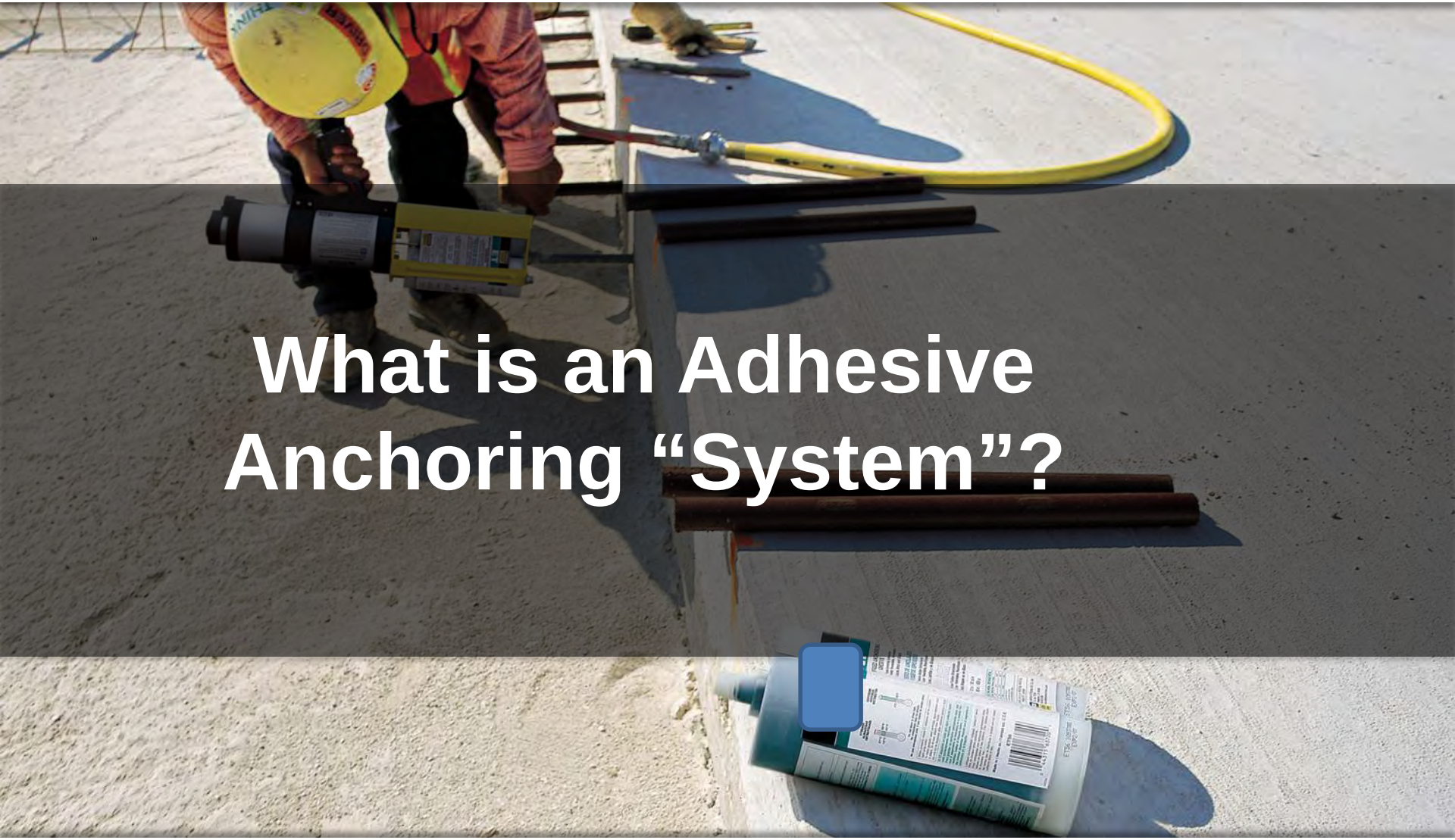
SIMPSON Strong-Tie®

Post-Installed Reinforcement

Overview

- What is an Adhesive Anchoring “System”?
- Reinforced Concrete Member Design
- Anchor Theory & Code Requirements
- Alternative Methods of Design
- Design Concept of Post-Installed Reinforcing
- Applications


What is an Adhesive Anchoring “System”?

