


SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

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

IBC Workshop: W-8 Service Life Design

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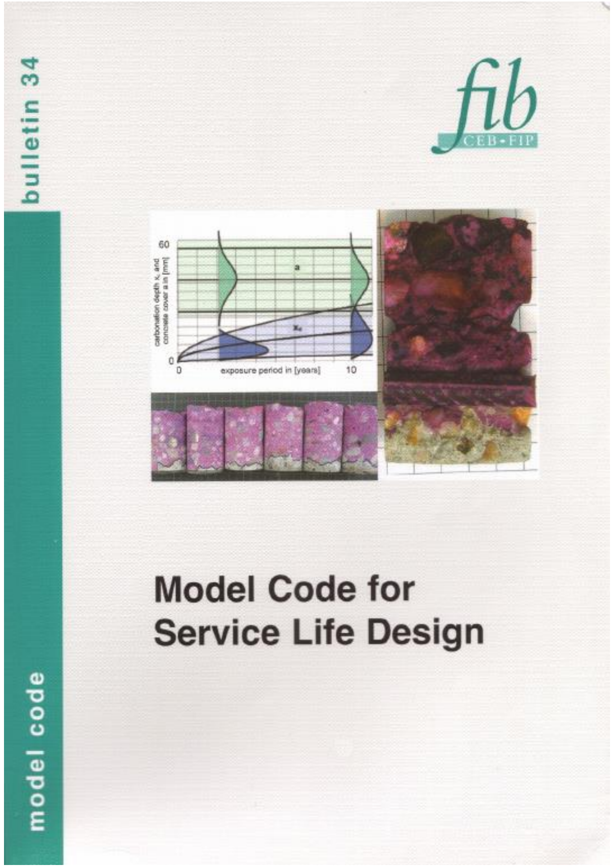
U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

fib Bulletin 34 Model Code for Service Life Design

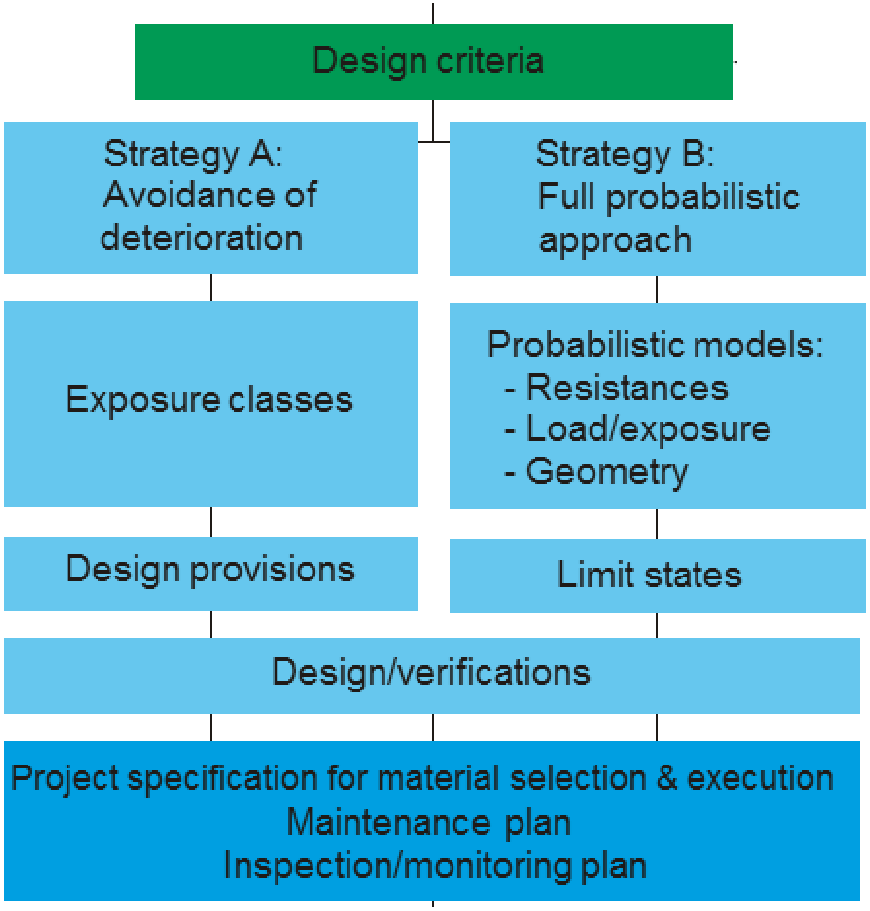
- Written and distributed by the International Federation of Structural Concrete (*fib*)
- A reliability-based service life design methodology for concrete structures
  - Concept is similar to AASHTO Load-Resistance Factor Design
- Based on ISO 16204:2012 Service Life Design of Concrete Structures



