

ACI Committee 365A

**ACI Convention
Denver
Monday, 6 November 2006
Directors J
2:00 PM to 5:00 PM**

Agenda

1. Call to order
2. Introductions and Sign In
3. Approval of agenda
4. Approval of minutes, Charlotte Meeting
5. Membership review. Please review enclosed listing and notify the Chair if there are corrections.
6. Old business

6.1. Review of Outline for document. The Outline Task Group has provided what should be the working outline of the document. We will review the completed outline. A copy of that outline is enclosed.

6.2. Assignment of individuals to prepare drafts of individual chapters. Volunteers are as listed in the minutes from the Charlotte meeting. We still need additional individuals for several of the chapters. The Chair will distribute electronic copies of previous drafts of the document for use by each of the chapter groups. The volunteers so far are:

Ch. 1 – Introduction: Shri Bhide, Tony Kojundic

Ch.2 – Factors affecting service life: Neal Berke

Ch. 3 – Service life modeling basics: Mike Thomas, Burkan Isgor

Ch. 4 – Modeling protection systems: Doug Hooton, Jan Prusinski

Ch. 5 – Maintenance and repair: Larry Church

Ch. 6 – Life cycle cost analysis: Tracy Marcotte, Mark Ehlen, Rico Fung

Ch. 7 – Looking beyond the basic calculations: None

7. New Business

7.1. The developers of Version 2 of Life 365 are interested in finding volunteers for Beta testing. Please let the Chair know if you are interested.

8. Next meeting.

9. Adjourn

ACI 365A Membership Roster

Updated 24 October 2006

| Last name | First name | Email |
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| Basheer | Muhammed | M.basheer@qub.ac.uk |
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NOTE 1: Associate Member of ACI 365.

Guide for Estimating Corrosion Service Life and Life Cycle Cost Of Reinforced Concrete Structures

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1. Introduction

- 1.1. Purpose: provide a document that will allow the user to predict the service life of reinforced concrete exposed to chlorides. Aimed at practicing engineer who may be faced with corrosion protection decisions and a need to prioritize alternatives, and evaluate sensitivity of uncertainties.
- 1.2. Scope – need for service life and LCC calculations, what is covered, types of applicable structures (reinforced and prestressed concrete, buildings, parking structures, bridges and transportation structures), new construction with normal maintenance and repairs.
- 1.3. Service Life – definition, service v/s design life, many causes of deterioration, significance of corrosion, effect of chloride ions, marine structures, code requirements – ACI, AASHTO LRFD, others
- 1.4. Life Cycle Cost – definition, importance for prioritization of projects and funds allocation, who uses it – parking garage owners, major bridge projects, international practices, etc.
- 1.5. Corrosion – brief description of the process (reference to ACI 222), chloride threshold and initiation, propagation, damage, basic transport mechanisms: absorption, diffusion, advection; diffusion: the predominant mode, effect of cracking, temperature, effect of chloride ions, case of marine structures, assumptions and limitations
- 1.6. The Process – flowchart,
- 1.7. Summary of models, Life 365, Stadium, Suma, Duramodel
- 1.8. Summary of Assumptions and Limitations – Evaluation and repair of existing structures is not included. Chloride exposure only, except for multiple ions for marine structures. Assumes limited cracking or the joints and cracks are sealed with sealants at construction.

2. Factors Affecting Service Life

- 2.1. Primary factors: Structure types – details, environmental conditions- exposure
- 2.2. Structure Types:
 - Buildings and Parking Structures
 - Transportation and Bridges
 - Marine
 - Special Structures
- 2.3. Primary Concrete Structures
 - CIP –mild steel, P/T
 - Precast –Prestressed
- 2.4. Chloride Exposure and Anticipated Loadings – surface concentration, constant v/s cyclic exposure

March 24, 2006

Guide for Estimating Corrosion Service Life and Life Cycle Cost Of Reinforced Concrete Structures