Adhesive Anchoring Systems

Adhesive "System" Has Two Components:

Adhesive

+

Threaded Rod

Torque-Controlled Bonded Anchor

Reinforcing Bar

Adhesive Anchoring Systems

Adhesive "System" Has Two Components:

Adhesive

+

Reinforcing Bar

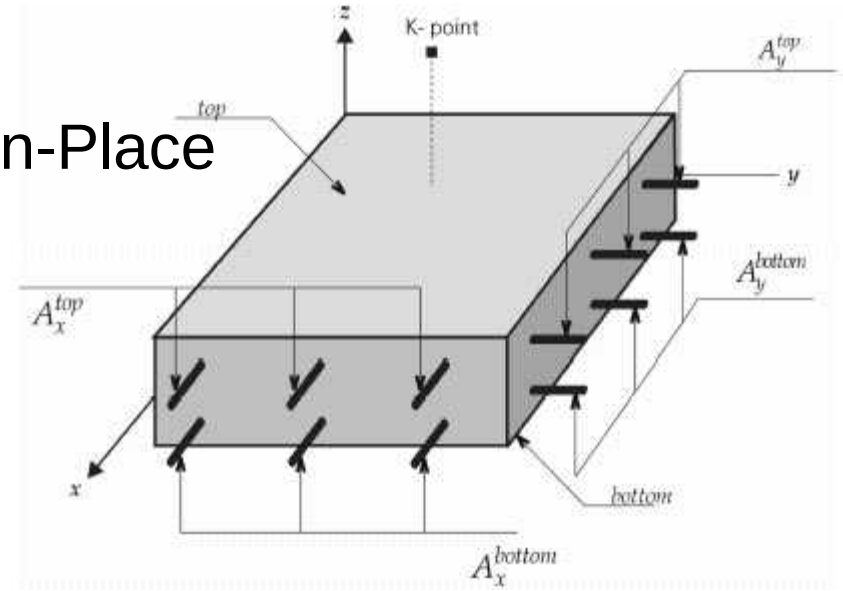
Reinforced Concrete Member Design

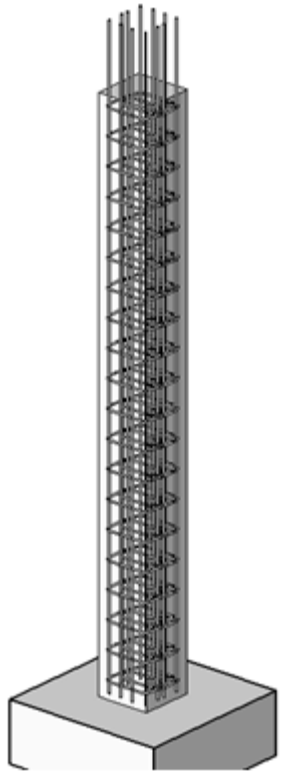
Reinforced Concrete Member Design

Uses Reinforcing Bar to:

- Increase bending strength
- Increase tensile strength
- Increase compressive strength (confinement)

Traditionally Cast-in-Place





Adhesive Anchoring Systems as Recognized by IBC

ACI 318-11 Scope

D.2.2 — This appendix applies to cast-in anchors and to post-installed expansion (torque-controlled and displacement-controlled), undercut, and adhesive anchors. Adhesive anchors shall be installed in concrete having a minimum age of 21 days at time of anchor installation. Specialty inserts, through-bolts, multiple anchors connected to a single steel plate at the embedded end of the anchors, grouted anchors, and direct anchors such as powder or pneumatic actuated nails or bolts are not included in the provisions of Appendix D. Reinforcement used as part of the embedment shall be designed in accordance with other parts of this Code.

