

FILE NO. 2-1925B.3.5

DATE: August 26, 2002

CODE APPLICATION NOTICE

CODE SECTION: Section 1925B.3.5, 1998 California Building Code

1925B.3.5 Drilled-in expansion bolts or epoxy-type anchors in concrete. When drilled-in expansion-type anchors are used in lieu of cast-in place bolts, the allowable shear and tension values and test loads shall be acceptable to the enforcement agency.

When expansion-type anchors are listed for sill plate bolting applications, 10 percent of the anchors shall be tension tested.

When expansion-type anchors are used for other structural applications, all such expansion anchors shall be tension tested. Expansion-type anchors shall not be used as hold-down bolts.

When expansion-type anchors are used for nonstructural applications such as equipment anchorage, 50 percent or alternate bolts in a group shall be tension tested.

The tension testing of the expansion anchors shall be done in the presence of the project inspector and a report of the test results shall be submitted to the enforcement agency. If any anchors fail the tension-testing requirements, the additional testing requirements shall be acceptable to the enforcement agency. The above requirements shall also apply to bolts or anchors set in concrete with epoxy if the long-term durability and stability of the epoxy material and its resistance to loss of strength and chemical change at elevated temperatures are established to the satisfaction of the enforcement agency.

INTERPRETATION:**1. Design Loads**

Design loads for expansion-type anchors and epoxy-type anchors should consider the tested capacity of the anchors, the properties of the concrete or masonry in which the anchor is placed, anchor edge distance and spacing, presence of metal deck, and the potential effects of cracking in the concrete or masonry. The long-term durability, stability, and temperature sensitivity of epoxy-type anchors must also be considered.

The mix design and mechanical properties of the materials in which the anchor was tested should be representative of the composition and mechanical properties of the materials in which the anchor will be installed. The relevant mechanical properties include unit weight, compressive strength, and aggregate type.

Exception: The design values for anchors tested in lightweight concrete may be used for anchors installed in normal-weight concrete, provided the compressive strength of the normal weight concrete equals or exceeds the compressive strength of the lightweight concrete in which the anchor was tested.

The compressive strength of the material in which the anchor will be installed should meet or exceed the compressive strength of the material in which the anchor was tested. Where the anchor is qualified for use in lightweight concrete, the lightweight aggregate type used in the concrete in which the anchor will be installed should be the same as the material in which the anchor was tested.

A. **Expansion-type anchors.** Expansion-type anchors may be used, provided the allowable shear and tension values are determined by test, using one of the following methods:

1. The allowable loads may be based on the ultimate shear and tension load data from qualification tests performed in accordance with the *Acceptance Criteria for Expansion Anchors in Concrete and Masonry Elements, AC01*, latest revision, as published by ICBO ES, including the seismic qualification tests of *AC01* Section 5.6. The following safety factors apply for allowable stress design:
 - a. To determine allowable loads, the mean ultimate value should be divided by a factor of safety of four (4) for tension and shear.
 - b. For anchors installed in the underside of a beam/slab, the allowable tension value should be based on the mean ultimate tension value divided by a factor of safety of eight (8).

Exception: Anchors installed in conformance with requirements of Section 2.B.

2. The allowable values listed in an ICBO ES Evaluation Report may be used for allowable stress design, provided the report states that the anchors were tested in accordance with *AC01*, latest revision, including the seismic qualification tests of *AC01* Section 5.6. Strength design values may be used provided the anchors have been tested in accordance with *AC193*, latest revision, including the seismic qualification tests of *ACI 355.2* Sections 9.6 and 9.7.
 - a. Allowable design values for anchors installed with special inspection may be used.
 - b. For anchors installed in the underside of a beam/slab, the allowable tension load should be based on the tabulated value for anchors installed without special inspection, unless allowable values for anchors installed in cracked concrete are provided in the ICBO ES Evaluation Report or the anchors have been tested in accordance with *ACI 355.2*, latest revision, Table 5.2.
3. If anchors have not been tested in accordance with the requirements for seismic qualification tests of Section 5.6 of the latest revision of *AC01*, the allowable

values listed in an ICBO ES Evaluation Report may be used, with the following modifications.

