



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

## IBC Workshop: W-8 Service Life Design

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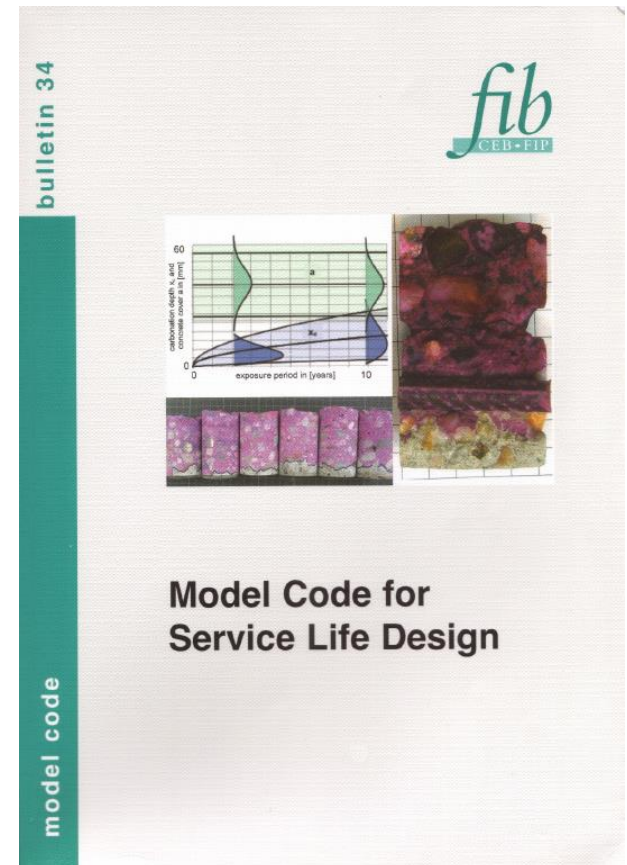
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# *fib* Bulletin 34 Model Code for Service Life Design

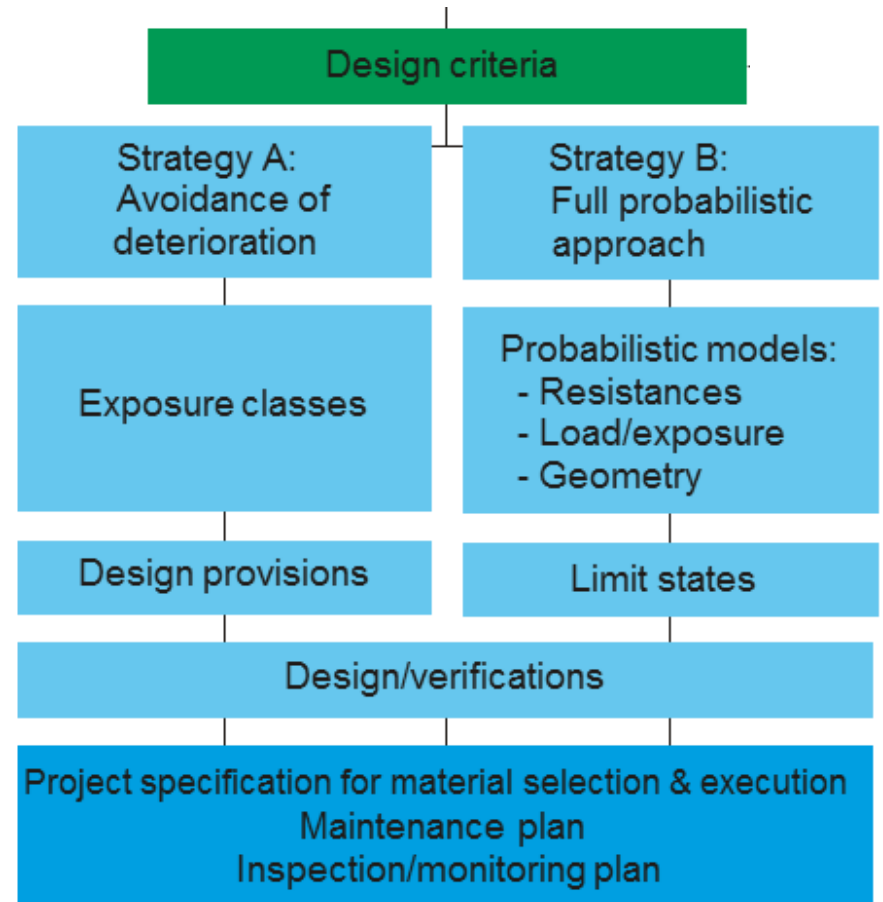
- Written and distributed by the International Federation of Structural Concrete (*fib*)
- A reliability-based service life design methodology for concrete structures
  - Concept is similar to AASHTO Load-Resistance Factor Design
- Based on ISO 16204:2012 Service Life Design of Concrete Structures



