

## MEETING MINUTES # 45

### ACI COMMITTEE 365 – SERVICE LIFE PREDICTION

#### ACI Fall 2010 Convention Pittsburgh, PA Monday, October 25, 2010

1. Call to Order: T. Marcotte called the meeting to order at 2:00 pm.
2. Self introductions and membership: Self Introductions were performed, attendance sheets are attached. Eleven voting members were present out of 28 eligible voting members. This fulfills the 40 % rule.
3. New Secretary: K. Stanish is taking over as secretary of the committee starting with this meeting.
4. Chicago Meeting Minutes: Z. Lounis moved for approval of Chicago Meeting Minutes. D. McDonald seconded. MINUTES APPROVED.
5. Agenda: T. Marcotte requested Item No. 6 (New Subcommittee discussion update) be removed from the agenda. C. Hansson moved that the agenda be accepted with this change, B. Isgor seconded. AGENDA APPROVED.
6. State of the Art Report (365.1R): Chapter 4 has been letter balloted. There were seven items, each meet the ½ Rule and the 2/3 Rule, but there were some negative comments to be resolved. Work was done to resolve the some of the negatives, summarized in the attached sheets. Some specific tasks to be completed:
  - a. Ballot 1:
    - i. Revise Table 4.1: Not Assigned
  - b. Ballot 2:
    - i. Rewrite section 4.2.5 (including 4.2.5.1): Lounis & Trejo
    - ii. References for 4.2.4.1: Weyers and Trejo
    - iii. Rewrite 4.2.4.1: Isgor
  - c. Ballot 3:
    - i. 4.3.1.1, Reference in addition to Browne Berke
7. Adjournment: The meeting adjourned at 4:30 pm.



**Committee Meeting Sign In Sheet\***

Committee: <i>Service Life Prediction</i>		Date: <i>10/15/2010</i>	
Name and Address (Please Print):			
* Members - Please give address, phone number, and e-mail only if changed		Comm. Member ?	Visitor? **
* Visitors - Please give complete address, phone number, and e-mail			
<i>Zaibir Lavis, National Research Council Canada</i>		<input checked="" type="checkbox"/>	
<i>RICHARD WEYERS, VIRGINIA TECH</i>		<input checked="" type="checkbox"/>	
<i>CAROLYN HANSSON, UNIVERSITY OF WATERLOO</i>		<input checked="" type="checkbox"/>	
<i>O. BURKAN ISGOR, CARLETON UNIVERSITY, OTTAWA, CANADA</i>		<input checked="" type="checkbox"/>	
<i>MATT MILTENBERGER, TCG, KALAMAZOO, MI</i>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<i>NEAL BERKE <sup>269-384-9980</sup> nberke@fourneyconsulting.com</i>		<input checked="" type="checkbox"/>	
<i>Michael Brown Michael.Brown@VMI.Virginia.gov</i>		<input checked="" type="checkbox"/>	
<i>P-A. Mutamad Basheer m-basheer@qub.ac.uk</i>		<input checked="" type="checkbox"/>	
<i>Bill Geers Bill.Geers@MMFX.COM</i>			<input checked="" type="checkbox"/>
<i>Larry Olson, lolson@olsonengineering.com</i>			<input checked="" type="checkbox"/>
<i>Tracy Marcotte</i>		<input checked="" type="checkbox"/>	

\***Technical Committee Attendees:** The purpose of an ACI technical committee is to reach consensus and publish information on concrete-related issues within its mission. The discussions at the committee's meetings are part of this consensus process, and are not the official position of the committee. Only a published committee document represents the formal consensus of the committee and the Institute.

\*\* Visitors Interested in committee membership should contact the chair or visit the ACI website, [www.concrete.org](http://www.concrete.org), for a membership application.



Committee Meeting Sign In Sheet\*

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Committee: <i>Service Life Products</i>		Date: <i>10/25/2011</i>	
Name and Address (Please Print):			
* Members - Please give address, phone number, and e-mail only if changed		Comm. Member?	Visitor? **
* Visitors - Please give complete address, phone number, and e-mail			
<i>Kyle Stanish, WAC</i>		X	
<i>TONY KOJUNDIC TONY.KOJUNDIC@ELKEM.COM (ELKEM)</i>		X	
<i>TARIF JABER 1 @ Tarif.Jaber - engineering - com</i>			✓
<i>Eldon Tipping TAC</i>			
<i>Pou-Erik Aravig Outokumpu pou-erik.aravig@outokumpu.com</i>			✓
<i>MURRAY ADAM, OUTOKUMPU. +44 7525298366 Murray-adam@outokumpu.com</i>			✓
<i>Catherine Houska 412-369-0377 chouska@fmc-iac.com</i>			✓
<i>TMR Stainless, 3209 McKnight Dr, Pittsburgh PA 15237</i>			✓
<i>DAVID McDONALD</i>		Assoc. ✓	
<i>Wael Zatar, College of Information Technology and Engineering Professor, Marshall University, WV, (304) 696-6043, Zatar@marshall.edu</i>		Would like to be a member	
<i>J.L. Quires Jr., JQUIRES@HOTMAIL.COM</i>			✓