fib Bulletin 34 Model Code for Service Life Design

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



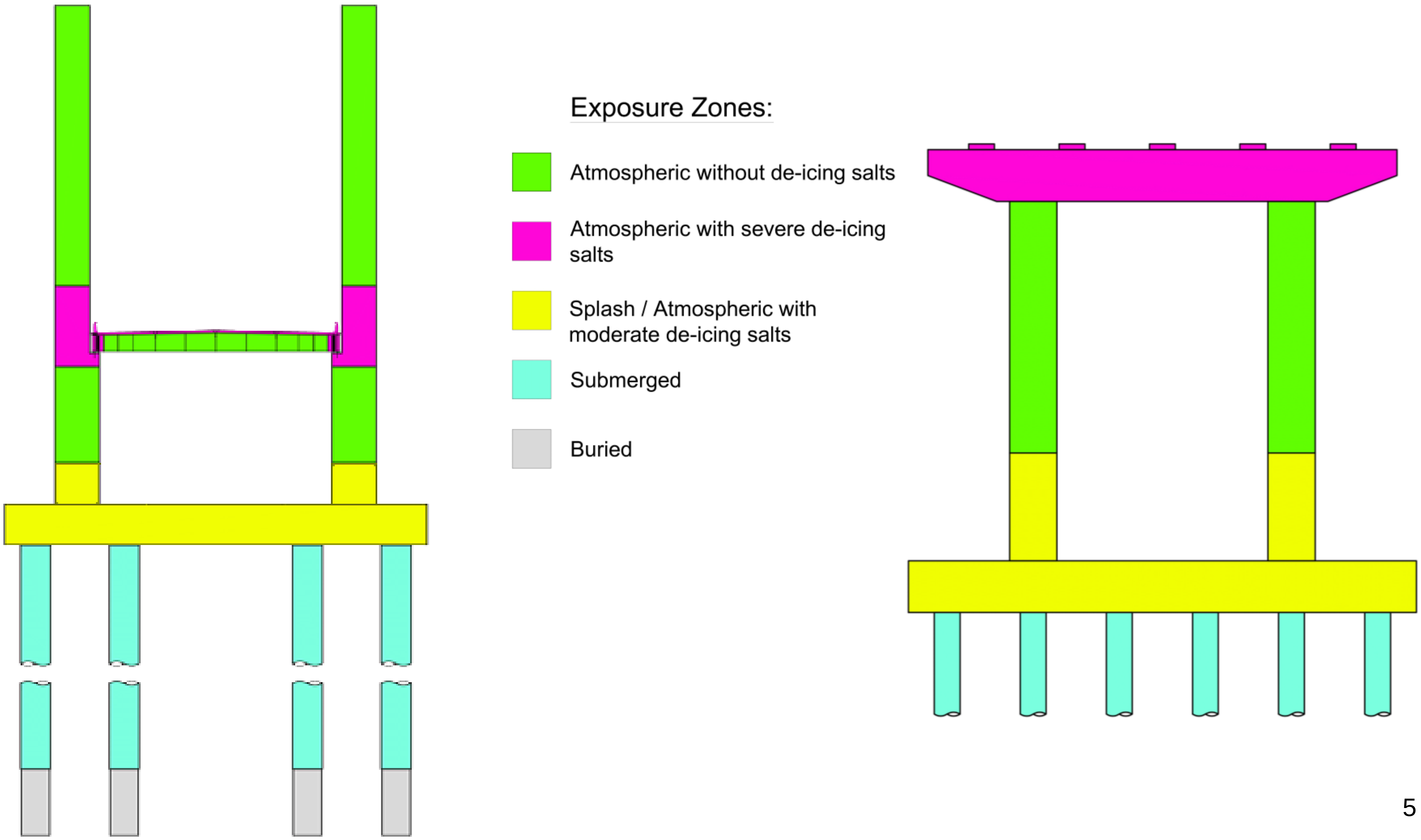
Service Life Design Strategy - Implementation Process

