T 97

FLEXURAL STRENGTH OF CONCRETE (USING SIMPLE BEAM WITH THIRD-POINT LOADING)
FOP FOR AASHTO T 97

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Scope

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

The most commonly tested beam size is one having a nominal width and depth of 6 inches and a length of at least 20 inches.

Apparatus

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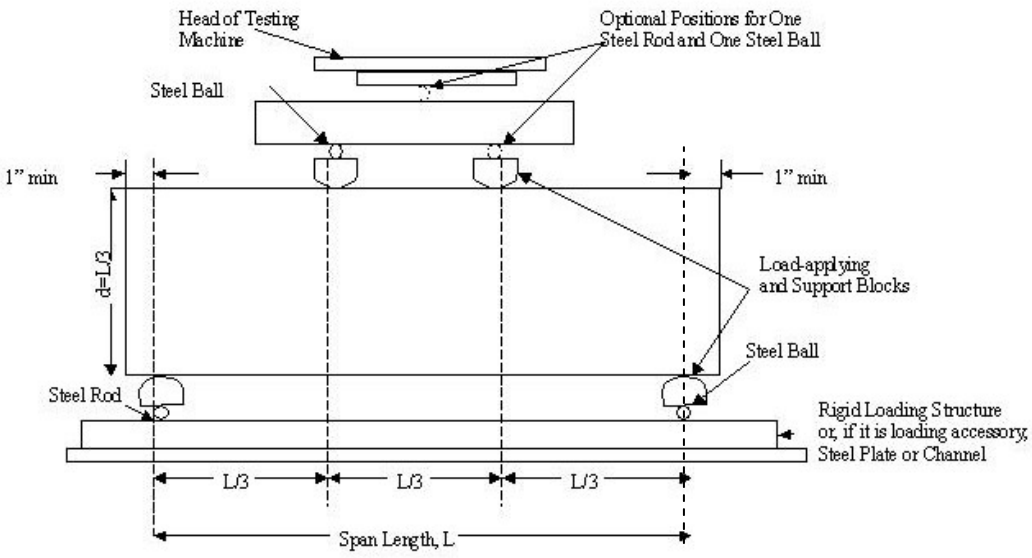
- **Testing Machine:** Capacity sufficient to cause specimen failure at prescribed loading rates. The machine shall be either power operated or of the hand operated pump variety such that a single stroke of the pump is sufficient to apply the entire load to specimen failure at the prescribed rate. The apparatus must apply the load continuously and without shock. The machine shall be accurate such that the percentage of error shall not exceed ±1.0 percent of the indicated load.
- **Loading Apparatus:** Suitable to insure that applied loads will be perpendicular to the face of the specimen and applied without eccentricity. See FIGURE 1 for a typical acceptable apparatus. The apparatus must be capable of maintaining the specified span length and loading points within 0.05” of that specified.

  Load-applying and support blocks must extend across at least the full width of the specimen. The shape of each block shall be a portion of a cylinder, the axis of which is coincident with either the axis of the steel rod or ball on which it pivots. The bearing surfaces shall not depart from a plane by more than 0.002” and shall be case hardened. The load-applying and support blocks must be maintained in a vertical position and in contact with the steel rod or ball with spring-loaded screws.

Figure 1



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***Note 1*:** The support blocks and loading blocks must bear on a steel rod at one location and one steel ball at the opposite location.

- **Feeler Gages:** Of 0.004" and 0.015" thickness, used for measuring gap between test specimen and load-applying or support blocks.
- **Leather Shims:** Uniform thickness of ¼ inch, 1 to 2 inches in width, of sufficient length to extend across the entire bearing width of the specimens.

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Specimens

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Specimens shall comply with all applicable provisions of AASHTO T 23, T 24, or R 39.

The test span may not depart by more than 2% of being three times the specimen depth as tested.

