

Meeting Minutes

ACI Committee 224 – Cracking

2011 Fall Meeting
Colonnade B, Millennium Hotel
Cincinnati, OH

Sunday, October 16, 2011
2:30-5:00 PM

1. Call to Order and Welcome

Chair West called the meeting to order at 2:30 PM and welcomed members and guests.

2. Introduction of Members and Guests

The Chair asked members and guests to introduce themselves. There were 19 members (15 Voting and 4 Associate) and 6 visitors in attendance. Regrets were received from Peter Bischoff, Paul Hedli and Andy Scanlon.

Members in attendance:

Florian Barth, Neal Berke, Jacob Bice, Dave Darwin, John Duntemann, Christopher Ferraro, Robert Frosch, Will Hansen, Harvey Haynes, Ralf Leistikow, Malcolm Lim, Edward Nawy, Randy Poston, Farshard Rajabipour, Guillermo Riveros, Ernie Rogalla, Brian Rubik, Andrea Schokker, and Jeff West.

Visitors in attendance:

Scott Jones, Zhibin Lin, Jim Loper, Mark Lukkarila, Jan Olek (TAC Contact), Carlos Videla

3. Update on Membership Status

Secretary Bice reported that Brian Rubik had joined the Committee as an Associate Member, Guillermo Riveros and Malcolm Lim moved from Associate Members to Voting Members, and Royce Rhodes moved from Voting Member to Consulting Member. Leroy Lutz resigned from the Committee as a Consulting Member. The Committee membership now stands at 22 Voting Members, 3 Consulting Members, and 16 Associate Members.

4. Approval of Meeting Minutes from the Tampa Meeting, April 3, 2011

Robert Frosch motioned to approve the Fall 2010 minutes, seconded by Andrea Schokker. The meeting minutes were approved by a unanimous voice vote.

5. Design Detailing to Mitigate Cracking (224.XR)
a. Web Ballot, Sept.-Oct. 2011: Resolution of Negatives

A web ballot to resolve negatives from a previous ballot was held between September and October, 2011. The Committee discussed the resolution of four negative ballots.

1. A negative vote was received by Frosch that requested that the objectives of the document be clarified further and provided suggested language. Schokker moved to find Frosch persuasive and accept new language, seconded by Barth. The motion was approved unanimously by the Committee.
2. A negative vote was received by Darwin to remove the word “about” on page 38, Line 2 since ACI 318 does not require an approximate range. Frosch stated that 318 does not state a maximum limit, but rather is based on an equation. The limits shown in the document are typical and approximate. Frosch suggested that the sentence be reworded to refer to the basis for maximum spacing in 318 and describe the range as a typical range. The sentence was rewritten to clarify based on the suggestion by Frosch. Barth moved and was seconded by Schokker to find the negative ballot persuasive and replace the language. The motion was approved unanimously by the Committee.
3. A negative vote was received by Darwin to provide more guidance with respect to discussion on 1” saw cuts in slabs-on-grade. Haynes revised the paragraph to add additional information on early-entry saw cuts to address the negative by Darwin. The Committee suggested revising the language to describe “creating a weakened cross-section” when saw-cutting. Lim stated that having a 1-day sawcut may not be sufficient to control shrinkage cracking and that cracking may initiate prior to sawcutting at 1-day. In thicker slabs (pavements) even after deepening the cuts after the initial sawcut, cracking may still occur, particularly at the edges. Barth suggested that the Committee has not done enough work in this area to change language that is based on the 360 document. The Committee suggested revising the proposed language such that providing a supplemental sawcut is not a recommendation specific to thicker slabs. Schokker moved and Riveros seconded to find the negative persuasive and accept the proposed revised language. The motion was approved unanimously by the Committee.
4. A negative vote was received by Darwin to remove discussion on ½-in. groove in slabs. Haynes removed reference to the ½ inch grooving tool. The Committee proposed new language to resolve the negative vote. Frosch moved and Schokker seconded to find the negative persuasive and to accept the proposed language.

In addition to the negatives, Frosch provided an affirmative with comment (A/C, p. 38, L14) that the Chair suggested required a substantive addition to the document. Frosch explained his comment, stating that he felt that the code maximum spacing of 18 inches does not adequately control cracking and that the document should recommend limiting reinforcement spacing to 12 inches. Following Committee discussion, Frosch drafted new language for this section, including two new references to support the language. Since the new language represented a substantial technical change, the A/C ballot was treated as a

Negative. Darwin motioned to accept the new language, seconded by Schokker. The motion was approved unanimously by the Committee.

