02 yields 0.08.

7. Guidelines for Retaining Significant Figures in Calculation and Reporting of Test Results

7.1 *General Discussion*—Rounding test results avoids a misleading impression of precision while preventing loss of information due to coarse resolution. Any approach to retention of significant digits of necessity involves some loss of information; therefore, the level of rounding should be carefully selected considering both planned and potential uses for the data. The number of significant digits must, first, be adequate for comparison against specification limits (see 6.2). The following guidelines are intended to preserve the data for statistical summaries. For certain purposes, such as where calculations involve differences of measurements close in magnitude, and for some statistical calculations, such as paired t-tests, autocorrelations, and nonparametric tests, reporting data to a greater number of significant digits may be advisable.

7.2 *Recording Observed Values*—When recording direct measurements, as in reading marks on a buret, ruler, or dial, all digits known exactly, plus one digit which may be uncertain due to estimation, should be recorded. For example, if a buret is graduated in units of 0.1 mL, then an observed value would be recorded as 9.76 mL where it is observed between 9.7 and 9.8 marks on the buret, and estimated about six tenths of the way between those marks. When the measuring device has a vernier scale, the last digit recorded is the one from the vernier.

7.2.1 The number of significant digits given by a digital display or printout from an instrument should be greater than or equal to those given by the rule for reporting test results in 7.4 below.

7.3 *Calculation of Test Result from Observed Values*—When calculating a test result from observed values, avoid rounding of intermediate quantities. As far as is practicable with the calculating device or form used, carry out calculations with the observed values exactly and round only the final result.

7.4 *Reporting Test Results*—A suggested rule relates the significant digits of the test result to the precision of the measurement expressed as the standard deviation σ. The applicable standard deviation is the repeatability standard deviation. The rounding interval for test results should not be greater than 0.5 σ nor less than 0.05 σ, but not greater than the unit in the specification (see 6.2). When only an estimate, s, is available for σ, s may be used in place of σ in the preceding sentence. An alternative statement of the suggested rule is: Write down the standard deviation. Round test results to the place of the first significant digit in the standard deviation if the digit is two or higher, to the next place if it is a one.

Example:
A test result is calculated as 1.45729. The standard deviation of the test method is estimated to be, 0.0052. Round to 1.457 or the nearest 0.001 since this rounding unit, 0.001, is between 0.05 σ = 0.00026 and 0.5 σ = 0.0026.

NOTE 3—A rationale for this rule is derived from Sheppard's adjustment for grouping, which represents the standard deviation of a rounded test result by $\sqrt{\sigma^2 + w^2/12}$ where σ is the standard deviation of the unrounded test result and w is the rounding interval. The quantity $w/\sqrt{12}$ is the standard deviation of an error uniformly distributed over the range w. Rounding so that w is below 0.5 σ ensures that the standard deviation is increased by at most 1 %.

7.4.1 When no estimate of the standard deviation σ is known, then rules for retention of significant digits of computed quantities may be used to derive a number of significant digits to be reported, based on significant digits of test data.

7.4.1.1 The rule when adding or subtracting test data is that the result contains no significant digits beyond the place of the last significant digit of any datum.

Examples:
(*1*) 11.24 + 9.3 + 6.32 = 26.9, since the last significant digit of 9.3 is the first following the decimal place, 26.9 is obtained by rounding the exact sum, 26.86, to this place of digits.
(*2*) 926 − 923.4 = 3
(*3*) 140 000 + 91 460 = 231 000 when the first value was recorded to the nearest thousand.

7.4.1.2 The rule when multiplying or dividing is that the result contains no more significant digits than the value with the smaller number of significant digits.

Examples:
(*1*) 11.38 × 4.3 = 49, since the factor 4.3 has two significant digits.
(*2*) (926 − 923.4) ⁄4.3 = 0.6 Only one figure is significant since the numerator difference has only one significant digit.

7.4.1.3 The rules for logarithms and exponentials are: Digits of $ln(x)$ or $\log_{10}(x)$ are significant through the n-th place after the decimal when x has n significant digits. The number of significant digits of e^x or 10^x is equal to the place of the last significant digit in x after the decimal.

Examples:

$ln(3.46) = 1.241$ to three places after the decimal, since 3.46 has three significant digits. $10^{3.46} = 2900$ has two significant digits, since 3.46 is given to two places after the decimal.

7.4.1.4 The rule for numbers representing exact counts or mathematical constants is that they are to be treated as having an infinite number of significant digits.

Examples:

(*1*) $1 - 0.23/2 = 0.88$ where the numbers 1 and 2 are exact and 0.23 is an approximate quantity.

(*2*) A count of 50 pieces times a measured thickness 0.124 mm is $50 \times 0.124 = 6.20$ mm, having three significant figures.

(*3*) A measurement of 1.634 in. to the nearest thousandth, is converted to mm. The result, $1.634 \times 25.4 = 41.50$ mm, has four significant digits. The conversion constant, 25.4, is exact.

NOTE 4—More extensive discussion of dimensional conversion can be found in IEEE/ASTM SI 10.

7.5 *Specification Limits*—When the rounding method is to apply to given specified limits, it is desirable that the significant digits of the specified limits should conform to the precision of the test following the rule of 7.4. That is, the rounding unit for the specification limits should be between 0.05 and 0.5 times the standard deviation of the test.

7.6 *Averages and Standard Deviations*—When reporting the average and standard deviation of replicated measurements or repeated samplings of a material, a suggested rule for most cases is to round the standard deviation to two significant digits and round the average to the same last place of significant digits. When the number of observations is large (more than 15 when the lead digit of the standard deviation is 1, more than 50 with lead digit 2, more than 100 in other cases), an additional digit may be advisable.

7.6.1 Alternative approaches for averages include reporting $\bar{x}$ to within 0.05 to 0.5 times the standard deviation of the average $\sigma/\sqrt{n}$, or applying rules for retaining significant digits to the calculation of $\bar{x}$. ASTM Manual 7 provides methods for reporting $\bar{x}$ and s for these applications.[3]

NOTE 5—A rationale for the suggested rule comes from the uncertainty of a calculated standard deviation s. The standard deviation of s based on sampling from a normal distribution with n observations is approximately $\sigma/\sqrt{2n}$. Reporting s to within 0.05 to 0.5 of this value, following the rule of 7.4, leads to two significant digits for most values of σ when the number of observations n is 100 or fewer.

Example: Analyses on six specimens give values of 3.56, 3.88, 3.95, 4.07, 4.21, and 4.47 for a constituent. The average and standard deviation, unrounded, are $\bar{x} = 4.0233...$ and $s = 0.3089...$. The suggested rule would report $\bar{x}$ and s as 4.02 and 0.31.

8. Keywords

8.1 absolute method; conformance; rounding; significant digits; specifications; test data

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Illinois Department of Transportation

Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants
Appendix A.1

Effective: January 1, 1994
Revised: December 1, 2021

A. Scope

Quality Control Plans for Hot-Mix Asphalt (HMA) and Portland Cement Concrete (PCC) contracts normally require incoming aggregate to be checked for gradation compliance before use in HMA and PCC plants. Aggregate is produced to tight gradation bands at the source but will degrade during handling and shipment.

B. Purpose

Establish a procedure to modify aggregate source gradation bands to develop mix plant gradation bands for use in checking gradation compliance on incoming aggregate at mix plants. The mix plant gradation bands will also be used in checking gradation compliance for required stockpile gradation tests at the mix plant.

C. Aggregate Source Gradation Bands

The Contractor shall obtain certified aggregate gradation bands (including master band, if required) from the aggregate source for all certified aggregates prior to any shipment of material to a mix plant. Natural sand gradation bands shall be obtained from the appropriate District Materials Engineer.

D. General Procedure

The Contractor may modify the aggregate source gradation bands according to the following procedures, if necessary, to check incoming aggregate for gradation compliance at the mix plant. If not modified, the aggregate source gradation bands shall be considered the mix plant gradation bands when checking incoming aggregate.

1. Coarse Aggregate—The Contractor may shift the aggregate source master band a maximum of three percent (3%) upwards to establish a Mix Plant Master Band for each coarse aggregate used. All other aggregate source gradation bands, except for the top sieve and bottom sieve bands in the gradation specification, may also be shifted upward a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed, except as follows:

    At PCC plants, the Contractor may increase the specification limit for the minus No. 200 (75-µm) Illinois Modified AASHTO T 11 sieve material upwards one half percent (0.5%) if the No. 200 (75-µm) material consists of dust from fracture, or degradation from abrasion and attrition, during

Illinois Department of Transportation

Development of Gradation Bands on Incoming Aggregate at Hot-Mix Asphalt and Portland Cement Concrete Plants
Appendix A.1
(continued)
Effective: January 1, 1994
Revised: December 1, 2021

stockpiling and handling (reference Article 1004.01[b] of the Department's *Standard Specifications for Road and Bridge Construction*).

2. Manufactured Sand—All aggregate source gradation bands, except the top sieve and bottom sieve bands in the gradation specification, for each certified manufactured sand may be shifted upwards a maximum of three percent (3%). The top sieve and bottom sieve bands shall not be changed.

3. Natural Sand—The gradation bands obtained from the Department for each natural sand shall not be changed.

E. Department Approval

All aggregate source gradation bands and mix plant gradation bands must be sent to the District Materials Engineer for approval prior to any shipment of aggregate to the mix plant. Once approved, the mix plant gradation bands shall not be changed without approval of the District Materials Engineer.

Illinois Department of Transportation
QC/QA PROCEDURE
Procedure for Sample Comparison
Appendix A.5

Effective Date: November 10, 1997
Revised Date: December 1, 2023

Precision Comparison Table*
State Monitor vs. Producer

	Size Fraction Between Consecutive Sieves (%) †	*Tolerance (%)*
Coarse Aggregate:	0 to 3.0	2
	3.1 to 10.0	3
	10.1 to 20.0	5
	20.1 to 30.0	6
	30.1 to 40.0	7
	40.1 to 50.0	9
Fine Aggregate:	0 to 3.0	1
	3.1 to 10.0	2
	10.1 to 20.0	3
	20.1 to 30.0	4
	30.1 to 40.0	4

* Split Samples only (reported values)

† The State Monitor Sample shall be used to pick tolerances.

Comparison Method

Calculate size fraction between consecutive sieves, including cutter sieves, for both the State Monitor and Producer test results (% Passing).

Show the fraction retained between consecutive sieves for both gradations, the fraction difference on each consecutive sieve grouping between the Monitor and Producer gradation, the applicable tolerance (if coarse aggregate, use coarse aggregate tolerances and, if fine aggregate, use fine aggregate tolerances- If size fraction between consecutive sieves exceeds largest fraction shown, use tolerance for largest size fraction), and whether they are in-tolerance or out-of-tolerance.

Illinois Department of Transportation
QC/QA PROCEDURE
Procedure for Sample Comparison
Appendix A.5
(continued)
Effective Date: November 10, 1997
Revised Date: December 1, 2023

If the comparison has no out-of-tolerance fractions, both sample results are considered valid. If an out-of-tolerance situation has been identified, both the producer certified technician and the State inspector shall immediately investigate the splitting procedure, test equipment, test method, and calculations for possible equipment failure or procedure errors. The State Monitor Sample shall always take precedence unless shown to be invalid during investigation.

Example:

CA11	1" (25 mm)	3/4" (19 mm)	5/8" (16 mm)	1/2" (12.5 mm)	3/8" (9.5 mm)	1/4" (6.3 mm)	#4 (4.75 mm)	#16 (1.18 mm)	#200 (75 µm)
Monitor, % Passing	100	87	67	36	13	4	2	1	0.7
Producer, % Passing	100	89	67	44	14	5	3	2	1.3

Comparison Data

Consecutive Sieve Sizes	Monitor Fraction	Producer Fraction	Fraction Differenc	Applicable Tolerance	Disposition
1" and 3/4" (25 mm and 19 mm)	13	11	2	5	OK
3/4" and 5/8" (19 mm and 16 mm)	20	22	2	5	OK
5/8" and 1/2" (16 mm and 12.5 mm)	31	23	8	7	OUT
1/2" and 3/8" (12.5 mm and 9.5 mm)	23	30	7	6	OUT
3/8" and 1/4" (9.5 mm and 6.3 mm)	9	9	0	3	OK
1/4" and #4 (6.3 mm and 4.75 mm)	2	2	0	2	OK
#4 and #16 (4.75 mm and 111.18mm)	1	1	0	2	OK
#16 and #200 (1.18 mm and 75 µm)	0.3	0.7	0.4	2	OK
#200 and Pan (75 µm and Pan)	0.7	1.3	0.6	2	OK

GUIDELINE FOR COMPARISON

Example:

CM 11

If the comparison has no out-of-tolerance fractions, both sample results are considered valid. If an out-of-tolerance situation has been identified, both the producer certified technician and the State inspector shall immediately investigate the splitting procedure, test equipment, test method, and calculations for possible equipment failure or procedure errors. The State Monitor Sample shall always take precedence unless shown to be invalid during investigation.

Example:

CM11	1" (25 mm)	3/4" (19 mm)	5/8" (16 mm)	1/2" (12.5 mm)	3/8" (9.5 mm)	1/4" (6.3 mm)	#4 (4.75 mm)	#16 (1.18 mm)	#200 (75 µm)
Monitor, % Passing	**100**	**95**	**70**	**40**	**20**	**11**	**4**	**3**	**1.9**
Producer, % Passing									

Comparison Data

Consecutive Sieve Sizes	Monitor Fraction	Producer Fraction	Fraction Difference	Applicable Tolerance	Disposition
1" and 3/4" (25 mm and 19 mm)					
3/4" and 5/8" (19 mm and 16 mm)					
5/8" and 1/2" (16 mm and 12.5 mm)					
1/2" and 3/8" (12.5 mm and 9.5 mm)					
3/8" and 1/4" (9.5 mm and 6.3 mm)					
1/4" and #4 (9.5 mm and 4.75 mm)					
#4 and #16 (4.75 mm and 1.18mm)					
#16 and #200 (1.18 mm and 75 µm)					
#200 and Pan (75 µm and Pan)					

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Illinois Department of Transportation

Aggregate Laboratory Equipment
Appendix D.3

Effective: October 1, 1995
Revised: December 1, 2020

All equipment listed is required unless noted otherwise. This list recommends 12" sieves and 12" shakers. Individual needs may vary for the specific products. Eight-inch sieves and other alternate equipment may be substituted provided they conform to Illinois Test Procedure or ASTM requirements and are approved by the Engineer.

Quantity	Description
1	Mechanical Sieve Shaker – 8" and 12" sieve capacity
1	Coarse Aggregate Sample Splitter (Illinois Test Procedure 248, Method A)
4	Splitter Pans, for coarse aggregate
1	Fine Aggregate Sample Splitter (as required)
4	Splitter Pans, for fine aggregate
1	Sink and clear Water Supply
1	Oven, electric drying, capable of maintaining a uniform temperature of 110 ± 5 °C (230 ± 9 °F), (optional – see Hot Plate)
2	Hot Plate, electric, or burner, gas – in lieu of Oven, if approved by the Engineer
1	Gloves, pair, insulated
1	Balance, electronic, see Illinois Specification 101 for capacity and readability requirements
15	Sample Pans, (constructed to minimize loss of material during testing)
2	Spoon, stainless steel, 15 in. minimum
1	Brush, stencil
1	Brush, brass
1	Knife, putty
1	Thermometers, -18 – 150 °C (0 – 300 °F), readable to 0.5 °C (1.0 °F), to verify Oven temperature
1	Set (11) Fine Aggregate Sieves, brass, 8 in. or 12 in. diameter, with brass or stainless cloth, 9.5 mm, 4.75 mm, 2.36 mm, *2.00 mm, 1.18 mm, 600 mm, 425 mm, 300 mm, 180 mm, 150 mm, 75 mm (3/8 in., No. 4, No. 8, *No. 10, No. 16, No. 30, No. 40, No. 50, No. 80, No. 100, No. 200), according to ASTM E 11. *The 2.00 mm (No. 10) sieve required as needed.
1	Lid for 8 in. and 12 in. sieve
1	Pan, catch, bottom, 8 in. and 12 in.
1	Set (11) Coarse Aggregate Sieves, brass, 12 in. diameter, with brass or stainless cloth, 37.5 mm, 25 mm, 19 mm, 16 mm, 12.5 mm, 9.5 mm, 6.3 mm, 4.75 mm, 2.36 mm, 1.18 mm, 75 mm (1 1/2 in., 1 in., 3/4 in., 5/8 in., 1/2 in., 3/8 in., No. 4, No. 8, No. 16, No. 200), according to ASTM E 11
1	Additional 12 in. brass sieves are required for testing larger coarse aggregate (e.g., a 1 3/4 in. sieve is required for CA 5 testing)
1	Wash Sieve, 12 in. diameter, No. 200, recommended 3 1/4 in. nominal height*
1	Wash Sieve, 12 in. diameter, No. 16, recommended 3 1/4 in. nominal height*

* Distance from the top of the frame to the sieve cloth surface

Illinois Department of Transportation

Aggregate Laboratory Equipment
Appendix D.3
(continued)
Effective: October 1, 1995
Revised: December 1, 2020

VENDOR LIST – For Information Only

Dual Manufacturing Co., Inc.
3522 Martens St.
Franklin Park, Il 60131
Phone: 847-260-5370
info@dualmfg.com

Gilson Company, Inc.
P.O. Box 200
Lewis Center, OH 43035-200
Phone: 800-444-1508
sales@gilson.com
www.globalgilson.com

Humboldt Scientific, Inc.
875 Tailgate Road
Elgin, IL 60123
Phone: 800-544-7220
708-468-6300
Fax: 708-456-0137
www.humboldtmfg.com

Instro Tek, Inc.
1 Triangle Dr.
P.O. Box 13944
Research Triangle Park, NC 27709
Phone: 919-875-8371
Fax: 919-875-8328

McMaster-Carr
600 N. County Line Rd.
Elmhurst, IL 60126-2034
Phone: 630-833-0300
630-600-3600
www.mcmaster.com

Rainhart Company (An Instro Tek company)
P.O. Box 4533
Austin, Texas 78765
Phone: 800-628-0021
512-452-8848
www.rainhart@instrotek.com

VWR Scientific (Part of Avantor)
911 Commerce Ct.
Buffalo Grove, IL 60089
Phone: 847-229-0835
800-932-500

Illinois Department of Transportation

Illinois Specification 101
Minimum Requirements for Electronic Balances
Appendix D.5

Effective Date: April 1, 1999
Revised Date: December 1, 2021

Electronic balances for materials testing laboratories shall be top-loading, direct-reading, with specified minimum capacity and readability per the table below. Underhooks are required for hot-mix asphalt laboratories.

Purchasers are advised to specify balances that are manufactured according to AASHTO M 231. Laboratories may, at their option, provide additional balances that comply with each individual test procedure.

Note: Units—The values stated in metric units are to be regarded as standard. Within the text, English units are shown when commonly used and may not be an exact equivalent.

Minimum Requirements for Laboratory Balances

LAB TYPE	MINIMUM CAPACITY	READABILITY
AGGREGATE (AGCS, HMA, PCC)		
Moisture, Gradation, Specific Gravity		
Fine Aggregate	8 kg	0.1 g
Coarse Aggregate CA/CM 6 through	8 kg	0.1 g
20Coarse Aggregate CA/CM 1 through 5	12 kg	0.1 g
HOT- MIX ASPHALT 1/		
Volumetric Analysis		
Mix Design Labs	15 kg	0.1 g
QC, QA Labs	8 kg	0.1 g
Asphalt Content		
(Nuclear AB Gauge, Approved Solvent Extraction, or Ignition Furnace)	12 kg	0.1 g
PORTLAND CEMENT CONCRETE 1/		
Aggregate Moisture Content 2/	8 kg	0.1 g
Unit Weight 2/	4/	5/
Cylinder Strength Specimens 3/	4/	50 g

1/ Also requires Aggregate Balances
2/ The weighing equipment may be a balance or scale, and it does not have to be electronic.
3/ The weighing of the cylinder strength specimens prior to compressive strength testing is optional.
4/ Sufficient capacity
5/ A 20 g (0.05 lb) or smaller readability shall be required for unit weight measures and air meter measuring bowls which have a capacity less than 0.3 cu ft. A 50 g (0.1 lb) or smaller readability shall be required for unit weight measures which have a capacity greater than or equal to 0.3 cu ft.

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State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: July 27, 2023	6-08.8
This Policy Memorandum supersedes number 6-08.7 dated February 7, 2023	

TO: REGIONAL ENGINEERS AND HIGHWAY BUREAU CHIEFS
AGGREGATE, HOT-MIX ASPHALT (HMA), AND
PORTLAND CEMENT CONCRETE (PCC) PRODUCERS

SUBJECT: MINIMUM PRIVATE LABORATORY REQUIREMENTS FOR CONSTRUCTION MATERIALS TESTING OR MIX DESIGN

1.0 SCOPE

This policy governs the minimum qualifications for materials **Private Quality Control (QC)** and **Quality Assurance (QA) Laboratories** operated by **Contractors**, **Producers** and **Consultants**.

It applies to three categories of materials testing:

1. Aggregate (Agg)
2. Hot-mix asphalt (HMA)
3. Portland cement concrete (PCC)

Private Quality Control Laboratories shall be approved as one or more of the following laboratory types:

1. Agg QC
2. HMA/Agg QC
3. HMA Design/Agg QC
4. PCC/Agg QC
5. Jobsite PCC QC

Private Quality Assurance Laboratories shall be approved as one or more of the following laboratory types:

1. HMA /Agg QA
2. PCC/Agg QA

Qualified Private Laboratories are permitted to conduct **Acceptance Program** testing for localities such as counties, cities and municipalities. Note, however, that **Qualified Private Laboratories** are not permitted to perform **QC** (including mix design) and acceptance testing on the same project.

2.0 PURPOSE

1. To ensure that **Private QC and QA Laboratories** are equipped and maintained at a uniform and high level of quality.
2. To establish uniform procedures for evaluating and approving **Private QC and QA Laboratories**.
3. To maintain a uniform standard for inspecting test equipment and test procedures.

3.0 AUTHORITY AND REFERENCES

3.1 **Authority.** Federal regulations (23 CFR Part 637) require the **Department** to establish an **Acceptance Program** for qualifying construction testing laboratories.

3.2 **References.**

1. IDOT Standard Specifications for Road and Bridge Construction.
2. IDOT Manual of Test Procedures for Materials.
3. IDOT Bureau of Design and Environment Special Provisions for Hot-Mix Asphalt and Portland Cement Concrete.
4. AASHTO, ASTM, and IDOT Test Procedures.
5. Code of Federal Regulations (23 CFR Part 637).
6. Department Policy MAT-15, "Quality Assurance Procedures for Construction."
7. IDOT Bureau of Local Roads and Streets Manual

4.0 DEFINITIONS

AASHTO - American Association of State Highway and Transportation Officials.

AASHTO R 18 - The **AASHTO** Standard for "Establishing and Implementing a Quality System for Construction Materials Laboratories." The principles and/or requirements of **AASHTO R 18** are used by the **Bureau** to administer the **Qualified Laboratory** program for **District** and **Private Laboratories**.

AASHTO RE:SOURCE - Administrator of the Accreditation, Laboratory Assessment, and Proficiency Sample Programs for **AASHTO** (formerly the American Materials Reference Laboratory or AMRL). Re:source is part of the Engineering and Technical Services Division of **AASHTO**.

ACCEPTANCE PROGRAM – All factors that comprise the Department's determination of the quality of the product as specified in the contract requirements. These factors include verification (**QA**) sampling, testing, and inspection and may include results of **QC** sampling and testing.

ACCREDITED LAB - A laboratory that is currently accredited by the **AASHTO** Accreditation Program (AAP) or other accrediting body recognized by **FHWA**.

ASTM - American Society for Testing Materials.

ASTM C 1077 - The **ASTM** "Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation"

The principles and/or requirements of **ASTM C 1077** are used by the **Bureau** to administer the **Qualified Laboratory** program for **District** and **Private Laboratories**.

BUREAU - Central Bureau of Materials (CBM), Illinois **Department** of Transportation.

BUREAU LABORATORY - The **Department's** central laboratory maintained and operated by the **Bureau**. The **Bureau Laboratory** administers the **Qualified Laboratory** program for **District** and **Private Laboratories**.

CCRL – Cement and Concrete Reference Laboratory.

CONSULTANT - A private firm which performs construction materials testing for the **Department**, **Producer**, or **Contractor**. **Department** prequalification and **AASHTO** accreditation requirements apply where **Department** construction testing is performed directly for the **Department** under a **Department** contract or subcontract.

CONTRACTOR - The individual, firm, partnership, joint venture, or corporation contracting with the **Department** for performance of prescribed work.

DEPARTMENT - Illinois Department of Transportation (IDOT), including its **Districts** and Central Bureau offices.

DISTRICT - District office, Illinois **Department** of Transportation.

DISTRICT LABORATORY - A **Department** laboratory that is operated by a **District**.

FHWA - Federal Highway Administration.

FIELD TESTS - Tests that may be performed outside of a laboratory. For example, a portland cement concrete (PCC) or hot-mix asphalt (HMA) test performed at the jobsite.

INDEPENDENT ASSURANCE – Activities that are an unbiased and independent evaluation of all the sampling and testing (or inspection) procedures used in the quality assurance program. [*IA* provides an independent verification of the reliability of the acceptance (or verification) data obtained by the agency and the data obtained by the contractor. The results of *IA* testing or inspection are not to be used as a basis of acceptance. *IA* provides information for quality system management.] Policies and procedures contained in this memorandum are also an aspect of independent assurance.

LOCAL AGENCY - Governmental agency such as a county, city, or municipality.

NIST - National Institute for Standards and Technology.

PRIVATE LABORATORY - Any construction materials testing or design laboratory not operated by the **Department** or a **Local Agency**. This includes **Contractor**, **Producer**, or **Consultant** laboratories performing **Quality Control**, **Quality Assurance**, acceptance, **Independent Assurance**, or any other required or contracted testing on a **Department** project.

PRODUCER - An individual or business entity providing materials and/or products for performance of prescribed work.

QUALIFIED LABORATORY - A laboratory that is inspected and approved by the **Department**. FHWA's regulations (23 CFR 637.203) define these as *Laboratories that are capable as defined by appropriate programs established by each state transportation department. As a minimum, the qualification program shall include provisions for checking test equipment, and the laboratory shall keep records of calibration checks.*

QUALIFIED PERSONNEL - Personnel with demonstrated and documented capability to perform the applicable inspection and testing. The minimum requirement for aggregate, hot-mix asphalt or portland cement concrete testing is successful completion of the prescribed **Department** Quality Management Training Program classes. (Note: Additional personnel or experience requirements may apply to labs performing professional service work for the **Department**, e.g. Professional Engineer (P.E.) registrations, resumes, documented experience. When required, such notice will be provided in the prequalification process or solicitation notice.)

QUALITY ASSURANCE (QA) - All those planned and systematic actions necessary to provide adequate **Department** confidence that materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures; etc. will satisfy the requirements of the **Specifications**, **Quality Control Plan**, etc., as applicable.

QUALITY CONTROL (QC) - The sum total of activities performed by a **Producer**, **Contractor**, **Consultant**, **Manufacturer**, etc. to make sure materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures; etc. will satisfy the requirements of the **Specifications**, **Quality Control Plan**, etc., as applicable.

QUALITY ASSURANCE TESTING CONSULTANT – A Professional Engineering firm that is prequalified by the **Department** to perform field and/or laboratory tests for the **Department**. Required tests for **Quality Assurance Testing Consultants** are listed in Attachment A Table 2.

QUALITY ASSURANCE LABORATORY - Any laboratory used for **Quality Assurance** testing (**Department** tests) required by the **Department**. Required tests for **Quality Assurance Laboratories** are listed in Attachment A Table 2.

QUALITY CONTROL LABORATORY - Any laboratory used for **Quality Control** testing (**Contractor** or **Producer** tests) required by the **Department**. Required tests for **Quality Control Laboratories** are listed in Attachment A Table 1.

QUALITY CONTROL MANAGER - A **Consultant** or an employee of a **Contractor**, **Producer**, **Manufacturer**, etc. who is responsible for compliance with the **QC** requirements in a **Department** contract or policy.

STATE - The state of Illinois.

SPECIFICATIONS - Specifications for materials; manufactured, fabricated or constructed items; processes; products; designs; conducted test procedures, etc. which includes the **Standard Specifications**, supplemental specifications and recurring special provisions, highway standards, shop drawings, contract plans, project special provisions, **AASHTO Specifications**, **ASTM Specifications**, etc., as applicable.

STANDARD SPECIFICATIONS - The **Department's** Standard Specifications for Road and Bridge Construction.

TECHNICAL MANAGER - The individual with responsibility for the overall operations, condition, and maintenance of the **Private Laboratory**. The **Technical Manager** shall be identified in writing. The **Technical Manager** is not required to be the **QC Manager** defined in the contract. However, the **Technical Manager** shall be familiar with the **Quality Control** testing requirements and the specified equipment.

5.0 PRIVATE LABORATORY REQUIREMENTS

5.1 **Personnel Qualifications/Responsibilities.**

5.1.1 All testing for **Department** contracts shall be performed by **Qualified Personnel** as specified in the contract. This includes any testing related to **Quality Assurance**, **Quality Control** and **Independent Assurance**.

5.1.2 The **Department** will maintain a computer database of **Qualified Personnel** who have successfully passed the appropriate Quality Management Training Program classes.

5.2 **Facilities and Equipment.**

5.2.1 The **Department** will approve all **Private Laboratories** used on **Department** projects.

5.2.2 Each **Private Laboratory** shall maintain the equipment and facilities necessary to perform the tests required for each laboratory type it is approved for. Lists of required **Private Laboratory** test capabilities for each **Qualified Laboratory** type are provided in Tables 1 and 2 located in Attachment A.

5.2.3 Each **Private Laboratory** shall have adequate floor space to efficiently conduct the required tests for each laboratory type it is approved for. Minimum floor space requirements are provided under "Model Quality Control Plans" in Appendices B and C of the Manual of Test Procedures for Materials.

5.2.4 Each **Private Laboratory** shall have HVAC equipment capable of maintaining a room temperature of 20 to 30º C (68-86º F). A **Private Laboratory** that performs only aggregate gradation and/or aggregate moisture testing is exempt from this requirement.

5.2.5 Each **Private Laboratory** shall maintain, at a minimum, the required equipment for each laboratory type it is approved for as outlined in the appropriate appendix to the Manual of Test Procedures for Materials. Appendix D.3 applies to aggregate equipment, Appendix C.3 applies to portland cement concrete equipment, and Appendix D.4 applies to hot-mix asphalt equipment.

6.0 QUALITY SYSTEM CRITERIA

6.1 **AASHTO R 18 and ASTM C 1077.** Each **Private Quality Assurance Laboratory** shall maintain **AASHTO** accreditation for the required tests outlined in Attachment A Table 2 for each laboratory type it is approved for. The implemented quality system shall be according to **AASHTO R 18** for HMA/Agg labs, and **AASHTO R 18** and **ASTM C 1077** for PCC/Agg labs.

6.2 **Technical Manager.** Each **Private Laboratory** shall have a **Technical Manager** (however titled) who has overall responsibility for the technical operations of the **Private Laboratory**. The **Technical Manager** shall be responsible for equipment maintenance, calibration, standardization, verification and checks; maintaining records; and ensuring that current test procedures are utilized. If the **Private Laboratory** is prequalified in a Professional **Consultant** service category, a licensed Illinois Professional Engineer shall have direct supervision of the laboratory.

6.3 **Equipment Calibration, Standardization, Verification and Checks (C/S/V/C).** The **Private Quality Control Laboratory** shall calibrate, standardize, verify or check all testing equipment associated with tests performed for each laboratory type it is approved for according to Attachment A Table 3. The table also provides descriptive notes and links to forms that may be used to document lab equipment C/S/V/Cs. Heavy use or specific test requirements may require more frequent intervals than those given in Attachment A Table 3. **Department** verification of **Private Quality Control Laboratory** equipment shall not be construed as part of, or substitute for, equipment calibration, standardization, verification or check requirements, except for **Department** verification of the gyratory compactor using the DAV-2 and **Department** verification of the gyratory molds using the bore gauge.

The **Private Quality Assurance Laboratory** shall meet the requirements listed above for the **Private Quality Control Laboratory** for each laboratory type it is approved for. In addition, the **Private Quality Assurance Laboratory** shall calibrate, standardize, verify or check all equipment associated with the tests for which the **Private Quality Assurance Laboratory** is accredited according to **AASHTO R 18** and **ASTM C 1077**, as applicable.

6.4 **Department Proficiency Testing. Private Laboratory** qualifications may include round-robin proficiency testing conducted by the **Department**. Results of proficiency testing may be considered in the overall evaluation of the **Private Laboratory** to conduct specific tests.

6.5 **Records.**

6.5.1 Test Records. Each **Private Laboratory** shall maintain test records which contain sufficient information to permit verification of any test report.

6.5.2 Laboratory Quality Records. Each **Private Laboratory** shall maintain documentation of internal quality controls. At a minimum, the records shall include:

1. Documentation of assignment of personnel responsible for internal quality controls.
2. Documentation of equipment calibration, standardization, verification and checks.
3. All documentation shall be maintained and available for **Department** inspection for a period of three years.

6.5.2.1 Equipment Calibration, Standardization, Verification and Check Records. Calibration, standardization, verification and check records shall include the minimum information listed below. **AASHTO R 18** and **ASTM C 1077** provide additional guidance for recording calibration, standardization, verification and check records for testing equipment.

1. Description.
2. Model & Serial Number.
3. Name of person calibrating, standardizing, verifying or checking.
4. Equipment used for calibration, standardization, verification or checks (e.g., standard weights, proving rings, thermometers).
5. Date calibrated, standardized, verified, or checked & next due date.
6. Reference procedure used.
7. Results of calibration, standardization, verification or checks.

6.5.3 Proficiency Sample Records. Each **Private Laboratory** shall retain results of participation in any proficiency sample program, including the documentation of steps taken to determine the cause of poor results and corrective action taken.

6.6 **Publications.** Each **Private Laboratory** shall maintain current copies or electronic access to the required test procedures for each laboratory type it is approved for. Each **Private Laboratory** shall maintain a current copy or electronic access to the Manual of Test Procedures for Materials.

7.0 LABORATORY INSPECTIONS

7.1 **General.** The **Department** will approve **Private Quality Control** and **Quality Assurance Laboratories** by inspection and other requirements, as applicable.

7.1.1 Aggregate and Jobsite PCC **Private QC Laboratories**. Initial inspections and re-inspections will be performed by the District.

7.1.2 All Other **Private Laboratories**. Initial inspections are performed by the Bureau. Re-inspections are performed by the District.

7.1.3 Documentation review of a **Private Laboratory's** equipment calibration, standardization, verification and check records by the **Bureau** and resolution of any nonconformities is required prior to the initial **Bureau** inspection according to Subsection 7.4.4 for **Private Laboratories** seeking to become a **Quality Control Laboratory** or **Quality Assurance Testing Consultant**.

7.1.4 Initiation of the prequalification process with the Bureau of Design and Environment is required prior to initial **District** pre-inspection according to Subsection 7.4.3 and initial **Bureau** inspection according to Subsection 7.4.4 for **Private Laboratories** seeking to become a **Quality Assurance Testing Consultant.**

7.2 **AASHTO Accredited Private Quality Assurance Laboratories.**

7.2.1 Current **AASHTO** accreditation as well as providing **Departmental** access to the results of participation in the **AASHTO** Proficiency Sample Program is a prerequisite for beginning the prequalification process for a **Private Laboratory** to become a **Quality Assurance Testing Consultant**. Other prerequisites may be found in the prequalification instructions and forms. **AASHTO re:source** shall provide accreditation assessment for HMA/Agg **QA Laboratories**. **CCRL** shall provide accreditation assessment for PCC/Agg **QA Laboratories**. Instructions for providing the **Department** access to a **Private Laboratory's** Proficiency Sample Program results can be found in Attachment B.

7.2.2 **AASHTO** accreditation does not waive the right of the **Department** to conduct inspections and/or re-inspections.

7.3 **Initial Private Laboratory Inspection Scope.**

1. Facilities - Physical and environmental conditions.
2. Equipment - Test apparatus for specification compliance.
3. Documentation - Calibration, standardization, verification and check records.
4. Personnel - A review of **Qualified Personnel** credentials.
5. Observation - The **Private Laboratory** may be required to demonstrate required tests. Some test procedures, such as **Field Tests**, may be evaluated through discussion with laboratory personnel.
6. Report - The **Private Laboratory** will be provided with a report listing those tests for which it is approved. The report will note deficiencies.

7.4 **Initial Private Laboratory Inspection Procedure.**

7.4.1 The **Private Laboratory** shall submit a written request for an inspection to the **District**. The request shall indicate the following:

1. The location of the **Private Laboratory**.
2. The type of **Private Laboratory**, i.e., Agg QC, PCC/Agg QC, HMA /Agg QA, etc.
3. The name of the **Technical Manager** who will be present for the inspection.
4. The date the **Private Laboratory** will be ready for inspection.

7.4.2 The **District** will notify the **Bureau** of the inspection request and coordinate with the **Private Laboratory** to submit equipment calibration, standardization, verification, and check records to the **Bureau**. Once all record nonconformities are resolved, **Bureau** personnel will establish a tentative date to perform the inspection (see also Subsection 7.1.3).

7.4.3 The **District** will perform a pre-inspection approximately seven calendar days before the **Bureau** inspection. The **District** will verify that the **Private Laboratory** is ready for inspection and notify the **Bureau**.

7.4.4 **Bureau** personnel will perform the inspection and prepare a preliminary report. Standard inspection forms and a preliminary report, developed and maintained by the **Bureau Laboratory**, will be used.

7.4.5 **Bureau** personnel will assign identification numbers to all test equipment. Unless a **District** has an established numbering system, the following sequences will be used:

<u>Sieves</u>
e.g., IL07 -1418-01

where: IL = State

07 = inspection year
1418-01 = Producer/Supplier Number

Sieves are engraved on the inside of the bottom lip directly beneath the label. If a laboratory does not have a producer/supplier number, all sieves will be engraved with one number that follows the numbering system for HMA or PCC lab equipment, as appropriate.

