Manual for Modulus of Rupture/Flexural Test (4-pt bending) of 6x6 inch (~150x150 mm) Fiber-Reinforced Concrete Beams

Using the JCI-SF4 method or ASTM C78 and C1609 methods
(ASTM C1018 was withdrawn in 2006)

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Version date: 12/11/2008

What you need

- □ Concrete beams - 6x6x21 inches (152x152x533 mm)
  - Recommendation: 3 beams for each mixture
  - Dimensions are based on steel molds available in concrete lab, but should be recorded to the nearest 0.05 inch (1 mm)
- □ Angle bracket for each beam
- □ Quick-set epoxy
- □ Hammer and chisel (set) from student instrumentation workshop
- □ Sharpie or grease pencil
- □ Deflection frame (see details later)
- □ 20-kip (89 kN) MTS testing frame, INSTRON 8500 Plus controler, LabView based data logger
- □ ±0.1 inch (or 2.5 mm) range LVDT

Procedure

- □ Take concrete beams out of moist curing room
  - ASTM standard calls for test to be started within 15 minutes from removal of curing room or to cover the specimen with wet purlap to minimize drying
  - Other suggested method: take out specimens roughly 24 hrs in advance or be consistent with moisture condition for each test
- □ Dry surface to attach angle bracket and label.
  - Use the epoxy to glue angle brackets to the top center of "bottom" face where the "top" face is the finished, rough surface (you want the deflection measurement to come from the smooth face opposite of the rough surface). You may want to mark this location before gluing (at 10.5 inches or 267 mm from the ends).
- □ Mark the specimen: (see Figure 1)
  - Location of the deflection frame points above pin/roller and at neutral axis: at 1.5 inches (38 mm) from the ends and 3 inches (76 mm) from the bottom/top on the rough and smooth bottom/top surfaces.
  - Location of the pin and rollers from the supports and loading head: mark at 1.5 inches (38 mm) from the ends and at 7.5 inches (191 mm) and 13.5 inches (343 mm) from the end.

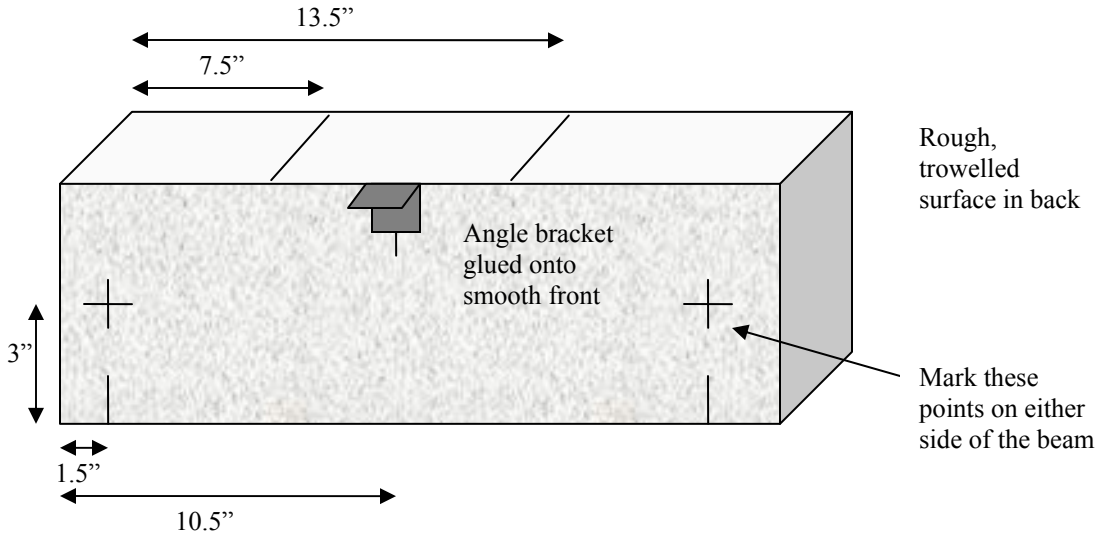

Figure 1. Suggested marking locations with dimensions in inches (1 inch = 25.4 mm).

Test setup

You can use the 20-kip (89 kN) MTS testing frame on the east end of the crane bay. You need an LVDT which can measure up to 0.12 inches or 3 mm total, so a ± 0.1 inch (± 2.5 mm) LVDT will work fine. You need a loading head with two rollers spaced 6 inches (~150 mm) apart. The base plate should contain a roller and a pin spaced 18 inches (~450 mm) part (pin and rollers are attached from the bottom of the base plate with bolts).

