



TOPIC: Structural Design - IBC/16/#5

CODE: Oregon Structural Specialty Code: 2022 Edition

APPROVED: August 3, 2023 [Rebecca Esau] , Director

REFERENCE: Oregon Structural Specialty Code – Chapter 16

SUBJECT: Use of Adhesive Anchors in Existing Unreinforced Masonry Buildings

QUESTION: What are the acceptable design methods and testing requirements when using adhesive anchors for seismic strengthening of existing unreinforced masonry buildings?

RESPONSE: The Bureau of Development Services (BDS) will accept adhesive anchor installations that follow either a system approved by ICC-ES or an equivalent nationally recognized evaluation service (Method A) or a system which relies on pre-construction testing of specific anchors in a specific building (Method B), as outlined below.

Method A – International Code Council (ICC) Evaluation Service (ES) Or Equivalent Nationally Recognized Evaluation Service Approved Adhesive Anchor Systems for Unreinforced Masonry

Unreinforced masonry adhesive anchor systems with an approved evaluation report will be accepted by BDS for their approved use. Anchor systems that have an approved evaluation report will be allowed without pre-construction testing. Installation shall strictly follow the requirements of the approved evaluation report, including seismic design category; Installations not meeting this requirement shall be required to follow Method B.

The following requirements apply to adhesive anchors submitted under Method A:

1. Design Requirements

The shear and tension design values stated in the approved evaluation report may need to be adjusted to match the design approach used to

determine the anchor demands. At this time, the approved evaluation reports that exist for adhesive anchors are intended to be used for allowable stress design (ASD) and are based on a factor of safety of 5.0, so the following modification factors may be used:

- a. If the anchor demands are based on service level loads and allowable stress design is to be used, no modification to design values is necessary.
- b. If the anchor demands are based on load and resistance factor design (LRFD), the design values stated in the approved evaluation report may be multiplied by a factor of 1.4.
- c. If the anchor demands are based on ASCE 41, the design values stated in the approved evaluation report may be converted to lower-bound strength by multiplying them by a factor of 3.0 where the approved test report does not provide a method. The expected strength of adhesive anchors in URM shall not be used or considered in the design.

2. Plan Submittal Requirements

The following information must be clearly provided on the submitted plans:

- a. Adhesive type(s) and evaluation report number(s).
- b. The special inspection and field-testing requirements for the anchor system.
- c. A bolt installation and configuration diagram or construction details that indicate how the bolt shall be installed, and the approved adhesive type.
- d. Brick shear test report that shows conformance to the minimum brick shear strength that is required by the approved evaluation report. Quantity and location of brick shear tests to be per ASCE 41.

3. Project Construction Requirements

The adhesive anchor type used during construction shall be the same type(s) identified on the approved plans.

a. Quality Control During Construction

The approved evaluation report requirements for special inspection shall be followed. Note that this typically includes but may not be limited to direct-tension testing and/or calibrated torque wrench tests.

b. **Test Failures During Construction**

A torque test failure is defined as any movement of the bolt during the torque test. In case of torque test failures during construction, the special inspector shall notify the BDS Inspections section and the Engineer of Record (EOR). An increased level of testing, as described below, shall be conducted. All failed anchors shall be replaced.

Increased Testing Requirements

Increased anchor testing shall be as follows:

- 1) A minimum of 6 anchors in the immediate vicinity of the failed anchor shall be torque tested.
- 2) In the event of any additional failure, all anchors placed on the same day as the failed anchor shall be tested.

4. **Final Summary Report**

The EOR Structural Observation Final Summary Report and the Special Inspection Final Summary Report shall be submitted to BDS at the conclusion of the project.

Method B – Field Tested Pre-Qualified Adhesive Anchor System

This method involves testing anchor installations prior to construction in order to obtain appropriate load values for specific anchors in a specific building.

1. **Pre-Permit Application Requirements**

In order to pre-qualify an adhesive anchor system with BDS, the following steps must be completed prior to a permit application. The load capacity of pre-qualified anchor systems shall be determined using field testing before design completion.

