Integrated Pavement Solutions
Product Solutions for Every Paving Need

Application
- Mainline highways
- Commercial airports
- General aviation airports
- Heavy-duty industrial
- Med/Heavy-volume roads
- Low-volume roads
- Parking lots
- Shoulders
- Intersections
- Concrete pavement subbase
- Flexible pavement rehab
- Improve poor subgrade soils

Solution
- PCC pavement
- Concrete overlays
- RCC pavement
- Cement-treated base
- Full-depth reclamation
- Cement-modified soil
- Pervious concrete
- Concrete pavement restoration
Integrated Solutions Guide

- Intended technical guidance that identifies what cement-bound material options are available for specific pavement applications.

- The Guide will provide a basic description of each option, and recommend how/where to seek out more information.
Integrated Solutions Guide

Each Solution description is intuitively formatted and thoroughly illustrated.

- Solution Type
- Description
- Typical Applications
- Design
- Materials
- Construction
- Benefits and Limitations
- Sustainability
Full Depth Concrete Pavements
Basic Components / Terminology for Concrete Pavements

Surface smoothness
Longitudinal joint
Transverse joint
Surface Texture
Thickness Design
Concrete materials
Dowel bars
Tie bars
Subbase
Subgrade

Credit ACPA
Jointed Plain

Paved Shoulders
Jointed Plain

• Most common pavement type
• Saw cut joint spacing 15-20 ft
  – Dowels used for thicknesses 8 in. or greater
  – No dowels (aggregate interlock) < 8 in.
• Cracks occur at joints
• Longitudinal tie-bar reinforcement
• Transverse dowel bars used for load transfer
Continuously Reinforced

- Steel reinforcement to hold pavement together.
- Steel reinforcement is not counted in structural design.
Concrete Overlay Guide

Contents

• Overview of Overlay Families
• Overlay Types and Uses
• Evaluations & Selections
• Six Overlay Summaries (11”x17 “shts)
• Design Section
• Miscellaneous Design Details
• Overlay Materials Section
• Work Zones under Traffic
• Key Points for Overlay Construction
• Accelerated Construction
• Specification Considerations
• Repairs of Overlays
Types of Concrete Overlays

Bonded

2” – 5”

Bonded Concrete Overlays of Concrete Pavements
—previously called bonded overlays—

Bonded Concrete Overlays of Asphalt Pavements
—previously called ultra-thin whitetopping—

Bonded Concrete Overlays of Composite Pavements

Unbonded

4” – 11”

Unbonded Concrete Overlays of Concrete Pavements
—previously called unbonded overlays—

Unbonded Concrete Overlays of Asphalt Pavements
—previously called conventional whitetopping—

Unbonded Concrete Overlays of Composite Pavements
Pervious Concrete
Pervious Concrete

- Special type of concrete
- Contains little to no fines
- 15-25% voids
- Allows water to pass through
- Reduces stormwater runoff
- Recharges groundwater
- Typically used for exterior flatwork
- Reduces need for retention ponds
Applications

- Parking areas
- Roadways
- Walks
- Driveways
- Recreational areas
- Erosion control
Stormwater Environmental Perspective

- Vertical flow through the pavement vs. traditional horizontal runoff
  - EPA Best Mgt. Practice (BPM)
    - Reduces the size of retention ponds and swales
  - First Flush Pollution Mitigation – 90% of pollutants typically in first 1 1/2” of Run-Off

LEED Pts. (2-5) Available
## Typical Values for Pervious Material Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Weight</td>
<td>70-80% of conventional concrete mixtures</td>
</tr>
<tr>
<td>Density</td>
<td>100-125 lb/ft³ (1600-2000 kg/m³) – this is dependent on mix design and construction procedures</td>
</tr>
<tr>
<td>Percent Voids</td>
<td>15-25%</td>
</tr>
<tr>
<td>Permeability</td>
<td>100 in./hr – over 2000 in/hr (2.5-50 m/hr)</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>2500 psi (17 MPa) but this can range from 500 – 4000 psi (3.5 – 28 MPa)</td>
</tr>
</tbody>
</table>
Pervious Design Features

• In freeze-thaw climates, pervious concrete systems should not be designed to store water in the concrete itself.

• Typical design thicknesses include 5- to 6-in. thick pervious concrete.

• A minimum of 12 in. of a drainable aggregate base, such as 1-in. crushed stone, is typically constructed with percolation rate of 0.5 in./hr.
Machined Placed

Hand Roller
Precast Pavements
Precast Pavements

• Precast panels are fabricated off site.

• Then installed on site and opened to traffic.

