Bridge Preservation with ECC

2010 Midwest Bridge Preservation Partnership
Annual Meeting, Detroit, MI
Oct. 12-14th 2010

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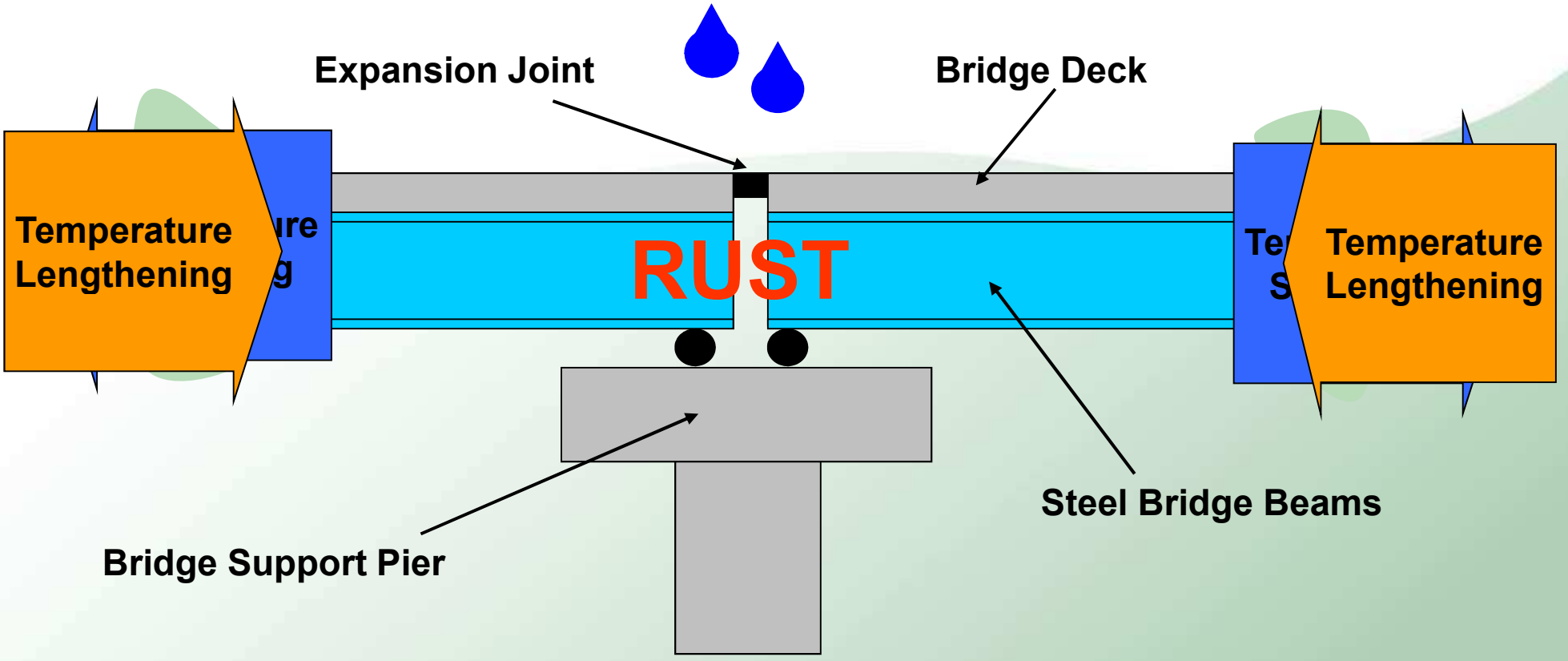
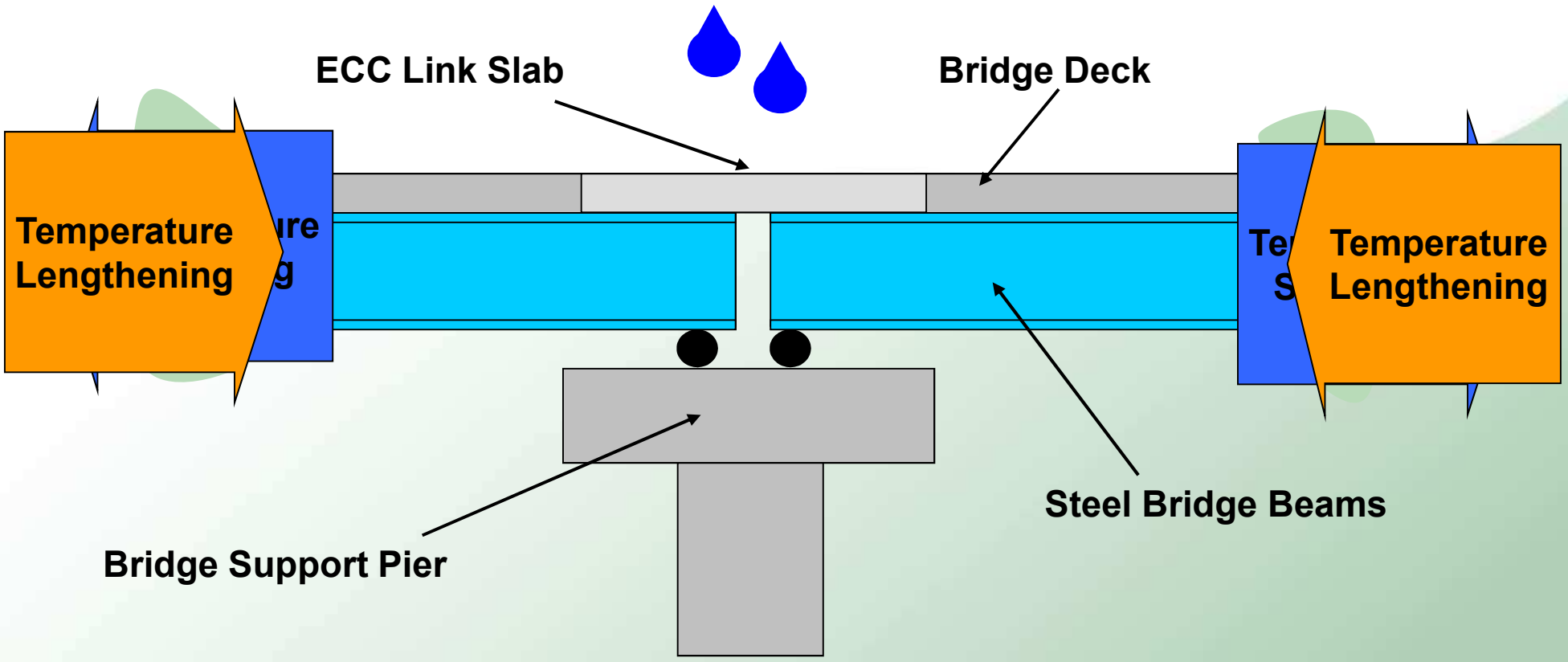
“Bendable” Concrete (ECC)