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



Service Life Assessment

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

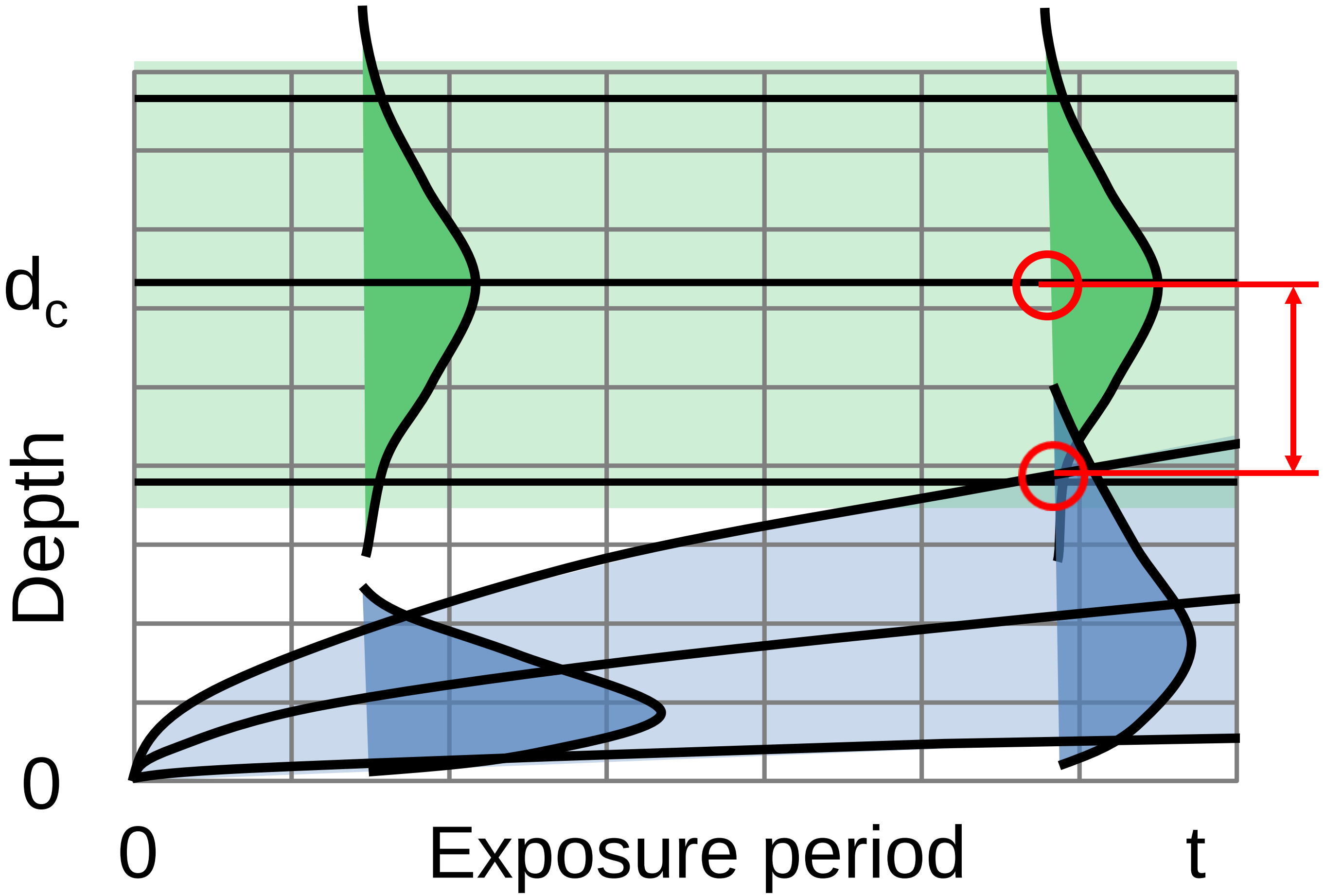
Modelling Chloride-induced Corrosion

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

Modeling Chloride-induced Corrosion

3. Design Parameters – probabilistic approach



Service Life Assessment

4. Input into Project Specification

Exposure Zone	Structural Element	Nominal cover [in]	Max. w/cm [-]	Max. mean Chloride Migration Coefficient $D_{28} \times 10^{-9}$ [in²/s] Mix 1	Mix 2	Mix 3
De-icing salt spray	Towers, pier caps, abutments	3.0	0.40	14.1	3.4	4.9
	Deck			11.3	2.7	4.0
	Concrete barriers	2.75		12.4	3.4	4.6
Atmospheric	Towers, pier caps, pier columns	3.0	0.40	15.0	11.0	12.0
Splash	Towers, pier caps, pier columns	3.0	0.40	15.0	5.1	7.1
	Pile caps	4.0			9.9	12.0
Submerged	Concrete plug for piles	2.5	0.40	15.0	5.8	8.3

