PROCEDURE FOR

FSEL

COMPRESSION TESTING OF CONCRETE CYLINDERS AND CORES

1. PROCEDURE OVERVIEW

This procedure is to be used for determining the compressive strength of concrete cylinders and cores. After preparing the ends, a compressive axial load will be applied to the samples at a continuous rate until failure occurs. The compressive strength will be determined by dividing the maximum load by the cross-sectional area of the sample. ASTM C39 (Ref. 7.1) and ASTM C42 (Ref. 7.2) formed the basis for the development of this procedure.

Two concrete test machines 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 detailed 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 C39 (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 cylinders or cores 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

▪ Pi Tape ▪ Calipers ▪ Ruler ▪ Camera ▪ Brush and Dustpan

3. MATERIALS

- Concrete Samples (Cores, Cylinders, or Both)

4. PERSONAL PROTECTIVE EQUIPMENT

- Safety Glasses
- Safety Shoes
- Dust Mask
- Work 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 compression testing.

5.2.1. Verify that the compressive strength 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. 7.1).

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.

Sulfur mortar caps prepared in accordance with ASTM C617 (Ref. 7.4) are a suitable alternative to the use of an end grinding machine. The sample length must be recorded prior to preparing the sulfur caps.

5.2.3. Use calipers or a ruler to measure the sample length (L) according to the guidance of ASTM C1542 (Ref. 7.3).

Measure the length of the cylinder or core at four locations separated by 90 degrees around the perimeter. Measurements should be taken to the nearest 0.01 in. if using calipers or to the nearest 1/16 in. if using a ruler or tape measure.

5.2.4. Use a pi tape to measure the sample diameter (D) and subsequently calculate the length-to-diameter ratio and cross-sectional area (A).

Measure the sample diameter at midheight to the neatest 0.01 in.

5.2.5. 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.

A length-to-diameter ratio less than 1.9 is acceptable by not desirable. Correction factors are provided in Article 5.5.2 and Table 2.

5.2.6. Record the sample identifier, final sample length, sample diameter, length-to-diameter ratio, and cross-sectional area for each cylinder or core tested.

5.3. Prepare the compression-testing machine.

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

5.3.2. Turn on the compression-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.

5.4.2. Wipe clean the bearing faces of the upper and lower bearing blocks and place the sample on the lower bearing block.

5.4.3. Using the concentric circles on the bearing block and lower platen as points of reference, carefully align the axis of the sample with the upper spherical seat.

5.4.4. Tilt the spherically seated block so that the bearing face is parallel to the top surface of the sample.

5.4.5. Zero the force readout of the compression-testing machine and prepare the machine for testing.

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.

5.4.6. Apply load continuously at a rate of movement corresponding to a stress rate on the sample of 35 ± 7 psi per second; refer to corresponding load rates in Table 1.

Table 1 - Rate of Loading

Nominal Sample Diameter	Stress Rate	Load Rate
3 in.	35 ± 7 psi/s	250 ± 50 lb/s
4 in.		440 ± 90 lb/s
6 in.		900 ± 200 lb/s

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.

5.4.7. Continue to apply load until the sample fails and displays a well-defined fracture pattern.

5.4.8. Record the maximum load carried by the sample during the test and note the type of fracture pattern (refer to Figure 1).

If the fracture pattern is not one of the typical patterns shown in Figure 1, record a description of the failure pattern. The fracture pattern should also be documented with a camera.

5.4.9. Photograph the failed test specimen.

5.5. Calculate the compressive strength of the cylinder or core.

5.5.1. Calculate the compressive strength of the sample by dividing the maximum load by the cross-sectional area as determined from the measurements taken in Article 5.2.4.

5.5.2. If the length of the sample was not greater than 1.75 times the diameter of the sample, correct the compressive strength by applying the appropriate correction factor of Table 2; interpolate as necessary.

5.5.3. Correct the measured compressive strength of cored samples as noted in ACI 214.4R (Ref. 7.6) and other applicable industry guidance.

5.5.4. Record the compressive strength of each sample to the nearest 10 psi and note any corrections made.

5.6. Clean the test machine after testing.

5.6.1. 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.

