

# ACI Committee 209 –CREEP AND SHRINKAGE IN CONCRETE

## MINUTES

### ACI 2010 Fall CONVENTION

Pittsburgh, PA, October 25, 2010

#### 1. Opening of the Meeting and Welcome

The meeting was called to order by Chairman Videla at 8:45 AM and all in attendance were welcomed to the meeting.

#### 2. Welcome and Introduction of Members

##### Attendees

##### VOTING MEMBERS

Carlos Videla (Chair)  
Domingo J. Carreira (Secretary)  
Akthem Al-Manaseer  
Mario A. Chiorino  
Marwan A. Daye  
Will Hansen  
Hesham Marzouk  
Hani H. Nassif  
Ian Robertson  
Jason Weiss

##### ASSOCIATE MEMBERS

Gianluca Cusatis  
Matthew D'Ambrosia  
Sungjin Bae  
Mauricio Lopez

##### VISITORS

Patrick Bamonte  
Peter Bischoff  
Jake Hiller  
Hui Liu  
David Mokaren  
Yt Sun  
David Stringer

Meeting attendees introduced themselves.

##### Apologies

Voting members Zdeněk P. Bažant and Mohsen A. Issa offered apologies for not being able to attend the meeting.

#### 3. Announcements

Next meeting will be on Monday, April 4, 2011 from 8:30 to 11:30 AM at Marriott Tampa Westin Harbour Island, Tampa, FL.

Changes in membership:

- ACI sent official notification to the Chairman of the appointment of Alhassan, Mohammad A, Gilbert, Raymond Ian, and Hamedanimojarrad, Pedram as new associate members.
- Due to his new position as Executive Vice President of the American Concrete Institute, Ronald Burg informed the chair that he could no longer be voting member of the committee.
- The chair informed that Galit Agranati, Mai A. Almarzouq, and Ziad Sabha are no longer associate members since they are not ACI members.

Copies of the following documents were distributed at the meeting:

- Agenda for this meeting.
- Minutes of the Chicago, IL Spring 2010 meeting.
- Committee Roster (10/21/2010) (see Attachment A).
- TAC Final Comments to “Report on Factors Affecting Shrinkage and Creep of Hardened Concrete” (209.1R) (see Attachment B).

These documents were previously distributed via the ACI 209 web site and email.

#### **4. Approval of Minutes from the Spring Meeting in Chicago, IL.**

Chairman Videla asked for review and approval of the minutes. Hansen moved and Marzouk seconded to accept the minutes as submitted. All members present voted in favor of approving the Chicago meeting minutes.

#### **5. Current Subcommittees Actions Updates.**

##### **5.1 Status of ACI 209.1R-05 “Report on Factors Affecting Shrinkage and Creep of Hardened Concrete.”**

Carreira reported on the status of the TAC comments and their resolution. Al-Manaseer, Marzouk and Hui Liu (with the translation of chinese language references, hliu@mail.bradley.com) volunteered to help in the resolution of the TAC comments.

TAC comments will be sent again to all ACI 209 committee members for their input of possible responses to the type P comments. Then, the proposed responses to TAC comments will be balloted.

##### **5.2 Status of ACI 209.3R-XX “Analysis of Creep and Shrinkage Effects in Concrete Structures”**

Concerning the status of ACI 209.3R-XX Chair Videla reminded that the report was approved through two subsequent ballots, ending 10/26/2008 and 11/6/2009 respectively, with a limited number of remaining negatives to be resolved. After the Chicago meeting Chair Videla was informed by Gardner and Nassif the withdrawal of their negatives concerning the first ballot (see Attachment C).

Concerning the remaining negative by Bažant related to the first ballot, Chiorino informed the Committee that, according to the agreement reached in the Chicago meeting, Bažant forwarded a text intended to widen previous Section 2.4.5.2 “Rate-type creep laws” of the report, providing more detailed information on rate type 3D computer analysis. In order to give higher visibility to all the methods of solution for creep analysis problems, Chiorino indicated that the corresponding sections will be raised to two digits. Therefore, the revised old Section 2.4.5.2 will be redenominated Section 3.7 “Numerical solutions for structural analysis based on rate-type creep law”. Similarly, previous Section 2.4.5.1 “Incremental numerical solution based on the hereditary integral” will also be raised to two digits being redenominated Section 3.6 “Numerical solutions for structural analysis based on history integrals”. Section 2.5 “Age-Adjusted Effective Modulus method (AAEM)” (already two digits) will become Section 3.8.

The changes in the first digit from 2 to 3 are due to the need to comply with new ACI standards format, requiring adding to the report a new Chapter 2 – Notation (presently Appendix L) in the main body of the report, with the sections renumbering the document accordingly.

Referring to the new revised Section 3.7 “Numerical solutions for structural analysis based on rate-type creep law”, Chiorino indicated that while this section, through the incorporation of Bažant’s contribution, will provide adequate guidance for rate type 3D analysis, only basic information will be given for more refined analyses based on local constitutive laws, instead of through-thickness average, and, in general, for problems of non stationary humidity and temperature conditions, and their possible combinations with the effects of cracking. To establish adequate profession-oriented guidelines to cover these advanced aspects, further committee activity will be required, aiming to a specific guidance document.

Chiorino indicated that Bažant’s contribution being edited in the form of a scientific paper will need some adjustments to comply with the present structure of the document. Namely, fundamentals will be located in the main body of the report and detailed algorithms in Appendix B, in the same way as already done for current Section 2.4.5.1 (to become Section 3.6 as indicated above). Consequently, present Appendix B will be re-denominated “Numerical Solutions of the Aging Linear Viscoelasticity Problems: Integral-type and Rate-type Approaches – Detailed Algorithms”. As for the example of application concerning the case study of Palau bridge collapse, members of Subcommittee for ACI 209.3R-XX suggested that a concise description of the paper published by Bažant et al. in Concrete International June 2010 issue should be include in the report.