HMA Equipment
e.g., IL07B1 - 123

where: IL = State
07 = inspection year
B = hot mix asphalt (bituminous)
1 = district number
123 = sequential numbers

PCC Equipment
e.g., IL07C1 - 123

where: IL = State
07 = inspection year
C = concrete
1 = district number
123 = sequential numbers

Note: The numbering system prior to 2007 was IL07-123 for HMA and IL07CND1-123 for PCC. The change was made to make the numbering system more uniform.

7.4.6 **Bureau** personnel will perform a close-out with the **Technical Manager** and the **District** representative. The **Technical Manager** and the **District** will be given a copy of the preliminary report.

7.4.7 If a review of the preliminary report indicates there are no deficiencies, the **Bureau** will provide written notification to the **Private Laboratory** indicating the **Private Laboratory** is now an approved **Quality Control** or **Quality Assurance Laboratory**. The notification will include an equipment list. A copy of the notification will be provided to the **District**.

7.4.8 If the preliminary report indicates there are deficiencies, the **Bureau** will provide written notification to the **Private Laboratory**, indicating the deficiencies and that corrective action is required. A copy of the written notification will be provided to the **District**.

7.4.9 After correction of all cited deficiencies, the **Private Laboratory** shall notify the **District**. The **District** will inspect the **Private Laboratory** to verify the deficiencies have been corrected and will notify the **Bureau** in writing.

7.4.10 The **Bureau** will provide written notification to the **Private Laboratory**, indicating the **Private Laboratory** is now an approved **Quality Control** or **Quality Assurance Laboratory**. The notification will include an equipment list. A copy of the written notification will be provided to the **District**.

7.4.11 Uncorrected deficiencies will not be waived. Equivalent equipment specifications may be approved only with the written approval of the **Bureau's** Engineer of Concrete, Soils, and Metals.

7.5 Initial Private Aggregate Quality Control Laboratory Inspection. For aggregate and Jobsite PCC **Private Quality Control Laboratories**, the procedures outlined in 7.4 shall be followed, except **District** personnel will perform the inspection instead of personnel from the **Bureau**.

7.6 Re-Approval of Approved Private Laboratories.

7.6.1 The re-inspection of **Private Laboratories** shall be conducted at intervals deemed appropriate by the **District**. The interval between inspections shall not exceed two calendar years. The **District's** evaluation may include the following:

1. Physical inspection of the laboratory facility and equipment.
2. Review of the **Private Laboratory's** internal quality plan and documentation in accordance with this policy and those parts of **AASHTO R 18** and **ASTM C 1077** incorporated by this policy.
3. Observations of tests performed by **Qualified Personnel**.
4. Results of split sample testing between the **Private Laboratory** and the **District**.
5. Results of proficiency sample testing programs conducted by the **Department**.
6. Overall past performance and experience.

7.6.2 The **District** may not waive any requirements for **Private Laboratories** or test equipment for required tests.

7.6.3 The **District** shall issue a letter of re-approval to the **Private Laboratory**, or provide a written and itemized deficiency list. The **Private Laboratory** shall notify the **District** when deficiencies are corrected and ready for re-inspection.

7.6.4 At any time, if the **District** identifies deficiencies in the facility, equipment, or test procedures that could affect the results of any **QC** or **QA** tests, the **District** will require the **Private Laboratory** to take immediate action to correct the deficiency.

8.0 EXEMPTIONS – AASHTO ACCREDITATION PROGRAM

If a **Private Laboratory** maintains current accreditation through the **AASHTO** Accreditation Program (AAP) for the appropriate test procedures, the **District** may waive the re-inspection requirements of this policy. To enact the waiver, the **Private Laboratory** shall provide copies of inspection reports and proficiency sample results to the **District**. This waiver does not apply to the initial inspection requirements, including the required equipment list.

9.0 LABORATORY DATABASE

The **Bureau** is responsible for maintaining a database that monitors the approval status of **Department and Private Laboratories**. Online queries and reports are available to the **Districts** to assist them in tracking **Qualified Laboratories**. The **Bureau** is responsible for updating the database with the approval status of **District Laboratories** and for entering the initial approval of **Private Laboratories**. The **District** shall be responsible for updating the approval status of **Private Laboratories** based on subsequent re-inspections. The **District** shall also be responsible for initial recording and updating the approval status of **Local Agency Laboratories**, Aggregate Only **Private Laboratories** and PCC Jobsite **Private Laboratories**. The database will include the following information:

1. Laboratory Codes (**Department**, **Producer**, etc.)
2. Responsible **District**
3. Type Laboratory (Agg QC, HMA/Agg QC, HMA Design/Agg QC, PCC/Agg QC, Jobsite PCC QC, HMA/Agg QA, or PCC/Agg QA)
4. Demographics (Address, etc.)
5. Date Inspected
6. Approval Status

10.0 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**.

TABLE 1
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE	PRIVATE QC LAB TYPE					
	Illinois Modified AASHTO (IL Mod.)	AGG	HMA QC	HMA DESIGN	PCC QC	Jobsite PCC QC	TITLE
AGGREGATE TESTS	IL Mod. R 90	✓	✓	✓	✓		Sampling of Aggregates
	IL Mod. T 11	✓	✓	✓	✓		Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
	IL Mod. T 19	✓[1]					Bulk Density ("Unit Weight") and Voids in Aggregate
	IL Mod. T 27	✓	✓	✓	✓		Sieve Analysis of Fine and Coarse Aggregate
	IL Mod. T 84	✓[2]					Specific Gravity and Absorption of Fine Aggregate
	IL Mod. T 85	✓[2]					Specific Gravity and Absorption of Coarse Aggregate
	IL Mod. R 76	✓	✓	✓	✓		Reducing Samples of Aggregate to Testing Size
	IL Mod. T 255	✓	✓	✓	✓		Total Evaporable Moisture Content of Aggregate by Drying

Note 1: Required for laboratories that test Air Cooled Blast Furnace Slag.

Note 2: Required for laboratories that run the Department's Slag Producers' Self-Testing Program

TABLE 1 (CONT'D)
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE		PRIVATE QC LAB TYPE		TITLE
	Illinois Modified AASHTO (IL Mod.)	Illinois Modified ASTM (IL Mod.)	HMA QC	HMA DESIGN	
HOT-MIX ASPHALT TESTS	IL Mod. T 30	-	✓	✓	Mechanical Analysis of Extracted Aggregate
	IL Mod. T 164	-	✓[3] or IL Mod. T 287 or IL Mod. T 308[4]	✓[3]	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	IL Mod. T 166	-	✓	✓	Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	IL Mod. T 209	-	✓	✓	Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	IL Mod. T 283	-		✓	Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	IL Mod. T 287	-	✓ or IL Mod. T 164 or IL Mod. T 308[4]		Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	IL Mod. T 308	-	✓ or IL Mod. T 164 or IL Mod. T 287[4]		Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	IL Mod. T 312	-	✓	✓	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
	-	IL Mod. D 2950	✓		Determination of Density of Bituminous Concrete in Place by Nuclear Methods – Field Test; not observed during Lab Inspection

Note 3: Method A or B shall be used for quantitative extraction. Method A or E shall be used to recover binder for qualitative analysis. If a QC HMA Mix Design laboratory does not have the ability to perform AASHTO T 164 (IL), outsourcing the test to a qualified QC or QA laboratory will be permitted.

Note 4: Determined by which piece of equipment is more appropriate for the lab to determine asphalt content.

TABLE 1 (CONT'D)
PRIVATE QUALITY CONTROL LABORATORY TESTS

	PROCEDURE		PRIVATE QC LAB TYPE		TITLE
	Illinois Modified AASHTO (IL Mod.)	Illinois Modified ASTM (IL Mod.)	PCC QC	Jobsite PCC QC	
PORTLAND CEMENT CONCRETE TESTS	IL Mod. R 39	-	Required if developing mix designs.		Making and Curing Concrete Test Specimens in the Laboratory
	IL Mod. R 60	-	✓	✓	Sampling Freshly Mixed Concrete
	IL Mod. R 100	-	✓	✓	Making and Curing Concrete Test Specimens in the Field
	IL Mod. T 22	-	✓[5] or IL Mod. T 177		Compressive Strength of Cylindrical Concrete Specimens
	IL Mod. T 119	-	✓	✓	Slump of Hydraulic Cement Concrete
	IL Mod. T 121	-			Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	IL Mod. T 152	-	✓	✓	Air Content of Freshly Mixed Concrete by the Pressure Method - Type A or B Air Meter
	IL Mod. T 177	-	✓[5] or IL Mod. T 22		Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	IL Mod. T 196	-			Air Content of Freshly Mixed Concrete by the Volumetric Method
	IL Mod. T 231	-	✓ or IL Mod. C 1231		Capping Cylindrical Concrete Specimens
	-	IL Mod. C 1064	✓	✓	Temperature of Freshly Mixed Hydraulic Cement Concrete
	-	IL Mod. C 1231	✓ or IL Mod. T 231		Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders

Note 5: For an exception to the strength testing requirement of performing compressive or flexural testing (Example: Labs at Concrete Producer Plants), refer to the Department's "Required Sampling and Testing Equipment for Concrete" document and check with District for approval of exception.

TABLE 2
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1,2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION Private QA Lab Type: HMA/Agg and PCC/Agg			TITLE
	Illinois Modified AASHTO/ AASHTO	ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
AGGREGATE	Mod. R 90 R 90	-	✓			Sampling of Aggregates
	Mod. T 11	-	✓			Materials Finer Than 75-µm (No. 200)Sieve in Mineral Aggregates by Washing
	T 11	-		✓	✓	
	Mod. T 19	-	✓			Bulk Density (“Unit Weight”) and Voids in Aggregate
	T 19	-		✓		
	Mod. T 27	-	✓			Sieve Analysis of Fine and Coarse Aggregates
	T 27	-		✓	✓	
	Mod. T 84[3]	-	✓			Specific Gravity and Absorption of Fine Aggregate
	T 84[3]	-		✓	✓	
	Mod. T 85[3]	-	✓			Specific Gravity and Absorption of Coarse Aggregate
	T 85[3]	-		✓	✓	
	Mod. R 76	-	✓			Reducing Samples of Aggregate to Testing Size
	R76	-		✓		
	Mod. T 255	-	✓			Total Evaporable Moisture Content of Aggregate by Drying
	T 255	-		✓		

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 3: Required for laboratories that run the Department’s Slag Producers’ Self-Testing Program.

TABLE 2 (CONT'D)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION – Private QA Lab Type: HMA/Agg			TITLE
	Illinois Modified AASHTO/ AASHTO	Illinois Modified ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
HOT-MIX ASPHALT	Mod. T 30	-	✓	✓		Mechanical Analysis of Extracted Aggregate
	T 30	-		✓	✓	
	Mod. T 164	-	✓			Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
	T 164	-		✓	✓	
	Mod. T 166	-	✓			Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
	T 166	-		✓	✓	
	Mod. T 209	-	✓			Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt Paving Mixtures
	T 209	-		✓	✓	
	Mod. T 283	-	✓			Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
	T 283	-		✓		
	Mod. T 287	-	✓[4]			Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
	Mod. T 308	-	✓[4]			Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
	T 308	-		✓[4]	✓	
	Mod. T 312	-	✓			Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
	T 312	-		✓	✓	
	-	IL Mod. D 2950	✓			Density of Bituminous Concrete in Place by Nuclear Method – Field Test

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 4: Requirement determined on case-by-case basis by District in which lab is located.

TABLE 2 (CONT'D)
REQUIRED TESTS – QUALITY ASSURANCE TESTING CONSULTANTS [1, 2]

	PROCEDURE		REQUIRED FOR PREQUALIFICATION			TITLE
			Private QA Lab Type: PCC/Agg			
	Illinois Modified AASHTO/ AASHTO/ Illinois Test Procedure (ITP)	Illinois Modified ASTM/ ASTM	IDOT QA	AAP On-Site Assessment	AAP Proficiency Sample Program	
PORTLAND CEMENT CONCRETE	-	C 192			✓	Making and Curing Concrete Test Specimens in the Laboratory
	Mod. R 60	-	✓			Sampling Freshly Mixed Concrete
	-	C 172		✓		
	Mod. R 100	-	✓			Making and Curing Concrete Test Specimens in the Field
	-	C 31		✓		
	Mod. T 22	-	✓			Compressive Strength of-Cylindrical Concrete Specimens
	-	C 39		✓	✓	
	Mod. T 119	-	✓			Slump of Hydraulic Cement Concrete
	-	C 143		✓	✓	
	Mod. T 121	-	✓			Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
	-	C 138		✓	✓	
	Mod. T 152	-	✓			Air Content of Freshly Mixed Concrete by the Pressure Method-Type A or B Air Meters
	-	C 231		✓	✓	
	Mod. T 177	-	✓			Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
	-	C 293		✓[5]		
	Mod. T 196	-	[6]			Air Content of Freshly Mixed Concrete by the Volumetric Method
	-	C 173		[6]	[7]	
	Mod. T 231	-	[6]			Capping Cylindrical Concrete Specimens
	-	C 617		[6]		
	-	Mod. C 1064	✓			Temperature of Freshly Mixed Hydraulic Cement Concrete
		C 1064		✓		
	-	Mod. C 1231	✓			Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders
		C 1231		✓		
	ITP 301		[6]			Fine Aggregate Moisture Content by the Flask Method
	ITP 302		[6]			Aggregate Specific Gravity and Moisture Content by the Dunagan Method
	ITP 303		[6]			Fine or Coarse Aggregate Moisture Content by Pycnometer Jar Method

Note 1: Compliance with IDOT test methods will be required for IDOT QA lab inspections. However, AASHTO re:source or CCRL lab inspections shall require compliance with the corresponding AASHTO or ASTM test methods.

Note 2: QA labs have the option to be HMA/Agg, PCC/Agg or HMA/PCC/Agg approved.

Note 5: The AAP on-site assessment is not required for Illinois type portable beam breakers but is required for all other types of beam breakers. Additional information regarding use of portable PCC labs and their approval is provided in Department Policy MAT-15, "Quality Assurance Procedures for Construction".

Note 6: Test equipment shall be presented during an inspection if the consultant lab has the ability to perform the test.

Note 7: Test shall be performed if consultant lab has the ability to perform the test.

TABLE 3
EQUIPMENT CALIBRATION, STANDARDIZATION, VERIFICATION AND CHECK SCHEDULE[1]

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
GENERAL			
General Purpose Balance and Scale	Commercial Service or Verification using Standardized NIST Traceable Masses	12	BMPR QCD01
Standard Masses	Standardize	60	Outside Calibration
Caliper	Standardize	12	BMPR QCD02
Micrometer	Standardize	12	BMPR QCD03
Oven	Standardize Thermometric Device	12	BMPR QCD04
Working Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD05
Reference Thermometer	Calibrate	60	Outside Calibration
Timer	Check Accuracy	12	BMPR QCD06
Caliper Checker or Gauge Blocks	Calibrate	60	Outside Calibration
AGGREGATE			
Mechanical Shaker	Check Sieving Thoroughness	12	BMPR QCD07
Agg. Unit Weight Measure	Standardize	12	BMPR QCD08
Conical Mold and Tamper	Check Critical Dimensions	24	BMPR QCD09
Coarse Sieves (Openings ≥ 4.75 mm)	Check Overall Physical Condition and Dimensions of Openings	12	BMPR QCD10 Calipers BMPR QCD11 Go/No-Go Gauges
Fine Sieves (Openings < 4.75 mm)	Check Overall Physical Condition	12	BMPR QCD12

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
HOT MIX ASPHALT			
Gyratory Compactor	Verify Angle[2], Pressure, and Height	Once a Month During Use	Manufacturer's Instructions[2]
	Verify Angle using a DAV-2	12	MTP Appendix B.19
Molds, Base Plates, and Ram Face	Check Critical Dimensions	12	BMPR QCD13
Tensile Strength Machine	Verification	12	ASTM E4
Ignition Furnace Balance	Commercial Service or Verification using Standardized NIST Traceable Masses	12	BMPR QCD01
Manometer and Vacuum Pump	Standardize and Check Pressure	12	BMPR QCD14
TSR Breaking Head	Check Critical Dimensions	12	BMPR QCD15
Pycnometer	Standardize Volume	12	CBM QCD16
Water Baths	Standardize	12	BMPR QCD17
Bore Gauge	Standardize	Each Use	IL Mod AASHTO T312
Master Ring	Calibrate	60	Outside Calibration
Hamburg Wheel Tracking Machine:			BMPR QCD18
Water Temperature	Verification	6	
Speed	Verification	12	
Wheel Weight	Verification	24	
LVDT'S	Verification	12	
I-FIT	Verify with Validator (Servo-hydraulic Machines only)	Once a Month During Use	See I-FIT Validator Lab Worksheet

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (MONTHS)	FORM AND/OR PROCEDURE
PORTLAND CEMENT CONCRETE			
PCC Unit Weight Measure	Standardize	12	BMPR QCD34 Unit Weight Bucket BMPR QCD35 Air Meter Bowl
Air Meter (Pressure Type)	Standardize	12 (Type A)	BMPR QCD36
	Standardize	3 (Type B)	BMPR QCD37
Air Meter (Volumetric Type)	Standardize	12	BMPR QCD38
Compression & Flexural Testing Machine	Verification	12	ASTM E4
Capping Material	Check Strength	3 or New Shipment	BMPR QCD39
Slump Cone	Check Critical Dimensions	12	BMPR QCD40
Beam Molds	Check Critical Dimensions	12	BMPR QCD41
Plastic Cylinder Mold 4 x 8	Check Dimensions	Each Shipment	BMPR QCD42
Plastic Cylinder Mold 6 x 12	Check Dimensions	Each Shipment	BMPR QCD43
Retaining Rings and Neoprene Pads	Check Critical Dimensions and Neoprene Pad Usage	12	BMPR QCD44
Metal Stem Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD45
Moist Room/Storage Tank Recording Thermometer or Max/Min Thermometer	Standardize with Calibrated NIST Traceable Reference Thermometer	12	BMPR QCD46

Note 1: See AASHTO R 18 for equipment calibration, standardization, verification and check terminology definitions.
Note 2: See Manual of Test Procedures Appendix B.19 for permissible verification procedures.

Instructions for Providing Departmental Access to Results of Participation in the AASHTO Proficiency Sample Program for Quality Assurance Testing Consultants

Consultants seeking to become prequalified as a **Quality Assurance Testing Consultant** shall be accredited by **AASHTO**. Participation in the **AASHTO** Proficiency Sample Program is one of the requirements for accreditation. **Consultants** who are accredited by **AASHTO** shall also allow the **Department** access to their Proficiency Sample Ratings as part of the prequalification process.

To allow the **Department** access to these data from **AASHTO re:source** provided proficiency samples, **Consultants** should go to the **AASHTO re:source** website (http://www.aashtoresource.org) and follow the instructions given below:

1. Log into your account and navigate to your home page.
2. Using the green vertical menu on the left side of the page, click “My Specifiers”
3. Click “Search for Specifiers” at the top of the page
4. Using the drop-down menu, select “Illinois” as the State, or type in “Illinois Dept. of Transportation”. A list of results should populate including the ILDOT option. It is important to type in the specifier name EXACTLY as shown or it won’t find the Illinois Department of Transportation.
5. Click the green “Request” button. Confirm that you want to send a request.
6. The samples to be made available to the **Department** (with unlimited time periods) for evaluation shall be taken from Attachment A Table 2 and need only correspond to the QA Lab Type(s) a **Consultant** is seeking prequalification for.

To allow the **Department** access to these data from **CCRL** provided proficiency samples, **Consultants** should contact **CCRL** directly for assistance.

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State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	7-08.4
This Policy Memorandum supersedes number 7-08.3 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: RECYCLING PORTLAND CEMENT CONCRETE INTO AGGREGATE

1.0 SCOPE

Section 1003 and 1004 of the Standard Specifications for Road and Bridge Construction includes “crushed concrete” as an acceptable source of aggregate material. Care must be taken, however, to assure that quality and gradation requirements are not compromised when recycled concrete is used in lieu of other aggregate materials. Concrete removal and crushed concrete stockpiling and handling must be performed in such a manner as to avoid contamination of the aggregate with dirt and foreign matter.

2.0 SAMPLING/TESTING PERSONNEL

All sampling and testing for gradation shall be conducted by an Aggregate Technician or Mixture Aggregate Technician, as designated in the Bureau of Materials Policy Memorandum, “Aggregate Gradation Control System (AGCS)”. Quality testing sampling, when specified shall be conducted by an IDOT Aggregate Inspector.

The overall program shall be administered by a Quality Control (QC) Manager, as designated in the AGCS.

3.0 GENERAL PROCEDURE

Acceptance of crushed concrete from jobsite recycling, or central recycling shall be according to 4.0 herein. Acceptance of returned Ready-Mix Concrete shall be according to 5.0 herein.

4.0 ACCEPTANCE AT JOBSITE OR CENTRAL RECYCLER

4.1 Acceptance of crushed concrete begins with approval of the raw feed stockpile. Crushed concrete used as raw feed at a central recycling plant or at a jobsite shall not be contaminated with soil or foreign matter. A small amount of soil embedded in the base of the concrete slab is acceptable. A small amount of construction debris, steel, fabric, wood from forms, and a small amount of RAP leftover from milling is also acceptable. Raw feed piles shall not have excavated soil, bricks, slabs of HMA pavement, or washout from concrete trucks. Previously approved crushed stone or crushed gravel from the jobsite is allowed but shall be limited to 25 percent of the total raw feed. Contamination in the stockpile area is as detrimental as contamination when picking up the broken concrete. The plant area, haul roads, and stockpile pads shall be properly maintained to assure that acceptable material is not contaminated prior to use.

4.2 Stockpiling, hauling, and loading shall conform to the AGCS.

4.3 Quality testing, when specified shall consist of one quality sample per every 10,000 tons (9,072 Metric tons) per specific gradation. The quality samples shall be taken from stockpiled material. Quality testing limits by use are specified below:

Aggregate Use	Illinois Modified AASHTO T 327* (% Loss)	Illinois Modified AASHTO T 96* (% Loss)
HMA Surface and Binder	15	40
Granular Embankment Special, Granular Subbase, Stabilized Subbase, Aggregate Base, Aggregate Surface, and Aggregate Shoulders		45
Aggregate Wedge Shoulders, Type B		45

Aggregate Use	IL Test Procedure 203* (% Deleterious)		
	RAP	OTHER	TOTAL
HMA Surface and Binder		2.0	2.0
Granular Embankment Special, Granular Subbase, Stabilized Subbase, Aggregate Base, Aggregate Surface, and Aggregate Shoulders	5.0	2.0	7.0
Aggregate Wedge Shoulders, Type B		2.0	2.0
Aggregate Subgrade Improvement**			10.0

* Found in the current Manual of Aggregate Quality Test Procedures

** This shall be performed with a visual of the Raw feed by the IDOT Aggregate Inspector. If disputed a sample of the finished product shall be sent to the Central Bureau of Materials for verification testing. Jobsite stockpiles that are for use on the same contract that the material originated from may be sent to a Central Recycler for crushing but must be kept separate from the other material to ensure no contamination takes place.

5.0 RECYCLED RETURNED READY-MIX CONCRETE

5.1 Portland Cement Concrete may be recycled by curing returned concrete either at the Concrete Mix Plant or at a Central Recycling Plant as outlined below:

5.1.1 Returned concrete shall be dumped on a clean stockpile area or concrete pad. A small amount of fines scattered on the pad prior to dumping the returned concrete, will assist in removal of the cured concrete.

5.1.2 No water shall be added to the returned concrete before dumping.

5.1.3 After the concrete truck is empty, it shall then proceed to a different area to "wash out". Wash out refers to the use of water and agitation to remove the ready-mix residue from the inside the ready-mix truck.

5.1.4 The returned concrete shall be cured for a minimum of 2 weeks to gain strength. Cured concrete is then broken up and placed in piles.

5.2 **Quality**. IDOT reserves the right to test this material for quality, as outlined in Section 4.3 herein, if contamination is present in the stockpile.

5.3 **Gradation**. Gradation sampling and testing shall comply with the Aggregate Gradation Control System. "Wash out" material may be mechanically blended with the returned concrete during aggregate production as long as the final product still meets the required gradation.

5.4 **Stockpiling**. Stockpiling, hauling, and loading shall comply with the Aggregate Gradation Control System. The plant area, haul roads and stockpile pads shall be properly maintained to assure that acceptable material is not contaminated prior to use.

6.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

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State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	11-08.7
This Policy Memorandum supersedes number 11-08.6 dated December 4, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

This program shall apply to all Sources that supply certified aggregate for uses identified in this program to projects let under the jurisdiction of the Illinois Department of Transportation (includes local agency projects with state/federal funding). All aggregate shipped for program-designated uses on these projects shall be from a Certified Source.

2.0 PURPOSE

2.1 To establish a procedure of certification whereby Sources shall supply aggregate for designated use meeting test properties cited by the Bureau.

2.2 To set forth the conditions for Source certification and revocation of certification.

3.0 DEFINITIONS

AGCS Technician – A technician at the Source who has successfully completed the Department's AGCS Technician Course. The AGCS training course is no longer available; however, there are still individuals that hold this title. This individual may perform all duties of the Aggregate Technician under the Gradation Control Program except gradation testing. Gradation testing (including splitting) must be performed by an Aggregate Technician or a Mixture Aggregate Technician.

Aggregate Inspector – District materials inspector who has successfully completed the Department's Aggregate Technician Course and is responsible for inspection at an aggregate Source. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, shall not be allowed to take any quality or Freeze-Thaw samples at an aggregate source.

Aggregate Technician – Sampling and testing technician at the Source who has successfully completed the Department's Aggregate Technician Course and is responsible for the Gradation Control Program at the Source. The Aggregate Technician course (CET 021) is a 5-day course, offered as a part of the IDOT Quality Management Training Program administered through Lake Land College in Mattoon, IL. https://www.lakelandcollege.edu/idot/idot-training-schedule/

Bureau – Bureau of Materials, Illinois Department of Transportation, Springfield, Illinois.

Department – Illinois Department of Transportation.

District – Materials Office located at each Illinois Department of Transportation highway district office.

Failing Gradation Sample – A gradation sample which, when tested, exceeds the established Master Band on the critical sieve and/or exceeds the specification ranges on the other sieves for that gradation.

Gradation Technician – A technician who has successfully completed the Department's Gradation Technician Course and is responsible only for splitting and testing gradation samples. The Gradation Technician shall be monitored on a daily basis by the Aggregate Technician. To become a Gradation Technician, contact the local IDOT Aggregate Inspector. The Gradation Technician Course is a ½ day course that is taught by IDOT District personnel and is not administered by Lake Land College.

Mechanical Blending – Blending for gradation or of different types of materials shall be through interlocked feeders or a blending plant such that the prescribed blending percentage is maintained throughout the blending process.

Mixture Aggregate Technician – A technician who has successfully completed the Department's Mixture Aggregate Technician course (CET 020) and is responsible only for gradation sampling and gradation testing. The Mixture Aggregate Technician course (CET 020) is a 3-day course, offered as a part of the IDOT Quality Management Training Program administered through Lake Land College in Mattoon, IL. https://www.lakelandcollege.edu/idot/idot-training-schedule/

Monitor Sample – Gradation sample taken from the Source, Terminal, Supplier Yard, or mix plant and tested by the Department to monitor the gradation being produced by the Source under its Gradation Control Program. This sample shall also be used to evaluate the adequacy of procedures and equipment used by the Source in its Gradation Control Program.

Outlying (OS) Source – A certified aggregate source located out-of-state which is specifically designated by the inspecting District and the Bureau and required to follow the requirements listed in Section 8.0 herein.

Qualified Products List (QPL) – The current Approved/Qualified Producer List of Aggregate Sources, maintained by the Department identifying aggregate sources certified to supply aggregate to Department/Local Agency projects.

Quality Control (QC) Manager – The Aggregate Technician or the AGCS Technician designated by the Source who shall be responsible for compliance with the requirements of the Aggregate Gradation Control System. The QC Manager shall have successfully completed the Department's Aggregate Technician Course or the AGCS Technician Course.

Source – Individual aggregate source, i.e., a specific quarry or pit location supplying a specific product or products.

Source Classification – Under this program, a **Source** will be classified as Certified, De-Certified, or Non-Certified.

Certified Source – A **Source** that has met the requirements for certification and is allowed to supply aggregate for Department/Local Agency projects.

De-Certified Source – A **Source** that has had its **Certified Source** status revoked because requirements warranting certification have not been maintained. A De-Certified Source shall not be allowed to supply aggregate to Department/Local Agency projects.

Non-Certified Source – A **Source** that does not initially meet certification requirements or has not applied for certification.

Source QC Plan – A QC Plan detailing how an **Outlying Source** will comply with the AGCS.

Standard Specifications – Current edition of the Illinois Department of Transportation Standard Specifications for Road and Bridge Construction.

Supplier Yard – A Yard which buys aggregate from an AGCS or IDOT-inspected source and resells the aggregate from the yard for use on IDOT contracts (includes local agency projects with state and or federal funding).

Terminal – A location owned by, leased to, or provided to an AGCS or IDOT-inspected source from which the source ships aggregate for use on IDOT contracts (includes local agency projects with state and/or federal funding).

4.0 GENERAL RESPONSIBILITIES

4.1 The Bureau shall maintain a **QPL** identifying **certified sources**. Only **Certified Sources** shall supply material to Department/Local Agency projects. Each **Certified Source** shall maintain its own Gradation Control Program unless producing Category IV aggregate only. Aggregate shipped from a **Certified Source** shall be certified to meet the quality and gradation requirements in the **Standard Specifications**. However, if approved by the District, the **Source** may choose to certify and supply other than standard **Department** gradations as established by the criteria in Article 6.2 herein.

4.2 A **Supplier Yard** shall meet the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived. The incoming aggregate sampling/testing shall be according to the current Department QC/QA document, Model Annual Quality Control (QC) Plan for Hot-Mix Asphalt (HMA) Production, Section B. Materials, 1. Aggregates, b. Incoming Aggregate Gradation Samples.

4.3 A **Terminal** shall meet all the requirements of the AGCS on all aggregates which will be used on IDOT contracts (including local agency with state/federal funding). Start-of-Production (6.3.1) and Normal-Production (6.3.2) sampling/testing shall be waived.

5.0 REQUIREMENTS FOR SOURCE CERTIFICATION

5.1 A Certified Source shall have been checked using the procedures set forth in Section 10.0 herein and found to meet the requirements for Source certification. Any Source subsequently found not meeting these or any other requirements of this program shall be removed from the **QPL** based on the procedure detailed in Section 11.0.

The requirements for Source certification are as follows:

5.1.1 Gradation Control Program - Gradation samples shall be taken and tested as per Section 6.0 herein. Gradations and their ranges established per Article 6.2 herein which do not meet the Standard Specifications shall be submitted to the District for approval prior to production.

5.1.2 Stockpiling and Handling - Degradation is of primary concern in handling aggregates. Steel-tracked equipment shall not be operated on stockpiles. Free-fall from conveyor equipment onto load-out stockpiles shall be held to a maximum of 15 feet. The fall height requirement may be waived if the aggregate source uses special remixing procedures or a device approved by the Bureau. A comparison of a series of samples taken during the reclaiming or loading-out operation to those taken from the production belt should be made to estimate the effect of the aggregate-handling method on degradation.

5.1.2.1 Stockpiling and handling of aggregate should be designed to hold segregation to a minimum. Coned stockpiles shall not be built with stationary or movable conveyor equipment unless the reclaiming method is such that the loaded-out material visually shows minimal segregation. Radial and longitudinal conveyors or stackers shall be kept in motion to reduce coning. Where possible, a spreader chute on the stacker shall be used to broaden or flatten the wedge shape of the pile. Cascading down the sides of the pile should be held to a minimum. Material shall be reclaimed from wedge-shaped piles with an end-loader or equipment having similar type loading action working from the end of the pile, with care taken to work the entire width of the pile to remix the material as much as possible. Aggregate-handling methods using tunnel conveyor systems to reclaim aggregate from coned surge piles shall be checked for consistency of gradation. The method of aggregate-handling and stockpiling currently in use at a particular Source shall be considered satisfactory provided that the product, when checked at a load-out point, meets the gradation requirements.

5.1.2.2 Materials certified under this program shall be stockpiled separately and identified by signs. Signs shall have a minimum of 3" lettering. Each individual sign shall be free-standing and moveable. Any changes made to signing must be pre-approved by the District.

5.1.3 Approved Laboratory - Laboratory facilities and equipment shall conform to Section 7.0 herein. Laboratories shall be checked by District personnel and reapproved on a biennial basis. One (1) laboratory may be used as an approved laboratory for more than one (1) Source as long as no problems occur in maintaining each Source's Gradation Control Program.

5.1.4 Sampling and Testing Personnel - Sampling and testing personnel overseeing the Source's control processes (including consultants and contractors) at the Source shall be Aggregate Technicians.

5.1.4.1 The Source may use an AGCS Technician to perform all duties of an Aggregate Technician except when splitting and gradation testing. When an AGCS Technician is used, splitting and gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician.

5.1.4.2 The Source may use Gradation Technicians for splitting and gradation testing only. The Gradation Technician shall be under the direct supervision of the Aggregate Technician when testing gradation samples. The Source may also use Mixture Aggregate Technicians for sampling and gradation testing only. The Mixture Aggregate Technician shall be under the supervision of the Aggregate Technician or the AGCS Technician.

5.1.4.3 The Aggregate Technician, Gradation Technician or Mixture Aggregate Technician, shall demonstrate gradation testing proficiency to the Aggregate Inspector on a quarterly basis.

5.1.4.4 Any Mixture Aggregate Technician qualified personnel, when performing sampling and testing for a HMA or PCC Contractor, shall not concurrently perform the duties of an Aggregate Technician, an AGCS Technician, or a Mixture Aggregate Technician in the AGCS.

6.0 GRADATION CONTROL PROGRAM

6.1 The Gradation Control Program shall be run by an Aggregate Technician or an AGCS Technician as defined in Section 3.0 herein. The QC Manager shall assume responsibility for compliance with the Aggregate Gradation Control System and specifically shall ensure that the Aggregate Technician, AGCS Technician, or Mixture Aggregate Technician is performing all the required duties under the Aggregate Gradation Control System.

6.2 All communication concerning the Aggregate Gradation Control System shall be directed to the QC Manager.

6.3 Primary duties of the Aggregate Technician shall include frequent visual inspection, gradation sampling and testing, documentation, etc., as detailed herein and in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities", located in the current Manual of Test Procedures for Materials.

6.4 The AGCS Technician may perform the same duties as the Aggregate Technician except splitting and gradation testing. Splitting and gradation testing shall be performed by an Aggregate Technician or a Mixture Aggregate Technician or a Mixture Aggregate Technician.

6.5 **Gradation Specifications.** Sieve limits for each sieve/each product under the Aggregate Gradation Control System shall be as specified in the Department's Standard Specifications and/or as amended herein. The special critical sieve criteria applies to designated products as described in QC/QA Procedure, "Aggregate Producer Control Chart Procedure" located in the current Manual of Test Procedures for Materials.

6.5.1 The midpoint/tolerance range of a designated critical sieve shall be developed from an average as shown in QC/QA Procedure, "Aggregate Producer Control Chart Procedure". The average shall be a historical average, or a start of production average derived from 5 start-of-production samples agreed to by the Department. All 5 start of production samples must pass the established critical sieve limit. Critical sieve limits will take precedence over Standard Specification limits. Requests for critical sieve limits shall be submitted in writing to the District Materials Engineer for approval.

6.5.2 The top and bottom sieves shall not be altered. For all other sieves, limits may be developed based on historical or start of production values. These sieve limits may be different from those in the Standard Specifications. These modifications are also allowed for fine aggregate. Changes in the top sieve or any No. 200 sieve ranges will not be permitted. In cases where the bottom sieve is other than the No. 200 sieve, a variance in limits may be granted if the Bureau determines the minus No. 200 material to be within acceptable limits. The Source shall request in writing to the District Materials Engineer approval of limits other than those in the Standard Specifications, but the range of the limits shall remain the same as the Standard Specifications except on critical sieves where critical sieve limits will take precedence. The agreed upon gradation limits shall apply at the final point of shipping within the Source's control.

6.5.3 The Department reserves the right to reject unacceptable material at any point prior to incorporation into the final product.

6.6 **Sampling and Testing**. Gradation samples shall be reduced to testing size by Illinois Modified AASHTO R 76. Minimum Field Sample Size and Minimum Test Sample Size shall be as noted in the Sample Size table, Illinois Specification 201. All sampling and gradation testing shall conform to Illinois Modified AASHTO R 90, Illinois Modified AASHTO R 76, Illinois Modified AASHTO T 11, and Illinois Modified AASHTO T 27. The Illinois Test Procedures noted above are located in the current Manual of Test Procedures for Materials.

6.6.1 Sampling and testing frequencies (including washed tests) by category/use shall be as noted in Table 1 herein.

Definitions of each frequency are as follows:

6.6.1.1 **Start-of-Production Frequency**. After a seasonal shutdown of production or when first producing a new product, the sampling and testing of start-up production or of the new product shall be at start-of-production frequencies/requirements noted in Table 1.

6.6.1.2 **Normal-Production Frequency**. During normal production, the minimum production sampling and testing frequency/requirements as noted in Table 1 shall be maintained.

6.6.1.3 **Stockpile Frequency**. During loadout of stockpiles, the minimum stockpile sampling and testing frequency/requirements as noted in Table 1 shall be maintained for each stockpile.

6.6.1.4 **Production Changes (Short-Term Shutdowns for Screen Changes, Crusher Modifications, Different Feed Rates, New Products, etc.)**. If a production change is made, a washed gradation sample shall immediately be run on all affected products. The start-of-production sampling frequency shall be implemented if the result on any critical sieve in that sample exceeds the warning bands on the critical sieve or if any results fail any specified sieve limits.

6.7 **Documentation**. Gradation results shall be charted on control charts, if required in Table 1, according to QC/QA Procedure, "Aggregate Producer Control Chart Procedure", located in the current Manual of Test Procedures for Materials. Within one (1) working day of sampling, all gradation results shall be charted, posted, or entered into a Source computer, each of which shall be located at the Source and/or approved laboratory, at the District's option. Computer-maintained charting must be approved by the Department and accessible in a timely manner during any Department inspection. Computer-maintained charts shall be printed and displayed once per week or at the request of the Department. Control charts are the property of the Department and shall not be removed or altered in any manner. The Aggregate Inspector will check the control charts on a regular basis. Source gradation computation sheets will be maintained by the Department for a minimum of three (3) years after the date run.

