ANCHOR TEST

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The purpose of this testing is to establish the strength and behavior of of the hybrid anchoring system developed by Bennett Fasteners and to show compliance with the required building codes.

2. BACKGROUND

2.1. Hybrid Anchoring System

The hybrid anchoring system developed by Bennett Fasteners combines both mechanical and adhesive anchoring technologies into one anchor. The anchor portion of this system is shown in Figure 1 and illustrates the anchor in its expanded state. The anchor is produced in 4 sizes 3/8, 5/8, 7/8 and 1". Shown is the 5/8. The Anchors are proportional. The anchors body is partially threaded on one end and has a tapered section on one end to retain a base ring. When installed, the expanding plates extend into a groove cut into the base of a borehole. This mechanically locks the anchor into the borehole. Once installed, adhesive can be placed into the borehole, providing an additional load carrying path and solidification of the mechanical aspects.

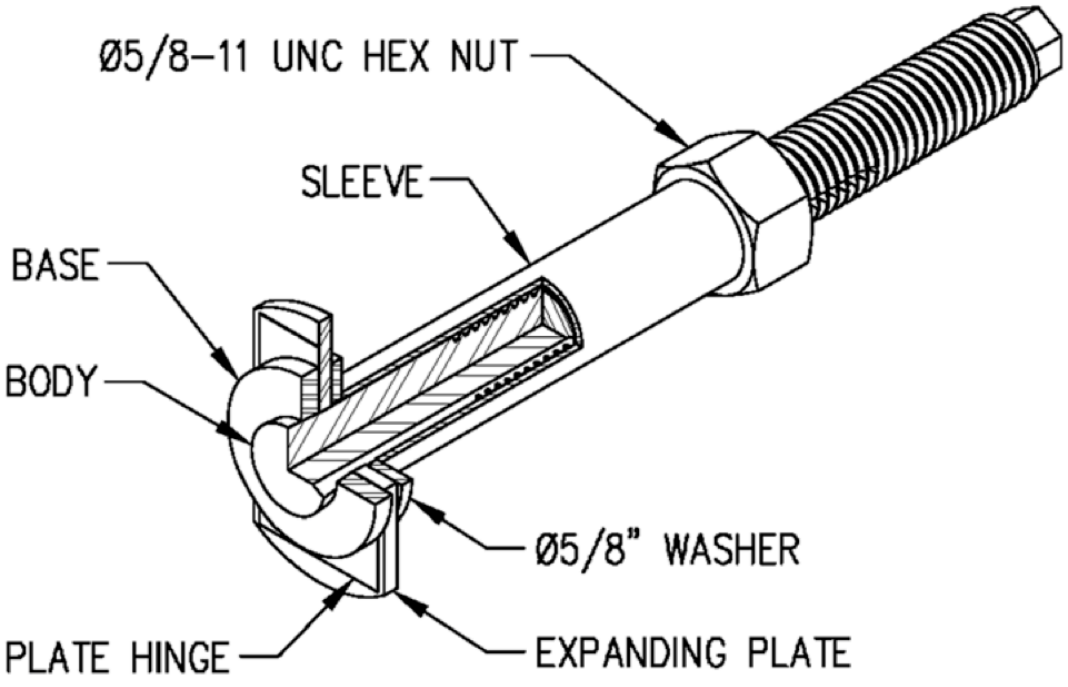

Figure 1: Hybrid Anchoring System

Code/Standard	Title	Description
IBC	International building code	Specifies the required analysis method for anchors (points to ACI 318 for design).
ACI 318	Building Code Requirements for structural concrete	Specifies how to analyze and what standards to test to (points to ACI 355.2/355.4 for testing).
ACI 355.2	Qualification of post-installed Mechanical Anchors in Concrete	Specifies test requirements for mechanical anchors to meet ACI 318 (points to E488 for test methods).
ACI 355.4	Acceptance Criteria for Qualification of Post-Installed Adhesive Anchors in Concrete	Specifies test requirements for adhesive anchors to meet ACI 318 (points to E488/E1512 for test methods).
ICC-ES AC193	Mechanical Anchors in Concrete Elements	Specifies acceptance criteria for mechanical anchor in concrete elements to meet building code.
ICC-ES AC308	Post-installed Adhesive Anchors in Concrete Elements	Specifies acceptance criteria for adhesive anchors in concrete elements to meet building code.
ICC-ES ESR	Evaluation Services Report	Document issued by ICC-ES to show a product is in compliance with the building code.
ASTM E488	Standard Test Methods for strength of Anchors in Concrete Elements	Test methods for testing anchors in concrete.
ASTM E1512	Standard Test Methods for Testing Bond Performance of Bonded Anchors	Test method for testing bond strength of adhesive anchors.
CSA A23.3	Design of Concrete Structures	Specifies the required design method and what standards to test to (point to ACI 3555.2 for testing). Does not cover adhesive anchors at this time.

