Designing Resilient Structures

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Agenda

- What is Resiliency?
- Construction Costs
- What have previous guidelines given us?
- Changes already implemented
- Future Changes
- How does this affect you?

Resiliency?

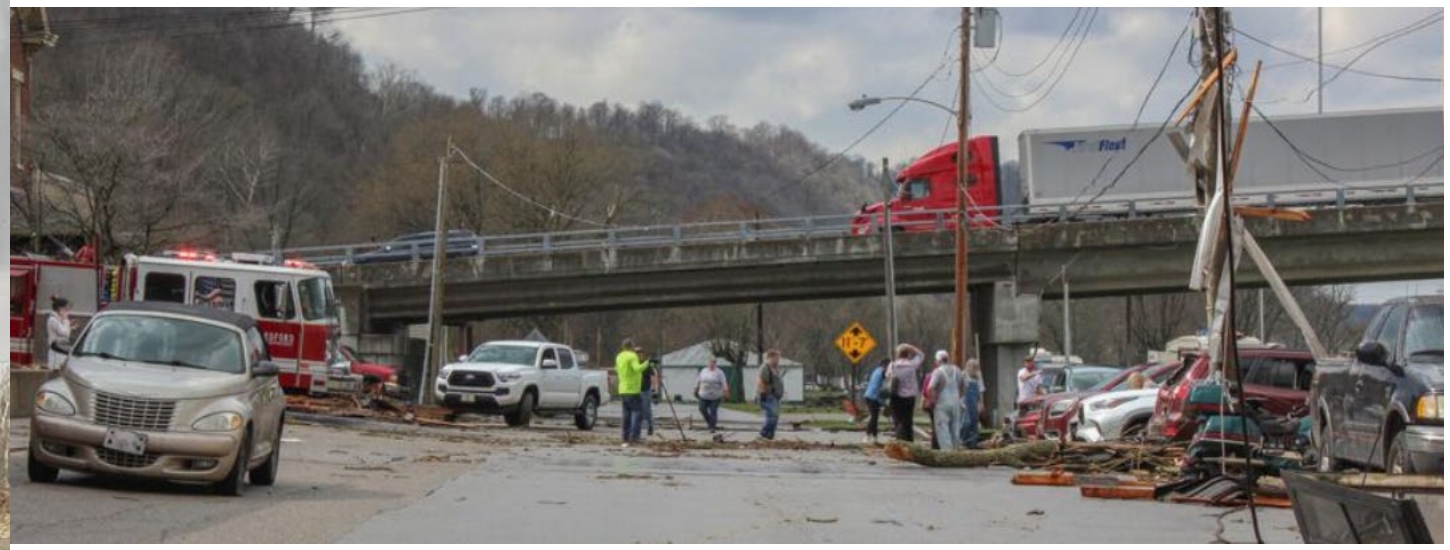
- The ability to withstand or recover quickly from difficulties; toughness.

Resiliency?

- What attacks our bridges?
  - Scour

Resiliency?