6.7.1 A Source diary shall be maintained by the Aggregate Technician or the AGCS Technician. The Aggregate Technician or the AGCS Technician shall log all actions taken during the production day, such as new product production, sampling, resampling, screen changes, separate stockpiling, visual inspections, etc., as noted in QC/QA Procedure, "Quality Control (QC) Manager / Aggregate Technician / AGCS Technician / IDOT Inspector / Gradation Technician Responsibilities" in the current Manual of Test Procedures for Materials.

6.7.2 The Source shall immediately notify the District whenever new products are being produced at the Source under its Gradation Control Program.

6.8 **Failing Gradation Samples**. Any Failing Gradation Sample (start-of-production, normal-production, or stockpile) shall be evaluated according to the following procedure and, if necessary, immediate action taken to correct a failing gradation.

6.8.1 If a gradation sample fails, one (1) resample from the same sampling location shall immediately be taken and tested. If the resample passes, the testing frequency being run prior to the failure shall be resumed. If the resample fails, a second resample shall immediately be taken.

6.8.2 If the second resample passes, the start-of-production sampling frequency shall be initiated. All samples in the series must pass before the normal production or stockpile sampling frequency for that location can be restarted.

6.8.3 If the second production resample fails, production of that specified aggregate shall not be incorporated in the approved stock, or, in the case of the second stockpile resample failing, shipment from that stockpile shall cease. Corrective action shall be initiated by the Source. No material shall be placed on or, in the case of stockpile problems, shipped from the certified stock until a passing gradation sample is taken and tested. The start-of-production frequency shall then be run at that location. All samples in the series must pass before the normal-production or stockpile sampling frequency for that location can be restarted.

6.8.4 All resamples shall be washed gradation tests except as stated under Note 2 in Table 1.

6.8.5 Any action taken, such as resampling, screen changes, separate stockpiling, etc., shall be noted in the remarks area of the failing test computation sheet and in the Source diary.

6.8.6 The Aggregate Technician or the AGCS Technician shall monitor the corrective action. Failure to comply with Section 6.8 herein shall cause the **Source** to be removed from the **QPL** as per Section 11.0 herein.

6.9 **Failing Monitor Gradation Samples**. Any **Source**'s failing Monitor gradation sample taken and tested by the Department and determined to be a Source problem per Section 9.6 will be considered a Failing Gradation Sample under the Source's Gradation Control Program and shall cause the Source to enact Section 6.8 herein.

7.0 APPROVED LABORATORY

7.1 An approved Source laboratory shall have the required equipment or alternatives approved by the Bureau specified in the Appendix D3 "Aggregate Laboratory Equipment" in the current Manual of Test Procedures for Materials.

7.2 If a mixture QC laboratory is used for AGCS testing, the following additional equipment is required for use only on AGCS aggregate samples:

- One set of nested sieves for coarse and/or fine aggregate.
- One set of wash sieves.
- One coarse and/or fine aggregate splitter.

8.0 OUTLYING (OS) SOURCE REQUIREMENTS

8.1 Each district may designate a certified aggregate Source located out-of-state which shall follow specific requirements in running the AGCS, listed herein. The District shall detail the criteria used to qualify the Source for the Outlying designation. The Source QC plan tentatively approved by the District shall accompany the District request.

8.1.1 The **Bureau** shall notify the District Materials Engineer in writing as to whether the aggregate **Source** has met the Outlying criteria, the **Source QC Plan** is acceptable, and the **Source** will be designated as an **Outlying (OS) Source** and placed on the **QPL**.

8.2 The **OS Source** shall follow all requirements of the AGCS program unless otherwise noted within this section. A **Source QC Plan** shall be submitted for department approval to the inspecting **District**. Other states' QC/QA programs or parts thereof may be substituted for the Illinois AGCS program, if approved by the **Bureau**. All substitutions/ changes shall be noted in the **Source QC Plan**. The minimum sampling frequencies noted in the Illinois AGCS program shall be met regardless of frequencies listed in the other state programs.

8.3 The **District** will, at least annually, visit each Source to obtain quality and gradation samples, observe program procedures, and inspect the AGCS laboratory. Laboratory inspections conducted under other states' programs may be used if the **OS Source** has been approved to use the other states' QC/QA program.

8.3.1 These inspections may be unannounced.

8.4 The **District** will inspect, sample, and test incoming aggregate according to the specified AGCS monitor frequency at Illinois sites (job sites, mix plants, terminals, or supplier yards). Split sample, load-out, and comparison requirements noted in Section 9 herein will be waived.

8.4.1 The **District** will communicate the test results to the **QC Manager** at the aggregate **Outlying Source** (OS) for appropriate action, including any needed corrective action. In addition, the District will communicate the test results to any **QC Manager** or Resident Engineer at the jobsite, mix plant, terminal, or supplier yard, for appropriate action, including the need for corrective action.

8.5 **Outlying Sources** shall notify their inspecting **District** of all scheduled AGCS shipments/ production (including shipments to mix plants, terminals, and supplier yards) prior to the shipment/production.

8.6 Once designated as an **Outlying Source** (OS), all aggregate, including Category I, III, and IV, shipped to Illinois Department of Transportation projects (including all Local Agency projects) shall be produced under the AGCS program. Category IV shall be run at the Category III frequency.

9.0 DEPARTMENT RESPONSIBILITIES

9.1 Sampling and testing for quality shall remain the responsibility of the Department. A Consultant, hired by the Department to perform the duties of an Aggregate Inspector, will not be allowed to take any quality or Freeze-thaw samples at an aggregate **Source**.

9.2 Monitor gradation samples at the **Source** shall be taken, by or in the presence of an Aggregate Inspector, from each aggregate being produced for designated use at each Certified **Source**. All Monitor samples shall be split samples of a **Source's** gradation sample taken as per the **Source's** Gradation Control Program. Additionally, the Department reserves the right to sample Monitor samples at any time. At least two (2) out of every five (5) Monitor samples shall be taken from the stockpile's loadout face once loadout procedures have started. The Monitor samples will be tested by District personnel on Department testing equipment according to the first paragraph of Section 6.3 herein. All Monitor samples shall be washed gradation tests unless Note 2 in Table 1 is applicable. Each Monitor sample shall be identified as to sampling location.

9.3 Sampling and testing frequency for the Monitor gradation samples shall be a minimum of one (1) sample per every twenty (20) production days for each gradation being produced for designated use.

9.4 All Monitor gradations run will be reported in the MISTIC system. Computation sheets will be retained for a minimum of three (3) years in the Department's **Source** file.

9.5 The Inspector will compare both the Monitor sample and the Source's split sample for validity as defined by the Department's "Guideline for Sample Comparison" (see Appendix A of the current Manual of Test Procedures for Materials). The reason for any significant difference between the two (2) samples shall be identified and corrected.

9.6 All Monitor gradations will be communicated to the **QC Manager**. All failing monitor gradations will be investigated by the Department. Any failing gradations, which are determined to be a **Source** problem not already corrected by the Producer, shall cause Article 6.6 herein to be enacted by the **Source**. The Aggregate Inspector will compare the failing gradation to the **Source's** control charts and/or split sample computation sheet. If the control chart indicates that the **Source** is aware of the problem and is taking corrective action, normal Monitor sampling may resume. The Aggregate Inspector will continue to visually monitor the problem and the **Source's** corrective action. If the control chart indicates the **Source** is not aware of the problem, a split sample of the **Source's** next sample as specified in Article 6.5 shall be tested. Failure of the **Source** to follow Article 6.6 shall result in the **Source** being removed from the **QPL** per Section 11.0 herein.

10.0 SOURCE CERTIFICATION PROCEDURE

10.1 An aggregate **Source** wishing to become certified shall verbally contact the **District**. A preliminary meeting may be held to discuss requirements of the program. After the initial contact or the preliminary meeting, a written request for certification shall be submitted to the District Materials Engineer.

10.2 An evaluation team composed of two (2) **District** personnel shall conduct an inspection of the **Source** for compliance to the certification checklist for all **Sources** producing Category I and III aggregate. A formal meeting with the **Source's** management, **QC Manager**, and quality control personnel shall be held to discuss the **Source's** Gradation Control Program requirements. The **Source** shall submit a certification letter and an Aggregate Shipping Tickets Information Form for Producers (BMPR AGG01) as designated by the **Department**. Each **Source** shall provide and maintain their own quality-on-tickets form and a listing of current certified gradations being produced under the Aggregate Gradation Control System. The certification letter and the Aggregate Shipping Tickets Information Form for Producers Form (BMPR AGG01), shall be forwarded to the **Bureau** before the **Source** will be added to the **QPL**.

10.3 Each **Certified Source** will be reevaluated on a biennial basis by **District** personnel. The reevaluation shall be a complete evaluation of the **Source's** laboratory and technician(s). A copy of the reevaluation checklist and comments shall be forwarded to the **Bureau**. Failure to comply with the certification criteria will result in the **Source's** certification being revoked as per the procedure detailed in Section 11.0 and the **Source** will be classified as De-Certified and removed from the **QPL**.

10.4 If at any time a **Certified Source** does not maintain the proper QC personnel, the **Source** will be given thirty (30) days to comply by either hiring a new QC person, training existing personnel or by contracting with a qualified consultant. If after thirty (30) days the source does not have the proper QC personnel; the **Source's** Certification will be revoked by the **Bureau**. Section 11.0 will not apply to this type of Revocation. The **Source** will be reinstated on the **QPL** once the proper QC personnel are acquired.

10.4.1 As an option to this type of Revocation, a **Source** may utilize a Gradation Technician for gradation testing as long as the following criteria are met:

- The **Source** shall inform the district, in writing, of the QC personnel change.

- The **Source** shall have an **Aggregate Technician** visit the **Source** a minimum of three (3) times a day to oversee the **Gradation Technician**.
- The **Source** shall have the proper personnel trained and in place in a timeframe acceptable to the **Bureau**.

11.0 REVOCATION OF A SOURCE'S CERTIFICATION

11.1 The **Department** may revoke a **Source's** Certification for any of the following reasons:

- Failing to follow the procedures and requirements of the Aggregate Gradation Control System (AGCS) Policy Memorandum.
- Misrepresentation of materials or products.
- Failing to follow the approved **Quality Control Plan**.

11.2 Before removal, the District Materials Engineer will detail, in a non-conformance letter to the **Source's QC Manager**, reason/s the **Department** is seeking to revoke the **Source's** Certification. The **Source** will have two weeks to reply. The **Source** shall not place materials in question on certified stockpiles during the two-week period. If the **Department's** reasons warrant, the **Source** may be required to stop shipment of any and all products to **Department** and/or Local Agency projects.

11.3 Within this two-week period, the **Source's QC Manager** shall reply provide a written response outlining the steps the Source is taking to address the issues outlined in the **Department's** non-conformance letter.

11.4 After receipt of the **Source's** letter, the **District** will schedule a meeting with the **Source** to discuss the proposed revocation and the **Source's** response. Based on this meeting, the District Materials Engineer will either (1) conclude the steps taken by the **Source's QC Manager** are adequate and terminate the revocation process, or (2) conclude the **Source's** response does not adequately address the issues outlined in the **Department's** non-conformance letter and recommend in writing to the **Bureau** that the **Source** be taken off the **QPL**. The recommendations shall include details and **District/Source** comments concerning the proposed revocation. Copies of all correspondence, including meeting minutes, shall be sent to the **Bureau** and the **Source**.

11.5 If requested by the **Source** within seven days of the **District's** recommendation to revoke the Certification, the **Bureau** will schedule a meeting with the **Source's QC Manager** and the **District**. Based on this meeting, the **Bureau** will either terminate the revocation process or proceed with removing the **Source** from the **QPL**.

11.6 The **Bureau's** decision to revoke the **Source's** Certification is a final agency decision of the Illinois Department of Transportation.

11.7 The **Bureau** will notify the District Materials Engineer and **Source** in writing when a **Source's Certification** has been revoked and that the **Source** has been removed from the QPL and has been listed as a **De-Certified Source**. The **Source** shall not supply aggregate materials or products for **Department** and/or Local Agency projects until the **Source's Certification** has been reinstated on the **QPL**.

11.8 If the revocation process is not based on misrepresentation of materials or products, and/or failure to follow the overall general requirements of this policy, the **QC Manager**, at any time, may inform the **District** in writing that the **Source** is no longer producing or shipping a specific gradation. This action will terminate any revocation process against the **Source** concerning the materials in question. Production of that gradation for the AGCS shall not be restarted unless the **District** concurs that corrective action has been completed by the **Source**.

12.0 REINSTATEMENT OF A SOURCE'S CERTIFICATION

The **Source** may re-apply for reinstatement of its certification at the end of the revocation period. Re-application shall be in writing to the **Bureau** and include the specific steps to be taken to correct the cause for loss of certification.

13.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the **Bureau**.

TABLE 1

Category	Use	Start of Production	Normal Production	Stockpile/ Loadout	Control Charts	Master Band
I (Notes 1 & 5)	Coarse Aggregate and Manufactured Sand Used in HMA and PCC Coarse Aggregate for Pavement Drainage	1 per 1,000 T (907 metric tons) for the first 5,000 T (4,536 metric tons) (all wash)	1 per 2,000 T (1,814 metric tons) 2 per day max (wash 1/3 coarse agg.) (wash all manufactured sand)	2/week (all wash) (Note 3)	Yes	Yes (Note 8)
III (Notes 1 & 5)	Natural Sand for All PCC and HMA Projects Aggregate Surface Course Granular Shoulders Granular Sub-base Granular Base Granular Embankment Special Cover/Seal Coat Sand Bedding Porous Granular Embankment and Bedding, Sand Backfill for Underdrains French Drains Membrane Waterproofing Mortar Sand Blotter Granular Embankment Aggregate Subgrade (Note 9)	1 per 2,000 T (1,814 metric tons) for the first 4,000 T (3,629 metric tons) (all wash) (Note 2)	1 per 10,000 T 2 per day max 1 per week min (all wash) (Notes 2 & 6)	1/week (all wash) (Notes 2 & 7)	No	No

Table 1 (cont.)

Category	Use	Start of Production	Normal Production	Stockpile/ Loadout	Control Charts	Master Band
IV (Note 4)	Rock Fill Erosion and Sediment Control Rip-Rap Bedding Ice Control Abrasives Trench Backfill	Department Testing				

Note 1: A producer may adjust gradation bands for any product in accordance with Article 6.2 of the AGCS.

Note 2: Wash only products used for HMA, PCC, Seal/cover coat and products with # 200 sieve requirements.

Note 3: No loadout tests for quantities under 500 tons (454 metric tons) or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 500 tons (454 metric tons), a loadout sample shall be run.

Note 4: Testing to be performed by IDOT personnel.

Note 5: Testing frequency may be reduced based on conformance to QC requirements, consistency in meeting sieves' midpoints, statistical consistency, etc.

Note 6: Minimum of 1 per week after the first 10,000 tons (9,072 metric tons) of production per week for aggregate surface course, granular shoulders, granular subbase, granular base, and granular embankment special; minimum of 1 every 2 weeks if production less than 10,000 tons (9,072 metric tons) per 2-week period.

Note 7: No loadout tests for quantities under 1,000 tons (907 metric tons) or less shipped weekly. When loadout occurs but no weekly loadout test is run, the tonnage shipped shall be accumulated from the start of that week. When the accumulated tonnage exceeds 1,000 tons (907 metric tons), a loadout sample shall be run.

Note 8: Refer to current QC/QA Procedure, "Aggregate Producer Control Chart Procedure" for required gradation.

Note 9: Only Normal Production testing shall apply. No Wash.

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 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

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.

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.

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.

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.

Coarse Aggregates Art. 1004.03

<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="5">HMA
High ESAL</td><td rowspan="5">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></td><td></td><td>75% Limestone</td><td>Crushed Slag (ACBF) or Crushed Sandstone</td></tr>
</table>

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.

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.

App B – Aggregate “BDE” and “Policy Memorandums”

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This Page is Reserved

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: July 24, 2018	9-08.2
This Policy Memorandum supersedes numbers 9-08.1 dated June 1, 2012	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: CRUSHED SLAG PRODUCER CERTIFICATION

1.0 INTRODUCTION

The Central Bureau of Materials has recognized a potential pollution problem in the use of crushed slag in subbase/base course, porous/non-porous granular embankment, backfill, and French drains. Some crushed slags may exhibit the tendency to leach out a greenish-yellow effluent producing an objectionable odor. In order to prevent such an occurrence, this memorandum establishes a certification and self-testing program for crushed slag producers.

2.0 STANDARD SPECIFICATION REFERENCE

2.1 **Referenced Articles.**

- 1003.01
- 1003.04
- 1004.01
- 1004.04
- 1004.05

3.0 CONSTRUCTION USES COVERED

Crushed slag (air-cooled blast furnace) used for the following construction/ maintenance uses shall conform to this policy memorandum. The construction/ maintenance uses covered are as follows:

1. Subbase (1004.04)
2. Base Course (1004.04)
3. Porous/Non-porous Granular Embankment (1003.04, 1004.05)
4. Porous/Non-porous Backfill (1003.04, 1004.05)
5. French Drains (1003.04, 1004.05)

4.0 PRODUCER SAMPLING AND TESTING PROGRAM

All crushed slag producers supplying material for the uses noted in Section 3.0 of this policy memorandum shall initiate a sampling and testing program as detailed in the current Illinois Department of Transportation Test Procedure 202, "Leachate Determination in Crushed Slag" as detailed in the Department's Manual of Test Procedures for Materials.

5.0 PRODUCER CERTIFICATION LETTER

All crushed slag producers supplying material for the uses noted in Section 3.0 of this policy memorandum shall submit a certification letter each year to the Illinois Department of Transportation, Central Bureau of Materials, 126 East Ash Street, Springfield, Illinois 62704-4766. This letter shall certify that the producer will ship only material that has been tested and accepted under Section 4.0 of this policy memorandum.

6.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	10-08.3
This Policy Memorandum supersedes number 10-08.2 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: USE OF NON-CERTIFIED AGGREGATE STOCKPILES UNDER THE AGGREGATE GRADATION CONTROL SYSTEM (AGCS)

1.0 SCOPE

The AGCS requires the aggregate Source to control the gradation of its certified aggregate during production. Non-certified aggregate stockpiles are those that were not produced under the requirements of the AGCS.

2.0 PURPOSE

To establish a procedure to accept specific non-certified aggregate for use under the AGCS.

3.0 ELIGIBILITY

Only certified aggregate Sources currently running the AGCS are eligible to participate in this program.

4.0 AGGREGATE QUALITY

Non-certified stockpiles shall have current acceptable quality test data (no more than three [3] years old) before processing. Any stockpile not conforming to this requirement shall be sampled as required by the District and tested for quality at the Bureau of Materials .

5.0 GENERAL PROCEDURE

5.1 The aggregate Source shall submit a letter through the District to the Bureau of Materials requesting to certify a non-certified stockpile for AGCS use using this policy memorandum. The letter shall detail the aggregate code number (Example: 032CM16), stockpile location, and the method to be used to certify the stockpile.

5.2 One of the following two methods shall be used to certify non-certified stockpiles for use under the current AGCS. Upon approval from the Bureau of Materials, the District and aggregate Source shall meet to review the method to be used for certification, as outlined below.

Method #1:

The designated non-certified stockpile shall be sampled and tested for gradation to establish the critical sieve Master Band prior to shipping the material to a certified project. A minimum of one (1) gradation sample per 500 tons (454 metric tons) for at least 2,500 tons (2,268 metric tons) of stockpiled aggregate shall be taken and tested during loadout to avoid requiring certified aggregate. The average of these results shall be used by the aggregate Source to establish the Master Band on the critical sieve. The aggregate Source may set the specification limits on the other sieves as allowed in Section 6.2 of the current Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System." After IDOT approval of the Master Band and other sieve limits, the material may be shipped to projects requiring certified aggregate and shall be tested at a minimum rate of one (1) gradation sample for each 1000 tons (907 metric tons) of loadout.

Method #2

The aggregate Source may submit a plan to the Bureau of Materials proposing a satisfactory method of sampling and testing the entire pile either in-situ or by restockpiling (or any combination thereof). If approved, the aggregate Source shall average all the tests taken to establish a Master Band on the critical sieve. The aggregate Source may set the specification limits on the other sieves as allowed in Section 6.2 of the current AGCS policy memorandum. After District approval of the Master Band and other sieve limits, the material may be shipped to projects requiring certified aggregate. When shipping activity begins, loadout sampling and testing shall be performed in accordance with Section 6.3.3 of the current AGCS policy memorandum.

5.3 All requirements of the AGCS shall apply except those referring to production samples. In addition, all samples shall be washed gradations run in accordance with Illinois Modified AASHTO T 11 and Illinios Modified AASHTO T 27. Failing gradation samples shall be handled in accordance with Section 6.5 of the current AGCS policy memorandum, except that references to production samples shall apply to the samples obtained to meet the requirements of this policy memorandum. All test data shall be plotted on control charts as specified in Section 6.4 in the current AGCS memorandum.

6.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	12-08.3
This Policy Memorandum supersedes number 12-08.2 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: CRUSHED GRAVEL PRODUCER SELF-TESTING PROGRAM

1.0 SCOPE

The crushed gravel aggregate producer is responsible for processing round raw feed gravel into coarse and/or fine crushed gravel aggregate complying with applicable quality and gradation specifications. Consistent application of quality control (QC) of the raw feed to the crusher is required to achieve quality crushed gravel aggregate for construction use.

All coarse and/or fine crushed gravel products for Department / Local Agency use shall be produced according to this policy.

2.0 PURPOSE

The purpose of this policy is to establish a quality control procedure to control the raw feed designated for crushing or, as an option, control the crushed particle content in coarse and/or fine crushed gravel products prior to shipment.

3.0 SAMPLING/TESTING PERSONNEL

3.1 All sampling and testing shall be conducted by an Aggregate Technician as designated in the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System." For the optional procedure listed herein, the Aggregate Technician shall have passed the training course conducted by the Central Bureau of Materials (CBM) in the crushed particle test method used.

3.2 The overall program shall be administered by a QC Manager, as designated in the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System."

4.0 GENERAL PROCEDURE

4.1 All crushed gravel sources shall sample, test, and chart a washed gradation per the frequency noted in Section 6.0 on each raw feed (either belt, bin, shaker deck, or stockpile) being fed to a crusher to produce crushed gravel/crushed gravel sand for Department/Local Agency contracts.

4.2 The washed gradation shall include the following in the nested set of sieves:

1. A sieve equal to the smallest size wire cloth in the screen deck over which material is being separated into a raw feed for crushing.
2. A sieve equal to the maximum nominal size of the largest product in the production stream being produced as crushed gravel, if different than #1.
3. A No. 200 sieve.

4.3 Appropriate cutter sieves shall be inserted into the nested set of sieves for overload situations and small sieve protection. The washed gradations shall be run according to the test methods noted in Section 6.0.

4.4 The gradation result from this procedure shall be the result achieved by subtracting the percent passing the No. 200 sieve (to one decimal place) from the percent passing the maximum nominal size sieve (to one decimal place).

4.5 Raw feed which has a gradation result that fails the test limit as per Section 7.0 shall be considered unacceptable. An immediate raw feed resample shall be taken and the sample shall be tested for compliance. The Department may verify the compliance of the product stockpiles prior to further shipment.

4.6 If the resample passes, the material may be placed on the approved stockpile. The testing frequency shall be increased to two tests per week frequency for two consecutive weeks. The one test per week frequency may be resumed if no failures occur during the two-week period.

4.7 If the resample fails, the Department shall be contacted and production shall stop until corrective action has been initiated by the source. After production is restarted, an immediate raw feed sample shall be taken and the sample shall be tested for compliance. Any crushed products produced shall be stockpiled separately. Once the sample passes, the inspection procedure noted above shall be followed and material produced may be placed on the approved stockpile.

5.0 OPTIONAL PROCEDURE

5.1 As an option to Section 4.0 herein, a crushed gravel source may request, in writing to the Bureau of Materials, to sample, test, and chart all crushed aggregate products as to their crushed particle content prior to shipment to any Department / Local Agency contract. If approved in writing by the Bureau of Materials, a sample for crushed particle content shall be run and charted on all crushed gravel products according to the frequency and test method detailed in Section 6.0.

5.2 Crushed gravel products which fail the appropriate test limit as per Section 7.0 herein shall be considered unacceptable. Production shall be stopped until corrective action has been initiated by the Source. After production is restarted, the inspection procedure detailed in the last three (3) paragraphs of Section 4.0 herein shall be followed.

6.0 TEST METHODS / SAMPLE FREQUENCY

6.1 Each crushed gravel source shall test their crushed gravel by per table below. The samples for each raw feed gradation or crushed particle content shall be tested, reported, and charted within 24 hours of sampling. Test calculation sheets shall be retained in a file at the aggregate source for three (3) years.

Procedures	***Test Method****	***Test Frequency (minimum)***
Raw Feed Sieve Analysis	Illinois Modified AASHTO T 11 Illinois Modified AASHTO T 27	1 per week
Crushed Particle Content	Illinois Test Procedure 5821	1 per week

*Current IDOT *Manual of Test Procedures for Materials*

7.0 RAW FEED SIEVE ANALYSIS / CRUSHED PARTICLE CONTENT

7.1 The following test limit for the testing procedure run by the Source shall be applied to crushed gravel production tested under this policy memorandum. All crushed gravel products shipped per this policy memorandum shall meet these test limits prior to shipment.

Crushed Gravel Individual Test Limits	
Raw Feed Sieve Analysis	(Percent Passing Nominal Maximum Sieve) - (Percent Passing No. 200 Sieve) ≤ 3.0%
Crushed Particle Content (%)	• Category I Coarse Aggregate Products ** ≥ 85.0% Two-faced or more Crushed Particles and ≥ 97.0% One-faced or more Crushed Particles • Category III Products/All Manufactured Sand ** (Crushed Gravel Sand Only) ≥ 97.0% One-faced or more Crushed Particles • Category III Aggregate Subgrade Materials ** (Crushed Gravel CS01 and CS02 Only) ≥ 90.0% One-faced or more Crushed Particles

**Aggregate products per Table 1 in the current Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System."

8.0 IDOT MONITORING

8.1 The Aggregate Inspector will witness the sampling and splitting of one of the crushed gravel producer's samples a minimum of every 20 production days. The Aggregate Inspector will obtain one of the two final split portions for IDOT testing. The specific testing run by the producer shall also be conducted by IDOT on its split portion for test results comparison.

8.2 Comparison of the sample splits will be considered acceptable if the crushed gravel producer's test result falls within the following limits of the IDOT test result.

Raw Feed Sieve Analysis	2.0%
Crushed Particles Content	2.0%

8.3 Any IDOT result not comparing within the appropriate above limits or that fails the test limit noted in Section 7.0 shall be cause for an IDOT investigation. Corrective action may be required by the Department if determined to be a producer problem. Continued lack of comparison or continued failure of the IDOT monitor sample is considered non-compliance with the program and may be cause for removal of the crushed gravel source from this program per Section 9.0 herein.

9.0 ACCEPTANCE / REJECTION

9.1 Coarse and/or fine crushed gravel products produced from failing raw feed or having an unacceptable crushed particle content shall be isolated and removed from the approved product pile to the satisfaction of the District Materials Engineer or his/her representative.

9.2 Shipment of coarse and/or fine crushed gravel products produced from failing raw feed or having an unacceptable crushed particle content (Optional Procedure) may result in the crushed gravel source's removal from the "Approved Aggregate Source List," as per Section 11.0 in the current Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System."

9.3 Continued failure of a raw feed or the crushed particle content of a crushed gravel product or non-compliance with the current "Crushed Gravel Producer Self-Testing Program" shall result in the crushed gravel production method being rejected by the Department. In addition, crushed gravel products from the failed Source shall not be used on Department/Local Agency projects. The general response procedure detailed in Section 11.0 in the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System," shall be followed.

10.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

State of Illinois
Illinois Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	13-08.3
This Policy Memorandum supersedes number 13-08.2 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: SLAG PRODUCER SELF-TESTING PROGRAM

1.0 SCOPE

The slag aggregate producer is responsible for processing raw slag into aggregate complying with applicable quality and gradation specifications. Consistent application of quality control (QC) over specific gravity/absorption is required to achieve quality air-cooled blast furnace (ACBF) and steel slag aggregate for use in Portland cement concrete (PCC) and hot-mix asphalt (HMA) mixtures, where allowed.

2.0 PURPOSE

The purpose of this policy is to establish a QC procedure to control specific gravity/absorption on ACBF and steel slag prior to shipment to Illinois Department of Transportation (IDOT) contracts for use in PCC or HMA mixtures.

3.0 SAMPLING/TESTING PERSONNEL

3.1 All sampling and testing shall be conducted by an Aggregate Technician or Mixture Aggregate Technician, as designated in the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System," who has had additional training by the Bureau of Materials in the test methods specified herein.

3.2 The overall program shall be administered by a QC Manager, as designated in the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System."

4.0 GENERAL PROCEDURE

4.1 All ACBF and steel slag aggregate sources shall run the required tests at the specified frequency listed in this policy memorandum.

4.2 These results shall be reported within 24 hours of the completion of the test to the appropriate District Materials Engineer and to all contractors using this product. The test results shall be retained in a file at the source for 3 years. Charting of test data is recommended.

4.3 All slag sources shall submit a stockpile QC Plan to the District Materials Engineer for approval prior to any production. The QC Plan shall detail all procedures the source shall conduct to assure all slag aggregate in IDOT-approved stockpiles conforms to the specific gravity/absorption requirements of this program prior to shipment.

4.4 Any slag source running this QC procedure certifies that all slag shipped for use in PCC and HMA mixtures on IDOT contracts and local agency contracts meets the specific gravity/absorption test limits and ranges cited herein prior to shipment.

4.5 Non-compliance with the "Slag Producer Self-Testing Program" will result in the slag source's removal from the current IDOT "Approved/Qualified Producer List of Aggregate Sources."

4.6 All slag aggregate data (specific gravity absorption, etc.) for any mix design shall be obtained from the appropriate District Materials Engineer.

5.0 TEST METHODS / SAMPLE FREQUENCY

5.1 The following slag characteristics shall be tested per table below.

Slag Characteristic	*Test Method **	*Test Frequency (minimum)*
Specific Gravity / Absorption Fine Aggregate:	Illinois Modified AASHTO T 84	1 per 2,000 tons (1,814 metric tons)
Coarse Aggregate:	Illinois Modified AASHTO T 85	1 per 2,000 tons (1,814 metric tons)

6.0 SPECIFIC GRAVITY/ABSORPTION TEST LIMITS / RANGES

6.1 The following specific gravity/absorption test limits and ranges shall be applied to slag tested under this policy memorandum. All slag shipped per this policy memorandum shall meet these test limits and ranges prior to shipment.

Individual Test Limits	
Specific Gravity	± 0.050 from the approved production target** specific gravity per product/production point
Absorption	• Maximum 5.0% per product/production point • ± 1.0 from the approved production target** absorption per product/production point
Moving Target Test Range	
Specific Gravity (the running average§ of the last four specific gravity test results)	± 0.040 from the approved production target** specific gravity per product/production point

* IDOT Manual of Test Procedures for Materials

** The production targets for both specific gravity and absorption shall be developed by averaging the first four test results at the start of production. If requested by the slag source, historical data for the characteristic may be used to establish the average. All averages shall be approved by the department prior to shipment. A source may request a target change at any time pursuant to departmental approval. Slag aggregate produced after a target change shall be stockpiled separately. Any change in the target may require a new mix design to be run.

§ The running average for specific gravity shall be calculated using the method noted in Section 9.3.1 of IDOT's QC/QA document "Aggregate Producer Control Chart Procedure" in the IDOT Manual of Test Procedures for Materials.

7.0 IDOT MONITORING

7.1 The Aggregate Inspector will witness the sampling and splitting of one of the slag producer's samples a minimum of every 20 production days. The Aggregate Inspector will obtain one of the two final split portions for IDOT testing. All specific gravity/absorption testing run by the slag producer will also be conducted by IDOT on its split portion for test results comparison.

7.2 Comparison of the sample splits will be considered acceptable if the slag producer's test result falls within the following limits of the IDOT test result.

	Fine Aggregate	***Coarse Aggregate***
Specific Gravity	0.066	0.038
Absorption	0.66	0.41

7.3 Any specific gravity/absorption result not comparing within the above limits shall be cause for an IDOT investigation. Corrective action by the slag producer may be required at the discretion of IDOT. Continued lack of comparison may be cause for removal of the slag source from this program.

8.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

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State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	14-08.3
This Policy Memorandum supersedes number 14-08.2 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: INSPECTION OF LARGE SIZED AGGREGATE AND RIP RAP USED FOR EROSION PROTECTION, SEDIMENT CONTROL, ROCKFILL, AND AGGREGATE SUBGRADE IMPROVEMENT

1.0 PURPOSE

This memorandum establishes an inspection procedure for Large Sized Aggregate used for Erosion Protection, Sediment Control, Rockfill, and Aggregate Subgrade Improvement.

2.0 AUTHORITY

IDOT Standard Specifications for Road and Bridge Construction, Article 1005.01

3.0 STOCKPILING

Stockpiling and handling procedures of material for Department use shall be according to the Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System."

4.0 INSPECTION

The materials will be inspected at the source according to Article 106.04.

5.0 QUALITY SAMPLING AND TESTING PROCEDURE

5.1 *For Gradations RR1 & RR2* - Sodium sulfate soundness testing will be conducted on bedding material (Gradations RR1 and RR2) using the manufactured gradation.

5.2 *For Gradations RR3 thru RR7* - Sodium sulfate soundness testing will be conducted on ledges used for erosion control protection and sediment control. Gradations RR1, RR2, CA01, or CA03 shall be sampled for testing of RR3 thru RR7. If the above sizes are not produced, other sizes approved by the Bureau of Materials may be sampled.

5.3 The Department reserves the right to test all riprap or bedding material in the Department's Rapid Freeze-Thaw for final acceptance.

6.0 GRADATION PROCEDURE

6.1 The minimum size of stockpile for inspection shall be 1,000 tons (907 Metric Tons) or the amount needed for the job, whichever is smaller.

6.2 The Producer shall notify the Engineer at least five (5) days in advance of the date when the material will be ready for inspection.

6.3 BEDDING MATERIAL (RR1 & RR2)

6.3.1 Gradation sample sizes shall be taken according to Illinois Specification 201 (LARGE SIZED AGGREGATE GRADATION TABLE) located in the Manual of Test Procedures for Materials. The gradation shall be performed according to Illinois Modified AASHTO T 27 located in the Manual of Test Procedures for Materials. Testing shall be performed by the District when material is produced.

6.4 GRADATIONS RR3 THRU RR7

6.4.1 A minimum of one gradation check for each gradation produced will be performed by the District during initial production each year.

6.4.2 Gradations will be performed by visual inspection of the stockpile including a visual inspection for Flat & Elongated pieces. To assist in the visual gradation inspection the producer shall maintain a set of keystones on all standard specification gradations produced per Table 1, herein. These keystones shall be located in a close proximity of the represented stockpile. The keystones shall be selected by the Producer and agreed upon by the District. If at any time the keystones become non-representative of the gradation, a new set of keystones shall be established.

Table 1

Gradation	Keystone #1 (lbs)	Keystone #2 (lbs)	Keystone #3 (lbs)
RR3	50 (±5)	10 (±1)	1 (±0.1)
RR4	150 (±15)	40 (±4)	1 (±0.1)
RR5	400 (±40)	90 (±13)	3 (±0.1)
RR6	600 (±60)	170 (±17)	6 (±0.5)
RR7	1000 (±100)	300 (±30)	12 (±1)

6.4.3 If the gradation test results using the procedure as described in 6.4.2 are disputed, then the procedure in Section 6.4.4 will be conducted.

6.4.4 DISPUTED GRADATION PROCEDURE (Visual)

6.4.4.1 If the producer disputes the results of the visual inspection conducted by the District a second visual inspection will be conducted by the Bureau of Materials.

6.4.4.2 If the visual gradation performed by the Bureau of Materials is disputed by the producer, a gradation test will be conducted by the District using the Dispute Gradation Procedure (Weighed) described in Section 6.4.5

herein. The Bureau of Materials reserves the right to be present during the weighed gradation dispute procedure. The weighed dispute gradation procedure will be the final method of acceptance for this material.

6.4.5 DISPUTED GRADATION PROCEDURE (Weighed)

6.4.5.1 The District will direct all sampling operations, and the Producer shall provide the equipment and personnel necessary to sample and assist in testing according to this procedure.

6.4.5.2 A grid of the dimensions indicated in the table below shall be marked on a clean surface (e.g., canvas, conveyor belting, concrete pad, etc.), so that an uncontaminated weight of fines and rock spalls may be obtained. Each grid shall be broken down into 5' increments or blocks (e.g., A grid for RR3 will consist of five (5) blocks that are 2' wide by 5' long, aligned in a row, for a total grid length of 25').

Table 2

Gradation	Grid	Sample Size, (blocks to be tested), Minimum
RR3	2' by 25'	2
RR4	3' by 25'	2
RR5	4' by 25'	3
RR6	5' by 30'	3
RR7	5' by 35'	3

6.4.5.3 Under direction of the District, the producer shall use a front end loader to excavate a representative sample from the working face of the stockpile to be sampled. The front end loader will then spread the sampled material over the grid, by backing and slowly dumping over the length of the grid. The material should be spread to an approximate one (1) rock thickness, in a fairly even distribution over the grid. The minimum sample size for each gradation is indicated Table 2 above, by the number of grid blocks to be tested. The test sample shall consist of all the material contained within the selected blocks, as well as all material on or above the grid lines of the selected blocks.

6.4.5.4 Gradation RR3 thru RR7 - The material excavated shall be weighed piece-by-piece until all pieces above the minimal specified weight have been weighed and recorded. All fines and rock spalls below the minimum specified weight shall then be gathered and weighed separately. Percentages of each size range for the gradation specified shall be calculated.

6.5 GRADATIONS CS01 & CS02

6.5.1 Gradation sample sizes shall be taken according to the most recent Illinois Specification 201 (LARGE SIZED AGGREGATE GRADATION TABLE) located in the Manual of Test Procedures for Materials. The gradation shall be run according to Illinois Modified AASHTO T 27 located in the Manual of Test Procedures for Materials.