The sides of the specimens must be at right angles to the top and bottom. The bearing surfaces must be smooth, free of scars, holes, and indentations.

$$\frac{3d - S}{S} \leq 2\%$$

where:

d = specimen depth as tested

S = test span, distance between supports

Table 1
Permissible Time Tolerances

Specified Age	*Tolerance*
12 hrs	15 min (2.1%)
24 hrs	30 min (2.1%)
3 days	2 hrs (2.8%)
7 days	6 hrs (3.6%)
28 days	20 hrs (3.0%)
90 days	2 days (2.2%)

Procedure

1. All test specimens for a given test age shall be broken within the permissible time tolerances prescribed in Table 1.
2. Flexure tests of moisture-cured specimens shall be made as soon as practicable after removal from moist storage. Specimens shall be kept moist by any convenient method until tested.
3. Place the test specimen in the apparatus by turning the specimen on its side so that the sides as molded become the top and bottom against which the loading and support blocks will bear.
4. Apply a load between 3 and 6% of the anticipated ultimate load.
5. Determine that full bearing is achieved between all four blocks and the specimen. If full bearing is achieved, the specimen may be tested as is without the use of leather shims or capping.

   If there is any gap 1 inch or more in length exceeding 0.004 inch but not greater than 0.015 inch, leather shims may be used to achieve proper specimen bearing.

   If there is a gap 1 inch or more in length exceeding 0.015 inches, the specimen must be ground or capped such that the bearing surfaces meet the required specifications.

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6. No loose particles may be trapped between the test specimen and any bearing point, or between shims and bearing points during application of the test load.
7. Apply the load continuously and without shock. Control the rate between 125 and 175 psi per minute when calculated according to the formulas under "Calculation" below**.**

Note 2: For a 6-inch nominal beam cross-section, the prescribed loading rate of 125 to 175 psi per minute equates to a range of approximately 1500 to 2100 load pounds per minute.

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Measurement of Test Specimens After Test

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Take three measurements across each dimension (one at each edge and one at the center) to the nearest 0.05 inches to determine specimen width, depth, and location of the fracture. Fracture location is to be measured along the bottom (tension) face as oriented for testing.

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

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Calculation

- If the fracture occurs within the middle third of the span length, calculate the modulus of rupture according to the following formula:

$$R = \frac{P\,l}{b\,d^2}$$

where:

R = modulus of rupture, psi
P = maximum applied load, lbf
l = span length, in.
b = average specimen width, in.
d = average specimen depth, in.

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- If the fracture occurs outside of the middle third of span length by not more than 5%, calculate the modulus of rupture as follows:

$$R = \frac{3\,P\,a}{b\,d^2}$$

where:

a = average distance between line of fracture and the nearest support, in.

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- If the fracture occurs outside of the middle third of span length by more than 5% of span length, discard the results of the test.

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Tips!

- Support blocks must bear on a steel rod at one span support and on a steel ball at the other. Loading blocks may also be required to conform to this configuration (see Figure 1 and explanatory notes in T 97)
- Remember to check for gaps between beam and apparatus bearing surfaces using feeler gages. Use leather shims or cap specimens as required.
- Measure location of failure along the bottom side of the beam as tested.
- Modulus of rupture is calculated and reported to the nearest 5 psi.

Report

- Results shall be reported on standard forms approved for use by the agency
- Identification number
- Specimen age
- Average width to the nearest 0.05”
- Average depth to the nearest 0.05”
- Span length, in.
- Maximum load
- Modulus of rupture to the nearest 5 psi
- Curing history and apparent moisture condition at time of test
- If specimen was capped, ground, or if leather shims were used
- Observed defects in specimens
- Age of specimen.

Calculation Examples

Calculate modulus of rupture according to one of the following formulas:

1. When fracture is within the middle third of span:

$$R = \frac{P\,l}{b\,d^2}$$

where:

R = modulus of rupture, psi.
P = maximum applied load, lbf
l = span length, in.
b = specimen width, in.
d = specimen depth, in.

2. When fracture is outside the middle third of span by not more than 5%:

$$R = \frac{3\,P\,a}{b\,d^2}$$

where:

a = distance between line of fracture and nearest support, in.