- What attacks our bridges?
  - Weather Events

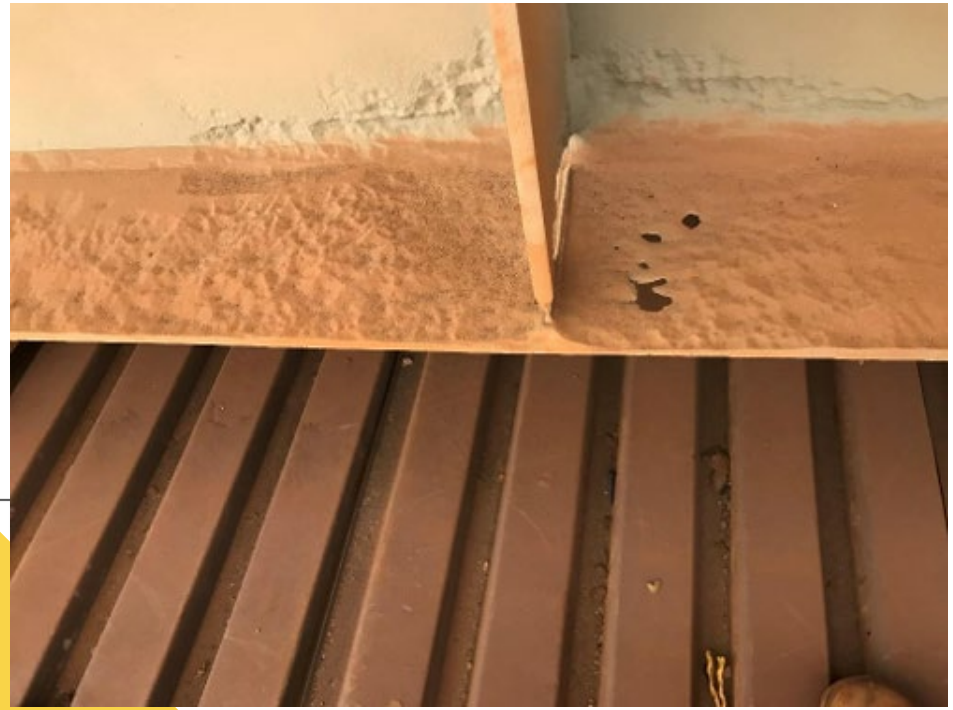


Resiliency?

- What attacks our bridges?
  - Collisions

Resiliency?

- What attacks our bridges?
  - Corrosion



Construction Costs

- Where have construction costs gone?

2017 Costs	2023 Costs
$150.92/sq. ft.	$287.72/ sq. ft.

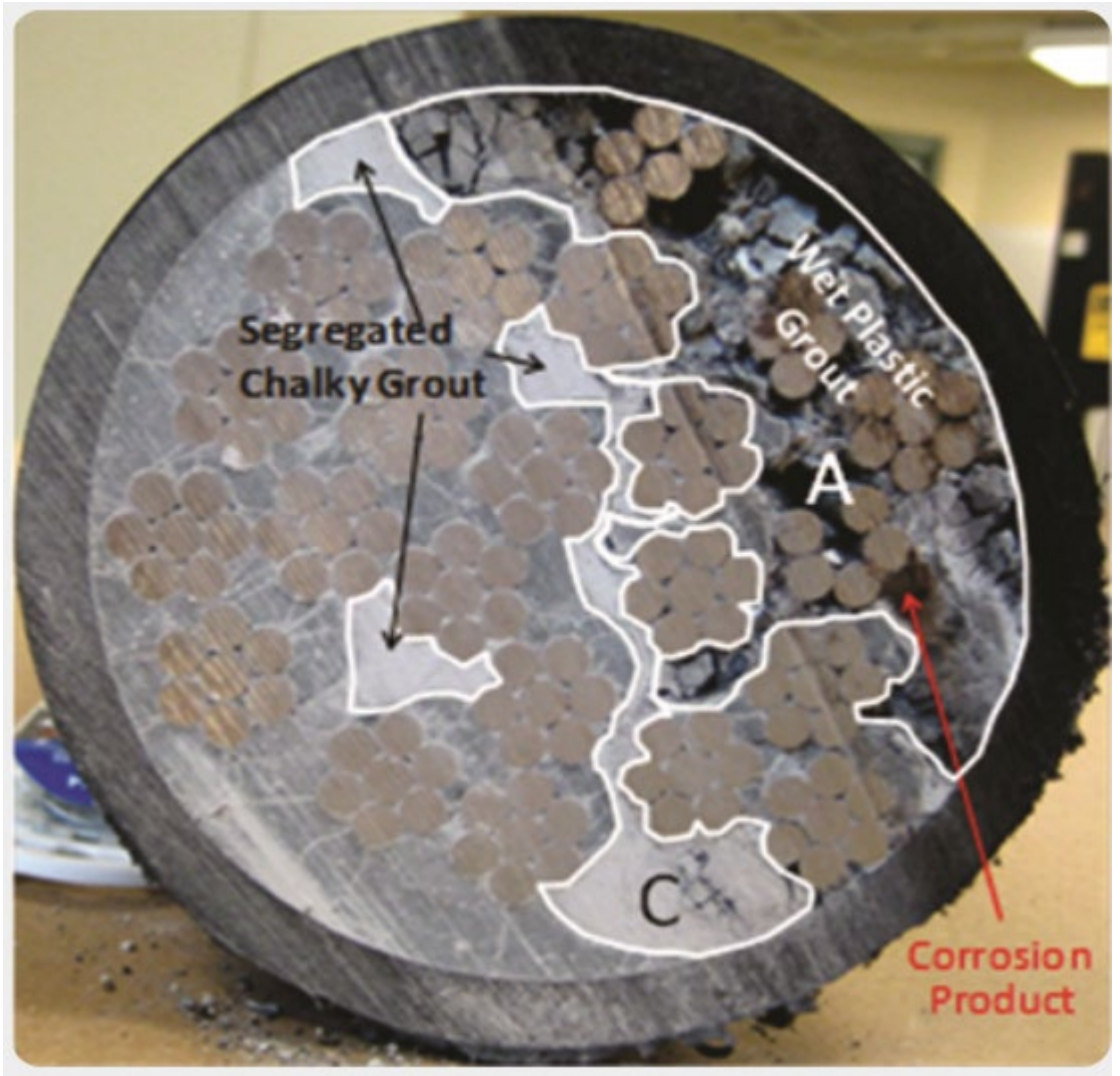
- Inflation is ~12%/yr on bridge costs.