Chair Videla asked Chiorino to proceed to the editorial amendments of ACI 209.3R-XX document in agreements with items above, giving priority to the reshaping of Section 3.7 and Appendix B. After circulation within the Subcommittee for ACI 209.3R-XX for preliminary discussion, these two sections will be submitted to a new ballot.

### **5.3 Status of ACI 209.4R-XX “Test Methods for Creep and Shrinkage,”**

Nassif informed of the progress in the proposed report subcommittee ACI 209.4R-XX.

## **6 Other Business**

No other business.

## **7 New Business**

No new business.

## **8. Presentations**

From 9:35 AM to 9:45 AM, Chiorino presented the SEWC 2011 Structural Engineers World Congress to be held in Villa Erba, Como, Italy, from April 4Th to 6th. The Congress contains a Special Session entitled “Time dependent behavior of concrete: prediction models and methods of analysis”. Chiorino will deliver the invited lecture: “Analysis of structural effects of time-dependent behavior of concrete: an internationally harmonized format”. See the flyer of the Congress in Attachment D.

From 9:45 AM to 9:55 AM, Chiorino presented the “CISM Advanced Course Analysis of Creep and Shrinkage Effects in Concrete Structures,” to be held from May 23 to 27, 2010 in Udine, Italy. He invited all the attendees to sent students and young professional to this event. See the program of the Course in Attachment E.

## **8. Adjournment**

A motion to adjourn was submitted by Al-Manaseer and seconded by Marzouk. All members present voted to adjourn. The meeting adjourned at 10:00 AM.

### **Attachments:**

- A. Committee Roster (10/21/2010) with corrections.
- B. TAC Final Comments to “Report on Factors Affecting Shrinkage and Creep of Hardened Concrete” (209.1R)
- C. Resolution of Nassif and Gardner negatives votes to ACI209.3R ballots
- D. Flyer of SEWC 2011 Structural Engineers World Congress
- E. Program of the CISM “Advanced Course Analysis of Creep and shrinkage Effects in Concrete Structures.”

Respectfully submitted by D. J. Carreira, Secretary.

## ATTACHMENT A

### Committee Roster Creep and Shrinkage in Concrete (10/21/2010)

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## ATTACHMENT B

### TAC Final Comments to “Report on Factors Affecting Shrinkage and Creep of Hardened Concrete” (209.1R)

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
1.	0	0	G	The committee is asked to generally follow ACI style for a notation section. The document often uses notation that is explained in the text. Please include all notations in the notation section.	
2.	0	0	G	The committee is asked to generally follow ACI style for a definition section. The terms should be alphabetized, followed by a definition. Where terms exist in ACI Concrete Terminology, copy that definition unless it is inappropriate. Return general information to chapter 1.	
3.	0	0	G	Please review all figures for clarity and revise as appropriate.	
4.	0	0	S	<p>Consider reviewing information in the following papers that report on recent research in this area:</p> <p>1- Effect of silica fume on mechanical properties of high-strength concrete, Mazloom, M.; Ramezaniyanpour, A.A.; Brooks, J.J. Source: Cement and Concrete Composites, v 26, n 4, p 347-357, May 2004</p> <p>Effect of supplementary cementitious materials on shrinkage and crack development in concrete, Akkaya, Y.; Chengsheng Ouyang; Shah, S.P. Source: Cement and Concrete Composites, v 29, n 2, 117-23, Feb. 2007</p> <p>2-Influence of fly ash proportion on creep characteristics of high-performance concrete and its mechanism Zhao Qingxin; Sun Wei; Zheng Keren; Chen Huisu; Qin Honggen; Liu Jianzhong Source: Journal of the Chinese Ceramic Society, v 34, n 4, 446-51, 2006</p> <p>3-Creep character of high performance concrete with ground granulated blast furnace slag and fly ash, Zhao, Qing-Xin; Sun, Wei; Liao, Chang-Wen; Tian, Qian; Zhen, Ke-Ren; Lin, Wei Source: Wuhan Ligong Daxue Xuebao/Journal of Wuhan University of Technology, v 27, n 11, p 35-38, November 2005</p> <p>4-Creep characteristics of concrete with compound ultra-fine fly ash, Xie Youjun; Ma Kunlin; Liu Baoju; Shi Mingxia Source: Journal of the Chinese Ceramic Society, v 35, n 12, 1636-40, Dec. 2007</p> <p>5-Development of high volume fly ash cements for use in concrete</p>	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
				construction, McCarthy, M.J.; Dhir, R.K. Source: Fuel, v 84, n 11, p 1423-1432, August 2005 6-Influence of fly ash and GGBS on volume stability of high performance concrete, Zhao, Hua-Geng; Peng, Jin; Zhou, Ming-Kai Source: Wuhan Ligong Daxue Xuebao/Journal of Wuhan University of Technology, v 27, n 7, p 36-38, July 2005	
5.	1	20	E	Suggest “guide” should be “report.”	
6.	4	3	E	Change “enable” to “enables.”	
7.	4	18	E	ACI style is as follows: ACI 209R-72 summarized ... however, committee 209 didn’t publish in 1972, so this must be a typo. Perhaps 1982 or 1992 was intended.	
8.	4	6	E	State what Chapter 2 contains	
9.	4	14	E	Delete “the” before cement	
10.	4	17	E	Suggest replacing “these” by “other,” “relevant”, or “pertinent”	
11.	5	1	P	Delete this mechanism from the list because (1) it is a derivative of the two previous mechanisms, not a third mechanism, and (2) it is not described very well and is confusing. The term “delayed elasticity” is confusing – is this referring to delayed elastic deformation due to restraint (i.e. visco-elastic deformation) or is it some kind of reference to the development of the elastic modulus?	
12.	6	7	E	Change “in the references” to “in the following references.”	
13.	6	7	E	Replace “Ulm, Le Maou, and Boulay” with :”Ulm et al.”	
14.	6	12	E	“Effect of chemical and mineral admixtures” should be changed to “Effect of chemical admixtures and supplementary cementitious materials”	
15.	6	16	S	Recommend adding creep recovery to the list of areas for further research	
16.	6	8	P	Section 1.3 has an imbalance that impairs its message. Some items are so broad as to be meaningless – i.e. effect of outdoor exposure. Some items are specific kinds of concrete – i.e. high strength concrete. Can this list be more insightful? Perhaps this section should be deleted.	
17.	8	7	E	Change “occurs” to “occur.”	
18.	9	14	E	Change “x10 <sup>6</sup> ” to “x10 <sup>-6</sup> .”	
19.	9	16	E	Change “Zia, Ahmad and Leming” to “Zia et al.”	
20.	9	3	E	Change “occurs” to “occur”	
21.	9	19	P	The references need to have more recent research work cited.	
22.	11	11	S	A few comments about carbonation shrinkage would be helpful. Not clear	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
				why it's outside the scope.	
23.	11	14	S	A few comments about plastic shrinkage would be helpful. Not clear why it's outside the scope	
24.	11	20	E	Delete "the" before age	
25.	12	11	P	Does load duration refer to the time taken to complete the test? Please clarify.	
26.	13	6	P	The 30 years of measurement seems to be referencing a 1975 Bazant paper. Has there been any further review of this?	
27.	13	6	P	What is the practical significance? Presumably the rate of increase in strain at 30 years is small.	
28.	13	10	P	What time frame does long term refer to 5 years, 30 years?	
29.	13	20	E	Consider changing to "...caused by a constant uniaxial sustained stress applied at loading age..."	
30.	14	3	E	Delete "the" twice	
31.	14	12	P	Fig 2.2 shows a "quirky" s-curve shape for some of the curves. This kind of figure is offered to the reader as "classic behavior" and it may be more instructive to show classic smooth curves. I believe that some experiments have shown those s-curves, but most do not.	
32.	15	11	P	It is not clear what is meant by the time taken to measure it. Please explain why using the specific creep is not recommended.	
33.	15	15	P	At the initial loading of the specimen, should there be a minimum period of time before one can have a stabilized reading – would 2 minutes be too short?	
34.	15	18	P	Please provide an example of a type of concrete that would have a creep coefficient at 6?	
35.	15	7	E	Define $E_c(t_0)$ after this equation (2-3), rather than a page later	
36.	16	3	P	Please explain the reason to only report a 28-day creep coefficient?	
37.	16	4	E	The reference style should be CEB, 1990. What is GL2000 referencing?	
38.	16	5	E	Change to "28-day"	
39.	16	14	E	Definition seems to include instantaneous strain on unloading. Is this what is intended?	
40.	17	4	E	Replace "detail" with "details."	
41.	17	4	P	Improve the figure's presentation. Fig 3.1 should show "restraint" under Element. Under Environmental Parameters, remove "Type of curing" since that is already described by the RH, Temp, Curing period.	