Example #1 (Fracture within the middle third of span) 25

Maximum Load (P): 8,520 lbs.
Span Length (l): 18.00”
Specimen Width (b): 6.10”
Specimen Depth (d): 6.05”

$$R = \frac{8520 \times 18}{6.10 \times 6.05^2}$$

$$R = \frac{153360}{223.28} = 687, \text{say } 685 \text{ psi}$$

Example #2 (Fracture not more than 5% outside of middle third of span) 26

Maximum Load (P): 8,520 lbs.
Span Length: 18.00”
Distance of Fracture From Nearest Support (a): 5.75” (1.4%)
Specimen Width (b): 6.10”
Specimen Depth (d): 6.05”

$$R = \frac{3 \times 8520 \times 5.75}{6.10 \times 6.05^2}$$

$$R = \frac{146970}{223.28} = 658, \text{say } 660 \text{ psi}$$

REVIEW QUESTIONS

1. Why is this test performed?

2. The support and loading blocks must be positioned in the apparatus within _____ of that specified.

3. Describe the method of load application.

4. After specimen failure, what must be recorded? Describe.

5. Given the following, calculate the modulus of rupture:

Maximum sustained load:	6,240 lbs.
Span length:	18.00”
Distance of fracture from nearest support:	5.80”
Average specimen width:	6.05”
Average specimen depth	6.15”

6. What is wrong with the test conducted as described in question number 5?

PERFORMANCE EXAM CHECKLIST

FLEXURAL STRENGTH OF CONCRETE (USING SIMPLE BEAM WITH THIRD-POINT LOADING)

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Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Participant Name:_____ Exam Date:_____

Apparatus	Trial 1	Trial 2
1. Testing machine capable of applying load continuously, without shock, accurate to ±1.0% of indicated test load?	_____	_____
2. Supports and loading blocks within 0.05" of required location and have steel rod at one end, steel ball at the other with spring loaded screws to maintain alignment?	_____	_____
3. Feeler gages of 0.004" and 0.015" present to check for gaps?	_____	_____
4. Leather shims available if needed of 1/4" uniform thickness, 1 to 2 inches wide and long enough to span across full bearing distance?	_____	_____
Specimens		
1. Test span does not depart by more than 2% from being three times specimen depth?	_____	_____
2. Specimen sides at right angles to top and bottom; bearing surfaces smooth and free from scars, holes, and indentations?		_____
3. Specimen sides at right angles to top and bottom; bearing surfaces smooth and free from scars, holes, and indentations?	_____	_____
Procedure		
1. Test specimens kept moist between removal from storage and testing?	_____	_____
2. Test conducted within the specified time limits for the test age?	_____	_____
3. Test specimen positioned in apparatus so that the sides as cast become the top and bottom; apparatus allowed to bear on beam surfaces at zero load?	_____	_____
4. Feeler gages used to check for gaps greater than 1" in length; leather shims or capping as required; no loose particles trapped?	_____	_____
5. Load applied continuously and without shock; designated rate of load application maintained over last half of anticipated load; load recorded?	_____	_____
6. Specimen measured in three locations each for width, depth, and fracture; fracture measurements along bottom of beam as tested?	_____	_____
7. Fracture not more than 5% outside middle third of span?	_____	_____
Calculations		
4. Appropriate formula selected based on fracture location and modulus of rupture calculated to nearest 5 psi?	_____	_____
5. Result discarded if fracture more than 5% outside of middle portion of span?	_____	_____

a. When fracture is within the middle third of span:

$$R = \frac{P\,l}{b\,d^2}$$

where:

R = modulus of rupture, psi.
P = maximum applied load, lbf
l = span length, in.
b = specimen width, in.
d = specimen depth, in.

- **When fracture is outside the middle third of span by not more than 5%:**

$$R = \frac{3\,P\,a}{b\,d^2}$$

where:

a = distance between line of fracture and nearest support, in.

Problem #1

Maximum Load (P): 7,710 lbs.
Span Length: 18.00”
Distance of Fracture From Nearest Support (a): 5.80”
Specimen Width (b): 6.00”
Specimen Depth (d): 6.05”

R = _____

Problem #2

Maximum Load (P): 9,310 lbs.
Span Length (l): 18.00”
Distance of Fracture From Nearest Support (a): 8.75”
Specimen Width (b): 6.05”
Specimen Depth (d): 6.10”

R = _____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

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_____
_____
_____
_____
_____

Signature of Examiner_____