Application as a Bridge Deck Link-slab

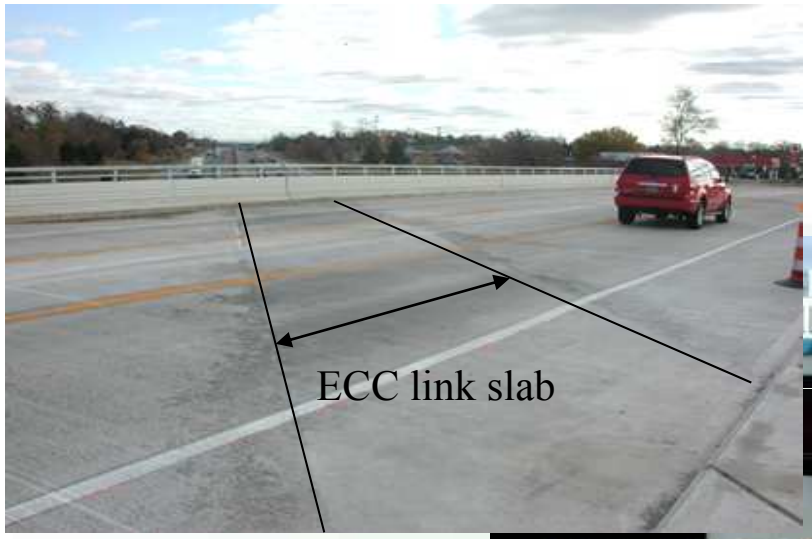


Conventional Expansion Joint Design

ECC Link-slab Concept



ECC Bridge Deck Link-Slab

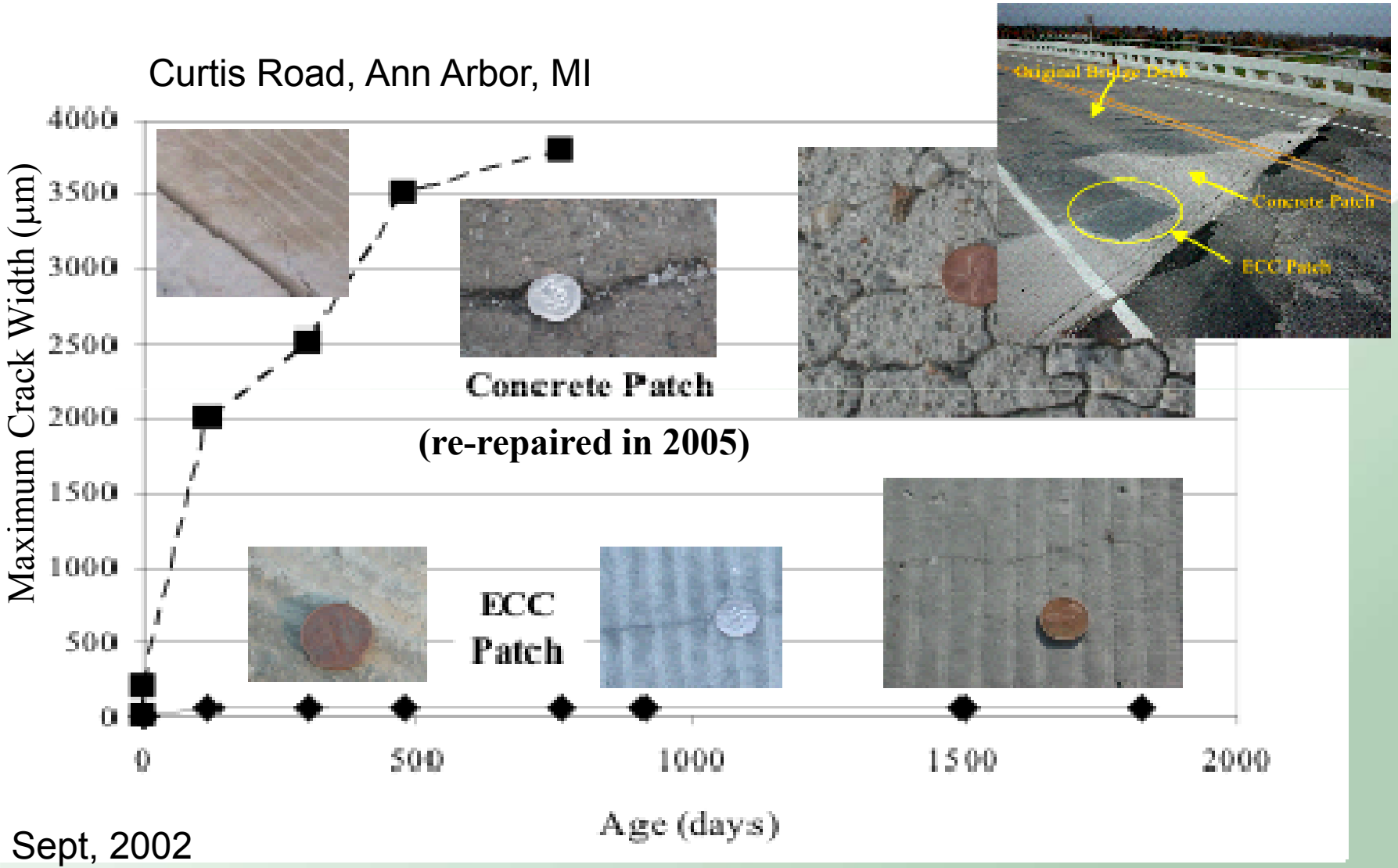


Michigan Department of Transportation
Bridges and Structures Department

Bridge-deck Link Slab Retrofit,
