Standard Method of Test for

Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

AASHTO Designation: T 96-02 (2006)
ASTM Designation: C 131-01

AASHTO T 96-02 (2006) is identical to ASTM C 131-01 except for the following provisions:

1. All references to the ASTM standards contained in ASTM C 131-01, listed in the following table, shall be replaced with the corresponding AASHTO standard.

Referenced Standards

ASTM	AASHTO
C 136	T 27
C 702	T 248
D 75	T 2
E 11	M 92

2. Add a new Section after Section 3.1 of ASTM C 131-01 as follows:

   3.2 DESCRIPTION OF TERMS

   Constant Mass—Test samples dried at a temperature of 110 ± 5°C (230 ± 9°F) to a condition such that it will not lose more than 0.1 percent moisture after an additional two hours of drying at 110 ± 5°C (230 ± 9°F). Such a condition of dryness can be verified by determining the mass of the sample before and after successive two hours of drying periods. In lieu of such a determination, samples may be considered to have reached constant mass when they have been dried at a temperature of 110 ± 5°C (230 ± 9°F) for an equal or longer period than that previously found adequate for producing the desired constant mass condition under equal or heavier loading conditions of the oven.

3. Add the phrase to the first sentence in Section 6.1 of ASTM C 131-01 as follows:

   …machine "equipped with a counter and" conforming…

   Also replace the seventh sentence of this section as follows:

   "A removable steel shelf shall extend along the length of the cylinder to within 5 mm (0.2 in.) of the full inside length of the cylinder, project inward 89 ± 2 mm (3.5 ± 0.1 in.) and shall be mounted on the interior cylindrical surface of the cylinder, or on the inside surface of the cover, in such a way that a plane centered between the large faces coincides with an axial plane."

   Also the third from the last sentence of Section 6.1 of ASTM C 131-01 is not included in AASHTO T 96-02 (2006).

4. Changes to Figure 1 of ASTM C 131-01 are as follows:

   a. The phrase "NOT LESS THAN 1270 mm MEASURED ON OUTSIDE OF DRUM" is not included in AASHTO T 96-02 (2006).

b. The steel wall thickness shall be changed from "12.7 mm THICK" to "12.7 ± 3.2 mm ($^1/_2$ ± $^1/_8$″) THICK."

5. Add the following note after Note 2 in ASTM C 131-01:

   "NOTE—Due to its mass, the location of the shelf relative to the opening influences the "at rest" position of the opening. The shelf location should be chosen to provide a convenient position of the opening to facilitate the loading of aggregate and spheres and to avoid impact of the charge on the cover."

6. Add the following new section after Section 6.3 of ASTM C 131-01:

   "*Oven*—The oven shall be capable of maintaining a uniform temperature of 110 ± 5°C (230 ± 9°F)."

7. Replace Section 6.3 of ASTM C 131-01 with the following:

   "*Balance*—The balance shall conform to AASHTO M 231, Class G 5."

Designation: C 131 – 01

Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[1]

This standard is issued under the fixed designation C 131; 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 Department of Defense.

1. Scope *

1.1 This test method covers a procedure for testing sizes of coarse aggregate smaller than 37.5 mm (1½ in.) for resistance to degradation using the Los Angeles testing machine (Note 1).

NOTE 1—A procedure for testing coarse aggregate larger than 19.0 mm (¾ in.) is covered in Test Method C 535.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 125 Terminology Relating to Concrete and Concrete Aggregates[2]

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[2]

C 535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[2]

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

C 702 Practice for Reducing Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[3]

E 11 Specification for Wire-Cloth and Sieves for Testing Purposes[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology C 125.

4. Summary of Test Method

4.1 This test is a measure of degradation of mineral aggregates of standard gradings resulting from a combination of actions including abrasion or attrition, impact, and grinding in a rotating steel drum containing a specified number of steel spheres, the number depending upon the grading of the test sample. As the drum rotates, a shelf plate picks up the sample and the steel spheres, carrying them around until they are dropped to the opposite side of the drum, creating an impact-crushing effect. The contents then roll within the drum with an abrading and grinding action until the shelf plate picks up the sample and the steel spheres, and the cycle is repeated. After the prescribed number of revolutions, the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as percent loss.