# *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



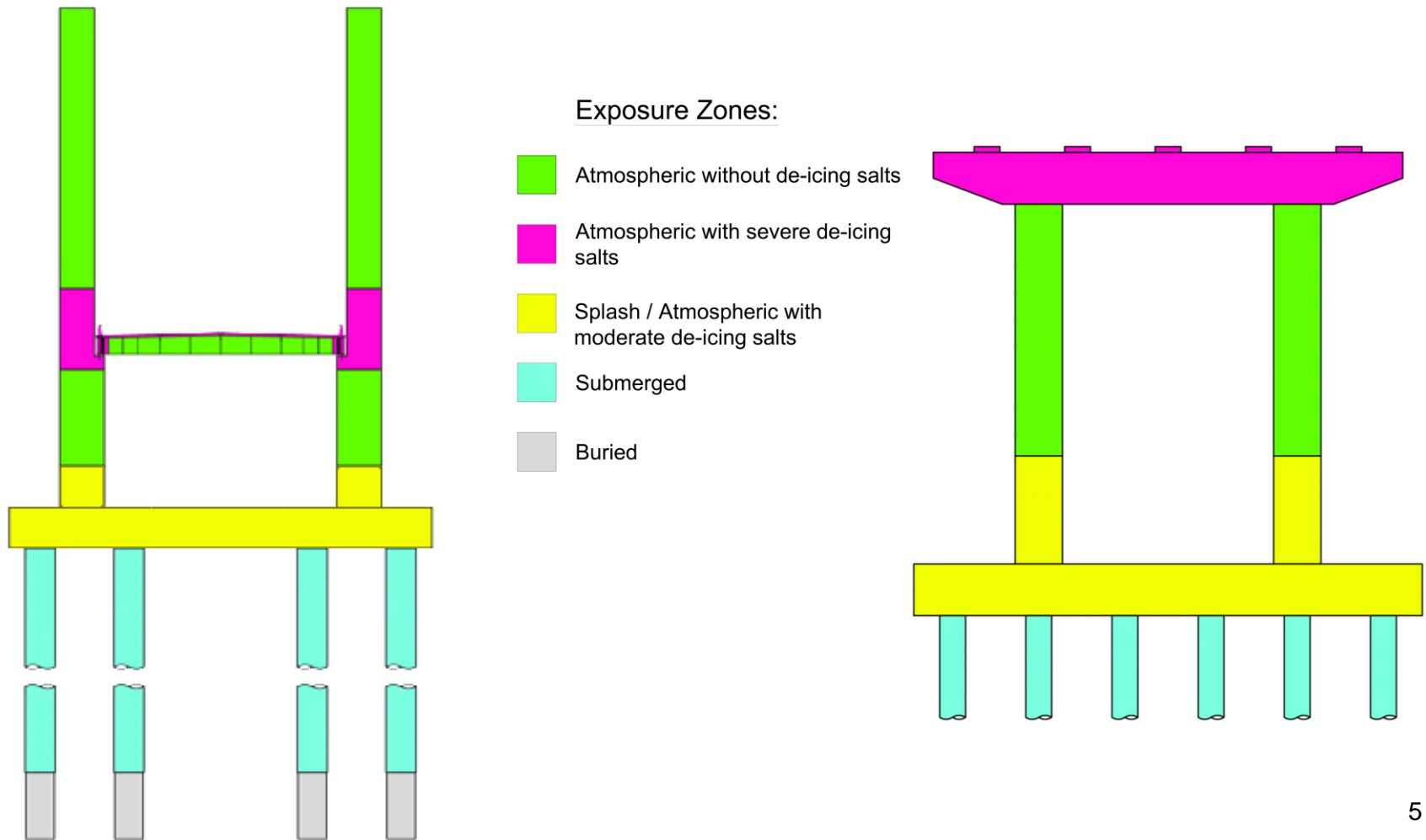
# Service Life Design Strategy - Implementation Process



