



SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Service Life Design on Alternative Delivery Projects

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AASHTO

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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
    - Rapid chloride migration NTBuild 492
    - Acid soluble chloride content ASTM C1152
    - Plastic air content
    - Hardened air content
    - 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/

SHRP2 Project 19A

Project Summary – January 17. 2018

ODOT's Sample D/B Specifications

Prepared by

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Bridge Operations & Standards Managing Engineer

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**

	Major Bridges	Other Bridges
Concrete Bridge Barriers	40 years	40 years
Steel Bridge Rail Elements	40 years	30 years
Deck Wearing Surface	25 years	25 years
Bridge Bearings	40 years	40 years
Expansion Joints	30 years	30 years
Coating Systems	20 years	20 years

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.