ACI 318-11 Scope

D.2.3 — Design provisions are included for the following types of anchors:

(a) Headed studs and headed bolts having a geometry that has been demonstrated to result in a pullout strength in uncracked concrete equal to or exceeding $1.4N_p$, where N_p is given in Eq. (D-14);

(b) Hooked bolts having a geometry that has been demonstrated to result in a pullout strength without the benefit of friction in uncracked concrete equal to or exceeding $1.4N_p$, where N_p is given in Eq. (D-15);

(c) Post-installed expansion and undercut anchors that meet the assessment criteria of ACI 355.2; and

(d) Adhesive anchors that meet the assessment criteria of ACI 355.4.

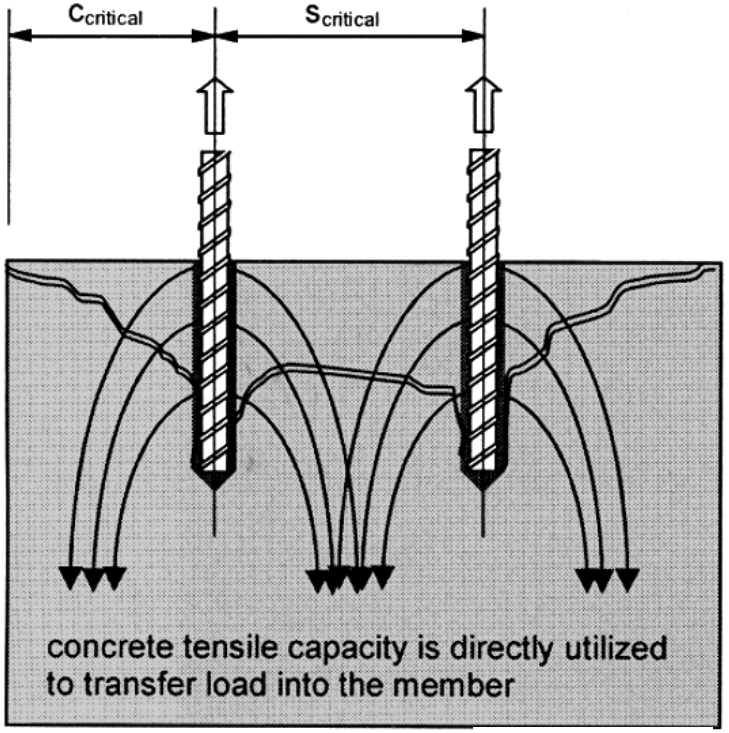
ACI 355.4

- Establishes Requirements for Code Recognition
- Addresses Conditions Using “Anchor Theory” Only
- Post-Installed Reinforcing Applying Concepts of Development & Lap Splices is Excluded

Principles of Anchor Theory

Basic Principles of “Anchor Theory”

- ACI 318 Appendix D uses “Anchor Theory” as a Calculation Model
- Reinforcing Dowels Are Designed As Anchor Bolts
- Principle stresses transferred from the rods to the surrounding concrete
- Three failure modes considered for both tension and shear

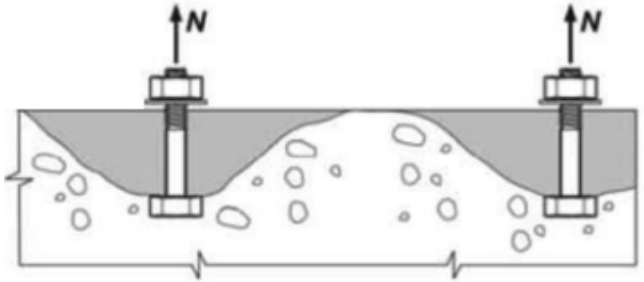


Basic Principles of “Anchor Theory”

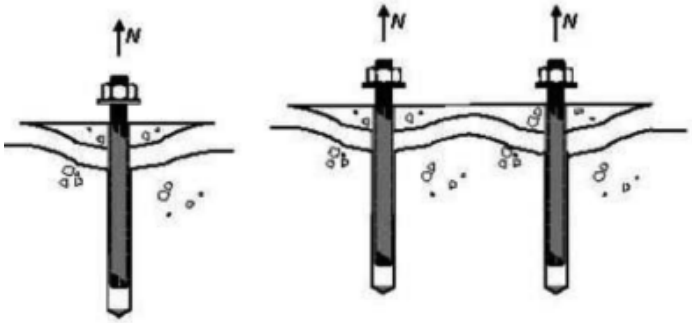
Tension Failure Modes:

