FSEL

PROCEDURE FOR

SPLITTING TENSILE STRENGTH TESTING OF CONCRETE CYLINDERS AND CORES

1. PROCEDURE OVERVIEW

The determination of the splitting tensile strength of cylindrical concrete samples such as molded cylinders and drilled cores is outlined in this procedure. A diametral compressive load will be applied along the length of the sample at a continuous rate until failure occurs. This loading induces tensile stresses on the plane containing the applied load, causing tensile failure of the sample. The splitting tensile strength will be determined by dividing the maximum applied load by the appropriate geometrical factors. ASTM C496 (Ref. 7.1) formed the basis for the development of this procedure.

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 C796 (Ref. 7.1) 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 cylinders and cores 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

▪ Diamond End Grinding Machine ▪ Compression Testing Machine ▪ Assorted Test Fixtures

▪ Capping Fixture ▪ Combination and Centering Square ▪ Pi Tape ▪ Calipers

▪ Ruler ▪ Camera

3. MATERIALS

▪ Concrete Samples (Cores, Cylinders, or Both) ▪ Bearing Strips

▪ High-Strength Gypsum Paste ▪ Fine Point Permanent Markers ▪ Adhesive

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 splitting tensile testing.

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

5.2.2. Use a diamond end grinding machine as necessary to square off and flatten each of the sample ends to meet the tolerances of ASTM C39 (Ref. 7.2).

Diamond end grinding of the sample ends may be completed well in advance (e.g. upon demolding) of compression testing. Information about grinding cylinder and core ends can be found in the FSEL Procedure For Grinding the Ends of Concrete Cylinders and Cores.

5.2.3. Use a straight-edge and square to draw a line parallel to the sample axis on the circumferential face of the sample.

5.2.4. Use a suitable device (e.g. combination and centering square) to draw diametral lines on each end of the sample connecting with the line drown in Article 5.2.3. The diametral lines must be drawn within the same axial plane.

5.2.5. Use calipers or a ruler to determine the sample length (L) by averaging a minimum of two length measurements taken in the plane containing the diametral lines.

5.2.6. Use a pi tape to determine the sample diameter (D) by averaging the following three diameter measurements: near the top of the sample, approximately at mid-height of the sample and near the bottom of the sample. Subsequently calculate the length-to-diameter ratio.

5.2.7. If the length-to-diameter ratio (L/D) exceeds 2.1, shorten the sample through further grinding until the sample length is between 1.9 and 2.1 times the diameter.

5.2.8. If testing a cored sample, cap the contact areas of the sample with a thin layer of high-strength gypsum paste.

5.3. Record the sample identifier, average sample length (to the nearest 0.1 inches), sample diameter (to the nearest 0.01 inches), and length-to-diameter ratio for each sampled to be tested.

5.4. Prepare the compression-testing machine.

5.4.1. Install bearing blocks and other test fixtures as necessary to successfully complete splitting tensile testing of the samples.

5.4.2. 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.

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

Control of the load rate, as outlined in Articles 5.5.7 and 5.5.8, may be accomplished with an automatic compression-testing machine with a digital control system or through manual control.

5.5.1. Wipe the concrete sample as necessary to remove any surface moisture

5.5.2. Wipe clean the bearing faces of the upper and lower bearing blocks.

5.5.3. Place a wood strip along the length of each contact area. Ensure that each end of each plywood strip is aligned with the respective diametral line.

The single-use wood strips should be about 1/8 inch thick, approximately 1 inch wide and as long as or slightly longer than the sample length. Typically, paint-stirring sticks are used for this purpose. The wood strips may be held in place with a small amount of adhesive to facilitate alignment in the testing machine.

5.5.4. Place the sample in the compression-testing machine. First center the sample along the length of the upper bearing block and then ensure that the projections of diametral lines are centered on the upper and lower bearing plates.

5.5.5. Verify that the top bearing block is parallel with the top surface of the sample and make adjustments as necessary.

