T 96 AND ASTM C 535

RESISTANCE TO ABRASION OF SMALL-SIZE AND LARGE-SIZE COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE FOP FOR AASHTO T 96 AND ASTM C 535

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02 ## Scope

This FOP describes methods for testing coarse aggregate using the Los Angeles machine. Two procedures are presented: AASHTO T 96 for small-size coarse aggregate (smaller than 1½ inch), and ASTM C 535 for large-size coarse aggregate (smaller than 3 inch).

A graded aggregate sample is placed in a hollow steel cylinder along with a charge consisting of steel spheres and rotated for a specified number of revolutions (500 or 1000 depending on test method). The interior of the cylinder has a shelf that picks up the sample and charge during each rotation and drops them on the opposite side of the cylinder, subjecting the sample to abrasion or attrition.

03 ## Significance

The L.A. Abrasion test determines the relative competence or resistance to abrasion of the aggregate. Aggregates with distinctly different origins should be expected to perform differently in the Los Angeles machine.

Apparatus

04 - **Los Angeles machine:** An abrasion machine consisting of a hollow steel cylinder, closed at both ends, with an inside diameter of 28 ±0.2 inch. The machine should be mounted and counterbalanced to provide a uniform peripheral speed, and shall rotate at 30 to 33 rpm. *See Figure 1 AASHTO T 96 for a more complete description of the apparatus.*

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06 - **Shelf:** A removable steel shelf extending the full length of the cylinder and projecting inward 3.5 ±0.1 in. shall be mounted on the interior cylindrical surface of the drum or on the inside surface of the cover.
- **Sieves:** Woven wire-cloth sieves with square openings, conforming to the requirements of AASHTO M 92.
- **Balance:** Accurate to 0.1% for the range required by this procedure.

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- **Oven:** An oven capable of maintaining a uniform temperature of 230 ±9°F.
- **Charge:** Steel spheres averaging approximately $1^{27}/_{32}$ inches in diameter, with a mass of 390 to 445 g. (See Table 1 for charge requirements).

Table 1 – Charge for Selected Methods and Gradings 08

Test Method -- Grading	Number of Spheres	Mass of Charge, g
T 96 -- A	12	5000 ±25
T 96 -- B	11	4584 ±25
T 96 -- C	8	3330 ±20
T 96 -- D	6	2500 ±15
C 535 -- All Gradings	12	5000 ±25

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Sampling

Obtain the sample according to AASHTO T 2. Reduce to appropriate testing size according to AASHTO T 248.

Sample Preparation

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- The test sample shall consist of clean washed aggregate that has been oven-dried to constant mass at a temperature of 230 ±9° F.
- Separate the sample into individual size fractions by sieving, and recombine to the grading of Table 2 or Table 3 that most nearly corresponds to the range of sizes in the aggregate as furnished for testing. The sample mass shall be recorded to the nearest 1 g.

Note: Constant mass is that condition where the moisture loss does not exceed 0.1% after an additional 2 hours of drying.

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Table – 2 AASHTO T 96 Sample Grading

Sieve Size		Mass of Indicated Sizes, g.			
Passing	***Retained on***	***Grading***			
		A	B	C	D
1½”	1”	1250 ±25	-----	-----	-----
1”	¾”	1250 ±25	-----	-----	-----
¾”	½”	1250 ±10	2500 ±10	-----	-----
½”	⅜”	1250 ±10	2500 ±10	-----	-----
⅜”	¼”	-----	-----	2500 ±10	-----
¼”	No. 4	-----	-----	2500 ±10	-----
No. 4	No. 8	-----	-----	-----	5000 ±10
Total		5000 ±10	5000 ±10	5000 ±10	5000 ±10

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Table – 3 ASTM C 535 Sample Grading

Sieve Size		Mass of Indicated Sizes, g.		
Passing	***Retained on***	***Grading***		
		1	2	3
3”	2½”	2500 ±50	-----	-----
2½”	2”	2500 ±50	-----	-----
2”	1½”	5000 ±50	5000 ±50	-----
1½”	1”	-----	5000 ±25	5000 ±25
1”	¾”	-----	-----	5000 ±25
Total		10000 ±100	10000 ±75	10000 ±50

Procedure

14 1. Inspect the inside of the cylinder to be sure that no residue from previous samples is present.

2. Place the test sample and charge in the cylinder and close the opening with the dust-tight cover.

3. Rotate the cylinder at 30 to 33 rpm for the required number of revolutions: 500 revolutions for test method AASHTO T 96; 1000 revolutions for test method ASTM C 535.

15 4. Carefully remove all material from the cylinder and make a preliminary separation of the sample on a sieve coarser than the No. 12.

16 5. Sieve the finer portion of the material on a No. 12 sieve in a manner conforming to AASHTO T 27. Discard the portion passing the No. 12 sieve.