No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
42.	18	13	E	Figure 3.2 is not clear. Please revise.	
43.	19	6	E	Figure 3.3 is not clear. Please revise.	
44.	19	7	E	Remove the second sentence from the caption and place in the text of the report at the appropriate place.	
45.	19	13	E	Change “due to” to “by”	
46.	20	6	E	Replace “aggregate” with “aggregate shape.”	
47.	20	13	E	Put comma after respectively	
48.	21	15	E	Change “also” to “also increase.”	
49.	21	10	E	Figure 3.5 is not clear. Please revise.	
50.	21	1	P	Please provide a reference for Eq 3-2. Is this the same alpha as Eq 3-1?	
51.	22	2	E	Figure 3.6 is not clear. Please revise.	
52.	23	5	E	Figure 3.7 should be made larger for legibility. Several other figures were also somewhat difficult to read due to their size.	
53.	23	7	P	The figure is based on 70 year old information. Is this still valid considering the differences in concrete then versus now? If this is only ‘classic’ information, please note that.	
54.	23	7	E	Figure 3.7 is not clear. Please revise.	
55.	24	2	E	Change “high alumina content” to “high alumina cement content” or to “cement with high alumina content.”	
56.	24	12	E	Change “Both chemical” to “Both chemical admixtures.”	
57.	24	15	P	There is a need to re-examine Table 3.1 with regard to more recent studies on the effect of silica fume and Fly ash on shrinkage. Brooks (1989 and 1999) are relatively outdated. There is a need to cite more recent references regarding the effect of silica fume on drying shrinkage. Also it has been shown that Fly Ash helps reduce shrinkage.	
58.	25	10	E	Change “Portland” to “portland” (lower case).	
59.	25	20	E	de Larrand 1994 is not in references. Should it be de Larrand et al. 1994?	
60.	25	1	E	Section heading 3.2.5.1 “Mineral Admixtures” should be changed to “Supplementary Cementitious Materials” to be consistent with current usage and heading of Section 4.2.5.1	
61.	26	18	E	Change “rather than increase” to “rather than to increase.”	
62.	27	2	E	Change “concluded that at” to “concluded that in.”	
63.	27	2	P	Can the committee expand information on “ice replacement?”	
64.	27	7	E	Missed a comma between references.	
65.	27	11	E	SRA’s should be SRAs	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
66.	27	7	E	Change reference to "...2002, ACI 213)"	
67.	28	2	E	Change "most used" to "most frequently used."	
68.	28	2	E	Insert "widely" between most and used. Is there a reference for Eq 3-3?	
69.	28	18	E	Figure 3.8 is not clear. Please revise.	
70.	28	7	S	Range of 1 to 4 seems to be too large to be useful, without a clear guidance of selection criteria. Can you elaborate?	
71.	28	19	P	Fig. 3.8 has a typo, D should be 50 mm, not 0.50 mm. Also, relative humidity graph on the top of Fig. 3.8 is not clear.	
72.	29	5	P	Is the information presented in this section related to CEB 1990 or 1999? Why not discuss the more recent shrinkage CEB model?	
73.	29	17	E	Change "Jenson and Hanson" to "Jensen and Hansen."	
74.	29	21	P	Fig 3-9 seems to indicate that drying shrinkage can be decreased by reducing the curing time. This seems counterintuitive. Can the committee address this more fully?	
75.	30	2	E	Figure 3.9 is not clear. Please revise.	
76.	30	7	E	Re-word. Not sure what "5 to 10 times lower than" means	
77.	30	9	E	Chapter 3 deals with shrinkage, so consider removing reference to creep	
78.	31	5	E	Figure 3.10 is not clear. Please revise.	
79.	31	17	E	Change "tension effects as water hydrates within the concrete" to "tension effects developing in the pore system within the concrete as a result of removal of water during the hydration process."	
80.	31	10	P	What is the relationship – proportional?	
81.	31	3	E	Be consistent with units used in figures: some use SI and US, some SI only, and this figure uses US only.	
82.	32	7	E	Delete "also."	
83.	32	16	E	Fig 4-1 should be moved to p33 line 9. Place after paragraph where first mentioned.	
84.	33	19	E	ACI makes 'normal weight' one word, normalweight.	
85.	34	5	E	Change "easier" to "more easily."	
86.	34	10	E	Figure 4.2 is not clear. Please revise.	
87.	35	15	E	Replace "concrete" with "concretes."	
88.	35	18	E	Change "water alone" to "water content alone."	
89.	36	11	E	Change "complex effect of mineral" to "complex effect of chemical admixtures."	
90.	36	14	P	The basis for table 4.1 is questioned since it from a reference that is more	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
				than 20 years old. Please check other references and confirm.	
91.	36	18	E	Change “cement” to “portland cement.”	