- a. Allowable shear and tension design loads shall be limited to 80% of the tabulated allowable values for anchors installed with special inspection.
- b. For anchors installed in the underside of a beam/slab, the allowable tension load should be based on 80% of the tabulated allowable value for anchors installed without special inspection.

Exception: Anchors installed in conformance with requirements of Section 2.B.

- B. Epoxy-type anchors.** Epoxy-type anchors include anchors that rely on organic and inorganic compounds (including epoxies, polyurethanes, methacrylates and vinyl esters) to develop bond in the concrete.

The use of epoxy-type anchors in overhead applications is not allowed.

Epoxy-type anchors should only be installed in conditioned, interior spaces.

Exception: Where epoxy-type anchors are used as shear dowels at the perimeter of an existing opening (slab or wall) to be filled with concrete, or are being used to connect new concrete elements to existing concrete elements, they may be installed in exterior locations with prior approval of the Office.

If epoxy-type anchors are exposed to fire, all epoxy-type anchors in the affected area should be inspected and evaluated by a qualified person to ensure their load carrying capability has not been compromised.

The allowable shear and tension values for epoxy-type anchors must be determined by test, using one of the following methods:

1. The allowable loads may be based on the ultimate shear and tension load data from qualification tests in accordance with the *Acceptance Criteria for Adhesive Anchors in Concrete and Masonry Elements, AC58*, latest revision, published by ICBO ES. All tests shall include the Seismic Qualification procedures of Section 5.3.7 of *AC 58*. The following safety factors apply for allowable stress design:
 - a. To determine allowable loads, the mean ultimate values should be divided by a factor of safety 5.33 to determine allowable tensile and shear loads.
 - b. If creep tests are performed in accordance with Section 5.3.3 of *AC58*, the mean ultimate values should be divided by a factor of four (4) to determine allowable tensile and shear loads.

2. The allowable loads may be based on the allowable load values listed in an ICBO ES Evaluation Report that complies with the requirements of AC58 for a specific anchor in the same configuration as tested. Supporting data shall include the Seismic Qualification test performed in accordance with the procedures of Section 5.3.7 of AC58.
3. Where epoxy-type anchors are used for structural applications, such as dowels between new and existing concrete, the anchor shall be installed in a manner such that the ultimate tensile capacity of the steel element can be reliably developed, i.e., the anchor capacity is controlled by the ultimate strength of the steel element.

Exception: Epoxy-type anchors which cannot develop the tensile capacity of the steel element may be used to transfer shear forces only, provided that the loads on the anchor are amplified by a factor of 4.0. Alternatively, shear resistance may be based on the bolt shear capacities in the 1998 CBC, Table 19B-E.

When epoxy-type anchors are used to resist tensile forces in structural applications, the minimum depth of embedment shall be greater than or equal to the development length l_d determined in Section 1912B.1 for a cast in place reinforcing bar of the same diameter and grade.

2. **Installation Requirements**

All anchors should be installed per the requirements of the ICBO ES Evaluation Report for the specific anchor, or as required by the manufacturer.

For epoxy-type anchors, all drilled holes should be prepared in accordance with manufacturer's recommendations, thoroughly cleaned, and all debris removed by vacuum or oil-free compressed air. Jetting holes with water is not permitted.

Set torque-controlled expansion-type anchors to the manufacturer recommended installation torque, using a calibrated torque wrench. Following attainment of 10% of the specified torque, 100% of the specified torque shall be reached within 7 or fewer complete turns of the nut. If the specified torque is not achieved within the required number of turns, the anchor shall be removed or abandoned.

Set displacement-controlled expansion-type anchors to the manufacturer recommended displacement. If the concrete cracks during installation of the anchor, the anchor shall be removed or abandoned.

Holes drilled for anchors that do not set properly or fail a tension test may not be reused, and shall be filled with non-shrink grout.