7.0 CLOSING NOTICE

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The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: July 24, 2018	27-08.1
This Policy Memorandum supersedes number 27-08.1 dated January 1, 2008	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION, AGGREGATE PRODUCERS, SUPPLIER YARDS AND TERMINALS

SUBJECT: DESIGNATION OF AGGREGATE INFORMATION ON SHIPPING TICKETS

1.0 SCOPE

This policy shall apply to all sources that supply certified aggregate for uses identified in the Central Bureau of Materials Policy Memorandum "Aggregate Gradation Control System" to projects let under the jurisdiction of the Illinois Department of Transportation (IDOT), including local agency projects.

2.0 PURPOSE

This memorandum establishes a procedure for designating producer information and aggregate properties on shipping tickets.

3.0 PRODUCER/SUPPLIER'S RESPONSIBILITY - GENERAL

3.1 Each Aggregate Producer and Supplier Yard shall submit to the Central Bureau of Materials, a completed IDOT Aggregate Shipping Tickets Information Form for Producers (BMPR AGG01) form. Information provided on the completed form indicates how each aggregate source will identify the Producer/Supplier Designation, Product Designation and Freeze-thaw Designation on their shipping ticket. A separate form must be completed for each IDOT Producer/Supplier Number.

If the source makes changes to their Producer/Supplier Designation, a Product Designation, or the Freeze-thaw Designation, the source shall notify the IDOT District Office that inspects the source, by close of business the next working day. The source shall then complete the IDOT Aggregate Shipping Tickets Information Form for Producers (BMPR AGG01) form and submit to the Central Bureau of Materials within ten (10) working days. A copy of the form shall also be submitted to the IDOT District Office that inspects the source.

3.2 **Producer/Supplier Designation** - Each aggregate source shall submit on the appropriate "Aggregate Shipping Tickets Information Form," identification for the source. The identification shall meet one of the following methods:

Method 1: The aggregate source shall use the appropriate IDOT Producer/Supplier Number.

Method 2: A unique identification shall be used for the producing source. If a producer has multiple sources, a different identification shall be established for each source. (i.e., a producer has 3 plants; Joe's Plant #1, Joe's Plant #2, and Joe's Plant #3. The identification is defined as JP1, JP2, and JP3.) The source shall indicate on the appropriate "Aggregate Shipping Tickets Information Form," the IDOT Producer/Supplier Number that corresponds to the source identification (i.e., JP1, JP2, and JP3 correspond to IDOT Producer/Supplier Numbers 50000-01, 50000-02, and 50000-03, respectively).

3.3 **Product Designation** – Each aggregate source shall submit on the appropriate "Aggregate Shipping Tickets Information Form," identification for each product sold. The identification shall meet one of the following methods:

Method 1: The appropriate IDOT Material Code shall be used for each material (i.e., 022CM1101 shall be used for A Quality Superstructure CM11).

Method 2: A unique product designation, using the appropriate CA/CM, FA/FM, CS or RR identification, shall be defined by the source, to identify each product sold. The source shall indicate on the appropriate "Aggregate Shipping Tickets Information Form," the IDOT Material Code that corresponds to the source's product designation (i.e., the aggregate source uses "CA06 Base" to represent 052CA06). If the source makes two different quality materials for a particular gradation, and each is being stockpiled separately, each shall have a different product designation (i.e., The source could not use "CA06 Base" to represent both the 042CA06 stockpile and the 052CA06 stockpile). However, if a particular gradation meets the requirements for multiple qualities, the same product designation may be used for both materials (i.e., The aggregate source has a stockpile of CM11 that is sold as 022CM11 for use in Portland cement concrete. The same stockpile is also sold as 032CM11 for use in Hot Mix Asphalt. The product designation for the material is "CM11 Mix".)

3.4 **Freeze-thaw Designation** – For IDOT "A" Quality coarse aggregate, each source shall indicate on the appropriate "Aggregate Shipping Tickets Information Form," whether the aggregate has IDOT Freeze-thaw approval. The designation shall meet one of the following methods:

Method 1: The designation "FT" shall be used to identify an IDOT Freeze-thaw approved product. It shall be included with the "A" Quality Product Designation described in Section 3.3.

Method 2: A designation shall be defined by the source to identify a Freeze-thaw approved product. The source shall indicate on the appropriate "Aggregate Shipping Tickets Information Form," the Freeze-thaw Designation, along with the "A" Quality Product Designation described in Section 3.3. Sources that make both Freeze-thaw "A" Quality coarse aggregate and Non-Freeze-thaw "A" Quality coarse aggregate shall use separate designations for the different coarse aggregates.

3.5 Each Aggregate Producer, Supplier Yard and/or Terminal's shipping ticket shall also include the net weight of the material being shipped.

4.0 PRODUCER/SUPPLIER'S RESPONSIBILITY – SHIPPING TICKETS

4.1 Aggregate Producers shall include on their shipping ticket, the Producer/Supplier Designation, the Material Designation, and the Freeze-thaw Designation (if "A" Quality), as described in Section 3.0.

4.2 Supplier Yards and Terminals shall include on their shipping ticket, their Supplier Designation, the Producer/Supplier Designation of the Certified Source that produced the material, the Material Designation, and the Freeze-thaw Designation (if "A" Quality), as described in Section 3.0. Supplier Yards and Terminals shall use the same Producer/Supplier Designation, Material Designation and Freeze-thaw Designation as the Certified Source that produced the material.

5.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

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State of Illinois
Department of Transportation
Bureau of Materials
Springfield

POLICY MEMORANDUM

Revised: April 14, 2022	31-13.2
This Policy Memorandum supersedes number 31-13.1 dated June 1, 2018	

TO: REGIONAL ENGINEERS AND BUREAU CHIEFS IN THE OFFICE OF HIGHWAYS PROJECT IMPLEMENTATION

SUBJECT: RECLAIMED ASPHALT PAVEMENT (RAP) FOR AGGREGATE APPLICATIONS

1.0 SCOPE

The RAP aggregate producer is responsible for processing raw feed grindings, asphalt pavement or pavement preservation courses into aggregate that will comply with applicable gradation specifications. Consistent application of quality control (QC) at the crushing/screening plant or jobsite is required to achieve consistent RAP aggregate product for construction use.

All RAP products for Department/Local Agency aggregate use, whether at the jobsite, mix plant or central recycling facility, shall be tested according to this policy.

2.0 PURPOSE

The purpose of this policy is to establish a QC procedure to manage RAP material designated for use in aggregate applications.

3.0 SAMPLING/TESTING PERSONNEL

3.1 All sampling and testing shall be conducted by either an Aggregate Technician or a Mixture Aggregate Technician as designated in the current Bureau of Materials Policy Memorandum, "Aggregate Gradation Control System (AGCS)."

3.2 The overall program shall be administered by a QC Manager, as designated in Section 3.14 in the Policy Memorandum, "Aggregate Gradation Control System (AGCS)" or the HMA QC Manager designated in Section 1030.05 (d)(1) of the Standard Specifications.

3.3 Jobsite stockpiles are for use on the same contract the material originally came from. If the material is used on a different contract, the contractor for that project will have to restart this testing program with the production testing procedure defined in Section 4.1, herein.

4.0 SAMPLING/TESTING PROCEDURE

4.1 Production Testing

4.1.1 All RAP aggregate shall be 100% passing the top sieve of the gradation specified. The material shall be sampled and tested for gradation at a minimum of 1 test every 1,000 tons (907 metric tons) for the first 5,000 tons (4,536 metric tons) during production. After the first 5,000 tons (4,536 metric tons), the material shall be sampled and tested at a minimum of 1 test every 5,000 tons (4,536 metric tons).

4.1.2 Sampling shall be according to one of the approved methods listed Illinois Modified AASHTO R 90, in the IDOT Manual of Test Procedures for Materials. The required gradation testing sieve shall be the top sieve of the gradation specified.

4.1.3 As part of the gradation testing, a visual of the material to check for uniformity shall also be performed. Material that is one-sized, over-sized, or gap-graded shall be rejected.

4.2 Failing Gradation Samples

4.2.1 Material that does not have 100% passing the top sieve of the specified gradation shall be immediately resampled. The producer shall immediately cease adding new material to their approved pile.

4.2.2 If the resample passes, the material may be placed on the approved stockpile.

4.2.3 If the resample fails, the District will be contacted and production shall stop until corrective action has been initiated by the source, through either additional crushing or rescreening the material. Upon the restart of production, the material shall be stockpiled separately and an immediate production sample taken. Once the sample passes, the production testing frequency may continue and the material can be moved to the approved stockpile.

4.3 Loadout Testing

4.3.1 Loadout samples shall be taken as soon as the pile is shipped/loaded out and then a minimum of 1 test every 5,000 tons (4,536 metric tons) thereafter. If a loadout sample fails, an immediate resample shall be taken and loadout of the approved stockpile shall cease until passing results of the resample are known.

4.3.2 If the resample passes, loadout of the approved stockpile may continue.

4.3.3 If the resample fails, the approved stockpile is rejected and the source will need to re-crush or rescreen the material. Production testing frequency shall be followed during this reprocessing.

4.3.4 Jobsite stockpiles shall be visually inspected for over-sized agglomerations (RAP particles that have melded back together), excessive segregation, and any construction debris. If any of these are present, the material shall be rescreened and retested prior to use. If none of the above are present, the jobsite stockpile shall be exempt from loadout sampling.

5.0 IDOT MONITORING

5.1 The Aggregate Inspector or Mixture Aggregate Technician shall witness the sampling of one of the RAP aggregate samples a minimum of 1 every 20,000 tons (18,144 metric tons). The Aggregate Inspector or Resident Engineer (RE) will obtain a final split of the product for IDOT testing. The District will run the gradation over the same sieve size the producer is using. The samples shall be compared according to Illinois Manual of Test Procedures, Appendix A.5 "Procedure for Sample Comparison."

5.2 Any District result not comparing within the limits noted above or fails the limits noted under production testing, shall be cause for a District investigation. Corrective action may be required by the Department if determined to be a producer problem. Continued lack of comparison or continued failure of the District monitor sample shall be considered non-compliance and may be cause for removal of the source from this program per section 6.0 herein.

6.0 ACCEPTANCE/REJECTION

6.1 RAP aggregate sources shall submit a certification letter stating that this material meets the requirements of this policy and the AGCS policy prior to shipment for use in any Department/Local Agency project.

6.2 RAP aggregate products having unacceptable oversize or gradation shall be isolated and removed for the approved stockpile to the satisfaction of the District Materials Engineer, RE or his/her representative.

6.3 Shipment or placement of RAP aggregate having unacceptable properties as defined in Section 4.0 herein shall result in the removal from the Approved/Qualified Producer List of Aggregate Sources.

7.0 CLOSING NOTICE

Archive versions of this policy memorandum may be examined by contacting the Bureau of Materials.

The current Bureau Chief of Materials has approved this policy memorandum. Signed documents are on file with the Bureau.

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Illinois Department of Transportation

Memorandum

To:	Regional Engineers
From:	Jack A. Elston
Subject:	Special Provision for Aggregate Subgrade Improvement
Date:	January 14, 2022

This special provision was developed by the Central Bureau of Materials to allow the use of coarse aggregate in fills ranging from 12 in. to over 24 in. in thickness. It has been revised to reduce the CA 2, CA 6, and CA 10 maximum lift thickness from 12 inches to 9 inches. In addition, it has been revised to fit with the 2022 Standard Specifications.

It should be included in contracts utilizing aggregate subgrade improvement.

The designer should check with the District Geotechnical Engineer to determine the appropriate thickness of the aggregate subgrade material.

The districts should include the BDE Check Sheet marked with the applicable special provisions for the April 29, 2022 and subsequent lettings. The Project Coordination and Implementation Section will include a copy in the contract.

80274m

AGGREGATE SUBGRADE IMPROVEMENT (BDE)

Effective: April 1, 2012
Revised: April 1, 2022

Add the following Section to the Standard Specifications:

"SECTION 303. AGGREGATE SUBGRADE IMPROVEMENT

303.01 Description. This work shall consist of constructing an aggregate subgrade improvement (ASI).

303.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Coarse Aggregate	1004.07
(b) Reclaimed Asphalt Pavement (RAP)	1031.09

303.03 Equipment. The vibratory roller shall be according to Article 1101.01, or as approved by the Engineer. Vibratory machines, such as tampers, shall be used in areas where rollers do not fit.

303.04 Soil Preparation. The minimum immediate bearing value (IBV) of the soil below the improved subgrade shall be according to the Department's "Subgrade Stability Manual" for the aggregate thickness specified.

303.05 Placing and Compacting. The maximum nominal lift thickness of aggregate gradations CA 2, CA 6, and CA 10 when compacted shall be 9 in. (225 mm). The maximum nominal lift thickness of aggregate gradations CS 1, CS 2, and RR 1 when compacted shall be 24 in. (600 mm).

The top surface of the aggregate subgrade improvement shall consist of a layer of capping aggregate gradations CA 6 or CA 10 that is 3 in. (75 mm) thick after compaction. Capping aggregate will not be required when aggregate subgrade improvement is used as a cubic yard pay item for undercut applications.

Each lift of aggregate shall be compacted to the satisfaction of the Engineer. If the moisture content of the material is such that compaction cannot be obtained, sufficient water shall be added so that satisfactory compaction can be obtained.

303.06 Finishing and Maintenance. The aggregate subgrade improvement shall be finished to the lines, grades, and cross sections shown on the plans, or as directed by the Engineer. The aggregate subgrade improvement shall be maintained in a smooth and compacted condition.

303.07 Method of Measurement. This work will be measured for payment according to Article 311.08.

303.08 Basis of Payment. This work will be paid for at the contract unit price per cubic yard (cubic meter) or ton (metric ton) for AGGREGATE SUBGRADE IMPROVEMENT or at the contract unit price per square yard (square meter) for AGGREGATE SUBGRADE IMPROVEMENT, of the thickness specified."

Add the following to Section 1004 of the Standard Specifications:

"**1004.07 Coarse Aggregate for Aggregate Subgrade Improvement (ASI).** The aggregate shall be according to Article 1004.01 and the following.

(a) Description. The coarse aggregate shall be crushed gravel, crushed stone, or crushed concrete. In applications where greater than 24 in. (600 mm) of ASI material is required, gravel may be used below the top 12 in (300 mm) of ASI.

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

(c) Gradation.

(1) The coarse aggregate gradation for total ASI thickness less than or equal to 12 in. (300 mm) shall be CA 2, CA 6, CA 10, or CS 1.

The coarse aggregate gradation for total ASI thickness greater than 12 in. (300 mm) shall be CS 1 or CS 2 as shown below or RR 1 according to Article 1005.01(c).

Grad No.	COARSE AGGREGATE SUBGRADE GRADATIONS				
	Sieve Size and Percent Passing				
	8"	6"	4"	2"	#4
CS 1	100	97 ± 3	90 ± 10	45 ± 25	20 ± 20
CS 2		100	80 ± 10	25 ± 15	

Grad No.	COARSE AGGREGATE SUBGRADE GRADATIONS (Metric)				
	Sieve Size and Percent Passing				
	200 mm	150 mm	100 mm	50 mm	4.75 mm
CS 1	100	97 ± 3	90 ± 10	45 ± 25	20 ± 20
CS 2		100	80 ± 10	25 ± 15	

(2) Capping aggregate shall be gradation CA 6 or CA 10."

Add the following to Article 1031.09 of the Standard Specifications:

"(b) RAP in Aggregate Subgrade Improvement (ASI). RAP in ASI shall be according to Articles 1031.01(a), 1031.02(a), 1031.06(a)(1), and 1031.06(a)(2), and the following.

(1) The testing requirements of Article 1031.03 shall not apply.

(2) Crushed RAP used for the lower lift may be mechanically blended with aggregate gradations CS 1, CS 2, and RR 1 but it shall be no greater than 40 percent of the total product volume. RAP agglomerations shall be no greater than 4 in. (100 mm).

(3) For capping aggregate, well graded RAP having 100 percent passing the 1 1/2 in. (38 mm) sieve may be used when aggregate gradations CS 1, CS 2, CA 2, or RR 1 are used in the lower lift. FRAP will not be permitted as capping material.

Blending shall be through calibrated interlocked feeders or a calibrated blending plant such that the prescribed blending percentage is maintained throughout the blending process. The calibration shall have an accuracy of ± 2.0 percent of the actual quantity of material delivered."

80274

CRUSHER TERMINOLOGY

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CRUSHER TERMINOLOGY

Crusher and Portable Plant Association
P.O. Box 149
Darien, Connecticut 06820

1978

In the belief that a common understanding of the technical terms applicable to crushers and crushing equipment would benefit the manufacturers, the distributors, the users and operators, and engineering students, the Crusher and Portable Plant Association is publishing this booklet. It represents the combined thinking of representatives of recognized leading United States manufacturers of this equipment. Those contributing to this publication are:

Allis-Chalmers Corporation
Appleton, Wisconsin

Eagle Crusher Company, Inc.
Galion, Ohio

The Frog, Switch & Manufacturing Company
Carlisle, Pa.

Hewitt-Robins Div., Litton Systems, Inc.
Columbia, S.C.

Jeffrey Manufacturing Div., Dresser Industries
Woodruff, S.C.

Pennsylvania Crusher Corporation
Broomall, Pa.

Rexnord, Inc.
Milwaukee, Wisconsin

Telsmith Div., Barber-Greene Company
Milwaukee, Wisconsin

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INDEX

ILLUSTRATIONS

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General terms applying to most types of crushers

ACCESS DOOR — Covered opening in frame provided for inspection and access to interior for maintenance.

ATTRITION — Reduction of material by a grinding or rubbing action between materials and/or hard surfaces.

AUTOMATIC LUBRICATION — Either splash or circulating oil or other lubricant, non-manual lubricating system. May have filter, sight glasses and temperature and pressure alarm systems.

BACKLASH — Total clearance between teeth of pinion and gear at pitch line.

BEARING HOUSINGS — Enclosure for main bearings mounted on crusher frame.

BEARING RETAINER — Means of locating a bearing axially.

BEARING SEAL — Device to retain lubricant and exclude foreign matter. Common types are: labyrinth, piston rings, lip seals, cap, slinger rings, shrouds.

BLOCKING — A single piece of material too large to enter the crushing chamber.

BRIDGING — Multiple pieces of material wedged or covering the feed opening of the crusher and preventing entry of additional material.

CHEEK PLATE — Replaceable wearing surface for sides of crushing chamber. Usually of manganese or abrasion-resistant material.

CHOKE FEED — A condition whereby the feed completely fills the crushing chamber.

CIRCULATING OIL SYSTEM — System in which lubricating oil, after passing through the bearings, is returned to a reservoir and recirculated for the purpose of cooling or heating and filtering.

CLOSED-CIRCUIT CRUSHING — System in which the oversize material is separated from the product and returned to the crusher.

CRUSHING CHAMBER — The area of the crusher where crushing takes place.

COUPLING — A device used to direct-connect a crusher to a driving mechanism.

DRIVE — Any device used to transmit rotating force from the power unit to the crusher shaft: V-Belt, Flat Belt, Coupling, etc.

DRIVE GUARD — Safety enclosure for the drive.

EXPANSION BEARING — Free or floating bearing on one end of a shaft to allow for expansion and contraction of the shaft.

FEED OPENING — The inlet opening of the crusher where material enters the crushing chamber.

FINES — Material having particle size smaller than a specified opening.

FINISHED PRODUCT — The resultant material after it has been processed.

FLYWHEEL — A heavy, flat or grooved wheel or sheave used to store and release energy.

FRIABLE — Material that fractures easily.

GRINDABILITY — An index for the resistance of material to size reduction. For coal, see Hardgrove Test; for stone and ore, see Bond and Wang Theory. (Ref: Bureau of Mines, "Dictionary of Mining, Mineral and Related Terms").

GRIZZLY — A heavy duty screening surface consisting of a series of spaced bars, rails, or pipe members; may be stationary, rotating, or vibrating.

GUARD — A protective shield covering exposed moving elements of machinery.

HADFIELD PROCESS MANGANESE — A steel alloy used for abrasion-resistant surfaces containing 11 to 14% manganese. (See ASTM - A 128-64).

INSPECTION DOOR — See "ACCESS DOOR".

LABYRINTH SEAL — See "BEARING SEAL".

LUBRICATION — (Bearings) usually oil or grease. Consult manufacturer for lubricant specifications.

General terms cont'd.

MOBILE CRUSHING UNITS – Moveable crushing units with crawlers, rails, walking beams or pads, rubber, etc. Can be towed or self-propelled. Off-highway application.

MOHS SCALE – The relative hardness of a material as compared to: 1 - Talc; 2 - Gypsum; 3 - Calcite; 4 - Fluorite; 5 - Apatite; 6 - Feldspar; 7 - Quartz; 8 - Topaz; 9 - Corundum; 10 - Diamond.

NOMINAL – Term frequently used in describing product size, and denoting that at least 90% of product is smaller than the size indicated.

OIL RETAINER – A seal to prevent loss of lubricant.

OIL SEAL – See "OIL RETAINER".

OPEN CIRCUIT CRUSHING – One pass through the crusher.

OVERLOAD – When the design capability of a crusher is exceeded.

OVERSIZE – Material that will not pass through a specified opening.

PACKING – Compacted or compressed condition of material in the crushing chamber characterized by a complete or nearly complete absence of voids.

PILLOW BLOCK – A self-contained bearing housing separate from the frame of the crusher.

PLUGGING – Blockage restricting flow of material.

PORTABLE CRUSHING UNITS – Units which can be moved on the highway with minimum disassembly.

PULLEY, FLYWHEEL – Usually the large, heavy, driven pulley designed to transmit energy. Often grooved to take a V-Belt drive.

RATIO OF REDUCTION (REDUCTION RATIO) – Relationship of the top size of the feed to the top size of the crusher product.

REGULATED FEED – Flow of material when controlled.

ROM – Run-of-Mine.

ROQ – Run-of-Quarry.

SCALPING – Removing from crusher feed most of the undersize material.

SEMI-PORTABLE CRUSHING UNITS - SKID OR BASE MOUNTED – Units which are mounted on a structural steel frame having legs or supports to grade.

SHEAR CRUSHING – Reduction of material by a cutting action between two hard surfaces.

SKIDDABLE CRUSHING UNITS – Similar to "SEMI-PORTABLE CRUSHING UNITS", but are capable of being towed or dragged. Off-highway application.

THRUST BEARING – Any plain or anti-friction bearing designed to accept thrust loads.

TOP SIZE – The largest particle size in feed or product.

TRAMP IRON – Any uncrushable metal in the crusher feed.

■

Cage Mills

SINGLE CAGE – A crusher with a horizontal shaft where the material is fed through an opening in the housing into the center of the rotating cage. The cage impacts the material as it passes through the opening between the cage pins, and then impacts on breaker plates or blocks which form the internal crushing surfaces of the housing that surrounds the rotating cage. The material rebounds on to the outside surfaces of the rotating cages and is impacted again to return to the breaker surface. This action continues until the material exits through the bottom discharge opening. See Fig. 1.

MULTI-CAGE – A crusher with two horizontal shafts which counter-rotate and have cages that intermesh single or multiple rows of pins. The material is fed through an opening in the housing into the innermost cage which impacts the material as it passes through the opening between the cage pins. The material is then impacted by the next row of pins traveling in the opposite direction. This action continues until the material passes through all the rows of pins. The material then impacts on liner plates which form the internal crushing members of the housing which surrounds the rotating cages. The material rebounds against the outside of the outer cage and is impacted and returned to the liner plates. This action continues until the material passes through the bottom discharge opening. See Fig. 2.

Cage Mills

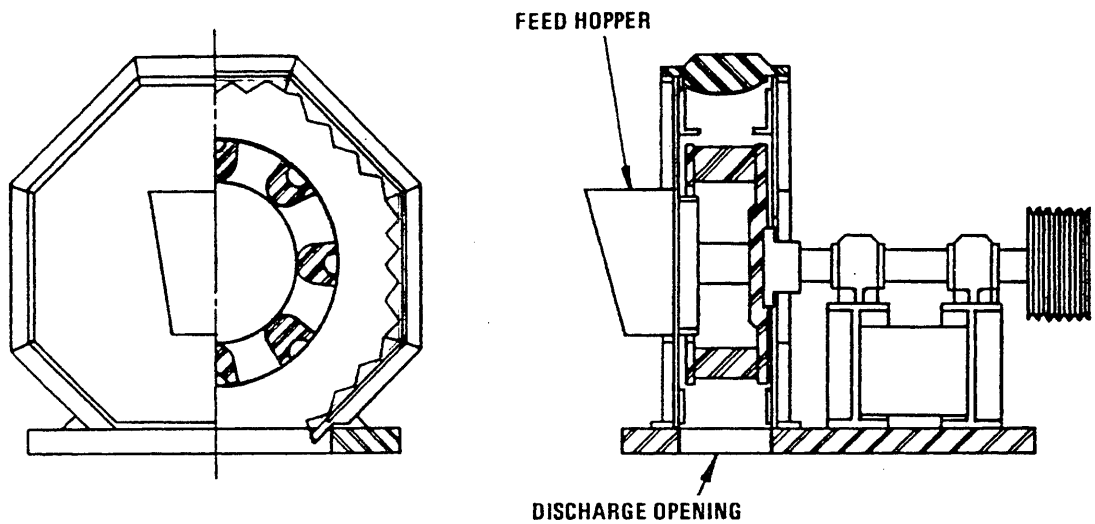


FIG. 1 – SINGLE CAGE MILL.

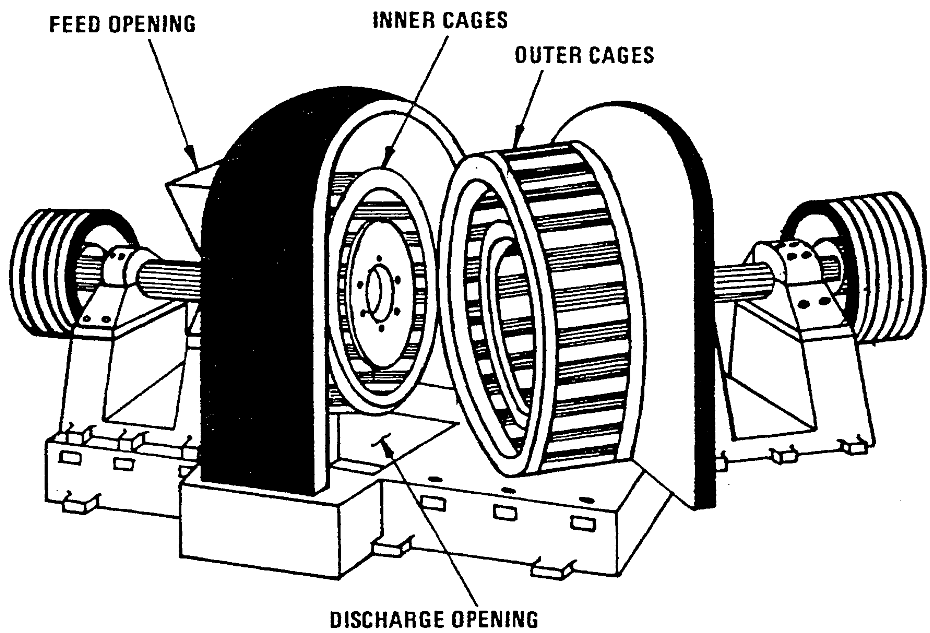


FIG. 2 – MULTIPLE CAGE MILL (4 ROW ILLUSTRATED).

Cage Mills
Terminology

ASSEMBLY DISC – Device attached to horizontal shaft that retains cage.

BALANCE WHEEL – Flywheel-type part on opposite end of shaft from cage used as a flywheel and to counterbalance weight of cage.

BASE – Part of crusher on which the housing and pedestal are assembled.

BREAKER – Plate or block-device against which material is impacted.

CAGE – A disc or ring with protruding pins equally spaced on its flat surface. These pins are attached in circular rows by a ring or disc. Cages may be cast or fabricated.

DRIVE SIDE – Side of housing which shaft assembly enters.

FEED HOPPER – A box-type device used to direct the feed into the cage through the housing.

FEED PLATE – Adjustable plate used to help control feed into crusher.

FEED RING – Device used to keep material being crushed from entering the area between the housing and feed side of cage.

FEED SIDE – Side of housing which feed material enters.

HOUSING LINER – Liner used to protect the housing sides from wear.

INTERNAL IMPACT – Term used to describe the cage action because the feed is to the inside of the crushing member.

PEDESTAL – Part of a crusher on which the shaft assembly is mounted.

PIN – The crushing devices equally spaced on the cage.

PIN SLEEVE – Replaceable hollow pin used on fabricated cages.

SEAL RING – A device to retain material being crushed in the housing where the shaft assembly enters the housing.

Cone Crushers

CONE CRUSHERS – The cone crusher, normally used as a secondary, tertiary, or quaternary crusher, is a relatively high speed gyratory incorporating a flatter head angle. The number of gyrations employed are approximately twice that used in a primary gyratory crusher. See Figs. 3, 4, 5, 6.

■

Cone Crushers

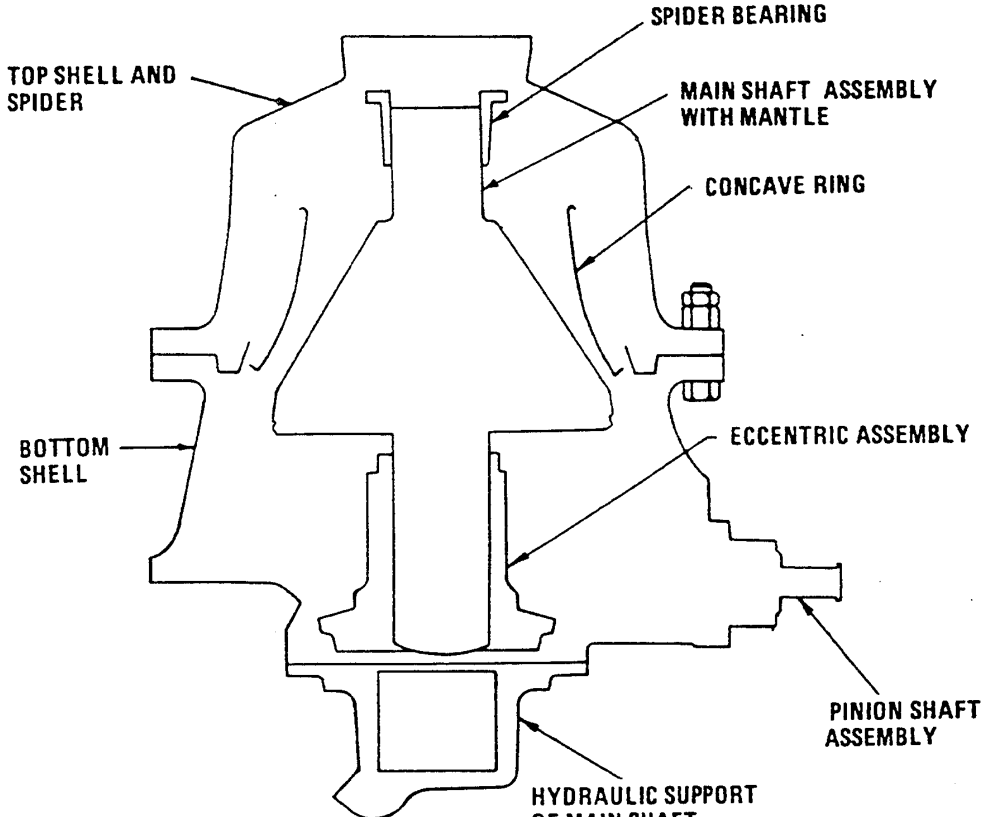


FIG. 3 – CONE CRUSHER.

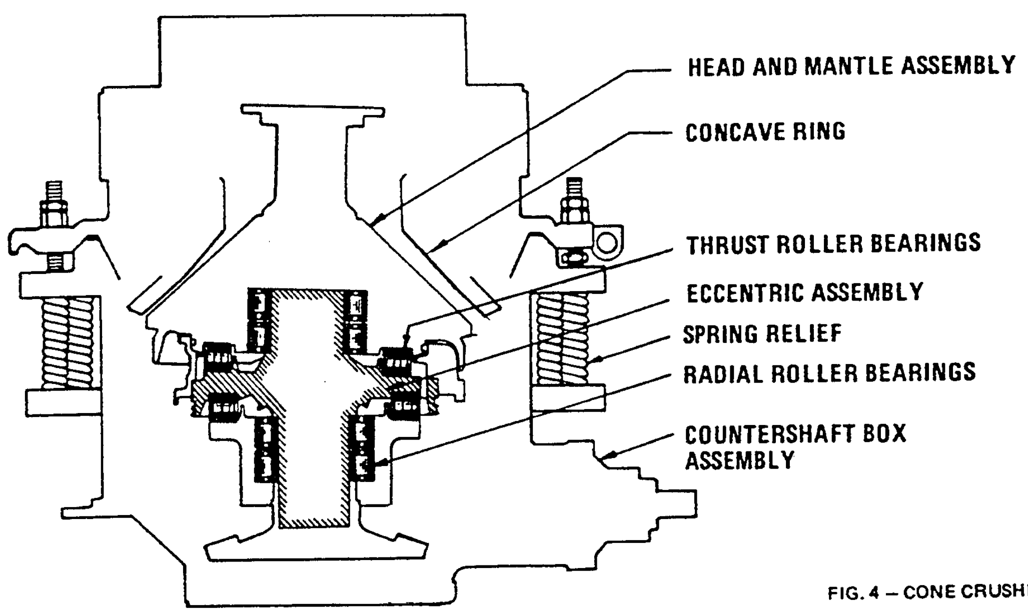


FIG. 4 – CONE CRUSHER.

Cone Crushers

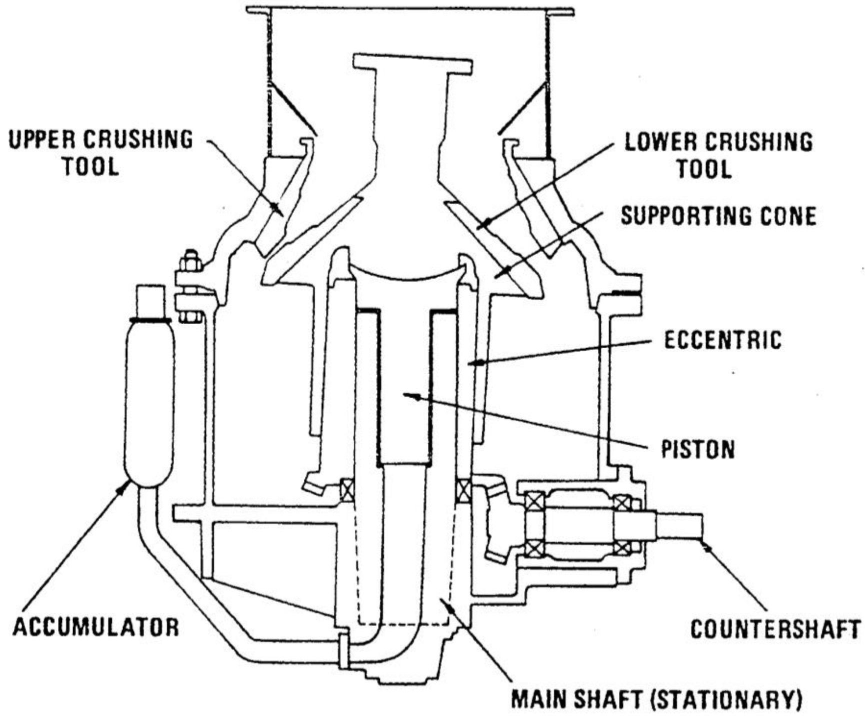


FIG. 5 – CONE CRUSHER.

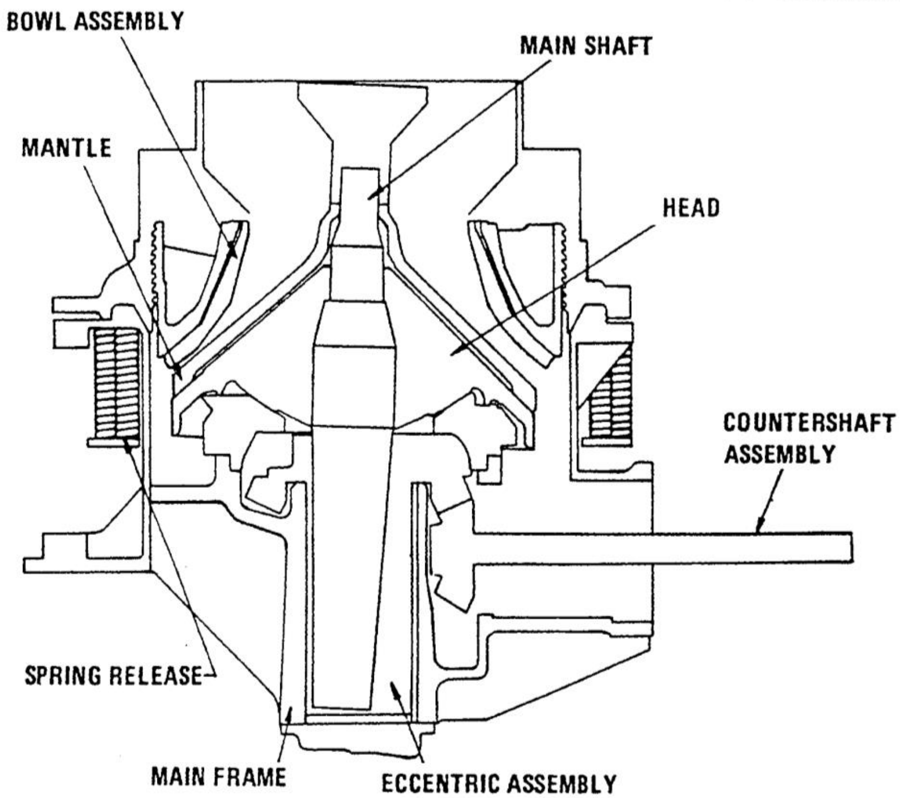


FIG. 6 – CONE CRUSHER.

Cone Crushers

Terminology

ACCUMULATOR — A gas-hydraulic operated unit to provide crushing chamber relief and automatic reset.