92.	37	10	E	Change “posses” to “possesses.”	
93.	38	21	E	Change “exposed and loaded” to “exposed when loaded.”	
94.	38	13	E	Change “considerably” to “significant.”	
95.	38	17	E	Change to “...difference compared with plain....	
96.	38	19	E	Change “was” to “were.”	
97.	39	8	E	Figure 4.3 is not clear. Please revise.	
98.	40	2	E	Figure 4.4 is not clear. Please revise.	
99.	41	6	E	Figure 4.5 is not clear. Please revise.	
100.	42	5	E	Change “are important when minimizing” to “are important when it is necessary to minimize.”	
101.	42	12	E	Change “Fig. 1.2” to “Fig. 2.2.”	
102.	43	3	E	Remove “)” after “8890 psi”	
103.	44	9	E	Change “under load greater” to “under load for a period greater.”	
104.	44	7	E	The reference to an 1871 Austrian paper and a 1909 Italian paper sent me to Wikipedia! Would it be sufficient to simply refer the reader to McHenry?	
105.	44	5	E	What does “it was assumed” refer to?	
106.	44	14	P	Creep recovery at early age , e.g. on removal of shoring/re-shoring during construction is an important issue. Can the committee provide any information on the order of magnitude that can be expected for irrecoverable creep as opposed to the assumption of the principle of superposition?	
107.	46	15	E	Update the committee 363 reference to 1992.	
108.	46	15	E	Change “to” to “with”	
109.	46	16	E	Provide reference to “Section 8.5.1” in ACI 318	
110.	47	21	E	Reference for (Neville 1977) is missing, needs to be added	
111.	47	4	P	What is $R^2$ and where is the term $R^2 = 0.68$ in ACI 318?	
112.	47	6	E	The number of significant figures in coefficient seems excessive.	
113.	47	10	P	How significant is the dispersion? Please elaborate.	
114.	47	12	P	Even with improved estimates of $E_c$ field measured deflections can be expected to vary significantly from calculated values due to inherent variability. Suggested re-wording for sentences in lines 12 to 15: “These equations provide approximate values for $E_c$ based on $f'_c$ that can be used for deflection calculations required to satisfy the deflection control	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
				requirements of ACI 318. An improved estimate for $E_c$ could be obtained from tests on concrete used for a specific project.	
115.	47	16	E	Change “is available” to “are available”	
116.	47	11	E	Provide reference to “Section 8.5.1” in ACI 318	
117.	48	17	E	Change “at mixing as low” to “at mixing to as low.”	
118.	48	17	P	Is there a reference to substantiate the low mixing temperature connection?	
119.	48	21	E	Re-word as “ ..but some test data show otherwise...”	
120.	48	20	P	Please clarify – shrinkage in HSC could be more and creep could less than in concrete with $f'_c$ between 4-6 ksi.	
121.	49	4	E	Change: matrix with volumes as high as twice as to: matrix with paste volumes as high as twice of	
122.	49	10	E	The first sentence “All factors.....and shrinkage” appears to be incomplete. Needs to be re-written.	
123.	49	6	E	Suggest “aggregate <u>in the mixture proportion</u> should be maximized <del>during mixture design</del> to increase ...”	
124.	49	10	E	Suggest “All factors <u>that result</u> in a high modulus of elasticity in the concrete <del>apply</del> similarly result in a concrete with low creep and shrinkage.”	
125.	50	10	E	Change: Carreira and Burg to: Procedures suggested by Carreira and Burg	
126.	50	21	P	While the idea that more curing results in less drying creep makes sense, are there experimental results that bolster the case?	
127.	50	20	E	No need to reference specific sections here within the same document	
128.	51	4	E	Change “only curing method” to “only practical curing method.”	
129.	51	18	E	Add ACI 301 to section 6.1	
130.	51	19	P	By reducing the maximum achievable strength through early heat, wouldn't this have the effect of increasing long-term creep? If so, this would be in opposition to the statement on line 16.	
131.	52	2	E	Change “construction in creep” to “construction of creep.”	
132.	52	4	E	Change “that verify design” to “that verify that the design.”	
133.	52	3	P	Please give examples of shrinkage sensitive structures that would require the additional tests and measurements you are proposing.	
134.	53	21	E	Provide reference to “Section 5.6.3.3” in ACI 318	
135.	58	11	E	Replace <i>Cement and Concrete Research</i> with <i>Cement and Concrete Composites</i>	
136.	61	17	E	This draft is 11 years old. Was it ever finalized? Revise reference.	
137.	62	1	E	Reference from 2003 should be placed after reference from 2000	

