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METHOD FOR DETERMINING ULTIMATE TENSILE STRENGTH OF CONCRETE ANCHORAGE DEVICES

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read **"SAFETY AND HEALTH"** in Section H 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. OVERVIEW

This method describes the test procedure to be followed in determining the tensile strength of various concrete anchorage devices, including cast-in-place concrete inserts, undercut anchors, and threaded bars and rebar dowels post-bonded with cartridge epoxy, portland cement grout, magnesium phosphate concrete, or other approved bonding materials.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever chooses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Those using this standard do so at their own risk.

B. TEST APPARATUS

1. A testing apparatus, similar to that shown in Figure 1, capable of applying a tension load to an anchorage system is required to perform this test. The base of the testing apparatus should contact the concrete surface outside the expected concrete failure zone, so that is does not affect test results. A base-bearing ring with a radius of $\sqrt{3}$ times the embedment depth, ED, from the center of the insert should be sufficient for this purpose. The testing apparatus shall be of sufficient size to prevent failure of any of its various components and proper design to ensure that the tension loads applied to the anchorage system remain parallel to the axes. The width of the base bearing ring shall be of sufficient size to prevent bearing failure of the surrounding concrete.

2. Two shackles, a chain, or a multi-directional swivel assembly connecting the anchorage to the pull rod to eliminate the transfer of bending moment to the anchorage system are required. The pull rod and the various parts of the connector shall be of sufficient size to develop the ultimate strength of the anchorage.

3. A hydraulic ram and pump, or suitable device capable of supplying a constant load rate and with an ultimate capacity exceeding the expected ultimate load of the anchorage system is required.

4. A load cell or load-monitoring device capable of measuring the ultimate tensile force applied to the pull rod to within ± 1 % of the applied load.

5. Two dial indicators, linear variable differential transformers (LVDTs), or

other suitable displacement gages capable of measuring linear displacement to within an accuracy of ± 0.025 mm are required.

6. An XYY recorder, a data logger or another suitable type of data acquisition system capable of plotting or recording load and displacement versus time at a rate greater than ten samplings per second is required.

C. PREPARATION OF TEST SPECIMENS

1. Installation of cast-in-place inserts:

   a. Position and secure the inserts to the bottom form of the concrete test slab form using plastic setting plugs [setting plugs recess the insert 6 mm from the concrete surface]. Provide enough edge distance (minimum of √3 ED) and spacing between inserts (minimum of 2 times √3 ED).

      Prior to screwing the insert onto the setting plug, lubricate the internal threads of the insert with grease.

   Concrete for test slabs:

   a. Fabricate an unreinforced concrete test slab having sufficient size to provide adequate edge distance and spacing between anchorages (see Section C-1.a.) to be tested. Minimum slab thickness shall not be less than:

      - 200 mm or overall insert length plus 50 mm for inserts with stud diameters up to and including 19 mm.
      - 300 mm or overall insert length plus 50 mm for inserts with stud diameters greater than 19 mm and up to and including 38 mm.
      - 1.5 ED for post-bonded threaded bars and rebar.

   b. The concrete mixture shall contain 350 kg/m^3 of "Type II Modified" portland cement, and shall conform to requirements in Section 90-2.01 of the Caltrans Standard Specifications. The coarse aggregate used shall be rounded or crushed gravel or crushed rock and the combined aggregate gradings shall conform to the 25-mm maximum grading in Section 90-3.04, "Combined Aggregate Grading". Admixtures shall not be used. The slump shall be between 75 to 125 mm. Concrete shall be cured in accordance with the provisions in Section 90-7.03 "Curing Structures" of the Standard Specifications. At the time of the tension test, the concrete shall have an age of not less than 21 days and a compressive strength of not more than 27.6 MPa. Anchorage systems to be used in early age or lightweight concrete, or concrete having low compressive strength or requiring special ingredients should be evaluated using concrete specimens having similar composition and properties.

3. Installations of bonded threaded bar and rebar dowels:

   Drill holes to the diameter and embedment depth and clean as recommended by the manufacturer. For rebar, weld a threaded stud to the end to provide a means to secure the load collar. Install according to engineer's directions or cure no longer than two days for epoxies and five days for magnesium phosphate concrete and portland cement grout.