Complete ballot details and resolution of negative ballots (including Meeting Ballot details) are provided in the attached “Summary of Negatives and Editorials” for this ballot.

Action Item: Document to be forwarded to TAC by Chair after meeting.

6. 224R-01 “Control of Cracking in Concrete Structures”

a. Web Ballot June-July 2011 – Chapters 3, 6, 8, 9 and 10: Discussion of results and resolution of negatives from Web Ballot

The Committee discussed the results of web ballot on Chapters 3, 6, 8, 9 and 10. Chapter authors Leistikow, Duntemann and Rogalla led a discussion of negative ballots in Chapters 6, 9, and 10. Responses to several negative ballots in Chapter 6 were balloted during the meeting. Meeting Ballot Details for Chapter 6 are provided in the attached “Summary of Negatives and Editorials” for this ballot. Outstanding negative ballots for Chapters 3, 6, 8, 9 and 10 are to be resolved by web ballot.

Action Item: Chapter Authors (Haynes and Darwin (3), Leistikow (6), Ferraro (8), Duntemann (9) and Rogalla(10)) to address editorial comments and outstanding negatives and prepare for web balloting before Dallas meeting.

b. Revision Update for remaining chapters
Not addressed due to lack of meeting time.

7. 224.3R-95 “Joints in Concrete Construction”

a. Revision Update
Not addressed due to lack of meeting time.

8. Technical Sessions

a. Cracking and Corrosion (Co-sponsored with 130 and 222) - (Bice)
Not addressed due to lack of meeting time.

9. New Business

None.

10. Adjourn

The meeting was adjourned at 5:00 PM.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Jacob Bice". The signature is fluid and cursive, with a long horizontal stroke at the end.

Jacob Bice, 224 Secretary

Attachments:

1. ACI 224.X Web Ballot – Summary of Negatives and Editorials including Meeting Ballot Details and Results
2. ACI 224R Chapter 6 Web Ballot – Summary of Negatives and Editorials including Meeting Ballot Details and Results

Committee 224 Ballot Comment Form

Ballot: September 2011 - ACI 224.X – Summary of Negatives and Editorials and Meeting Ballot Results (October 16, 2011)

No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
1.	Frosch	4	17	N	<p>It is stated that the “objective of this document is to address the overall nature of a structure and how members may experience additional cross-sectional stresses due to the restraint caused by the overall structural system.”</p> <p>This objective doesn’t seem to really indicate what the objective of the document is about. Also “Address the overall nature of a structure” seems way too broad. Suggest we clean this up to indicate to precisely state what the objective is. Seems that the objective should somehow have wording about “control of cracking” in it.</p>	<p>Persuasive. Text revised as follows:</p> <p>“In contrast, the objective of this document is to address the control of cracking by considering the overall nature of a structure and how members may experience additional cross-sectional stresses due to the restraint caused by the structural system. The effect of the geometry and layout of the concrete framing system on the unexpected cracking of individual members or joints is discussed, and recommendations for more favorable arrangements of structural framing to minimize restraint are presented. Additionally, specific framing conditions where the cracking of a particular part of the structure is directly or indirectly affected by the neighboring elements or the overall framing system are discussed, and suggested reinforcement and release details to avoid or minimize such cracking are provided.”</p> <p>Motion: Schokker Second: Barth Affirmative: 13 Opposed: 0 Abstain: 0 <u>Motion Passes</u></p>
2.	Darwin	7	18	A	<p>It is not clear that we need to identify the specific version of ACI 318 since the report states that “This document may call for minimum reinforcement...” Suggest dropping “-11” This recommendation does not pertain to other sections of the report where specific sections of ACI 318-11 are referenced.</p>	Change made.
3.	Bischoff	9	6-8	A/C	Suggest rephrasing as "However, specific slab systems are NOT PROVIDED".	Change made.
4.	Darwin	11	8	A	Change “since” to “following”	Change made.
5.	Bischoff	13	4	A/C	Should "shortening tensile stress" be "axial shortening tensile stress"?	Change made.
6.	Darwin	29	10	A	Add a comma after “case”	Change made.

