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METHOD FOR TESTING DEFLECTION AND BENDING STRENGTH OF FIBER-REINFORCED PLASTIC POLES

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read **"SAFETY AND HEALTH"** in Section F of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This method describes the test procedure to be used for determining deflection under a specified bending load and ultimate bending strength of fiber-reinforced lighting poles.

B. DESCRIPTION OF TERMS

Fiber-reinforced plastic (FRP) lighting pole - a round hollow tapered pole designed to serve as the vertical support for aluminum mast arms or top mounted luminaires. The shaft is composed of a matrix of thermal-setting resin reinforced with continuous spirally-wrapped fiberglass filaments.

Anchor base pole - a FRP pole which has a metal flanged anchor base bonded to the pole base and is mechanically fastened to a concrete foundation via anchor bolts.

Direct burial pole - a FRP pole whose extra length allows it to be directly buried in augured holes in the ground.

Pole deflection test load - the amount of force applied at the tip of a cantilevered pole at which the measured tip deflection at the pole cannot exceed 13% of the height of the pole projecting above the ground.

Bending strength test load - the minimum amount of force applied at the tip of a cantilevered pole perpendicular to the pole axis, which the pole must withstand before it, fails.

C. TESTING APPARATUS

The following testing apparatus is required to evaluate FRP lighting poles for compliance with maximum pole deflection and minimum ultimate bending strength requirements:

1. An FRP test fixture, equivalent to that shown in Figure 1 and designed to withstand deflection/bending tests of both anchor base and direct burial style FRP poles.

2. Two linear variable differential transformers (LVDTs) having a minimum 50 mm stroke capable of measuring linear movement to within an accuracy of ±0.03 mm.

3. One draw wire position transducer (DWT) designed to measure movement of the pole tip up to 4800 mm (pre-calibrated),

4. A load cell or similar device (11 kN capacity) capable of monitoring the vertical tension load applied to pole tip to within ±1% of the actual load applied.

5. A data acquisition system which can be programmed prior to testing to receive and store voltage signals/measurements from the LVDTs, DWT, and load cell at 1/4-second intervals.

6. A personal computer with appropriate software.

7. An X-Y recorder/plotter which can be wired to the load cell and DWT to provide a graph and visual output of load versus time.

8. A DWT calibration potentiometer.

9. A power supply for the LVDTs.

10. A power supply for the DWT.

11. A forklift with adequate capacity.

12. A sling/choker and two lengths of chain with suitable connecting links.

13. Two adjustable LVDT supports.

14. A fixed support on which the DWT can be mounted.

15. A car scissor jack.

16. A level (or transit) and tripod.

17. A strain indicator to convert the voltage output from the load cell to a tensile force.

18. A distribution splitter for LVDTs.

19. A video camera.

D. TEST PROCEDURE

1. Mounting and leveling procedure for poles:
   a. Anchor base poles.

      (1) Using a forklift, position the anchor base pole in a cantilevered horizontal position with the electrical access handhole located in the desired quadrant (face down to put handhole region in tension or up to put handhole region in compression).

      (2) Align the four radial slots of the pole's flanged anchor base with the four anchor bolt holes in the test fixture. Insert the four anchor bolts, mounting washers, and nuts and torque to appropriate level.

      (3) Place jack to provide support near the top of the pole and adjust to lift the pole tip in a horizontal position. Remove the forklift.

   b. Direct burial poles.

      (1) Using a forklift, place the direct burial pole in a cantilevered horizontal position with its electrical access handhole located in the desired quadrant (facing down to load handhole region in tension or up to load handhole region in compression).

      (2) Secure the lower tube section of direct burial poles between two rubber-lined wooden support saddle blocks positioned to resist the bending moment, with one block attach section of the two-part steel test fixture. Cinch down wed straps with the two winch binders to firmly hold the base of the pole tube.

      (3) Position a jack near the top of the pole to support the pole tip in a horizontal position. Remove the forklift.

   c. After mounting the pole to the test fixture, establish a longitudinal centerline along the outside surfaces of the horizontal pole. Using a level to check elevation, adjust the pole tip up or down with the jack until the pole is straight and horizontal.