What have previous Guidelines Given us?

- Side by side box beams with no deck – replacing after 30 years
- Post tension bridge replace after 50 years in Frankfort
- Concrete Pier patching after 30 years – Patching not holding up
- Bridge replacement after 50 years (KY/Brook in Louisville)

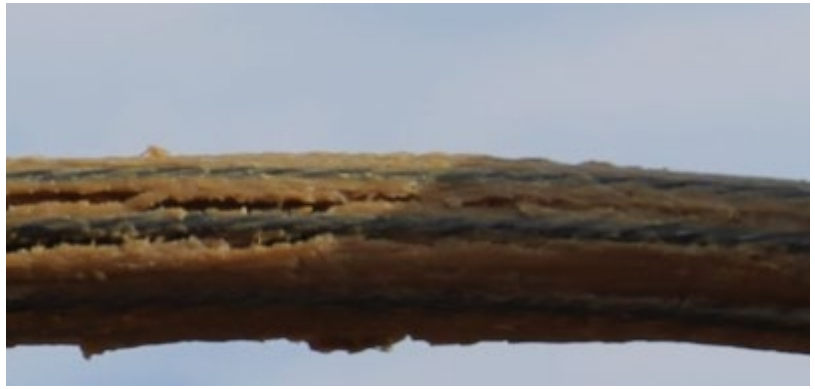
Changes Implemented in Current Guidance

- Post Tensioning
  - Grout issues – Weak Grout, Segregation, High Chlorides
  - Corrosion issues -
  - Very hard to inspect Grout encased strands