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## **Electronic Comments for TAC Review**

### **Preliminary Voting Summary for 365.1, Chapter 4:**

There are 30 committee members eligible to vote.

Passage of an item requires resolution of any negative votes. Passage of an item also requires that the number of affirmative votes be at least that given by the 1/2 and 2/3 rules. Please refer to the ACI Technical Committee Manual for additional information on balloting procedures.

<b>Item #</b>	<b>Affirmative</b>	<b>Affirmative with Comments</b>	<b>Negative</b>	<b>Abstain</b>	<b>Not Returned</b>	<b>The 1/2 Rule</b>	<b>The 2/3 Rule</b>
1	14	7	2	1	6	Item Meets	Item Meets
2	12	5	5	2	6	Item Meets	Item Meets
3	16	4	3	1	6	Item Meets	Item Meets
4	20	2		2	6	Item Meets	Item Meets
5	14	6	2	2	6	Item Meets	Item Meets
6	18	4		2	6	Item Meets	Item Meets
7	19	1		4	6	Item Meets	Item Meets

Ballot 1:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	MCB	2	41	E	Table 4.1 appears at the end of the Introduction section 4.1, but is never referenced or discussed in the paragraph. Indeed the table presents predicted time of chloride diffusion based on cover and diffusion rates, but none of these physical parameters are directly discussed in the section. This table should be moved to section 4.2.4.1 in the document where chloride diffusion is discussed in detail.	See Comment 8	N/A
2	SB	2	43	E	Minor editorial comment. Page 2, line 43. Revise to read "... by mass of concrete"	Editorial	N/A
3	B.I.	2	42	E	Table 4.1 does not seem to fit in this section; I suggest moving it down where it fits properly. Also the table has the words "chloride ion"; chloride is already an ion. The word "ion" is redundant.	See Comment 8 & 9	N/A
4	DT			E	Nice introduction. Remove Table 4 from this section.	See Comment 8 & 9	N/A
5	DT			E	Also, line 20 - add "can" between "that" and "manifest."	Editorial	N/A
6	DT			E	line 22 - change "increased" to "longer"	Editorial	N/A
7	RDH	2	16-18	N	First sentences do not read well. Revise as follows: The selection of concrete materials and mixture proportions is usually based on empirical relationships between laboratory and field performance of concrete mixtures. This approach assumes that the concrete selected will be adequate for the desired service life for the structure.	Move to adopt suggested wording. Move: MacDonald Second: Kojundic	11/0/0
8	RDH	2	42-44	N	Where is Table 4.1 cited in the document? It seems out of place here. What is the source of this table data?	This table is out of place, and should be on page 6. See also Comment 9.	Letter Ballot

9	NB			N	In Table 1 the 0.4% chloride on cement is too high. 0.2% would be better, but I believe that 0.1% for rebars and 0.06% for strand might be better. See my later comments.	Revise table to also include 0.2 % chloride threshold and add text referencing 222	Letter Ballot
10	ZL			E*	Add word "Structures" in title of Chapter 4, i.e. "Methods for ... service life of concrete structures"	Move to adopt suggested change.	Letter Ballot