2. Setup of data acquisition system (Figures 2, 3 and 4):

   a. Position the data logger and power supplies near the forklift on a wheeled table cart.

   b. LVDT placement on anchor base poles.
      (1) Utilizing an adjustable LVDT stand, position LVDT #1 so it is centered on the backside of the test fixture's main support column, 740 mm above the top of the test fixtures base plate. Then position LVDT #2 250 mm directly below LVDT #1. Wire both LVDTs to a distribution splitter and the distribution splitter to the data logger.

   c. LVDT placement on direct burial poles:

      (1) Use an adjustable LVDT stand to position LVDT #1 on the underside of the pole lower tube section 25 mm below the joint at the ground line. A second LVDT adjustable stand is used to center LVDT #2 on the top of the pole above the rear pole butt support fixture. Wire both LVDTs to the distribution splitter and then the distribution splitter to the data logger.

   d. Position a large concrete block near the top of the pole as an anchorage for the DWT. Fasten the DWT to the block so that its draw wire is aligned with the centerline of the tip of the pole. Pull the spring-loaded draw wire from its casing approximately 50 mm and attach it to the pole tip. Wire the DWT through a calibration potentiometer to the data logger.

   e. Position the forklift over and in line with, the load application point at the top of the pole tip. Center a sling/choker of sufficient strength to load the pole at the load application point 300 mm from the tip of the pole and cinch it down. Connect the free triangular end of the choker strap to the load cell by a chain, which is attached to the forklift tines. Raise the forklift tines to remove slack from the loading line and position so that the loading line is perpendicular to the axis of the lighting pole. The loading line must be maintained to within ±5° of vertical while applying loads. Correctly position the loading line, and then wire the load cell through the P3500 strain indicator to the X-Y recorder/plotter and the data logger.

   f. Prepare the X-Y recorder/plotter with the desired load/time graph line of 445 N per minute so that it can be followed while testing to maintain a steady even load.

   g. Focus the video camera on the handhole and pole base area.

3. Testing

   a. Connect the power source to the data acquisition system and turn on its components.

   b. Adjust the LVDTs, DWT and bad cell output readings according to the requirements of the data acquisition program.

   c. Start the video camera.

   d. Start the data acquisition system.

   e. Start the HP X-Y plotter.

   f. Following the desired load/time graph time, apply the vertical load to the pole tip by raising the forklift tines.

      (1) As the vertical load is applied, maintain a vertical/perpendicular pull (±5°) on the tip of the pole by adjusting the position of the forklift.

(2) Monitor load cell readings using the strain indicator and make spliced notes at 223 N increments, at the specified deflection value, and at the minimum bending strength of the pole.
(3) Continue to increase the load at a uniform rate until the pole fails.

g. Photograph failure mode.

h. Record test observations on the X-Y plotter/recorder graph sheet.

E. REPORTING OF TEST RESULTS

Results of all deflection and bending strength tests performed must be reported. The report of deflection and bending strength test results shall include the following minimum information.

1. Test sponsor and test agency.

2. Dates of testing and report preparation.

3. Identification of the pole type including Caltrans pole type, manufacturer, manufacturer's model number, pole length, and pole diameters at the tip and ground line.

4. Size of handhole and position daring bend test, i.e., in tension, compression, or neutral axis.

5. Pole dimensions including pole diameters at tip, mid-height, and ground line, and wall thickness at tip, mid-height, and ground line.

