What About Adhesive Anchors?
Part 1(A)

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Adhesive anchors - their reliable use in concrete

Applications:

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Reliable connections with adhesive anchor systems

Reliability depends on the amount of human errors and their effect on the structural behavior of adhesive anchors

- Requirement:
  - Reduction of erroneous contributions of humans to the adhesive anchor application process

  - Error-tolerant products
  - User-centered design
  - Safe installations
  - Qualified supervision, inspection

Requirements to ensure reliable fastenings

- Producer:
  - efficient fastening system
- Engineer:
  - accurate design
- User:
  - correct installation

RELIABLE FASTENING

Actual situation

- ICC AC 308
  - Adhesive Anchor Design
- ICC AC 308
  - Adhesive Anchor Prequalification

ACI 2011 - Approach for reliable fastenings

- ACI 318
  - App. D
  - Adhesive Anchor Design
- ACI 355.X
  - Adhesive Anchor Prequalification
- ACI 601
  - Adhesive Anchor Installer Certification

Adhesive anchor prequalification

Types of tests

- Identification test
  - compliance with fabrication requirements, establish baseline for quality assurance
- Reference tests
  - yield values to be compared with the results of the reliability tests
- Reliability tests
  - establish anchor categories used in ACI 318, App. D, demonstrate sensitivity to effects from possible deviations from the MPII likely to occur onsite and deviations occurring in service
- Service condition tests
  - establish characteristic resistance to be used in design

Reliability tests do not cover gross installation errors. They shall be prevented by appropriate installer training and qualified site inspection.

Characteristics influencing the bond strength of adhesive anchors - mandatory in prequalification

- Product
- Drilling method
- Concrete
  - low strength, high strength, regional variation
- Hole cleaning, installation
dry and water saturated concrete
- Mixing
- Cracked concrete
  - only for intended use in cracked concrete
- Installation direction
  - vertical down
- Temperature
  - longterm: > 110°F, shortterm: > 176°F
- Freeze/thaw
- Sustained loading
- Chemicals
- Resistance to alkalinity
- Curing time
  - standard temperature, 73°F
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Parameters influencing the bond strength of adhesive anchors - optional in prequalification

- Hole cleaning, installation
  - Water filled hole, submerged concrete
- Installation
  - Decreased installation temperature, < 50° F
- Chemicals
  - Resistance to sulfur
- Installation direction
  - Overhead
- Seismic loading

**Designer’s task:**
Compare exactly the requirements resulting from design for service life and installation with the field of application given in the ESRs of products from different manufacturers.

Adhesive anchor selection - designer

Anchor selection is governed by

- Loading conditions
  - Static, seismic, sustained, load direction 
- Location of fastening
  - Edge distance, spacing, member depth 
- Concrete, characteristics, condition
  - Strength, cracked, uncracked 
- Environmental conditions
  - Elevated temperatures, freeze/thaw conditions, humidity 
- Location of adhesive anchor
  - Installation conditions, detailing 
- Installation direction
  - Vertical down, horizontal, overhead 
- Environmental conditions
  - Concrete temperature, submerged hole 

Anchor selection is governed by service life and installation.

Adhesive anchor design - designer

Adhesive anchor design is based on ACI 318-08, App. D (mechanical anchors)

**Modifications:**

- Verification of the sustained load
  - ACI 308: reduction factor $\alpha_{\text{sust}} = 0.75$
  - ACI 318, App. D: reduction factor $\alpha_{\text{sust}} = 0.55$
- Prediction of the pull-out capacity by equations

Design provisions of ACI 308 and ACI 318 represent the state-of-art in adhesive anchor design.

Adhesive anchor installation

Actual situation:

- Qualification of the installer is not required
- Special inspection is required to take care of
  + Storage conditions of the adhesive
  + Application of the correct installation equipment
  + Sufficient hole cleaning
  + Correct insertion of the steel element
  + Adherence with the cure time 
- Special inspector must be aware of the negative impact of deviations from the Manufacturer’s Product Installation Instruction (MPII) on the adhesive anchor performance

Adhesive anchor installation - installer

The ACI 601 adhesive anchor installer training and certification program will consider

- The experience, limitations and capabilities of the installers
- The adhesive anchor relevant job site conditions
- The knowledge and understanding of the MPIIs
- The impact of deviations from the MPII
- The proper selection and use of the installation equipment and include
  + A written and a performance exam

Note: Gross errors are not covered by prequalification tests !!!
Conclusion

The prequalification test conditions and evaluation criteria of adhesive anchors according to AC308 and ACI 355.X represent installation and in-service conditions in practice.

The design of adhesive anchors according to AC 308 and ACI 318, App. D agrees with test results and considers the effect of sustained load with a reduction factor $\alpha_{\text{sust}}$.

The adhesive anchor installer training and certification program according to ACI 601 takes care of proper installation.

The provisions for adhesive anchors based on extensive research represent the state-of-art of fastening technique and yield reliable connections.

Related Documents

Anchorage to Concrete

- 355.2-07: Qualification of Post-Installed Mechanical Anchors in Concrete & Commentary
- 349.2R-07: Guide to the Concrete Capacity Design (CCD) Method - Embedment Design Examples
- 503.5R-92: Guide for the Selection of Polymer Adhesives in Concrete (Reapproved 2003)
- SP-103: Anchorage to Concrete
- SP-130: Anchors in Concrete--Design and Behavior
- 318-08: Building Code Requirements for Structural Concrete and Commentary

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