- Steel
- Concrete Breakout
- Bond Stress

(i) Steel failure



(iii) Concrete breakout

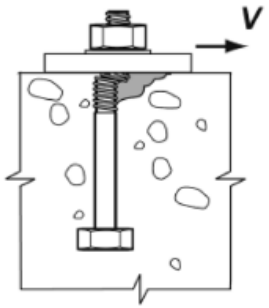


(vi) Bond failure

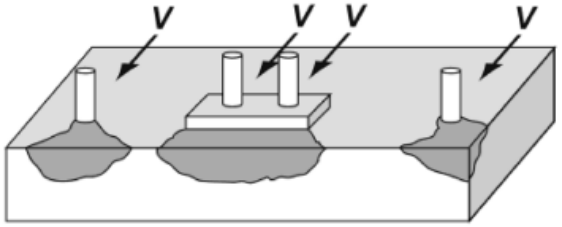
Basic Principles of “Anchor Theory”

Shear Failure Modes:

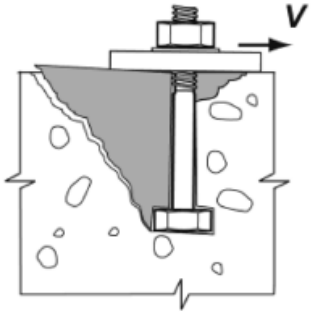
- Steel
- Concrete Breakout
- Concrete Pryout



(i) Steel failure preceede by concrete spall



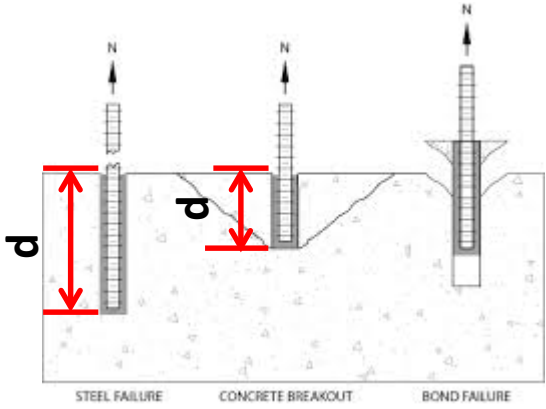
(iii) Concrete breakout



(ii) Concrete pryout for anchors far from a free edge

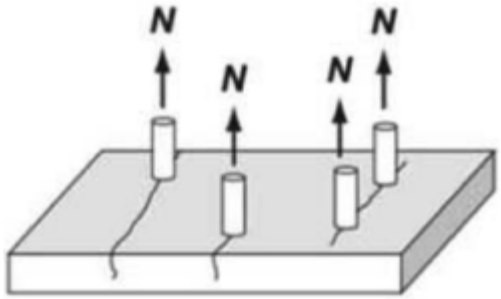
Basic Principles of “Anchor Theory”

- Embedment Depth: 4d to 20d
  #8 Rebar Max. Embedment Depth = 20”



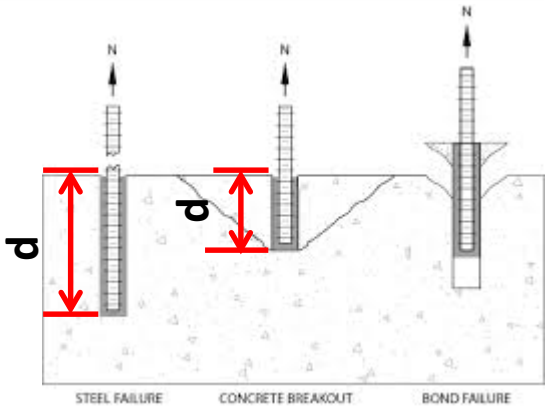
- Concrete Splitting Failure Precluded
  By Increasing Edge Distance