Ypsilanti, Michigan, 2005

Application in Patch Repair

Curtis Road, Ann Arbor, MI

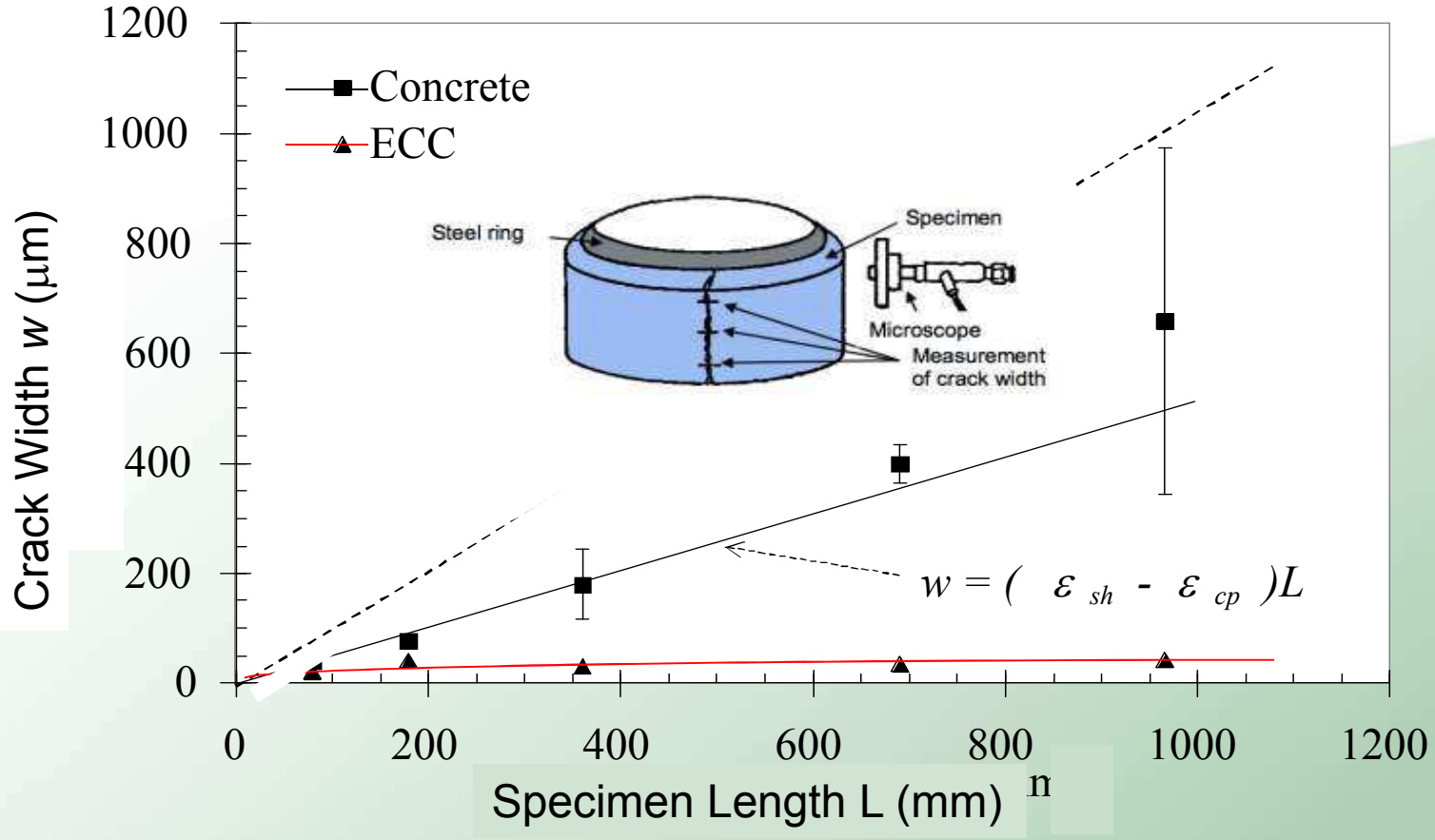


Sept, 2002

Application as jointless overlay in Composite Bridge Deck

Mihara Bridge in Hokkaido

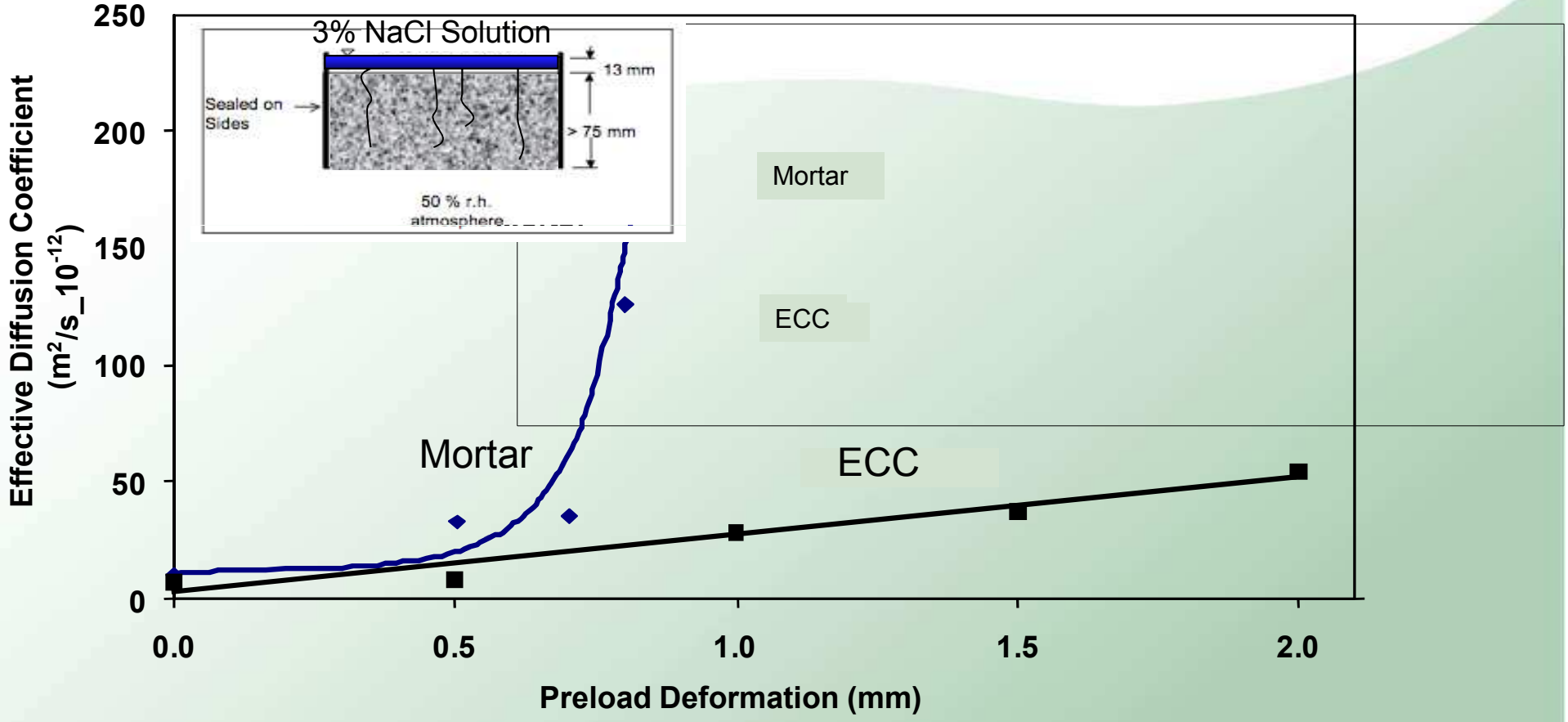
Crack Width Control Under Drying Shrinkage



