Test Procedure for

CALIBRATING A RAINHART 416 HYDRAULIC CONCRETE BEAM TESTER

TxDOT Designation: Tex-903-K

Effective Date: August 1999

1. SCOPE

1.1 This method describes the verification of a Rainhart recording concrete beam tester, used in Tex-448-A to determine the flexural strength of a concrete beam. A beam is broken in flexure using a third point loading head, which must be removed for calibration. Several different circular chart recorders, clock drives, and recording pen arrangements have been used in this device. Some of the older models are still in use.

1.2 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 Rainhart Catalog No. 400 elastic calibration device, a loading frame and proving ring combination that designed to fit inside the beam tester in place of a concrete beam. The proving ring (ring dynamometer) has a capacity of 53,400 N (12,000 lbs. force) Calibrate according to ASTM E 74 or Tex-902-K. The frame should have four saddle blocks that seat against the upper crossheads. A loading block on the bottom of the proving ring sits on a steel ball resting on the ram extension pedestal (See Figure 1).

2.2 Ram extension pedestal, with a 19 mm (3/4 in.) ball.

2.3 Calibrated stopwatch.

2.4 Steel straightedge.

2.5 Small magnifying lens.

2.6 Miscellaneous tools.
3. MATERIALS

3.1 Rainhart recording charts.

4. PROCEDURE

4.1 Several differing chart recorders have been used in this tester. A Bristol Pressure Recorder connected to the control valve manifold system has now replaced most. A Bourdon tube drives the recorder pen through a linkage system, which must be adjusted for both range and linearity. The chart drive is a clock mechanism that rotates one revolution once every 15 minutes.

4.2 Remove the two bolts holding the loading head to the ram. Clean away any debris and dirt. Lift the head off and clean around the ram. Try not to get dirt into the space between the ram and the cylinder walls.

4.3 If oil is leaking around the ram and wetting the top of the casting, replace the seal as explained in Section 5.

4.4 On the top left side of the base casting is a cover plate with the serial number stamped on it. Clean around the cover, remove the center bolt holding it, and lift the cover off. Use Type A or Dextron Automatic Transmission fluid. Section 5 describes how to service the hydraulic system.
4.5 Place the cylindrical loading pedestal with a steel ball on the top of the ram. The ram should be almost all the way down when doing this.

4.6 Turn the chain counterclockwise to raise the upper crossheads. Insert the calibration device with its attached proving ring. The ball resting on the pedestal fits into a small cavity in the loading block mounted on the bottom of the ring. The four saddle blocks must fit against the two crossheads. Lower the crossheads until they loosely support the loading frame on the pedestal and ball. Turn the dial indicator so that it faces the front of the beam breaker.

4.7 Install a recording chart in the recorder. Clamp it loosely on the hub so that it may be turned by hand.

4.8 Ink the recording pen. Rotate the chart by hand to determine if the pen is on the zero load line. If not, reset the pen to zero. There are two pen adjustment methods: one requires turning a small screw near the upper part of the pen arm; the second requires turning a small cam contacting the upper part of the pen arm. See Section 6 for more about cleaning and adjustment of the pen.

4.9 Zero the dial indicator with no load exerted by the ram or crossheads. A calibration chart for the proving ring must be readily available.

4.10 Rotate the chart so that the calibration points are now under the pen.

4.11 Close the hydraulic valve by turning all the way clockwise.

4.12 Turn the pump handle fully counterclockwise. This raises the pump piston to a full stroke position.

4.13 Turn the pump handle clockwise to put a small load on the calibration device. While increasing the load, be sure that the calibration device does not contact any part of the beam breaker except at the ball on the pedestal and the crossheads.

4.14 Increase the load until reaching a load of 8900 N (2,000-lbs. force). Increase pressure slowly as the load approaches and then stop on the load. Rotate the recording chart so that the pen makes a line through the calibration point. If the valves leaks, hold the load constant while making the pen mark by slowly turning the pump.