Condition Assessment and Rehabilitation

A condition assessment per ASCE 41 11.2.2 shall be completed to document the condition classification of the walls in the structure where anchors are intended to be installed. Where poor conditions exist, the area shall be repaired in accordance with ASCE 41 11.2.2.4. The condition assessment should be signed and sealed by a design professional licensed in Oregon.

Field Installation and Testing

a. **General.**

The EOR shall develop a field-testing program. Separate field-testing programs shall be developed for each specific anchor type used on the project. All testing shall be conducted by a qualified testing agency approved by the EOR and the City. Testing shall be observed by the EOR.

b. **Field testing submittal requirements.**

The EOR shall submit all the following information to the BDS Engineering Section for approval before conducting the required field tests:

- 1) A description of the anchor testing procedures
- 2) Drawings showing the test location(s)
- 3) Detailed anchor installation methods
- 4) Condition Assessment and Rehabilitation Report
- 5) Name of Testing Agency and their qualifications

c. **Anchor Installation Method**

Anchors must have an approved evaluation report for installation in unreinforced masonry material and must be installed in accordance with the methods identified in the approved evaluation report.

Tension anchors must be installed at 22.5° from the horizontal in a vertical plane to within 1" of the opposite face of the wall. This may be increased to 2" if approved by EOR if there are concerns regarding exterior face blowout. Shear anchors may be installed horizontally at the minimum embedment identified in the approved evaluation report, or they may be installed as is required for tension anchors.

d. **Field test anchor placement.**

Test anchors shall be placed in wall and mortar joint locations that replicate the thickness and mortar conditions of the anticipated location of the production anchors.

e. **Number of field tests required.**

The minimum number of tests shall be as follows:

- 1) At each of both the first and top stories, no fewer than two tension tests and two shear tests per wall or line of wall elements providing a common line of resistance to seismic forces

- 2) At each of all other stories, no fewer than one tension test and one shear test per wall or line of wall elements providing a common line of resistance to seismic forces
- 3) At parapets, no fewer than two tension tests per parapet. No shear testing is required at parapets. Testing is not required where the parapet's project scope does not include bracing or attachment to the building parapet.
- 4) In any case, no fewer than one tension test and one shear test is required per 1,500 sq. ft. of wall surface
- 5) No fewer than a total of (8) tension tests and (8) shear tests per building.

For Risk Category IV structures, the quantity of field tests required shall be increased to meet the requirements of ASCE 41 11.2.3.9.3 for Comprehensive Testing.

With the prior approval of the BDS Engineering section, testing quantities may be reduced on larger projects if the EOR determines such a reduction of testing is justified by consistent and representative test results.

f. **Field test requirements.**

The following applies to the adhesive anchor tests at this phase:

- 1) The masonry walls shall support the test apparatus. (See ASTM E488- 2003 edition, Fig 1 and/or ASTM E3121 for test apparatus details; other test methods may be submitted for approval as part of test plan prior to conducting tests). The clear distance between the anchor and the test apparatus support shall be at least equal to the anchor embedment depth.
- 2) Only non-impact electric drills shall be used to drill anchor installation holes.
- 3) Anchors shall be installed into cleaned installation holes. Installation holes shall be cleaned with oil-free compressed air and a nylon brush.
- 4) Anchor bolt nuts shall only be tightened with non-impact tools.
- 5) Anchors shall be loaded incrementally in accordance with ASTM E488 -2003 and/or ASTM E3121. Initial pre-load shall be 300 lbs.

- 6) Testing shall be capable of measuring the applied load and relative movement between the anchor and adjacent masonry surface.
- 7) For each anchor, the applied load at 1/8" relative movement shall be recorded. Additionally, for each anchor the peak load shall be measured. The peak load shall be defined to occur just prior to a significant drop in the test pressure gauge.

g. **Field testing agency report.**

A testing report shall be prepared by the testing agency and provided to BDS and the EOR.