ADJUSTMENT CAP — The adjustment cap which fits around the bowl and rests on the adjustment ring. Is used for raising the bowl into the crushing position in the adjustment ring.

ADJUSTMENT RING — See also "UPPER FRAME". The adjustment ring, which seats on a conical machined surface on top of the main frame, and is generally threaded to provide the means of adjusting the bowl assembly.

ADJUSTMENT RING DUST SHELL — A sealing member protecting the lower portion of the bowl and adjustment threads.

ANTI-SPIN DEVICE — Prevents rotation of the mantle and supporting head assembly with the eccentric while allowing free motion in the opposite direction when crushing material.

ARM GUARD — Guards to protect against the erosion of the main frame arms caused by material being discharged from the crushing cavity.

BOTTOM HYDRAULIC CYLINDER COVER — The cover plate below the piston on crushers with hydraulic support main shafts.

BOTTOM PLATE — See "MAIN FRAME CAP".

BOTTOM SHELL — See "MAIN FRAME".

BOTTOM SHELL BUSHING — See "OUTER ECCENTRIC BEARING".

BOWL-CONCAVE SUPPORT — The bowl, which is threaded on its outside diameter, is suspended on heavy duty threads inside the adjustment ring, and is the supporting member for the bowl liner.

BOWL ADJUSTMENT RAMS — Hydraulically adjust the crusher by rotating one threaded member in relation to another.

BOWL LINER — See "CONCAVE RING", "UPPER CRUSHING TOOL".

BOWL LINER "U" BOLT — "U" Bolts rigidly hold the bowl liner to the bowl.

BOWL LOCK — Acts as a safety device to prevent the bowl from turning while crushing.

BUSHING-ECCENTRIC — See "INNER ECCENTRIC BEARINGS".

BUSHINGS-HYDRAULIC CYLINDER, LOWER & UPPER — Bushings, located and keyed in the hydraulic cylinder to prevent wear on the cylinder from movement of the hydraulic piston.

CLAMPING RING — Is used to provide the means of locking the bowl assembly into the crushing position in the adjusting ring.

CLAMPING CYLINDER — The clamping cylinders, located between the clamping ring and the adjustment ring, which provide the clamping force to lock the bowl in place.

CONCAVE RING — Wearing surface, usually manganese steel, located in the stationary section of the crushing chamber. Also referred to as "BOWL LINER" or "UPPER CRUSHING TOOL".

CONE ASSEMBLY — See "HEAD".

CONICAL HOPPER — See "FEED CONE".

COUNTERSHAFT — Located in the countershaft box, has a bevel pinion keyed to it, and drives the gear on the eccentric assembly.

COUNTERSHAFT BOX — The countershaft box provides a housing for the countershaft.

COUNTERSHAFT BOX GUARD — The countershaft box guard provides wear protection to that portion of the countershaft box which is exposed to falling material.

COUNTERWEIGHT — A large counterweight is used to counterbalance the eccentric and head assembly.

DISTANCE SLEEVE — A spacer between the mantle and the mantle nut.

Cone Crushers

Terminology

DUST SEAL – See "HEAD SEALING RING".

DRIVE SHAFT – See "COUNTERSHAFT".

DRIVE SHAFT HOUSING – See "COUNTER-SHAFT BOX".

ECCENTRIC – The eccentric has an offset bore to provide the means whereby the head may follow an eccentric path during each cycle or rotation.

FEED CONE – The feed cone directs the falling feed into the crushing members as it comes off the feed plate.

FEED DISC – See "FEED PLATE".

FEEDER FUNNEL – See "FEED CONE".

FEEDER FUNNEL LINER – A replaceable wear liner over the conical section of the feed cone.

FEED HOPPER – Feed hopper is the upper cylinder used to collect the feed and direct the material into the crushing chamber.

FEED PLATE – The feed plate gyrates with the main shaft for the purpose of distributing the feed evenly around the entire crushing chamber.

FEED PLATFORM – The feed platform is a fabricated structure to direct material onto the feed plate.

GEAR – The large bevel gear is keyed to the eccentric and is driven by the pinion on the countershaft.

HEAD (HEAD CENTER) – A casting located between the main shaft and the mantle.

HEAD NUT – A threaded large nut used to tighten the mantle to the head center and mainshaft. See "MAIN SHAFT NUT", "LOCKING NUT".

HEAD SEALING RING – Sealing ring which protects internal components from dust and dirt located under the head.

HOLD DOWN STIRRUP – A clamping device to fasten the feed hopper to the upper frame.

HYDRAULIC CYLINDER-MAIN SHAFT – The cylinder containing the bushings, piston, piston wearing plate and clamp plate on crushers with hydraulic supported main shaft.

HYDRAULIC LOCK/UNLOCK RAMS – System of rams that lock or unlock the adjusting members prior to adjusting the machine.

HYDRAULIC PISTON– MAIN SHAFT – Piston mounted in hydraulic cylinder for raising and lowering mainshaft.

INNER BRONZE SLEEVE – See "INNER ECCENTRIC BUSHING".

INNER COUNTERSHAFT BEARING – The inner countershaft bearing is located adjacent to the pinion.

INNER ECCENTRIC BEARING – An inner eccentric bearing locked into the eccentric bore provides the bearing surface for the main shaft.

INTEGRAL OIL PUMP – Is gear driven from the countershaft and forces oil under pressure into the crusher.

LOCKING NUT – See "HEAD NUT", "MAIN SHAFT NUT".

LOCKING RING – Clamps the concave ring in position against the upper frame.

LOWER CRUSHING TOOL – See "MANTLE".

LOWER FRAME – See "MAIN FRAME".

LOWER RADIAL ROLLER BEARING – Transmits horizontal crushing pressures between the eccentric and the main frame.

LOWER SPRING RING – See "LOWER SPRING SEGMENT".

LOWER SPRING SEGMENT – The lower spring segment is located under the heavy coil springs and provides the means of adjusting the springs to obtain the correct spring force.

LOWER THRUST ROLLER BEARINGS – Transmits vertical crushing loads between the eccentric and the main frame.

Cone Crushers
Terminology

MAIN FRAME (LOWER FRAME) – Transmits the crushing force to the foundation and provides a rigid support for the remaining crushing components.

MAIN FRAME CAP – A plate bolted to the bottom of the frame which gives access to the eccentric assembly.

MAIN FRAME LINER – The main frame liner is welded to the inside of the frame to protect it from wear caused by falling material.

MAIN SHAFT – a.) The tapered shaft which is pressed or shrunk into the head and is driven by the eccentric providing the gyrating motion of the head. b.) The stationary shaft which is pressed into the main frame, and about which the eccentric rotates.

MAIN SHAFT NUT – The main shaft nut holds the torch ring and mantle firmly on the head and may provide support for the feed plate. See "HEAD NUT", "LOCKING NUT".

MAIN SHAFT SLEEVE – a.) The main shaft sleeve is on top of the mantle and is held firmly in place by a main shaft nut threaded directly onto the main shaft. b.) A steel sleeve pressed on the upper journal of the main shaft to protect the main shaft from wear.

MANTLE – A crushing surface, covering the head, is a replaceable casting generally of manganese steel.

OIL CHANNELS, GROOVES, LINES – Passages within the machine for distributing lubricating oil to internal wear surfaces.

OIL COLLAR GEAR – The oil collar gear drives the oil pump gear.

OIL PUMP GEAR – The pump gear is keyed and fitted to the oil pump shaft and is driven by a gear on the countershaft.

OIL RETAINING RING – Prevents loss of lubricants from the system.

OUTER COUNTERSHAFT BEARING – Located at outboard end of the countershaft box

OUTER ECCENTRIC BEARING – The outer eccentric bearing which is locked to the frame, provides the bearing surface for the eccentric assembly.

PINION – The pinion is keyed to the countershaft and drives the gear on the eccentric.

PISTON – Supports the head assembly and transmits vertical crushing force components to the main frame through the hydraulic support system.

PISTON RINGS – See "OIL RETAINING RING".

PUMP GEAR COVER – Located on the main oil pump gear housing and is used to provide access to the oil pump gear when servicing is needed.

PUMP GEAR HOUSING – See "PUMP GEAR COVER".

ROTARY SEAL RING – Provides labyrinth and piston ring seals to prevent dust from entering the crusher.

SOCKET – The socket supports the main shaft assembly and transmits the crushing force to the main frame.

SOCKET LINER – The socket liner is mounted on top of the socket, and provides the bearing surface for the head.

SPIDER CAP – An impact abrasion resistant cover over the upper end of the main shaft and the spider bearing which protects these items from impact and abrasion of the materials entering the crushing chamber.

STEP BEARING – A thrust bearing used to trans mit the vertical forces on the main shaft to the sup porting hydraulic cylinder.

STEP BEARING PLATES – The step bearin plates, located in the main frame, are thrust bear ings which support the eccentric or main shaft as sembly.

STUD CAP – Renewable cap that prevents wea on the stud nut.

SUPPORT CONE BEARING SEAT – See "STE BEARING".

Cone Crushers
Terminology

SUPPORTING CONE – Driven by the eccentric to impart a gyrating motion to the mantle which it supports.

SUPPORTING CONE BEARING – A convex spherical bronze bearing which supports the supporting cone assembly.

"T" NUT – See "BOWL LINER 'U' BOLT".

TOP SHELL – The upper stationary structure that contains the concave ring and supports the main shaft at the upper end.

TORCH/BURNING RING – A ring located between the locking nut and the mantles to remove extreme force on the locking nut when changing the mantles.

UPPER CRUSHING TOOL – See "CONCAVE RING" and/or "BOWL LINER".

UPPER ECCENTRIC RADIAL ROLLER BEARING – Transmits horizontal crushing pressures between the head and the eccentric.

UPPER FRAME – Supports the concave ring and seats in a conical machined surface and bolts to the main frame.

UPPER THRUST ROLLER BEARING – Transmits vertical crushing loads between the head and the eccentric.

WEAR COLLAR – A conical shaped deflector ring, located under the head assembly, to protect the labyrinth seal area.

Gyratory Crushers

These crushers derive their name from the gyrating action of a heavy mantle or crushing head located within a deep, conical bowl. The crusher is fed at the top. Material is crushed by compression between the mantle and the concaves, and is discharged from the bottom. See Fig. 7.

■

Gyratory Crushers

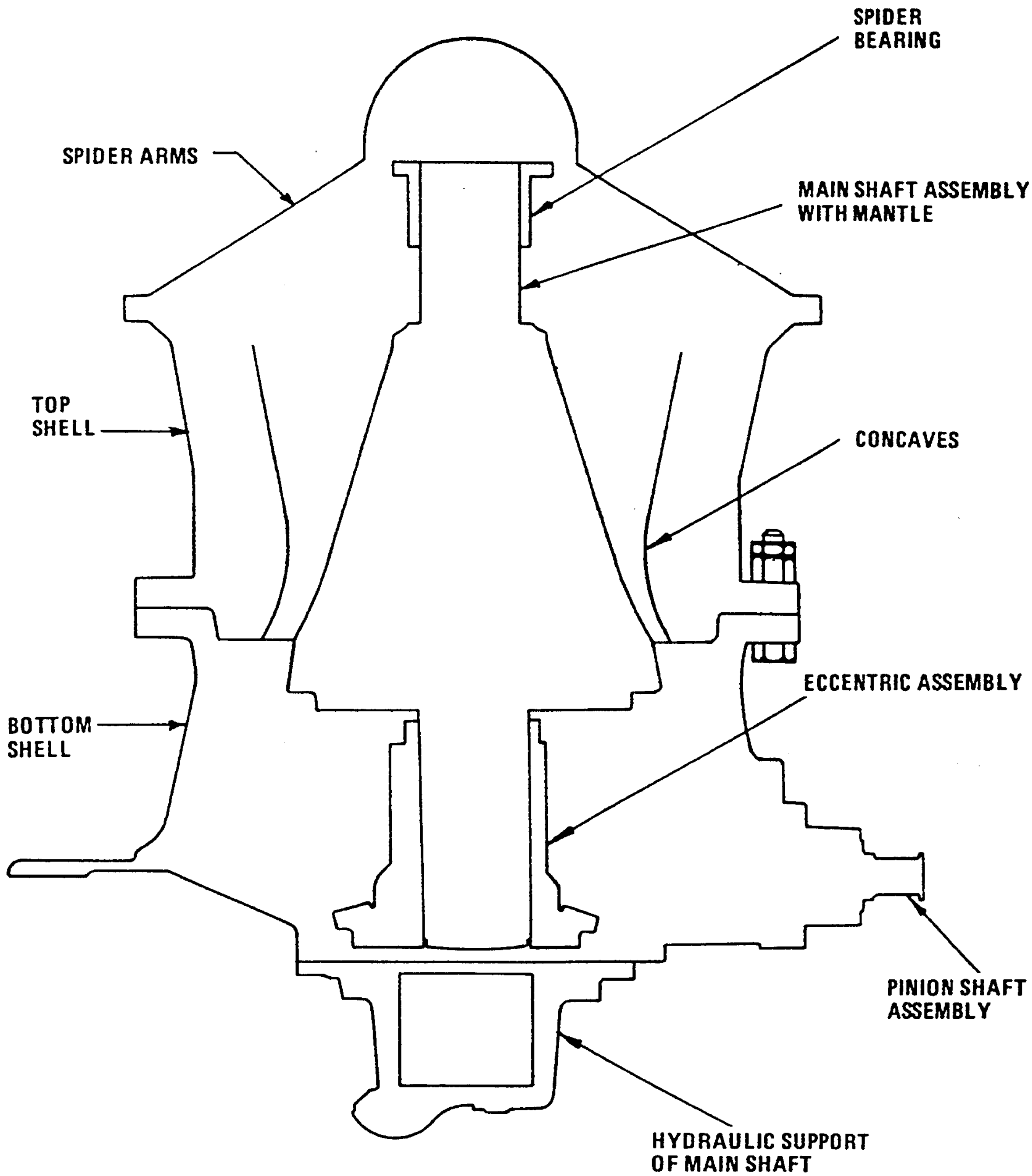


FIG. 7 – GYRATORY CRUSHER.

Gyratory Crushers

Terminology

ARM GUARD – Castings or fabrications which protect the bottom shell arms and countershaft housing from erosion caused by material being discharged from the crushing cavity.

BOTTOM HYDRAULIC CYLINDER COVER – The cover plate below the piston on crushers with hydraulically supported main shafts.

BOTTOM PLATE – The cover plate below the eccentric and gear on spider suspended crushers.

BOTTOM SHELL BUSHING – See "ECCENTRIC BUSHING-OUTER".

CHOKE POINT – That level in the crushing chamber where the capacity of the crusher is limited by the configuration of the crushing surface. See Fig. 8.

CONCAVES – Manganese or abrasion resistant material wearing surface located in the stationary section of the crushing chamber.

COUNTERSHAFT – The shaft that transmits power through the bottom shell from the motor or motor sheave to the pinion.

COUNTERSHAFT BEARINGS – The bearings which allow rotation of the countershaft within the housing.

COUNTERSHAFT HOUSING – The structural component that holds the countershaft bearings. See Fig. 9.

DUST SEAL – The sealing arrangement at the bottom of the crushing chamber designed to prevent dust and dirt from entering the main bearing area.

ECCENTRIC – The cylindrical member converting the circular gear motion to the gyrating motion of the main shaft.

ECCENTRIC BUSHING-INNER – The removable bearing member between the eccentric and the main shaft.

ECCENTRIC BUSHING-OUTER – The removable bearing member between the eccentric and the bottom shell.

Gyratory Crushers

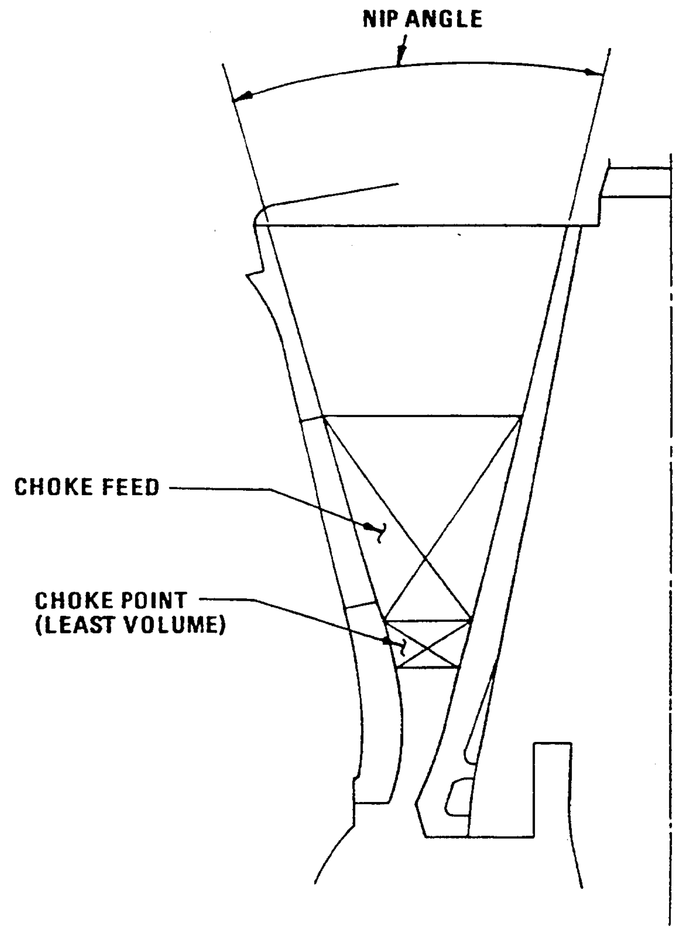


FIG. 8 – NIP ANGLE, CHOKE FEED, CHOKE POINT.

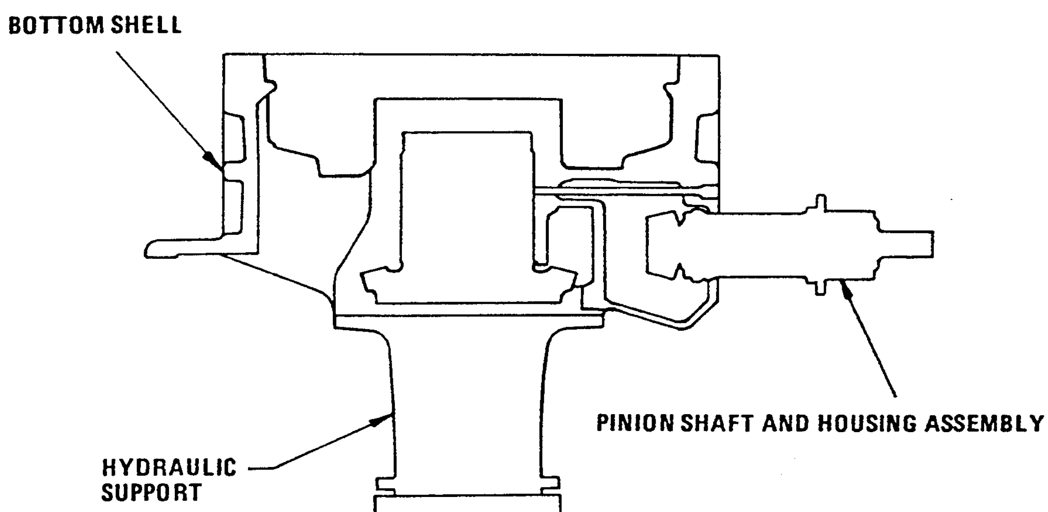


FIG. 9 –COUNTERSHAFT HOUSING.

Gyratory Crushers
Terminology

ECCENTRIC WEARING PLATE OR RING – The bearing support member for the eccentric.

FRAME – See "SHELL".

GEAR AND PINION OR DRIVING GEAR AND DRIVING PINION – The gearing used to transmit power from the countershaft to the eccentric.

HEAD CENTER – A casting located between the main shaft and the mantle.

HEAD NUT – A threaded large nut used to tighten the mantle to the main shaft. See Fig. 10.

HOPPER WEARING PLATES – See also "SPIDER RIM LINERS".

HYDRAULIC SUPPORT – The terms used to describe the hydraulic support of the crusher's main shaft. See Fig. 11.

HYDRAULIC SYSTEM – Term used in conjunction with Lube System on piston supported main shaft.

LUBE SYSTEM – The term used to describe the complete lubrication system for the internal component of gyratory crushers.

MAIN SHAFT – The main gyratory member of a gyratory crusher with appropriate bearing area to transfer the crushing forces to the stationary members.

MANTLE – Manganese steel or abrasion resistant steel casting wearing surface located on the gyrating main shaft portion of the crushing chamber.

NIP ANGLE – The included angle between the mantle and the concave. See Fig. 8.

NUT, SUSPENSION-ADJUSTING – A large nut used to support and adjust the position of the main shaft on spider suspended crushers. See Fig. 10.

PINIONSHAFT BEARINGS – See "COUNTERSHAFT BEARINGS".

PINIONSHAFT – See "COUNTERSHAFT".

PINIONSHAFT HOUSINGS – See "COUNTERSHAFT HOUSING".

PISTON – The moveable supporting member for the main shaft in the hydraulic support cylinder.

PISTON BUSHING – The removable bearing member between the hydraulic support piston and the hydraulic cylinder.

Gyratory Crushers

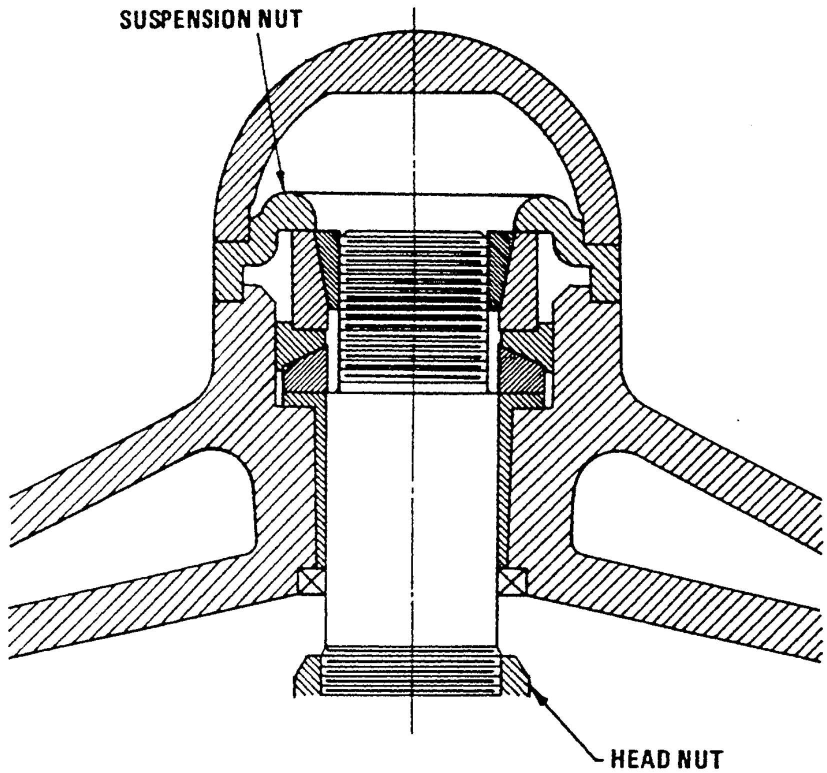


FIG. 10 – NUT, SUSPENSION AND HEAD NUT.

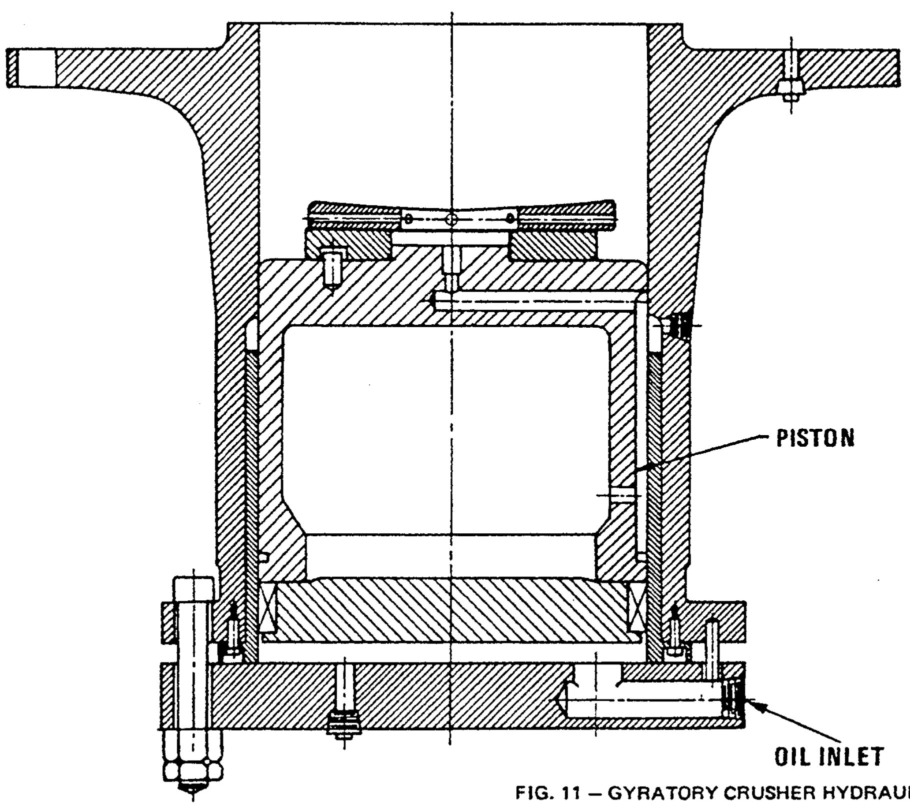


FIG. 11 – GYRATORY CRUSHER HYDRAULIC SUPPORT.

Gyratory Crushers
Terminology

POSITION INDICATOR – A device which indicates the position of the mantle in relation to a mantle to concave zero point.

SHELL – The main stationary structural member of a crusher composed of two or more sections depending upon the size of the crusher, and designated as:

TOP SHELL – Uppermost Section

MIDDLE SHELL – Center Section

BOTTOM SHELL – Bottom Section; see sketch under "COUNTERSHAFT HOUSING".

SPIDER – A casting with radiating arms installed across the top of a gyratory crusher which fixes the position of the upper end of the main shaft.

SPIDER ARM SHIELDS – Abrasion resistant covers to protect the spider from wear.

SPIDER BUSHING – The upper pilot bearing member mounted in the spider.

SPIDER CAP – An impact abrasion resistant cover over the upper end of the main shaft and the spider bearing which protects these items from the impact and abrasion of the material entering the crushing chamber.

SPIDER RIM LINERS-(HOPPER WEARING PLATES) – An abrasion resistant cover over the circumferential portion of the spider to protect it from wear.

STEP BEARING – A thrust bearing used to transmit the vertical forces on the main shaft to the supporting hydraulic cylinder.

SUPPORT WEAR RINGS – See "STEP BEARING".

SUSPENSION NUT – See "NUT".

SUSPENSION BEARING – See "SPIDER BUSHING".

Impactors and Hammermills

IMPACTOR — A crusher with rotor, without screen bars or grates, crushing primarily by impact. See Figs. 12, 13, 14.

HAMMERMILL — A crusher equipped with a rotor to which are attached hammers, normally free-swinging, and frequently equipped with grates. Crushing is achieved by impact, shear, and attrition. See Figs. 15, 16, 17.

■

Impactors and Hammermills

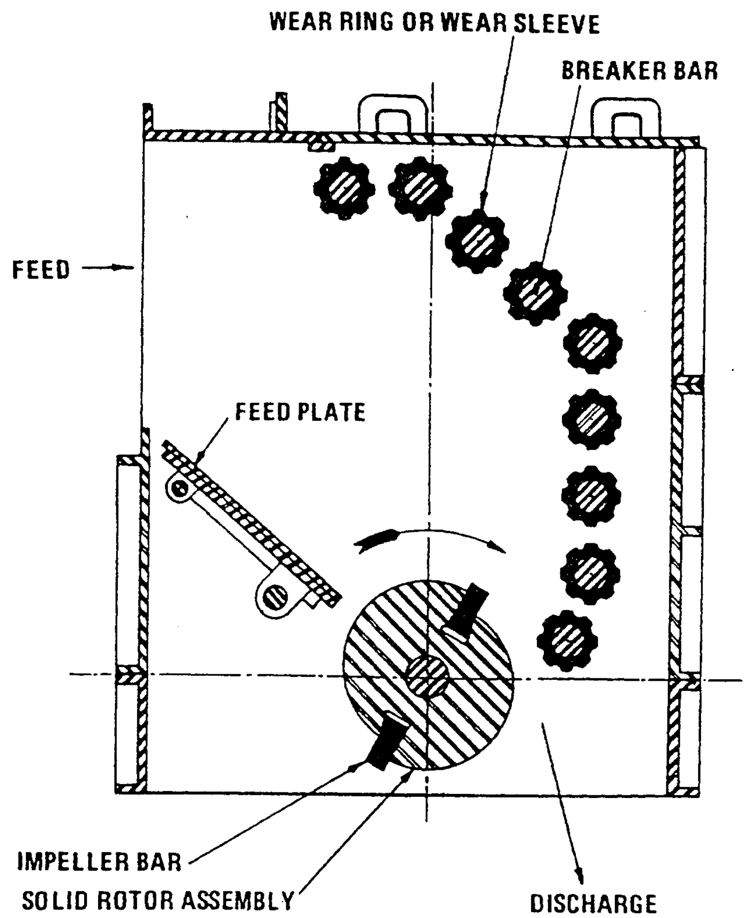


FIG. 12 – SINGLE ROTOR IMPACTOR.

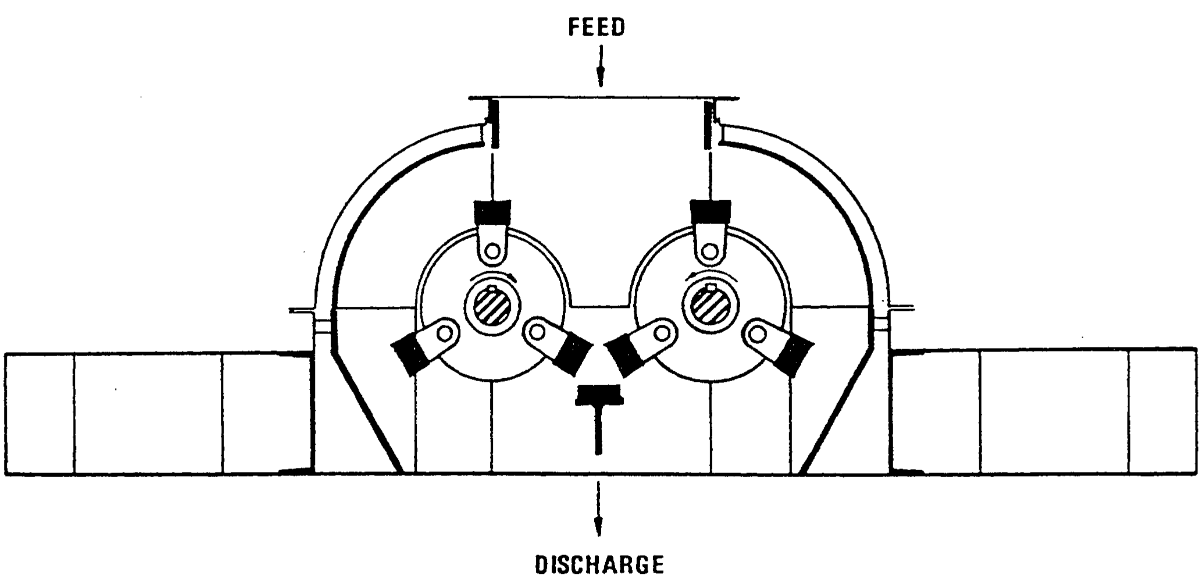


FIG. 13 – DOUBLE (TWIN)-ROTOR IMPACTOR.

Impactors and Hammermills

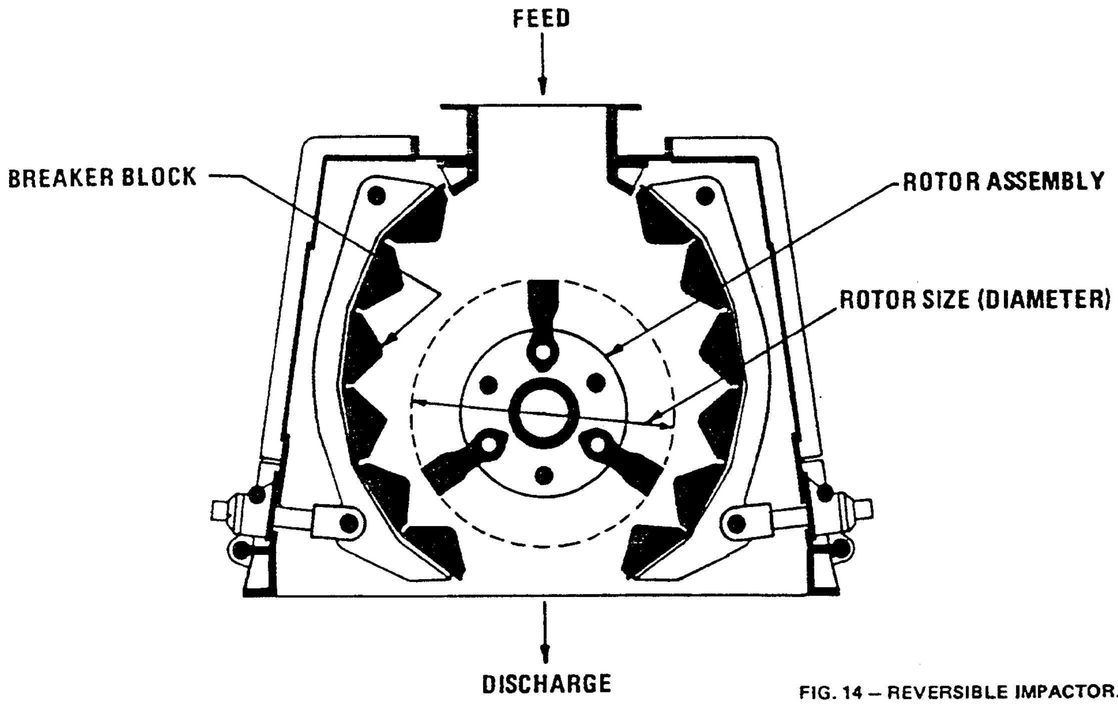


FIG. 14 – REVERSIBLE IMPACTOR.

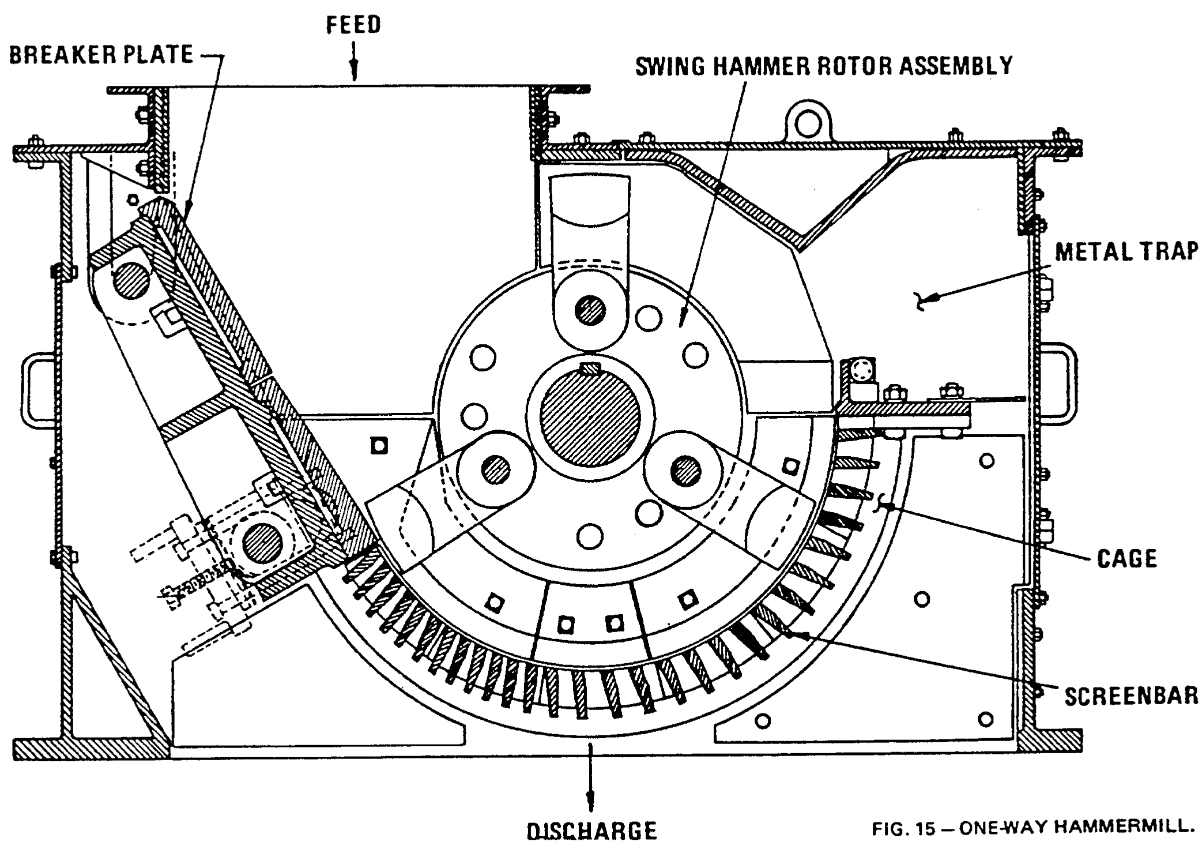


FIG. 15 – ONE-WAY HAMMERMILL.

