VDOT’s Experience with Performance Specifications

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Outline

- ERS (end result specification)
- Route 58 example
- VDOT Specifications
End Result Specifications Goals

• Provide long lasting concrete structures

• Allow contractor innovation

• Ensure consistent uniform concrete

• Pay based on the quality of concrete

• Pay based on Percent Within Limits (PWL): percentage of concrete between upper and lower specification limits
End Result Specifications

• Contractor: Entirely responsible for supplying a product

• Agency: Responsible for accepting, rejecting, or applying a price adjustment

TRB Circular E-C074, Glossary of Highway Quality Assurance Terms.
## Differences in Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Current</th>
<th>ERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix Design</td>
<td>Prescriptive</td>
<td>Based on properties</td>
</tr>
<tr>
<td>Testing</td>
<td>VDOT</td>
<td>Contractor and VDOT</td>
</tr>
<tr>
<td>Basis of Pay</td>
<td>Minimum</td>
<td>PWL</td>
</tr>
</tbody>
</table>
ERS

- Prequalification: Mix development and QC plan by the contractor; includes charts for process control
- Mix design approval by the agency
- Acceptance by the agency
Control Charts: Fresh Concrete

### Slump Results

- Y-axis: Inches
- X-axis: Test Number

### Air Content

- Y-axis: Air Content
- X-axis: Test Number

### Unit Weight

- Y-axis: Unit Weight
- X-axis: Test Number

### Temperature

- Y-axis: Temperature
- X-axis: Test Number
Control Charts: Hardened Concrete

Compressive Strength

Str. moving average of 3

Permeability

Perm. moving average of 3
ERS

• Used in pilot bridge and pavement structures
• Mix design portion has been incorporated into VDOT specifications as an option
• Pay factor portion is still under discussion
Pay Factor

• Pay factor based on PWL
  – Compressive strength
  – Permeability

• Pay factor in current pavement specification
  – Rideability
  – Thickness
Estimating PWL

- Compressive strength
  \[ Q_L = \frac{\text{Average} - \text{LSL}}{s} \]
- Permeability
  \[ Q_U = \frac{\text{USL} - \text{Average}}{s} \]

Q: Quality Index, used to determine PWL from Tables
LSL: lower specification limit
USL: upper specification limit
s: sample standard deviation
Pay Factor (PF)

PWL for strength and permeability:

- \( PF = 82 + 0.2 \times (PWL) \)

*PF IS NOT ENFORCED IN PILOT PROJECTS*

- 100% pay for PWL = 90%
ERS Sampling

Lots and sublots: structural concrete

• Lot is limited to 500 yd$^3$ and consists of sublots.

• Sublot has maximum of 100 yd$^3$ and at least one sublot for each day’s placement.
ERS Sampling

Lots and sublots: pavements

- Lot: 1 lane mile or a day’s production
- Sublot: 0.2 mile
  - One sample from each subplot randomly selected
ERS Tests

Screening tests at the fresh state (contractor):

- Air content
- Slump
- Density
- Concrete temperature
ERS Tests

• Acceptance tests at the hardened state (VDOT)
  ➢ Strength
  ➢ Permeability

• Also testing for drying shrinkage for MEPDG
Route 58 Project Description

- US 58 WB, Southampton County near Courtland, VA
- 4-in bonded: 2.6 miles
- 7-in unbonded: 2.2 miles
- 11-in JPCP: 0.30 miles
- Existing pavement: 8-in CRCP
Surface Preparation (Unbonded)

1 inch Asphalt Porous Friction Course (PFC)
Unbonded Overlay
Unbonded Surface After Construction
Bonded Overlay
Bonded Surface After Construction

Average bond strength = 335 psi (ASTM C1583)
Mixture

- 596 lb/yd$^3$ cementitious material
- 25% Class F fly ash
- w/cm: 0.43 to 0.45
- #57 coarse aggregate
- Natural sand
Route 58 ERS Sampling

- Total concrete produced: 8,088 yd$^3$
- Lot: One lane mile
- Sublot: 0.2 miles
- One sample from each subplot was selected randomly.
FHWA Mobile Lab
# Route 58 Project

Averages of lots (14 lots)

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Standard Deviation</th>
<th>Pay factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength (psi)</td>
<td>4870</td>
<td>340</td>
<td>101.31</td>
</tr>
<tr>
<td>Permeability (Coulomb)</td>
<td>600</td>
<td>120</td>
<td>102.00</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>101.66</td>
</tr>
</tbody>
</table>
Conclusions

• Route 58 construction was successfully executed on time
• Concrete was of high quality
  – Acceptable strength, low permeability
• Route 58 project would qualify for bonus
Three mix design options:

1. Prescriptive method

2. Contractor/producer designed mix with trial batch data showing compliance*

3. Contractor/producer designed mix with field data confirming compliance*

*no minimum cementitious material content
Thank you.
Questions?

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