- A. **Embedment, Spacing and Edge Distance.** All anchors should meet the minimum embedment, edge distance, spacing, and slab thickness criteria established by the relevant ICBO ES Evaluation Report.
1. Edge distance should be a minimum of ten (10) bolt diameters from the free edge of the slab and center-to-center spacing should be a minimum of twelve (12) bolt diameters, unless data is submitted indicating full anchor tension and shear capacity at a closer distance. If the edge distance is less than ten (10) diameters and the load is directed toward the free edge, the allowable shear load should be reduced per Section 1925B.3.3.
 2. Expansion-type and epoxy-type anchors shall be installed to comply with the minimum slab thickness requirements established by the manufacturers technical guide for the specified anchor provided sufficient test data is provided to support the installation.
 3. If an ICBO ES Evaluation Report is not available for an epoxy-type anchor or expansion-type anchor, test data should be submitted to the Office to determine the appropriate edge, spacing, and minimum thickness dimensions.
- B. **Underside of beam/slab installations.** Except as noted in Section 2.B.1, all expansion-type anchors installed in the underside of a beam/slab should use the reduced allowable design load values determined in Sections 1.A.1.b, 1.A.2.b, and 1.A.3.b.
1. The allowable design loads in Sections 1.A.1.a, 1.A.2.a, and 1.A.3.a may be used for expansion-type anchors installed in the underside of a beam/slab, provided the installation meets one of the following criteria:
 - a. The design engineer provides dimensions that indicate the anchor installation will occur in the negative moment (-M) region of the beam/slab, or
 - b. Data is submitted to indicate that the specific anchor is suitable for use in cracked concrete (e.g., testing per *ACI 355.2* Table 5.2), or
 - c. The anchor is installed in the high flute (rib) of the metal deck in a concrete on metal deck assembly, or
 - d. The anchor is installed with sufficient embedment that the load-transfer zone is above the neutral axis of the beam or slab.
- Exception: If the slab is intended to serve as a diaphragm for transferring earthquake forces to other lateral-load resisting elements, anchors to be installed in that slab must be qualified by test for use in cracked concrete.

2. When installing expansion-type anchors through the low flutes of metal deck into concrete, the anchors should be placed as close to the center of the flute width as practicable. The deck should be 20 ga. thickness minimum per Section 2204B.2 and the flute width should meet or exceed that value set forth in the ICBO ES Evaluation Report for the anchor or as otherwise tested, but not less than 4 inches. The minimum effective depth of embedment shall be as noted in the ICBO ES Evaluation Report for the anchor.

3. **Testing Requirements**

All anchors shall be tested per Section 1925B.3.5.

Exception: Where the design tension on anchors is less than 75 lbs. and those anchors are clearly noted on the contract documents, only 10 percent of those anchors need be tested.

If any anchor fails testing, test all anchors of the same type, installed by the same trade, not previously tested until twenty (20) consecutive anchors pass, then resume the initial test frequency. Refer to Note 8 on the Test Values Table (attached) for failure criteria.

Regardless of which test methods are chosen by the consultant(s), the test values shall be shown on the contract documents.

A. **Expansion-type Anchors.**

An acceptable testing procedure is attached to this CAN. The test load may be applied by any method that will effectively measure the tension in the anchor, such as direct pull with a hydraulic jack, calibrated spring loaded devices, or a calibrated torque wrench. Displacement-controlled anchors such as internal threaded shell-type anchors and self-threading screw-type anchors shall not be tested using a torque wrench.

Required test loads may be determined by either of the following methods:

1. Twice the allowable tension load as determined in Section 1, or;
2. Tension test and torque test values from the table and procedures attached to this CAN.

Anchors tested with a hydraulic jack should exhibit no discernable movement during the tension test, e.g., as evidenced by loosening of the washer under the nut.

Anchors tested with a calibrated torque wrench must attain the specified torque within ½ turn of the nut.

Exception: Undercut anchors that are so designed to allow visual confirmation of full set need not be tension or torque tested.