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

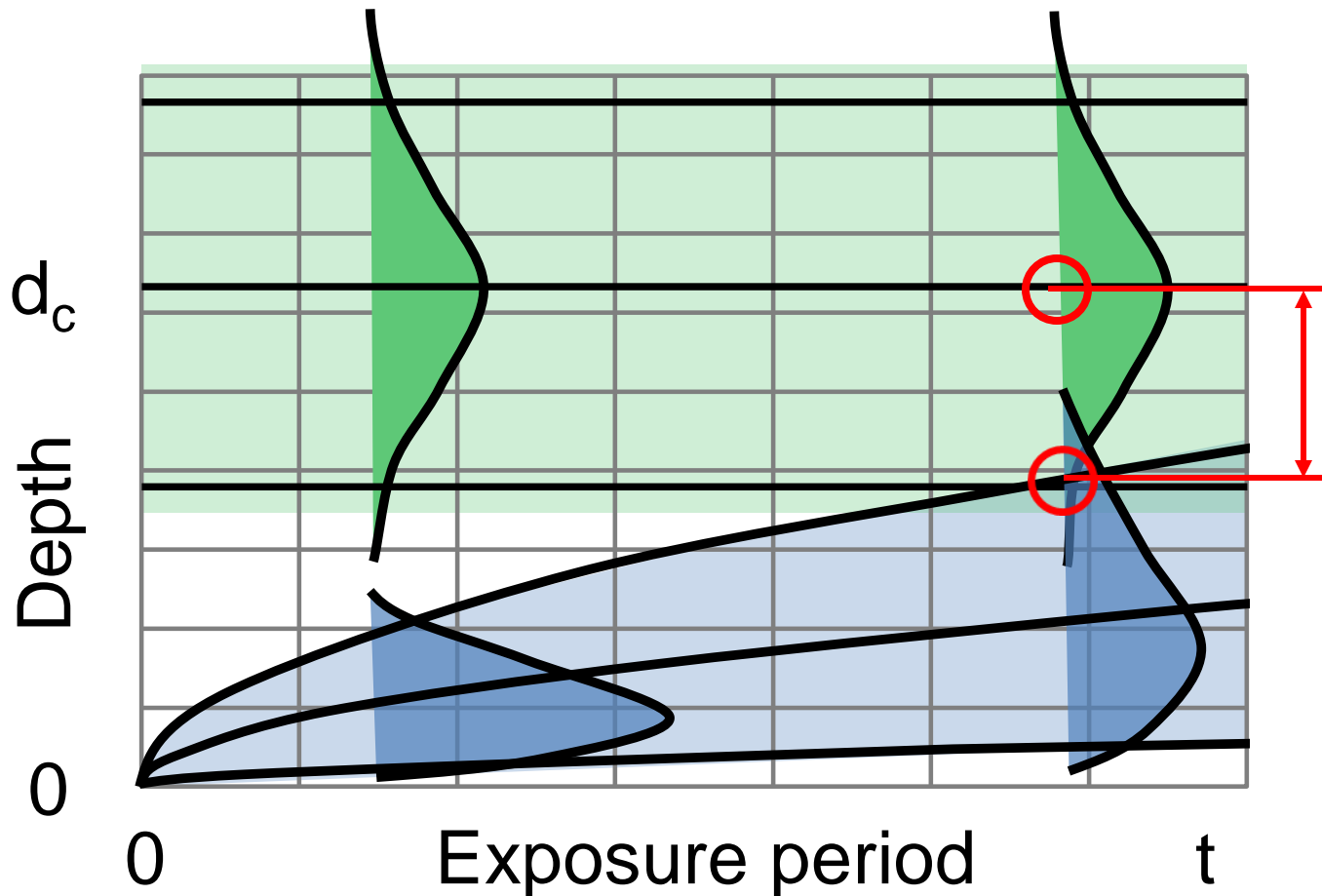
# Modelling Chloride-induced Corrosion

## 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

				Mix 1	Mix 2	Mix 3
Exposure Zone	Structural Element	Nominal cover	Max. w/cm	Max. mean Chloride Migration Coefficient		
		[in]	[-]	$D_{28} \times 10^{-9}$ [in <sup>2</sup> /s]		
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