Ballot 2:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	DT			E	Text after Eq. 4-13 – should this be “mass loss” instead of “mass lost”?	Editorial	N/A
2	PAMB	2	41	E	Source of the data not stated.	Editorial	N/A
3	PAMB	2	41	E	Table not introduced in the text.	Editorial	N/A
4	PAMB	5	28-31	E	The unit is needed for each parameter	Editorial	N/A
5	B.I.	4	12, 18, 34	E	We may be over-explaining this concept if the examples given in equations 4.2, 4.3, 4.4. I think the sulfate example at the end (line 23 and on) is adequate. Also, these three equations do not elaborate the “K” approach given in Eq. 4.1.	Editorial	N/A
6	B.I	5	9	E	Chloride ion vs. chloride (this exists in several places in the document; therefore I am not going to mark this anymore. If the editors want to change it, a “search and replace” can fix this quickly.	Editorial	N/A
7	EB	5	46	E	page 5, line 46: Bazant's name has a weird font for the Z in his name. It should actually be a z with a crescent moon on top giving a "Zsh" sound.	Editorial	N/A
8	EB	5	43	E	page 5, line 43: Ah, table 4.1 belongs in this section, not the first section.	Editorial	N/A
9	MCB	6	25	E	"(100/24)" should be "(100/25)"	Editorial	N/A
10	MCB	6	40	E	It is not necessary to define <i>erfc()</i> a second time.	Editorial	N/A
11	PAMB	7	19	E	m/sec to m/s	Editorial	N/A
12	EB	7		E	page 7: equation formatting wrong for caption.	Editorial	N/A
13	PAMB	7	23-33	E	The unit is needed for each parameter	Editorial	N/A
14	PAMB	7	48-53	E	The unit is needed for each parameter	Editorial	N/A
15	PAMB	6	8-14	E	The unit is needed for each parameter	Editorial	N/A
16	PAMB	9	7-10	E	The unit is needed for each parameter	Editorial	N/A

17	B.I.	9	30	E	Fig. 4.1 is too far down the document from where it was mentioned. Same is true for the other figures. Can we move the figures around to make the document read better?	Editorial	N/A
18	PF	5	38	N	Sentence beginning "The initiation period is....."  Rationale, the statement there is based on the concrete mixtures of the day, with mostly pure portland mixes. Modern concrete, with SCM's and in particular silica fume, have very muc	Not clear intent of comment. Move non-persuasive. Move: Weyers Second: Berke	11/0/0
19	ZL			N	Section 4.2.5 needs to be rewritten because: (i) Description of stochastic methods is not adequate , including a confusion between modeling using random variables and stochastic processes (ii) There is no mention of stochastic cumulative damage models, which are widely used in practice for modeling the deterioration and service life of concrete structures (iii) The references used are not adequate and outdated. The references to Martin et al., are not useful as they are related to the service life of coatings and asphaltic roofing membranes. Some relevant work by Ellingwood, Frangopol, Stewart, Lounis, Faber etc. on service life of RC structures is not included.	Zoubir Lounis to rewrite section.	Letter Ballot new section.
20	MDAT			N	I disagree with equation 4.7 (chloride binding) and the comment that follows this. Firstly, there is considerable evidence in the literature to show that the chloride binding isotherm is non-linear. Secondly, the statement "Because either carbonation or sulfate ions can release the bound chloride ions, R is usually assumed to be 0" marginalizes the importance of binding with regards to the rate of chloride ingress and the time to corrosion. In transportation structures exposed to deicing salts the carbonation front is unlikely to penetrate more than a few millimeters and there is not usually a source of sulfate, hence the bound chlorides are unlikely to be released.	Strike equation and revise text, including references.	Letter Ballot



21	MDAT			N	Regarding section 4.6, Few, if any, of the models discussed in this section consider the time-dependent nature of the transport coefficients. This is very significant for concrete containing pozzolans or slag. The section seems to be limited to "models" that use a numerical solution to Fick's second law to predict chloride ingress and no mention is made of models that implement Fick's law in by finite element/difference that allows the time- and temperature-difference of the surface concentration and transport coefficients to be properly considered.	Non-persuasive. Typical models that are currently being used. Move: Weyers Second: Brown	11/0/0
22	DT			N	Section 4.2.3.2 lines 3 - approximately 22 are not clear and provide limited value to the reader. It seems that additional follow on is needed or this section should be removed?	Non-persuasive. Move: Brown. Second: Stanish	11/0/0
23	DT			N	Section 4.2.4 at end of first paragraph it states that the NORD test is the only test for test ion diffusion yet ASTM C1556 (2004) is also available. The last sentence should be removed.	Strike last sentence, add references to ASTM C1556, ASTM C1585 and NordTest 443. Move: Hansson Second: Basheer	11/0/0
24	DT			N	Near the end of section 4.2.4.1 consider adding some newer references regarding sensitivity and applicability of these equations. Luping and Gulikers do a nice job in discussing errors in these functions. Ann et al (2007) discuss the influence of assumed build-up rate, and Trejo and Reinschmidt (2007) present the sensitivity of the different input values for predicting the service life. These will do two things: give the reader a sense of how changing variables can influence outcome (which is also discussed a bit later) but will also show the reader that significant errors can occur.	Will add references provided by Trejo and Weyers	Letter Ballot
25	DT			N	Significant work has been performed on Reliability and section 4.2.5.1 is very outdated. I would suggest a completely new section with references to steel in concrete. I can get this written if needed.	Accept Trejo's offer to re-write this section.	Letter Ballot