B. Epoxy-type Anchors

Epoxy-type anchors shall be tension tested per Section 1925B.3.5. The tension test load shall be equal to twice the allowable load for the specific location of the anchor to be tested (i.e., accounting for edge distance) or 80% of the yield strength of the bolt ($0.8A_bF_y$), whichever is less. The test procedures for expansion-type anchors in the attached table shall be used for epoxy-type anchors. Torque testing of epoxy-type anchors is not permitted

Where epoxy-type anchors are used as shear dowels across cold joints in slabs on grade and the slab is not part of the structural system, testing of those dowels is not required.

Anchors should exhibit no discernible movement during the tension test.

REASON:

Section 1925B.3.5 requires that the enforcement agency establish acceptable values for expansion and adhesive type anchors. This CAN establishes those values for use by the design community.

While current ICBO ES Evaluation Reports severely limit the use of expansion anchors in high seismic regions, observed performance of these anchors in hospital construction has proven satisfactory. The Office attributes this performance to special inspection procedures, and the requirement for testing 50% of the installed anchors to ensure proper installation procedures by the contractor.

The table of allowable tension and torque values is based on specific test procedures developed to derive the table. Those procedures and/or limitations are necessary to ensure that the listed tension or torque values are suitable for determining the adequacy of the installation by the contractor.

ORIGINAL SIGNED	9/3/02
Kurt A. Schaefer	Date

TEST VALUES
Hardrock or Lightweight Concrete

<u>ANCHOR</u> DIA. (in)	<u>WEDGE</u>		<u>SLEEVE</u>		<u>SHELL</u>	
	LOAD (lbs)	TORQUE (ft-lbs)	LOAD (lbs)	TORQUE (ft-lbs)	LOAD (lbs)	TORQUE (ft-lbs)
1/4	800	10	400	4	1000	-
5/16	-	-	400	5	1400	-
3/8	1100	25	700	10	1800	-
1/2	2000	50	900	20	2700	-
5/8	2300	80	1100	45	3700	-
3/4	3700	150	1400	90	5400	-
1	5800	250	-	-	-	-

NOTES

1. Anchor diameter refers to the thread size for the WEDGE & SHELL categories and to the anchor outside diameter for the SLEEVE category.
2. Apply proof test loads to WEDGE & SLEEVE anchors without removing the nut if possible. If not, remove nut & install a threaded coupler to the same tightness as the original nut using a torque wrench & apply load.
3. For SLEEVE/SHELL internally threaded categories, verify that the anchor is not prevented from withdrawing by a baseplate or other fixtures. If restraint is found, loosen and shim or remove fixture(s) prior to testing.
4. Reaction loads from test fixtures may be applied close to the anchor being tested, provided the anchor is not restrained from withdrawing by the fixture(s).
5. SHELL type anchors should be tested as follows:
 - a. Visually inspect 25% for full expansion as evidenced by the location of the expansion plug in the anchor body. Plug location of a fully expanded anchor should be as recommended by the manufacturer, or, in the absence of such recommendation, as determined on the job site following the manufacturer's installation instructions. At least 5% of the anchors shall be proof loaded as indicated in the table above, but not less than three anchors per day for each different person or crew installing anchors, or;
 - b. Test 50% of the installed anchors per Section 1925B.3.5.
6. Test equipment (including torque wrenches) is to be calibrated by an approved testing laboratory in accordance with standard recognized procedures.
7. Torque test values for SHELL type anchors can occur on a case-by-case basis when test procedures are submitted and approved by the enforcement agency.
8. The following criteria apply for the acceptance of installed anchors:

HYDRAULIC RAM METHOD: The anchor should have no observable movement at the applicable test load. For wedge and sleeve type anchors, a practical way to determine observable movement is that the washer under the nut becomes loose.

TORQUE WRENCH METHOD: The applicable test torque must be reached within the following limits;
 Wedge or Sleeve type: One-half (1/2) turn of the nut.
 One-quarter (1/4) turn of the nut for the 3/8 in. sleeve anchor only.
9. Testing should occur a minimum of 24 hours after installation of the subject anchors.
10. If the manufacturer's recommended installation torque is less than the test torque noted in the table, the manufacturer's recommended installation torque should be used in lieu of the tabulated values.
11. All tests shall be performed in the presence of the Inspector of Record.