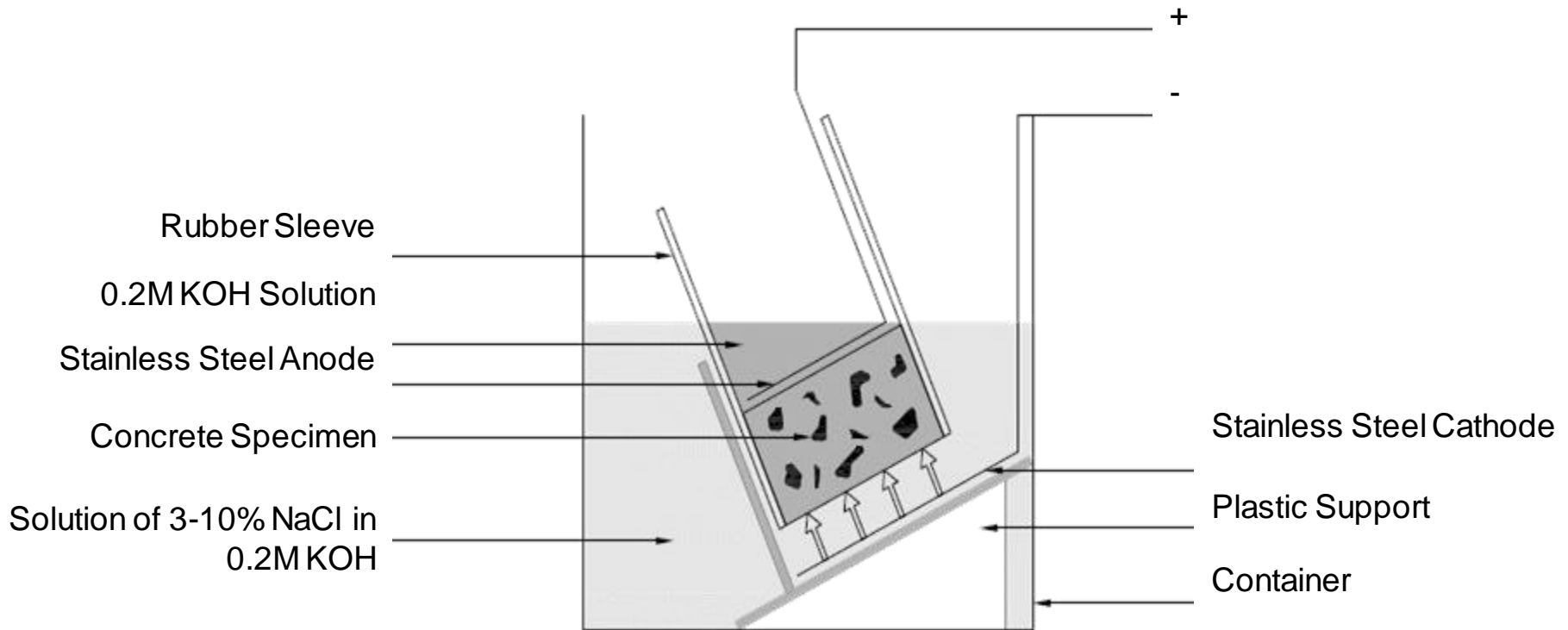
# Service Life Assessment

## 5. Construction → Pre-qualification and production