• Precast pavements have been used primarily for reconstruction and repair of JCP.

• Precast pavement systems can also be used as an unbonded overlay.

• The benefits of precast pavement are during short closures.
Types of Precast Pavements

- There are two primary types of precast pavement systems used in the United States to date:
  1. Prestressed concrete panels that are pretensioned in one direction during fabrication and posttensioned together in the other direction after placement on site.
  2. Jointed system, which replicates conventional JCP using precast panels.
Jointed Precast Pavements

Repair Panels – Full lane width, variable length

Conventional Jointed PCP System
Panels full lane width, ~15 ft long
Jointed Precast Pavements

• Precast panels are typically a minimum of 8 in. thick, but they can be adjusted as necessary to match the thickness and cross-section of the existing pavement.

• Jointed precast pavement systems are typically designed to replicate conventional JCP.

• For jointed systems, doweled joints are used similar to conventional JCP.
Cement-Treated Materials
Cement Treated Materials Definitions

*Modified material* – a material treated with a relatively small proportion of portland cement in order to amend its undesirable properties so they are suitable for use in subgrade or foundation construction (i.e. drying, reducing plasticity) (cement modified soils)

*Stabilized material* – a material treated with a predetermined amount of portland cement to provide a strong, durable, weather resistant base (cement treated base)
Reduction Moisture Susceptibility

Unstabilized Granular Base:
- Through high water table
- Through capillary action
- Causes softening, lower strength, and reduced modulus

Cement-Stabilized Base:
- Reduces permeability
- Helps keep moisture out
- Maintains high level of strength and stiffness even when saturated

Moisture infiltrates base:
Cement-Modified Soil (CMS)

- Eliminates removal/replacement of inferior soils
- Small quantity of cement (2-4%) added to soils to change properties
- Provides permanent (non-leaching) modification
- Reduces construction time (quick return to operation)
Cement-Modified Soil

- Uses variety of soil or aggregate
- Central plant or mixed-in-place
- Typical strengths 300+ psi (compressive)
- Frost resistant
- Long-term performance
- Typically 2-4% Cement
- Lowers plasticity index (PI) to 12 to 15 range
- Improves pavement support
- Forms weather-resistant work platform
Cement-Treated Base
Cement-Treated Base (CTB) (Stabilization)

- Uses variety of soil or aggregate
- Central plant or mixed-in-place
- Stronger than CMS (5-6% cement)
- Typical strengths 400 to 800 psi
- Eliminates rutting and fatigue cracking in asphalt
- Frost resistant
- Long-term performance

Tech Center
Improved Performance In Rutting And Fatigue Cracking

Unstabilized Granular Base

Cement-Treated Base

100 psi

15 psi

4 psi
Road Mix
Portland Cement Addition

Slurry spread

Dry spread

Pre-wetting Soil
Addition Of Water and Mixing

Via drum of reclaimer (mixer)

Gravity dump and mix
Compaction

- High density is critical for strength and durability
- Steel-drum
- Rubber-tire roller
- Sheep’s foot roller
- Usually 95% to 98% of standard Proctor
- Curing
  - Moist Cure
  - Concrete Curing Compound
  - Asphalt Emulsion
Full-Depth Reclamation

- Deep recycled layer
- Injection of water and/or fluid stabilizing agents
- Operating direction
- Milling drum
- Distressed pavement
- Granular material
Advantages of the FDR Process

- Reuse of in-place materials
- Little or no material hauled off and dumped
- Conserves virgin material
- Maintains or improves existing grade
- Saves cost by using in-place “investment”
- Eliminates patching
- Fast and convenient
- Economical
- Very sustainable process
Fairfield County, SC

- Maintains 220 miles of unpaved, gravel roads
- Upgrade gravel roads
- 6” aggregate base with 2” HMA surface, versus
- 6” FDR base with triple bit. surface treat (chip seal)
- 13.5 miles paved
- 6% cement

<table>
<thead>
<tr>
<th>Item</th>
<th>FDR Roadway</th>
<th>Asphalt Roadway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>$61,600</td>
<td>$88,000</td>
</tr>
<tr>
<td>Asphalt</td>
<td>-</td>
<td>$96,800</td>
</tr>
<tr>
<td>Chip seal</td>
<td>$52,800</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>$114,400</td>
<td>$184,800</td>
</tr>
</tbody>
</table>

Cost per mile for 20-ft roadway: 37
Pulverization

• Pulverize mat to appropriate gradation

• Usually, only one pass is required!