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7.	Darwin	30	19	A	Change “have” to “provide”	Change made.
8.	Darwin	35	14	A	Change “...frames to the exterior of the building result in restraint of the movement towards the 14 center of the structural resulting in a less favorable arrangement.” to “...frames near the exterior of the building restrain movement towards the center of the structure, resulting in a less favorable arrangement.”	Change made.
9.	Darwin	38	2	N	Drop “about.” ACI 318 does not require an approximate range.	Persuasive. Sentence has been rewritten as follows: “For typical one-way slabs, Section 10.6.4 of ACI 318-11 specifies the maximum spacing of reinforcing bars or post-tensioning tendons in the principal flexural direction depending on the amount of concrete cover and exposure conditions. Typically, this results in a maximum spacing of 10 to 12 in. (250 to 300 mm).” Motion: Barth Second : Schokker Affirmative: 13 Opposed: 0 Abstain: 0 <u>Motion Passes</u>
10.	Bischoff	38	3	A/C	Depending on THE amount of concrete cover	Change made.
11.	Frosch	38	14	N (A/C)	Seems that we should add a comment that 18 in. is too far and that a 12 in. max would control cracking to a much improved extent.	Persuasive. The following text has been added after sentence in question. “While 18 in. is the maximum permissible code spacing, ACI 224 recommends that this spacing be limited to 12 in. When using minimum amounts of temperature and shrinkage reinforcement, the reinforcement stress can exceed 40 ksi at first cracking resulting in crack widths greater than 0.016 in. Tests results and analytical modeling indicate that a maximum spacing of 12 in. will

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						<p>improve crack control (Blackman and Frosch 2005, Frosch 1999).”</p> <p>References added: Blackman, D.T. and Frosch, R.J. (2005). “Epoxy Coated Reinforcement and Crack Control,” Serviceability of Concrete, SP 225, American Concrete Institute, Farmington Hills, Mich, pp. 163-178. Frosch, R.J. (1999). “Another Look at Cracking and Crack Control in Reinforced Concrete,” ACI Structural Journal, Vol. 96, No. 3, May-June 1999, pp. 437-442.</p> <p>Motion: Darwin Second: Schokker Affirmative: 15 Opposed: 0 Abstain: 0 <u>Motion Passes</u></p>
12.	Darwin	55	13	N	<p>Committee 360 provides more guidance than this when dealing with 1-in. deep sawcut joints, including “This recommendation assumes that the early-entry dry-cut saw is used within the time constraints noted previously. Some slab designers require cutting the slab the following day to 1/4 of the slab depth to deepen the 1 in. (25 mm) early-entry sawcut and ensure the joint activates. Restricted joint activation using a 1 in. (25 mm) sawcut is a particular concern with doweled joints because dowels may restrain slab movement.” This report needs to provide similar warnings.</p>	<p>Persuasive.</p> <p>I agree a change to the text is appropriate, but to repeat all the details given in 360 is not necessary.</p> <p>Pg55, line 9 change para to read: “Traditionally, designers specify the depth of contraction joints as one-fourth the depth of the slab, regardless of the manner in which the joint was formed. ACI 360 states that one-fourth the depth of the slab is appropriate for joints sawcut by conventional wet-cut saws. Also, for early-entry dry-cut saws the depth can be a minimum of one inch (25 mm) for slabs up to 9 inches (225 mm) thick. Some slab designers require the slab to be cut the following day to one-fourth the depth of slab by deepening the one inch (25 mm) sawcut. The early-entry saw cuts need to be placed typically within 1 hour in hot weather and 4 hours in cold weather. Experience has shown that when creating a weakened cross-section in “fresh” concrete by tooling joints, inserting plastic strips, or saw-cutting with early entry saws, the resulting joints function successfully at depths</p>

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						<p>less than one-fourth of the slab depth.”</p> <p>Motion : Darwin Second: Riveros Affirmative: 13 Opposed: 0 Abstain: 0 <u>Motion Passes</u></p>
13.	Darwin	55	16	N	<p>Advising readers to use a ½-in. grooving tool for slabs up to 4 in. thick is inappropriate. It’s like the dark ages. I know that we get away with this quite often, but I’ve seen many cases where cracks in the slab run parallel to the grooved “joint.” The line says “experience has shown.” I would argue that other experience has shown that the slab will crack. The statement should not be in a 224 document.</p>	<p>Persuasive.</p> <p>See discussion above. Revised text for Item 12 eliminates the ½” joint and discusses permitting ¾” joints in slabs up to 5 in. thick. This is based on a number of years of experience when the early-entry saws were initially introduced into the field, the saws only cut to a depth of ¾” and the saws were used successfully on slabs up to 5 in. thick. The later models cut to a depth of 1.5”. Revised text is as follows:</p> <p>“Experience has shown that when creating a weakened cross-section in “fresh” concrete by tooling joints, inserting plastic strips, or saw-cutting with early entry saws, the resulting joints function successfully at depths less than one-fourth of the slab depth. The resulting contraction joints may be created by early-entry dry-cut sawcuts, plastic inserts, scoring, or grooving to a depth of ¾ inch (19 mm) for slabs up to 5 inches (125 mm) thick.”</p> <p>Motion: Frosch Second: Schokker Affirmative: 7 Opposed: 1 Abstain: 7 <u>Motion Fails.</u></p> <p>Revised response based on Committee discussion: Remove second sentence referring to ¾” joints.</p> <p>Motion: Frosch</p>