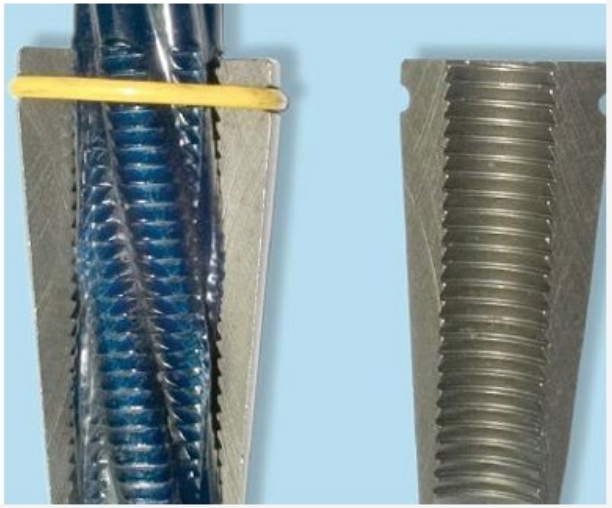
Changes Implemented in Current Guidance

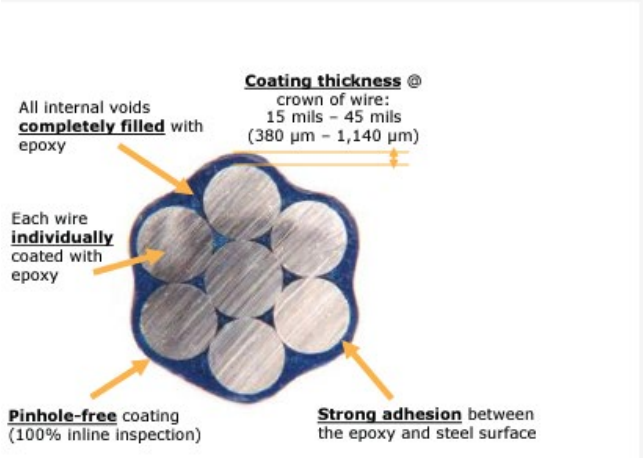
- Post Tensioning- Flexible filler
  - Wax/grease products are hydrophobic (repel water)
  - Inspectable
  - Replaceable
  - 1-2% more cost to the overall bridge structure than grout
  - Non-bonded



Changes Implemented in Current Guidance

- Post Tensioning- Epoxy Coated Strands
  - Not all ducts can be filled with Flexible Filler
  - Epoxy Coated Strands are an option as well.
  - Current post tensioning status quo has major issues.



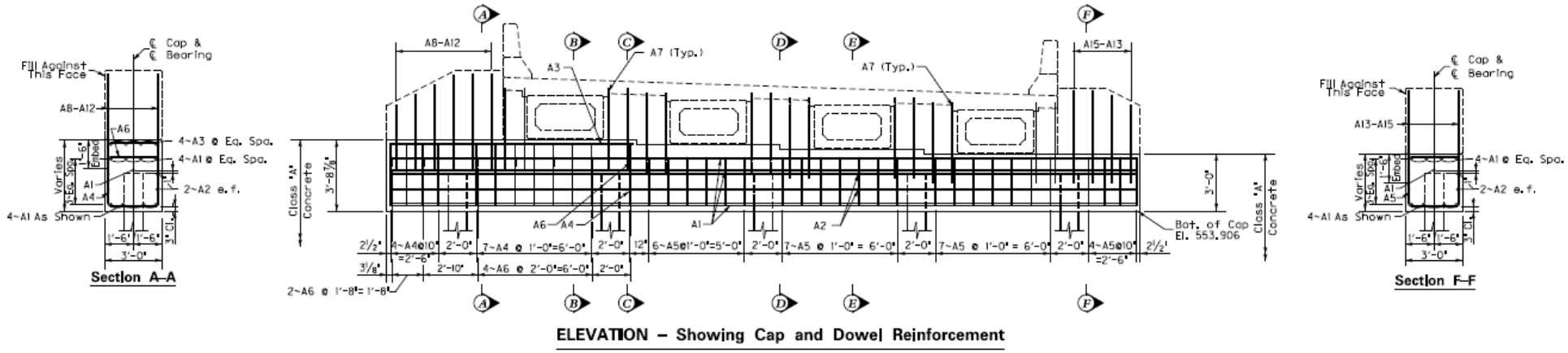


Changes Implemented in Current Guidance

- Epoxy or Galvanized reinforcement in salt exposure areas
- Piers or columns under joints.
- Piers or columns next to roadways where snow plows may throw ice/snow.

