Roller-Compacted Concrete Pavement:
Applications, Design, Construction, & Quality Control

ROAD SCHOOL
March 11, 2009

RCC Pavement

- Definition
- Applications
- Design
- Construction
- Quality Control
Definition

“Roller-Compacted Concrete (RCC) is a no-slump concrete that is compacted by vibratory rollers.”

- Zero slump (consistency of DGA)
- No forms
- No reinforcing steel
- No finishing
- Consolidated with vibratory rollers

Concrete pavement placed in a different way!

Benefits of RCCP

- Economical
- High load carrying ability
- Eliminates rutting and spans weak subgrades
- Excellent freeze-thaw durability
- Simple, fast construction
- High production with minimum labor
- Light surface reduces lighting requirements
Logging Yards

Intermodal Yards
Distribution Centers

18 acre distribution center in Austin, TX

10 years after construction

Warehouse Facilities
Parking Areas

134 acre parking lot at Saturn Plant, TN (1988-89)

200 acre parking lot at Honda Plant, AL (2004)

Streets & Roads
Highway Shoulders

I-285
Atlanta, GA

Use is Growing
### Completed Roller Compacted Concrete Pavement Projects

**Commence**

<table>
<thead>
<tr>
<th>Year</th>
<th>Job Name</th>
<th>Type of Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td><strong>City of Grove City</strong>&lt;br&gt;Grand Run</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td><strong>City of Petrides</strong>&lt;br&gt;Taylor Run, Section 1</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td><strong>City of Pekin</strong>&lt;br&gt;Longview Subdivision</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td><strong>City of Penfield</strong>&lt;br&gt;Baldwin Park</td>
<td>Complete Blacktop Resurfacing</td>
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<tr>
<td></td>
<td>Park of Flowers</td>
<td>New Subdivision</td>
</tr>
<tr>
<td></td>
<td>Quaker Park 1</td>
<td>New Subdivision</td>
</tr>
<tr>
<td></td>
<td>Vistas of Menomonee</td>
<td>New Subdivision</td>
</tr>
<tr>
<td></td>
<td><strong>Village of Hales Corners</strong>&lt;br&gt;Villages at Milk Run Green</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td><strong>Jack Strader</strong>&lt;br&gt;Strader’s Garden Center</td>
<td>Private Parking Lot</td>
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### Completed Roller Compacted Concrete Pavement Projects

**Continued**

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<th>Type of Pavement</th>
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<tr>
<td>2002</td>
<td><strong>Lifeline Society Estates</strong>&lt;br&gt;Cumberland Trails</td>
<td>New Subdivision</td>
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<td></td>
<td>Watkins Grove</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td><strong>Lifestyle Communities</strong>&lt;br&gt;Waukesha Park</td>
<td>New Subdivision</td>
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<td></td>
<td><strong>IOCCA LTD</strong>&lt;br&gt;Parr’s Brook Estate</td>
<td>Private Parking Lot</td>
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<td></td>
<td><strong>Ohio State University</strong>&lt;br&gt;woody hills center</td>
<td>Special Reconstruction of a Major Arterial Roadway</td>
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<td></td>
<td><strong>Village of Greenport</strong>&lt;br&gt;Hawley Grove</td>
<td>New Subdivision</td>
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<tr>
<td></td>
<td>Madison Road Resurfacing</td>
<td>Special Blacktop Rehabilitation</td>
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<tr>
<td></td>
<td><strong>Village of Sunbury</strong>&lt;br&gt;Gerrity Estates</td>
<td>New Subdivision</td>
</tr>
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</table>
Engineering Properties

- Compressive strength
  4,000 to 10,000 psi
- Flexural strength
  500 to 1,000 psi
  \( f_r = C(f'_c)^{1/2} \)
- Modulus of Elasticity
  3,000,000 to 5,500,000 psi
  \( E = C_E(f'_c)^{1/2} \)

Thickness Design of RCC Pavements

- Follows rigid pavement design methods
- Plain, undoweled, unreinforced concrete pavement
- PCA’s *Structural Design of RCC for Industrial Pavements*
- PCA RCC-PAVE Program
Mix Design