5. Significance and Use

5.1 This test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure. Assign specification limits with extreme care in consideration of available aggregate types and their performance history in specific end uses.

6. Apparatus

6.1 *Los Angeles Machine*—A Los Angeles machine, conforming in all essential characteristics to the design shown in Fig. 1, shall be used. The machine shall consist of a hollow steel cylinder, closed at both ends, conforming to the dimensions shown in Fig. 1, having an inside diameter of 711 ± 5 mm (28 ± 0.2 in.), and an inside length of 508 ± 5 mm (20 ± 0.2 in.). The cylinder shall be mounted on stub shafts attached to the ends of the cylinder but not entering it, and shall be mounted in such a manner that it may be rotated with the axis in a horizontal position within a tolerance in slope of 1 in 100. An opening in the cylinder shall be provided for the introduction of the test sample. A suitable, dust-tight cover shall be provided for the opening with means for bolting the cover in place. The cover shall be so designed as to maintain the cylindrical contour of the interior surface unless the shelf is so located that the charge will not fall on the cover, or come in

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[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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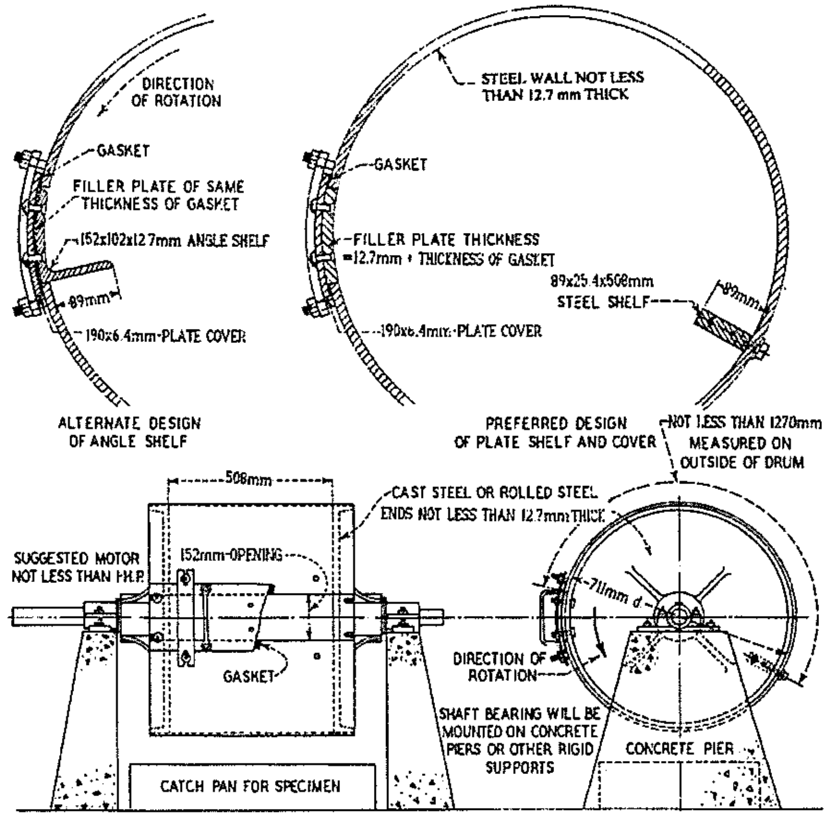
[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

*A Summary of Changes section appears at the end of this standard.



Inch Equivalents

mm	6.4	12.7	25.4	89	102	152	190	508	711	1270
in.	¼	½	1	3½	4	6	7½	20	28	50

FIG. 1 Los Angeles Testing Machine

contact with it during the test. A removable steel shelf extending the full length of the cylinder and projecting inward 89 ± 2 mm (3.5 ± 0.1 in.) shall be mounted on the interior cylindrical surface of the cylinder, in such a way that a plane centered between the large faces coincides with an axial plane. The shelf shall be of such thickness and so mounted, by bolts or other suitable means, as to be firm and rigid. The position of the shelf (Note 2) shall be such that the sample and the steel spheres shall not impact on or near the opening and its cover, and that the distance from the shelf to the opening, measured along the outside circumference of the cylinder in the direction of rotation, shall be not less than 1270 mm (50 in.). Inspect the shelf periodically to determine that it is not bent either lengthwise or from its normal radial position with respect to the cylinder. If either condition is found, repair or replace the shelf before further tests are conducted.

