Service Life Design on Alternative Delivery Projects

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What Is the Objective?

• Longer time before obsolescence and/or major rehabilitation:
  – Reduced maintenance and rehabilitation costs
  – Reduced disruption to users
  – Less reliance on outside contractors to do the work
  – No surprises re maintenance and rehab requirements

• Lower full-life costs… with reasonable initial cost premium

• Design, construction and quality management that provides confidence that
  the objectives will be achieved

• Scope: concrete, structural steel, cables, M&E systems, pavements and
  wearing courses
What Do We Need for Specifications?

• Avoid vague statements like:

  ➢ "Bridges are to be designed with consideration given to the Department’s 100-year-bridge life initiative."

  ➢ "The service life of the structure shall be 100 years."
What Do We Need for Specifications?

- Definition for service life
- Design methodology
- A limit state
- Specific exposure conditions
- Acceptance testing to be performed during construction (tests and frequency)
Definition of Service Life

- CSA A23.1-14 and S6: Service life — the time during which the structure performs its design function without unforeseen maintenance or repair.

- ACI 365: Service life (…) is the period of time after (…) placement during which all the properties exceed the minimum acceptable values when routinely maintained.

- AASHTO LRFD: The period of time that the bridge is expected to be in operation.

- *fib* Bulletin 34 - Model Code for Service Life Design: Design Service Life – assumed period for which a structure or a part of it is to be used for its intended purpose.
Design methodology

- fib Bulletin 34 Model Code for Service Life Design
- fib Model Code for Concrete Structures 2010
- ISO 16204:2012 Service Life Design of Concrete Structures
Limit State

• Concrete components must resist chloride ingress such that corrosion is not initiated within the service life based on a target confidence level of 90%.

• Specific service lives for different components:
  – Non-replaceable components
  – Replaceable components:
    • Bearings
    • Expansion joints
    • Concrete barriers
    • Coatings for structural steel (paint system)
Specifications

• Service life is the actual period of time during which a structure performs its design function without unforeseen costs for maintenance and repair.

• Non-replaceable components (state which ones) shall be designed for a 100 year service life.

• The service life of concrete components shall be in accordance with Bulletin 34, Model Code for Service Life Design, written by the International Federation for Structural Concrete (fib), February 2006.

• Concrete components must resist chloride ingress such that corrosion is not initiated within the service life based on a target confidence level of 90%.
Specifications

• Specific service life for non-replaceable components
  – Bearings
  – Expansion joints
  – Concrete barriers
  – Coatings for structural steel (paint system)
    • add definition of service life for structural steel
Specifications

• Testing during construction can be specified:
  – Concrete durability properties
    o Rapid chloride migration NTBuild 492
    o Acid soluble chloride content ASTM C1152
    o Plastic air content
    o Hardened air content
    o Aggregates properties (AAR)
  – As-built concrete covers
Specifications

• Clarify procedure for non-conformances
  – low cover
  – high concrete transport properties

• Expect deviations from Standard Specifications
  – type of cementitious materials and amount
  – tests types and acceptance limits
  – less prescriptive requirements in some instances
Public-Private-Partnership

• Requirements at Handback
  – Condition of the component
  – Remaining service life criteria
  – Methodology?
  – Operating Company to submit a proposed methodology and Handback Plan 10 years prior to Handback?
Questions?

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AASHTO SHRP2 R19A Website:
http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx

FHWA GoSHRP2 Website:
www.fhwa.dot.gov/GoSHRP2/

January 2018
Purpose:
Create a sample specification for durability design that could be used on a major project such as the Columbia River Crossing.
Documents Reviewed:

- I-5 Columbia River Crossing Design Criteria – Feb 2013
- ODOT Specification DB 141.11 – Structures – Oct 2013
- Design for Service Life: General Concepts (Prepared by Dr. Atorod Azizinamini for the TZHRC project) – June 2012
- Service Life Design for Alternate Project Delivery (presentation to the ASBI National Convention by Mike Bartholomew) – Nov 2016
- 100 Year Service Life Study – Chloride Migration Coefficient Evaluations – PennDOT Research Agreement E03134 by Clay Naito and others, June 2016
Sample Project Specifications Reviewed:

- Tappan Zee Hudson River Crossing – Nov 2012
- The East End Crossing (Louisville-Southern Indiana Ohio River Bridges) – July 2012
- Goethals Bridge Replacement (The Port Authority of New York and New Jersey) – Feb 2013
Reviewers:

- ODOT
  - Bruce Johnson, PE, State Bridge Engineer
  - Ray Bottenberg, PE, Bridge Preservation Managing Engineer
  - Andrew Blower, PE, Corrosion Protection Engineer

- COWI North America
  - Anne-Marie Langlois, PE, Bridge Engineer, Group Lead
  - Don Bergman, PE, Senior Project Director
  - Bradley Justin Pease, PhD, PE

- CH2M
  - Mike Bartholomew, PE, Design Practice Lead
Primary ODOT contributions:

- Language

  - Imperative Mood (vs. indicative mood)
    - Required by ODOT Specification and Writing Style Manual, 2009
    - Meets the “Plain Language” requirements of ORS 183.750
    - Results in specs that are shorter, crisper, and easier to understand
    - The subject is implied and the verb expresses command
      - Example: Furnish the following materials:
Primary ODOT contributions:

- Corrosion Loading
  - Will be determined by the project team
  - Current recommendations (% of chlorides by weight of concrete)
    - **1.1% for heavy exposure areas**
      - Siskiyou Mountains in SW Oregon
      - Coastal areas with direct exposure to the ocean
    - **0.12% for moderate exposure**
      - Portland Metro and the Willamette Valley
  - Expect modifications as we gather additional data
    - Volume of data is not adequate to establish a mean and standard deviation.
    - Available data is generally limited to decks
Specification Highlights

- **Scope**

  - This work consists of performing analysis, testing, and providing reports to demonstrate that the designed bridge is capable of providing the minimum required design service life according to **00XXX.50 Design Service Life Requirements**.
Specification Highlights

- **Definitions**

  - **Design Service Life** - The specified period of time for which a structure or a component is to be used for its intended purpose with appropriate maintenance activities and without unplanned major repair, or rehabilitation, or replacement.

  - **Service Life** - The actual period of time where the structure is used for its intended purpose with appropriate maintenance activities and without unplanned major repair, or rehabilitation or replacement.
Specification Highlights

- **Unacceptable Materials**
  - Stay-in-place deck forms
  - Steel girder or composite sandwich decking
  - Timber or timber composites
  - Proprietary composite steel/concrete girder systems
  - Previously used materials
Specification Highlights

- **Strategy**
  - Avoid the degradation mechanism.
  - Select materials and details which resist the degradation mechanism for the required period of time.
  - Supply supplementary measures to protect the structure from the degradation mechanism for the required period of time.
  - By other means acceptable to the Agency.
Specification Highlights

- Design Service Life – Non-Replaceable Components

  - Major Bridges 100 years
  - Other Bridges 75 years

Note that Design Service Life would typically be the same for all non-replaceable components.
### Specification Highlights

- **Design Service Life – Replaceable Components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Major Bridges</th>
<th>Other Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Bridge Barriers</td>
<td>40 years</td>
<td>40 years</td>
</tr>
<tr>
<td>Steel Bridge Rail Elements</td>
<td>40 years</td>
<td>30 years</td>
</tr>
<tr>
<td>Deck Wearing Surface</td>
<td>25 years</td>
<td>25 years</td>
</tr>
<tr>
<td>Bridge Bearings</td>
<td>40 years</td>
<td>40 years</td>
</tr>
<tr>
<td>Expansion Joints</td>
<td>30 years</td>
<td>30 years</td>
</tr>
<tr>
<td>Coating Systems</td>
<td>20 years</td>
<td>20 years</td>
</tr>
</tbody>
</table>
**Specification Highlights**

- **Service Life and Corrosion Protection Plan**

  - Provide a detailed Service Life and Corrosion Protection plan for all bridges, prepared by or under the direction of a qualified Professional Engineer licensed in the State of Oregon and bearing the engineer’s signature, seal, and expiration date.
**Specification Highlights**

- **Full Probabilistic Models**
  - Model the chloride-induced corrosion process in concrete components based on the fib Bulletin 34 approach using a full probabilistic model.
  
  - Test the concrete transport properties of the concrete mixes used in the permanent works using a test consistent with the chosen model. Use the NT Build 492 test if the modeling is performed according the fib Bulletin 34 chloride-induced corrosion model.

*** Need to specify the test frequency! ***
Thanks to:

- **Andrew Blower** for confirming the fine details, especially the recommended corrosion loading.

- **Mike Bartholomew** for providing sample documents to get us started and for a detailed review of the draft specs.

- **Anne-Marie Langlois** and the COWI team for their very detailed review of the draft specifications.