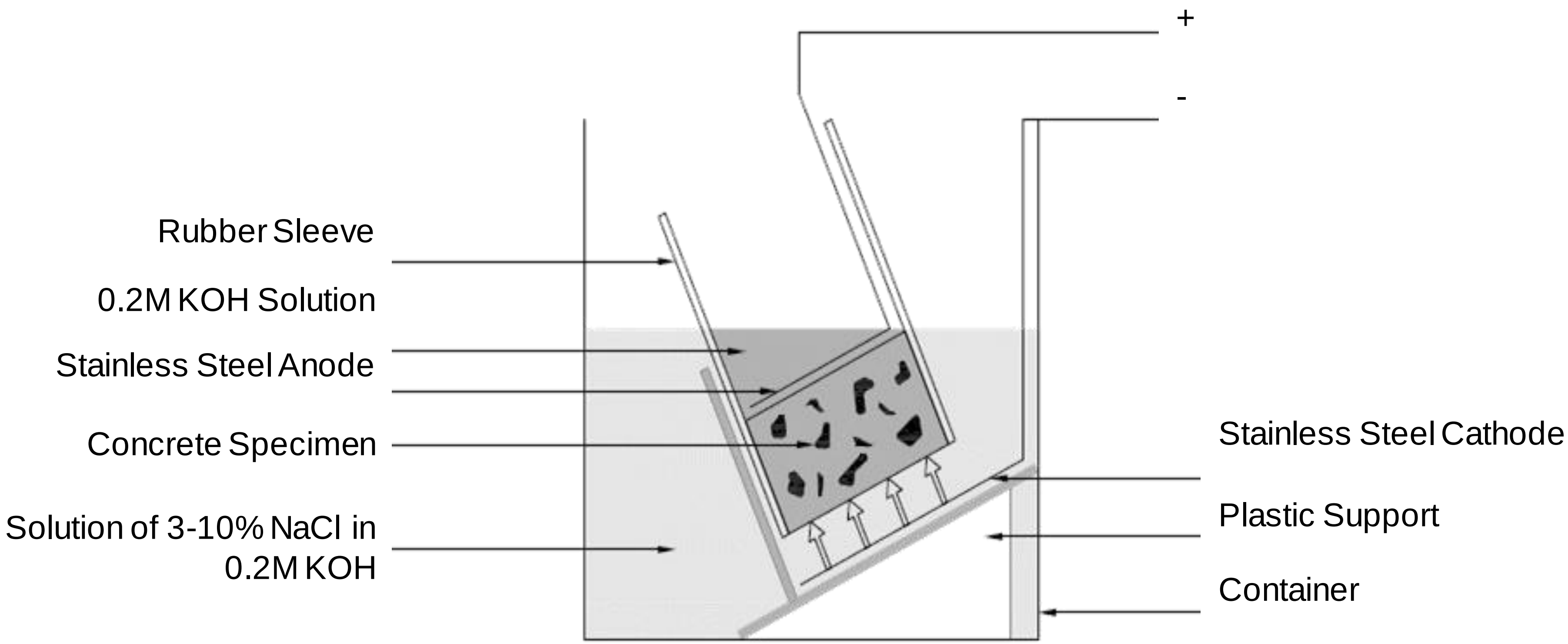
Service Life Assessment

5. Construction → Pre-qualification and production testing

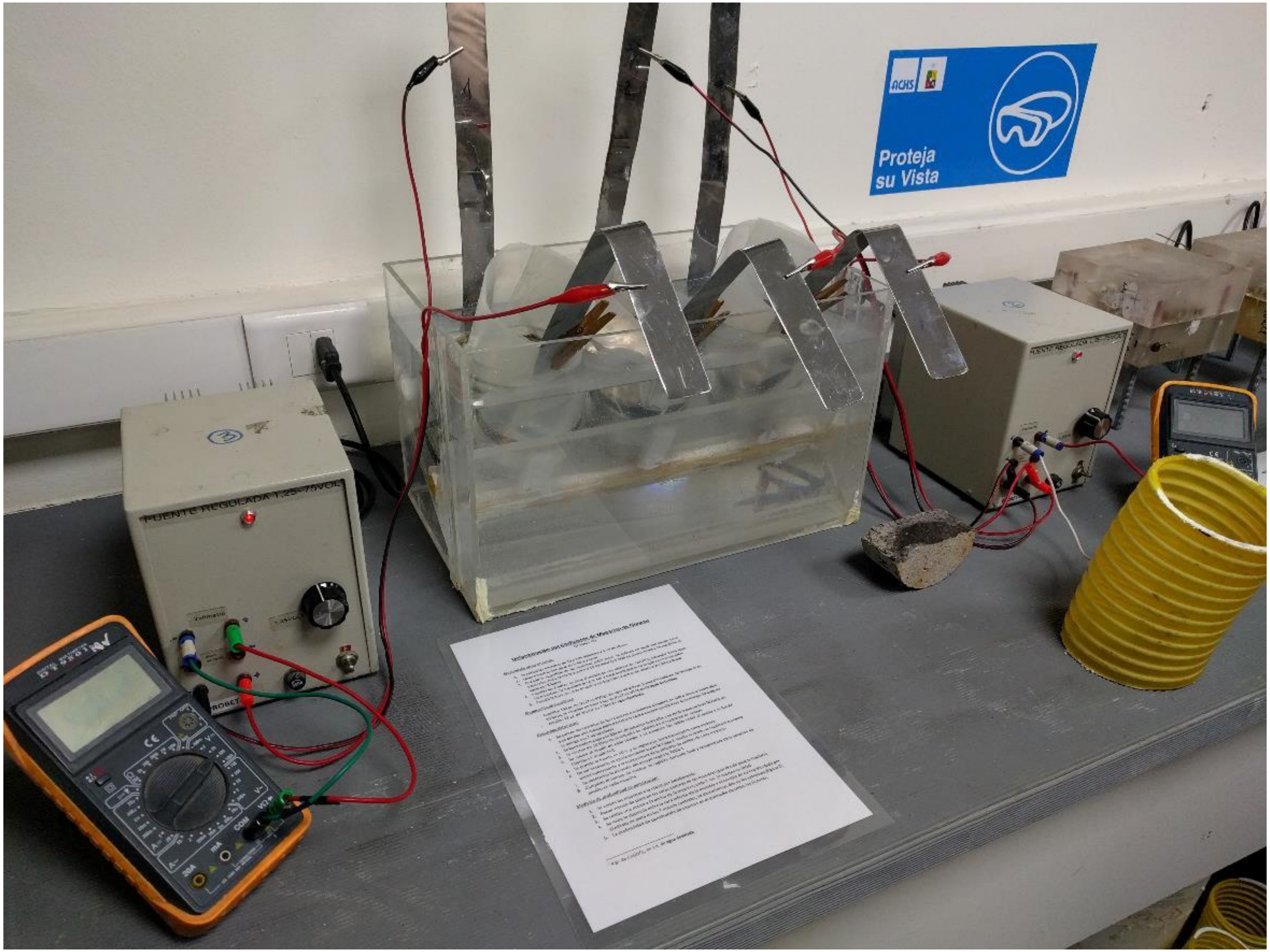
For time to corrosion modelling *fib* Model Code is based on