6. Pole weight.

7. The Caltrans deflection and bending strength specifications and test loads.

8. Amount of tip deflection at the specified deflection test load.

9. Bending test results at the specified test load.

10. Mode of failure.

11. Photographs of failure.

12. Discussion of test results.

13. Copy of X-Y recorder graph.

14. Copy of computer-generated graph from data acquisition system.

15. The test number and the number of poles tested under the same parameters.

16. A listing of observers of the tests and a signature and title of the person responsible for testing.

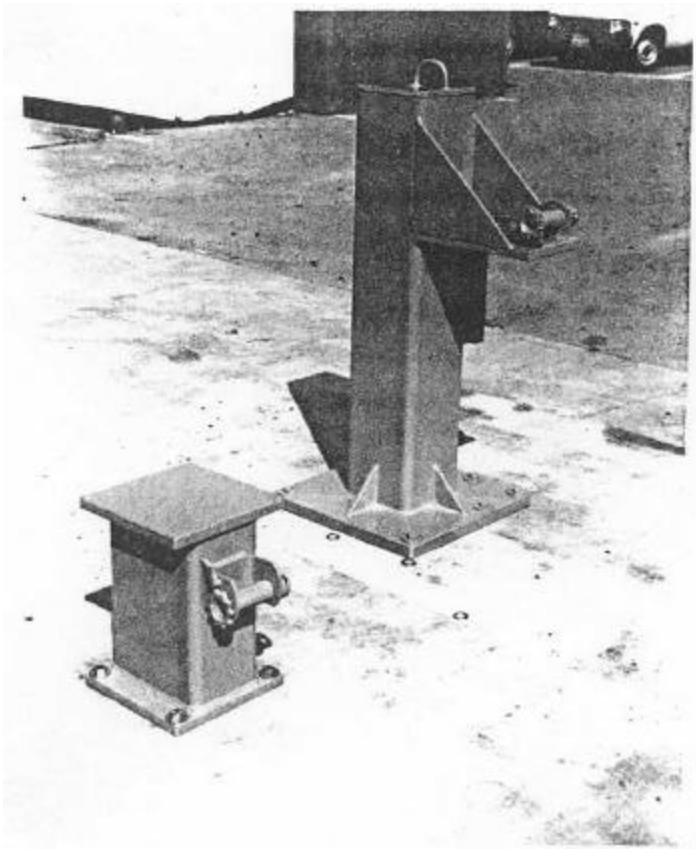
F. SAFETY AND HEALTH

This method may involve the use of hazardous chemicals. Prior to handling or testing of materials, Caltrans personnel are required to obtain, read and follow information in the materials data sheets for any hazardous materials being tested. In addition they are required to read and follow information in pertinent sections of Parts A, B, and C of the Caltrans Laboratory Safety Manual. Requirements for general safety principles, standard operating procedures, protective equipment or apparel and how to handle accidents, spills and emergencies are discussed in the above-noted reference.

Personnel are required to wear appropriate hand and eye protection when handling fiber-reinforced materials or any other potentially hazardous materials.

This method does not purport to address all the safety problems associated with its use. It is the responsibility of whoever uses this method to read, consult, understand, and follow appropriate material safety data sheets and safety manuals, and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Users of this method do so at their own risk.

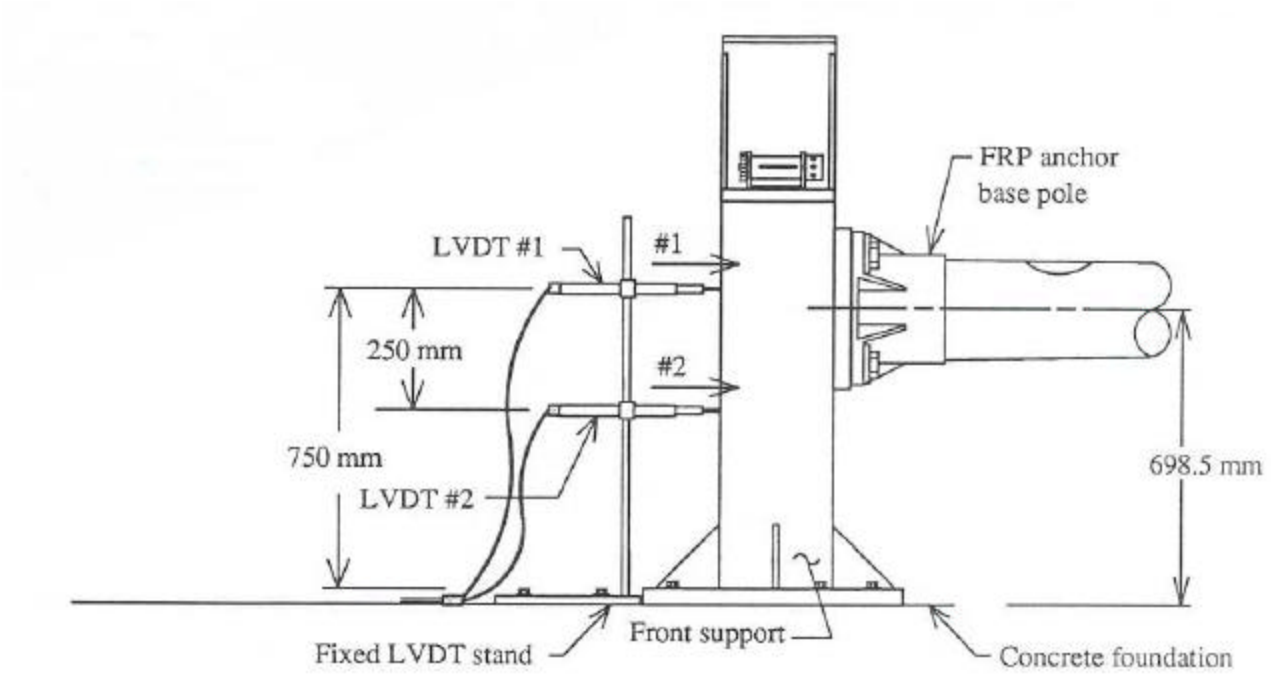
REFERENCES:
California Standard Specifications
End of Text (Test 683 contains 8 pages)