NOTE 2—The use of a shelf of wear-resistant steel, rectangular in cross section and mounted independently of the cover, is preferred. However, a shelf consisting of a section of rolled angle, properly mounted on the inside of the cover plate, may be used provided the direction of rotation is such that the charge will be caught on the outside face of the angle.

6.1.1 The machine shall be so driven and so counterbalanced as to maintain a substantially uniform peripheral speed (Note 3). If an angle is used as the shelf, the direction of rotation shall be such that the charge is caught on the outside surface of the angle.

NOTE 3—Back-lash or slip in the driving mechanism is very likely to furnish test results which are not duplicated by other Los Angeles machines producing constant peripheral speed.

6.2 *Sieves*, conforming to Specification E 11.

6.3 *Balance*—A balance or scale accurate within 0.1 % of test load over the range required for this test.

6.4 *Charge*—The charge shall consist of steel spheres averaging approximately 46.8 mm (1²⁷⁄₃₂ in.) in diameter and each having a mass of between 390 and 445 g.

6.4.1 The charge, (Note 4) depending upon the grading of the test sample as described in Section 8, shall be as follows:

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

NOTE 4—Steel ball bearings 46.0 mm (1¹³⁄₁₆ in.) and 47.6 mm (1⅞ in.) in diameter, having a mass of approximately 400 and 440 g each, respectively, are readily available. Steel spheres 46.8 mm (1²⁷⁄₃₂ in.) in diameter having a mass of approximately 420 g may also be obtainable.

TABLE 1 Gradings of Test Samples

Sieve Size (Square Openings)		Mass of Indicated Sizes, g			
Passing	Retained on	Grading			
		A	B	C	D
37.5 mm (1½ in.)	25.0 mm (1 in.)	1 250 ± 25	...	...	...
25.0 mm (1 in.)	19.0 mm (¾ in.)	1 250 ± 25	...	...	...
19.0 mm (¾ in.)	12.5 mm (½ in.)	1 250 ± 10	2 500 ± 10	...	...
12.5 mm (½ in.)	9.5 mm (⅜ in.)	1 250 ± 10	2 500 ± 10	...	...
9.5 mm (⅜ in.)	6.3 mm (¼ in.)	...	...	2 500 ± 10	...
6.3 mm (¼ in.)	4.75-mm (No. 4)	...	...	2 500 ± 10	...
4.75-mm (No. 4)	2.36-mm (No. 8)	...	...	...	5 000 ± 10
Total		5 000 ± 10	5 000 ± 10	5 000 ± 10	5 000 ± 10

The charge may consist of a mixture of these sizes conforming to the mass tolerances of 6.4 and 6.4.1.

7. Sampling

7.1 Obtain the field sample in accordance with Practice D 75, and reduce the field sample to adequate sample size in accordance with Practice C 702.

8. Test Sample Preparation

8.1 Wash and oven dry the reduced sample at 110 ± 5°C (230 ± 9°F) to substantially constant mass (see 9.1.1), separate into individual size fractions, and recombine to the grading of Table 1 most nearly corresponding to the range of sizes in the aggregate as furnished for the work. Record the mass of the sample prior to test to the nearest 1 g.

9. Procedure

9.1 Place the test sample and the charge in the Los Angeles testing machine and rotate the machine at a speed of 30 to 33 r/min for 500 revolutions. (Note 5) After the prescribed number of revolutions, discharge the material from the machine and make a preliminary separation of the sample on a sieve coarser than the 1.70-mm (No. 12). Sieve the finer portion on a 1.70-mm sieve in a manner conforming to Test Method C 136. Wash the material coarser than the 1.70-mm sieve and oven-dry at 110 ± 5°C (230 ± 9°F) to substantially constant mass (see 9.1.1), and determine the mass to the nearest 1 g (Note 6).

9.1.1 If the aggregate is essentially free of adherent coatings and dust, the requirement for washing after test may be waived, but drying before the test is always required. However, in the case of referee testing, the washing procedure shall be performed.