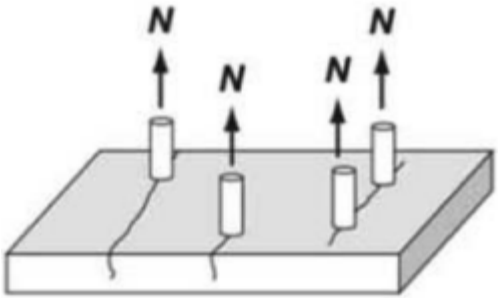
- Steel Strength Defined by Ultimate Tensile
  Strength, f_{uta}



Basic Principles of “Anchor Theory”

- Does Not Explicitly Consider the Influence of Reinforcement in the Member
- “Supplementary Reinforcement” Used to Control Splitting or Increase
- “Anchor Reinforcement” Increase Concrete Breakout Capacity





ACI 355.4

R1.2.6 This standard is intended to provide parameters for the design of adhesive anchors in conjunction with the provisions of ACI 318, Appendix D. Those provisions are derived from the principles of anchor theory, whereby anchor forces are transferred to the concrete in a manner that generally precludes splitting of the concrete and where spacing, edge distance, and member thickness are explicitly considered in the evaluation of the concrete breakout capacity (Fig. R1.1(a)). It is not intended to address the assessment or design of post-installed reinforcing bars proportioned according to the concepts of development and splicing of reinforcement (Fig. R1.1(b)). While the provisions of Chapter 12 of ACI 318 may be used to establish embedment lengths for post-installed reinforcing bars in such cases, the ability of an adhesive anchor system to transfer loads to adjacent embedded bars, particularly where longer splice lengths are required, should be verified by appropriate testing. Testing for the splice length is outside the scope of this standard.

Alternative Methods of Design

Alternative Methods of Design

[A] 104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. An alternative material, design or method of construction shall be *approved* where the *building official* finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, not less than the equivalent of that prescribed in this code in quality, strength, effectiveness, *fire resistance*, durability and safety. Where the alternative material, design or method of construction is not *approved*, the *building official* shall respond in writing, stating the reasons why the alternative was not *approved*.

[A] 104.11.1 Research reports. Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from *approved* sources.

ICC-ES AC308

ACCEPTANCE CRITERIA FOR POST-INSTALLED ADHESIVE ANCHORS IN CONCRETE ELEMENTS

AC308

Approved May 2014

Compliance date January 15, 2015

- Addresses Post-Installed Reinforcing Using Development & Lap Splices
- New Design Tool
- Significant Benefits To This Design Approach

AC308 Test Program

Total of 17 Tests:

- 4 Bond strength
- 1 Bond/Splitting
- 6 Reliability
- 2 Installation Procedure
- 3 Durability
- 1 Seismic

Table 3.8– Test program for evaluating deformed reinforcing bars for use in post-installed reinforcing bar connections

