I35 Reconstruction: High Performance Concrete with High Pozzolan Content

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Why HPC with high replacement levels?

- While this might not be the clearest opportunity for innovation, it was a requirement of the RFP to have a structure with a design life of 100 years.

Extreme Example

82 lb OPC, remainder recycled
Cement content below 550 lb
All aggregate recycled
All water reclaimed
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Planning
- As a result some very non-traditional concretes were utilized in the construction.
- Performance-based design
  - Designer Requirements
  - Owner Requirements
  - Constructor Requirements

AET 4060
- RCP at 84 days 490 Coulombs passed
- Setting Time 4:30 Initial Set
- Air Void System
  - Air Content 5.5 percent
  - Spacing Factor 0.008 in
  - Specific Surface 600 in$^2$/in$^3$
- Shrinkage 0.005 percent at 28 days
- Strength Gain
Performance Requirements

- The concrete had many requirements, some of which were in opposition to one another:
  - There were shafts drilled to a depth of over 120 feet to socket to the bedrock through to bridge superstructure concrete which has to resist the ingress of chloride ion for the next century.
  - All elements below the superstructure are mass concrete, as are the soffit slabs at the maximum shear elements, and the pier tables and diaphragms in the superstructure.
  - There was a requirement for high early strength in construction, as the bonus for early finishing was substantial.
  - There was a requirement for low permeability to water and aggressive chemicals such as chloride.
    - low permeability in the concrete itself
    - low shrinkage so that the concrete does not contain excessive cracking which short circuits the concrete as a protective layer.
  - The concrete needed to flow into congested reinforcement, into complicated forms and into shafts that could not be inspected visually.
  - The concrete should have as small an environmental impact as possible

A six sack mixture

Siberia of North America
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Superstructure
- Chloride
- Freeze Thaw
- Scaling
- Creep and Shrinkage
- Piers
- Mass Concrete
- Freeze-Thaw Exposure
- Chlorides

Footing
- Mass Concrete
- Freeze-Thaw Exposure
- Chlorides

Shafts
- Consolidation
- Freeze Thaw
- Chlorides

- 5000 psi SCC w 40 percent OPC

- 6500 psi concrete
  - 70 percent OPC

- 5000 psi SCC w 40 percent OPC

- 4000 psi concrete
  - 18 percent OPC

- 5000 psi SCC w 40 percent OPC

Mn/DOT has reviewed this deliverable and determined that it appears to meet the requirements of the Contract Documents.

Mn/DOT Representative

RELEASED FOR CONSTRUCTION

FOR ACCEPTANCE

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Shaft Concrete

- 60 Percent Pozzolan Replacement
- 24 inch spread
- Air entrained
- RCP
- Shrinkage
- Strength at 28 days (lab cure) 5500 psi
- Cores from 21 day old Shaft 10,250 psi
Footings
- 60 Percent Pozzolan Replacement
- 8 inch slump
- Air entrained
- RCP
- Shrinkage
- Strength at 28 days (lab cure)

Piers
- 60 Percent Pozzolan Replacement
- 24 inch spread
- Air entrained
- RCP
- Shrinkage
- Strength at 28 days (lab cure)
- Cores from 21 day old Shaft 10,250 psi
Superstructure

- 30 Percent Pozzolan Replacement
- 8 inch slump
- Air entrained
- RCP
- Shrinkage
- Modulus of Elasticity
- Strength at 28 days (lab cure)
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Shrinkage

![Shrinkage Graph]

Production Controls

Questions?