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No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
						Second: Darwin Affirmative: 12 Opposed: 0 Abstain: 2 <u>Motion Passes</u>
14.	Darwin	63	11	A	Remove the period after “ft”	Change made.

¹**Notes:** A/C – Affirmative with comment: use for editorial comments.

N - A negative vote must be explained in writing to receive committee consideration. The voter should provide alternative wording that would satisfy the voter’s concerns.

Committee 224 Ballot Comment Form - Table of Editorials and Negatives and Author Responses

Ballot: ACI 224R Revision – Revised Chapter 6 on Long-Term Cracking

Summary of Negatives and Editorials and **Meeting Ballot Results (October 16, 2011)**

No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
1.	West	--	--	N	Sections 6.3 and 6.4 do not provide substantial, or insightful, information on long-term cracking related to environmental effects or durability-related problems. Providing more detail or depth will duplicate information found in other ACI documents. These sections should be removed and replaced with a short section directing the reader to appropriate ACI Committee 201 documents for information on cracking related to lack of durability.	Negative withdrawn by voter. (Oct. 16 Meeting)
2.	Poston	1	8	A	Suggest "...can be affected..."	Persuasive, change as noted
3.	Darwin	1	9	N	Change "...extend the magnitude of cracks, principally their width and depth, in both reinforced and plain concrete,..." to "...increase the magnitude of cracking, which may be manifested by increases in crack width, crack depth, or crack length, ...".	Persuasive, change as noted Motion: Nawy Second: Schokker Affirmative: 12 Negative: 0 Abstain: 1 <u>Motion passes</u>
4.	Darwin	1	10	N (A/C)	Consider adding the following just after "...reinforced and plain concrete": "An example of long-term effects on cracking is shown in Fig. 6.1, which illustrates the increase in crack density (expressed as the average length of cracks per unit area) on bridge decks over time (Darwin, Browning, and Lindquist 2004). Data points connected by straight lines represent the same bridge deck at different ages. In the cases illustrated, the impact of age may result from repeated loading, on-going environmental effects, continuing volume change, or a combination of the three. The magnitude of cracking shown in the figure is expressed in terms of length, but the magnitude may also reflect an increase in crack width, which allows for easier crack identification." Darwin, D.; Browning, J.; and Lindquist, W. D., 2004, "Control of Cracking in Bridge Decks: Observations from the Field," <i>Cement, Concrete and Aggregates</i> , ASTM International, V. 26, No. 2, Dec., pp. 148-154.	Text will be revised to mention paper as an example, but figure will not be added. <u>To be web-balloted after the meeting.</u>

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No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
5.	Darwin	1	101		<p>Fig. 6.1—Bridge deck crack density versus bridge age for monolithically-cast bridge decks (Darwin, Browning, and Lindquist 2004). Points connected by lines indicate that the same bridge deck was surveyed multiple times. Note: 1 m/m² = 0.093 ft/ft².</p>	
6.	Roberts	--	--	G	Bryant Mather said that the moisture conditions and differential temperature of concrete are determinants of the long term effects on cracking. The well-written revision of ACI 224R-01 needs several clarifications:	