Testing				Bar size	Assessment		f_c'	Bar embedment ℓ_b	Minimum sample size n_{min}
Test no.	Test ref.	Purpose	Test parameters	US/M[§,¶]	α_{rel}	Load & displ.			
Service condition tests									
1a	9.4.3.1	Bond resistance	Tension, confined, single reinforcing bar[†]	#4/12	–	10.25.2 10.25.3	low	$7d_b$	Five
1b	9.4.3.1	Bond resistance	Tension, confined, single reinforcing bar[†]	#8/25	–	10.25.2 10.25.3	low	$7d_b$	Five
1c	9.4.3.1	Bond resistance	Tension, confined, single reinforcing bar[†]	$d_{b,max}$	–	10.25.2 10.25.3	low	$7d_b$	Five
1d	9.4.3.1	Bond resistance[§§]	Tension, confined, single reinforcing bar[†]	$d_{b,max}$	–	10.25.2 10.25.3	high	$7d_b$	Five
2	9.4.3.2	Bond/splitting behavior	Tension, confined, reinforcing bars in corner condition	#8/25	–	10.25.6	low	$35d_b$	Six[‡]
Reliability tests									
3	9.4.4.1	Sensitivity to hole cleaning, dry substrate[#,**]	Tension, confined, single reinforcing bar[†]	$d_{b,max}$	≥ 0.8	10.25.7	low	$7d_b$	Five
4	9.4.4.2	Sensitivity to installation in saturated concrete[#,**]	Tension, confined, single reinforcing bar[†]	$d_{b,max}$	≥ 0.8	10.25.7	low	$7d_b$	Five
5	9.4.4.3	Sensitivity to freezing/thawing conditions[#]	Tension, confined, single reinforcing bar[†]	#4/12	≥ 0.9	10.25.7	high	$7d_b$	Five
6	9.4.4.4	Sensitivity to sustained load at elevated temperature[#]	Tension, confined, single reinforcing bar[†]	#4/12	≥ 0.9	10.25.7	low	$7d_b$	Five
7	9.4.4.5	Decreased installation temperature[#]	Tension, confined, single reinforcing bar[†]	#4/12	≥ 0.9	10.25.7	low	$7d_b$	Five
8	9.4.4.6	Sensitivity to installation direction[#]	Tension, confined, single reinforcing bar[†]	$d_{b,max}$	≥ 0.9	10.25.7	low	$7d_b$	Five
Installation procedure verification									
9	9.4.5.1	Installation at deep embedment	Bar installation in injected hole, horizontal	$d_{b,max}$	–	10.25.8	–	$60d_b$	Three
10	9.4.5.2	Injection verification	Injection in clear tube	$d_{b,max}$	–	10.25.8	–	$60d_b$	Three
Durability									
11a	9.4.6.1.1	Resistance to alkalinity[#]	Slice test	#4/12	–	10.25.10	low	–	Ten
11b	9.4.6.1.2	Resistance to sulfur[#]	Slice test	#4/12	–	10.25.10	low	–	Ten
12	9.4.7	Corrosion resistance	Current and potential test	#4/12	–	10.25.9	low	$2^1/_{4''}$	Three
Special conditions									
13	9.4.8	Seismic qualification for reinforcing bar connections[##]	Cyclic tension, confined, single reinforcing bar	$d_{b,max}$	–	10.25.11	low	$7d_b$	Five

Qualified Adhesive Anchor Systems

Evaluation Report

Qualified Adhesive Anchoring System:

2.0 USES

The Hilti HIT-RE 500-SD Adhesive Anchoring System and Post-Installed Reinforcing Bar System are used to resist static, wind and earthquake (Seismic Design Categories A through F) tension and shear loads in cracked and uncracked normal-weight concrete having a specified compressive strength, f'_c, of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The anchor system complies with anchors as described in Section 1909 of the 2012 IBC and is an alternative to cast-in-place and post-installed anchors described in Section 1908 of the 2012 IBC, and Sections 1911 and 1912 of the 2009 and 2006 IBC. The anchor systems may also be used where an engineered design is submitted in accordance with Section R301.1.3 of the IRC.

The post-installed reinforcing bar system is an alternative to cast-in-place reinforcing bars governed by ACI 318 and IBC Chapter 19.

Evaluation Report

Qualified Adhesive Anchoring System:

3.2.5 Steel Reinforcing Bars for Use in Post-Installed Reinforcing Bar Connections: Steel reinforcing bars used in post-installed reinforcing bar connections are deformed bars (rebar). Tables 35, 36, 37, and Figure 8 summarize reinforcing bar size ranges. The embedded portions of reinforcing bars must be straight, and free of mill scale, rust and other coatings that may impair the bond with the adhesive. Reinforcing bars must not be bent after installation, except as set forth in Section 7.3.2 of ACI 318 with the additional condition that the bars must be bent cold, and heating of reinforcing bars to facilitate field bending is not permitted.

