STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY

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METHOD FOR TESTING CREEP PERFORMANCE OF CONCRETE ANCHORAGE SYSTEMS

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read **"SAFETY AND HEALTH"** in Section I 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 the creep performance of various concrete anchorage systems, including rebar dowels or threaded bars bonded with cartridge epoxy or resin capsules and mechanical expansion anchors.

B. DESCRIPTION OF TERMS

Creep - all movement associated with the installed concrete anchorage system that occurs while loading and during the sustained loading periods, including short-term slip and creep. Elastic deformations are considered small and are also included in overall creep measurements.

Mean Creep Value - total movement of the anchorage device calculated by subtracting the initial mean indicator value from the mean indicator value at the end of the creep test.

C. APPARATUS

1. A testing apparatus equivalent to that shown in Figure 1 shall be designed so that the anchorage system is loaded through a base plate beneath the nut on the threaded shaft of the protruding stud. The clear distance between the supports of the testing apparatus in contact with the concrete test slab and the protruding stud shall be 3-1/2 times the embedment depth for depths less than or equal to 165 mm, and 2 times the embedment depth for depths greater than 165 mm. The load collar with base plate attached and arms on which indicators are mounted shall be designed and built sufficiently rigid to minimize elastic deflections.

2. A pin or swivel connector near the base of the pull bar linkage shall be required to eliminate the transfer of bending moments to the anchorage system.

3. A load cell or load monitoring device is required to measure the external tensile force applied to the pull bar of the testing apparatus. This device shall be accurate to within ± 1% of the actual applied load.

4. Two dial indicators, linear variable differential transformers (LVDTs), or other suitable displacement gages per testing apparatus, shall measure the linear displacement to within ± 0.025 mm.

5. A large heat chamber shall be capable of maintaining the required testing temperature of concrete creep specimens to within ± 2°C of the specified value.

6. A suitable torque wrench is required.

7. A hammer and setting tool shall be utilized to install the mechanical expansion anchors, if required.

D. PREPARATION OF TEST SPECIMENS

1. Concrete Test Specimen

   a. Fabricate an unreinforced concrete test specimen having sufficient size to provide adequate edge distance and spacing between anchors, as described in Section D-2a, and to accommodate anchorage systems being tested. Minimum slab depth shall be the minimum required hole depth plus 4 hole diameters. See Section D-2b(3).

   b. Concrete used for the test slab shall contain 350 kg/m^3 of "Type II Modified" portland cement, and conform to requirements in Section 90-2.01 of the Caltrans Standard Specifications. The aggregate used shall be rounded or crushed gravel or crushed rock and conform to the 25-mm maximum grading in Section 90-3.04, "Combined Aggregate Gradings." Admixtures shall not be used. The maximum slump of the concrete shall be 100 mm. Concrete shall be cured by either the water method or the curing compound method in accordance with the provisions in Section 90-7.03, "Curing Structures." At the beginning of each sustained direct 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 compressive strength requiring special ingredients shall be evaluated using concrete having a similar composition.

2. Installation of Anchorage Systems

   a. Locate the hole positions on the concrete test slab so as to provide a minimum edge distance of 6 hole diameters and a minimum spacing between holes (center to center) of 12 hole diameters.

   b. Drill holes to conform to the following requirements:

      (1) Use the appropriate type of drilling apparatus and size of drill sites for preparing holes, as recommended by the anchor manufacturer or by Caltrans specifications. Dimensions of carbide tips of drill bits shall conform to ANSI Specification B94.12.

      (2) Drill holes so that their axes are normal to the plane of the concrete surface.

      (3) The required hole depth shall be as follows:

      - for mechanical expansion anchors;

        internally threaded shell drop-in type anchor, the required hole depth is 12.7 mm plus the anchor body length.

        integral stud-type anchor, the required hole depth is the minimum depth recommended by the manufacturer.

      - for resin capsule anchors, or threaded rods or rebar bonded with epoxy; the minimum hole depth shall conform to recommendations by the manufacturer.

   c. After drilling the hole, remove dust and residue in the hole by blowing out with oil-free compressed air, using an OSHA-approved nozzle. Use of a brush or other instrument to loosen dust particles or water to wash out residual dust in hole, unless specifically

required by the manufacturer, is not permitted.

d. Install the anchorage system using directions provided by the Engineer or the manufacturer's recommended instructions. For shell drop-in type mechanical expansion anchors, the top of the anchor body shall be installed 12.7 mm below the concrete surface. For resin capsule anchors, curing time shall not exceed 8 h or the minimum curing time as required by the Engineer. For epoxy-bonded rebar and threaded rods, curing time shall not exceed 24 h or the minimum curing time required by the Engineer, whichever is less. No artificial curing conditions (i.e., high heat) shall be permitted.

e. 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.

f. Position the load collar with displacement indicators over the protruding stud. Install a washer and nut onto the stud and apply an appropriate installation torque to the nut using calibrated torque wrench. If the manufacturer of the anchor device or the Engineer has not specified an installation torque value, the following will be used:

Installation Torque Values, N·m

Stud Diameter (in mm)	*Shell-Type Mechanical Expansion Anchors*	*Integral Stud-Type Mechanical Expansion Anchors*	*Resin Capsule Anchors Bonded Dowels*
29.01 to 33.00	--	--	745
25.01 to 29.00	--	--	405
21.01 to 25.00	--	--	270
19.01 to 21.00	110	235	175
15.01 to 19.00	45	120	100
12.01 to 15.00	30	65	45
9.01 to 2.00	15	34	20
6.00 to 9.00	5	10	7

E. TEST PROCEDURE

1. 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. Position the indicators so as to measure displacements normal to the concrete surface. The 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 not less than 12 hole diameters apart from each other.

