Concrete Deterioration and Residual Service Life Prediction of a Deteriorated Concrete Overpass

Highway 21 Southbound Viaduct, Newark NJ

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Establish the viability of concrete repair and maintenance scenarios to extend the service life by 25 years.

Investigation of the condition of the concrete elements (deck and beams).

Concrete and rebar characterization.
STADIUM® methodology

Visual Inspection
Walk through/damage survey

Concrete Core Extraction
Core sampling

Laboratory Investigation
Concrete characterization

Service Life Predictions
STADIUM®
Visual inspection

Damage summary

Expansion joints

Degradation

Concrete piers

Restrained bearings

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Core sampling

- Three sampling sites were selected.
- Cores were extracted from the lateral surface and the top of the concrete deck.

- A total of 38 cores were extracted:
  - 18 cores from deck
  - 20 cores from lateral face of the deck
Concrete characterization

- The average compressive strength of concrete was 4,136 psi (28.5 MPa).
- Individual results were variable (from 2,350 psi to 5,885 psi - 16.2 to 40.6 MPa). Concrete degradation?
- Splitting tensile test was less variable with an average value of 517 psi (3.6 MPa).
- The air-void spacing factor was higher than the recommended value of 230 µm for frost durability in saturated conditions.
Concrete characterization

- Petrographic examination revealed that the concrete was affected by ASR and suggested that the reaction has been initiated many years ago.
- The mature state of the gels indicate that the reaction is not likely to continue.
- Some parts of the viaduct (protected from water penetration by the pavement) are not affected by ASR.
Concrete characterization

• The chloride contamination was variable from one pier to another.

• Contamination of the deck cores was higher at the vicinity of lateral surfaces and near the joints.

• Chlorides were most likely added to the mixture during batching.
• Sound concrete showed little signs of rebar corrosion.
• In these regions, service life simulations were performed to evaluate the potential for future corrosion.
• The effect of the cracking on the ionic diffusion coefficient was taken into account in STADIUM®.
• Future chloride penetration was modeled. Results obtained for each pier allowed estimating time to initiate corrosion for different concrete covers.

Concrete characterization

Content vs Depth

Total Chloride [PPM]

Time History [years]

2008 Present Concrete Age ~55 years

Critical Threshold for Black Steel (Realistic)

Critical Threshold for Black Steel

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Concluding remarks

• The investigation of Highway 21 Southbound Viaduct revealed that:
  – The variability in the compressive strength results suggested internal defects in the concrete.
  – Petrographic examination revealed that concrete is affected by ASR but damage is limited to damp areas near the joints.
  – Concrete is not adequately protected against frost damage. Deterioration is probably increased by freeze-thaw cycles.
Concluding remarks

• Causes of cracking near the joints:
  – The restrained movement is believed to have triggered the formation of cracks at the beam-deck junction.
  – These cracks are confined to a section ranging over 6 to 8 ft from each side of the deck.
  – Concrete expansion due to ASR could also explain the damage observed at the exterior joint.
Recommendations

• Implementation of a repair and maintenance plan will increase the service life of the existing viaduct by an additional 25 years
  – Drainage system restoration
  – Concrete crack repair
  – Bearing cleaning/replacement
  – Joint replacement
  – Sealing of exposed surfaces
  – Repair delaminated areas
Conclusion

- This investigation allowed:
  - To validate the viability of the rehabilitation concepts
  - To verify/confirm the ability to obtain 25 years service life extension from the structure
  - To refine some of the recommended rehabilitation measures
  - To focus immediate attention on the most critical aspects of the structure
Bottom line

• Preliminary scenario - Full replacement

• Final recommendation - $32 M - 25 yrs extension