Evaluation Report

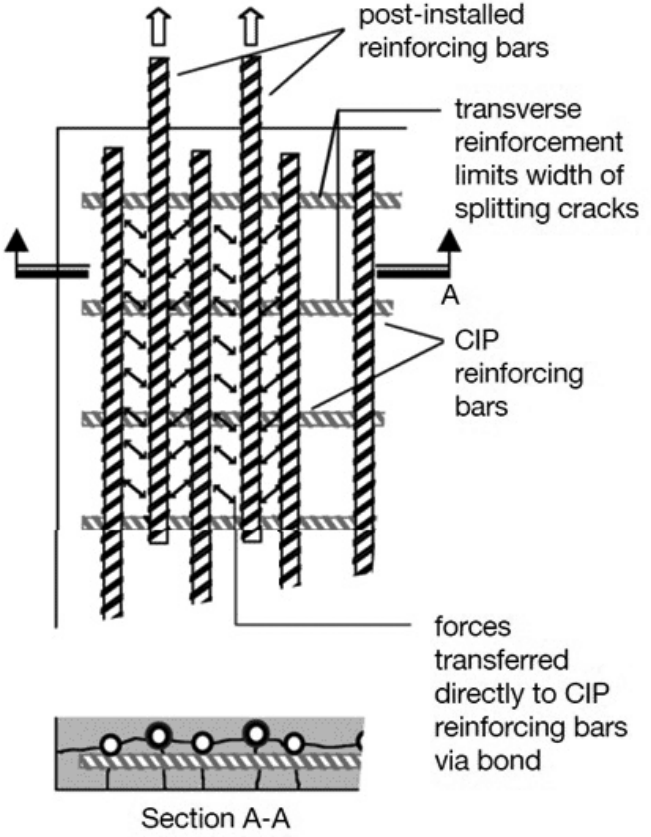
DESIGN INFORMATION	Symbol	Criteria Section of Reference Standard	Units	Bar size							
				#3	#4	#5	#6	#7	#8	#9	#10
Nominal reinforcing bar diameter	d_b	ASTM A615/A706	in. (mm)	0.375 (9.5)	0.500 (12.7)	0.625 (15.9)	0.750 (19.1)	0.875 (22.2)	1.000 (25.4)	1.125 (28.6)	1.250 (31.8)
Nominal bar area	A_b	ASTM A615/A706	in^2 (mm^2)	0.11 (71.3)	0.20 (126.7)	0.31 (197.9)	0.44 (285.0)	0.60 (387.9)	0.79 (506.7)	1.00 (644.7)	1.27 (817.3)
Development length for f_y = 60 ksi and f'_c = 2,500 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	in. (mm)	12.0 (304.8)	14.4 (365.8)	18.0 (457.2)	21.6 (548.6)	31.5 (800.1)	36.0 (914.4)	40.5 (1028.7)	45.0 (1143)
Development length for f_y = 60 ksi and f'_c = 4,000 psi (normal weight concrete)[4]	l_d	ACI 318 12.2.3	in. (mm)	12.0 (304.8)	12.0 (304.8)	14.2 (361.4)	17.1 (433.7)	24.9 (632.5)	28.5 (722.9)	32.0 (812.8)	35.6 (904.2)

Development & Lap Splices for Post-Installed Reinforcing

Concept of Development & Lap Splices

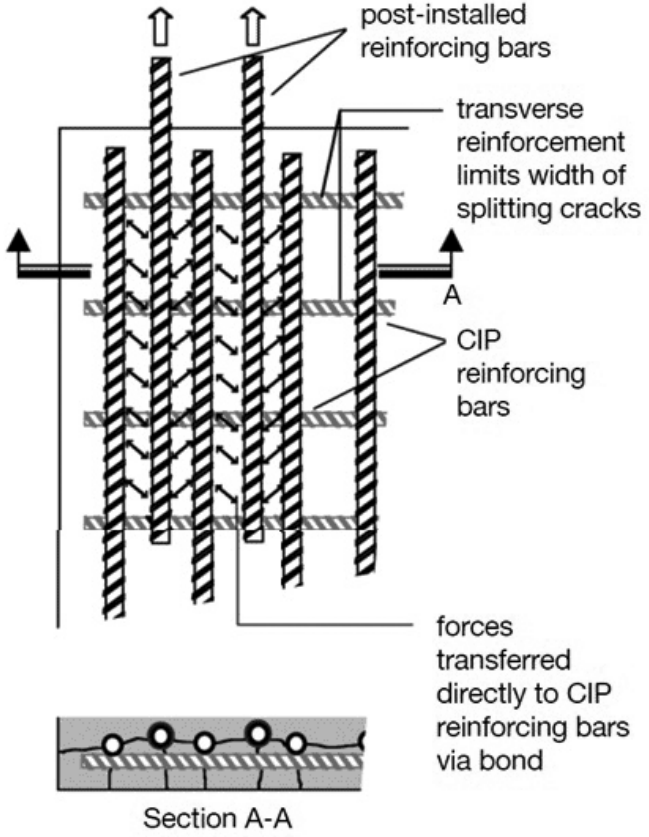
- Max. Embedment Depth: 60d
  #8 Rebar = 60”