NOTE 5—Valuable information concerning the uniformity of the sample under test may be obtained by determining the loss after 100 revolutions. This loss should be determined without washing the material coarser than the 1.70-mm sieve. The ratio of the loss after 100 revolutions to the loss after 500 revolutions should not greatly exceed 0.20 for material of uniform hardness. When this determination is made, take care to avoid losing any part of the sample; return the entire sample, including the dust of fracture, to the testing machine for the final 400 revolutions required to complete the test.

NOTE 6—Elimination of washing after test will seldom reduce the measured loss by more than about 0.2 % of the original sample mass.

10. Calculation

10.1 Calculate the loss (difference between the original mass and the final mass of the test sample) as a percentage of the original mass of the test sample. Report this value as the percent loss (Note 7).

NOTE 7—The percent loss determined by this test method has no known consistent relationship to the percent loss for the same material when tested by Test Method C 535.

11. Report

11.1 Report the following information:

11.1.1 Identification of the aggregate as to source, type, and nominal maximum size;

11.1.2 Grading designation from Table 1 used for the test; and

11.1.3 Loss by abrasion and impact of the sample expressed to the nearest 1 % by mass.

12. Precision and Bias

12.1 For nominal 19.0-mm (¾-in.) maximum size coarse aggregate with percent losses in the range of 10 to 45 %, the multilaboratory coefficient of variation has been found to be 4.5 %.[5] Therefore, results of two properly conducted tests from two different laboratories on samples of the same coarse aggregates should not differ from each other by more than 12.7 %[5] of their average. The single-operator coefficient of variation has been found to be 2.0 %.[5] Therefore, results of two properly conducted tests by the same operator on the same coarse aggregate should not differ from each other by more than 5.7 % of their average.[5]

12.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this procedure, no statement on bias is being made.

13. Keywords

13.1 abrasion; aggregate (coarse; small size); degradation; impact; Los Angeles machine

[5] These numbers represent, respectively, the (1S%) and (D2S%) limits as described in Practice C 670.

APPENDIX

(Nonmandatory Information)

X1. MAINTENANCE OF SHELF

X1.1 The shelf of the Los Angeles machine is subject to severe surface wear and impact. With use, the working surface of the shelf is peened by the balls and tends to develop a ridge of metal parallel to and about 32 mm (1¼ in.) from the junction of the shelf and the inner surface of the cylinder. If the shelf is made from a section of rolled angle, not only may this ridge develop but the shelf itself may be bent longitudinally or transversely from its proper position.

X1.2 The shelf should be inspected periodically to determine that it is not bent either lengthwise or from its normal radial position with respect to the cylinder. If either condition is found, the shelf should be repaired or replaced before further tests are made. The influence on the test result of the ridge developed by peening of the working face of the shelf is not known. However, for uniform test conditions, it is recommended that the ridge be ground off if its height exceeds 2 mm (0.1 in.).

SUMMARY OF CHANGES

This section identifies the location of changes to this test method that have been incorporated since the last issue.

(1) References to notes were updated.

Standard Method of Test for

Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

AASHTO Designation: T 97-03
ASTM Designation: C 78-02

1. SCOPE

1.1. This test method covers determination of the flexural strength of concrete by the use of a simple beam with third-point loading.

1.2. The values stated in SI units are to be regarded as the standard.

Note 1—For methods of molding concrete specimens, see T 23 and R 39.

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

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- R 39, Making and Curing Concrete Test Specimens in the Laboratory
- T 23, Making and Curing Concrete Test Specimens in the Field
- T 24M/T 24, Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- T 67, Standard Practices for Force Verification of Testing Machines
- T 231, Capping Cylindrical Concrete Specimens

