Implementing Service Life Design Using the *fib* Bulletin 34 Methodology

**IBC Workshop: W-8 Service Life Design**

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bulletin 34 model code for service life design

- Written and distributed by the International Federation of Structural Concrete (fib)

- A reliability-based service life design methodology for concrete structures
  - Concept is similar to AASHTO Load-Resistance Factor Design

- Based on ISO 16204:2012 Service Life Design of Concrete Structures
All degradation mechanisms are addressed with 1 of 2 strategies:

- **Avoidance** approach applied for:
  - Alkali Aggregate Reactivity
  - Delayed Ettringite Formation

- **Deemed-to-satisfy** approach can be applied to limit deterioration
  - Freeze-thaw degradation
  - Sulfate attack
  - Carbonation-induced corrosion
  - Salt scaling

- **Full probabilistic** approach for:
  - Chloride-induced corrosion
1. Define exposure zones and degradation mechanisms applicable to each component
2. Select limit states that define end of service life
3. Determine Design Parameters:
   - Materials
   - Concrete properties
   - Concrete cover thickness
4. Develop Project Specifications
   - Materials and design features
   - QA/QC procedures
5. Construction → pre-qualification and production testing → QC/QA process
Service Life Assessment

1. Define exposure zones and degradation mechanisms

Exposure Zones:
- Atmospheric without de-icing salts
- Atmospheric with severe de-icing salts
- Splash / Atmospheric with moderate de-icing salts
- Submerged
- Buried
1. Define exposure zones and degradation mechanisms:

- Temperature
- Extent of splash/spray zone
- Application of chloride – deicing salts, sea water
- Soil/water exposure

- Data should be gathered:
  - water chemistry (chlorides, sulfates, pH)
  - soil chemistry (chlorides, sulfates, pH)
  - aggregate characteristics
2. Select limit states:

- Applicable to time-dependent deterioration
- Depassivation of reinforcement marks end of service life
- Occurs when critical chloride threshold is reached at reinforcement
- Durability limit state:
  - 10% probability that corrosion will initiate within the service life
  - 90% probability that it will not!
- May be conservative in relation to SLS and ULS
3. Design Parameters – probabilistic approach
### Service Life Assessment

#### 4. Input into Project Specification

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Structural Element</th>
<th>Nominal cover</th>
<th>Max. w/cm</th>
<th>Mix 1</th>
<th>Mix 2</th>
<th>Mix 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-icing salt spray</td>
<td>Towers, pier caps, abutments</td>
<td>3.0</td>
<td>0.40</td>
<td>14.1</td>
<td>3.4</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Deck</td>
<td></td>
<td></td>
<td>11.3</td>
<td>2.7</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Concrete barriers</td>
<td>2.75</td>
<td></td>
<td>12.4</td>
<td>3.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Atmospheric</td>
<td>Towers, pier caps, pier columns</td>
<td>3.0</td>
<td>0.40</td>
<td>15.0</td>
<td>11.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Splash</td>
<td>Towers, pier caps, pier columns</td>
<td>3.0</td>
<td>0.40</td>
<td>15.0</td>
<td>5.1</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>Pile caps</td>
<td>4.0</td>
<td></td>
<td>15.0</td>
<td>9.9</td>
<td>12.0</td>
</tr>
<tr>
<td>Submerged</td>
<td>Concrete plug for piles</td>
<td>2.5</td>
<td>0.40</td>
<td>15.0</td>
<td>5.8</td>
<td>8.3</td>
</tr>
</tbody>
</table>
5. Construction → Pre-qualification and production testing

For time to corrosion modelling fib Model Code is based on NT Build 492: Rapid Chloride Migration Test

- measure the migration coefficient of concrete at 28 days
- direct input parameter to fib algorithm
NT Build 492 - Testing
NT Build 492 - Results

- Split specimen axially into 2 pieces
- Spray silver nitrate solution on broken surface
- Measure chloride penetration depth
- Calculate Chloride Migration Coefficient, $D_{RCM,0}$
• Important to perform test at 28 days
• Test usually takes 24 hours
• One test includes 3 specimens
• Cost of a single test is approximately $1,000+

• Note: specify the test frequency wanted during construction
Design Tools

- SHRP2 Website:
  - http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx
Summary

- Scientific approach to quantify and validate service life
- *fib* Bulletin 34 design strategies:
  - Avoidance or deemed to satisfy durability requirements
  - Probability-based mathematical modelling of time to corrosion
- Based on environmental loads and materials resistances and defined durability requirements
- Specifications are developed considering applicable exposure conditions, deterioration mechanisms, available materials, and work methods
- Verification procedures are implemented during construction
A Few Key Projects

• Governor Mario M. Cuomo (Tappan Zee) Bridge
  – 100 year service life
A Few Key Projects

- Abraham Lincoln Bridge (KY-IN)
  - 100 year service life
A Few Key Projects

- North Commuter and Traffic Bridge Replacement Project, SK, Canada
  - 75 year service life