Front support: used for 1) supporting anchor base poles and 2) used with wooden saddle to support direct burial poles at ground line.

Rear support: used with wooden saddle to support lower end of direct burial poles.

FIGURE 1. CALTRANS FIXTURES FOR SUPPORTING FRP POLES TO BE LOADED IN BENDING



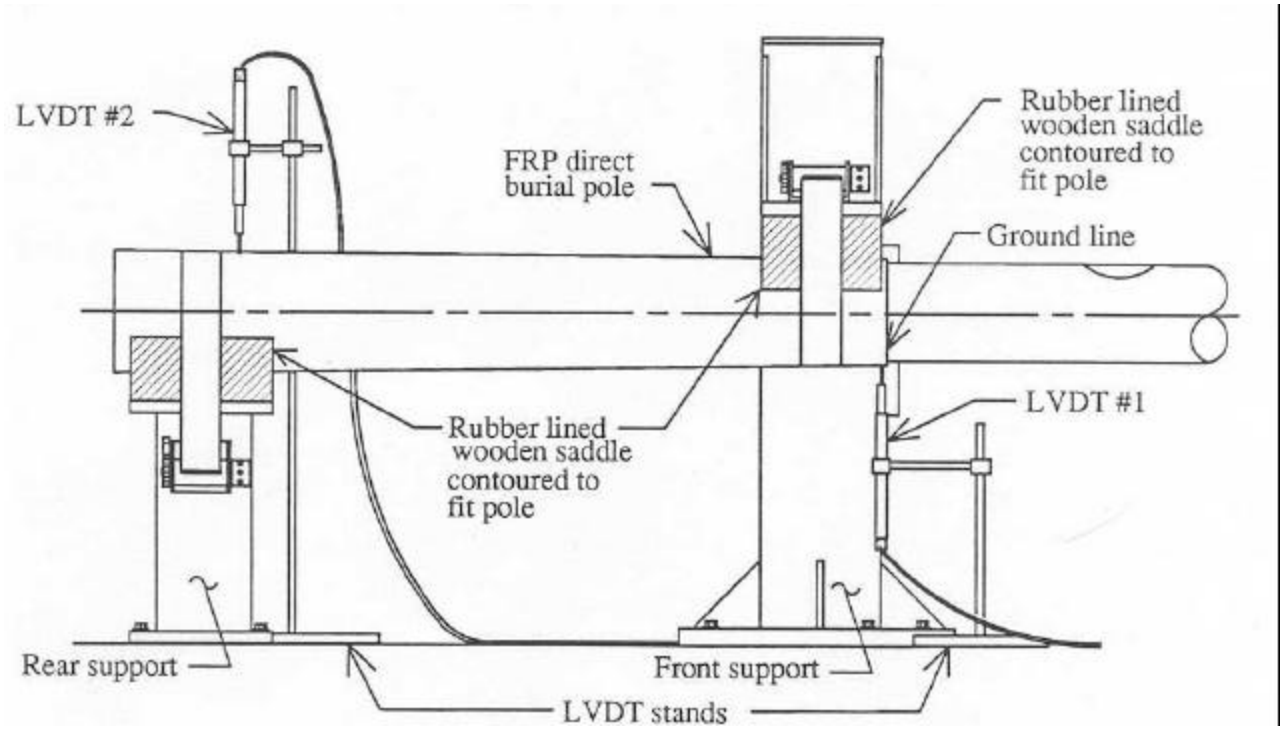


FIGURE 2. PLACEMENT OF LINEAR VARIABLE DIFFERENTIAL TRANSFORMERS (LVDTs)