2.3. Canadian Standards

In Canada, the design of concrete structures, and therefore concrete anchors, fall under CSA A23.3. The non-mandatory Annex D of CSA A23.3 provides the requirements for the design of post-installed mechanical concrete anchors, but does not cover adhesive anchors at this time. The testing requirements for this code point to the same ACI standards as the International Building Code (IBC). For this reason we have adhered to

the IBC requirements as it provides equivalent testing and includes requirements for adhesive anchors.

2.4. International Building Code (IBC)

Testing conforms to IBC ACI 318 Appendix D as the standard for post-installed anchors. This standard along with CSA A23.3 Annex D. outline the strength Design method for analyzing the bennett fastener. The values obtained were the result of testing done in accordance to ACI 355.2.

3. METHOD

Bennett Fastener testing installations were done with 3 different manufacturers construction epoxy and produced replicating results. Bennett Fasteners BF2 epoxy, Hilti HIT-RE 500 epoxy, Powers PE1000 epoxy. The concrete used was 25MPA. supplied by La Farge Canada Cast and cured according to requirements of ASTM E488 . Installation and rigging by Certified Red Seal Carpenter according to manufacturers instructions.

4.Test Schedule

In order of design importance

Test		Samples	Purpose
A	Pullout strength	With Each Epoxy 10) 3/8” 10) 5/8” 5) 7/8” 2) 1” Total:81	Determine Strength of base and shaft interface
B	Confined Tension, No Adhesive		Determine tensile Strength of anchor system without adhesive, examine failure mechanism
C	Unconfined Tension, With Adhesive		Determine Strength and failure mechanism, including cone failure
D	Shear, With Adhesive		Determine strength and failure mechanism
E	Confined Tension, With Adhesive		Determine strength and failure mechanism, excluding cone failure

4.1. Test A: Pullout Strength (Body through Base)

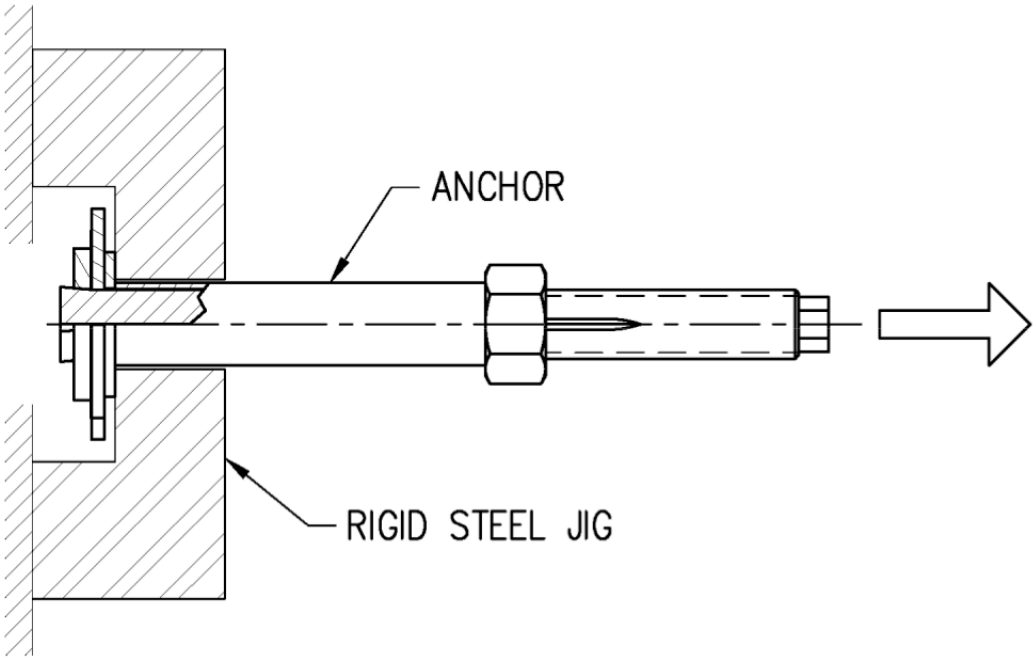

Figure 3: Pullout Strength Test

This test determined the strength and failure characteristics of the interface between the Base and the Body (see Figure 1). A rigid jig with a hole slightly larger than the sleeve diameter was placed over the anchor and bear on a 5/8” washer. The anchor was placed in its installed configuration and the jig fastened to the testing apparatus. The testing apparatus pulled the assembly in measured tension until failure.