D. TEST PROCEDURE

1. Calibrate the load cell. If an insert with female threads is being tested, screw a threaded rod into the insert to a minimum depth of one stud diameter thread engagement. Note: If zinc-coated (hot-dip galvanized or mechanically deposited) studs are required, inserts must be tapped oversize within limits listed in ASTM A563M or A563.

2. Slide the load collar over the anchorage stud and secure to the concrete using a washer and nut. Tighten the nut according to the manufacturer's installation torque requirement. If the manufacturer of the anchorage device has not recommended an installation torque value, the following will be used for installing mild steel anchorages:

Stud Diameter Values	***Installation Torque***
Range, mm	***N · m***
29.01-33.00	650
25.01-29.00	400
21.01-25.00	290
19.01-21.00	180
15.01-19.00	90
12.01-15.00	40
9.01-12.00	20
6.00- 9.00	7

If anchorages other than mild steel or sizes not listed above are specified, installation torque may be calculated from the formula: $T = 0.2d \cdot A_b \cdot f_y \cdot 0.65$

Where-

T = installation torque in $N \cdot m$

d = nominal diameter of the anchorage stud or bolt in m

A_b = cross sectional area of the nominal bolt size in m^2

f_y = yield strength of the stud or bolt steel in N/m^2

3. Bond two small flat metal bearing plates to the surface of the concrete at an appropriate distance from the anchorage device so as to provide smooth surfaces for the contacts of the dial indicators or LVDTs.

4. Assemble the tension apparatus and center directly over the anchorage device.

5. Install two displacement indicators (LVDTs or dial indicators), one on each end of a rigid arm securely fastened to the load collar of the testing apparatus, and position indicators so as to measure displacements normal to the concrete surface. Tips of the indicators shall rest on bearing plates previously bonded to the concrete surface. Mount these indicators so that their shafts are equidistant from the concrete anchorage device and are outside the zone of concrete cone failure.

6. Remove slack from the test assembly by applying a tension load of about 5 % of the estimated ultimate load of the anchor system.

7. Record each indicator reading and average the two readings to obtain the initial mean indicator measurement.

8. Apply the tension load at a rate of about 445 to 1330 N/s until the anchorage system fails. The load rate should be determined based on the stud size of the anchor system such that it takes over 60 seconds to reach the ultimate load.

9. Record load and displacement versus time throughout the test.

E. SAMPLING

1. Test at least three anchor devices per stud diameter. A satisfactory performance is obtained when all tests pass.

F. RETESTING

1. Retesting is permitted only if no more than one anchorage device of the group tested failed. When retesting is performed, six samples of the same type of anchorage device shall be tested under the same conditions. A satisfactory performance is obtained when all six anchorage devices pass. Should any of the tests fail, no further retesting is allowed, unless manufacturer alters the design of the anchorage device.

2. Any future change in anchorage design or materials will void approval and require retesting.

G. REPORTING OF RESULTS

Results of all tests performed shall be reported.

The report of test results shall include the following minimum information:

- test sponsor and test agency
- dates of testing and report preparation
- a list of observers who witnessed the qualification test with the signature and title of the person responsible for testing
- identification of the anchorage system including manufacturer, type and model number, dimensions, type of steel, type and thickness of corrosion-protective coating, and other pertinent information
- the number of test specimens tested
- the concrete mix design, type and gradation of aggregates used in the concrete, and unit weight and slump of the fresh concrete
- the compressive strength of the concrete and age of the test slab on the date of anchorage installation and testing
- a physical description of the test slab including dimensions, locations of anchorage devices, and method of curing
- photographs of test specimens
- illustration/photographs of testing equipment
- a thorough description of procedures used to drill and clean holes
- the outside diameter of the tip of the drill bit used, to the nearest 0.025 mm.
- depths of the drilled holes
- description of the procedure followed to install the anchorage device, including installation tools, materials used to install the anchorage system, and installation torque used
- the actual depths of embedment of each anchorage system
- the length of time from initial installation of the anchorage system to application of the tensile load
- a record of the curing temperature
- a plot of load and displacement versus time for each test specimen
- the ultimate load for each individual test specimen, and the mean displacement at that load