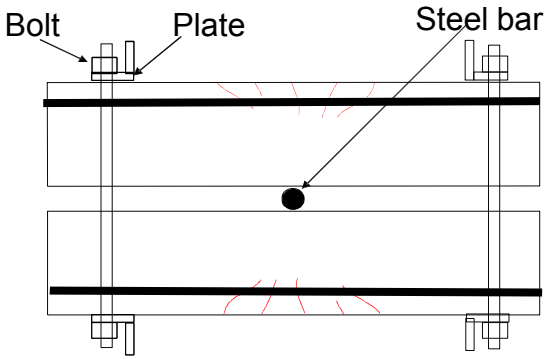
Weimann and Li, 2003

Effective Chloride Diffusion Coefficient of Pre-cracked Specimens

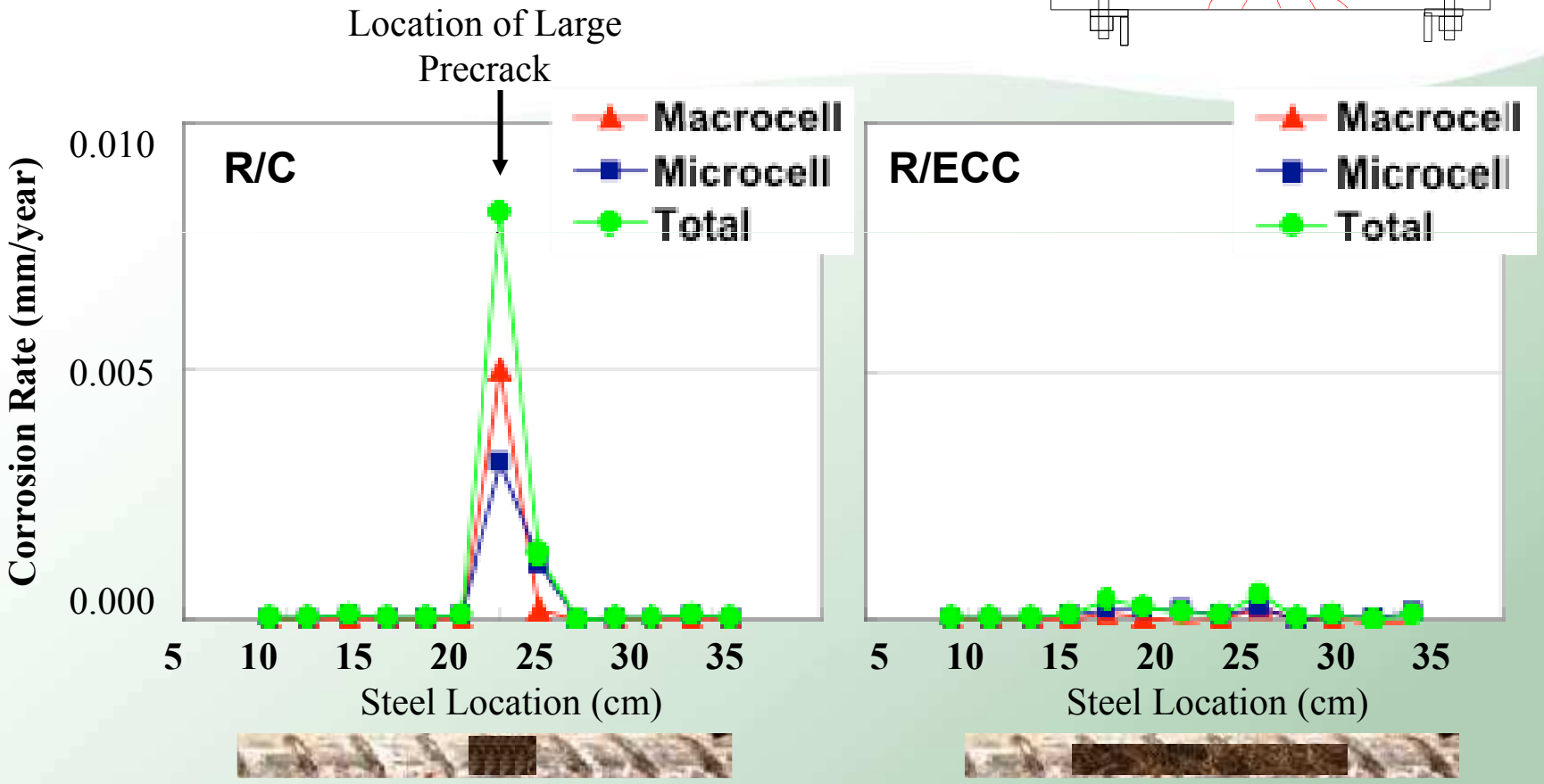
AASHTO T259 Salt ponding test on preloaded beams



Corrosion Test



28-day chloride accelerated environment:
Wet (saltwater shower 90%RH - 2d)
Dry (60%RH - 5d)