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

5.7. Power off the test machine.

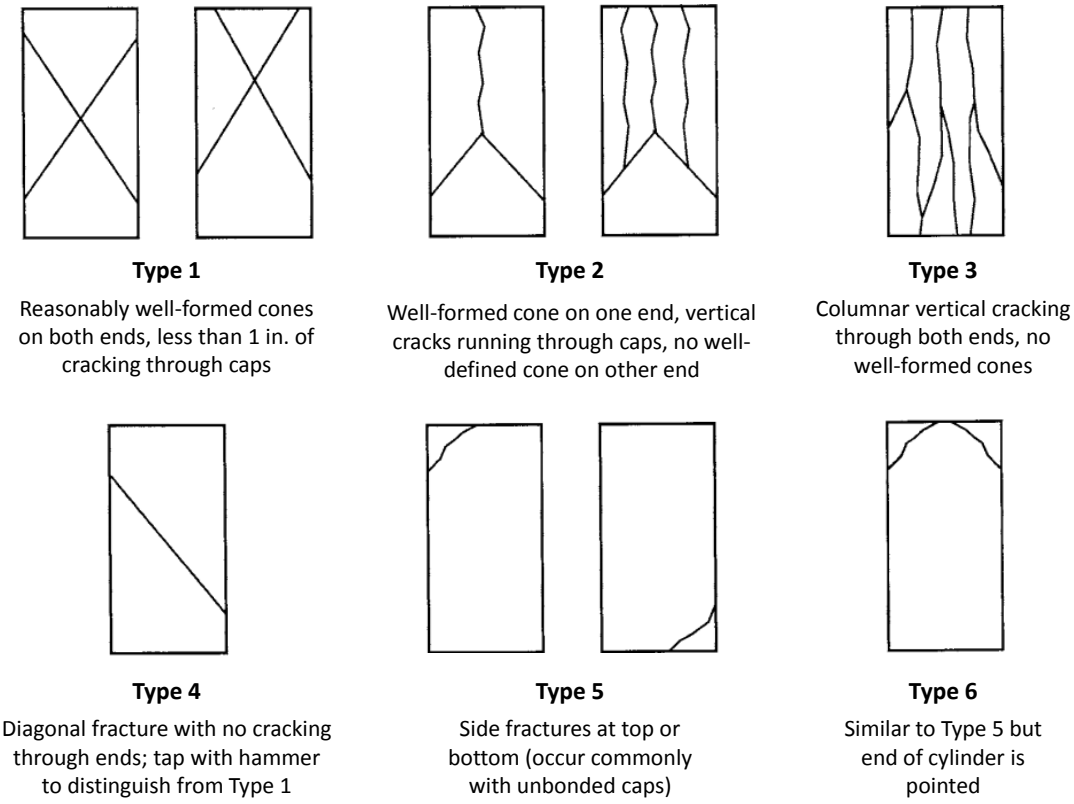

Figure 1 - Schematic of Typical Fracture Patterns

Table 2 - Correction Factors for L/D Ratios Less than 2.0

L/D Ratio	Correction Factor
1.75	0.98
1.50	0.96
1.25	0.93
1.00	0.87

6. SUPPORTING DOCUMENTS

None.

7. REFERENCED DOCUMENTS

7.1. ASTM C39-12: *Compressive Strength of Cylindrical Concrete Specimens*. West Conshohocken: ASTM International, 2012.

7.2. ASTM C42-12: Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. West Conshohocken: ASTM International, 2012.

7.3. ASTM C1542-02: *Measuring Length of Concrete Cores*. West Conshohocken: ASTM International, 2002.

7.4. ASTM C617-11: *Capping Cylindrical Concrete Specimens*. West Conshohocken: ASTM International, 2011.

7.5. ACI Committee 214. ACI 214.4R-10: *Guide for Obtaining Cores and Interpreting Compressive Strength Results*. Farmington Hills: American Concrete Institute, 2010.

7.6. ACI Committee 214. ACI 214.4R-10: *Guide for Obtaining Cores and Interpreting Compressive Strength Results*. Farmington Hills: American Concrete Institute, 2010.

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

5.3.2 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.

5.4.5 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 -> "Rate 35.0 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.

5.4.6 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*
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 5.4.6 and repeat.*

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 "Cylinder" 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 35 psi/s per the ASTM C39 (Ref 7.1). The default preload is set 10,000 lbf (or 796 psi on a 4 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.

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

5.4.6 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 5.4.6. After the test is complete and the sample is failed, choose the image corresponding go the correct failure type of the sample (Figure 1). Click and hold "Jog Retract" to reset the test machine for the next sample. To perform additional tests, repeat these provisions as needed.