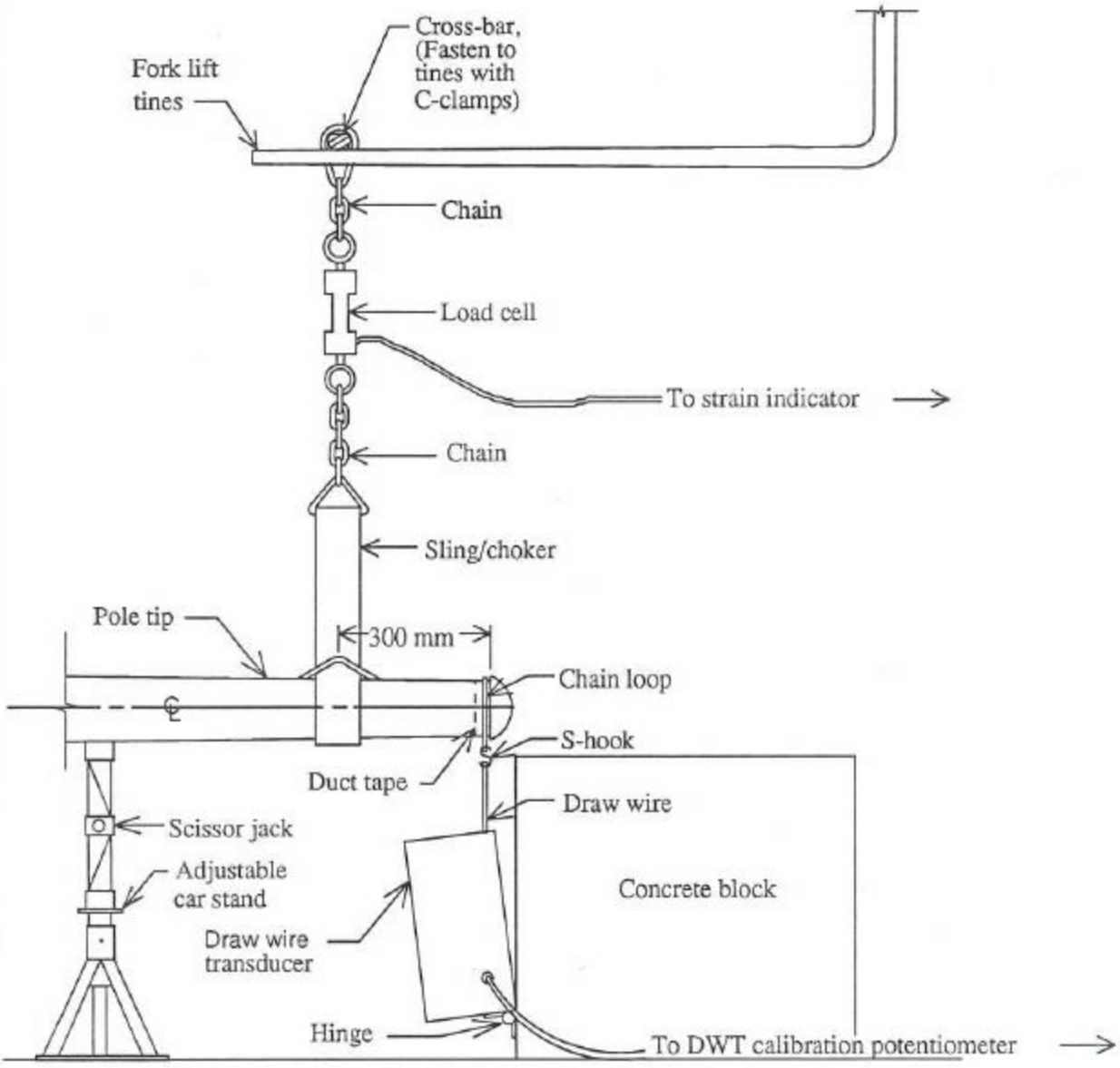


FIGURE 3. APPARATUS USED TO LOAD AND MONITOR DEFLECTION OF THE POLE TIP