4.15 Repeat the above step for loads of 17,800; 26,700; 35,600; 44,500; 53,400 N (4,000; 6,000; 8,000; 10,000; and 12,000 lbs. Force). Rotate the chart at each load to cause the pen to make a mark through the appropriate calibration point. If a point is missed, release pressure slowly until halfway to the previous load and then start loading again. Calibration checks are for increasing loads only.

4.16 After marking the chart at the last load, continue to rotate it slightly until the pen is exactly on the pen trace test line. Now hold the chart steady while performing the next step.

4.17 Open the hydraulic system value to release the pressure in the system. The pen will leave a mark on or next to the pen trace test line.
4.18 Measure the distance between where the pen's mark and the pen trace test touch the zero load circle. It should not exceed 0.8 mm (0.031 in.). Section 6 details how to adjust the pen tracing.

4.19 The recording chart has calibration marks for a variation of plus or minus 1% tolerance. Visually extend these marks for a range of 2%. Use a magnifying lens and estimate the deviation to the nearest 0.25%.

4.20 The concrete beam tester is calibrated if the results are within 2%. If it is not in calibration, adjust the linkage and repeat the previous Sections. Continue this until the tester is within calibration. Most testers can be calibrated to within 1%. Section 7 explains the calibration adjustments.

4.21 Wind the clock mechanism from 1/2 to 1 turn. Do not force it. Over winding may break the clock.

4.22 Clamp the chart securely to the hub.

4.23 The outer part of the chart has triangle markers that denote one-minute intervals. Watch these markers as they pass under the recording pen. Using a calibrated timer, measure the period between the passing of two adjacent markers. Start and stop the timer using the same part of each triangle (e.g. the center point of the triangle). Obtain better results by observing the marks with a magnifying lens.

4.24 The clock mechanism is acceptable if the clock is accurate to within one second for each one minute period checked. If measuring the period between two adjacent marks, the clock must have no more than a one-second error. If measuring the period between three successive marks, the error must be no more than two seconds.

4.25 Replace the clock if it is not within tolerance.

4.26 Using a straight edge such as a steel ruler, check the surface of each of the four hardened steel bars contacting the beam during testing. One is on each crosshead and two are on the third-point-loading head. The surfaces contacting the beam should not deviate more than 0.05 mm (0.002 in.) from a straight line. Record the condition of each loading bar.

4.27 Record the overall condition of the hydraulic system.

4.28 When the beam tester and the clock are within the desired tolerance, complete a label indicating that the tester has been calibrated. It should include the serial number, the date of calibration, and the name of the calibration technician.

4.29 Place the calibration label on the inside of the recorder, on the top plate above the chart and pen.
5. HYDRAULIC SYSTEM MAINTENANCE

5.1 Hydraulic Fluid:

5.1.1 The hydraulic fluid should be Type A or Dextron Automatic Transmission Fluid. Do not use any other kind. If another type has been introduced into the system, remove and replace it.

5.1.2 To examine the fluid, first clean all dirt from around the top left side cover plate on the casting. This is the one with the serial number stamped into it. Remove the single bolt holding it on and lift the cover off.

5.1.3 If the fluid appears black or dirty, replace it. First, turn the pump handle clockwise as far as it will go, then open the valve, and finally push the ram as far down as it will go. This forces most of the fluid into the left side reservoir. A small hand pump, siphon, or syringe works well for removing the fluid from the reservoir. Clean and dry the interior of the reservoir before refilling.

5.1.4 If the fluid was very dirty or had water in it, replace the metal filter that screws into the bottom of the reservoir.

5.1.5 It will take about 1.4 L (1.5 qt.) of fluid to refill the reservoir.

5.2 Valve Stem Seal:

5.2.1 If oil leaks from around the valve stem, replace the "O" ring seal. Remove the valve stem by turning it counterclockwise until free. Replace the "O" ring on the shaft. **Note 1**—To stop hydraulic fluid from flowing out of the opening, plug with a small stopper.