5.5.6. 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.

5.5.7. Apply load continuously at a rate of movement corresponding to a splitting tensile stress rate on the sample of 150 ± 50 psi per minute.

Loading rates for various sample sizes are provided in Table 1. The load rate may only be adjusted during application of the first half of the anticipated ultimate load and should not be adjusted thereafter. 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.

Table 1 – Load Rates for Various Sample Sizes

Nominal Sample Size	Stress Rate	Load Rate
3 in. by 6 in.	150 ± 50 psi/min. (2.5 ± 0.8 psi/s)	71 ± 24 lb/s
4 in. by 8 in.		126 ± 42 lb/s
6 in. by 12 in.		283 ± 94 lb/s

5.5.8. Continue to apply load until the force indicator shows that the load is decreasing steadily and the sample displays a well-defined fracture pattern.

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

The fracture pattern should also be documented with a camera.

5.6. Calculate the splitting tensile strength of each sample.

$$T = \frac{2P}{\pi LD}$$

Where: T *= splitting tensile strength in psi*
P *= maximum applied load indicated by the testing machine in pounds*
L *= average sample length in inches*
D *= sample diameter in inches*

5.7. Record the splitting tensile strength of each sample to the nearest 5 psi.

5.8. Clean the test machine after testing.

5.8.1. Discard the tested cylinder 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.

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

5.9. Power off the test machine.

6. SUPPORTING DOCUMENTS

None.

7. REFERENCED DOCUMENTS

7.1. ASTM C496-11: *Splitting Tensile Strength of Cylindrical Concrete Specimens.* West Conshohocken: ASTM International, 2011.

7.2. ASTM C39-14: *Compressive Strength of Cylindrical Concrete Specimens*. West Conshohocken: ASTM International, 2014.

8. RECORD OF REVISIONS

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

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

5.4.2 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.

5.5.6 To zero the force and ready the machine for the first test preform the following steps:

1. *Tare the system by pressing "0 / Zero";*
2. *Press play -> Display "RUN +";*
3. *Press Enter -> Display "Compression +";*
4. *Press Enter -> "Cube +";*
5. *Press Play -> "Cylinder +";*
6. *Press Enter -> "Edit Test ID";*
7. *Press play -> "Edit Specimen";*
8. *Press Enter -> "Dia 4.00000in";*
9. *Press Play -> "Len 8.00000in";*
10. *Press Play -> "Corr. 1.00000";*
11. *Press Play -> "Wt 8.4000lb";*
12. *Press Play -> "Age 28.0000days";*
13. *Press Play -> Set the load rate to 10.0 psi/s[1] ("Rate 10 psi/s");*
14. *Press Play -> "Exit"; and*
15. *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 8through 12 be left in place. Diameters and lengths as measured per this procedure should be used for all calculations after the test is completed.

5.5.7 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;*

[1] This value is a placeholder that is used to convert to the proper load rate for a split cylinder test. An axial stress application rate of 10 psi/s on a the round end of a cylinder results in a force application rate of that corresponds splitting tensile stress application rate of 2.5 psi/s as required by Ref 7.1 for splitting tensile testing.

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*
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 5.5.7 and repeat.*

B. INSTRUCTIONS FOR USE OF FX-500 TEST MACHINE

5.4.2 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 "Cylinder Split" 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 diameter and height of the specimen be entered rather than those measured per this procedure. The load rate, or "ramp" should be 150 ± 50 psi/min.(2.5 ± 0.8 psi/s) per the ASTM C496 (Ref 7.1). The default preload is set 1,000 lbf (or 20 psi on a 4 in. by 8 in. cylinder). If you expect your cylinder to fail near or less than this value, you should reduce the preload to a more appropriate level.

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

5.5.7 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 test. The test machine will automatically apply the specified preload then begin applying load at the rate specified in Article 5.5.7. Click and hold "Jog Retract" to reset the test machine for the next sample. To perform additional tests, repeat these provisions as needed.