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No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
7.	Roberts	2	20	N	Insert a sentence between “reinforcement” and “If” as follows: “UNDER IDEAL CONDITIONS OF MOISTURE AND TEMPERATURE ESPECIALLY WITH INSULATED FORMS AND INTERNAL CURING AUTOGENOUS SHRINKAGE AND CRACKING CAN BE REDUCED OR ELIMINATED IN HIGH PERFORMANCE CONCRETE (HPC).	Negative withdrawn by voter. (Oct. 16 Meeting)
8.	Iqbal	2	21	N	The phrase “critically saturated is vague and needs to be defined. Second, “bursting effect” is not proper term. Suggest using “expansive attribute”, just state: . . . develop because water expands when it freezes.	Persuasive. Text revised to <i>“If concrete is not resistant to freezing and thawing or does not meet the requirements in Chapter 4 of ACI 318, there is a risk that cracks will develop if the saturated concrete freezes.”</i> Motion: Ferraro Second: Riveros Affirmative: 10 Negative: 0 Abstain: 3 <u>Motion passes</u>
9.	Iqbal	2	25	N	“D-cracking” needs some explanation.	Non-persuasive. Change made based on 2009 ballot comments added reference to ACI 201.2R. <u>To be web-balloted after the meeting.</u>
10.	Iqbal	2	26	N	The “more extreme” is improper. Extreme means extreme. It can be “near extreme” but not “more extreme”. Suggest using “some”, or “severe”.	Persuasive and change to <i>'In severe cases, it is....'</i> <u>To be web-balloted after the meeting.</u>
11.	Iqbal	2	30	A	The sentence needs to re-phrased. Do pre-existing cracks affect frost resistance? Or, frost action causes cracks? Or both/	Non-persuasive. The sentences as written states that both conditions are possible. <u>To be web-balloted after the meeting.</u>

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No.	Last Name	Page #	Line #	A, A/C, N ¹	Comment	Committee Response
12.	Iqbal	2	36	N	The sentence should be deleted or more explanation needs to be provided. The sentence is vague. It compares “old-style” with “modern” deformed patterns with explaining what the patterns are. Is it based on 1967 study/	Persuasive. Delete sentence. To be web-balloted after the meeting.
13.	Bice	3		E	A brief discussion of delayed ettringite formation would appropriate in section 6.4.	<p>Non-persuasive. ACI 201.2R states the following in the introduction section:</p> <p>Because the topic of delayed ettringite formation (DEF) remains a controversial issue and is the subject of various ongoing research projects, no definitive guidance on DEF is provided in this document. It is expected that future versions of this document will address DEF in significant detail.</p> <p>A report issued by ACI 365, ACI365.1-R00, Service-Life Prediction provides a good description of DEF that could either be referenced or modified:</p> <p>2.2.1.2 Delayed ettringite formation—Structures undergoing delayed ettringite formation (DEF) can exhibit expansion and cracking. The distress often is attributed to excessive steam curing that prevents the formation or causes decomposition of ettringite that is normally formed during the early hydration of portland cement. Use of cements with high sulfate contents in which the sulfate has very low solubility can also lead to DEF. In one case where this has been reported (Mielenz et al. 1995), it was thought that the occurrence of DEF was due to the sulfate formed in the clinker of the cement being present as anhydrite and as a component of the silicate phases which are slowly soluble. Ettringite is the product of the reaction between sulfate ions, calcium aluminates, and water. If structures susceptible to DEF are later exposed to water, ettringite can reform in the paste as a massive development of needle-like crystals, causing expansive forces that result in cracking. The extent of development of DEF is dependent on the amount of sulfate available for late ettringite development in the particular concrete and on the presence of water during the service life. Elevated temperatures also increase the potential for damage due to DEF. Prevention or minimization of DEF can be accomplished by lowering the curing temperature, limiting clinker sulfate levels, avoiding excessive curing for potentially critical sulfate to aluminate ratios, preventing exposure to substantial water in service, and using proper air entrainment. Neither the mechanisms involved in DEF nor their potential consequences relative to concrete durability are completely understood. DEF leads to a degradation in concrete mechanical properties, such as compressive strength, and can promote increased permeability. A detailed review of over 300 publications dealing with DEF is available (Day 1992).</p> <p>To be web-balloted after the meeting.</p>

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14.	Bice	3	3	E	<i>Suggest changing this section title to Deleterious Internal Reactions</i>	Persuasive. Text revised to “ <i>Deleterious Internal Reactions and Other Effects</i> ” <u>To be web-balloted after the meeting.</u>
15.	Bice	3	5	E	Delete “from the cement” after pore water.	Persuasive
16.	Bice	3	9	N	Replace membrane with penetrating concrete sealer	Persuasive. Text revised to “ <i>membrane or penetrating sealer</i> ” <u>To be web-balloted after the meeting.</u>
17.	Roberts	3	7	N	between “cement” and “and” insert “USE OF LIGHTWEIGHT EXPANDED SHALE AGGREGATE”	<u>To be web-balloted after the meeting.</u>

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