Impactors and Hammermills

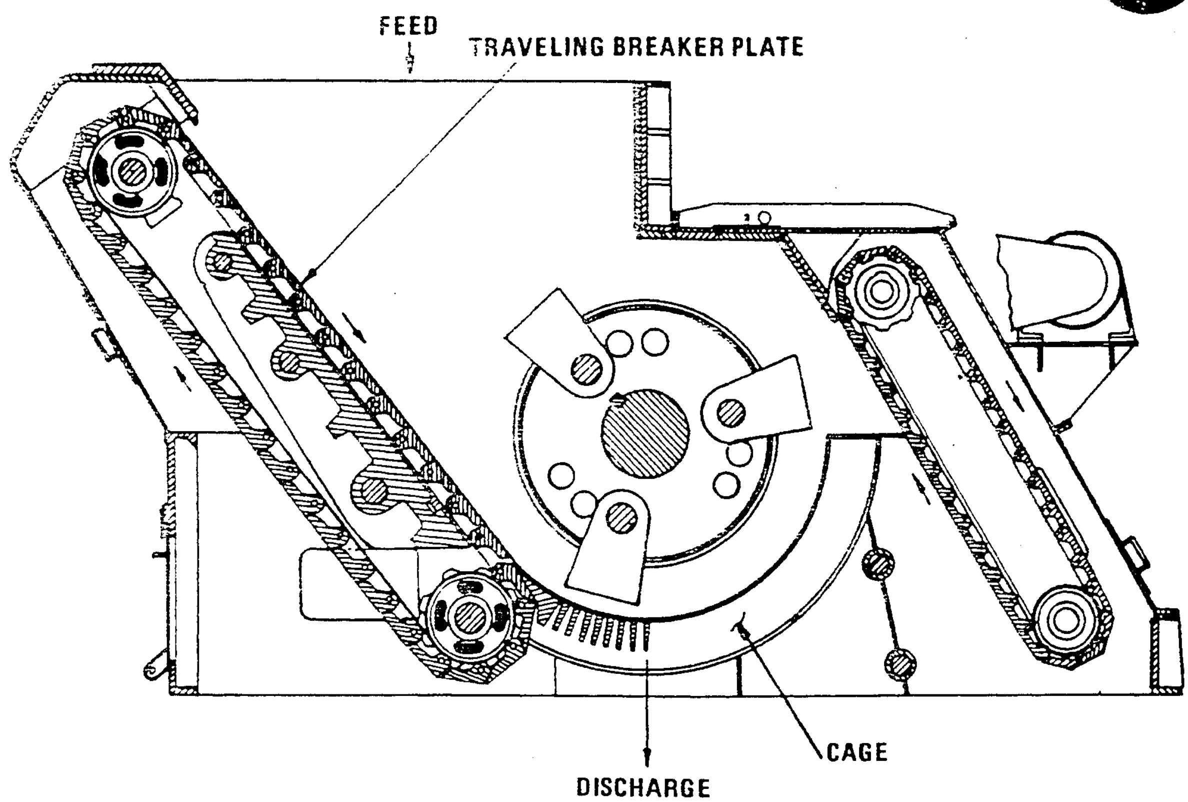


FIG. 16 – NON-CLOG HAMMERMILL.

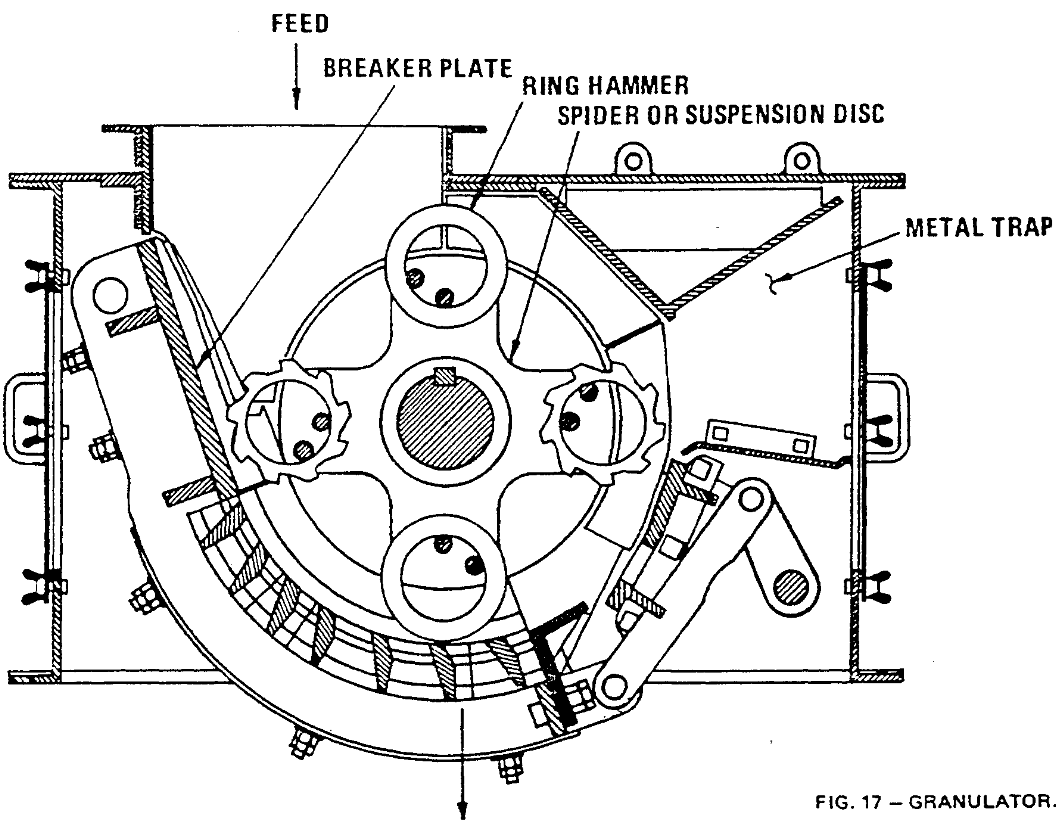


FIG. 17 – GRANULATOR.

Impactors and Hammermills

Terminology

BEATER – See "HAMMER" and/or "IMPELLER BAR".

BLOW BAR – See "IMPELLER BAR".

BREAKER BAR – Bar separate from the rotor for crushing and sizing of material. Such bar may be fixed or adjustable.

BREAKER BAR SLEEVE – See "WEAR SLEEVE".

BREAKER BED PLATE – Support for traveling breaker plate links.

BREAKER BLOCK – See "LINER".

BREAKER PLATE – Member against which material is crushed. This member may be fixed or adjustable. See Fig. 17.

CAGE – Assembly, fixed or adjustable, generally consisting of a frame holding screen bars, grate bars, grate sections, screen sections, or screen (perforated) plates. See Fig. 15.

CAGE MILL – See section of this Glossary giving definitions of cage mills and terms peculiarly applicable thereto.

CAGE SHAFT – Member attached to crusher frame for supporting cage assembly.

CENTER DISCS – See "SUSPENSION DISCS".

CHAIN CURTAIN – Strands of chain covering the feed opening of a crusher to prevent flyback or ricochet of material.

COLLARS – See "SPACING COLLARS".

CRUSHING CHAMBER – Space inside the machine provided for stone expansion following crushing of material.

DISCS – See "SUSPENSION DISCS".

DOUBLE (TWIN) ROTOR IMPACTOR – See "IMPACTOR" at beginning of Section.

DOWNRUNNING – See "HAMMERMILL".

DROP HEIGHT – Vertical free fall distance from the feed mechanism to the top of the hammer circle.

DUST GATE – Dust suppression device in top of hammermill.

END DISCS – Two steel discs, one on each end of the rotor, made with flanges to protect the ends of the hammer pins and the side frames.

END FRAME – Frame section parallel to the rotor shaft.

FEED PLATE – Sloped member, fixed or adjustable, used to transfer material to be crushed from feed opening to the rotor. See Fig. 12.

FEED PLATE-HYDRAULIC – Hydraulically actuated plate to assist in eliminating bridging of material across the rotor.

GRANULATOR – See Fig. 17.

GRATE – A sub-assembly of screen bars or perforated plates.

GRATE BAR – See "SCREEN BAR".

GRID – Breaker plate with multiple openings.

HAMMER – Crushing element attached to rotor, usually free-swinging.

HAMMER ARRANGEMENT – The configuration (spacing) of the hammers in the rotor assembly.

HAMMER BALANCE – 1. See "ROTOR BALANCE". 2. Weight of each hammer must equal the weight of the opposing hammer or hammers. 3. Arrangement of hammers in the rotor assembly so that weight distribution is achieved to minimize crusher vibration.

HAMMER-BULLHEAD – See "HAMMER T-HEAD".

HAMMER CIRCLE – Diameter of circle scribed by hammer tip with hammer extended.

HAMMER DISCS – See "SUSPENSION DISCS".

HAMMER PINS – Solid cylindrical rod or shaft which supports hammers in the rotor assembly.

Impactors and Hammermills

Terminology

HAMMER-RIGID — See "IMPELLER BAR" or "HAMMER".

HAMMER RING — Ring-shaped member, either smooth or toothed on external surface, supported by hammer pins. The ring hammer is free to rotate through the material while crushing by impact and compression.

HAMMER SHANK — Section of hammer that supports the head.

HAMMER-SLUGGER — Bar-type hammer with multiple shanks.

HAMMER T-HEAD — Hammer with head wider than shank.

HAMMERMILL-DOWNRUNNING — A hammermill where the material feeds into the downward rotation of the rotor.

HAMMERMILL GRANULATOR — A hammermill equipped with rings rather than hammers to achieve crushing action.

HAMMERMILL-PULVERIZER — A fine grind hammermill usually producing a product below 10 mesh.

HAMMERMILL-SHREDDER — An adaptation of the hammermill equipped with fixed or free-swinging hammers to reduce material mainly by shearing and attrition, and partially by impact.

IMPACT — Striking of one moving object against another moving or fixed object.

IMPACT BAR — See "BREAKER BAR".

IMPACTOR-DOUBLE (TWIN) ROTOR — A crusher equipped with two rotors with rigid or free-swinging hammers; rotors may turn in the same or opposite directions - normally used for either primary or secondary crushing; reduction is accomplished by impact. See Fig. 13.

IMPACTOR-REVERSIBLE — A crusher with a rotor that can be operated either clockwise or counter-clockwise. See Fig. 14.

IMPACTOR-SINGLE ROTOR — A crusher equipped with one rotor with impeller bars or free-swinging hammers used for either primary or secondary crushing; reduction is accomplished by impact. See Fig. 12.

IMPELLER — See "ROTOR".

IMPELLER BAR — Bar rigidly attached to and extending the full width of the rotor, and used as the crushing element in impactors. See Fig. 12.

LINER — Abrasion-resistant replaceable plate or shape protecting interior of frame from wear.

LINK — Traveling breaker plate element.

LINK PIN — Pin connecting links of traveling breaker plate.

LOWER FRAME — The lower section of the crusher housing, generally below the center line of the rotor.

METAL TRAP — Compartment within a crusher to collect uncrushable objects. See Figs. 15, 17.

NON-CLOG — Crusher with traveling breaker plate(s) for sticky materials. See Fig. 16.

PRIMARY CRUSHER — The first crusher used in a crushing system.

PULVERIZER — See "HAMMERMILL".

PULVERIZER-RING — See "HAMMERMILL-GRANULATOR".

REVERSIBLE CRUSHER — See "IMPACTOR-REVERSIBLE".

ROTOR — A rotating assembly with crushing element within an impactor or hammermill which imparts the force required to reduce the material fed to the crusher. (See General Drawings-Impactor and Hammermill.)

ROTOR BALANCE — Proper distribution of weight in rotor to minimize vibration due to operation.

ROTOR SIZE — Tip diameter by the width.

ROTOR WEIGHT — Weight of total rotor assembly less the bearings.

Impactors and Hammermills
Terminology

SCALLOPING — Uneven wear pattern on parts.

SCREEN BAR — Welded or cast bars arranged to control product size. Also known as "GRATE BAR". See Fig. 15.

SCREEN PLATE — A perforated plate, flat or curved.

SCREEN SECTION — See "GRATE".

SCRUBBER BAR — See "BREAKER BAR".

SET-OUT HOLES — Series of holes in discs to allow moving the hammer pins further from the rotor shaft, thereby compensating for hammer wear.

SHAFT SEALS — A device for sealing the opening between the shaft and the side frame.

SHIM — Plate, wedge, or bar used to fill gaps, achieve alignment or adjustment in various assemblies in machinery.

SHREDDER — See "HAMMERMILL-SHREDDER".

SIDE FRAME — Frame section perpendicular to the rotor shaft.

SINGLE ROTOR IMPACTOR — See "IMPACTOR-SINGLE ROTOR".

SPACING BLOCKS (LUGS) — Intermittent blocks welded or cast to the screen bars to give proper spacing between the bars for product sizing.

SPACING COLLARS — Short sleeves mounted on the rotor shaft to space the discs properly in an impactor or hammermill.

SPACING RINGS — Small rings used in conjunction with certain hammers to space the hammers between the discs properly.

SPIDERS — Elongated discs.

SPIDER ROTOR — A rotor equipped with spiders. See Fig. 17.

STOP PIN — Steel pins similar to hammer pins in a motor which prevent the hammers from wedging between the discs or impacting the spacing collars during flyback.

STRIPPER BAR — See "BREAKER BAR".

SUSPENSION BAR — See "HAMMER PINS".

SUSPENSION DISCS — Circular plate members that are fitted snugly on the rotor shaft and support the hammer pins.

TIE BAR — Strengthening member.

TIP SPEED — Speed of hammer tip expressed in feet per minute.

TRAMP IRON POCKET — See "METAL TRAP".

TRAVELING BREAKER PLATE — Traveling chain of links in a non-clog crusher. See Fig. 16.

TWIN-ROTOR IMPACTOR — See "IMPACTOR".

UPPER FRAME — That section of the frame assembly extending from the center line of the rotor upwards, containing the crushing chamber and the feed opening.

UPRUNNING — See "HAMMERMILL".

WEAR RING — Short cylindrical ring (doughnut) mounted on a breaker bar for protection of the bar from wear. See Fig. 12.

WEAR SLEEVE — Cylindrical cover for breaker bar protection. See Fig. 12.

WINDAGE — The air flow generated by the motion of a crusher during operation.

■

Jaw Crushers

JAW CRUSHERS – A jaw crusher consists of a main frame with a stationary crushing surface and a swing jaw with a moving crushing surface. The inclined swing jaw moves to compress material against the stationary crushing surface. See Figs. 18, 19.

Twin jaw crushers have two swinging (movable) jaws synchronized by chain or gear drive, no stationary jaws.

■

Jaw Crushers

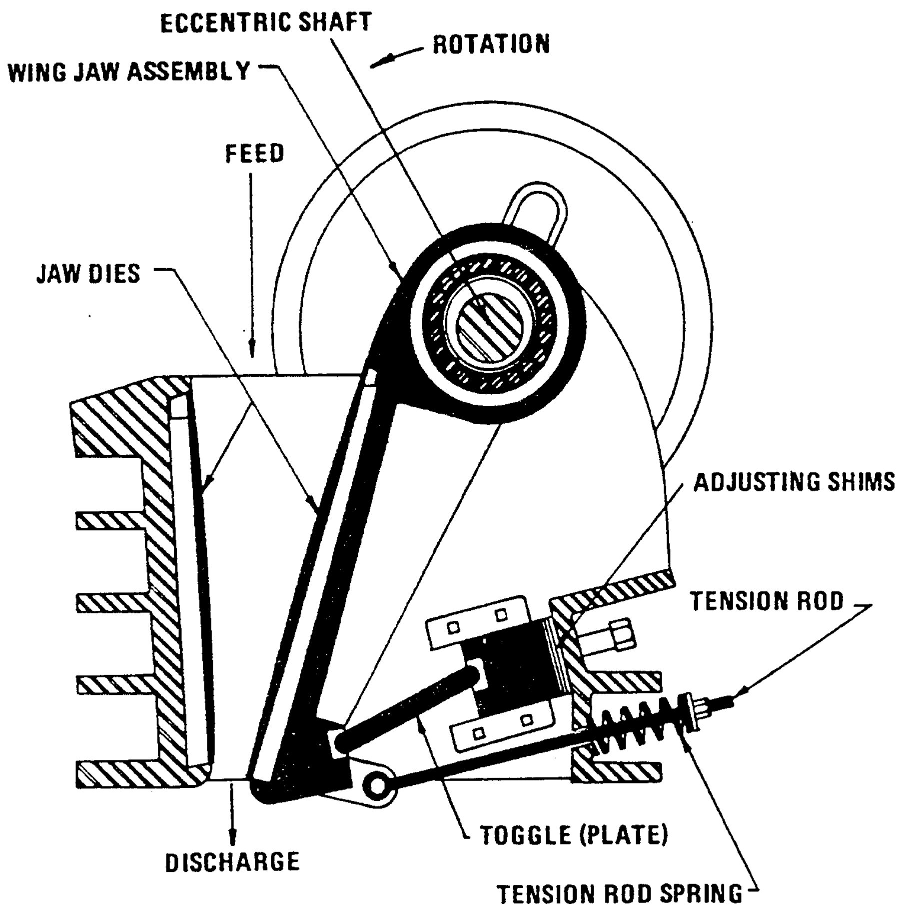


FIG. 18 – OVER HEAD ECCENTRIC JAW CRUSHER.

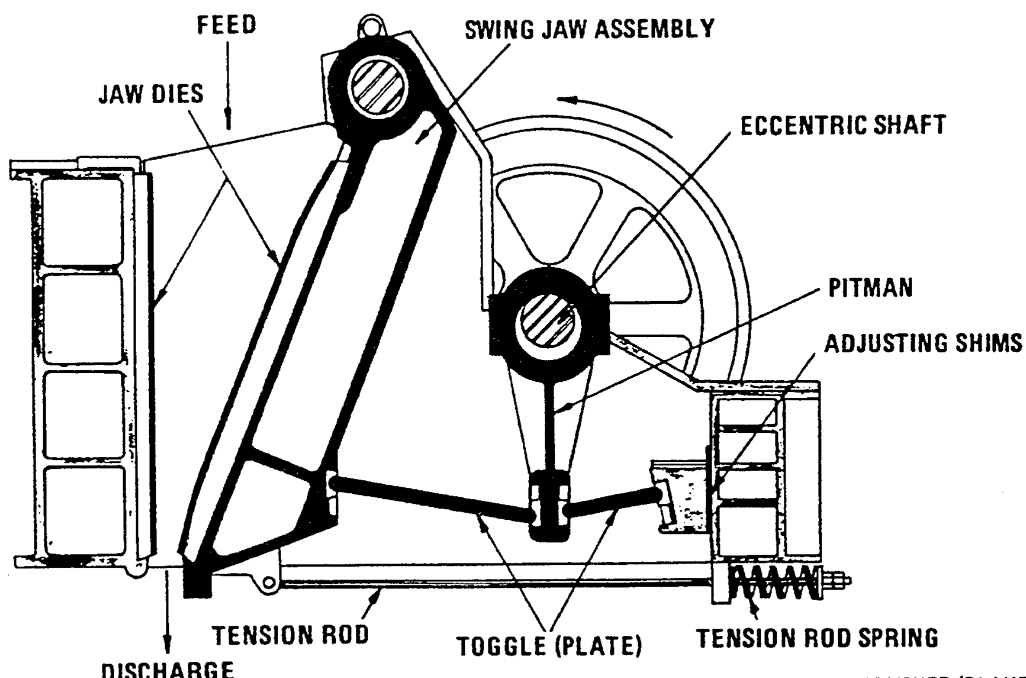
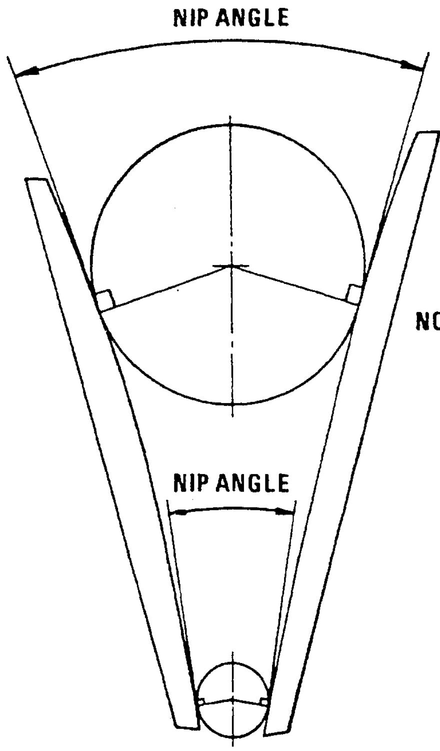


FIG. 19 – DOUBLE TOGGLE JAW CRUSHER (BLAKE TYPE).

Jaw Crushers



NOTE:

1. NIP ANGLE VARIES WITH CURVED JAW DIES
2. MAXIMUM NIP ANGLE OCCURS AT MINIMUM DISCHARGE SETTING

FIG. 20 – ANGLE OF NIP.

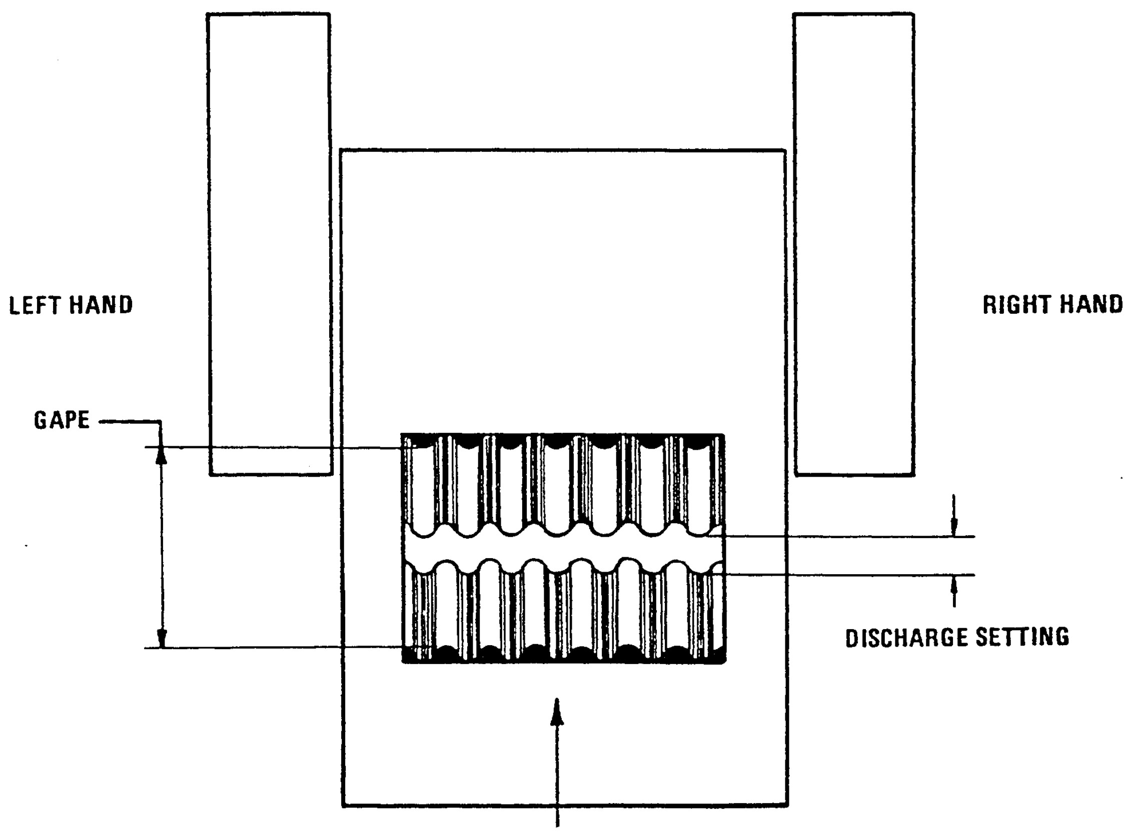


FIG. 21 – JAW CRUSHER - HAND OF DRIVE.

Jaw Crushers

Terminology

ANGLE OF NIP — Acute angle formed by stationary and swing jaw. See Fig. 20.

BEARINGS-JAW — A crusher component which allows rotation of the shaft on which it is mounted. Basic types are roller and sleeve (plain).

BEARING CAP — A type of bearing seal. Also the top portion of a split bearing housing.

BLAKE-TYPE JAW CRUSHER — Has two shafts and two toggles. The swinging jaw is pivoted at the top and actuated at the bottom.

CLOSED SIDE SETTING — Distance between jaw dies measured at their bottom with the jaw in the closed position. Measurement of distance is taken from peak of corrugation to valley of opposing corrugation on jaw die surfaces.

COUNTERWEIGHT — Weights placed on flywheels to balance the crusher.

CRUSHING CHAMBER-JAW — The area confined by the stationary and swinging jaw dies and the cheek plates in which crushing takes place.

DISCHARGE OPENING-JAW — The area between the jaw dies and the cheek plates at the bottom of the crushing chamber.

DOUBLE TOGGLE JAW CRUSHER — Has two shafts and two toggles. The swinging jaw is pivoted at the top and actuated at the bottom.

ECCENTRIC SHAFT — Shaft machined with a portion of the axis off-center to impart a crushing motion to the swinging jaw.

FEED OPENING — The inlet opening of the crusher confined by the jaw dies and the cheek plates.

GAPE — The distance between the jaw dies at the top, i.e., the gape of a 3042 jaw crusher is 30". See Fig. 21.

HAND OF DRIVE — Right or left on which drive is located. See Fig. 21.

HYDRAULIC ADJUSTING MECHANISM — Hydraulic pump which locates the swing jaw to assist in the addition or removal of shims when changing discharge settings.

JAW DIES (JAW PLATES) — Renewable crushing surfaces with different types of configurations on the surface. See also "SWING JAW ASSEMBLY".

JAW DIE WEDGES — Bolted wedges used to tighten and secure jaw dies.

LEFT HAND — See "HAND OF DRIVE".

MAIN FRAME — Major casting or weldment that supports the crushing members.

MOTOR BASE — Slide base to maintain proper V-belt tension.

MOVABLE JAW ASSEMBLY — See "SWING JAW ASSEMBLY".

OPEN SIDE SETTING — Distance between jaw dies measured at their bottom with the jaw in the open position. Measurement of distance is taken from peak of corrugation to valley of opposing corrugation on jaw die surfaces.

OVERHEAD ECCENTRIC-(SINGLE TOGGLE JAW CRUSHER) — Eccentric shaft and bearing mechanism located at the top of the swinging jaw assembly to impart crushing motion to the machine.

PITMAN — The eccentric mechanism in a Double Toggle or Blake-type jaw crusher, having two toggles and two shafts. Often referred to as the swing jaw mechanism in the overhead eccentric type jaw crusher.

RIGHT HAND — See "HAND OF DRIVE".

ROD TENSION — See "TENSION ROD".

ROLLER BEARING — Common types used in jaw crushers are spherical, taper, and cylindrical roller bearings.

ROTATION — Direction. See Fig. 18.

SAFETY RELEASE — A mechanism which prevents damage to the crusher from uncrushable objects.

Jaw Crushers
Terminology

SHIM-ADJUSTING – Steel spacer plates to locate and hold swinging jaw in the desired discharge position.

SINGLE TOGGLE JAW CRUSHER – See "OVERHEAD ECCENTRIC".

SIZE – Gape by width, i.e., 30 x 42.

SLIPPAGE – Action that occurs when the angle of the nip is too great, thus retarding acceptable flow rate of the material to be crushed.

SPEED – RPM of the eccentric shaft of the crusher flywheel.

STATIONARY JAW DIES – See "JAW DIES".

STROKE – Amount of movement of the swing jaw which is controlled by the amount of eccentricity of the eccentric shaft and the toggle system.

SWING JAW ASSEMBLY – Consists of jaw dies, shaft and bearings.

SWINGING (MOVABLE) JAW DIES – Manganese crushing surface mounted on the swing jaw. See "JAW DIES".

TENSION ROD SPRING ASSEMBLY – Designed to maintain a tight contact between the swinging jaw, toggle plate and main frame. See Figs. 18, 19.

TOGGLE OR TOGGLE PLATE – A spacing member located between frame and Pitman and/or swing jaw which may also act as a protective member.

TOGGLE BLOCK – Either holds or is the stationary toggle seat.

TOGGLE SEAT – A bearing surface, usually a replaceable insert, designed to take the wear due to toggle movement.

WEDGES – See "JAW DIE WEDGES".

■

Double and Triple Roll Crushers

DOUBLE ROLL CRUSHER – A crusher having two rolls mounted in the same plane, revolving towards each other. Material is crushed between them. See Fig. 22.

TRIPLE ROLL CRUSHER – A crusher using three rolls, allowing two crushing chambers, thus increasing the machine's ratio of reduction. See Fig. 23.

■

Double and Triple Roll Crushers

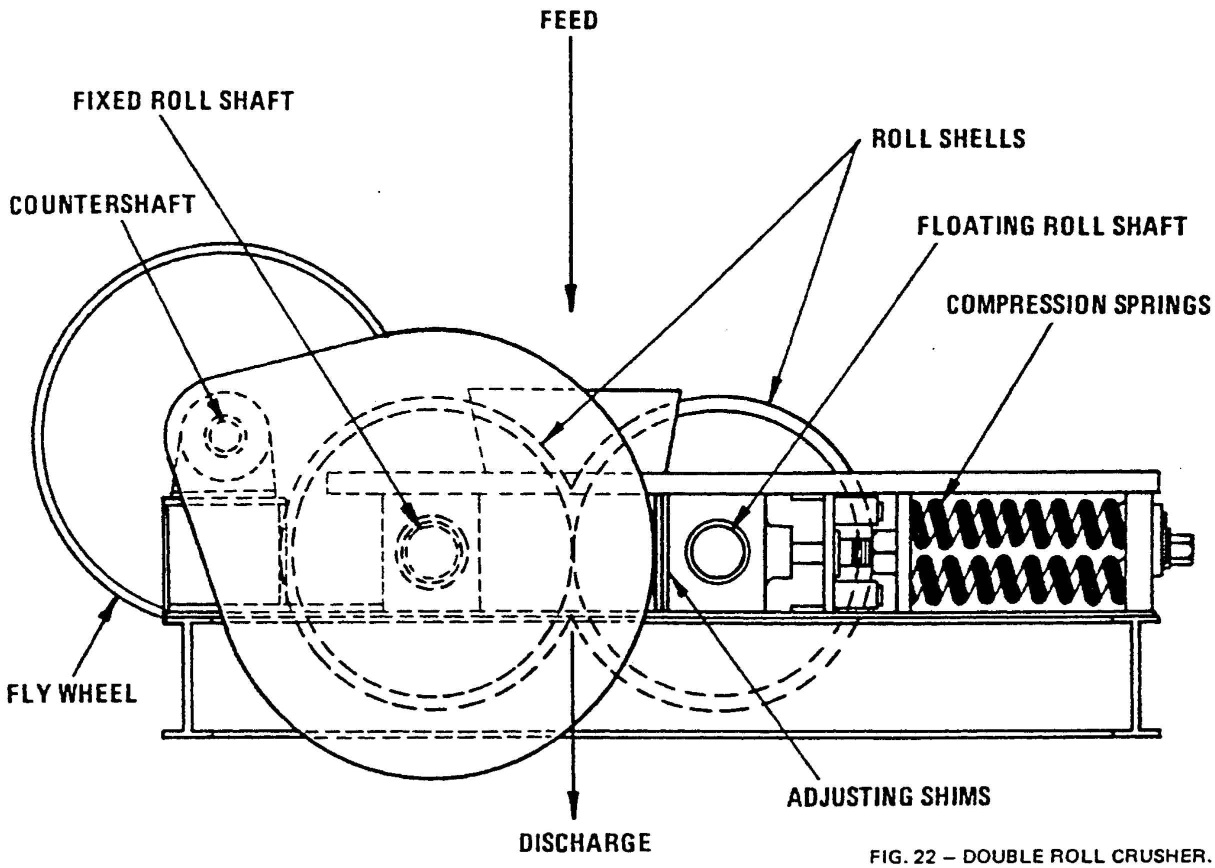


FIG. 22 – DOUBLE ROLL CRUSHER.

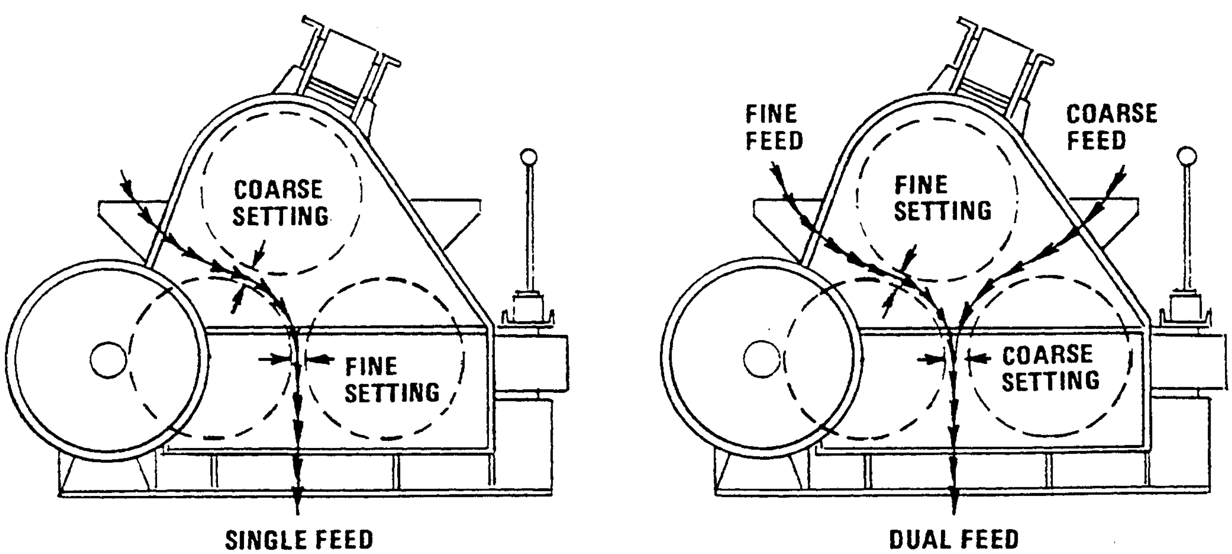


FIG. 23 – TRIPLE ROLL CRUSHER.

Double and Triple Roll Crushers

Terminology

ADJUSTING SHIMS – Fabricated steel plates used to maintain or change discharge setting between the rolls. See Fig. 22.

BEARING BLOCKS – Stationary and movable. See "MOVABLE AND FIXED BEARING BLOCKS".

BULL GEAR – Mounted on the drive roll shaft and is driven by pinion gear on countershaft. Also called "DRIVEN GEAR" or "SPUR GEAR".

CHAIN DRIVE – Roller chain and sprockets used to synchronize the rolls and impart power and motion to them from the countershaft.

COUNTERSHAFT – Shaft that transmits power from the flywheel-pulley to the power train for the stationary roll assembly. See Fig. 22.

DISCHARGE SETTING – Area defined by the space between the rolls at their closest point.

DRIVE GEAR – The pinion gear mounted on countershaft that drives the driven gear that is mounted on the stationary or drive roll shaft.

DRIVEN GEAR – See "DRIVE GEAR" or "BULL GEAR".

FEED HOPPER – Fabricated box located above the feed opening with or without feed control members.

FIXED ROLL SHAFT – Non-adjustable roll shaft assembly. See Fig. 22.

FLOATING ROLL SHAFT – Adjustable roll shaft assembly. See Fig. 22.

FRAME – Main support members.

GEAR CASE – Oil tight housing for pinion and bull gear.

GUIDE BAR – Wearing bar on which the guide plates work.

GUIDE PLATE – Small steel plates that keep the floating roll assembly in position on the frame (guide bars) throughout fore and aft movement due to adjustment or spring action.

HAND OF DRIVE – Determined when facing the crusher from the spring end.

HYDRAULIC ADJUSTMENT – Hand activated hydraulic pump which locates the moveable or floating roll to assist in the addition or removal of adjusting shims when changing discharge setting.

MOVABLE AND FIXED BEARING BLOCKS – Housing containing bearing and seals for movable and fixed roll shafts.

OIL FLINGER – Ring or flange on shaft used to insure lubrication or enhance sealing.

OIL LUBRICATION – System of lubricating crusher bearings - usually a splash oiling system.

OIL SLINGER – See "OIL FLINGER".

PINION, SPUR – Small gear on countershaft or back gear shaft, usually a driving gear. A lubricating gear.

PISTON RING – A metal seal to retain lubricant or protect the bearing from entrance of foreign material.

RIM – Wheel or part on which the pneumatic tire is mounted.

RIM SAFETY (TIRE) – Means of retaining a pneumatic tire on its rim.

RING, TAPER – Wedge-shaped part used to mount and lock roll shell to roll drum. Also called "roll shell wedge".

ROLL DRUM – Part that supports the roll shell to the roll shaft.

ROLL SHAFT – One of the two or three main shafts that carry a crushing roll.

ROLL SHELL – The removable wearing surface on a crusher roll, usually manganese steel.

RUBBER OR PNEUMATIC TIRE DRIVE – Tires mounted on fixed and movable roll shafts to keep movable roll speed synchronized with fixed roll.

SPACER BLOCK – Steel box located between the

Double and Triple Roll Crushers

Terminology

jib and the main frame to maintain a fixed dimension.

SPRING – Compression springs allow the floating roll to move when an uncrushable object enters between the two roll shells. It is a relief mechanism. See Fig. 22.

SPRING PLATE – Part used to provide a seat for the compression springs.

SPRING RETAINING ROD – Rod that guides the springs and provides means of compressing the springs.

SPUR GEAR – See "DRIVEN GEAR" and "BULL GEAR".

STAR GEARS – Deep tooth-type gears used to transmit the power and synchronize the stationary roll assembly to the floating roll assembly and allow for adjustment. Also called "finger gears".

STAR GEAR HOUSING – An oil and dust tight cover, protecting the star gears from entrance of foreign material. It also retains the lubricating oil for the star gears.

TAPER SEGMENT – Split or segmented taper ring. Also called "roll shell wedge segment".

TIRE GUARD – Safety guard around the pneumatic tires that synchronize the rolls.

TIRE HUB – The wheel upon which the pneumatic tires are mounted.

V-BELT DRIVE – Consists of a grooved pulley on the motor or power unit, a set of matched V-Belts, and the grooved flywheel/pulley on the crusher countershaft.

WEARING PLATE (FRAME) – Lower cheek plate which protects lower structural members from abrasion.

■

Single Roll Crushers

The single roll crusher consists of a revolving toothed roll and stationary breaker plate supported within a heavy steel frame. Crushing is performed by shearing and compressing material between the roll surface and breaker plate. See Fig. 24.