5.3 Quad Ring Seal:

5.3.1 After lifting the loading head off the ram, clean all dirt and dust from around the ram. Be careful not to get dirt between the ram and the cylinder walls. If oil has leaked around the ram and wet the top of the casting, replace the quad ring seal.

5.3.1.1 Close the valve and pump the ram up as far as possible.

5.3.1.2 Grasp the ram and pull it straight up and out with a twisting motion.

5.3.1.3 Cut the old seal off.

5.3.1.4 Buff all corrosion off the ram with a wire brush.

5.3.1.5 Use a hand pump and syringe to remove the oil from the cylinder bore.

5.3.1.6 Examine the walls of the bore for corrosion or wear.
5.3.1.7 If corroded or worn, hone the cylinder wall with a hand drill powered hone or very fine wet dry sandpaper. Then clean the cylinder bore to remove all fluid, dirt, and grit.

5.3.1.8 Slip a new quad ring onto the ram. Be careful not to over stretch or cut it.

5.3.1.9 Wet the seal with transmission fluid and insert the ram back into the cylinder bore.

5.3.1.10 With a combined push and twisting motion, the ram will go back into the cylinder bore.

5.4 Bottom Ram Seal:

5.4.1 A fixed position ram plugs the bottom of the cylinder bore. It is locked in place and uses a quad ring seal. It does not often leak, but when it does, remove it through the top.

5.4.1.1 Remove the ram as described in Section 5.3 and pump all oil from the cylinder bore.

5.4.1.2 Remove the hydraulic fitting into the base of the casting. This fitting locks the lower ram in place.

5.4.1.3 Now push the lower ram up and out of the cylinder bore. There is a hole in the bottom of the wooden platform that allows access for pushing this ram out.

5.4.1.4 Clean the ram and the cylinder walls, replace the quad ring, and reinsert the ram as described for the main ram.

6. PEN REPLACEMENT AND ADJUSTMENT

6.1 Removing and Replacing Pen:

6.1.1 There are two types of pen points:

6.1.1.1 Remove the V-point pen by sliding it out of the holder on the end of the pen arm. Figure 2 shows installation along with the Rainhart part numbers for pens and pen arms. Press a new pen point into the holder until its curved top corners just come through. The pen arm should be perpendicular to the chart, i.e., at 90° to the chart as seen from the front and sides as shown in Figure 2. Bend the pen arm slightly for adjustment.

6.1.1.2 An older type of pen point comes attached to the arm. Replace this pen and arm as a unit. The pen must contact the paper at an angle of about 15° as seen in Figure 3. Bend the pen arm slightly to adjust the angle.

6.1.2 There should not be any horizontal bends in either pen arm.
Figure 2—Pen Point Installation

Figure 3—Pen to Paper Contact

6.2  *Pen Point Pressure:*

6.2.1  A pen point should just contact the chart. Too much pressure will cause it to drag; too little will cause skipping.

6.2.2  Adjust the pressure by flexing the pen arm in the needed direction.
6.2.3 It helps when checking for correct pressure to place one drop of ink in the trough of the pen.

6.3 Pen and Ink:

6.3.1 If the pen does not write at first, sometimes it helps to moisten the tip of the point with saliva or to lift the point about an inch and drop it lightly until the ink flows properly.

6.3.2 Some of the new, replacement, V-points appear to have a coating that keeps them from accepting the ink and writing. Scraping with a small knife sometimes cleans off the coating; otherwise, return to the supplier.

6.3.3 A worn pen or over filling can cause a wide line that is not accurately readable.

6.4 Pen Cleaning:

6.4.1 When a pen is very dirty, washing in alcohol can clean it.

6.4.2 You may try to clean it by holding a small container of alcohol under the pen and dipping the assembly into it while still on the recorder.