4.2 Test B: Confined Tension, No Adhesive

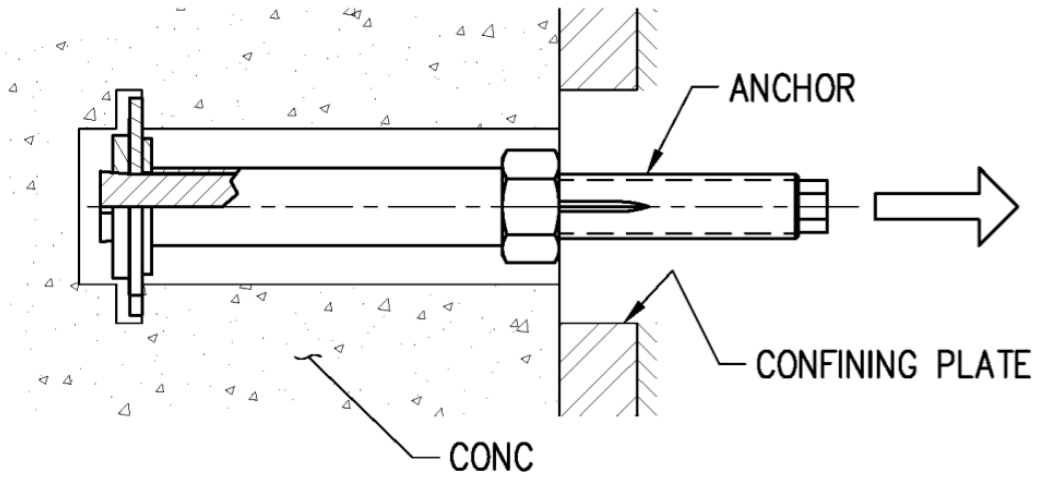

Figure 4: Tension Test, No Adhesive

This test determined the strength and failure characteristics of the anchor when acting as a mechanical anchor in tension. This test was conducted according to ASTM E488 where applicable.

4.3 Test C: Unconfined Tension, With Adhesive

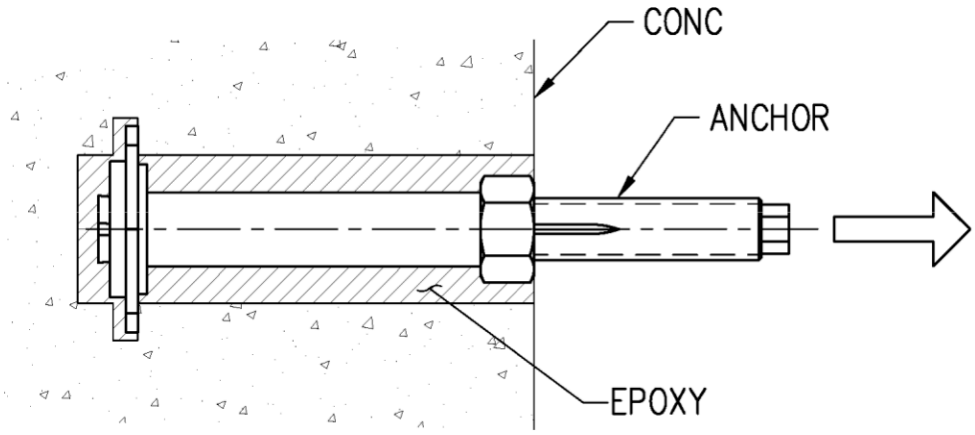

Figure 5: Unconfined Tension Test, With Adhesive

This test determined the strength and characteristic of the the anchor when acting as a hybrid mechanical and adhesive anchor in tension. This unconfined test was carried out in accordance with ASTM E488 where applicable.