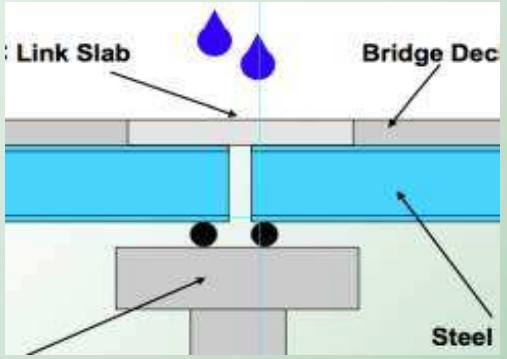
After Hiraishi et al. 2008

Self-healing Process

Potential Use of ECC for Bridge Preservation

- Patch repair

- Bridge deck link slab

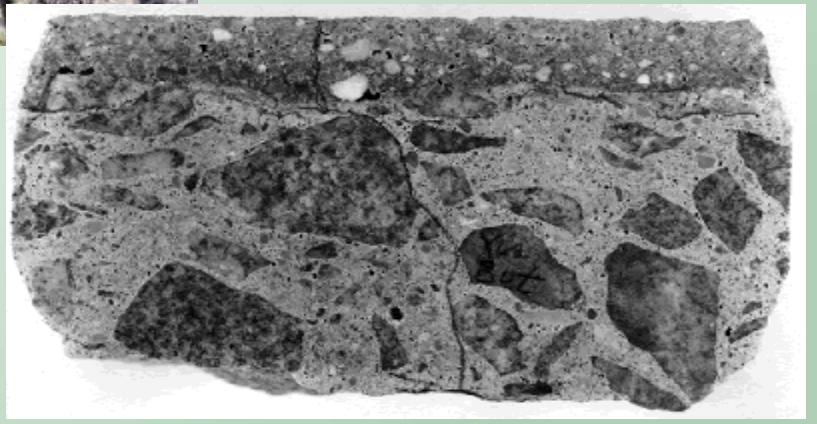


- Bridge deck overlay

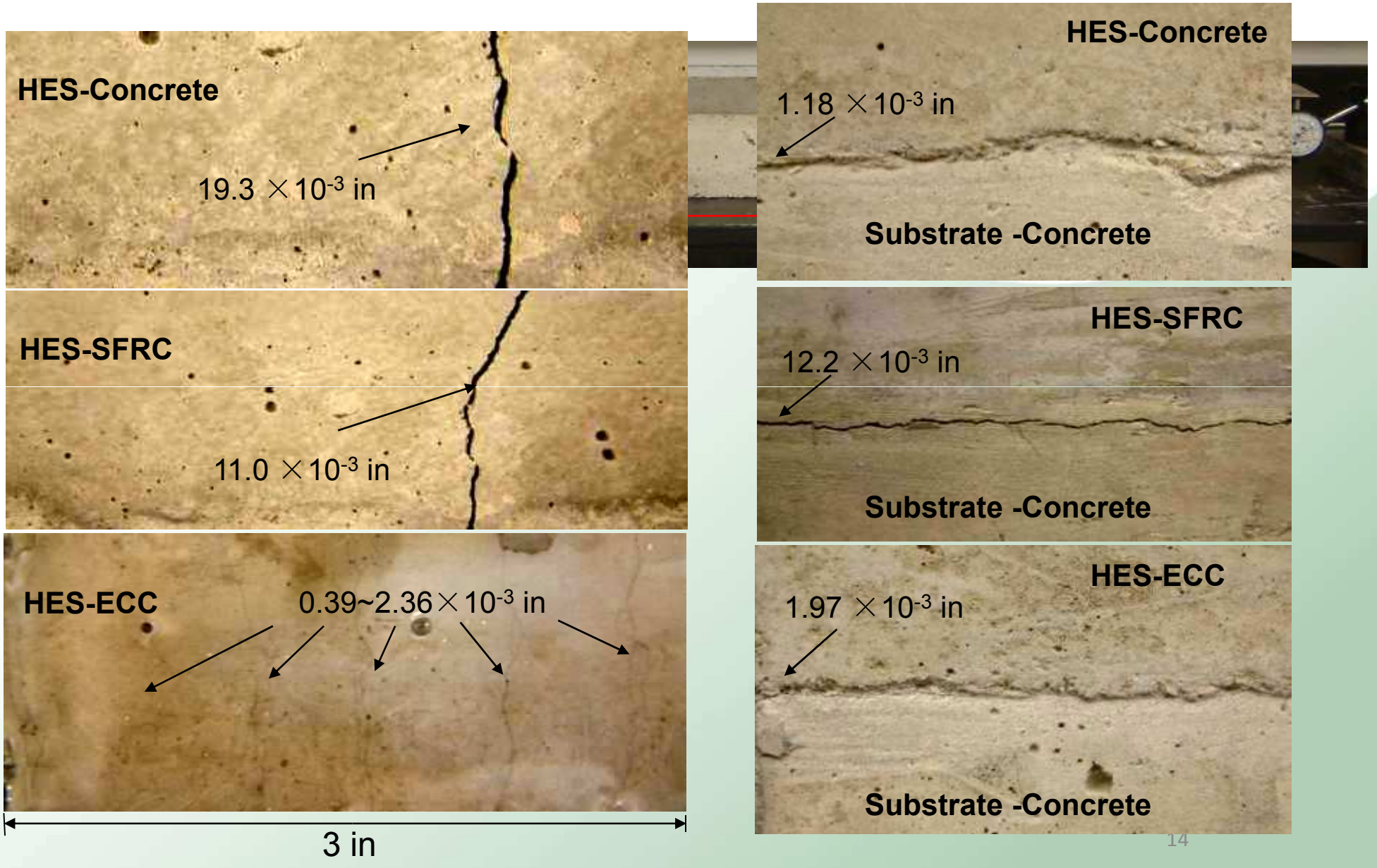
Potential Use as Bridge Deck Overlays

Delamination

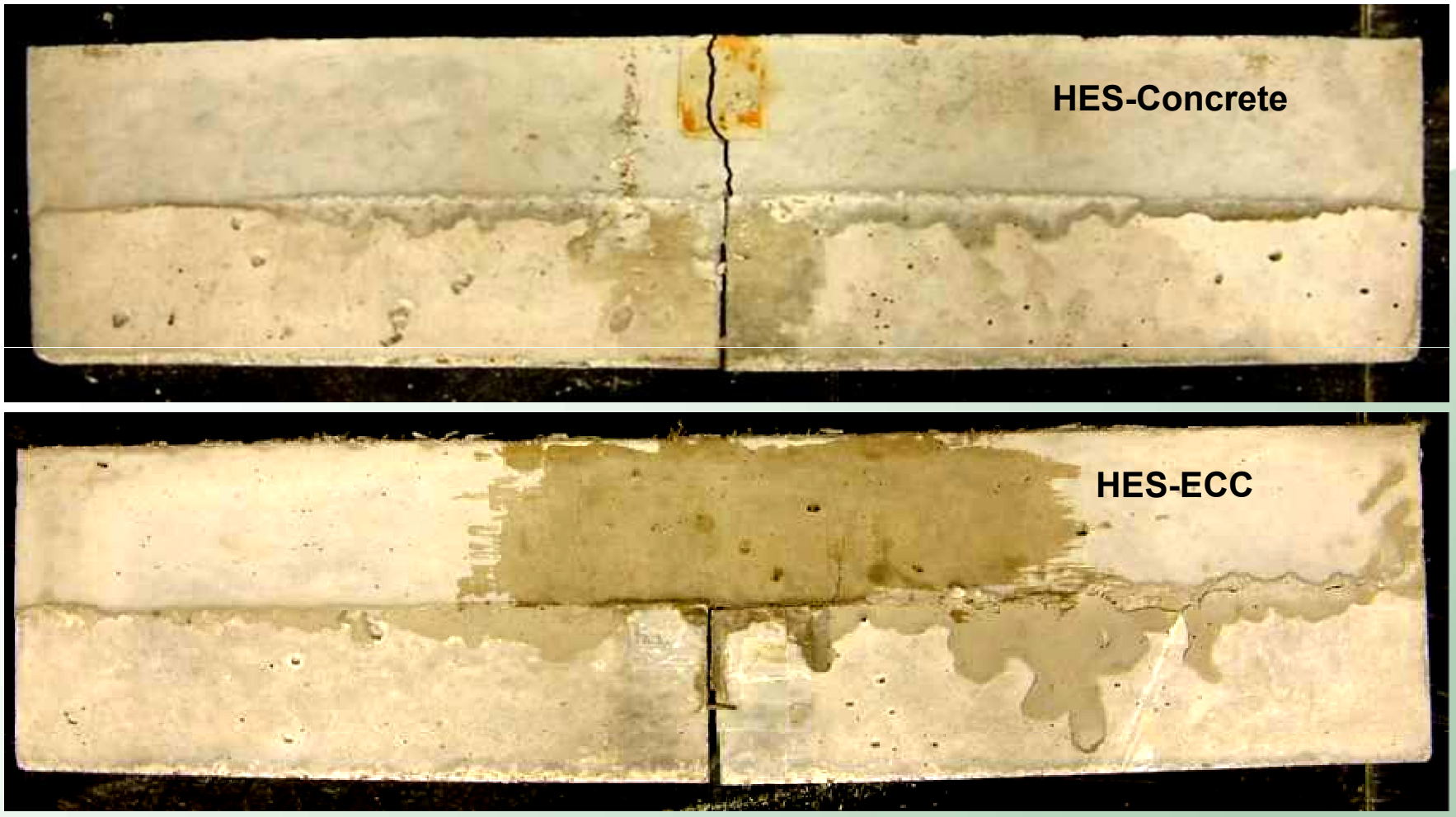
Reflective cracking



Preliminary Overlay Tests



Prevention of Reflective Cracking in ECC Under Fatigue Loading

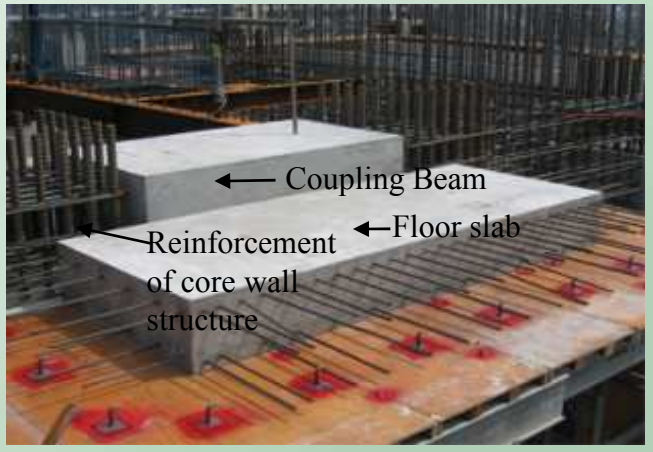


Summary & Conclusions

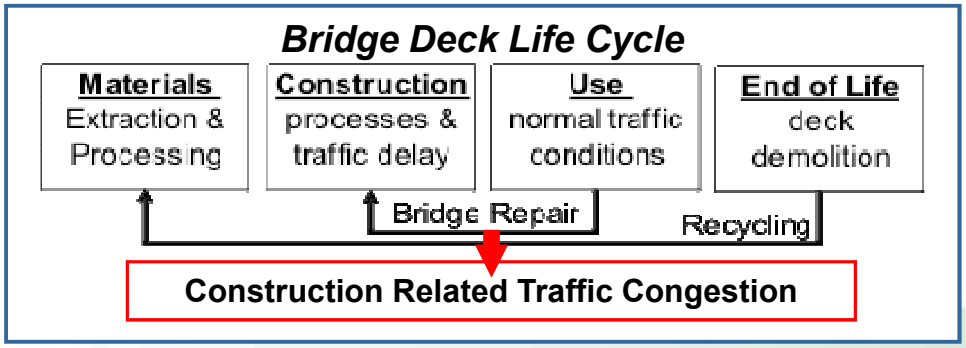
- ECC is designed to attain high **tensile ductility** with tight self-controlled crack width.
- **Damage tolerance** retains load carrying capacity despite microcracking.
- **Tight crack-width** maintains good transport properties and durability under typical exposure conditions.