testing

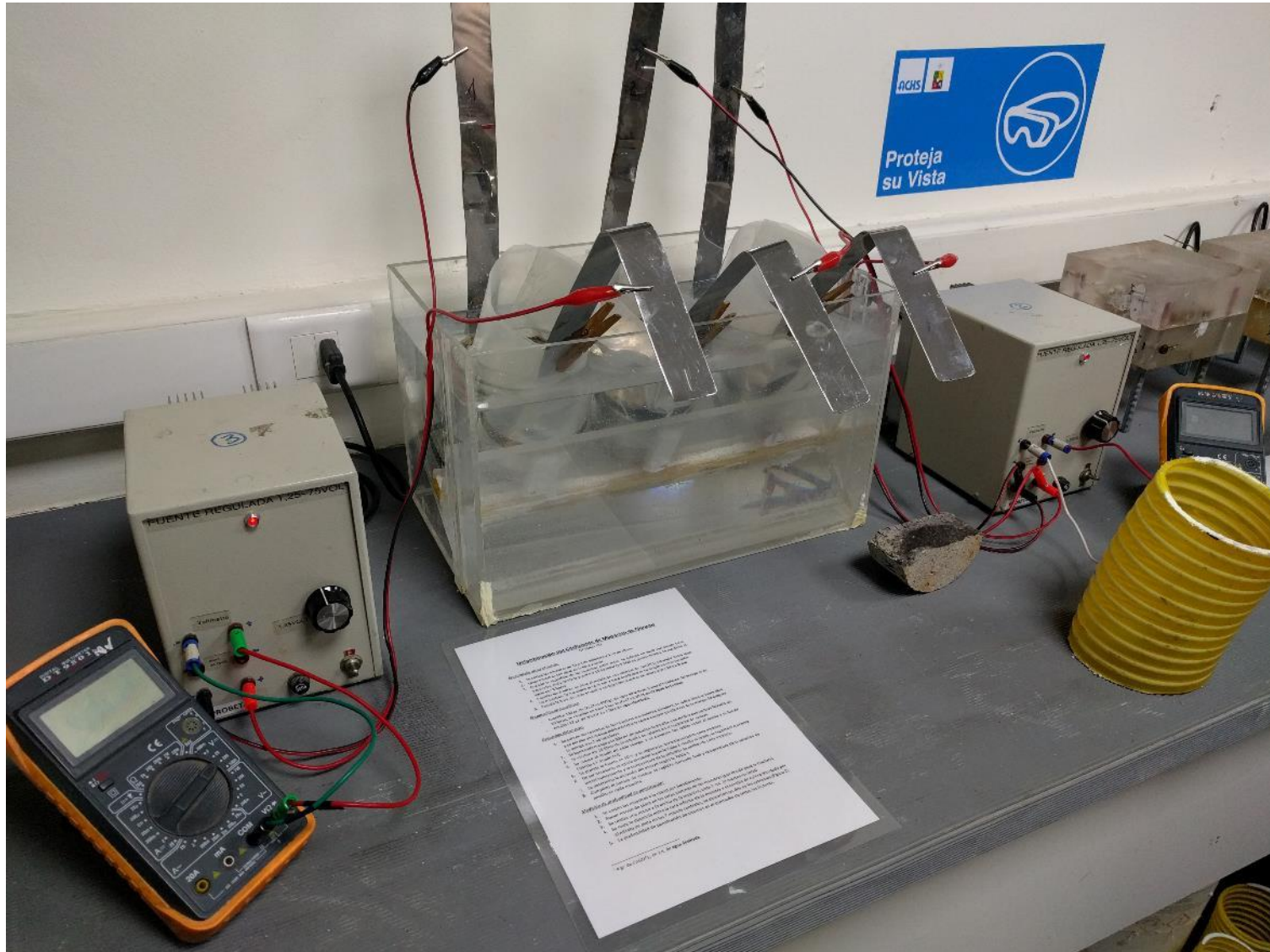
For time to corrosion modelling *fib* Model Code is based on