Changes Implemented in Current Guidance

- All End Bents Reinforcing Steel to be fully epoxy or galvanized.
  - Previous guidance was black in the cap, epoxy above seats for integral end bents.



Changes Implemented in Current Guidance

- Better guidance on weathering steel and galvanization
  - Weathering steel has issues when continuously wet or material is deposited that keeps it wet. (Soil in floods)
  - Weathering steel should never be submerged.
  - Weathering steel should be kept 10ft minimum above normal flow.
  - Weathering steel should never be used where salt spray/tunnel effect is present.

- Cabinet has seen issues on multiple structures built recently.

Changes Implemented in Current Guidance

- Better guidance on weathering steel and galvanization
  - What to do when steel has to be coated?
    - Hot Dip Galvanization is preferred where possible. We want a full 75 year life.
    - Metallization should be considered where beams cannot fit in pot or be double dipped.
    - Savings on the front end by painting W beams on small bridges may lead to large costs down the road.
    - Maintenance is not cheap.
    - Metallization is being considered on several projects right now.

Future Changes

- KTC Research on Reinforcement Corrosion Performance
  - Many different types of reinforcement available
  - Test data and reports by manufacturer
  - How good are these other options?
  - Salt fog chamber test 10000 hours.
  - Testing Epoxy, black, ChromX, hot dip galvanized
    Continuous galvanized, prestressing strands, stainless, various rebar coatings.

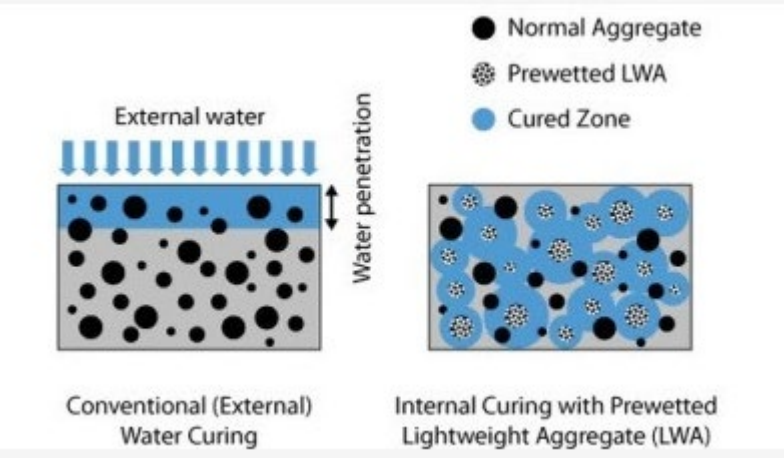
Future Changes

- KTC Research on Reinforcement Corrosion Performance
  - How do bars perform when coatings are damaged?
  - Are there options better than Epoxy at a similar cost?
  - Do we need to look at better performing bars to achieve lower maintenance later on?
  - Internal Data and not counting on manufacturer funded tests for our decisions.

Future Changes

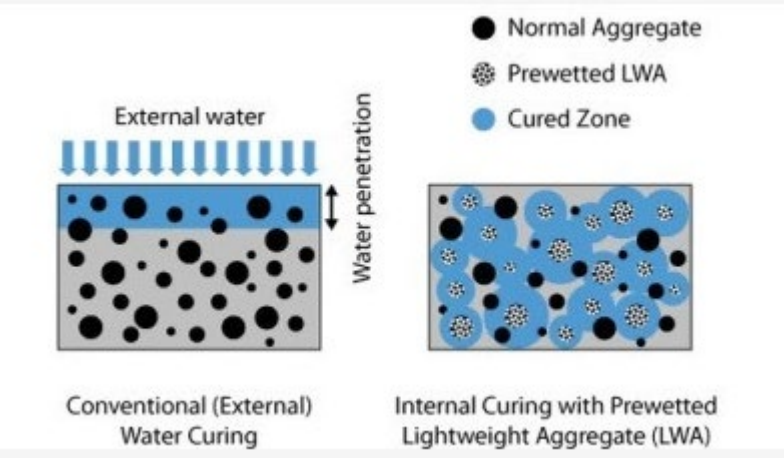
- KTC Research on Reinforcement Corrosion Performance
  - Testing has passed 5000 hour mark.
  - Uncoated steel performance is about as expected.
  - Will be interested in final results after testing is completed.