- Damage tolerance, durability and self-healing characteristics allow ECC to approach crack-free conditions ideal for **reducing structural maintenance frequency and cost.**
- ECC has emerged in a number of **full scale applications**.
- ECC is potentially a good fit with bridge preservation. For **overlay**, ECC can minimize surface cracking and delamination, and eliminate reflective cracking.

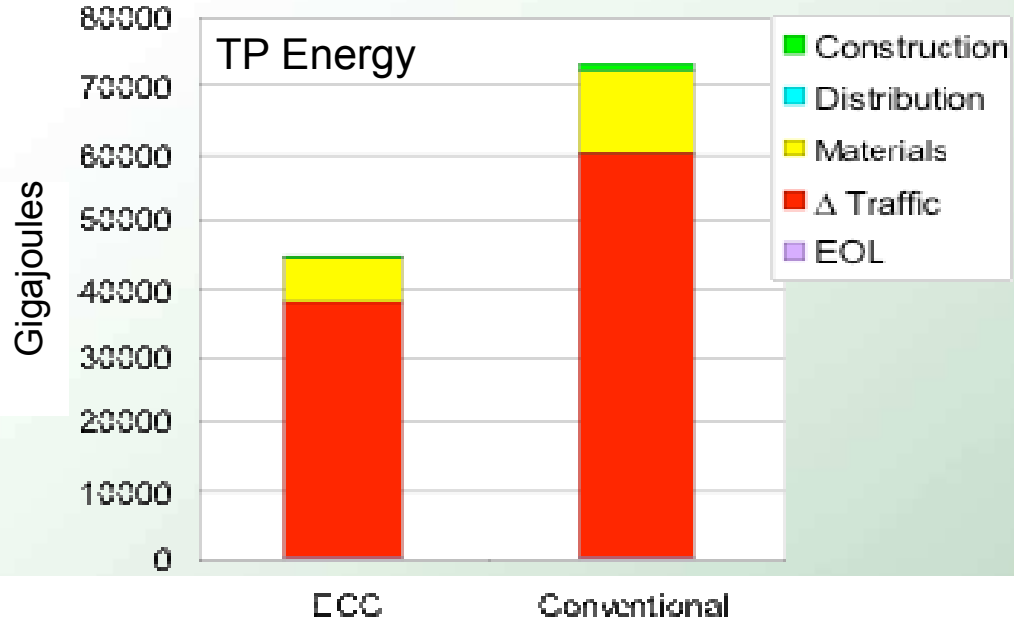
Precast Construction for Highway

Precast ECC element



Link Slab Sustainability Indicators





Keoleian et al, 2006

Engineered Cementitious Composites (ECC)

- A type of High Performance Fiber Reinforced Cementitious Composite (HPFRCC)
- Mix Design

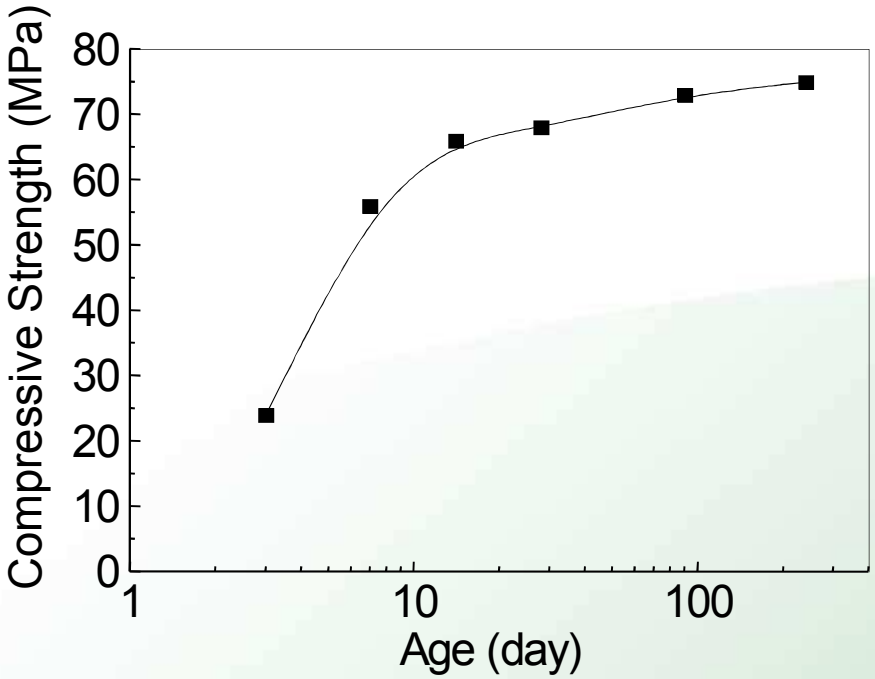
Typical Mix Design of ECC Material

Cement	Water	Sand	Fly Ash	HRWR	Fiber (%)
1.00	0.58	0.80	1.20	0.013	2.00

HRWR = High range water reducer; all ingredient proportions by weight except for fiber.