### 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

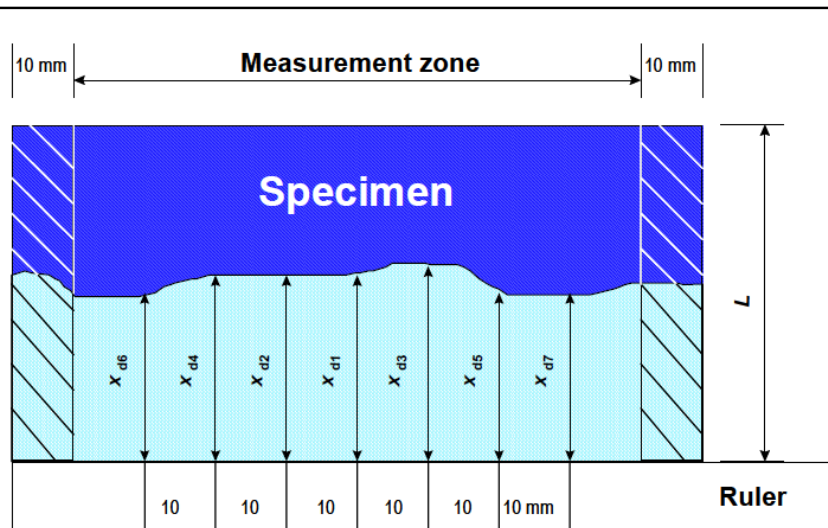
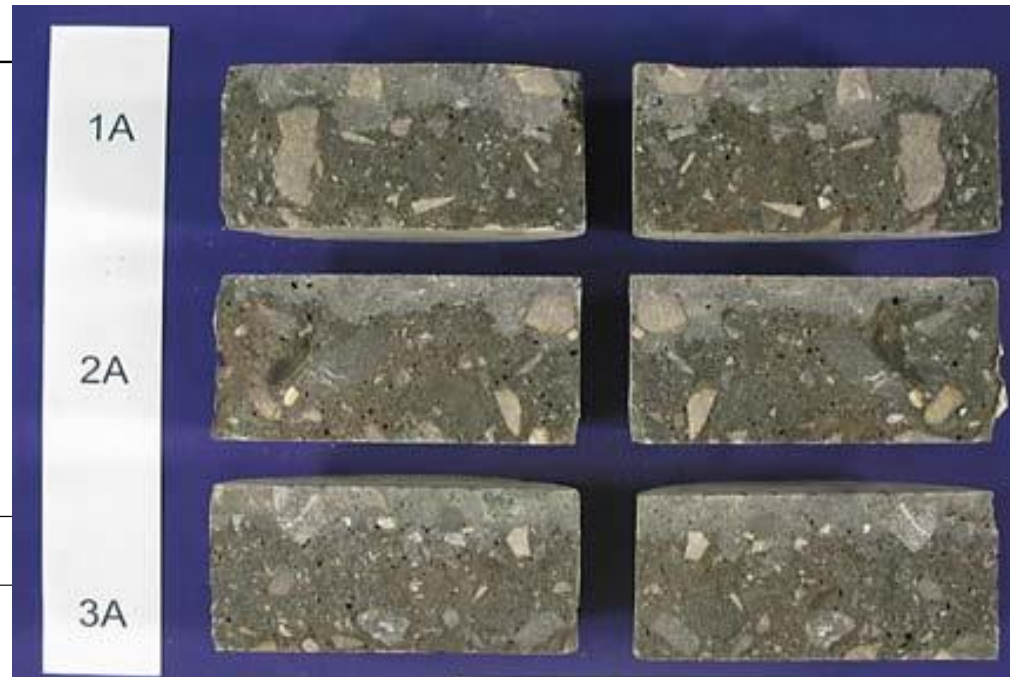


Fig. 5. Illustration of measurement for chloride penetration depths.



# 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>

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**Need More Information?**

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303-263-1212

**Service Life Design for Bridges**

AASHTO > Strategic Highway Research Program 2 > Service Life Design for Bridges

**SERVICE LIFE DESIGN FOR BRIDGES (R19A)**

**Product Overview**

Comprehensive guidance to select and design durable bridge systems and components that are both easier to inspect and better-suited to their environments.