- Assumes:
  1. Reinforcing Bar Reach Minimum Yield Strength
  2. Reinforcing Bar is Controlled by Yield Strength
  3. Embedment is Sufficient to Preclude Splitting



Concept of Development & Lap Splices

- Post-Installed Reinforcing is Limited to Straight Reinforcing Bars
- ACI 318 **Chapter 12** is Used to Determine Development Length
- ACI 318 **Chapter 7** is Used to Determine Spacing and Cover Requirements
- ACI 318 **Chapter 21** is Used for Earthquake-Resistant Structures Steel Steel Detailing



Powerful Design Tool

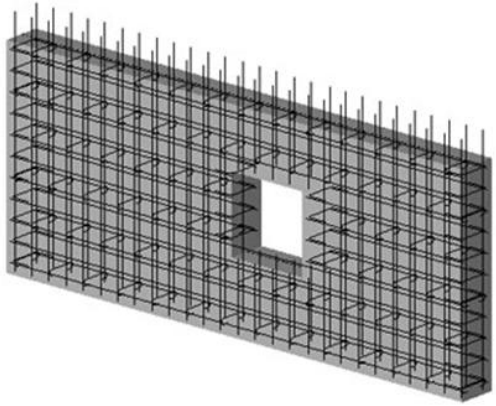
- Bypasses “Anchor Theory” Design Considerations:
    1. Concrete breakout
    2. Splitting reduction factor
    3. Ultimate tensile strength
    4. Embedment Depth Limit = 20d

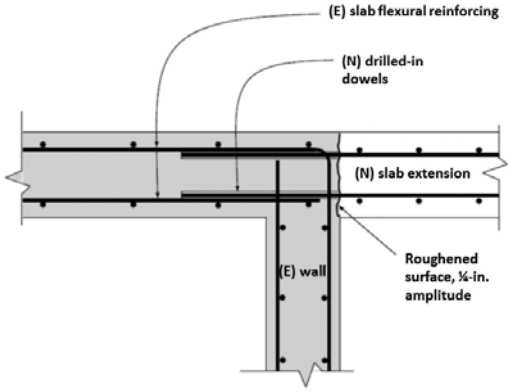
- “Post-Installed Reinforcement” Concept:
    1. Develops bar sufficiently to preclude splitting
    2. Develops bar sufficiently to yield reinforcing
    3. Embedment Depth Limit = 60d

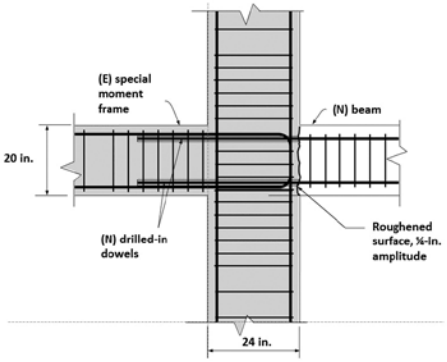
Applications

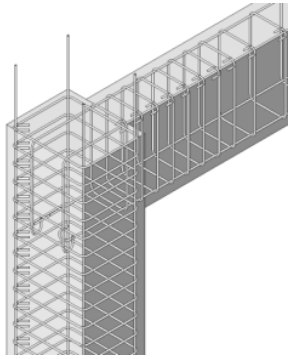
The Possibilities Are Endless!

- Slab Extension
- Stacked Wall Panels
- Moment Frame Extension
- Column Extensions









Questions?

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