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- 2.5. Effects of Climate on Chloride Transport – temperature and humidity
 - 2.6. Structure Geometry – 1D v/s 2D, vertical v/s horizontal surfaces,
 - 2.7. Clear Concrete Cover to Reinforcing Steel – effect on time to corrosion, significance of minimum cover requirements in various codes: ACI 318, AASHTO LRFD, international experience
 - 2.8. QA/QC – bar handling and placement, concrete quality
 - 2.9. Degree of Chloride Ion Saturation–
 - 2.10. Cracking – micro and macro cracking,
 - 2.11. Freeze-Thaw, Scaling, and Weathering –
 - 2.12. Marine Environment –
3. **Service Life Modeling Basics**
- 3.1. Base Case – Portland cement concrete
 - 3.2. Time to Corrosion (TTC) Initiation – chloride ion diffusion: Fickian model, concrete diffusion coefficient
 - 3.3. Factors Affecting Diffusion Coefficient – time and temperature effect, types of cement, chloride binding
 - 3.4. Solution Technique – ways to solve 2nd order differential equation
 - 3.5. Propagation Period – concept, observations, recommendations
 - 3.6. Effect of Variability of Parameters Influencing Service Life Calculation – statistical nature of variables influencing TTC, combined effect, ways to calculate the confidence interval of the predicted TTC,
 - 3.7. Types of cements - chloride binding
4. **Modeling Protection Systems**
- 4.1. High Performance Concrete – extending service life through improved durability, role of SCMs, blended cements,
 - Supplementary Cementitious Materials – slag, fly ash, silica fume, etc.; effect on diffusivity or the “m” value and thus on TTC (time to corrosion), recommendations for parameters affecting calculations
 - Corrosion Inhibiting Admixtures – types, effect on threshold, recommendations for parameters affecting calculations
 - 4.2. Type of Reinforcement – carbon steel, galvanized steel, epoxy coated steel, stainless steel, stainless clad, MMFX, etc., recommendations for parameters affecting calculations
 - 4.3. Sealers, Coatings, and Membranes – Modus operandi, recommendations for parameters affecting calculations
 - 4.4. Examples
5. **Maintenance and Repair**
- 5.1. Selection of maintenance and repair criteria

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- 5.2. Typical maintenance – inspection, washing and cleaning, interim expansion joint repair, filling of cracks, patching, sealing, coating, interim repair or replacement of membranes, resurfacing, schedule or frequency
- 5.3. Typical repair and reconstruction - effect on remaining service life and life cycle cost – effect on additional corrosion, relative costs of various repair and rehab options, evaluation of repair alternatives,
- 5.4. Owner (down time) and user costs (delays)

- 6. Life Cycle Cost Analysis**
 - 6.1. Types of Costs – first cost of construction, recurring costs of maintenance and repair, user costs of delays, owner costs due to shut-downs,
 - 6.2. Time Value of Money – the basic equation, real rate of return, inflation, and discount rate and recommended value (3%?), effect of discount rate and duration of service life on LCC, ASTM standards, federal discount rate recommendations (public), discount rate (private).
 - 6.3. Sensitivity of Predicted Life Cycle Costs – effect on LCC of statistical nature of variables influencing TTC, combined effect, probable cost, confidence interval,
 - 6.4. Comparing Alternatives – use of LCCA for comparing alternatives for allocating funds for repair, rehab, and reconstruction to maximize return on investment while satisfying competing demands for the limited pool of funds,

- 7. Looking Beyond the Basic Calculations**
 - 7.1. Other Modes of Chloride Ion Transport –
 - 7.2. Role of Other Ions –
 - 7.3. Effect of Cracking – micro, macro
 - 7.4. Importance of Simultaneous Reactions –
 - 7.5. External Sulfate Attack –
 - 7.6. Delayed Ettringite Formation –
 - 7.7. Carbonation –
 - 7.8. Frost Action –
 - 7.9. Alkali Silica Reactivity –
 - 7.10. Micro Environment
 - 7.11. Cathodic Protection
 - 7.12. Chloride Extraction

- 8. References**

- Appendix
 - 1. Examples of Service Life Techniques
 - o Model 1
 - o Model 2
 - o Model 3

**Guide for Estimating Corrosion Service Life and Life Cycle Cost
Of
Reinforced Concrete Structures**

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- 2. Details of Modeling and Analysis
 - Boundary Conditions
 - Chloride Transport
- 3. Corrosion
- 4. Economic and Life Cycle Cost
- 5. Deterioration Mechanisms
- 6. Maintenance and Repair
- 7. Chemical Equilibrium