

Minutes
ACI Committee 355
Anchorage to Concrete
April 21, 2002
Detroit, MI

Call to Order: Chairman Ron Cook called the meeting to order at 8:30 AM. All members and guests in attendance were self-introduced. The Chairman requested that all members sign the attendance sheet and check the roster for correctness. The following sent notice of their inability to attend this meeting: Pat Sullivan (also sent notice for the Dallas meeting prior to that meeting), Harry Wiewel, Harry Chambers, and Bruce Ireland.

A revised agenda was handed out.

Roster/Address Changes: David Niday and Joseph Mockapetris resigned as members, Sam Eskildsen and Brett Turley were added as Voting Members, and James Hammell added as an Associate Member. An updated roster is attached.

Minutes: Motion by Carrato, second by McGlohn, to approve the Dallas minutes as written was unanimously approved.

ACI Committee 355 Annual Report for 2001: Ron Cook handed out the committee annual report that he submitted and gave an overview. A copy is attached to the minutes. Pete Carrato pointed out the need (in the last item) for research for cast-in-place and grouted anchors under shear loading and with and without shear lugs.

Report from ACI 349 Subcommittee 3: Branko Galunic gave a report covering activities of ACI 349 Subcommittee 3, Embedments. A number of changes have been identified to Appendix B. Editorial changes have been sent to ACI staff to be sent out as errata for Appendix B. The main effort of Subcommittee B is to update and publish design examples using the CCD method for the ACI 349-01 Appendix B version, replacing ACI 349.2R-97.

Report on ACI 318 Appendix D (CB30): Ron Cook reported that ACI 318-02 has been published and contains Appendix D. A task group was appointed to develop recommendations to ACI 318 for changes identified by Committee 355. The Task Group consists of Ron Cook (Chair), Rolf Eligehausen, Branko Galunic, Pete Carrato, Rich Klingner, and Bret Turley.

The five following proposed changes were identified so far.

1. Equation B7 of ACI 349 Appendix B applies to Appendix D.

$$e_N \leq s/2 \text{ should be } e_N \leq s_o/2$$

2. Section B.6.2.4 of Appendix B for three or more edges also applies to Appendix D. The limitations should be as follows.

$$\text{either } c_{s,max}/1.5 \text{ or } h/1.5$$

3. (Robert McGlohn) Section D.8.5 should consider splitting failure for cast-in-place when torqued. Cast-in-place anchors are referred to in the Commentary but are not included in the Code section.

Pete Carrato suggested that this should apply to bolts in tension. See RD.5.2.6, post-installed and cast-in-place.

4. Pryout in D.6.3.1. Need to add an equation for V_{cbg} in addition to V_{cb} . Refer to equations D4 and D5.

5. Nam Ho Lee) Fig RD.6.2.1(b), right hand figure, are we clear? May need revision.

Please send proposed changes to Ron Cook by June 21, 2002 for consideration by the Task Group.

Report on ACI 355.2: Ron Cook reported that ACI 355.2-01 is now published as a full standard for use with ACI 318-02 Appendix D. A task group was appointed for considering corrections to ACI 355.2. Task Group consists of Richard Wollmershauser (chair), Pete Carrato, Rich Klingner, Chris La Vine, Don Meinheit, Rolf Eligehausen, and Lee Mattis.

The task group should identify corrections and changes needed as well as items previously identified as consideration for new business either from previous ballots or the response to public comments. Dick will check previous ballots for any outstanding items. Dick also presented several editorial and substantive items for consideration. Ron recommended clarification of shear in ACI 355.2 as well as any needed changes in Appendix D. Ron asked that proposed modifications be sent to Dick with a copy to Ron by June 30, 2002.

Chris La Vine asked about those anchor designs that don't fit the definitions in ACI 355.2. Ron recommended that proposals can be made and ACI 355.2 can be changed to accommodate any new types of anchor systems.

Lee Mattis indicated that at least one lab in the US can now run the tests in ACI 355.2, with several more labs working on necessary equipment.

