Results of Thin RCC Pavement Sections Under Accelerated Loading

ACI Committee 327
Roller-Compacted Concrete Pavements
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Background

- Why is LTRC and DOTD interested in RCC?
  - Shale gas exploration
  - Logging activities
  - Agricultural activities
- RCC is tough, economical, and may provide a potential solution for the above locations
Background

- RCC for roadways started in the mid-1980’s
- Successful RCC projects include:
  - U.S. 78 near Aiken, SC
    - 10” RCC – 1 mile 4 lane section completed in 2009
  - 2012 Arkansas completed a section in the Fayetteville Shale Play Area
    - 7” RCC over a reconstructed base course
    - 8” RCC placed as an overlay
Objectives

- Characterize the fresh and hardened RCC properties
- Characterize the load carrying capacity of the differing RCC sections
Lab Materials and Test Methods

- **Materials**
  - No. 67 crushed limestone
  - Manufactured sand
  - Type I portland cement

- **Test methods**
  - ASTM C1557 Modified Proctor
  - ASTM C1435 for cylinders
  - ASTM C39
  - ASTM C6938 and ASTM C1040
Laboratory Mixtures

- 350, 400, 450, and 500 PCY mixtures
- Tested for density first (Modified Proctor)
- Then tested for strength
Mixture Results - Strength
# Mixture Proportion

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity (pcy)</th>
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<tbody>
<tr>
<td>Cement</td>
<td>450</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>1521</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>2017</td>
</tr>
<tr>
<td>Water</td>
<td>154</td>
</tr>
</tbody>
</table>
Section Layouts

Section 1

8" RCC
12" Cement Treated Base
Existing Subgrade

Section 2

6" RCC
12" Cement Treated Base
Existing Subgrade

Section 3

4" RCC
12" Cement Treated Base
Existing Subgrade

Section 4

8" RCC
8.5" Soil Cement Base
10" Cement Treated Subgrade
Existing Subgrade

Section 5

6" RCC
8.5" Soil Cement Base
10" Cement Treated Subgrade
Existing Subgrade

Section 6

4" RCC
8.5" Soil Cement Base
10" Cement Treated Subgrade
Existing Subgrade
Field Constructed Sections
Pictures
Field Results

- Density slightly lower in the bottom depth
- Strengths at 55 days of age
  - Lane 1 – 5192 psi
  - Lane 2 – 4422 psi
    - Due to lower densities

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Thickness (in)</th>
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<tbody>
<tr>
<td>1</td>
<td>9.65</td>
</tr>
<tr>
<td>2</td>
<td>6.05</td>
</tr>
<tr>
<td>3</td>
<td>4.90</td>
</tr>
<tr>
<td>4</td>
<td>8.01</td>
</tr>
<tr>
<td>5</td>
<td>6.36</td>
</tr>
<tr>
<td>6</td>
<td>4.10</td>
</tr>
</tbody>
</table>
ATLaS30

Dual-tire load, 130psi
Load: up to 30 kips
Speed: 4~6 mph
Bi-directional loading
Effective length: 42-ft
About 10,000 passes/day
Accelerated Loading Testing

- Roughly 78,000 reps. for each load level
4” RCC Section

- After 78,000 reps. for each load level of 9-, 16, 20, 22-, 25-kip, respectively, and over ~600-650k additional reps of 16-kip
4” RCC Section – Strong Base

- Failed in fatigue
- Took 19.2 million ESALs
- Predicted life was 0.7 million ESALs!
6” RCC Section – Strong Base
6” RCC Section – Strong Base

- Failed in fatigue
  - With a wider area of influence as expected
- 87.4 million ESALs to failure
  - *1.9 million was predicted!*
- Post mortem trench still to come
8” RCC Section – Strong Base

- 390,000 reps. of various loads of 9-, 16, 20, 22-, 25-kip

Overall

Length of Lon. Crack = 2'-5"
Length of Trans. Crack = 2'-8"

Transverse Crack

Longitudinal Crack
4” RCC Section – Weak Base

- Failed in fatigue
- Took 2.7 million ESALs
- *Predicted life* 0.7 million ESALs
- Hypothesis is that since the IRI was really high contributed to early failure
6” RCC Section – Weak Base

- Failed in fatigue
- Took ~19 million ESALs
- *Predicted life 1.9 million ESALs*
Comparison of Cracking Pattern of Failed RCC Sections

- Crack initiated at the weakest subgrade location
- Cracking pattern for thicker section was much wider than the thinner section
- Uniform subgrade resulted in a final cracking failure covering the entire loading area for 6+8.5RCC & 4+12RCC
Preliminary Conclusions

- 450 pcy mixture chosen for desired surface characteristics and density
- 4000 psi strengths were easily met
- Speed of construction affected density, IRI, and surface characteristics
- 5000 psi+ strengths are to be expected in full scale construction efforts
- Thin RCC can hold a significant amount of load
Preliminary Conclusions

- Two preliminary fatigue models for thin RCC pavement fatigue analysis have been developed
  - Will finalize the developed fatigue model
  - Will perform cost-benefit analysis
  - Will build a finite element model to simulate thin-RCC pavement

- 6-in RCC over strong base has potential for heavy-loaded, medium speed pavements

- 4-in strong base and 6 in- weak base pavement structures have potential for low-volume roadways with heavy truck traffic
RCC Implementation

- The preliminary ATLaS30 loading results generally indicate that
  - a thin-RCC over soil cement pavement structure has a superior load carrying performance
  - Recommendation to select and build several field RCC test sections on those Louisiana highways where the pavements are often encountered by heavy truck loading
    - To validate the APT performance and provide further implementation guidelines
  - *Will not test the 8-inch sections to failure!*
Acknowledgements

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Questions