26	PAMB	3	33	N	The accelerated tests are normally carried out for single mechanisms and any relationship between accelerated tests and normal exposure performance can be obtained only for single mechanism. For multiple mechanisms, as normally found in most cases, the simple relationship given by equation 4.1 cannot be applied. I think, this needs to be highlighted at the beginning of this section before readers are carried away with the examples.	Revised Section. Move: Weyers Second: Berke	11/0/0
27	RDH	5	11-13	N	The sentence about ASTM standards is outdated. Revise as follows: Furthermore, methods for testing ion diffusion, such as chlorides, are also available (Nord Test 1995).Reliable data on transport properties, however, often are not always available but a standard ASTM apparent diffusion test method C1556, based on Nord Test NT Build 443 has been developed as well as ASTM C1585 for rate of absorption.	See Similar Comment 23.	See Comment 23.
28	B.I.	5	14	N	In section 4.2.4.1, we are only talking about the initiation models; however the title of the section is general, which should include the "propagation models as well. There are many propagation models: numerical (that are based on the solution of Laplace's equation), mathematical and empirical. To fix this, either we can change the title of the section to "corrosion initiation models" or add a new section for propagation models. I am willing to write a short propagation models section (or a couple of paragraphs with some references) if there is time.	Accept Isgor's offer to write short section.	Letter Ballot
29	PGT	5	13	N	We should include a mention of the use of multiple mechanistic models and refer to the description found in Section 4.5.	Not discussed.	Letter Ballot
30	PGT	5	20	N	Place another reference to MMM and Section 4.5.	Not discussed.	Letter Ballot

Ballot 3:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	DT		15	E	IN line 15 under the discussion regarding general procedures for predictiong remaining service life the procedures state that one needs to determine the condition of the concrete and identify causes of concrete deterioration. The reinforcement also has a significant impact on service life. I recommend that "determining the condition of the concrete" be changed to "determining the condition of the concrete structure," and "identifying the cause(s) of any concrete degradation," be changed to "identifying the cause(s) of any reinforced concrete structure degradation,"	Editorial	N/A
2	PAMB	11	10-12	E	The unit is needed for each parameter	Editorial	N/A
3	MDAT			N	The use of equation 4.18 assumes that the surface concentration and diffusion coefficient remain constant with time. This is a shortcoming of the approach which should be mentioned.	Inserted sentence: Typically, structures subject to remaining service life estimates are sufficiently mature such that the diffusion coefficient and surface chloride concentration can be considered constant.	11/0/0

4	BI	10	22	N	Remaining service life cannot be accurately determined by chloride ingress models only. Propagation models provide additional data that can help predict remaining life beyond depassivation. I think referring to Brown (1980) does not reflect what have been done in the last 20 years on this. I think the section provides an incomplete picture. I am willing to write a short propagation models section (or a couple of paragraphs with some references) if there is time. IF there is no time, we should at least provide some references to show that there has been progress in this area.	Accept Isgor offer to write a short section.	Letter Ballot
5	BI	11	19	N	Corrosion measurements provide instantaneous corrosion rates; therefore, I suggest we mention that remaining service life calculations as suggested should only be done after averaging repeated measurements over a reasonable period.	Added: However, such corrosion measurements provide only instantaneous corrosion rates. Ideally, remaining service life calculations include the averages of repeated measurements over a representative period, capturing seasonal changes in moisture and temperature.	11/0/0

6	PGT	11	18	N	It is important to note that: Predicting remaining service life based on diffusion processes and chloride ion profiles is questionable because the determination of Dcl is not a determination of a concrete property but rather a property heavily influenced by past exposure conditions. It would not be sound science to carry this Dcl forward. Ie. If the same concrete (same load from a RM truck was placed. One area was covered for ½ of the existing life (therefore much less exposure) and then chloride profiles were determined at time X. The Dcl would be different for the same concrete. This is not the intention of the solution to Fick's Second Law of Diffusion. We should not bend the laws of physics without a disclaimer. We should discuss.	Added text to address	11/0/0
7	PGT	11	22	N	The use of techniques to measure corrosion rate is highly variable. This should be noted and thus this will have a significant impact to the estimated remaining service life. The testing technique needs to be validated with physical and destructive observation wells. The number of test sites should be many. The problem is corrosion processes are rarely uniform across the tested structural element. <u>Suggested language:</u> It is important to note that testing corrosion rates with field techniques are highly variable due to boundary conditions, instruments used, operator skill, and degree of visible validation employed. Due to these variables, the range of estimated remaining service life should be considered.	Incorporated suggested text.	11/0/0
8	NB	11	16	N	Line 16 on page 11 uses Browne for the reference. There are numerous other references that would indicate smaller percent on cement should be used. Browne did his work on marine concretes where oxygen might have been low, and probably didn't catch the early stages of corrosion. I will provide other references for lower values.	Berke to provide references	Letter Ballot
9	WJW			N	Should we not mention the assumptions for 4-18 that are nearly always violated	Non-persuasive	11/0/0