6. Wash the material coarser than the No. 12 sieve, dry to constant mass at 230 ±9°F, and record mass to the nearest 1 g.

Calculation

17 Express the loss as a percentage of the original mass of the test sample according to the following formula:

$$P = \frac{a - b}{a} \times 100$$

where:

P = percent loss
a = original sample mass, g.
b = final sample mass, g.

(See the sample worksheet on page 5 for examples)

Sample Worksheet for Test Method AASHTO T 96

Date: _____ Project: _____

Material: _____

Source: _____ Tested By: _____

L.A. ABRASION TEST DATA (AASHTO T 96)

Grading	Charge		Sample Mass Before Test, g.	Sample Mass After Test, g	Percent Loss
A, B, C, or D	Number	Mass, g	a	b	P
A	12	5012	5008	3778	25

Sample Mass Used for Test, g					
Passing	Retained on	A	B	C	D
1½”	1”	1262	-----	-----	-----
1”	¾”	1241	-----	-----	-----
¾”	½”	1253		-----	-----
½”	⅜”	1252		-----	-----
⅜”	¼”	-----	-----		-----
¼”	No. 4	-----	-----		-----
No. 4	No. 8	-----	-----	-----	
Total		5008			

Calculation: $P = \frac{a-b}{a} \times 100$ $P = \frac{5008-3778}{5008} \times 100 = 24.6,\ \text{say } 25\%$ 18

REQUIREMENTS FOR SAMPLE MASS AND CHARGE

Sample Mass, g					
Passing	Retained on	A	B	C	D
1½”	1”	1250 ±25	-----	-----	-----
1”	¾”	1250 ±25	-----	-----	-----
¾”	½”	1250 ±10	2500 ±10	-----	-----
½”	⅜”	1250 ±10	2500 ±10	-----	-----
⅜”	¼”	-----	-----	2500 ±10	-----
¼”	No. 4	-----	-----	2500 ±10	-----
No. 4	No. 8	-----	-----	-----	5000 ±10
Total		5000 ±10	5000 ±10	5000 ±10	5000 ±10

Charge		
Grading	Number of Spheres	Mass of Charge, g
A	12	5000 ±25
B	11	4584 ±25
C	8	3330 ±20
D	6	2500 ±15

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Report

- Report on standard agency forms
- Project description and location
- Material source and description, including nominal maximum size
- Test method used (T 96 or C 535)
- Grading used for test (A, B, C, D, 1, 2, or 3)
- Percent loss to the nearest 1%

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Tips

- Make sure the aggregate is dry and clean
- Periodically check the mass of the steel spheres, and discard those that do not meet specifications
- Prior to each test, check the cylinder of the testing machine to insure that no material is left from the previous test
- When selecting the grading to be used for the test sample, use the one that most closely represents the aggregate gradation supplied for testing. Do not combine two or more gradings. Doing so will result in a nonstandard, invalid test.

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REVIEW QUESTIONS

1. What is the purpose of the shelf used in the Los Angeles Machine?

2. Describe the "charge." What does it consist of for grading "3"?

3. What is the difference between gradings "B" and "C"?

4. How does one know which sample grading to use for this test?

5. Describe the difference in aggregate grading between AASHTO T 96 grading "A" and ASTM C 535 grading "3."

6. Excluding the answer to question 5, name at least two differences between ASTM C 535 and AASHTO T 96.

PERFORMANCE EXAM CHECKLIST

RESISTANCE TO ABRASION OF SMALL-SIZE AND LARGE-SIZE COARSE AGGREGATE BY USE OF THE LOS ANGELES MACHINE FOP FOR AASHTO T 96 AND ASTM C 535

Participant Name:_____ Exam Date:_____

Procedure

Sample Preparation

1. Sample obtained by T 2 and reduced by T 248? _____
2. Aggregate washed to ensure that it is clean? _____
3. Clean aggregate dried to constant mass at 230 ±9° F? _____
4. Mass determined to nearest 1 g? _____
5. Specimen masses conform to those defined in FOP tables 2 or 3? _____
6. Number of spheres and mass of charge conform to table 1? _____

Procedure

1. Sample and spheres put in machine and tumbled for the required number of revolutions (500 or 1000) at the proper rate (30 to 33 rpm)? _____
2. Sample after testing initially separated on sieve coarser than a No. 12? _____
3. Finer material separated on a No. 12 sieve per T 27, and minus No. 12 discarded? _____
4. Material coarser than No. 12 washed and dried to constant mass at 230 ±9° F? _____
5. Mass of material coarser than No. 12 determined to nearest 1 g? _____
6. Percentage of loss calculated by dividing original mass into the difference between the original and final mass? _____

Comments: First attempt: (Pass/Fail) ___ Second attempt: (Pass/Fail) ___

Signature of Examiner_____.