H. SAFETY AND HEALTH

This method may involve the use of hazardous chemicals, including polyester and vinylester resins, catalysts, and epoxies. Prior to sampling, handling, or testing materials, Caltrans personnel are required to obtain, read and follow information in the material safety 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 epoxies, or any other potentially hazardous bonding 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, 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

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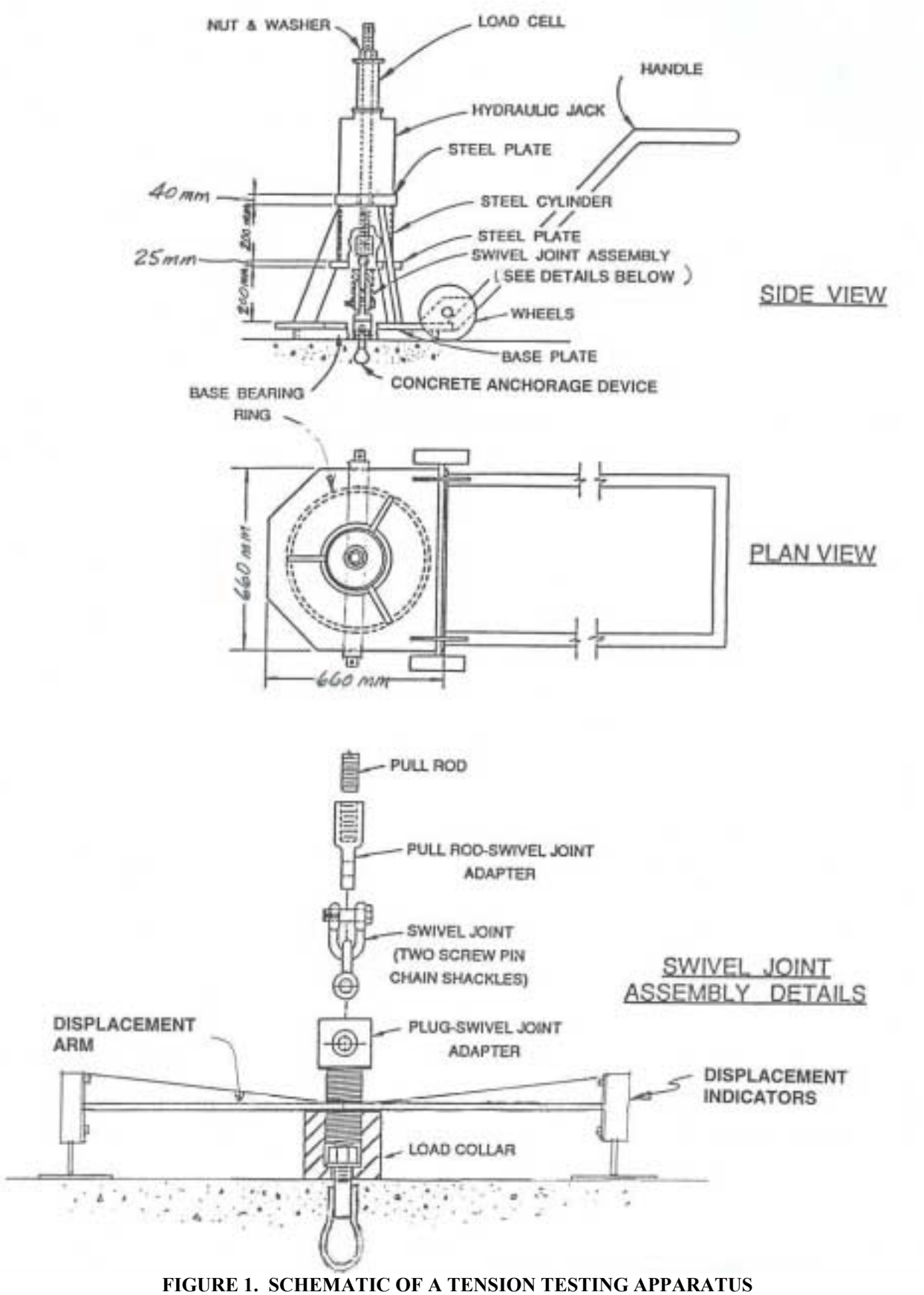

FIGURE 1. SCHEMATIC OF A TENSION TESTING APPARATUS