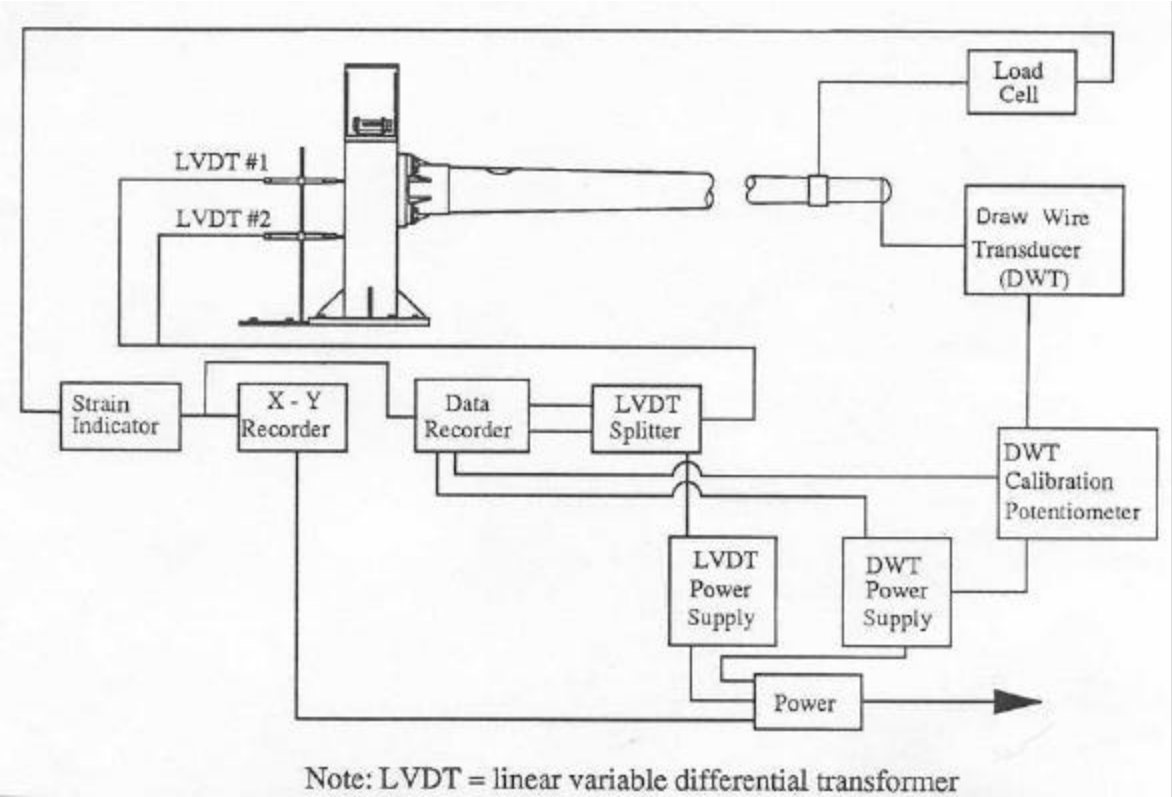


FIGURE 4. SCHEMATIC OF DATA ACQUISITION EQUIPMENT