

1. PROCEDURE OVERVIEW

This test method covers the determination of the flexural strength of concrete by the use of a simple beam with third-point loading. A simply supported concrete prism is loaded by two point loads placed at third points along the span. The load is monotonically increased until flexural failure occurs. Based on the peak load, the peak flexural stress within the prism is calculated. ASTM C78 (Ref. 7.1) formed the basis for the development of this procedure. This method is commonly referred to as the modulus of rupture.

Two concrete test machine are available for use in FSEL. The main body of this procedure is applicable to both test machines. There are two appendices with each appendix containing details instructions for one of these two machine.

The test machine located in the corner of the Room 180 is a Forney model FX-250T-TPilot machine with a compressive force capacity of 300,000 lbs. The FX-250T is an open-loop machine that requires the user to monitor and adjust the load rate to satisfy ASTM C78 requirements. The machine nearest the bay door in Room 180 is a Forney model FX-500-Auto-MOE with a compressive force capacity of 500,000lbs. The FX-300-Auto is a closed loop machine that can internally monitor and adjust load rates to comply with testing standards.

1.1. Student Responsibilities:

- Read and understand the requirements of this procedure
- Provide concrete samples for testing
- Dispose of prisms after testing
- Clean-up of the test machine after use

1.2. Staff Responsibilities:

- Read and understand the requirements of this procedure
- Assist students with testing as needed
- Ensure concrete test machines are calibrated on an annual basis

2. EQUIPMENT AND TOOLS

- Compression Testing Machine
- Assorted Test Fixtures
- Combination Square
- Calipers
- Ruler
- Camera
- Brush and Dustpan

3. MATERIALS

- Concrete Samples (Prisms)

4. PERSONAL PROTECTIVE EQUIPMENT

- Safety glasses
- Safety Shoes
- Dust Mask
- Gloves

5. DETAILED PROCEDURE

- 5.1. Verify that the compression-testing machine is in working order and that it has been calibrated per FSEL operating procedure.

The compression testing machine should be calibrated on an annual basis. It should also be noted that calibration of these machines is limited to 100,000 lb of compressive force due to the size of the compressive machine and the size of the calibration load cells available at FSEL.

- 5.2. Prepare concrete samples for flexural strength testing.

- 5.2.1. Verify that the samples do not have any significant defects that may affect the quality of the test results.

If there are any rough spots or lips on the specimens as a result of placing fresh concrete in the molds, those spots must be filed, sanded, or ground to ensure smooth and flat surfaces. Smooth surfaces are especially important at locations where the test fixtures contact the specimen.

- 5.2.2. Use calipers or a ruler to determine the sample width and depth to the nearest 0.05 inches by averaging a minimum of two measurements per direction and taken in the plane containing the midspan of the prism.

- 5.2.3. Record the sample identifier along with the average sample width and depth.

- 5.3. Prepare the compression-testing machine.

- 5.3.1. Install bearing blocks and other test fixtures as necessary to successfully complete flexural strength testing of the samples.

The loading apparatus for flexural strength testing is typically stored on the floor near the test machines. These pieces are heavy and should be lifted and installed in the machine by more than person.

TESTING FLEXURAL STRENGTH OF CONCRETE PRISMS

- 5.3.2. Turn on the testing machine and allow the electronic and hydraulic systems to equalize for a minimum of 15 minutes.

Equalization of the electrical and hydraulic systems is necessary to ensure stable readings and repeatable results. Detailed instructions for operating the FX-250T test machine are provided in Appendix A and detailed instructions for operating the FX-500 test machine are provided in Appendix B.

- 5.4. Test each concrete sample as soon as practicable after removal from its previous state of conditioning.

- 5.4.1. Wipe the concrete sample as necessary to remove any surface moisture and wipe clean the bearing faces of the upper and lower bearing blocks.

- 5.4.2. Place the sample in the compression-testing machine.

The sample should be placed in the machine such that form faces are on the top and bottom, that is, where these formed faces will contact the load and support points. Ensure the prim is centered over the supporting span and perpendicular to the support.

- 5.4.3. Zero the force readout of the compression-testing machine and ensure that the peak recording function is enabled.

Detailed instructions for operating the FX-250T test machine are provided in Appendix A and detailed instructions for operating the FX-500 test machine are provided in Appendix B.

- 5.4.4. Apply load continuously at a rate of movement corresponding to a rate of increase of stress on the tension face of the sample of 150 ± 25 psi per minute until rupture occurs.

Depending on the test machine being used, it may be necessary to determine a loading rate in lb/min as shown below.

$$r = \frac{Sbd^2}{L}$$

Where: r = loading rate in lb/min
 S = rate of increase in maximum stress on the tension face in psi/min
 b = average width of the specimen as oriented for testing in in.
 d = average depth of the specimen as oriented for testing in in.
 L = span length in in.

TESTING FLEXURAL STRENGTH OF CONCRETE PRISMS

Detailed instructions for operating the FX-250T test machine are provided in Appendix A and detailed instructions for operating the FX-500 test machine are provided in Appendix B.

- 5.4.5. Record the maximum load carried by the sample during the test and note the observed fracture pattern.

The numerical result of the test is a function of the observed failure mode as described in Article 5.5. The fracture pattern should also be documented with a camera.

- 5.5. Calculate the modulus of rupture value.

The modulus of rupture value is calculated based on the location of the observed fracture.

- 5.5.1. If the fracture initiates in the tension surface within the middle third of the span (between the loading points), calculate the modulus of rupture to the nearest 5 psi as:

$$R = \frac{PL}{bd^2}$$

Where: R = modulus of rupture in psi
 P = maximum applied load indicated by the test machine in lb
 L = span length in in.
 b = average width of the specimen as oriented for testing in in.
 d = average depth of the specimen as oriented for testing in in.