Future Changes



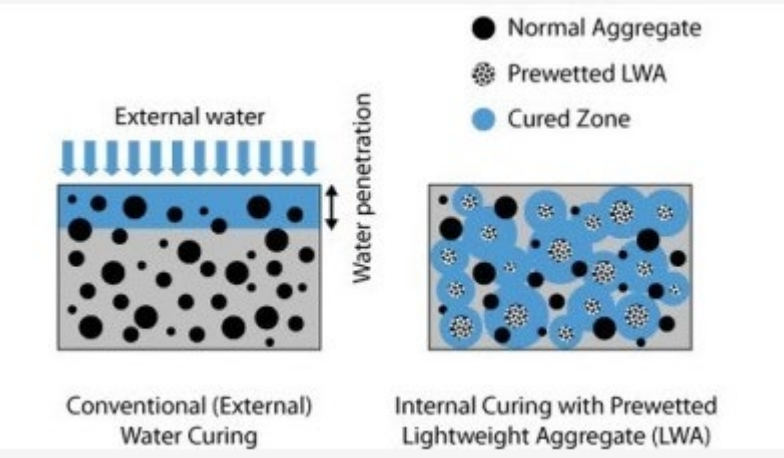
- Research on Internally cured Concrete.
  - KYTC has ongoing research with U of L regarding E5 concrete additive (NanoSilica).
- FHWA has initiative for Internally Cured Concrete Epic^2.
  - Prewetted Aggregate

Future Changes



- Research on Internally cured Concrete.
  - Traditionally low w/c ratio concrete suffers from early age cracking.
  - Internally cured concrete distributes cure water throughout mix instead of minimal water in mix and then adding water on top during curing.

Future Changes



- Research on Internally Cured Concrete.
  - Benefits
    - Reduces shrinkage
    - Reduces Cracking
    - Increases Strength
    - Lowers Permeability

Future Changes

- Research on Concrete Patching

Future Changes

- Research on Concrete Patching
  - KTC is leading the research on Concrete Patching.
  - Will be researching current practices.
  - Make site visits to concrete patching projects.
  - Research patching materials
  - Research Galvanic Anodes
  - Research Electrochemical Chloride Extraction

Future Changes

- What do we hope to get out of research?
  - Why is our current patching failing so soon?
  - Do the Galvanic Anodes work?
  - Is ElectroChemical Chloride Extraction worth the money?
  - How can we change our current practices to get another 35+ years out of our patches?

How will this affect your designs?

- KTC Research on Reinforcement
  - List of Reinforcement to use
  - Expect some reinforcement to not be allowed
  - Critical structures may be required to use more corrosion resistant reinforcement
  - Should we use higher corrosion resistant reinforcement on all structures?

How will this affect your designs?

- Research on Internally cured Concrete
  - Denser, less permeable concrete, less cracking.
  - If we use IC in conjunction with higher quality reinforcement, can we get rid of concrete sealing?

How will this affect your designs?

- Research on Concrete Patching
  - Currently have multiple notes for concrete patching.
  - Can we get to one Special Note for everybody with techniques/materials, etc. that will give us a long life?
  - Are we wasting money on Anodes?

Future?

- New Guidance Manual has a start towards more resilient Structures.
- More research to come.
- Implement changes from research. Watch for Transmittal Memos and/or changes to Guidance manual.

2024 PARTNERING CONFERENCE
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KYTC Structure Design for Resiliency 9:00am