6.4.2.1 Slip the V-point pen out of the holder for cleaning.

6.4.2.2 If removing the pen and arm combination, check the pen tracing.

6.5 Pen Arm:

6.5.1 Remove the pen arm by loosening the locking screw in the upper part of the arm as shown in Figure 4. Then pull the arm downward and free of the locking screw and rivets.

6.5.2 To install a pen arm, slip the slot at the upper end of the arm under the two rivets and locking screw. Gently press upward until the ears shown in Figure 2 engage the upper rivet. Tighten the locking screw.
6.6 Pen Tracing Test:

6.6.1 The position of the pivot point of the pen arm is critical to a good calibration.

6.6.2 The load lines on the chart are printed for a specific distance from this pivot point to the center of the chart.

6.6.3 Check this position by placing the pen in exact contact with the top of the pen tracing test line located just clockwise of the calibration marks.

6.6.4 Hold the chart steady and allow the pen arm to fall to the zero load line.

6.6.5 If the line drawn by the pen no longer contacts the trace test line, there is an error in its setting.

6.6.6 Measuring along the zero load line, find the distance between the line drawn by the pen and the printed trace test line. It should not exceed 0.8 mm (1/32 in.).

6.6.7 If it exceeds this, reset the pivot point and repeat the tracing test.

6.6.8 Continue this until the error is within acceptable limits.

6.7 Bristol Recorder Pen Trace Adjustment:
6.7.1 This is the current model of chart recorder, housed in a cast aluminum case. To adjust the pen arm:

6.7.1.1 Remove the top flat metal cover above the pen and chart.

6.7.1.2 Use a large screwdriver and loosen the two mounting screws at the base of the bracket supporting the pen arm pivot (See Figure 5, Item 5).

6.7.1.3 Note that the right mounting screw is in a slot.

6.7.1.4 Rotate the right side of the bracket up if the pen trace is below the trace test line or down if the pen trace is above the trace test line.

6.7.1.5 Tighten the two screws and perform the pen-tracing test again.

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**Figure 5—Bristol/Rainhart Recorder**

**Gotham Recorder Pen Trace Adjustment:**

6.8 This is the early chart recorder, housed in a black metal case. Figure 6 shows the configuration of this recorder.

6.8.1 The pen arm has a fork in its upper end (See Figure 6, Item 9).

6.8.2 Loosen the locking screw and shorten or lengthen the pen arm as needed.

6.8.4 Tighten the locking screw and perform the pen-tracing test again.
7. CALIBRATING THE RECORDER

7.1 Any adjustment for the range or span will change the linearity of the recorder. Any adjustment of the linearity will affect the range. It generally works best to start by adjusting the range until it is correct at no load and full scale. Then adjust linearity. Continue alternate adjustments until the recorder is satisfactory. Check the zero setting after each of these adjustments.

7.2 Bristol Recorder Calibration:

7.2.1 Remove the both cover plates above the pen and chart as shown in Figure 4. (Also refer to Figure 5.) With a large screwdriver, make sure that the Bourdon tube assembly (Item 1) and the pen pivot-mounting bracket (Item 5) are tight. Also be sure that the pen arm is properly installed and the locking screw (Item 2) tight.

Note 2—Check the pen tracing before doing any other calibration loading. On later models of this recorder, a small cam has replaced the pen adjustment screw (Item 2A).

7.2.2 Examine the calibration marks after a loading test and note the errors at each of the loads.

7.2.2.1 If the error at each load is off in the same direction by equally increasing amounts (e.g. 1/2 division at one load, 1 division at the next, 1-1/2 at the third) the recorder is linear but the range is high and must be lowered.
7.2.2.2 If it is off in equally decreasing amounts, the range is low and needs to be increased.

7.2.3 Adjust the range by loosening the two clamping screws (Item 10) and adjusting the length of this lever arm by rotating the knurled nut. Increase the range by lengthening the lever, or decrease the range by shortening the lever. Tighten the clamping screws before testing.