No.	Pg #	Line #	G/E/P/S	TAC Comment	Committee Response
138.	62	1	E	Reference from 2006 should be placed after reference from 2005	
139.	62	5	E	Incomplete citation (volume, page #?)	
140.	64	3	E	Fix the citation (source? Gaithersburg or Lung?)	
141.	66	12	E	Reference from 2006 should be placed after reference from 2005	

## ATTACHMENT C

### ATTACHMENT C

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**Carlos Videla Cifuentes**

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**De:** Hani Nassif [nassif@rci.rutgers.edu]  
**Enviado el:** Miércoles, 31 de Marzo de 2010 8:07  
**Para:** Carlos Videla  
**CC:** mario.chiorino@polito.it  
**Asunto:** Resolving my Negative

Dear Carlos,

It was my pleasure seeing you in Chicago. I hope you had a nice trip back to Chile. Please be informed that Mario and I met during the ACI Chicago convention and went over the change and updates that were made to the ACI 209.3R document. To help move forward with the document, I am changing my negative vote to an affirmative since the new changes are acceptable and have resolved my concerns. Please let me know if you need any other information.

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Best Regards,

Hani H. Nassif, Associate Professor  
Dept. of Civil & Env. Engineering  
Rutgers, The State University of New Jersey  
623 Bowser Road, Piscataway, 08854-8014  
Tel: (732) 445-4414 Fax: (732) 445-8268  
<http://www.civeng.rutgers.edu/faculty/?id=28>

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**Carlos Videla Cifuentes**

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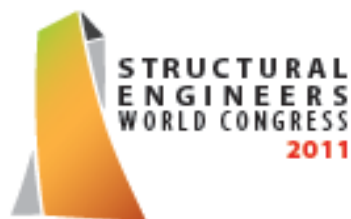
**De:** John Gardner [jgardner@eng.uottawa.ca]  
**Enviado el:** Lunes, 28 de Junio de 2010 11:53  
**Para:** 'Carlos Videla'  
**Asunto:** RE: Ballots ACI209 3R

Hello Carlos

I have spent some time reviewing the 2008 and 2009 documents and Mario's responses to my comments. I will change my negatives to affirm with editorial comments (which have already been addressed by Mario).

John

## ATTACHMENT D



**STRUCTURAL  
ENGINEERS  
WORLD CONGRESS  
2011**

**APRIL 4<sup>th</sup> to 6<sup>th</sup>  
Villa Erba  
COMO - ITALY**

Founding associations:  
**ACI - ASCE - IASS  
JSCA - NCSEA - SEAOC**

### THE AIMS OF SEWC 2011

The Structural Engineers World Congress (SEWC) is an international conference with worldwide participation by structural engineers.

The primary purpose of SEWC2011 is to focus on the overall practice of structural engineering, emphasizing the ethic, technical and theoretical aspects.

The conference will focus on a world-wide exchange of structural engineering experiences, and on the cooperation with the architects, under the common effort towards holistic and sustainable constructions.

The main aspects for the planning, the design and the construction of large structures and infrastructures will be illustrated.

The use of current and new materials, the correct definition of the actions, problems of design and construction, state of the art of research and testing techniques will be also discussed.

### THE ORGANIZING COMMITTEE

**R. Sundaram:**

President SEWC-WORLDWIDE – Honorary member.

**Gian Carlo Giuliani dr. eng:**

Structural professional engineer in Milano (Italy),  
Alberta (CAN) and Cyprus - Advisory member IASS  
Fellow member ASCE, IABSE - Member ACI, fib, PCI, GUS,  
ASSEI - President organizing committee IASS Symposium  
1995 in Milano.

**Riccardo De Col dr. eng:**

Structural professional engineer in Milano  
Secretary of ATE (Association of Building Technologists)  
Member ACI, ASCE, AISC, IABSE fib.

**Fabio Capsoni dr. eng:**

Structural consulting engineer in Como

**Enzo Siviero prof. eng:**

Structural professional engineer - Teacher of Theory and  
Design of Bridges and construction Techniques at IUAV  
University in Venezia  
Vice President of the National Universities Council - Civil  
Engineering and Architecture area.

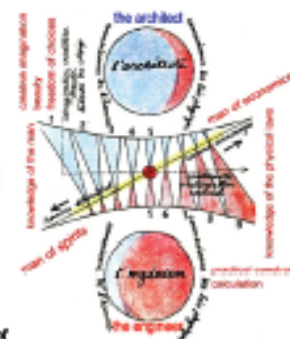
### THE PATRONAGES AND THE SPONSORS

Patronage to the Congress was given by International Universities and Professional Associations.

Sponsors are financially supporting the organization, thus allowing keeping the participation fees at a reasonable level.

### THE SCIENTIFIC COMMITTEE

Eminent professors and professional engineers, specialized in the Congress themes, and resident in a wide number of Countries, were appointed to evaluate the submitted abstracts, to revise the final papers, and to chair the sessions.



### THE THEMES

The themes are assigned according to the following table with an explicit recall to the thought of Le Corbusier which correctly represents the synergy we need for the development of structural engineering.