- 5.5.2. If the fracture initiates 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 to the nearest 5 psi as:

$$R = \frac{3Pa}{bd^2}$$

Where: a = the average distance between the line of fracture and the nearest support measured on the tension surface of the beam in in.

- 5.5.3. 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.

- 5.6. Clean the test machine after testing.

5.6.1. Discard the tested specimen in the hopper located in the concrete testing room.

If the hopper is full or nearly full, notify FSEL technical staff so that the hopper can be emptied.

5.6.2. Clean all concrete dust and debris from the test machine.

5.6.3. Return the test machine configuration to that which is required for cylinder testing.

Cylinder tests are much more common in FSEL. Remove the flexural strength testing hardware from the test machine after prism testing.

5.7. Power off the test machine.

6. SUPPORTING DOCUMENTS

None.

7. REFERENCED DOCUMENTS

7.1. ASTM C78-16: *Standard Test Method for Flexural Strength of Concrete (Using Simple beam with Third-Point Loading)*. West Conshohocken: ASTM International, 2016.

8. RECORD OF REVISIONS

Revision	Date	Affected Pages	Description
0	2016-10-21	All	Initial Issue

TESTING FLEXURAL STRENGTH OF CONCRETE PRISMS

A. INSTRUCTIONS FOR USE OF FX-250T TEST MACHINE

5.3.2 To turn on the FX-250T machine, toggle the pump power switch and press the digital power switch. The digital power switch should illuminate and the pump should be audibly running.

Press play -> "RUN +";

1. Press Enter -> "Compression +";
2. Press Play -> "Flexure +"
3. Press Enter -> "Beam Center Pnt +"
4. Press Play -> "Beam 3rd Point +"
5. Press Enter -> "Edit Test ID";
6. Press play -> "Edit Specimen";
7. Press Enter -> "Span 18.00000in";
8. Press Play -> "Width 6.00000in";
9. Press Play -> "Depth 6.00000";
10. Press Play -> "Wt 72.5000lb";
11. Press Play -> "Age 28.0000days";
12. Press Play -> "Rate 2.5 psi/s";
13. Press Play -> "Exit"; and
14. Press enter.

Note: The default Test ID is 0. If multiple specimens are tested, the Test ID will need to be incremented with each test. It is recommended that the default value for steps 9 through 14 be left in place. Specimen dimensions as measured per this procedure should be used for all calculations after the test is completed.

5.4.3 To zero the force and ready the machine for the first test tare the system by pressing the "0 / Zero" button on the control panel.

5.4.4 To perform the compression tests, perform the following steps:

1. Briefly move lever to full advance to close gap;
2. After gap is nearly closed (<1/8 in.), move the lever to "Hold";
3. Press "8/Stress" twice to show the load rate in psi/s;
4. Close and latch the door to the test frame;
5. Move lever to metered advance;
6. Adjust the load rate using the knob/valve;
7. After failure move lever to "Hold";
8. Move lever to "Retract" to retract the piston until a visible gap between the specimen and test platen appears;
9. Move the lever to "Hold"; and

TESTING FLEXURAL STRENGTH OF CONCRETE PRISMS

10. Press "7/Force" then "9/Peak" to show peak force.

Notes: During testing, the load rate will be displayed along with one of the following symbols: ---, --, -, ###, +, ++, or +++. Minus (-) signs indicate the load rate is less than specified, plus signs (+) indicate the load rate is greater than specified, and pound signs (###) indicate the load rate is approximately correct. The more minus (-) or plus (+) signs, the further out of tolerance the load rate. After the cylinder or core reaches its peak stress and prior complete failure, the load rate may begin to go negative. If this happens, leave the rate control valve in its current state until visible failure of the specimen.

To perform an additional test with the same input values for diameter, length, load rate, etc.:

1. Press "-/New" -> Display "Test ID";
2. Press Enter -> Type the sequential test number;
3. Press Enter;
4. Press Play, and
5. Go to the Appendix A section for Article 5.4.4 and repeat.

TESTING FLEXURAL STRENGTH OF CONCRETE PRISMS

B. INSTRUCTIONS FOR USE OF FX-500 TEST MACHINE

5.3.2 *To turn on the FX-500 machine use the toggle switch near the lower left corner of the display. The display should power on and the onboard computer should start.*

Log in to the machine using your User ID and PIN. After logging into the machine, check and update the user information as needed. When the information is completed, click "Done."

Select "Beam" for the dropdown menu at the upper right corner of the screen. Confirm the data displayed on the right side of the screen. It is recommended that the nominal dimensions of the specimen be entered rather than those measured per this procedure. The load rate, or "ramp" should be 2.5 psi/s per the ASTM C78 (Ref 7.1). The default preload is set 200 lbf. If you expect your cylinder to fail near or less than this value, you should reduce the preload to a more appropriate level.

5.4.3 *Confirm that the load displayed is 0 lbf. If the load is not 0 lbf, click the "Tare Load" button on the screen.*

5.4.4 *To begin the test, click and hold "Jog Advance" to raise the testing table. Hold "Jog Advance" until the top of the cylinder or core is less than 1/8 in. from the upper test platen. Click the "Start Test" button to begin the compression test. The test machine will automatically apply the specified preload then begin applying load at the rate specified in Article 5.4.4 **Error! Reference source not found.** Click and hold "Jog Retract" to reset the test machine for the next sample. To perform additional tests, repeat these provisions as needed.*