The testing report shall be typed and include all the following information:

- 1) Date of test
- 2) Testing lab and technician's name
- 3) Test locations clearly shown and identified on floor plans and/or elevations
- 4) Anchor description
- 5) Specific adhesive product name and number
- 6) Wall thickness and embedment depth
- 7) Anchor distance from nearest corner
- 8) Condition of brick and mortar
- 9) Brick orientation at test location
- 10) Test equipment and set up
- 11) Loading procedure, loading increments and rate of loading
- 12) Description of anchor movement or elongation
- 13) Mode of failure in each test

h. **Anchor design strength determination.**

The EOR shall evaluate the test values and calculate the shear and tension design capacities. Average shear and tension capacities shall be computed for the entire building and for each individual floor using one of the methods outlined below. Different capacities for each floor of the building shall be calculated. The design strength at each floor shall be the capacity for the floor under consideration or the overall building capacity, whichever value is lower. (Design Note: Per ASCE 41 7.2.11.1, in no case shall the spacing between anchors exceed 8'-0" unless it can be

demonstrated that the wall has adequate capacity to span horizontally between the supports for greater distances.)

For resisting ASD seismic loads, the anchor bolt capacity shall be determined as the lesser of:

- 1) The average peak load divided by a safety factor of 5.
- 2) The average load at which 1/8" relative movement occurs.

For resisting LRFD seismic loads, the anchor bolt capacity shall be determined as the lesser of:

- 1) The average peak load multiplied by $(1.4/5 = 0.28)$.
- 2) The average load at which 1/8" relative movement occurs.

For resisting ASCE 41 seismic loads, the lower-bound anchor bolt capacity shall be determined as the lesser of:

- 1) The mean minus one standard deviation of the average peak load, multiplied by the knowledge factor, κ . Where the coefficient of variation at a given floor or for the building exceeds 25% the knowledge factor shall be equal to 0.75. is permitted to be taken as 1.0 in all other cases,
- 2) The average load at which 1/8" relative movement occurs.

i. **EOR field testing summary report.**

At the completion of the testing program, a testing program summary report shall be prepared by the EOR. The EOR summary report shall include:

- 1) The testing agency test reports; and
- 2) The EOR conclusions and recommendations regarding anchor system design strength.

EOR testing summary report shall be submitted to BDS for review with the project design calculations.

2. Plan Requirements

The following information must be clearly provided on the plans submitted to BDS for review:

- a. A bolt installation and configuration diagram indicating wall thickness, adhesive type, anchor embedment, use of non-impact tools, hole cleaning requirements.

- b. The plan notes regarding special inspection shall indicate that 20% of the anchors shall be torque tested by a special inspector using a torque wrench with values as set below. Anchor testing shall be as equally distributed throughout the building as possible.

Anchor Diameter (In inches)	Foot-Pounds
1/2	40
5/8	50
3/4	60

No visible deformation or elongation of the anchorage is permitted with the torque tests.

- c. The anchor bolt design strengths at the different floors of the building.

3. Project Construction Requirements

a. **Anchor Type.**

The adhesive type used during construction shall be the same as that used in the testing program. If different anchor bolts or adhesive systems are to be used for construction, they shall be pre-qualified by the testing procedure outlined above. No bolts shall be installed for construction until they have been pre-qualified and approved by BDS.

b. **Quality Control During Construction.**

For Method B, special inspection in accordance with Section 1702 of the OSSC and approved evaluation report is required prior to and during placement of the anchor and adhesive into the drilled hole. In addition, a minimum of 20% of the anchors installed shall be torque tested as described on the construction plans. Other trades shall not use vibratory or other equipment that can have a negative effect on the integrity of the mortar joints of the masonry construction.

c. **Test Failures During Construction.**

A torque test failure is defined as any movement of the bolt during the torque test. In case of torque test failures during construction,

the special inspector shall notify the BDS Inspections section and the EOR. An increased level of testing, as described below, shall be conducted. All failed anchors shall be replaced.

Increased testing requirements.

Increased anchor testing shall be as follows:

- 1) A minimum of 6 anchors in the immediate vicinity of the failed anchor shall be torque tested.
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4. Final Summary Report

The EOR Structural Observation Final Summary Report and the Special Inspection Final Summary Report shall be submitted to BDS at the conclusion of the project.

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