7.2.4 The range adjustment is correct when the pen trace is correct at both the zero and the full-scale loads.

7.2.4.1 If the in-between steps are also correct, the recorder is calibrated.

7.2.4.2 If the in-between readings are not correct, the linearity needs adjustment.

7.2.5 If the range is OK and the middle load values are high, loosen the two screws in the connecting link (Item 6) and shorten this link. This is a trial and error procedure. Steps of about 1.6 mm (1/16 in.) are a good value to start with. When the middle load values are low, loosen the two screws in the connecting link (Item 6), and lengthen the link. Tighten the screws after each adjustment. Zero the pen and run a calibration chart. After adjusting the linearity, the range will probably need further adjustment. It usually takes several successive trial and error runs to find the correct set of adjustments.

**Note 3**—Some recorders will calibrate correctly at no load, the mid points, and at full scale, but are off by nearly equal amounts in different directions at the quarter scale loads. If the errors are within the two percent limit, the tester is OK; if this unable to correct, the pressure element (Bourdon tube) may need replacing.

7.2.6 After calibration, replace the cover plates.

**Note 4**—Do not oil the recorder mechanism. This will cause it to collect dirt and start sticking.

7.3 **Gotham Recorder Calibration:**

7.3.1 The link assembly, shown in Figure 6, Item 6, comes installed in the correct holes (Those not used are generally filled with black sealing wax to prevent incorrect installation). The pen arm pivots also come installed in the proper position holes in the post assembly (Item 7).

7.3.2 Changing the length of the lever arm identified in Figure 6, Item 30 changes the range of this recorder.

7.3.2.1 This lever arm is attached to the Bourdon tube and drives the pen through a vertical slip link (Item 6). Hold the lever arm's clamping assembly and loosen the two screws (Item 26) that hold the plate to the center of the Bourdon tube.

7.3.2.2 Turning the knurled vernier screw (Item 28) clockwise will increase the lever arm length, increasing the pen travel and range. Shortening it decreases the pen travel, thus lowering the range.

7.3.2.3 The backlash in this screw assembly makes adjustment troublesome. It may help to keep track of the change in lever arm length by putting marks on the center clamping washer
of the lever arm. Rotate the lever (Item 30) and clamp it to set the pen point within 3 mm (1/8 in.) of the zero circle. Then zero the pen using the vernier screw (Item 29).

7.3.3 When the range is correct at no and full scale loads, examine the errors in the middle load values.

7.3.3.1 If the middle values are high, loosen the two screws (Item 27) on the Bourdon tube mounting plate.

7.3.3.2 Rotate the entire Bourdon tube until the pen point rests on the first calibration point above the zero line of the chart.

7.3.3.3 Clamp the assembly down to lower the center readings by approximately 1/2 division.

7.3.3.4 Now loosen the rotary adjustment screws (Item 26) at the center of the pressure element (the range clamp) and rotate the lever arm (Item 30) until the pen rests within 3 mm (1/8 in.) of the zero circle.

7.3.3.5 Tighten the screws.

7.3.3.6 Zero the pen with the vernier screw near the top to the pen arm (Item 29) and run a calibration test. The recorder will very likely read high and the range will need reducing.

7.3.3.7 Alternate the adjustment of range and linearity until making a good calibration run.

7.3.4 The pen arm (Item 9) should be perfectly straight with the pen mounting bracket assembly (Item 8). The nut of the vernier screw (Item 29) should be centered.

7.3.4.1 Sometimes this is not possible and the pen arm cannot be straight with the mounting bracket in order to obtain good linearity.

7.3.4.2 Some recorders will calibrate accurately at no load, mid scale, and full scale but are off by almost equal amounts in different directions at the quarter load points (e.g. Low by a division at one and high by a division at the other). If this cannot be corrected, nothing can be done except to replace the pressure element.

7.3.5 Replace all cover plates before returning to service.