ANALYSIS - DESIGN CONSTRUCTION		
STRUCTURAL AND ARCHITECTURAL DESIGN CONSTRUCTION IN LABORATORY AND ON SITE TESTS STATIC AND DYNAMIC ANALYSIS	"ARCH ENGINEERING" STRUCTURAL REHABILITATION HISTORY OF CONSTRUCTIONS	
INVERSE ANALYSIS AND DIAGNOSTICS	NEW STRUCTURAL PROBLEMS RESEARCHES	
ACTIONS	and	ENVIRONMENT
FIRE WIND EARTHQUAKE ABNORMAL LOADS PROBLEMS AND SOLUTIONS		CORROSION DURABILITY SUSTAINABILITY RESISTANCE GREEN STRUCTURES
MATERIALS	and	COMPONENTS
CONCRETE STEEL WOOD ALUMINUM GLASS COMPOSITES		BEARINGS JOINTS BOLTERS DAMPERS CABLES AND STAYS
DEVELOPMENT AND USE OF MATERIALS		DEVELOPMENT AND USE OF DEVICES
INTRODUCING INVITED LECTURES		WEB SEMIPOSIA



## THE INVITED LECTURERS

J. Martínez Calzón	Forms, structures and energy
M. A. Chlorino	Analysis of structural effects of time dependent behaviour of concrete: an internationally harmonized format
M. A. Chlorino	Pier Luigi Nervi Architecture as challenge
M.E. Gullani	About structural details
K. Goepfert	New stadium structures
W.B. Kraetzig	Solar domes
G. Maier	Inverse analysis methods
M. Majowicki	Structures in architecture
F. Molis	Conceptual approach and analysis in the structural design of tall buildings
R. Motro	Art and structural engineering
P. Samyn	Rhythms in steel structures
E. Siviero	Bridges and architecture
R. Sundaram	Shell structures
M. Vrlonjevic	Bridges in historical sites

## LARGE INFRASTRUCTURES

TBD	The Messina Strait Crossing
TBD	The 2015 EXPO in Milano

## SPECIAL PARALLEL SESSIONS

L. Binda	Assessment and repair of Historic masonry buildings
M.A. Chlorino	Time dependent behaviour of concrete: prediction models and methods of analysis
A. Martelli	Seismic protection techniques
R. Motro	Actuality of seismicity
A. Murthy	Prestressed and Precast Concrete
A. Palermo	Design of innovative solutions for timber structures
E. Siviero	Engineering versus architecture
K. Sobieski	Aluminum structures
TBD	Fire engineering for steel and concrete structures
TBD	Super tall buildings

Other ones expected

## CALL FOR PAPERS

The abstracts should be e-mailed up to November 30th 2010; the acceptance of the abstracts will be confirmed by the Scientific Committee before December 30th, 2010. The authors will be kindly requested to e-mail the final papers before January 31st, 2011 and to pay by this date the reduced participation fee.

## THE LANGUAGE

All oral presentations and all written papers will be in English; no simultaneous translation will be provided.

## WEB SITE

A web site was implemented to provide more details on the Congress, the status of the submitted abstracts and papers, the registration, and so on. Contact [www.sewc-worldwide.org](http://www.sewc-worldwide.org) specifying the SEWC2011 - Italy reference. On the web site, links to the sponsors and exhibitors homepages are also given.

## THE DATE

The Congress will take place from Monday April 4th to Wednesday April 6th 2011. An optional cultural and technical tour to Milano could possibly be organized on Thursday April 7th.

## CLIMATE

At the beginning of April the climate in Como is mild but a little bit cold in the evening; occasional rain can be expected.

## THE VENUE

Villa Erba (Como Carnobbio). The recently built Villa Erba convention and exhibition facilities are located in a park on the shore of the well renowned Lario Lake. Very nice hotels can be found in the town of Como or in the villages of Carnobbio and Moltrasio. A fortyfive minute walk or a fifteen minute ride on city buses or ferries is necessary to reach Villa Erba from Como center. The trip from Milano Malpensa Intercontinental airport to Como requires a train change in Saronno and an hour time. Two railways lines, (one regional and one international from Switzerland and Germany) connect Como to Milano in a 45 minute travel time. The exit Como Nord of the A9 highway is convenient for people travelling by car.

## THE PARTICIPATION FEE

The normal participation fee is fixed at € 650 if paid before December 31st 2010, or at € 750 for late payments. The fee for the members of the Scientific Committee and for the authors is set at 550€. For the Italian participants only all the fees will be charged with 20% VAT. A reduced fee of 325€ will be applied for students upon the submittal of a specific request from their Teachers.



## THE SERVICES

The participation fee will include:

- Lunches from April 4th to April 6th
- Morning and afternoon coffee breaks
- Welcome cocktail on April 4th
- Farewell dinner on April 6th
- A printed copy of the abstracts
- A CD with the complete presented papers
- Free visit to the exhibition (see below)

No accompanying persons' program is planned.

The delegate's eventual guests will be kindly requested to pay for their lunches, welcome cocktail and farewell dinner.

## HOTEL AND INDIVIDUAL TRIP BOOKING

The hotel booking, via the local MIZAR agency 22012 Carnobbio (CO) - Via S. Giordano 2/r ITALY Tel. +39 031 342025 Fax. +39 031 342015 - [www.mizarconventions.com](http://www.mizarconventions.com) - will be directly effected by the participants; reduced rates will be applied for the period of the Congress. Travel agencies will support the delegates in planning their one day or longer trips. Tours to Milano city for visiting monuments, art galleries and shopping areas can be easily and directly effected, taking a train for a 45 minute ride. Individual trips to the close-by Italian and Swiss ski areas located in the Alps can be organized. The view of the glaciers and of the snowy mountains from the top stations of the cable cars is really breathtaking and can be enjoyed by everyone.

## PATRONAGING INSTITUTIONS

AIMETA (Associazione Italiana di Meccanica Teorica ed Applicata)  
ASSISI (Anti-Seismic Systems International Society) - ATE (Associazione Tecnologi Edilizia) - CISM (International centre for mechanical sciences)  
Collegio dei Ingegneros da caminos, canales y puertos  
CSCE (Canadian society for civil engineering) - ENEA (Agenzia nazionale nuove tecnologie energia e sviluppo sostenibile) - Fondazione Promozione Acciaio - GLIS (Gruppo Lavoro Istituzionale Sismico) - IUAV (Istituto Universitario Architettura Venezia) - Ordine Ingegneri Architetti di Milano - Ordine Architetti di Como - Ordine Ingegneri di Como  
Politecnico di Milano - Universidad Politecnica de Madrid - Universidad Politecnica de Valencia - Université Montpellier 2 - YLDIZ TEKNİK UNIVERSITESI - The Institution of Structural Engineers - CNI (Consiglio Nazionale Degli Ingegneri).