Discussion ensued about returning this standard to ASTM. This should take place in the near future, but ACI 355 should continue to process any needed changes. It will take some time for the document to be reformatted into ASTM style before any balloting can take place in ASTM. The task group to discuss this issue. There are eight members of ACI 355 who are voting members of ASTM Subcommittee E06.13.

Seminar on ACI 318 Appendix D and ACI 355.2 by ACI 355: Ron Cook reported that the PCA/ACI seminars have been setup for 2002 and that the second half day is devoted to Appendix D – 70 slides and two design problems. It was the consensus of ACI 355 that this subject be placed on hold until the design examples are finished.

Status of Joint ACI 318, 349, 355 Design Guide: Ron Cook reported that the task group had worked most of the identified design examples. A meeting of the task group was scheduled for 1:30 PM this afternoon. (Minutes attached.) The design examples will be balloted in ACI 355, with publication expected in 2003.

Anchorage Programs of Interest:

a. Rolf Eligehausen gave a presentation on testing and design of redundant fastenings. The presentation is attached. The concept is that for redundant systems, a constant probability of failure can be maintained (1.0×10^{-6}) with the failure of two adjacent fastenings if certain design considerations are met for the attachment. The attached system should be able to transfer support

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to other fasteners, but should have the same probability of failure. Then, the fasteners can be tested to less stringent requirements.

b. Don Meinheit gave a report on Phase 2 of the cast-in-place headed studs program being performed by WJE for PCI. The program consists of testing with combined tension and shear loading. Neal Anderson is the responsible project leader. When finished, they will distribute the report to the committee.

Testing was conducted at 30 and 60 degree angles and is finished. Analysis is underway so no conclusions were available at this time. Testing included 4-anchor groups with embedment to diameter ratios of 64 and 10.7, no edge effects, and with edge effects of 8d (4 in.) and 16d (8 in.). Tests were also conducted for 8 anchor groups and single anchors. Shear was applied toward the free edge. There were no compression forces directed into the concrete. Some studs were strain gaged.

Also, some testing was performed with anchors near the edge with loads parallel to the edge. At 4d, got edge spall; at 6d, steel failure with no edge spall.

c. Rolf Eligehausen presented Behavior of Concrete Screw Anchors. The handout is attached. The *k*-factor may be product independent. The behavior is a combination of that of a mechanical anchor as well as of a bonded anchor.

Could use a database of these anchors and possibly include in Appendix D and ACI 355.2.

d. Pete Carrato presented two anchor details to give the committee some appreciation of the complexities of designs being used in real world applications. A design was presented using ACI 349-01 at Hanford Washington. It is a 3 ft thick wall 25 ft high to support a roof structure. Uplift loads are 1×10^6 pounds.

d. Rolf Eligehausen gave a brief presentation on possible recommendations for design considerations for bonded anchors (attached). He and Ron Cook will develop design recommendations and language to be added to Appendix D for bonded anchors, with a bonded anchor prequalification standard being developed in ASTM.

Unfinished Business: Richard Wollmershauser reported that on April 5, 2002, ICBO ES adopted Acceptance Criteria 193 for mechanical anchors that uses the testing and requirements of ACI 355.2-01 and applies to the UBC '97, the IBC 2000 and the IRC 2000.

New Business:

a. The date and time of the fall meeting in Phoenix was proposed to be Sunday October 27, 2002 from 8:30 AM to 1:00 PM. A task group meeting will be held at a time to be determined. It was requested that there not be a conflict with the Committee 408 meeting. Ron will request Sunday first, with Monday as a backup choice.

Meeting was adjourned at 12:10 PM.