Single Roll Crushers

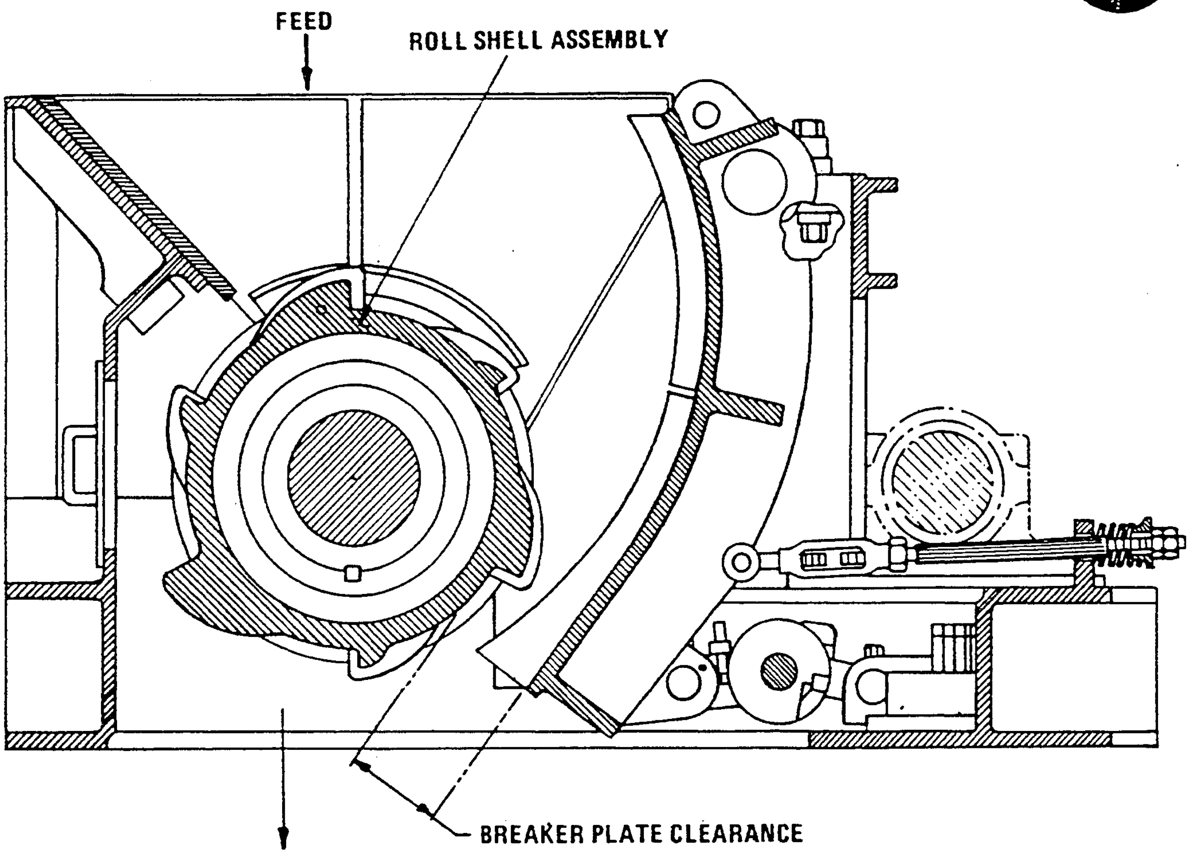


FIG. 24 – SINGLE ROLL CRUSHER.

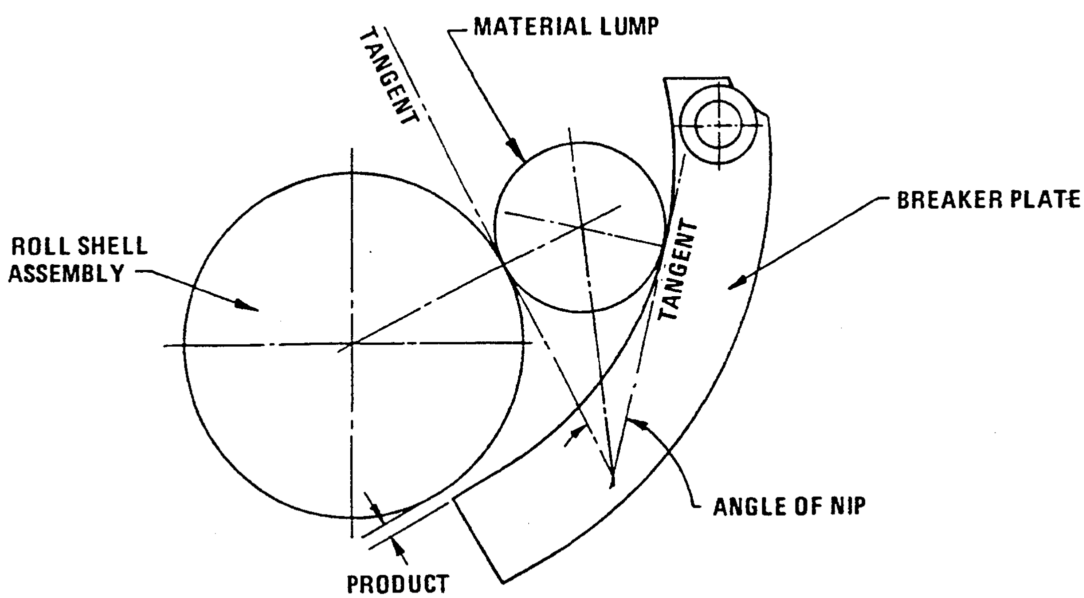


FIG. 25 – SINGLE ROLL CRUSHER - ANGLE OF NIP.

Single Roll Crushers

Terminology

ANGLE OF NIP — The angle formed by lines tangent to the roll face and breaker plate at those points where the particle to be crushed is in contact. See Fig. 25.

BREAKER PLATE CLEARANCE — Space between bottom of wear tip and roll shell matrix. See Fig. 24.

BULL GEAR — Large gear on roll shell.

BUSHING — Bronze sleeve bearing in which roll shaft and countershaft operate.

CHOKE FEED — Completely filled crushing chamber.

COUNTERSHAFT — Shaft upon which drive pulley and pinion are mounted.

DRUM — See "ROLL SHELL".

FROZEN COAL CRACKER — Single roll crusher specifically designed to break frozen masses of coal.

HOLDBACK ROD — Device that keeps breaker plate in position.

MATRIX — Roll shell cylinder surface from which the teeth protrude.

PINION — Small gear on countershaft engaging roll shaft gear.

ROLL SHAFT — Shaft on which roll is mounted.

ROLL SHELL ASSEMBLY — Roll shell and shaft. See Fig. 25.

ROLL SHELL SEGMENT — Sections of roll shell when shell is not a single piece (usually in quarters).

SEGMENTS — Replaceable plates mounted on the roll shell.

SLUGGER TEETH — The large teeth on a single roll face which first strike material with impact.

TEETH — Protrusions on roll shell.

TENSIONING RODS — Long rods which hold the breaker plate in place and equipped with cushioning springs to protect against severe shock.

TOGGLE RELEASE MECHANISM — Spring-loaded device that automatically allows breaker plate to release and pass an uncrushable piece of material.

V-SHAPED MAW — The area formed by the breaker plate and the moving crusher roll.

WEAR PLATE — Renewable liners on breaker plate that form one side of the nip angle.

WEAR SHOE — Replaceable section at lower edge of crushing face of breaker plate, designed to assist in product sizing.

WEAR TIP — Replaceable section synonymous with "WEAR SHOE".

■

Test Definitions

BULK DENSITY OF SOLIDS — Weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature. Refer to ASTM E12-61T-61 for procedure.

BURBANK ABRASION — A standard method of comparing the relative abrasiveness of rocks, minerals and ores. The testing device serves only to compare one material with another under identical conditions of processing, and does not measure abrasion in absolute terms. Procedure is outlined in Pennsylvania Crusher Corporation Burbank Test Procedure.

COMPRESSIVE STRENGTH — Method of determining a material's resistance to compressive failure. Resistance is measured in pounds per square inch. Refer to ASTM C170-50 for procedure.

DEVAL — Test to determine resistance to wear of aggregate, sometimes referred to as a measure of hardness. The lower the percent of loss, the harder the rock. Refer to ASTM D2-33 for procedure.

FINENESS MODULUS — An empirical factor obtained by adding the total percentages of a sample retained on each of a specified series of sieves and dividing the total by 100. Refer to ASTM C-125 for procedure.

GRINDABILITY INDEX (HARDGROVE) — The grindability of a coal is expressed as an index showing the relative hardness (or ease of pulverizing) of that coal compared with a standard coal chosen as 100 (unity) grindability. Refer to ASTM D409-37T for procedure.

LOS ANGELES RATTLER ABRASION TEST — Test to determine resistance to wear of aggregate, sometimes referred to as a measure of hardness. The lower the percent of loss, the harder the rock. Refer to ASTM C-535-65 (large) and ASTM C-131-69 (small) for procedure.

SOUNDNESS TEST — Test to determine resistance of material to freezing and thawing disintegration. Tested by direct methods or by a simulated soundness test using sodium sulfate or magnesium sulfate crystallization as the disrupting agent. Refer to ASTM C88-73 for procedure.

SPECIFIC GRAVITY — Ratio of unit weight of matter to that of water. Refer to ASTM C127059 and 128-59 for procedure.

TOUGHNESS — Impact test to determine energy required to cause fracture. The height of the fall, in centimeters of a 2KG hammer is called toughness. See ASTM C-131-39 for procedure.

WORK INDEX — The purpose of this test is to measure the foot-pounds per inch of thickness required to crush material of a standard size. From this value a work index is calculated. By applying the work index, specific gravity, feed analysis, and a certain constant, an approximation of crusher horse power may be determined. The test was originated by Fred Bond of Allis-Chalmers Corporation. Refer to A-C Test No. 07R9235B for procedure. Will also be able to be found in new AIME Minerals Processing Handbook when published.

■

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Technical Paper T - 551

STOCKPILE SEGREGATION

By Jerry Nohl, P.E. and Bob Domnick

CONTENTS

ABSTRACT

Material segregation is a problem that is inherent to most stockpiling techniques. As the demand for a higher quality product increases, the problem of stockpile segregation becomes more significant. Telescoping radial stacking conveyors are known to be the most effective solution for stockpile segregation. They are capable of creating a stockpile in layers, with each layer consisting of a series of windrows of material. In order to create a stockpile in this manner, the conveyor must be in motion almost continuously. Although the motion of a telescoping conveyor can be controlled manually, automation is by far the most effective method of control. An automated telescoping conveyor can be programmed to create customized stockpiles of many different sizes, shapes, and configurations. This nearly unlimited flexibility can add efficiency to an overall operation, as well as provide a higher quality product.

STOCKPILING

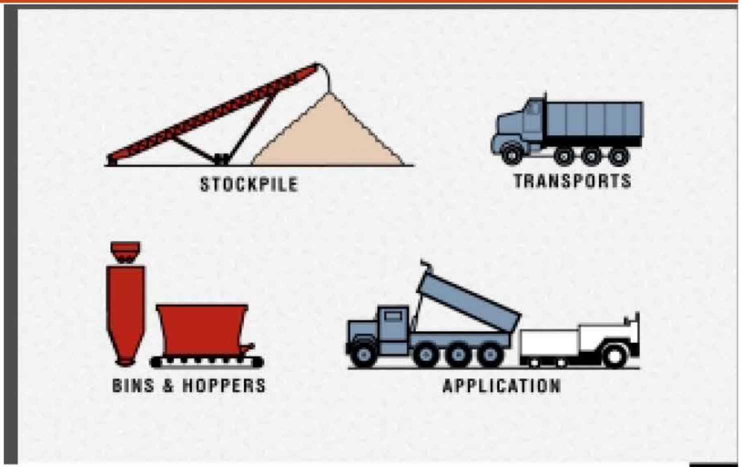
Each year contractors spend millions of dollars to produce aggregate products that are used for many different applications. Among the most popular applications are base material, asphalt, and concrete. The process of creating the products for these applications is very complex and costly. Tighter specifications and tolerances mean that the importance of product quality is becoming more and more significant.

There are many phases to the process of aggregate production. The virgin material must be stripped or blasted from its original location within the quarry. Once the material is removed from the mining surface, the process of reduction begins. The original material is first run through a primary crusher to reduce the product to a manageable size that can be handled by conveyors. Next, the material is run through a secondary crusher and possibly a tertiary crusher to reduce the product size even further. Along with the various crushing operations, the product is also passed through vibrating screens to sort it by particle size. Once the material has been sorted into different sized products, it is then ready to be stockpiled for storage. Eventually, the material is reclaimed from the stockpile and transported to a location where it will be incorporated into a road base, asphalt product, or concrete.

The equipment required for stripping, blasting, crushing, and screening is very expensive. However, today's equipment is capable of consistently producing aggregate material that is within specifications. Stockpiling may seem to be a trivial part of aggregate production; nevertheless, if done incorrectly, stockpiling can cause a perfectly "in spec" product to become out of spec. This is to say that some of the cost of creating a good product can be wasted by using poor stockpiling techniques.

Although placing product in a stockpile endangers its quality, stockpiling is a vital link in the aggregate production process. Stockpiling is a storage method that ensures material availability. The rate of production often differs from the rate at which the product is required for a given application, and stockpiles help to absorb this difference. Stockpiles also allow contractors sufficient storage to respond effectively to fluctuating market demands. Because of the benefits offered by stockpiling, it will always remain an important part of the aggregate production process. Therefore, producers must continually improve their stockpiling techniques in order to reduce the risks associated with stockpiling.

STOCKPILING PROBLEMS



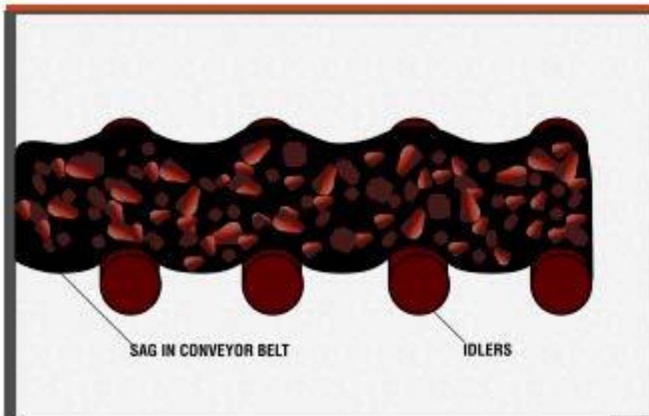
WHERE SEGREGATION CAN OCCUR F1

The three most common stockpiling problems are segregation, degradation, and contamination. The primary focus of this paper is on segregation. Segregation is defined to be "the separation of material by particle size." Different applications of aggregate products require very specific and consistent gradations of material. Segregation causes excessive variation in the gradation of a product.

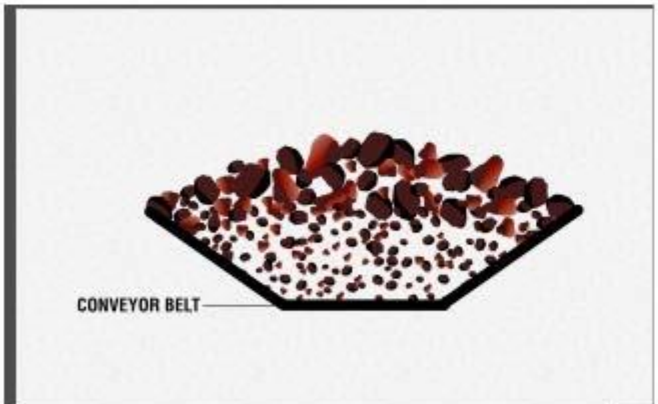
Segregation can occur virtually anywhere throughout the process of aggregate production after a product has been crushed, screened, and blended to its proper gradation. The first likely place for segregation to occur is within the stockpile (**Figure 1**). Once the material has been placed in the stockpile, it will eventually be reclaimed and transported to a location where it will be used. The second place that segregation can occur is during handling and transport. Once on site at an asphalt or concrete plant, the aggregate material is placed in feed hoppers and/or storage bins from which the product will be withdrawn and used. Segregation can also occur when hoppers and bins are filled and emptied. After the aggregate is blended into an asphalt or concrete mix, segregation can also take place during the application of final mix to a road or other surfaces. Segregation can be a problem in many different areas; however, the emphasis of this paper will be on causes and solutions for segregation within the stockpile (Figure 1).

PROBLEMS CAUSED BY SEGREGATION

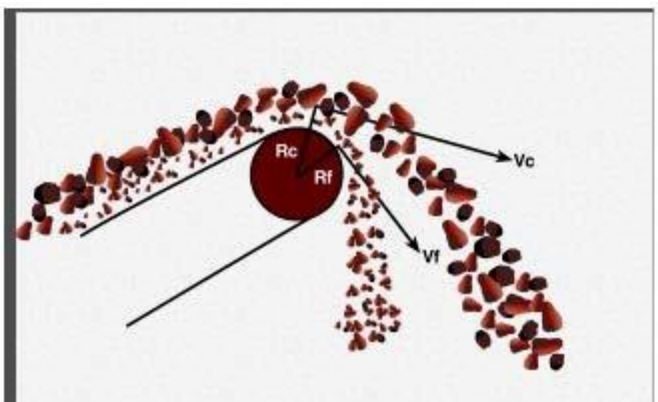
A uniform aggregate product is essential to producing high quality asphalt or concrete. The fluctuating gradation of a segregated aggregate product makes it nearly impossible to produce an acceptable asphalt or concrete product. A given weight of smaller particles has a larger total surface area than the same weight of larger particles. This presents a problem when combining the aggregate into an asphalt or concrete mixture. If the aggregate contains too high of a percentage of fines, there will be a shortage of concrete paste or asphalt, and the mixture will have an overly stiff consistency. If the aggregate contains too high a percentage of large particles, there will be an excess amount of concrete paste or asphalt, and the mixture will have a runny consistency. Roads constructed with segregated aggregate product will have poor structural integrity and, ultimately, a shorter life expectancy than those made from a properly desegregated product.



ROLLING MOTION OVER IDLERS F2



FINE SETTLES TO BOTTOM F3



PARTICLE SPEED AT DISCHARGE PULLEY F4

CAUSES OF STOCKPILE SEGREGATION

There are many factors that contribute to segregation within a stockpile. Since most stockpiles are created with a belt conveyor, it is important to understand the inherent effects of a belt conveyor on the gradation of a material. As a belt carries material along the conveyor, a slight bouncing motion is created by the belt rolling over the idlers (**Figure 2**). This is due to the slight sag in the belt between each idler. This motion causes the finer particles to settle to the bottom of the material cross section on the belt, and the coarser particles to stay on the top of the material cross section (**Figure 3**). Bridging of the coarse particles causes them to remain on top.

Once the material reaches the conveyor discharge pulley, it is already somewhat segregated with the coarser material on top and the finer material on the bottom. As the material begins to travel around the curvature of the discharge pulley, the top (outside) particles travel at a greater velocity than the bottom (inside) particles (**Figure 4**). This difference in velocity then causes the larger particles to travel farther from the conveyor before landing on the stockpile and the smaller particles to drop closer to the conveyor. Furthermore, the fine material has a greater tendency to cling to the conveyor belt and not be discharged until the belt has continued further around the discharge pulley. This causes even more fines to be pulled back to the front side of the pile.

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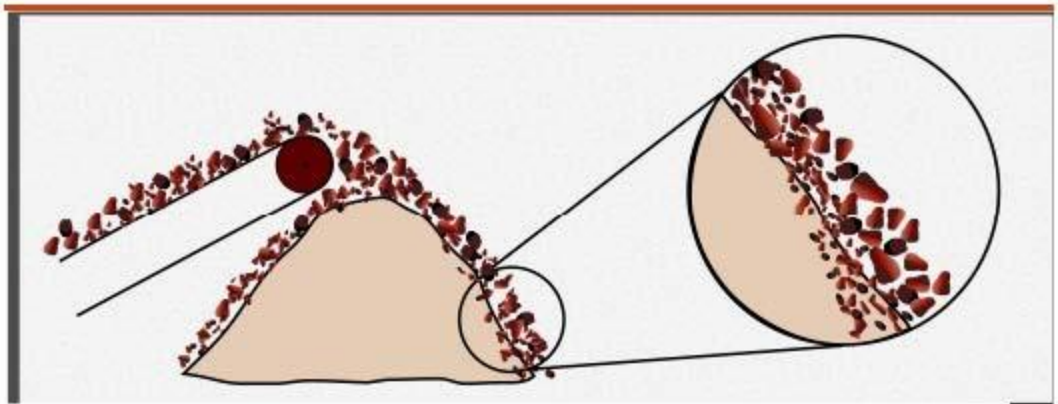
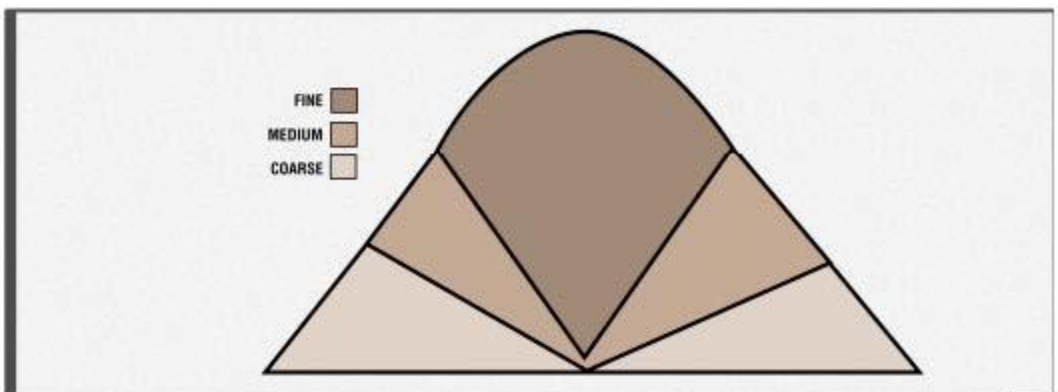


OVERRUN ON A STOCKPILE F5

When the material lands on the stockpile, the larger particles have a greater forward momentum than the smaller particles. This causes the coarse material to continue moving down the side of a pile more so than the fines. Any material, regardless of size, that cascades down the side of a stockpile is called overrun (**Figure 5**). Overrun is one of the leading causes of segregation in a stockpile and should be avoided if at all possible. As overrun begins to tumble down the slope of a pile, the larger particles tend to roll down the entire length of the slope while the finer material tends to settle into the side of the pile (Figure 5). Therefore, as overrun proceeds down the sides of a pile, fewer and fewer fines remain with the tumbling material. When the material reaches the bottom edge, or toe, of the pile, it consists primarily of the larger particles. The effect of overrun causes a pronounced segregation that is visible in a section view of a stockpile (**Figure 6**). The outer toes of the pile consist of the coarser material, while the inner and upper portions of the pile consist of more fines. Particle shape also contributes to the effects of overrun. Particles that have a smooth or round shape are more likely to roll farther down the slope of a pile than crushed particles that typically have a boxier shape. Overrun can also cause material degradation. As the particles tumble down the side of the pile, they rub against each other. This abrasion can erode some of the particles into smaller sizes.



STOCKPILE GRADATION DIAGRAM F6

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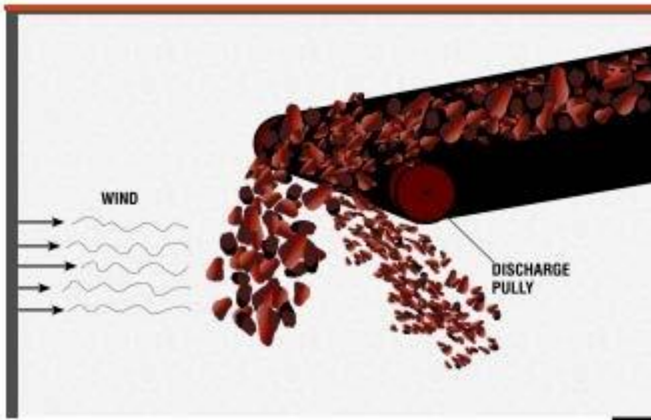
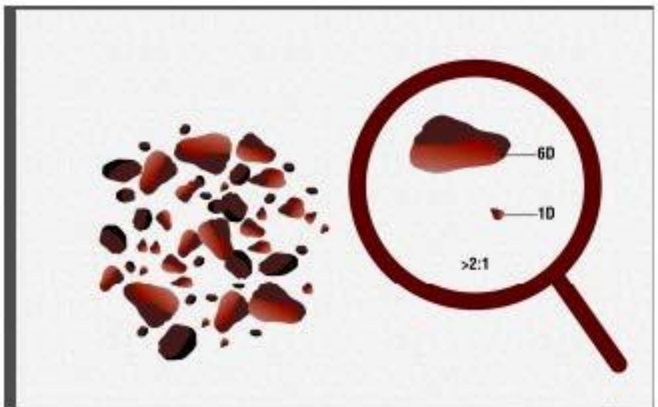
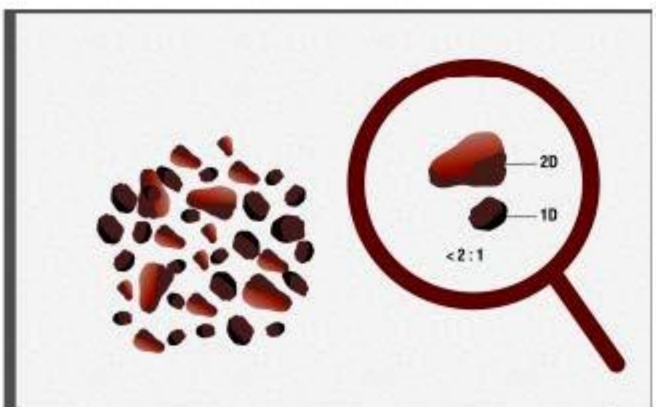


EFFECT OF WIND ON FALLING MATERIAL F7



RATIO OF PARTICLE SIZE GREATER THAN 2:1 F8



RATIO OF PARTICLE SIZE LESS THAN 2:1 F9

Wind is another cause of segregation. After material leaves the conveyor belt and begins its descent to the stockpile, wind will affect the trajectory of different size particles. Wind has a great effect on fine material but little or no effect on larger material (**Figure 7**). This is due to the fact that the surface area-to-weight ratio is greater for small particles than it is for large particles.

WHEN IS STOCKPILE SEGREGATION A PROBLEM?

The potential for segregation within a stockpile may vary depending on the type of material being stockpiled. The most significant factor related to segregation is the degree of variation of particle size within the material. Materials with a greater variation in particle size will have a higher degree of segregation when stockpiled. A general rule of thumb is that if the ratio of the size of the largest particles to the size of the smallest particles exceeds 2:1, stockpile segregation is likely to be a problem (**Figure 8**). On the other hand, if the ratio of the particle sizes is less than 2:1, stockpile segregation will be minimal (**Figure 9**). For example, a road base material which contains ¾" particles all the way down through 200 mesh particles is likely to segregate when stockpiled. However, segregation will be insignificant when stockpiling a product such as ¾" washed stone. Sand can usually be stockpiled without a segregation problem due to the fact that most sand is produced wet. The moisture causes the particles to cling together, preventing segregation.

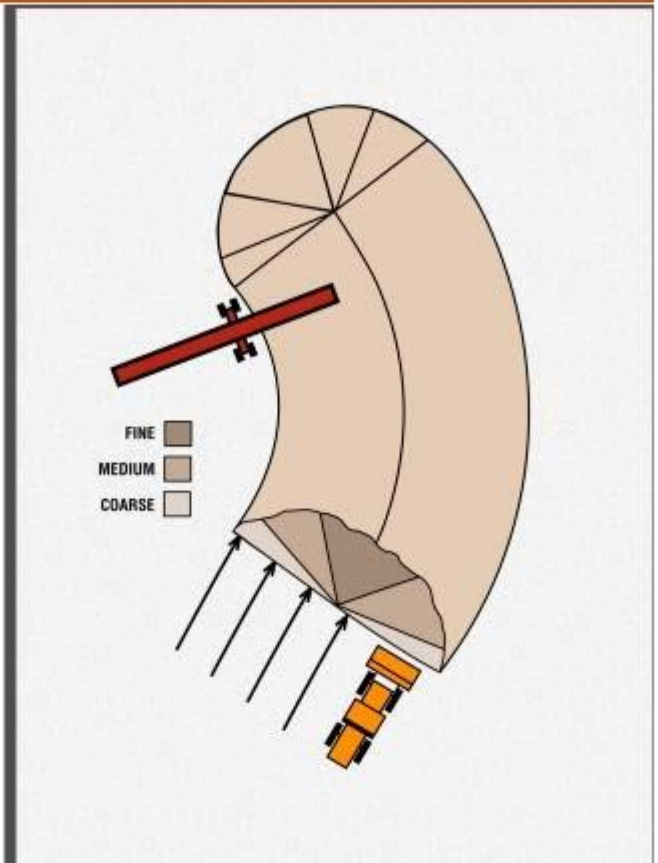
DEALING WITH SEGREGATION

There may be times in which segregation was not prevented when the product was stockpiled. The outside edges of a finished pile consist primarily of coarse material and the inner portion of the pile has a higher concentration of fines (Figure 6). When reclaiming from the end face of this type of pile, scoops must be taken from various locations in order to blend the material (**Figure 10**). Reclaiming only from the front face or back face of the pile will result in all coarse material or all fine material.

There is also an opportunity for further segregation when loading a truck. It is important that the method used does not result in overrun. The front of the truck should be loaded first, then the back, and finally the middle. This will minimize the effect of overrun within the truck.

PREVENTING SEGREGATION

Methods of dealing with segregation after the building of a stockpile are useful, but the goal should be to prevent or minimize segregation as the stockpile is made. Mixing the stockpile, building the stockpile in layers, telescoping conveyors, variable height conveyors, radial travel conveyors, rock ladders, telescoping chutes, and paddle wheels are all useful in the prevention of segregation.



TOP VIEW SHOWING PROPER LOADER RECLAIM F10

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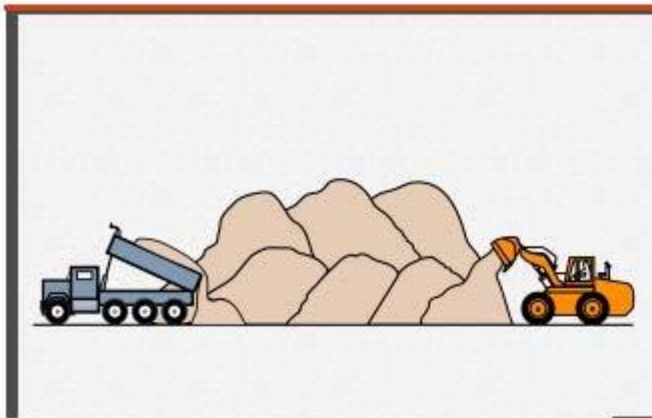
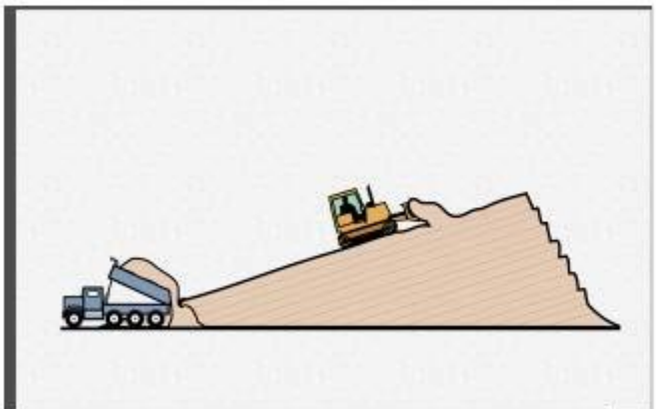
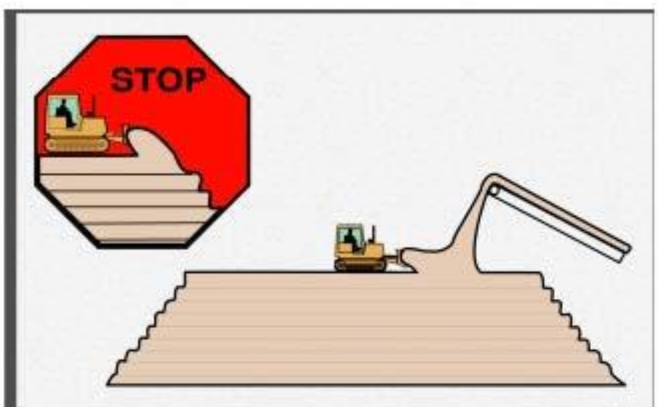


STOCKPILING WITH LOADER AND TRUCK F11



STOCKPILING WITH DOZER AND TRUCK F12



STOCKPILING WITH CONVEYOR AND DOZER F13

When building a stockpile with a truck, care should be taken to dump into separate piles to minimize overrun (**Figure 11**). A loader should be used to push the pile together by raising the material to full bucket height and dumping, which will blend the material. Building larger piles should not be attempted if it requires the loader to drive on and degrade the material.

Building the stockpile in layers can minimize segregation. This type of stockpile can be built with the aid of a dozer (**Figure 12**). If material is brought to the stockpile with a truck, the dozer should push the material into inclined layers. If the stockpile is built with a conveyor, the dozer should push the material into horizontal layers (**Figure 13**). In either case, care should be taken not to push material over the edge of the pile. This results in overrun, which is one of the leading causes of segregation.

There are several disadvantages to making a stockpile with a dozer. Two significant risks are degradation and contamination of the product. Heavy equipment continuously running over the product will compact and crush the material. Using this method, producers must be careful not to degrade the product too much in an attempt to alleviate the segregation problem. The extra labor and equipment required often make this method cost prohibitive and results in producers settling for methods of dealing with segregation upon reclaim.

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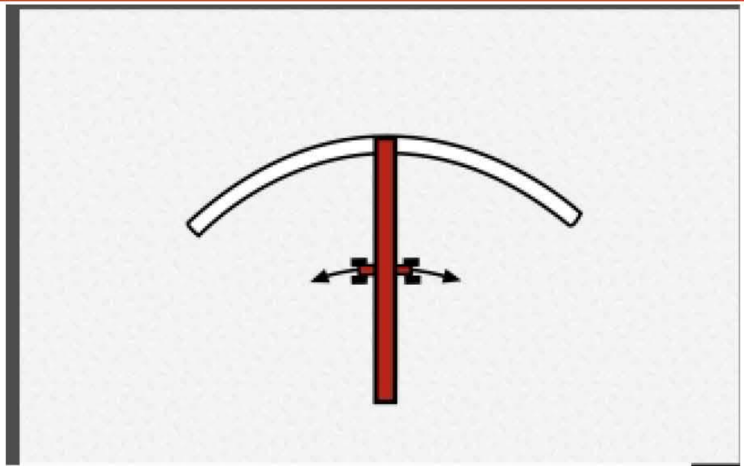
A radial stacking conveyor will help minimize the effects of segregation (**Figure 14**). As the stockpile is being built, the conveyor moves left and right radially. The end toe of the pile, which is normally coarse material, will be covered with fine material as the conveyor travels radially. The front and back toe will still be coarse material, but the stockpile will be blended more than a conical pile.

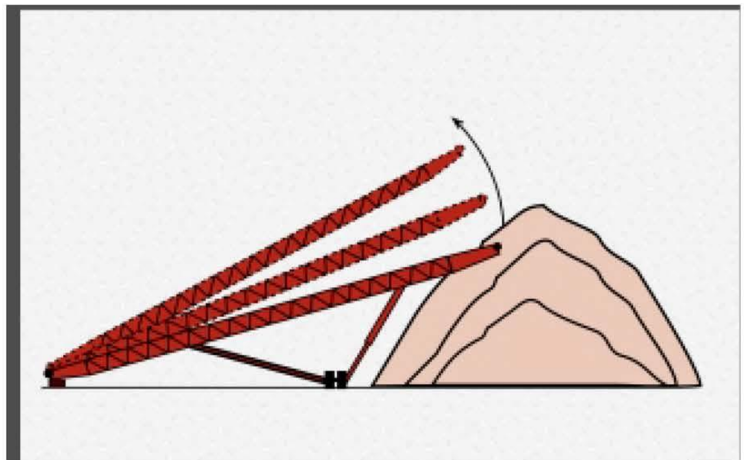
There is a direct relationship between the height of free fall of material and the degree of resulting segregation. The fines are separated more and more from the coarse material as the height increases and the trajectory of falling material widens. Therefore, variable height conveyors are another method of minimizing segregation (**Figure 15**). During the initial stages, the conveyor should be in the lowest position. The distance from the head pulley to the pile should always be minimized.

Free fall from the conveyor onto the pile is another cause of segregation. A rock ladder will minimize segregation by eliminating the free fall of the material. A rock ladder is a structure that allows the material to flow down a series of steps onto the pile. This is effective, but has limited application.

Segregation caused by wind can be minimized with a telescoping chute. A telescoping chute at the discharge pulley of a conveyor that extends from the pulley to the pile will shield the wind and limit the effects of it. If designed correctly, it can also limit free fall of material.



RADIAL MOVEMENT CONVEYOR F14



VARIABLE HEIGHT CONVEYOR F15

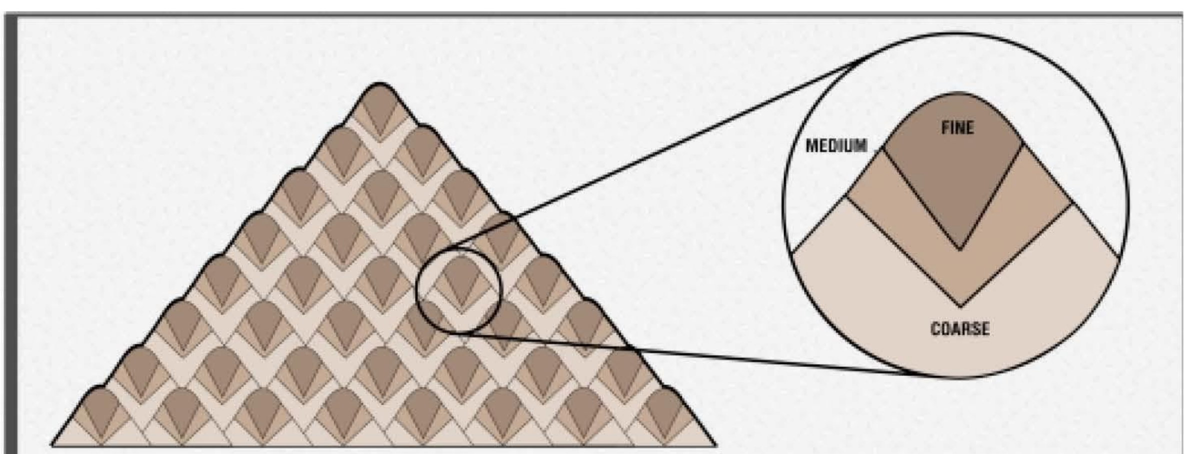
As discussed previously, there is already segregation on the conveyor belt prior to reaching the discharge point. Also, further segregation occurs as the material leaves the belt. Paddle wheels may be installed at the discharge point to re-blend this material. The rotating wheel has wings or paddles on it that intersect and agitate the trajectory of material. This will minimize segregation, but the material degradation may not be acceptable.