- Design Approach
  - Micromechanics based; Synergistic interactions between ingredients of fiber, matrix and fiber/matrix interface
  - No exotic ingredients; control ingredient chemical composition, geometric size and proportion holistically
  - Designed to use common construction equipment

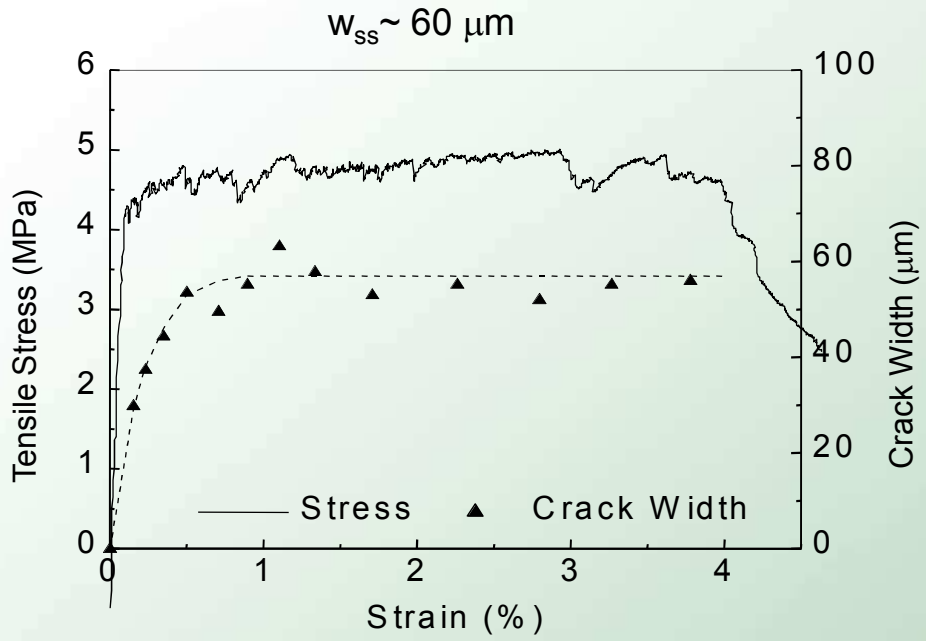
Compressive Properties



- Similar to normal-high strength concrete
- Slightly higher compressive strain capacity (~50% increase over normal concrete)

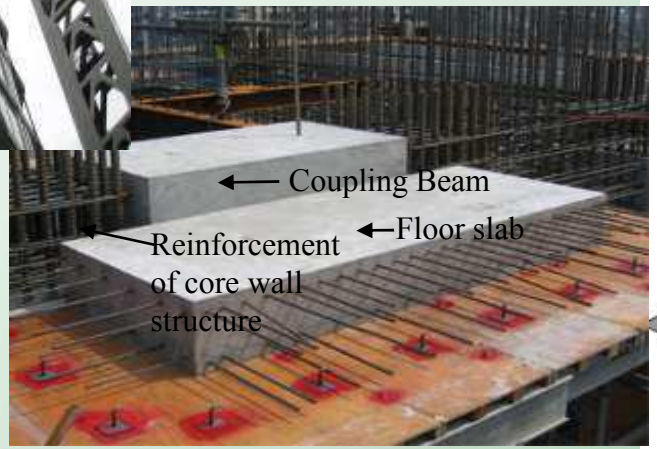
Tensile Behavior

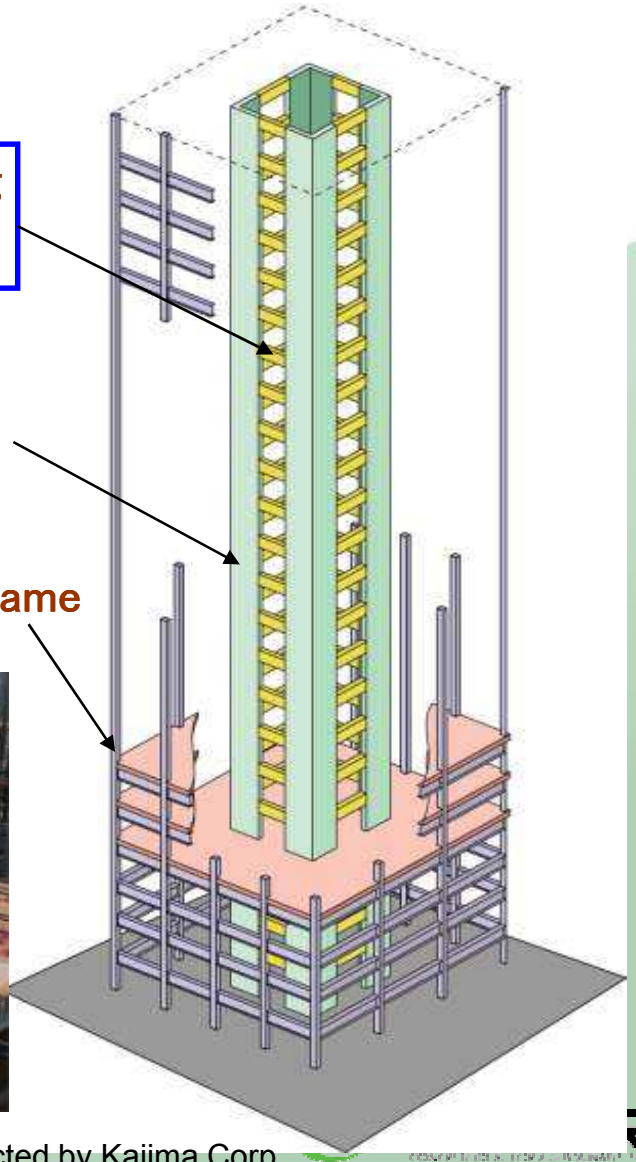
- High ductility (>300 times that of normal concrete)
- Damage tolerant (load capacity maintained after microcracking)
- Tight crack width (~50-80 μm)



41-story Nabeaure Yokohama Tower

http://www.tower41.jp/





Designed by Mitsubishi Jisho Sekkei Inc. & Kajima Corp.; Constructed by Kajima Corp.

Abrasion and Wear Testing

- Michigan Department of Transportation Testing Method (MTM-111)

Pavement Friction Tester

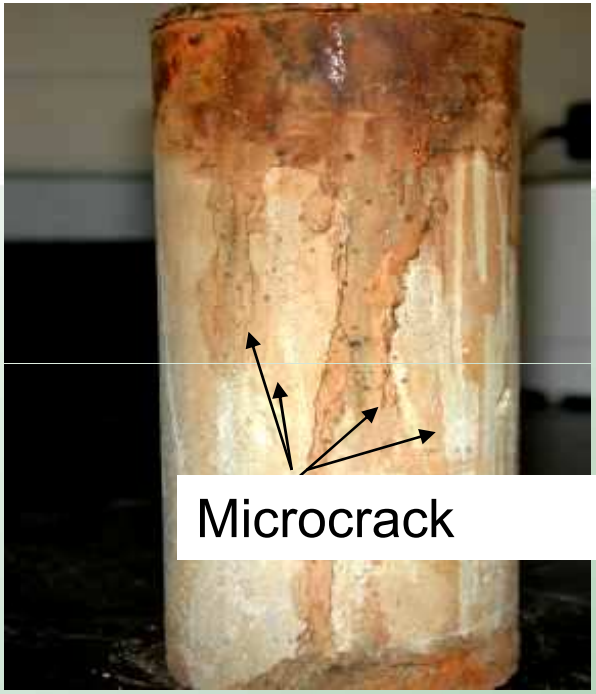
Test Slab	AWI (lbf)
Tined	531
Sand Texture	495
Turf-Drag	486
Towel Texture	353
Minimum Rqd.	260