Respectfully submitted,
Richard E. Wollmershauser
Secretary

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Members in attendance: J. Ardahl, R. Bandyopadhyay, P. Carrato, R. Cook, R. Eligehausen, S. Eskildsen, W. Fuchs, B. Galunic, J. Hammell, K. Heinert, C. Heinz, R. Klingner, H. Lancelot, C. La Vine, B. Lavon, L. Mattis, R. McGlohn, D. Meinheit, R. Orr, R. Smith, B. Turley, R. Wollmershauser

Guests: Neal Anderson, Roger Becker, Kang Sik Kim, Steve Kurtz, Nam Ho Lee, R. McGrath, P. Pusill-Wachsmuth, B. Shahrooz, Don Stehler,

Attachments:

1. Design Guide Task Group Meeting Minutes
2. Corrected Roster
3. Annual Report
4. Presentation on "Requirements for anchors for redundant use in concrete"
5. Presentation on "Behaviour and Design of Fastenings with Concrete Screws"
6. Presentation on "Bonded Anchors"

Minutes
Joint Design Guide Task Group
ACI Committees 355, 249, and 318
April 21, 2002
Detroit, MI

The Joint Task Group meeting was called to order by Chairman Ron Cook at 1:30 PM.

Members and others in attendance: R. Bandyopadhyay, R. Becker, p. Carrato, R. Cook, S. Eskildsen, w. Fuchs, B. Galunic, J. Hammell, C. Heinz, R. Klingner, C. La Vine, Nam-Ho Lee, R. McGlohn, D. Meinheit, R. Orr, B. Turley, R. Wollmershauser. Guests were: N. Chehar, H. Graves, P. Pusill-Wachsmuth, J. Silva,

Task Group Membership: Ranjit Bandyopadhyay, Pete Carrato, and Werner Fuchs were added to the Task Group.

Design Examples: The design examples were handed out as prepared by the assigned task group members. A consensus was reached that the final document would have a table of contents, a brief introduction of explanation, the design examples, and appendices that will include appropriate standardized anchor bolt data and referenced standards. The purpose of the design examples is to help others to understand Appendix D and illustrate the methodology for the design of connections in anchoring to concrete.

It was agreed that a full design guide would be prepared after the design examples are complete. (A task group was created at the last meeting to develop a proposed outline for the design guide.)

Standard Methodology: It was agreed that a standard methodology would be used. This includes the following.

1. Ron also handed a set of tables that were used in the PCA document and should be used in these design examples. The list of standards will be updated with the latest (or appropriate) year/version designation.
2. The procedure for calculations should use factored loads. Use lb and in. units.
3. Use MS Word, Times New Roman 11 pt font. Use MS Equation Editor for equations, also with 11 pt, *variables as italic*. See ACI 318 for examples.
4. Use as many figures as needed. The more the better to illustrate the example. The design connection should be shown in a figure. For figures it is recommended to use PowerPoint draw and "paste special picture" into the word document.
5. The calculation should follow the failure mode methodology from Appendix D. For tension, work through all the failure modes. If not applicable, so state and give reason why.
6. ASTM F 1554-99 should be used for the anchor bolt specification.
7. Don Meinheit will research the stud data to be used in the examples.
8. Dick Wollmershauser will prepare a data table for a post-installed torque-controlled expansion anchor for use in the associated problems.

The table of design examples has been revised and is given below.

No.	Design Example	Responsible Persons
1	Single anchor – tension - away from edges A - uncracked – CIP headed anchor bolt and L-bolt B - cracked – post-installed torque-controlled expansion anchor	McGlohn Wollmershauser
2	Tension group near an edge	Cook / Ireland / Bandyopadhyay
3	Single anchor – shear – near edge	Cook / Ireland / Bandyopadhyay
4	Single anchor – tension & shear – near edge. Post-installed anchor data to be supplied.	Cook / Turley
5	Groups of anchors in tension and shear – 4 bolts – near 2 edges With supplemental reinforcement / large edge distance / thickness influence	Ward / Eskildsen / Fuchs
6	Group of fasteners in tension near one edge with eccentricity	Turley / Cook
7	Multiple anchor connection subjected to tension and shear - elastic - plastic	Klingner / Lee / Heinz
8	Multiple anchor connection loaded in “torsion”	Lee / Heinz / Carrato
9	Lap splice of bars & anchors – column base pier	Eskildsen / Orr
10	Eccentric shear directed away from the free edge	Roger Becker / Sam Eskildsen
11	Shear parallel to free edge	Ireland / McGlohn / Wollmershauser (data)

In reviewing ASTM F 1554, it was discovered that there is no head information for headed bolts. Dick Wollmershauser will initiate a change in ASTM Subcommittee F16.02 to add head dimensions.