## SPONSORING COMPANIES



## EXHIBITORS

ALGA - Carnobbio - FP Industriale - HRC  
Interbau - Mapel - Maurer Söhne



## ATTACHMENT E

**TIME TABLE**  
(Registration on Monday at 8:30)

TIME	Monday May 23	Tuesday May 24	Wednesday May 25	Thursday May 26	Friday May 27
9.00 - 9.45	Opening Lecture	Chiorino	Sassone	Carreira	Carreira
9.45 - 10.30	Chiorino	Chiorino	El Badry	Carreira	Sassone
11.00 - 11.45	Chiorino	Chiorino	El Badry	Carreira	Sassone
11.45 - 12.30	Chiorino	Chiorino	El Badry	Carreira	Sassone
14.30 - 15.15	Vid da	Sassone	El Badry	El Badry	El Badry
15.15 - 16.00	Vid da	Sassone	El Badry	El Badry	El Badry
16.30 - 17.15	Vid da	Sassone	Robertson	Robertson	Robertson
17.15 - 18.00	Vid da	Sassone	Robertson	Robertson	Robertson

### ADMISSION AND ACCOMMODATION

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through our web site: <http://www.cism.it> or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by March 23, 2011 along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

The Deutscher Akademischer Austausch Dienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) offer support to German students. Please contact:

DAAD, Kennedyallee 50, 53175 Bonn  
tel. +49 (228) 882-0  
e-mail: [postmaster@daad.de](mailto:postmaster@daad.de)  
web site: <http://www.daad.de/de/kontakt.html>

DFG, Kennedyallee 40, 53175 Bonn  
tel. +49 (228) 885 2655  
e-mail: [ing4@dfg.de](mailto:ing4@dfg.de)  
web site: <http://www.dfg.de>


Information about travel and accommodation is available on our web site, or can be mailed upon request.

*For further information please contact:*

CISM  
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e-mail: [cism@cism.it](mailto:cism@cism.it)

ACADEMIC YEAR 2011  
The Germain Session

Centre International des Sciences Mécaniques  
International Centre for Mechanical Sciences



## ANALYSIS OF CREEP AND SHRINKAGE EFFECTS IN CONCRETE STRUCTURES


Advanced Professional Training  
coordinated by

**Mario A. Chiorino**  
Politecnico di Torino  
Italy

**Domingo J. Carreira**  
Illinois Institute of Technology  
Chicago, IL  
USA

**Udine, May 23 - 27, 2011**

with the patronage of



American Concrete Institute®  
Advancing concrete knowledge

## ANALYSIS OF CREEP AND SHRINKAGE EFFECTS IN CONCRETE STRUCTURES

Modern concrete structures are becoming more and more complex as a result of elaborate conceptual design and intricate construction techniques combining cast-in-place and prefabricated elements, structural steel components, prestressing and segmental erection, tensioning of stays and ties, jacking, and so on. Typical examples are large span cantilever and cable-stayed bridges, cast-on-form or cantilever built arches prestressed by jacking, composite steel-concrete structures, concrete or steel-concrete high-rise and supertall buildings. Some of these examples represent extreme recent applications of structural concrete. In general, we may speak of structures characterized by sequential applications of external actions (loads and imposed deformations) and by progressive variation in the restraint conditions during construction and early life. For these reasons, these structures are very sensitive, from the construction stage until the end of their service life, to time-dependent effects caused by delayed deformations of concrete (creep and shrinkage). If proper attention is not devoted to these effects, structural reliability in

terms of serviceability and, in some instances, of ultimate safety may be adversely affected. An appropriate evaluation of such effects for designing durable and safe structures requires the establishment of reliable methods for predicting creep and shrinkage strains (a material properties problem), and for determining the consequent time-dependent structural response with an adequate degree of accuracy (a structural analysis problem). The first part of the course briefly addresses the problem of selecting realistic prediction models, focusing on factors affecting rheology of hardened concrete, criteria for construction of a comprehensive database of creep and shrinkage tests and validation/calibration of prediction models with respect to it, comparison and statistical evaluation of different models, with a discussion on adequate statistical indicators. The second and main part of course deals with analysis of structural effects. Fundamentals of the theory of aging linear viscoelasticity are reviewed and basic theorems and general solutions illustrated for the

cases of effective homogeneous structures with rigid or elastic (steel) restraints and of heterogeneous structures and sections. Numerical methods for the solution of hereditary integral equations in terms of incremental forms based on a sum or on conversion to rate-type laws with internal variables are illustrated, as well as algebraic simplifications like the age-adjusted-effective-modulus method. Guidelines are indicated for selecting the appropriate computational approaches, with attention to the stage and sensitivity of the structure. Advanced problem like hygrothermal effects and cracking, interaction of creep with shear-lag and with flexible shear-connectors in composite beams, effects of creep and shrinkage in complex structures such as tied arches, cable-stayed bridges and high-rise buildings are discussed in the last part of the course, together with techniques for long-term structural monitoring and interpretation of results. The course is modeled after the harmonized formats of the following technical guidance documents: the CEB Manual on the same subject (1984), the corresponding sections

of CEB-FIP Model Code 1990 and of fib Textbook on Structural Concrete (2010), and, especially, the recent advanced ACI Guide "Analysis of Creep and Shrinkage Effects in Concrete Structures" (2010, under final approval). The whole set of these documents was edited by the first coordinator, with the cooperation, for the ACI Guide, of the second coordinator and most of other lecturers. Emphasis will be given within the course to this favorable scenario of internationally agreed, although progressively evolving, fundamentals and basic rules of application for codes and technical guidance documents on a subject of significant relevance for the long-term reliability assessment of modern concrete structures, highlighting areas of well established consensus and open problems. The course is addressed to doctoral and postdoctoral researchers, teaching and research assistants in structural mechanics, civil and structural engineering, specialists and practicing engineers in the field of advanced structural analysis and design.