- SHRP2 Service Life Design Guide For Bridges Document

**Presentations and Webinars**

- Concept Overview presentation: Durability Design Structure Birth Certificate
- Product Detail presentation: Integrating Durability and Structural Design
- Service Life Design for Bridges Progress Update Webinar

**Tools and Technologies**

**Reports**

- Durability Assessment of a Bridge Substructure (R19A)

**Design Tools**

- Service Life Design – Graphical Solution
  - Calculations Instructions
  - Oregon Charts
- Service Life Design – Full Probabilistic Tools

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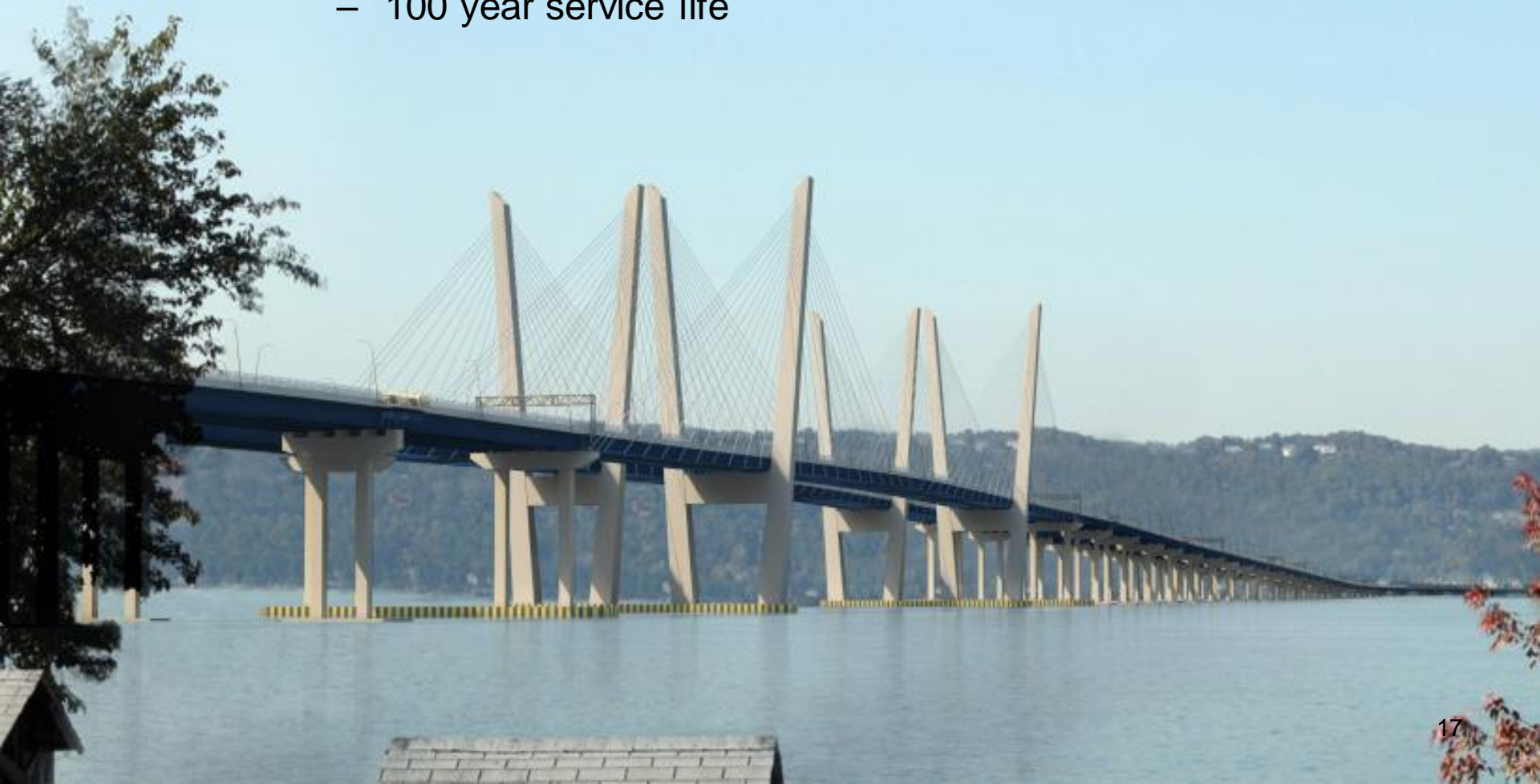
# Summary