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 – Test Setup



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, $D_{RCM,0}$

NORDTEST METHOD

NT BUILD 492 7

APPENDIX 1

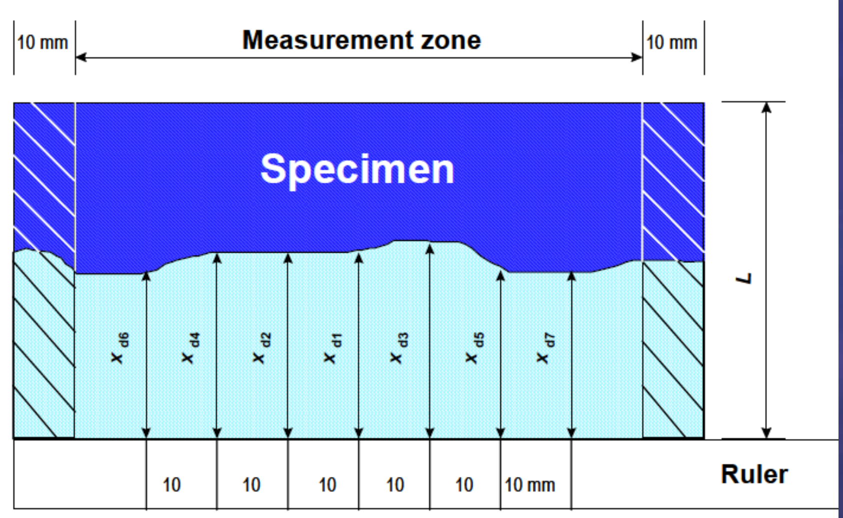


Fig. 5. Illustration of measurement for chloride penetration depths.