Note: the ASTM standard requires you to record the actual span between pin and roller to the nearest 0.1 inch (2 mm).

Deflection Frame: The deflection frame should be a metallic device that attaches to the concrete beam's neutral axis above the pin and roller on either side of the beam. It should contain a metallic stick at least on one side of the beam for which a LVDT can be held by. The LVDT should be placed at the beam's midspan and should be allowed to read deflections from the epoxied angle bracket.

Attach the deflection frame by screwing it into the points marked on the beam with the LVDT holder just under the angle bracket. **Make sure all screws and nuts are tightened on the frame against the beam.** ** If any of the components are loose, the beam may spontaneously break and the data will not be useful.

Make sure to place wood below the beam to catch the beam should it suddenly or unexpected break – the wood also aids in putting the beam temporarily back together in order to remove the deflection frame at the end of the test.

Figure 2 shows a photograph of what the completed test setup should appear to be.

Figure 2. Fiber-reinforced concrete beam before testing.

Testing

The Hydraulic Power Supply (HPS) from the basement tunnels must be on in order to test (Greg or Glen can turn these on for you). You will know they are on when the grey box on the far north side of the wall has the top right yellow light on.

INSTRON 8500 Plus controller should be set up for you in advance and should be connected to the load cell and LVDT. This also has buttons to turn on the actuator and hydraulics (if not already on) – when turning on the actuator, make sure to turn the on the LOW first before HIGH; there is a manual for that controller available on line: http://cee.uiuc.edu/nsel/website2008upgrade/facility/instr/manuals.htm. It is recommended that each new user reads and understand the manual prior to testing.

Make sure all the equipment works properly – you should certainly double check this if you are unsure of the controls and testing. A dummy specimen (usually use an extra concrete beam with a glued angle bracket) is always best to use beforehand.

Always make sure LOAD PROTECT is ON when setting up the beam or equipment. You may now apply a seating load to the beam which should be roughly 3 to 6% of the ultimate load (roughly 200 to 500 lb or 0.9 to 2.2 kN). The LOAD PROTECT can be set to this seating load value for convenience.

Insert the LVDT into the deflection frame and tighten the screw and wing nut such that the output reads somewhere around 9 volts and to make sure you get maximum range of motion that way. The polarity for the LVDT should be set such that initially there are positive values and as the LVDT is pushed in, the values should go towards negative values. **Make sure all screws and nuts are tight on the frame.**

On the control tower go under WAVEFORM for the STRAIN 1 and set to SRAMP loading and with the maximum number at -0.16 inches or -4 mm. The loading rate according to ASTM C78 should be 125 to 175 psi/min or the peak should be reached in 30-60 seconds from the test start) which comes to between 0.002 to 0.005 in/min or 0.06 to 0.12 mm/min for the 6x6 inch (~150x150 mm) beams. You will need to set maximum and minimum LVDT limits at ±0.1 in (±2.54 mm) and start data collection before loading begins.

Note: during testing this loading rate is often maintained for at least a deflection equal to the span/600 (0.03 inches or 0.75 mm). Afterwards to speed up the testing time, the rate may be doubled up to 0.01 in/min or 0.24 mm/min. The peak load should occur at roughly 0.002 inches (or 0.05 mm) deflection.

SET LIMITS! Set the MAX and MIN LIMITS to the STRAIN 1 control to match the range of the LVDT gauge (i.e. ± 0.1 inches or ± 2.5 mm) and make sure it is set to UNLOAD and turned ON. You can also put a limit to UNLOAD onto the load cell at its range.

Data Collection

If you are using the 20-kip MTS testing frame on the east end of the Crane Bay, the calibration is often set up such that channel 0 is 10 V = 76.2 mm Position, channel 1 is 10 V = 100 kN Force, and channel 2 is 10 V = 2.54 mm LVDT. In general the number of milliseconds between data points should be set to 250 ms.

Make sure a data collecting program is set up and ready to RUN and START. Once you hit run and verify that it is collecting data, you may turn LOAD PROTECT OFF and hit the STRAIN 1 button and select IMMEDIATE. Then assuming all is set up ok, you may hit the START button on the control tower.