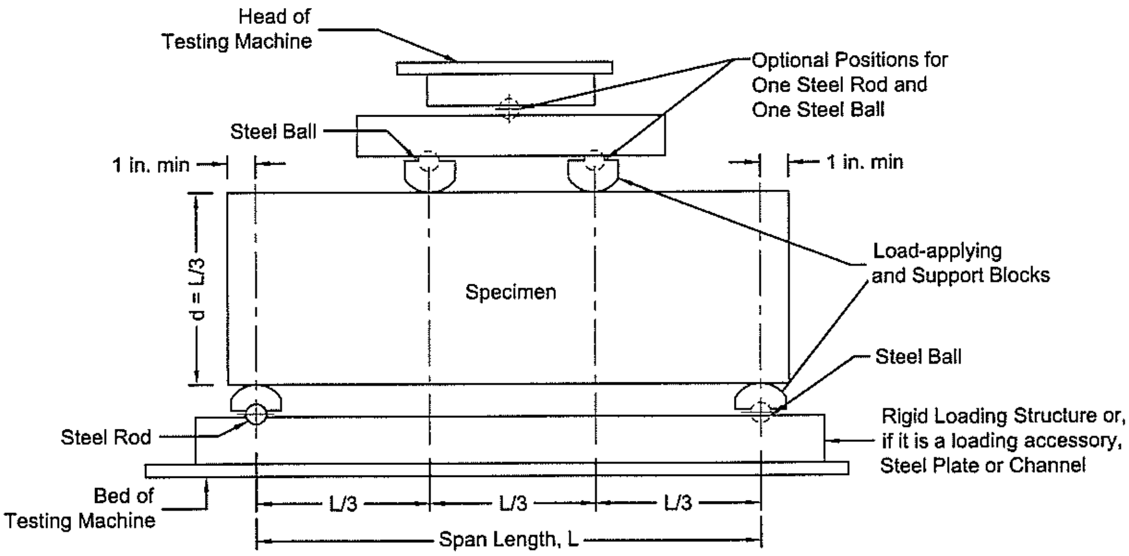
3. SUMMARY OF METHOD

3.1. *Significance and Use:*

3.1.1. This test method is used to determine the flexural strength of specimens prepared and cured in accordance with T 23, T 24M/T 24, or R 39. Results are calculated and reported as the modulus of rupture. The strength determined will vary where there are differences in specimen size, preparation, moisture condition, curing, or where the beam has been molded or sawed to size.

4. APPARATUS

4.1. The testing machine shall conform to the requirements of Sections 16, 17, and 18 of T 67. Hand-operated testing machines having pumps that do not provide a continuous loading in one stroke shall not be permitted. Motorized pumps or hand-operated positive displacement pumps having sufficient volume in one continuous stroke to complete a test without requiring replenishment are permitted and shall be capable of applying loads at a uniform rate without shock or interruption. The third-point loading method shall be used in making flexure tests of concrete employing bearing blocks, which will ensure that forces applied to the beam will be perpendicular to the face of the specimen and applied without eccentricity. A diagram of an apparatus that accomplishes this purpose is shown in Figure 1.



Notes: 1. in. = 25.4 mm
2. This apparatus may be used inverted. If the Testing Machine applies force through a spherically seated head, the center pivot may be omitted, provided one-load applying block pivots on a rod and the other on a ball.

Figure 1—Diagrammatic View of a Suitable Apparatus for Flexure Test of Concrete by Third-Point Method

4.2. All apparatus for making flexure tests of concrete should be capable of maintaining the specified span length and distances between load-applying blocks and support blocks constant within ±1.3 mm (±0.05 in.).

4.3. Reactions should be parallel to the direction of the applied forces at all times during the test and the ratio of distance between the point of load application and nearest reaction to the depth of the beam should not be less than 1.0 ± 0.03.

Note 2—If an apparatus similar to that illustrated in Figure 1 is used:

(a) The load-applying and support blocks should not be more than 64 mm ($2^1/_2$ in.) high, measured from the center or axis of pivot, and should extend entirely across or beyond the full width of the specimen. Each case-hardened bearing surface in contact with the specimen shall not depart from a plane by more than 0.05 mm (0.002 in.) and should be a portion of a cylinder, the axis of which is coincidental with either the axis of the rod or center of the ball, whichever the block is pivoted upon. The angle subtended by the curved surface of each block should be at least 45 degrees (0.79 rad).

(b) The load-applying and support blocks should be maintained in a vertical position and in contact with the rod or ball by means of spring-loaded screws which hold them in contact with the pivot rod or ball.

(c) The uppermost bearing place and centerpoint ball in Figure 1 may be omitted when a spherically seated bearing block is used, provided one rod and one ball are used as pivots for the upper load-applying blocks.

5. TEST SPECIMEN

5.1. The test specimen shall conform to all applicable requirements of T 23, T 24M/T 24, and R 39. The specimen shall have a test span within 2 percent of being three times its depth as tested. The sides of the specimen shall be at right angles with the top and bottom. All surfaces in contact with load-applying and support blocks shall be smooth and free of scars, indentations, holes, or inscribed identifications.