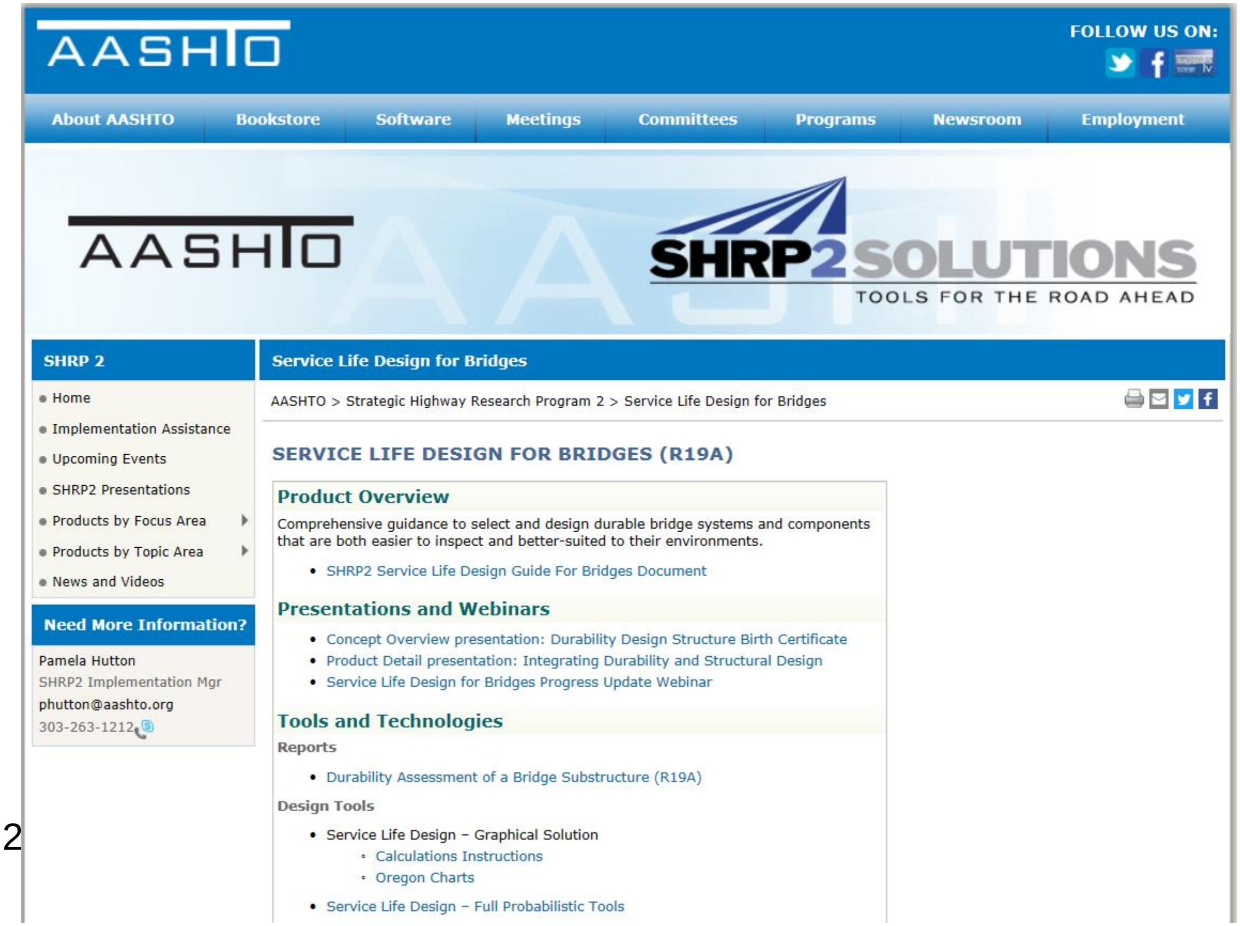
NT Build 492 Test Summary

- 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