- 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

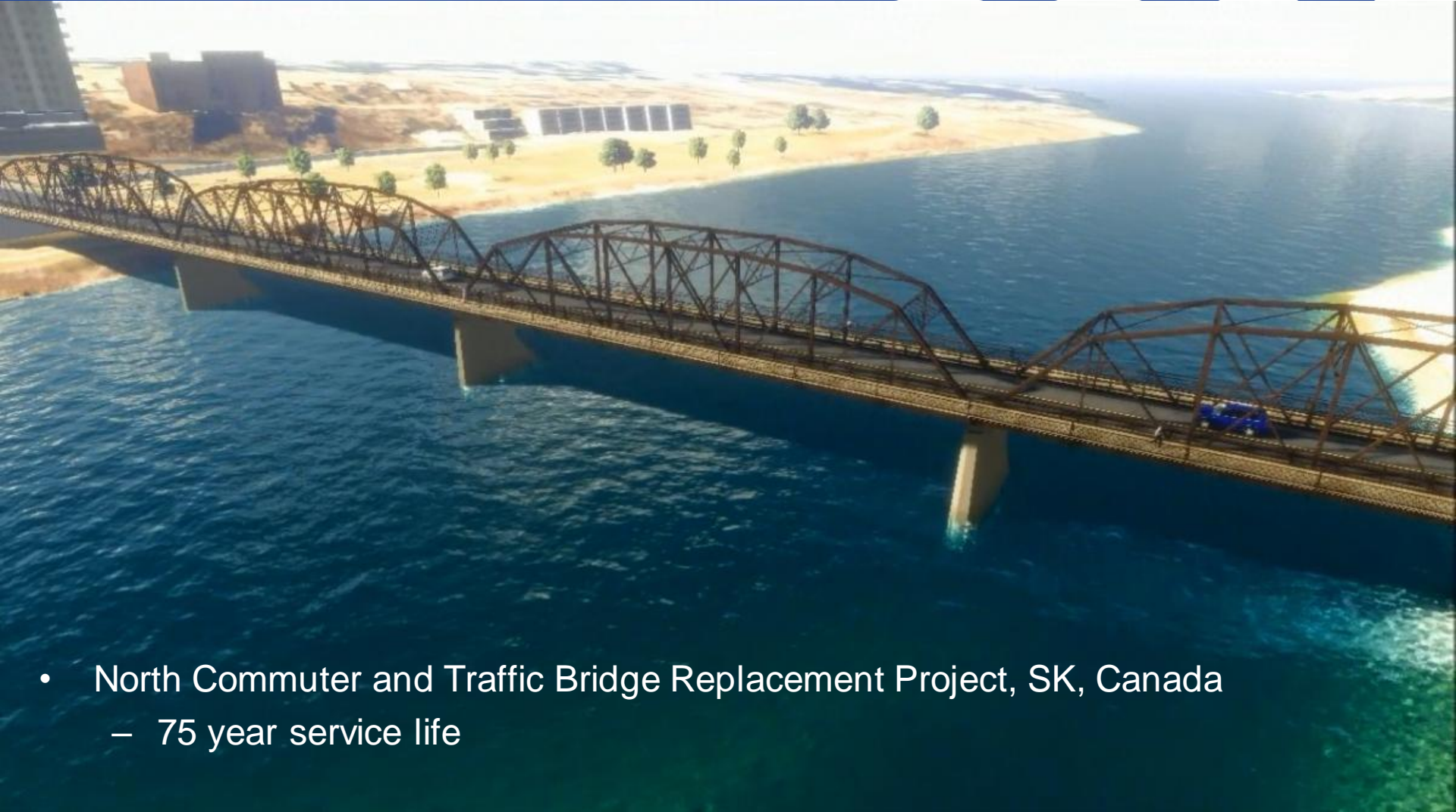


# A Few Key Projects

- 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