Ballot 4:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	PAMB	12	37-40	N	Wouldn't be better to reproduce the values of n in this document?	Not Addressed	Letter Ballot

Ballot 5:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	EB			E	I'm going to assume that Marchand or one of his colleagues is going to check the equations and methods in here to confirm that this is correct.	Editorial	N/A
2	PAMB	13	34	E	Normally et al. is used instead of & al. for multiple authors.	Editorial	N/A
3	PAMB	13	35	E	As above	Editorial	N/A
4	MCB	15	14	E	I believe the second instance of "I>Icr" should be "I<Icr". Otherwise, the sentence contradicts itself.	Editorial	N/A
5	MCB	17	13	E	"ion" should be "on"	Editorial	N/A
6	ZL			E	This section must be shortened and should focus on the main contribution and implications for service life. Some of the mathematics can be removed (refer to published papers)	Editorial	N/A
7	MDAT			E	Equation 22 refers to the approach proposed by Saetta et al for considering the time-dependence of the diffusion coefficient. There have been other approaches which could also be referenced.	Editorial	N/A
8	PAMB	17	24	N	This section is meant to deal with multiple species approach to service life prediction, but it appears as if the work is incomplete. As such, I feel that this section is not useful to practicing engineers. In my view, most of the derivation could be presented in an appendix and the principle of application of the equations should have been provided in this section.	Not addressed in meeting.	Letter Ballot
9	BS			N	The mathematical models in section 4.5 are far too complex and specialist in nature for me to understand or find meaningful. I would suggest referencing the PhD thesis or research papers and present a more simplified practical model or equations in the Report.	Not addressed in meeting.	Letter Ballot

10	B.I.	0	0	N	Although I like the idea of a section on multi-species approach, it looks like this section is copied and pasted from a journal paper, and does not provide any context – it directly goes into the formulation. The section could have been presented much better to the document.	Not addressed in meeting.	Letter Ballot
11	DT			E*	Interesting section but very different from the previous sections. It seems to me that the title of the section does not closely match the write up or more explanation is needed at the beginning of the section. The section also ends rather abruptly - how does this section specifically help the reader with predicting the service life? It seems to me that a summary is needed.	Not addressed in meeting.	Letter Ballot
12	PGT	Any		N	Since this is a State-of-the-Art report, it would be good for the author to include a summary of what is modeled and what is not at this time. It would be good to note what relationships within modeling would require research in order to incorporate into multiple mechanistic models (MMM).	Not addressed in meeting.	Letter Ballot



Ballot 6:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	ZL			E	Change the word "construction materials" in the first sentence to "concrete structures".	Editorial	N/A
2	DT			E	IN line 18 is "stochastic models" correct? Should this be "probabilistic models"?  Change & al. to et al. at several locations. Also, page 17, line 13 change "ion" to "on."	Editorial	N/A
3	LC		8-10	E*	Revise lines 8, 9 and 10 to state that service life of a building or building component is approximate based on assumed environmental conditions and on installation, operating and maintenance procedures. Also state that the predicted service life of components or assemblies may be assessed by one or more of the three methods: demonstrated effectiveness, modeling of deterioration processes, and testing in accordance with building science principals. Provide a reference to CSA Standard S478-95 Guidelines on Durability in Buildings	Not addressed in meeting.	Letter Ballot
4	PAMB	18	9	N	I am not convinced that we could state multiple species approach given in the document is most promising.	Not addressed in meeting.	Letter Ballot

Ballot 7:

#	Initials	Pg	Ln	E/N	Comment	Proposed Response	Vote (Y/N/A)
1	ZL	7		E	Must include the relevant references to stochastic service life models , which are currently used by many transportation agencies and other concrete infrastructure owners.	Not addressed in meeting.	Letter Ballot

E/N:

E refers to comments that are marked editorial and are editorial in nature. Will be addressed by Chair or designated representative by minor editorial change.

N represents more significant, primarily negative comments which must be resolved by committee vote.

E\* references a comment that was indicated as affirmative but appears to be negative.