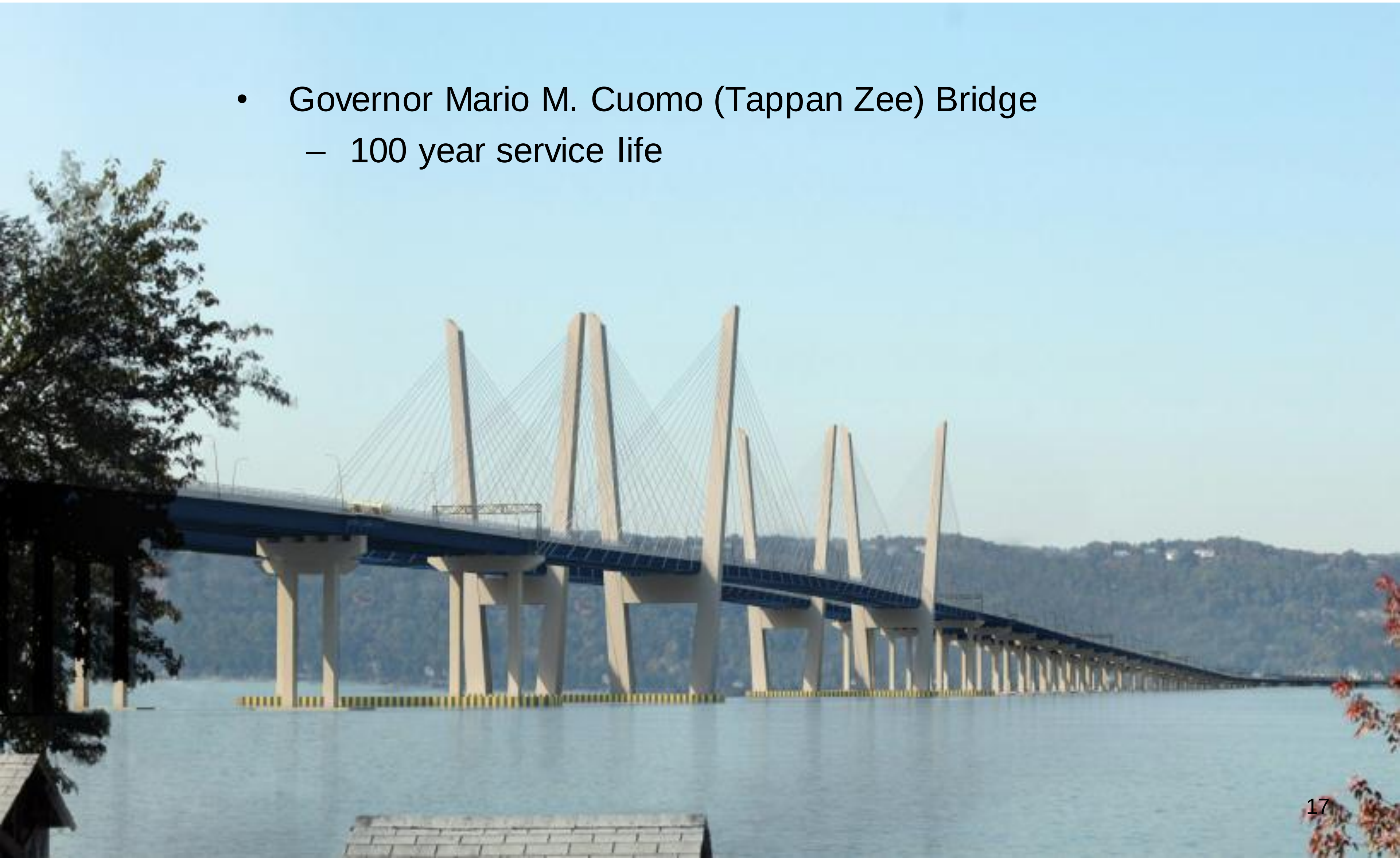


Summary

- 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

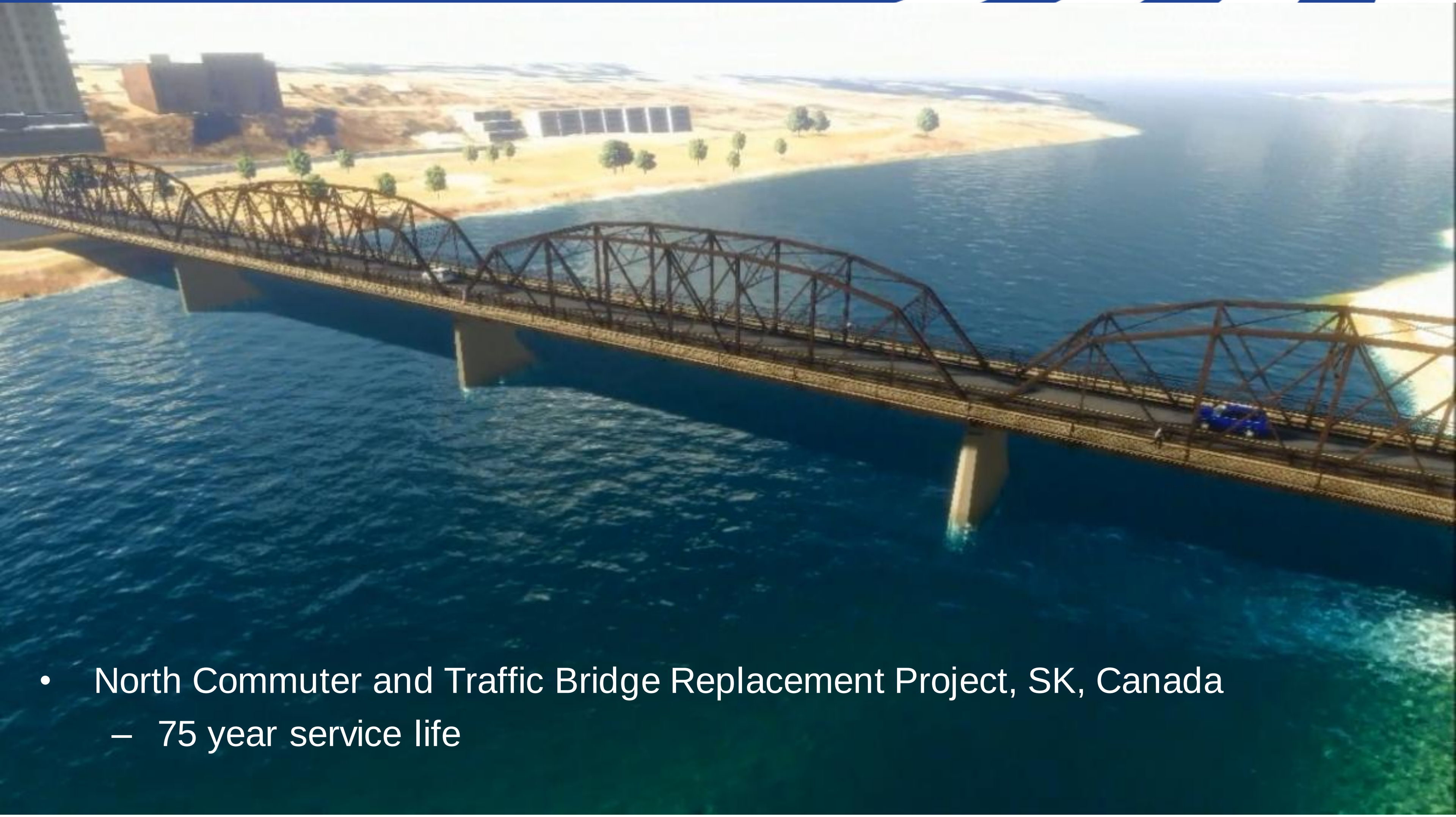
- Governor Mario M. Cuomo (Tappan Zee) Bridge
  - 100 year service life



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