Send design examples to Ron Cook by June 21, 2002. Ron will assemble and decide if a small group is needed to review before sending out to the task group.

The meeting was adjourned at 3:25 PM.

Respectfully submitted,
Richard Wollmershauser

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2001 Annual Report of ACI 355 Committee Activities

Committee 355, Anchorage to Concrete

Chairman: Ronald A. Cook

Date: March 31, 2002

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1. Progress on goals (including technical sessions) published in the 2001 *ACI Committees* booklet:
 - 1.1 Completed the closure statement in response to public comments on ACI 355.2-00 Provisional Standard, *Evaluating the Performance of Post-Installed Mechanical Anchors in Concrete*. Closure statement was published in the February 2002 issue of *Concrete International*. ACI Standard ACI 355.2-01 *Evaluating the Performance of Post-Installed Mechanical Anchors in Concrete* was published in January 2002.
 - 1.2 Established a Task Group with members from 355, 318 and 349 to prepare a *Design Guide on Anchoring to Concrete* and developed initial drafts of design examples.
 - 1.3 Continued to maintain mechanical and adhesive anchor databases.
 - 1.4 Presented information on research and proposed design models for adhesive and grouted anchors.
 2. Goals for the upcoming year to be published in the 2002 *ACI Committees* booklet:
 - 2.1 Develop a *Design Guide on Anchoring to Concrete* to provide discussion and design examples for ACI 318-02 Appendix D Anchoring to Concrete.
 - 2.2 Work on potential revisions to ACI 355.2-01 *Evaluating the Performance of Post-Installed Mechanical Anchors in Concrete*.
 - 2.3 Based on anchorage research, develop revisions to the existing testing standard (ACI 355.2-01) and design standard (ACI 318-02 Appendix D) for cast-in-place and post-installed mechanical anchors and develop recommendations for new testing and design standards for anchorage systems not included in ACI 355.2-01 and ACI 318 Appendix D.
 - 2.4 Maintain databases for anchors.
 3. Documents to be submitted to TAC in the next 12 months:
 - 3.1 Pending completion of a Design Guide on Anchoring to Concrete, the document may be submitted to TAC by the end of 2002 but more likely in early 2003.
 4. Report progress on preparing responses to TAC review comments (if applicable). (**N/A**)
 5. Liaisons or conflicts with other ACI committees or other organizations, educational programs for seminars, and any new technology to be featured in *Concrete International*:
 - 5.1 Liaison with ACI 318 Subcommittee B and ACI 349, Subcommittee 3.
 - 5.2 Liaison with fib SAG 4 on Fastenings – 7 member overlap.
 - 5.3 Liaison with ASCE 06.13 Structural Performance of Connections in Building Construction – 8 member overlap



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6. Balance of Interests (TCM 1.6.3.8 Membership Summary)

Total	=	25 members
Users	=	11 members
General	=	7 members
Producers	=	7 members (No producer has more than one voting member)
$18 \geq 7$	=	Balanced

7. List one or two high priority research topics that would assist your committee. (TCM 2.6)

Research projects related to anchorage to concrete are typically sponsored by anchor manufacturers (i.e., manufacturers of post-installed mechanical and bonded anchors or cast-in-place welded studs). The evaluation of the strength of cast-in-place headed bolts, L-bolts, and J-bolts receives little if any funding. Normally when these cast-in-place anchors are specified, a grout pad is used between the base plate and the existing concrete to account for construction tolerances. Currently, ACI 318-02 Appendix D requires that the shear strength of the steel for this type of connection be limited to 80% of that without a grout pad regardless of the thickness of the grout pad (ACI 318-02 Appendix D Section D.6.1.3). This requirement is based on the results of a single test program conducted over 25 years ago that did not involve actual failure of the anchor and did not vary the grout pad thickness. The following research project is recommended:

Proposed Research:

ACI should consider sponsoring a research program to determine the strength of cast-in-place anchors (headed bolts, L-bolts, and J-bolts) installed with varying thickness of grout pads between the base plate and the cast-in-place surface of the concrete.