4.4 Test D: Shear, With Adhesive

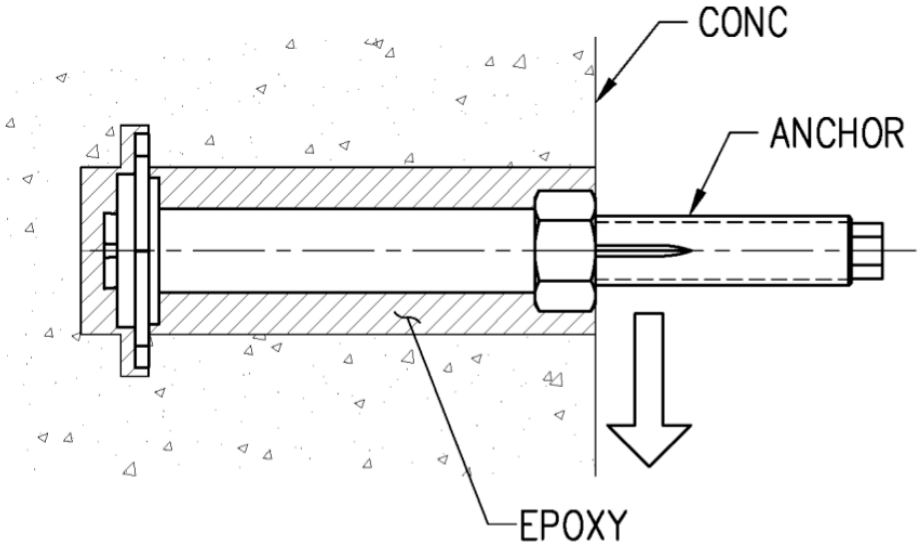

Figure 6: Shear Test, With Adhesive

This test determined the strength and failure characteristics of the anchor while acting as a hybrid mechanical and adhesive anchor in shear. This test was carried out in accordance with ASTM E488 where applicable.

4.5 Test E: Confined Tension, With Adhesive

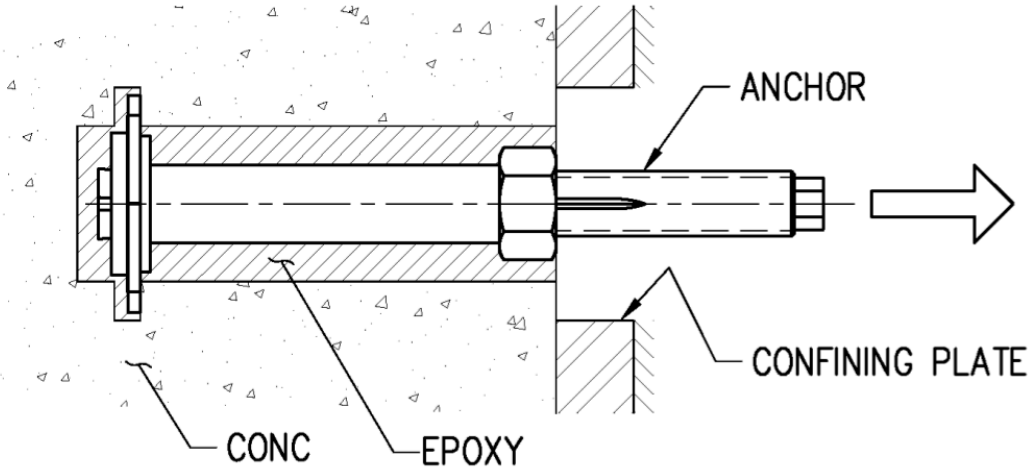

Figure 7: Confined Tension Test, With Adhesive.

This test determined the strength and failure characteristics of the anchor when acting as a hybrid mechanical and adhesive anchor in tension. This was a confined test to prevent cone failure and measured the tensile failure. The test was carried out according to ASTM E488 where applicable.

4.6 Test F: Body Tensile Strength

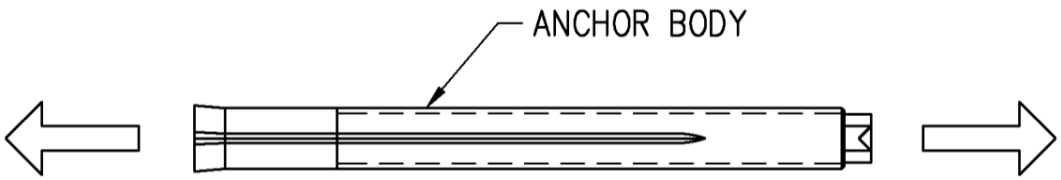

Figure 8: Body Tensile Strength

This test determined the strength and failure characteristics of the anchor body. Tensile force was applied to the anchor body until failure.