Wear Track

- Simulate aggregate and pavement wearing
- AWI determination
  - Initial peak frictional value (lbf) between wheel and pavement surface is measured
  - Pavement subjected to 4 million tire passes
  - Final peak frictional value (lbf) is Aggregate Wear Index (AWI)
- Minimum AWI value for main trunkline in Michigan is 260 lbf

Durability
Corrosion and Spall Resistance

Mortar after 95 hrs accelerated corrosion

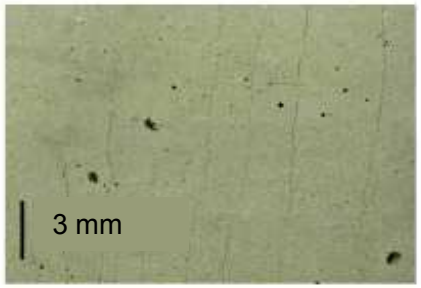


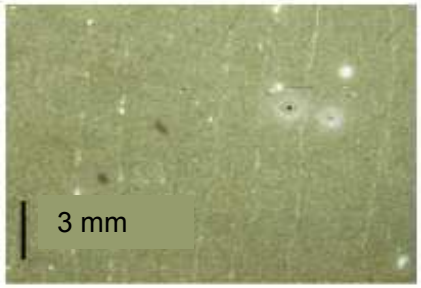
ECC after 350 hrs accelerated corrosion

Self-Healing

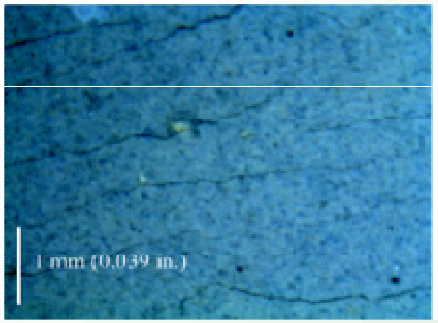
Before

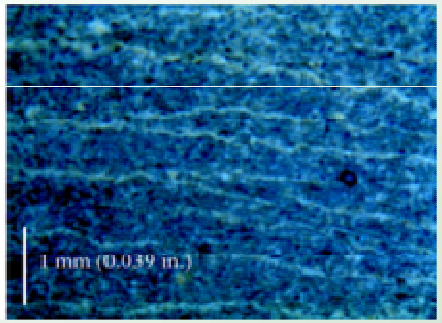
After



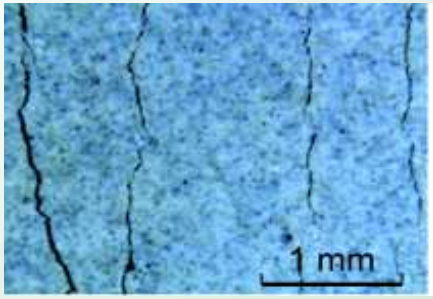


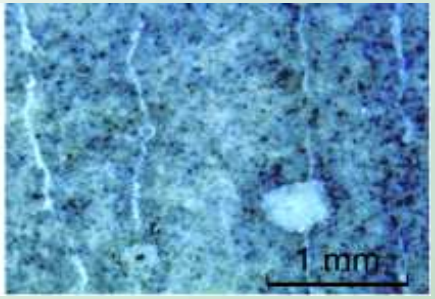
Under water permeation





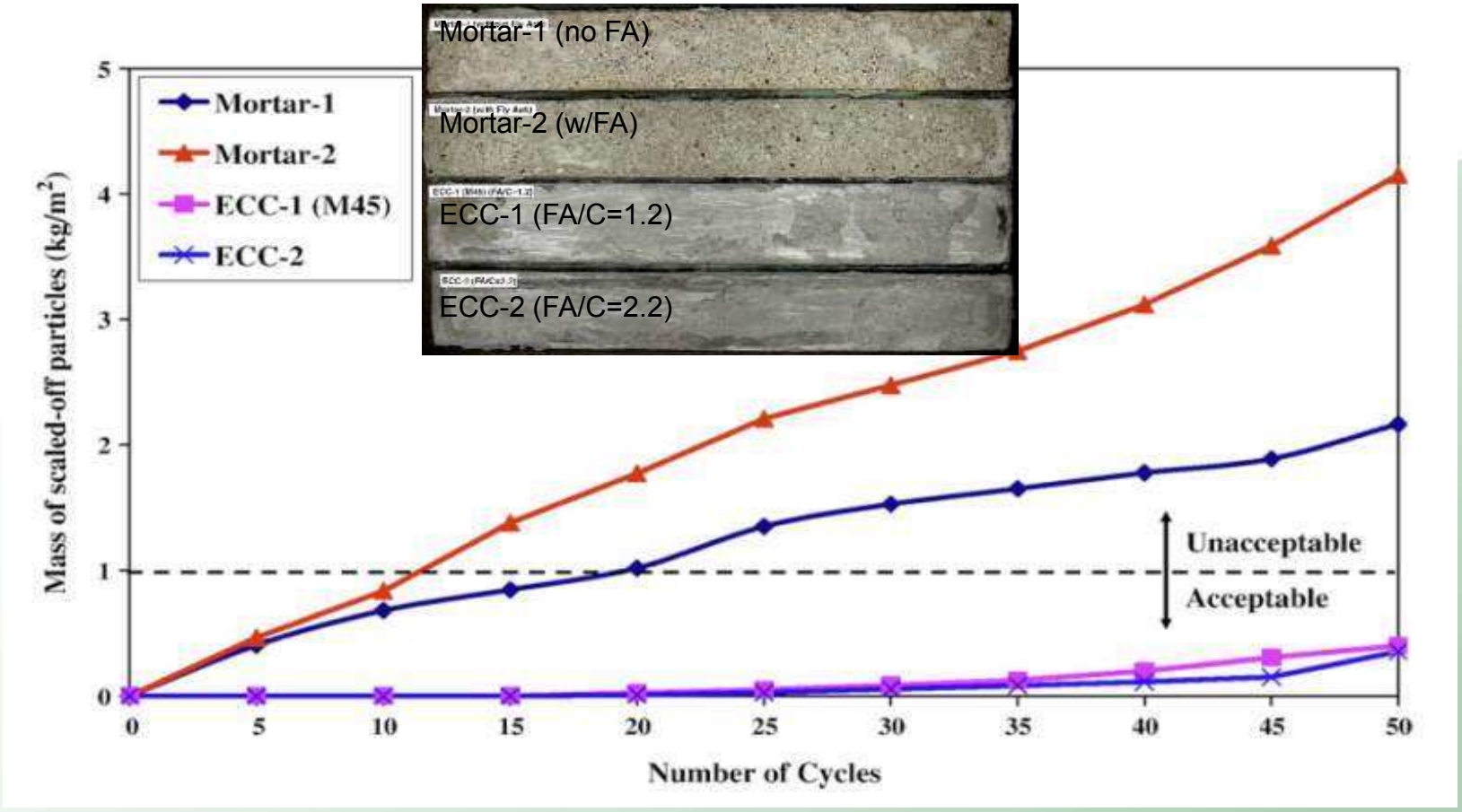
Under chloride exposure





Under wet/dry cycles

Durability under F-T Cycles in Presence of De-icing Salt



ASTM C 672

Repair/Substrate Interface Delamination