## INVITED LECTURERS

**Mario A. Chiorino** - Politecnico di Torino, Italy  
*7 lectures on:* Fundamentals of aging linear viscoelasticity. Effective homogeneous concrete structures with rigid or plastic yielding restraints. Basic theorems: imposed loads and deformations; single and multiple changes of structural system. Effective homogeneous concrete structures with elastic restraints. Heterogeneous structures. Computational methods for the numerical solution of hereditary integral equations. Algebraic simplifications: AAEM method. Guidelines for time dependent analysis of structures.

**Carlos C. Videla** - Pontificia Universidad Católica de Chile, Santiago  
*4 lectures on:* Creep and shrinkage prediction models and related uncertainty aspects. Factors affecting creep and shrinkage of hardened concrete. Comprehensive database on creep and shrinkage. Guide for modeling and calculating shrinkage and creep in hardened concrete. Statistical evaluation of available prediction models. Discussion of statistical indicators. Influence on the reliability assessment of structures: random scatter, uncertainty of prediction and confidence limits.

**Mario Sassone** - Politecnico di Torino, Italy  
*8 lectures on:* General numerical incremental solutions for heterogeneous and sequential structures in the aging linear viscoelastic domain. Solutions by AAEM method. Solutions for effective homogeneous concrete structures with elastic restraints. Discussion of case studies: segmental concrete bridges and constructions, tied concrete arches, cable-stayed bridges, high-rise concrete or steel concrete buildings. Analysis of beams and framed structures with account for cross section heterogeneities.

**Mamdouh M. El-Badry** - University of Calgary, Canada  
*7 lectures on:* Cross section analysis. Prestress losses in members with one layer of prestressing steel. Time dependent analysis of prestressed concrete members with multiple layers of prestressing and reinforcing steel using creep-transformed section method. Time dependent analysis of composite members: influence of different thickness of concrete, steel-concrete composite members. Members subjected to sustained temperature gradient.

**Domingo J. Carreira** - Illinois Institute of Technology, Chicago, USA  
*5 lectures on:* Advanced problems. Hygrothermal effects and cracking. Interaction of creep with shear lag effects in box girders and in wide flanged concrete or steel-concrete composite beams and additional influence of flexible shear connections. Effects of creep and shrinkage in high-rise concrete or steel-concrete buildings.

**Ian W. Robertson** - University of Hawaii, Manoa, USA  
*4 lectures on:* Monitoring of time dependent effects in large structures. Design of instrumentation system for long-term structural monitoring. Instrument installation and monitoring challenges. Short-term loading and thermal effects. Long-term shrinkage and creep effects. Comparison with shrinkage and creep prediction models.

## LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

## PRELIMINARY SUGGESTED READINGS

### BOOKS

- Gross B., *Mathematical Structure of the Theories of Viscoelasticity*. Hermann, 1953.
- Lovitt W., *Linear Integral Equations*. Dover, 1950.
- Salençon, J., *Viscoélasticité pour le Calcul des Structures*. Editions Ecole Polytechnique, 2009.
- Ghali A., Favre R., Elbadry M., *Concrete Structures - Stresses and Deformations*. Spon, 2002.
- Jirásek M., Bazant Z.P., *Inelastic Analysis of Structures*. Wiley, 2002.

- Chiorino M.A., Gardner J. (Eds), *Structural Implications of Shrinkage and Creep of Concrete*, ACI SP-246, 2007.

### GUIDES, MANUALS AND PRE-STANDARD DOCUMENTS:

- ACI 209.1R-05, ACI 209.2R-05, ACI 209.3R-XX, *Analysis of Creep and Shrinkage Effects in Concrete Structures*, M. A. Chiorino (Ed), 2010, final draft from Editor.
- Chiorino M.A., Sassone M., Further considerations and updates on time dependent analysis of

- concrete structures, in "Structural Concrete", V. 2, fib Bull. 52, 2010, p. 43-69.

### PAPERS

- Chiorino M.A., et al., Effects of creep and shrinkage on serviceability limit state, fib Symp. Dubrovnik, 2007, p. 623-632.
- Chiorino M.A., An Internationally Harmonized Format for Time Dependent Analysis of Concrete Structures, IABSE-fib Conf., Dubrovnik, 2010, pp. 473-480.
- Casalegno C., et al., Time depen-

- dent effects in cable-stayed bridges built by segmental construction, fib Congress, Washington, 2010.
- Robertson I. N., Prediction of vertical deflections for a long-span prestressed concrete bridge structure, Eng. Structures, V. 27, 2005, p. 1820-1827.

### WEB SITES

- Creep Analysis Research Group: [www.polito.it/creepanalysis](http://www.polito.it/creepanalysis)
- Papers by Z.P. Bazant may be downloaded from: [www.civil.northwestern.edu/people/bazant.html](http://www.civil.northwestern.edu/people/bazant.html)

**ANALYSIS OF CREEP AND SHRINKAGE EFFECTS  
IN CONCRETE STRUCTURES**

Udine, May 23 - 27, 2011  
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(Please print or type)

Surname \_\_\_\_\_

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Affiliation \_\_\_\_\_

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Phone \_\_\_\_\_ Fax \_\_\_\_\_

**Method of payment upon receipt of confirmation (Please check the box)**

*The fee of Euro 700,00 includes IVA/IVT tax and excludes bank charges*

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Payment will be made to CISM - Bank Account N° 094570210900,  
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**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please  
indicate to whom the invoice should be addressed.**

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**Only for Italian Public Companies**

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**Privacy policy:** I understand that data received via this form will be used only to provide  
information about CISM and its activities, within the limits set by the Italian legislative  
decrees n. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at [www.cism.it](http://www.cism.it).

I have read the "Admission and Accommodation" terms and conditions and agree.

Date \_\_\_\_\_ Signature \_\_\_\_\_