Mix Design

Differs from conventional concrete mixture procedures

- Not air-entrained
- Lower water content
- Lower paste content
- Larger fine aggregate content
- Nominal maximum size aggregate (NMSA) +/- 5/8”

Mix Design

- Dry enough to support a vibratory roller
- Wet enough to permit adequate distribution of paste
Aggregate Selection

- Aggregate selection very important
- Responsible for mix workability, segregation, ease of consolidation
- Pre-blended or stored separately

Cementitious Materials

- Select materials based upon availability, economics, and design requirements:
  - Portland cement: Type I or II
  - Fly ash
  - Normally 500 lb/cy cementitious (12% to 17% of dry weight)
  - If used, fly ash proportions are typically 15% to 25%
Admixtures

- Retarder or water reducer can be used to increase working time
- Air entrainment not yet technologically possible, but
  - Experience has shown RCC can be made freeze/thaw resistant
  - It’s too dense to be saturated

Soil Compaction Method

- Determine moisture content
  - Construct moisture/density curve
  - Modified proctor ASTM D1557
  - Assume a median cement content (e.g. 15 percent)
Standard vs Modified Proctor

Construction
Continuous Pug Mill

- High-volume applications
- Excellent mixing efficiency for dry materials
- 250 to 500+ tons/hr
- Mobile
- Erected on site
- Higher mobilization costs

High Volume Production
Central Concrete Batch Plant

- Highly accurate proportioning
- Local availability
- Smaller output capacity
- Longer mix times than conventional concrete
- Frequent cleaning
- Dedicated production

Low Volume Production

Clifton Road  Union County, IN
Transporting

- Dump trucks normally used
- Covers required for long hauls, or hot/windy conditions

Subbase/Subgrade Preparation

- Same requirements as conventional concrete
- Must be stiff to provide full compaction
- Stable subgrade
- Non-pumping subbase
- Moisten subbase prior to RCC placement
Placing Equipment

- High density pavers
  - Vibrating screed
  - Dual tamping bars
  - High initial density (90% to 95%)
  - Reduces subsequent compaction
  - High-volume placement (1000 - 2000 tons/shift)
  - Designed for harsh mixes
  - Smoothest RCC surface

High Density Pavers
Placing Equipment

- Conventional Asphalt Pavers
  - Provides some initial density (80%-85%)
  - Relatively smooth surface

Compaction

- Proper compaction is critical for strength and durability
- Compact to 98% of modified Proctor
- Vibratory roller
- Non-vibratory steel wheel roller
- Rubber-tire roller
Curing

- Extremely important for surface durability
- Low moisture in RCC
- Three methods:
  - Moist cure
  - Concrete curing compound
  - Asphalt emulsion

Construction Joints

- Most critical area of project
- Must be constructed properly for durability
- Ensures bond/interlock, so slab acts monolithically
- Three types of construction joints:
  - “Fresh joints”
  - “Cold joints”
  - “Horizontal joints”
Fresh Joint

Tight Fresh Joint
Cracking / Jointing

- Saw-cut joints unnecessary for performance
- Natural cracks provide excellent load transfer due to aggregate interlock
- Saw-cut joints control cracks for aesthetic purposes

Natural Cracks

- Most economical
- ~30ft spacing
- Often first cracks appear within 24 hours
- Narrow crack widths
- Seal if > 1/8-inch
- Best load transfer
- Minimal raveling
Saw-Cut Joints

- More aesthetically pleasing
- Early entry saws very effective, shortly following placement
- Need to saw within 12 hours to avoid uncontrolled cracking
- 1/3 to 1/4 of total layer thickness

Surfacing

- Paver-placed RCC needs no surface for durability
- Adequate for low-speed traffic
- High-density pavers can provide smoothness for medium-speed traffic
- Thin asphalt surface (1-1/2 to 3 inches)
  - Improves surface for high-speed traffic
  - Placed immediately or any time thereafter
Surface Textures

Testing
Moisture / Density

Nuclear Gauge
ASTM C1040

Strength Testing

Fabricating Cylinders
With Vibrating Hammer
ASTM C1435
for additional information, please visit PCA's website at www.cement.org/pavements