2. Immediately after the required installation torque has been applied to set/preload the anchorage system being tested and indicators have been properly oriented, apply a 445-N external tensile load to seat components of the testing apparatus. Record each indicator reading and average the two readings to obtain the initial mean indicator measurement.

3. Adjust the ambient temperature of the concrete test slab. It must be at least 21°C for testing mechanical expansion anchors and 44.5 $\pm$ 1.0°C for testing of resin capsule anchors or epoxy-bonded systems. Read and record the load and displacement.

4. For mechanical expansion anchors, apply the appropriate full sustained tension test load, shown in Section 75-1.03 of Caltrans Standard Specifications, at a uniform rate not to exceed 4.45 kN/min, within 48 h of installation of the anchorage system. For cartridge epoxies and other bonded dowels, apply a sustained tensile test load equal to 0.4 times the manufacturer's published ultimate tensile load after curing of the bonding material (minimum cure time as specified by the manufacturer) has occurred. This load shall be applied to the base plate of the test fixture so as to indirectly load the stud of the anchorage system.

5. Read and record each indicator again immediately after the specified sustained

tension test load has been applied and average the values.

6. Maintain the sustained tension test load to within ± 5% of the required value for the duration of the creep test.

7. Monitor the displacement and sustained load for at least 48 h for mechanical expansion anchors and 120 days for resin capsule anchors and bonded dowels, after applying the full test load. For mechanical expansion anchors, read and record a minimum of 5 additional sets of displacement values at 2-h intervals during the last 10 h of testing. One of the required readings shall be made at 48 h with the specified sustained tension test load applied.

8. For resin capsule anchors and bonded dowels, ample displacement readings shall be taken so that a smooth continuous load-displacement curve can be plotted. The final reading shall be at 120 h at the elevated temperature, and with the load applied. Determine and report the mean value for each test performed by subtracting the mean indicator value of the fully loaded final displacement reading from the initial mean indicator measurement. See Sections E-7 and E-2.

9. At the conclusion of the creep test, unload each anchor until a 445-N tension value remains; record and report a final mean displacement value.

F. SAMPLING

In order to qualify a particular brand and diameter of anchorage device, a minimum of three replicate tests per diameter must be performed. A satisfactory performance is obtained when all qualification tests performed on a particular anchorage device pass. A satisfactory performance for an anchorage device of a given diameter, design and particular embedment depth tested will constitute acceptance of additional anchor lengths having greater embedment depth.

G. RETESTING

1. When a system fails to pass initial qualification testing, only one retest shall be allowed. Duplicate samples are required for testing (6 replicate tests). If any failure occurs during retesting, the device is rejected and no further testing will be permitted, unless the manufacturer significantly alters the design of the anchorage device.

2. Any future changes in the anchor design or materials from what was originally tested will void approval. Retesting will then be required.

H. REPORTING OF RESULTS

Results of all creep tests shall be reported. The report of creep tests shall include:

- the name of the testing sponsor and testing agency
- dates of testing and report preparation
- a listing of the observers of the qualification tests with the signature and title of the person responsible for testing
- identification of the anchorage system including the manufacturer, type and model number, the type of steel used in anchor parts, the thickness and type of corrosion protective coating, dimensions, and other pertinent information
- the number of specimens tested
- the concrete mix design, type of aggregates used in the concrete, and slump of the fresh concrete
- the compressive strength of the concrete and age, in days, of the test slab and the date when creep tests were started
- a physical description of the test slab including dimensions and method of curing used
- photographs of the test specimen

- a drawing and photographs of the testing apparatus.
- a description of the procedure, installation tools, and materials used to install the anchorage system, including the installation torque
- the diameter of the carbide tip on the drill bit used, to the nearest 0.025 mm
- the depth of the drilled hole
- the depth of embedment of the anchorage system
- the length of time, in hours, from the installation of the anchorage system to the application of the sustained tension test load
- a continuous record of the temperature of the concrete slab during the creep test
- a description of the procedure used to apply and maintain the sustained tensile test load and actual rate of loading used
- a plot of mean indicator displacement values and corresponding tension loads as required per Sections E-2, E-3, E-5, E-7 and E-9 with their respective elapsed test times
- the mean creep value per Section E-8 for the anchorage system tested (one required for each test conducted)

I. 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, testers are required to obtain, read and follow information in the material safety data sheets for all hazardous materials. 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 resin capsules, 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, 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 (California Test 681 contains 6 pages)

FIGURE 1. EXAMPLE OF A SUITABLE CREEP TESTING APPARATUS