Value Engineered Heavy Duty RCC Pavements

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Outline of Presentation

- A Case Study – South Carolina Inland Port
  - Project Background
  - Challenges
  - Value Engineered Solution
  - Base Layer
  - RCC Surface
  - Test Section
  - Construction Photos
South Carolina Inland Port
Greer, SC
SC Inland Port - Background

- Owned by South Carolina State Port Authority
- Serviced by Norfolk Southern
- Rail Service to/from the Port of Charleston
Paving Areas

- Constructed July to December 2013
- 3,000 ft. by 600 ft. container yard
- Access Road
- About one half (Area 1) heavy duty and one half (Area 2) medium duty
SC Inland Port – Site Conditions

- Variable soils
  - Sandy SILT in fill area
  - Silty SAND in cut areas
- 0.5% grade
**Design and Value Engineered Sections**

- **Area 1: 97,000 yd\(^2\)**
  - **Design**
    - 14” RCC
    - 3” GAB
    - Prepared Subgrade
  - **Value Engineered**
    - 13” RCC
    - 6” CTSB
    - Prepared Subgrade

- **Heavy-Duty Section**
  - Constructability challenges considering 3” GAB, expected rain frequency, geologic conditions, and 0.5% grade
  - Value engineered solution offered better structural support at no additional cost, and reduced downtime after rain events

GAB: Graded aggregate base  
CTSB: Cement treated soil base
Design and Value Engineered Sections

Area 2: 85,500 yd²

Design
- GAB: Graded aggregate base
- Prepared Subgrade
- 3"
- RCC
- 10" and 10.5"

Value Engineered
- CTSB: Cement treated soil base
- Prepared Subgrade
- 6"
- RCC
- 9.5"

GAB: Graded aggregate base  CTSB: Cement treated soil base
SC Inland Port – Loads/Traffic

- Containers
  - Stacked 5 loaded
  - Stacked 7 empty

- Cranes
  - Eight tires each side

- Container Handler
  - Single axle, 4 tires
Analyses using RCC Pave and AirPave

- RCC Pave 14 in. RCC 3 in. GAB
- AirPave 14 in. RCC 3 in. GAB
- RCC Pave 13 in. RCC 6 in. CTS
- AirPave 13 in. RCC 6 in. CTS

Dual-wheel loading
### RCC Pave and AirPave Results for Container Handler, Dual Wheels

<table>
<thead>
<tr>
<th>Maximum Allowable Load For Unlimited Repetitions, kips</th>
<th>RCC Pave</th>
<th>AirPave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Section</td>
<td>37</td>
<td>48</td>
</tr>
<tr>
<td>Value Engineered Section</td>
<td>38</td>
<td>50</td>
</tr>
</tbody>
</table>

About 30% higher capacity using AirPave for this loading condition
SC Inland Port – Cement Treated Soil Base

- **Cement content by dry weight of soil**
  - 6 percent in cut area (Silty SAND soil)
  - 7 percent in fill area (Sandy SILT soil)

- **Compressive Strength**
  - Lab specimens (mix design): 400 psi minimum at 7 days
  - Field quality control: 300 psi minimum at 7 days, or CBR of 50 percent minimum as determined by the Kessler Dynamic Cone Penetrometer
Why CTS base?
SC Inland Port – Benefits of CTS Base

- Added structural capacity
- Improved load transfer at RCC joints and cracks
- Reduced downtime after rain events
- Economical
- Sustainability attributes
SC Inland Port – RCC Mixture

- **Requirements**
  - Specified compressive strength: 5,000 psi at 28 days (ASTM C1435 cylinders)
  - Specified split-tensile strength: 400 psi at 28 days
  - Minimum cement content: 500 pcy

- **Aggregates**
  - Considered aggregates from 2 quarries
  - At the time of construction, closest quarry did not produce washed manufactured sand
  - Natural sand not available locally
  - Tested a series of trial mixes using aggregates from both quarries
  - Selected #67 and washed manufactured sand
SC Inland Port – RCC Mixture

■ Trial Batches
  - Cement contents: 500 and 575 pcy, Type I/II
  - Aggregates
    • #67 from each quarry
    • Washed manufactured sand from the farthest quarry and unwashed manufactured sand from the quarry closer to the job site
    • Crushed aggregates from both sources are granitic gneiss
  - Target lab strength: 6,000 psi at 28 days

■ Selected Mix
  - 500 pcy cement
  - Aggregates: 45% #67 and 55% washed screenings
## RCC Combined Aggregate Gradation

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
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<tr>
<td></td>
<td>Selected RCC Mix</td>
</tr>
<tr>
<td>1”</td>
<td>100</td>
</tr>
<tr>
<td>¾”</td>
<td>95</td>
</tr>
<tr>
<td>½”</td>
<td>79</td>
</tr>
<tr>
<td>3/8”</td>
<td>70</td>
</tr>
<tr>
<td>#4</td>
<td>57</td>
</tr>
<tr>
<td>#16</td>
<td>32</td>
</tr>
<tr>
<td>#100</td>
<td>4.4</td>
</tr>
<tr>
<td>#200</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Figure 1. General layout of RCC test section (not to scale)
SC Inland Port – Test Section

- Testing of Test Section
  - Density of each lift
  - ASTM C1435 cylinders
  - Cores
    - Confirmed bond of both lifts
    - Met split tensile and compressive strengths
    - Determined density
SCIP RCC Mixing Plant
SCIP RCC Placement

RCC Placement - Dual lifts when thickness > 10”
SCIP RCC Placement

RCC Placement – 1st lift”
SCIP RCC Placement

RCC Placement – 2nd lift”
Added Compaction at Longitudinal Joint
Concluding Remarks

- Soil types and 0.5% grade were very challenging. Designers should consider 1% grade whenever possible.

- Using a cement-treated soil base instead of a thin unbound aggregate base was a game changer for this project built during the summer months when rain events are very frequent.

- Locally available manufactured granitic gneiss sands containing more than 6% fines may not be adequate for strength higher than 5,000 psi at 28 days
Concluding Remarks

- Analyses using different computer programs, field performance, and on-going research demonstrate the need for a unified design method that predicts the required thickness more accurately.

- Results using RCC Pave appear to be too conservative, especially when designing for heavy loads for ports and intermodals.

- Rapid strength gain of RCC allowed the owner to start assembling cranes and open the intermodal for operations quickly.
Questions?

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