Significant costs may be incurred as a result of segregation. Out-of-spec piles may lead to penalties or rejection of entire stockpiles. If out-of-spec material is delivered to a job site, the penalty may be in excess of $0.50/ton. The labor and equipment cost to rebuild an out-of-spec pile is often cost prohibitive. The cost per hour of using a dozer and operator to build the stockpile is higher than that of an automated telescoping conveyor, and the material may be degraded or contaminated in the effort to maintain the proper gradation. This will decrease the value of the product. In addition, there is an opportunity cost associated with using equipment such as a dozer for a non-production task when it has been capitalized for a production task.

THE WINDROW CONCEPT

When creating a stockpile in an application where segregation can be a problem, another method can be used to minimize the effects of segregation. This involves making a stockpile in layers, with each layer consisting of a series of windrows (**Figure 15**). In a section view of a windrow stockpile, each windrow appears as a miniature pile (**Figure 16**).

Segregation still occurs within each individual windrow from the same effects discussed earlier. However, the segregation pattern is repeated more often throughout the cross section of the pile. Such a pile is said to have a greater "segregation resolution" because the segregated gradation pattern repeats itself more often in smaller intervals. When reclaiming a windrow pile with a front-end loader, there is no need to blend the material because one scoop includes several windrows (**Figure 17**). As a windrow pile is being reclaimed, the individual layers are clearly visible (**Figure 18**).



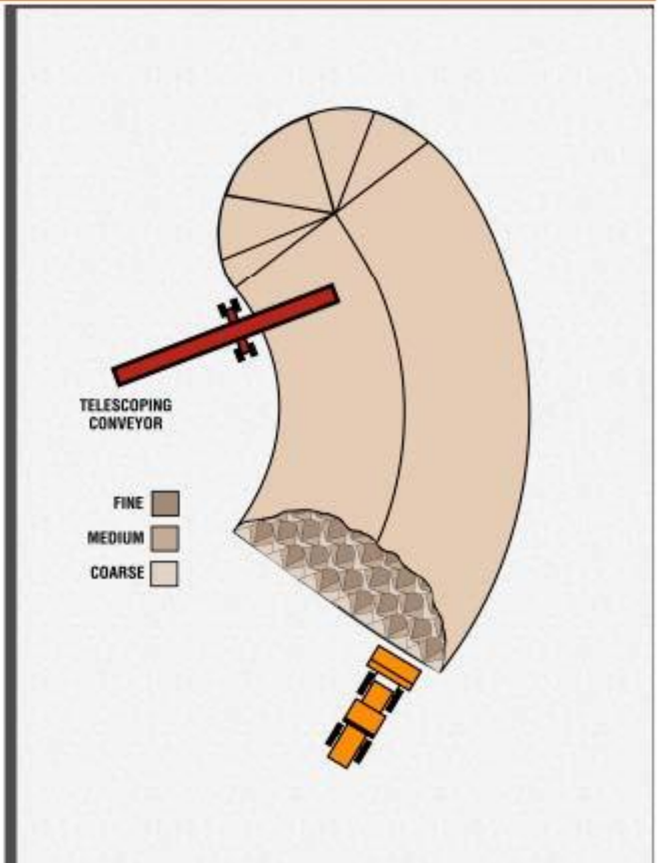
SEGREGATION RESOLUTION IN A WINDROW PILE F16

Windrows can be created using different techniques of stockpiling. One method is to use a bridge and tripper conveyor system, though this alternative is feasible only for stationary applications. One significant disadvantage of stationary conveyor systems is that they are typically fixed in height, which can result in segregation by wind as discussed earlier.

Another method is to use a telescoping conveyor. Telescoping conveyors are typically preferred over stationary systems because they can be relocated when necessary, and many are actually designed to be road-portable (**Figure 19**).

TELESCOPING CONVEYORS

The most effective way to build a windrow stockpile is by using a telescoping conveyor. The telescoping conveyor consists of a conveyor (stinger conveyor) mounted inside an outer conveyor of similar length (**Figure 20**). The stinger conveyor has the ability to move linearly along the length of the outer conveyor, thereby varying the location of the discharge pulley. The height of the discharge pulley is variable as well as the radial position of the conveyor. The three-axis variation of the discharge pulley is essential in making the layered pile that overcomes segregation.



RECLAIM FROM A WINDROW PILE F17

VISIBLE LAYERS OF A WINDROW PILE F18

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TELESCOPING CONVEYOR READY FOR TRANSPORT F19

A cable winch system is often used to extend and retract the stinger conveyor. The radial movement of the conveyor may be driven by a chain and sprocket system or hydraulic powered planetary drives. The height of the conveyor is often varied via cylinders that extend a telescoping undercarriage system. All of these movements must be controlled in order to build a layered pile automatically.

The telescoping conveyor has the mechanisms in place to build a completely layered pile (**Figure 21**). Minimizing the depth of each layer will help to limit segregation. This requires the conveyor to be moving constantly as it builds the stockpile. The need for constant movement makes automation of the telescoping conveyor essential. There are several different methods of automation, some of which are less costly with significant limitations, while others are fully programmable and offer much versatility when building a stockpile.

One method of automation includes limit switches that control the motion of the conveyor. As the conveyor begins to build the stockpile, it moves in a radial direction while conveying material. The conveyor moves until a limit switch mounted to the axle of the conveyor is tripped by a trigger that is in its radial path. This trigger is placed according to the length of the arc the operator wants the conveyor to travel. At this point the stinger conveyor extends a predetermined distance and starts traveling in the other direction. This process continues until the stinger conveyor has been extended out to its maximum extension and the first layer is complete (**Figures 22 & 23**).

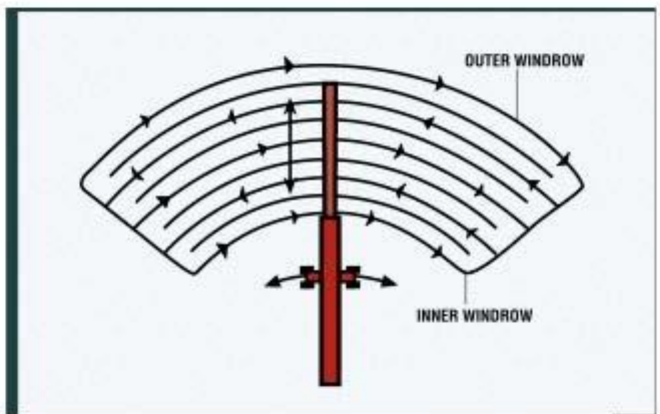
When the second layer is built, the stinger begins retracting from its maximum extension, traveling radially and retracting at the arc limits. Layers are built until a tilt switch mounted at the discharge pulley is activated by the pile.


TELESCOPING CONVEYOR F20

The conveyor will raise a predetermined distance and begin its second lift. Each lift may consist of several layers, depending on the rate at which the material is being conveyed. The second lift is built similar to the first lift and so on until the entire pile is built. A large part of the resulting pile is desegregated; however, there is overrun on each edge of the pile. This is because the conveyor cannot automatically adjust the limit switches or the location of the objects used to trip them. The retract limit switch must be adjusted so the overrun does not bury the conveyor axle. Another limitation deals with the fact that it takes the same amount of time to travel the outer arc as the inner arc (Figure 21). Since the outer windrow is much longer than the inner windrow, the rate the discharge pulley moves with respect to the ground is much faster on the outer windrow than the inner windrow. Assuming constant conveying capacity, the layer will be higher on the inner arc than the outer arc (**Figure 24**).

Another method of automation consists of utilizing a programmable logic controller (PLC) to control operations of the conveyor. A PLC is a computer that receives data from input devices and processes this data to control the operation of various components. An encoder can be mounted to the winch that extends and retracts the stinger conveyor. As the conveyor extends or retracts, the PLC is aware of the exact location of the stinger conveyor, making its movements programmable. The extension and retract limits of the stinger can be automatically changed for each layer. By making each subsequent layer narrower, overrun can be eliminated (Figure 24). The retract limit can be adjusted so the axle does not get buried by overrun. The extend increments can be shortened as the conveyor approaches the outer arc. This will result in a level pile at constant conveying capacity (**Figure 25**).

WINDROW STOCKPILING WITH A TELESCOPING CONVEYOR F21



WINDROW CONFIGURATION F22

CREATING WINDROWS WITH A TELESCOPING CONVEYOR F23

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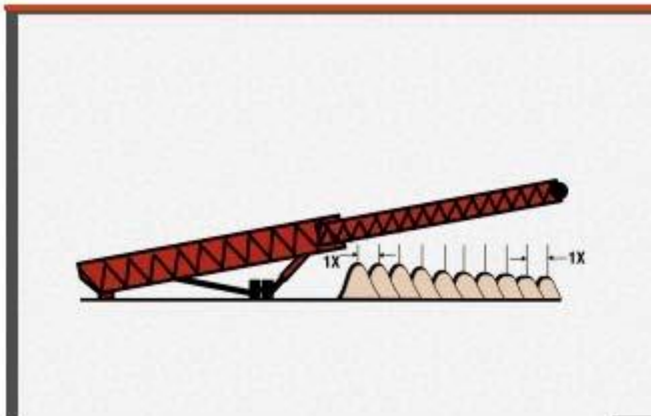
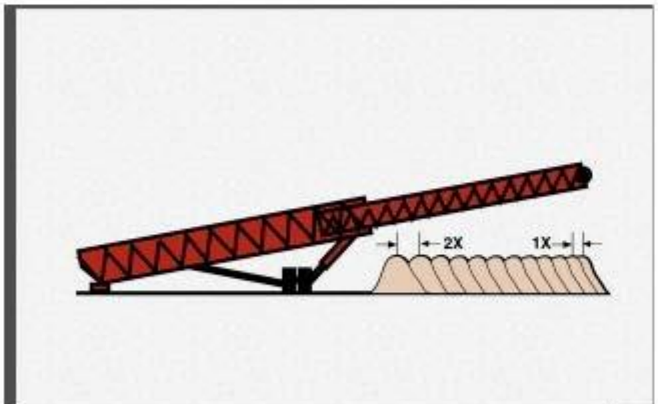
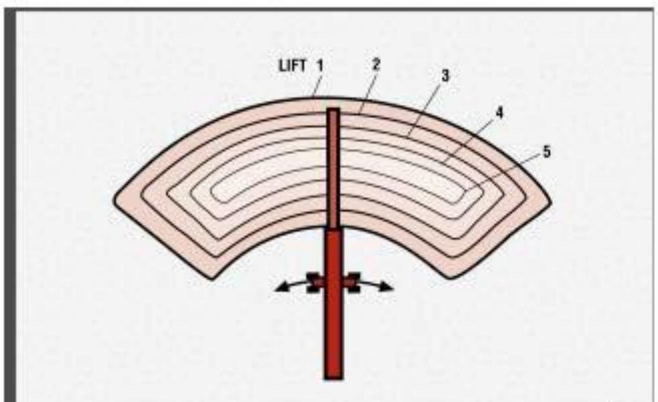


WINDROW HEIGHT DECREASES TOWARD OUTER ARC F24



HEIGHT OF WINDROWS REMAINING CONSTANT F25



TOP VIEW OF DESEGREGATED PILE F26

An encoder can also be mounted to one of the wheels of the conveyor to monitor the radial position of the conveyor. The encoder for the radial travel does not rely on off-board devices to activate switches. Instead, the encoder is self-contained and can be programmed to adjust the arc limits to eliminate overrun on the ends of a pile (**Figure 26**).

A tilt switch is mounted at the discharge point on the stinger conveyor to indicate at what point the conveyor must raise to the next lift. This ensures that the conveyor will raise before burying the discharge pulley in the pile. Some automation packages allow the tilt switch to indicate when to move one radial increment, rather than travel continuously, which gives the ability to build a desegregated pile when conveying capacity is not constant.

This method of automation lends itself to customized automation packages. The arc pile is by far the most common (Figure 21). The arc pile is built of windrows that are concentric to the conveyor feed point. In certain situations, it is advantageous to customize the program. At some job sites, it is more convenient to load-out parallel to the conveyor. In this case an inline pile would be desired (**Figure 27**). The inline pile is built of windrows that are radial to the conveyor feed point. It is a small matter to program the telescoping conveyor to build this type of a stockpile. Unusual site layout or lack of real estate could be reasons to choose a rectangular pile (**Figure 28**). In each instance, proper reclaiming methods are not compromised.

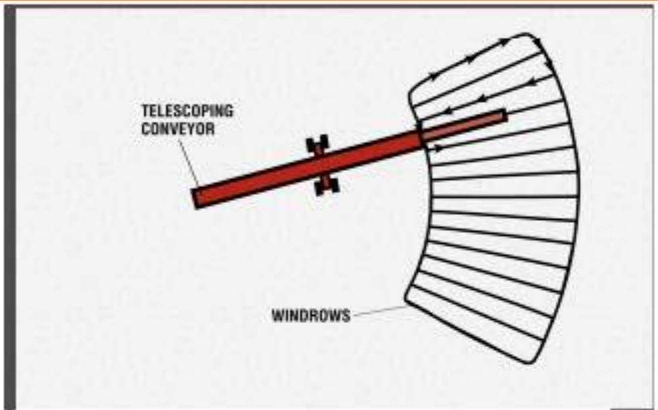
Customized automation extends beyond stockpiling. When loading a rail car or vessel a linear pile is needed. Conventional radial stacking conveyors cannot build the pile. However, a telescoping conveyor with an encoder on the winch can be programmed to build the pile (**Figure 29**). In the past this type of pile would have had to be built by a stationary system with multiple conveyors.

Automation options are not limited to those listed above, as new processes and user expectations will be revealed in time. The automated telescoping conveyor is currently the most versatile tool in stockpiling, and will continue to be the most adept at meeting these new processes and expectations.

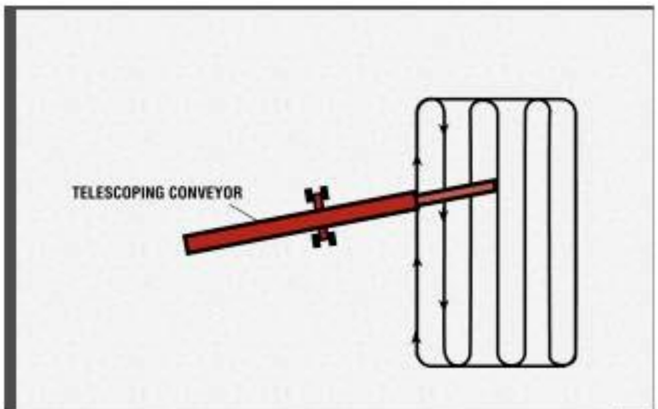
PARTIALLY DESEGREGATED PILE

The windrow method of stockpiling greatly reduces segregation, but overrun can still be a problem if the proper method is not used (Figure 5). This occurs when a lift of windrows is as wide as the lift below it. Material in each lift must be prevented from rolling over the edges of the previous lift and creating overrun in order to minimize segregation completely. If overrun is not prevented, certain portions of the stockpile will still be subjected to segregation, and a partially desegregated pile will be created.

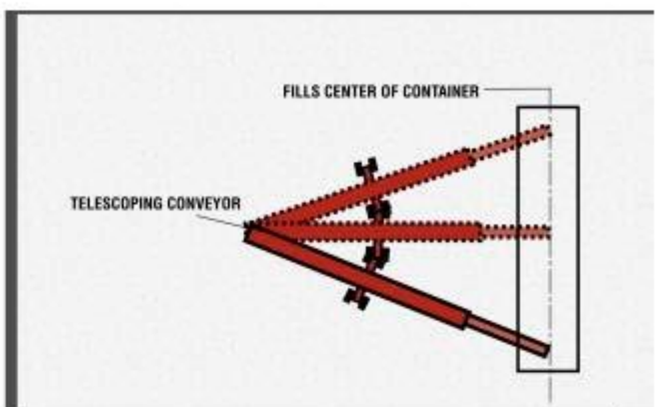
The bottom lift of a windrow pile created with a telescoping conveyor is approximately as wide as the length of the telescoping section of the conveyor (**Figure 30**). When the second lift of windrows is created, overrun begins to occur when the telescoping conveyor reaches its extension limits and is making the innermost and/or outermost windrows. Material spills over the edge of the first lift and rolls down to ground level, creating overrun (**Figure 31**).



INLINE PILE F27



RECTANGULAR PILE F28



LOADING CONTAINER F29

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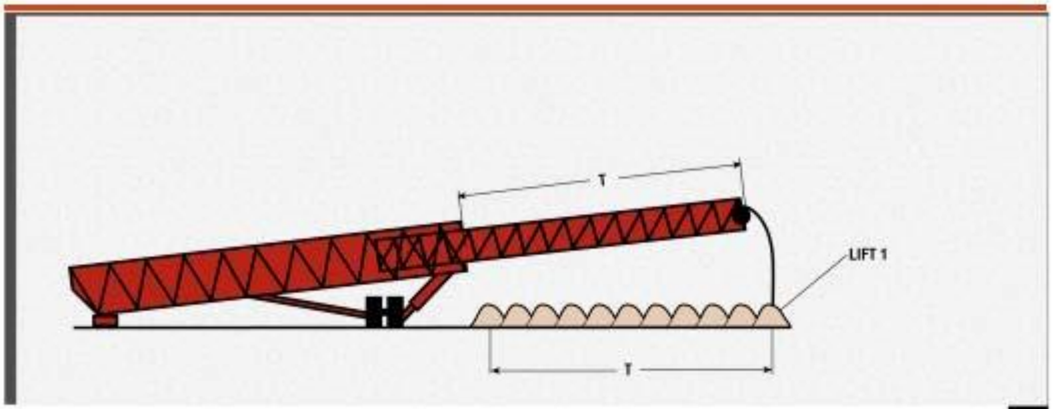
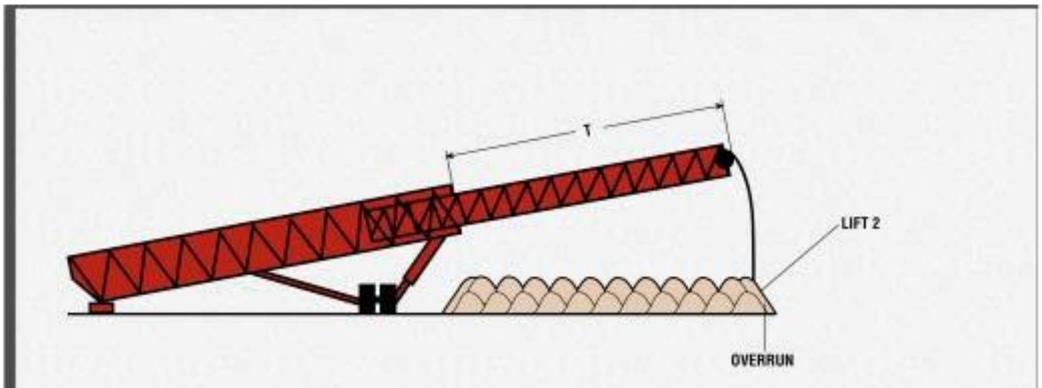
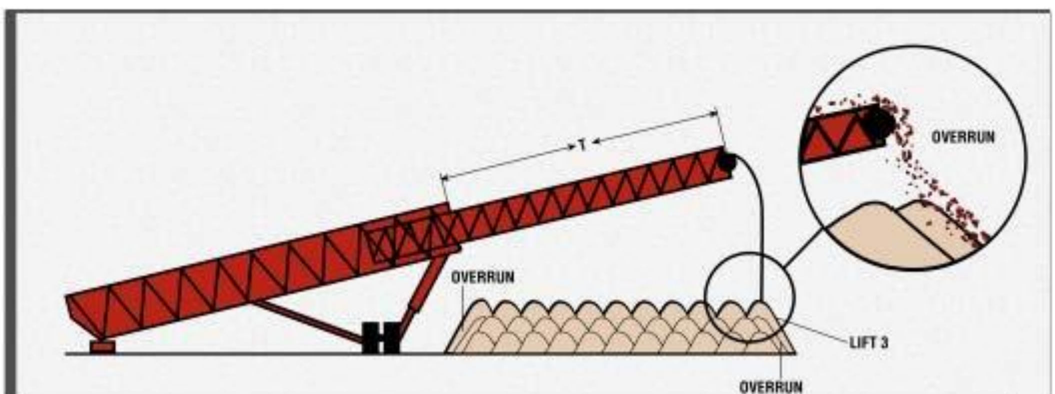


BOTTOM LIFT OF PARTIALLY DESEGREGATED PILE F30



SECOND LIFT OF PARTIALLY DESEGREGATED PILE F31



THIRD LIFT OF PARTIALLY DESEGREGATED PILE F32

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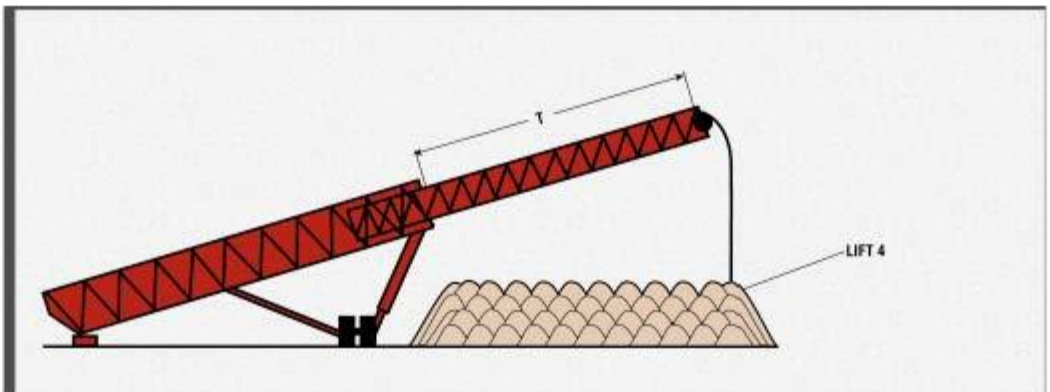
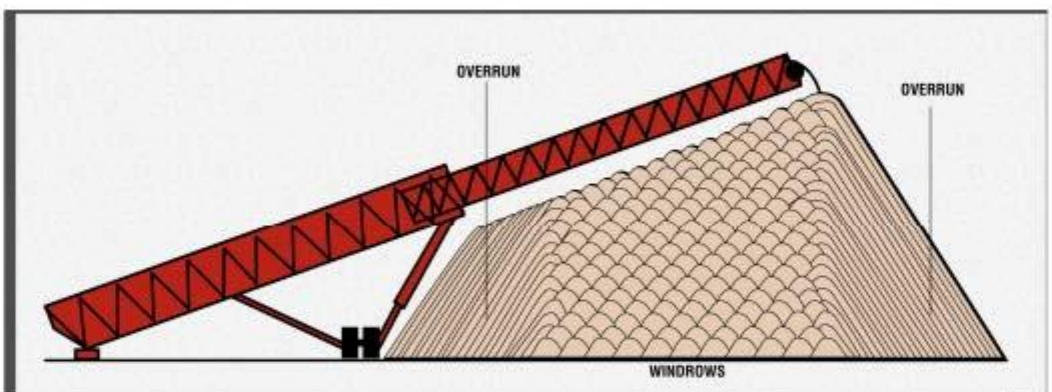
The same problem occurs when making the third lift. Again, as the telescoping conveyor reaches its maximum extension, material spills over the edge of the second lift and rolls down the back side of the pile to ground level (**Figure 32**). This problem continues to worsen as the pile gets higher because the slope down the side of the pile gets longer (**Figure 33**).

When a partially desegregated pile is completed, the final result is a stockpile that consists of up to 40% overrun (**Figure 34**). Segregation has been essentially eliminated in the windrowed portion of the pile; but the effects of segregation remain significant in the portion of the pile made up of overrun. In order to minimize overrun, the actual stockpiling process must be altered to create a fully desegregated pile.



FOURTH LIFT OF PARTIALLY DESEGREGATED PILE F33



PARTIALLY DESEGREGATED PILE F34

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FULLY DESEGREGATED PILE

In order to eliminate overrun in a layered windrow pile, the extension limits must be changed for each lift. By changing the limits of travel of the telescoping portion of the conveyor, each lift of windrows can be made slightly smaller than the lift underneath of it (Figure 26).

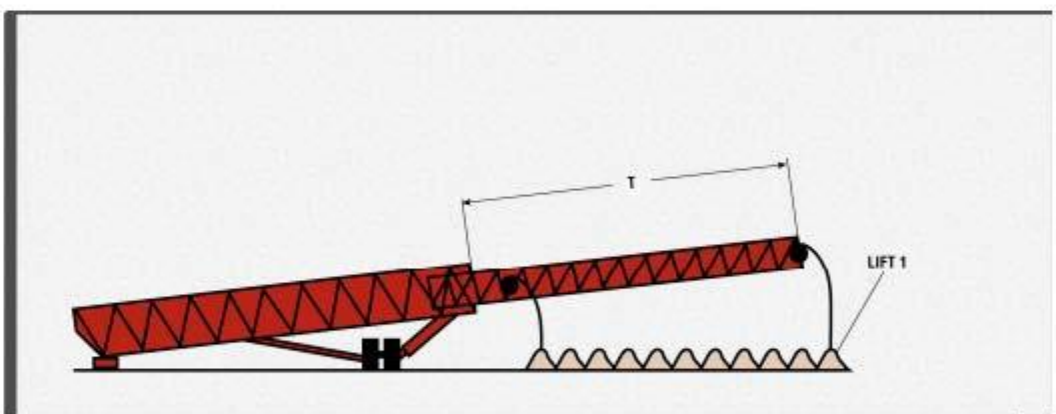
The bottom lift of a fully desegregated pile is created the same way as a partially desegregated pile. The dimensions of the bottom lift are identical. As mentioned before, the base of the pile is approximately as wide as length of the telescoping section of the conveyor (**Figure 35**).

The stockpiling process begins to differ in the second lift by changing the extension and retraction limits of the telescoping portion of the conveyor (**Figure 36**). Both of the limits are changed by an amount 'A'. This adjustment prevents material from being discharged from the conveyor over the edge of lift 1. This essentially eliminates overrun.

When creating the third lift of the stockpile, the extension and retraction limits are adjusted again by amount 'A' (**Figure 37**). These adjustments prevent material from spilling over edge of the second lift and rolling down the front and back of the pile to ground level.

For each subsequent lift, the extension and retraction limits are adjusted to prevent overrun on the front and back of the pile (**Figure 38**). The limit adjustments actually decrease the distance that the telescoping portion of the conveyor travels. As the number of lifts increases, the telescoping distance decreases. This causes each lift of windrows to be narrower than the lift underneath it.

The cross section of a fully desegregated pile is completely made up of windrows, and overrun is eliminated (**Figure 39**). Pile volume is sacrificed when creating a fully desegregated; however, the quality of the material in a fully desegregated pile is significantly better than that in a partially desegregated pile, due primarily to the absence of overrun.



BOTTOM LIFT OF FULLY DESEGREGATED PILE F35

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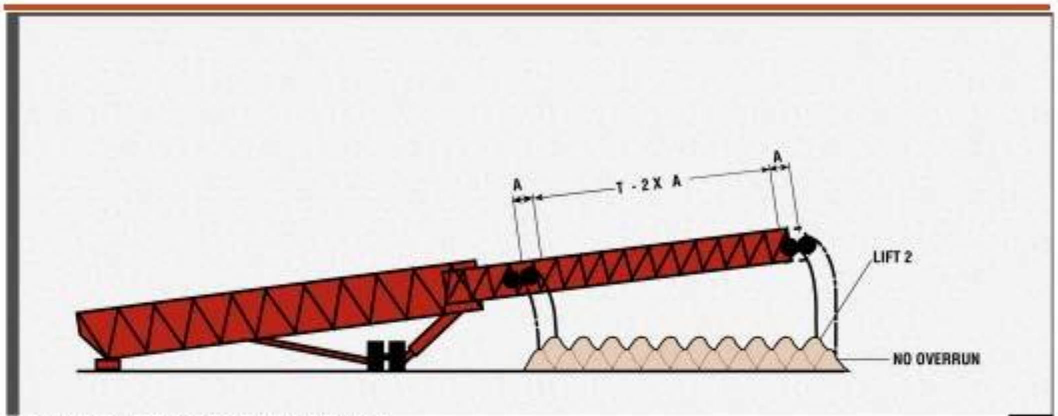
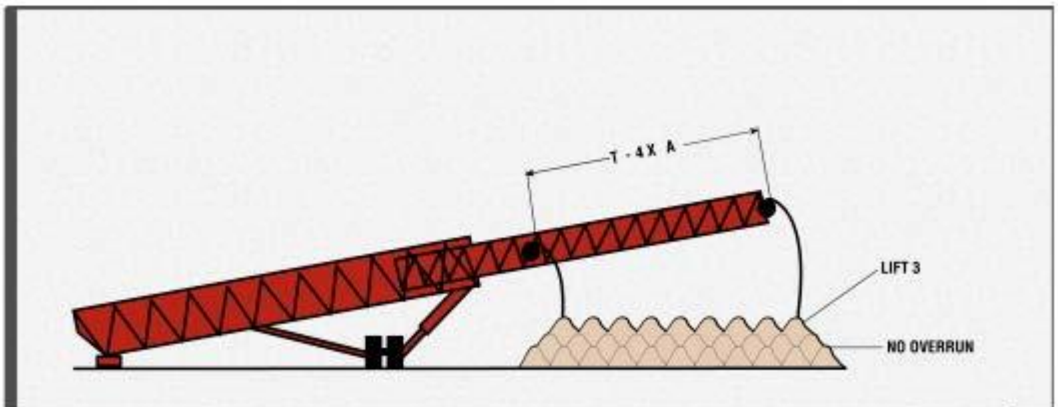
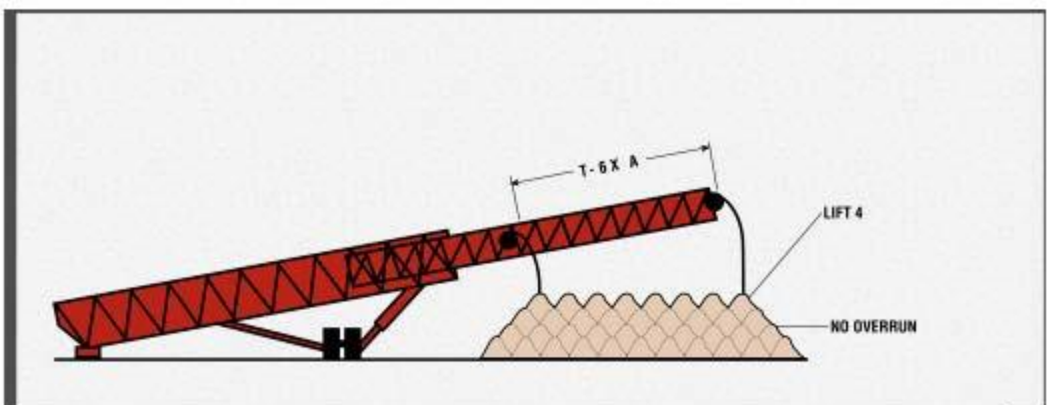


SECOND LIFT OF FULLY DESEGREGATED PILE F36



THIRD LIFT OF FULLY DESEGREGATED PILE F37



FOURTH LIFT OF FULLY DESEGREGATED PILE F38

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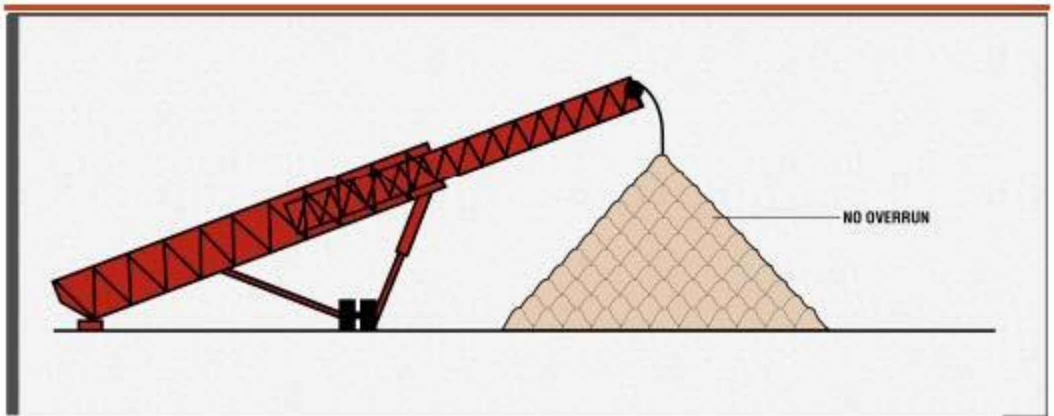


COMPLETED FULLY DESEGRATED PILE F39

Overrun is also created on the ends of a stockpile created by a telescoping radial conveyor. This overrun can be eliminated if adjustments are made to the limits of radial travel of the conveyor. To prevent overrun on the ends of a stockpile, the total radial arc must be decreased inward for each layer.

STOCKPILE VOLUME

The stockpile volumes of a fully desegregated and partially desegregated stock-pile differ greatly (**Table 1**). A pile built with a conventional (non-telescoping) radial stacking conveyor is shown for comparison and is designated as area R1. The axle on a telescoping conveyor is placed closer to the feed point than that of a conventional radial stacking conveyor. Because the stinger conveyor is able to retract, the operator is able to stockpile back to the axle. This result-ing pile is partially desegregated and is the highest volume pile as indicated by areas R1+R2 (**Figure 40**). The conventional pile has the next highest volume but is segregated and is indicated by area R1. The fully desegregated pile has the lowest volume but is free of overrun and is indicated by area R3 (Figure 40). The factor that affects the volume of a fully desegregated pile is the extension distance. By maximizing that extension distance, the fully desegregated pile volume is maximized and the towing length of the conveyor is minimized.

SUCCESS WITH AUTOMATION

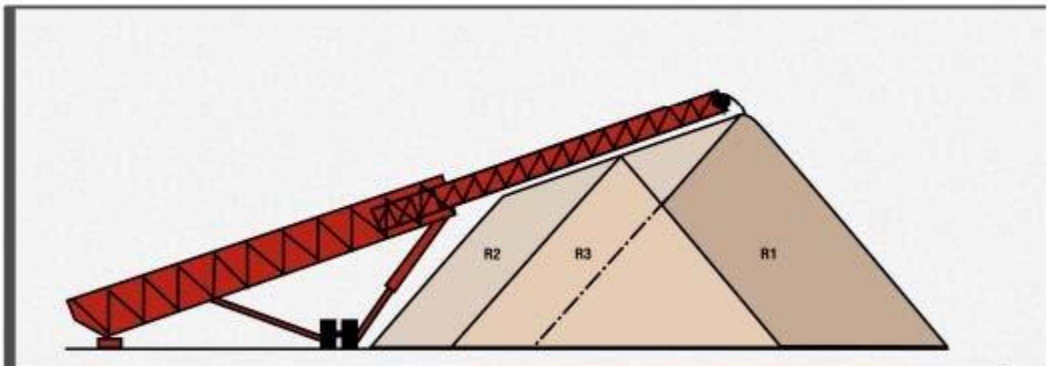
Automation is significantly changing many industries as it can offer a means of achieving higher productivity and higher quality products in many different types of operations. Although automation can prove to be the best method of control-ling a given operation, there are often several factors that seem to cause some apprehension with automated systems.

One of the biggest factors is simply the fear of change; especially a change from an existing system that seems to work well to a system that is much more complex. In many cases, the original system may have been a relatively simple piece of equipment, but controls, sensors, and electronic devices are required to incorporate automation. The complexity of an automated system often in-timidates a user because of the inability to troubleshoot and fix problems that may arise. It is essential that the manufacturer have a good customer service program to assist users with service and maintenance on their systems. This includes the ability to provide good technical support over the phone and to be capable of responding immediately to the need for parts or a field service tech-nician.

Another concern that users may feel is that they are not capable of learning how to operate an automated system. The key to overcoming these attitudes is for the manufacturer to provide excellent training for the users. It is also important to provide good operator's manuals and reference materials that give clear operation instructions.

			CONVEYOR LENGTH		
			110'	130'	150'
R1	Conventional	Yards	13,400	21,600	32,500
		Tons	18,090	29,160	43,875
R1 & R2	Partially Desegregated	Yards	17,530	27,600	44,050
		Tons	23,666	37,260	59,468
R3	Fully Desegregated	Yards	5,400	8,000	14,000
		Tons	7,290	10,800	18,900

90 DEGREE STOCKPILE VOLUMES T1



PILE VOLUME COMPARISON DIAGRAM F40

Finally, automation components often have the perception of being delicate and unable to withstand the harsh environments inherent to many applications. As technology has progressed, suppliers of automation components have considered these factors and addressed the vastly differing needs. For example, there are literally thousands of different sensors available today, and each is designed for a specific application. Ultimately, it is the responsibility of the designers and manufacturers of an automated system to select the right components for the right application. This requires designers and engineers to be well aware of user expectations, application, environment, and what is available in terms of automation components.

CONCLUSION

In conclusion, automation is clearly the way to build a fully desegregated stockpile. An automated telescoping conveyor is the most effective method of minimizing segregation. It will save money and time while providing a better product. The equipment and labor costs of alternative stockpiling methods are higher, and equivalent product quality is unattainable by these other methods. The automation technology available today provides exciting opportunities both now and in the future to maximize the production of high-quality aggregates while reducing or eliminating labor-intensive operations. This will give the producer the ability to make a product that will always meet increasingly stringent specifications.

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