6. PROCEDURE

6.1. Turn the test specimen on its side with respect to its position as molded and center on the bearing blocks. Center the loading system in relation to the applied force. Bring the load-applying blocks in contact with the surface of the specimen at the third points between the supports and apply a load of between 3 and 6 percent of the estimated ultimate load. Using standard 0.10-mm (0.004-in.) and 0.38-mm (0.015-in.) leaf-type feeler gauges, determine whether any gap between the specimen and the load-applying or support blocks is greater or lesser than each of the gauges over a length of 25 mm (1 in.) or more. Grind, cap, or use leather shims on the specimen contact surface to eliminate any gap in excess of 0.10 mm (0.004 in.). Leather shims shall be uniform 6.4 mm (0.25 in.) thickness, 25 to 50 mm (1 to 2 in.) width, and shall extend across the full width of the specimen. Gaps in excess of 0.38 mm (0.015 in.) shall be eliminated only by capping or grinding. Grinding of lateral surfaces should be minimized in as much as grinding may change the physical characteristics of the specimens. Capping shall be in accordance with T 231.

6.2. Load the specimen continuously and without shock. The load shall be applied at a rate which constantly increases the extreme fiber stress between 0.9 and 1.2 MPa/min (125 and 175 psi), until rupture occurs. The loading rate is computed using the following equation:

$$r = Sbd^2/L \qquad (1)$$

where:

r = loading rate, MN/min (lb/min);
S = rate of increase in extreme fiber stress, MPa/min (psi/min);
b = average width of specimen mm (in.);
d = average depth of specimen mm (in.); and
L = span length, mm (in.).

7. MEASUREMENT OF SPECIMENS AFTER TEST

7.1. After testing, at one of the fractured faces, take three measurements across each dimension (one at each edge and at the center) to the nearest 1.3 mm (0.05 in.) to determine the average width, average depth, and line of fracture location of the specimen at the section of failure.

7.1.1. If fracture occurs at a capped section, include the cap thickness in the measurement.

8. CALCULATIONS

8.1. If the fracture initiates in the tension surface within the middle third of the span length, calculate the modulus of rupture as follows:

$$R = Pl/bd^2 \qquad (2)$$

where:

R = modulus of rupture, kPa (psi);
P = maximum applied load indicated by the testing machine, N (lbf);
l = span length, mm (in.);
b = average width of specimen mm (in.); and
d = average depth of specimen mm (in.).

8.2. If the fracture occurs in the tension surface outside of the middle third of the span length by not more than 5 percent of the span length, calculate the modulus of rupture as follows:

$$R = 3Pa/bd^2 \quad (3)$$

where:

a = average distance between line of fracture and the nearest support measured on the tension surface of the beam, mm (in.).

Note 3—The weight of the beam is not included in the above calculations.

8.3. If the fracture occurs in the tension surface outside of the middle third of the span length by more than 5 percent of the span length, discard the results of the test.

9. REPORT

9.1. *The report shall include the following*:

9.1.1. Identification number;

9.1.2. Average width to the nearest 1 mm (0.05 in.);

9.1.3. Average depth to the nearest 1 mm (0.05 in.);

9.1.4. Span length in millimeters (inches);

9.1.5. Maximum applied load in newtons (pounds-force);

9.1.6. Modulus of rupture calculated to the nearest 0.05 MPa (5 psi);

9.1.7. Curing history and apparent moisture condition of the specimens at the time of test;

9.1.8. If specimens were capped, ground, or if leather shims were used;

9.1.9. Defects in specimens; and

9.1.10. Age of specimens.

10. PRECISION AND BIAS

10.1. *Precision*—The coefficient of variation of test results has been observed to be dependent on the strength level of the beams. The single operator coefficient of variation has been found to be 5.7 percent. Therefore, results of two properly conducted tests by the same operator on beams made from the same batch sample should not differ from each other by more than 16 percent. The multilaboratory coefficient of variation has been found to be 7.0 percent. Therefore, results of two different laboratories on beams made from the same batch sample should not differ from each other by more than 19 percent.

10.2. *Bias*—Since there is no accepted standard for determining bias in this test method, no statement is made.