If anything occurs you can hit the HOLD button or even FINISH the test from the control tower. *Hopefully* if some polarity issues occur (you will see the machine unload for example) then your set limit should stop the test. If the beam breaks spontaneously, especially after the peak has been reached, it is likely that something was loose in your deflection frame or the epoxy was not dry. Also a sign of uncured/non-dried epoxy is the initial slope before the peak is reached will be lower (more gradual) than expected.

Finishing/clean up

Once the test has reached 0.12 inches or 3 mm of total deflection (you may want to run it out a bit longer just to be sure since the deflection on the screen is shown as absolute rather than relative deflection), you may hit the FINISH button on the control tower. You may also stop the data collecting program.

Make sure to switch the control frame from STRAIN to POSITION – IMMEDIATE and turn LOAD PROTECT – ON before touching any of the testing equipment or beam or else the equipment will go haywire and you may break the load cell or LVDT (both $$$ expensive).

Be careful when removing the LVDT and set it aside in a safe place where it won't fall or become damaged. You may take the deflection frame off the beam and knock off the angle bracket.

Be sure to clean off all concrete and epoxy from the angle bracket so it can be reused. You may use the hammer and chisel set with the vise grip on the south side table.

Always throw out any trash or left over concrete. Make sure to clean any dust or concrete chunks that may have fallen during your testing. Return all equipment.

When finished you may turn off the actuator and hydraulics on the control tower. Shut off the monitor on any computer or close any laptop you used.

Double check to see if anyone else is using the hydraulics for any other testing (in the east end, the strong wall or the basement) before deciding to turn off the hydraulic pumps in the basement. If no one else is using them for the rest of the day – you may turn them off by hitting STOP on the gray box along the north wall just below the right yellow light.

Testing Tips

Always think twice before you do something. Then think about it a third time too.

Be wary of wires and chords so you don't trip or step on anything for it could distort data or break equipment. The voltage output from the LVDT may jump if it is moved or touched during the testing.

An example data set directly from the raw data recorded from a fiber-reinforced concrete flexure test can be seen in Figure 3. The load/force values can be switched to positive values during the analysis and the deflection from the LVDT reading can be adjusted such that the start of the test is at a deflection of zero and the deflections increase afterwards towards positive values.

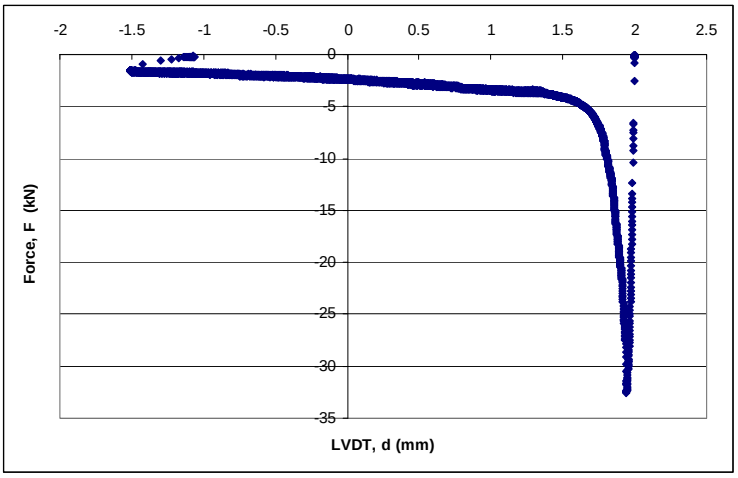

Figure 3. Example resulting plot directly obtained from .dat file.

Manual Calibration tips:
When item has a slow blinking calibration light, go to "SET UP" > "CAL" > "CAL"
Under second "CAL" select "MANUAL" > "COARSE BAL" for coarse balancing. Make sure that the gauge shows almost zero output. Press ENTER button to run coarse calibration. Under SPAN, put 2.54 mm. Rotate the scale on the calibration clamp by 2 times. This means that LVDT core was moved exactly 2.54 mm, which is equal to the SPAN; example with a ±0.1 inches (±2.54 mm), LVDT after two rotations it should have a span reading of 2.54 mm (in other words at 1 rotation it should read 1.27 mm. If this is correct return gage to zero and select "FINE BAL" for fine balancing.

Other gages such as clip gages can be automatically calibrated.

Conversions on hand:
1 lb(f) = 4.448222 N
1 inch = 25.4 mm