• 12” pulverize recommended because compaction limit of 12”
Cement Spreading

- Cement is spread on top of the pulverized material in a measured amount in either a dry (common) or slurry form
  - In dry form (lbs./S.Y.)
  - In slurry form (gal./S.Y.)
Blending of Materials and Moisture Addition

• Cement is blended into pulverized, material with a reclaimer/mixer

• With the addition of water, is brought to optimum moisture
Compaction and Grading

Material is compacted to 95 to 98 percent minimum standard Proctor density and then graded to appropriate Plan lines, grades, and cross-sections.
Curing

If asphalt surface there
Bituminous Compounds
(cutbacks or emulsions)

Water
(kept continuously moist)
or approved sealing compound
Advantages of the FDR Process

- Reuse of in-place materials
- Little or no material hauled off and dumped
- Conserves virgin material
- Maintains or improves existing grade
- Saves cost by using in-place “investment”
- Eliminates patching
- Fast and convenient
- Economical
- Very sustainable process
Fairfield County, SC

- Maintains 220 miles of unpaved, gravel roads
- Upgrade gravel roads
- 6” aggregate base with 2” HMA surface, versus
- 6” FDR base with triple bit. surface treat (chip seal)
- 13.5 miles paved
- 6% cement

<table>
<thead>
<tr>
<th>Item</th>
<th>FDR Roadway</th>
<th>Asphalt Roadway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>$61,600</td>
<td>$88,000</td>
</tr>
<tr>
<td>Asphalt</td>
<td>-</td>
<td>$96,800</td>
</tr>
<tr>
<td>Chip seal</td>
<td>$52,800</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>$114,400</td>
<td>$184,800</td>
</tr>
</tbody>
</table>

Cost per mile for 20-ft roadway
Pulverization

- Pulverize mat to appropriate gradation
- Usually, only one pass is required!
- 12” pulverize recommended because compaction limit of 12”
Cement Spreading

- Cement is spread on top of the pulverized material in a measured amount in either a dry (common) or slurry form
  - In dry form (lbs./S.Y.)
  - In slurry form (gal./S.Y.)
Blending of Materials and Moisture Addition

- Cement is blended into pulverized material with a reclaimer/mixer.
- With the addition of water, is brought to optimum moisture.
Compaction and Grading

Material is compacted to 95 to 98 percent minimum standard Proctor density and then graded to appropriate Plan lines, grades, and cross-sections.
Curing

If asphalt surface there Bituminous Compounds (cutbacks or emulsions)

Water (kept continuously moist) or approved sealing compound
Typical CTB/FDR Costs

• Depends on contractor availability, material of the exiting pavement, material costs, site access and difficulty

• Typical In-Place cost
  – $0.70 to $1.10 / S.Y. per inch of depth
  – $4.20 to $6.60 / S.Y. for 6” depth
Roller Compacted Concrete Pavements
Applications

• Ports, intermodal yards and military hard stands
• Warehouse facilities & auto manufacturing plants
• Maintenance & storage yards
• Airport service areas
• Arterial roads
• Highway shoulders
• Local streets & intersections
How Does it Work?

Conventional PCC Pavement

- Shared materials characteristics:
  - Same materials (different proportions)
  - Similar curing requirements

Hot-Mix Asphalt Pavement

- Shared construction characteristics:
  - Similar aggregate gradation
  - Similar placement and compaction

Roller Compacted PCC Pavement

Figure 3. RCC combines aspects of conventional concrete pavement with construction practices similar to HMA pavement.
Figure 4. Typical aggregate gradation of RCC (black on chart) is similar to aggregate gradation of intermediate HMA layer (blue on chart).

Figure 5. Strength vs. density for various RCC mixtures.
Basic Difference Between RCC & PCC

Comparison of aggregate distribution of conventional concrete (left) and roller compacted concrete (right) (photos courtesy of CTL Group)
Comparison of Surfaces

Diamond Grinding
Freeze-Thaw Durability

• It has been demonstrated non air entrained RCC can provide reliable and durable performance in F-T condition.

• The use or non use of air entrainment in RCC has been debated for years.

• Requires adequate cement content, sound aggregates, proper mixing, adequate compaction and proper curing.

• Most air voids in RCC from consolidation consolidation
Benefits of RCC

- The primary benefit of RCC is that it can be constructed quickly and cost-effectively.
- Savings associated with RCC primarily due to:
  - Reduced cement content
  - Reduced forming, placement, and compaction
  - RCC needs no forms or finishing
  - No dowels, tie rods, or steel reinforcement
  - Can be placed up to 10 inch lifts
  - Reduced construction times
- The lower paste content in RCC results in less concrete shrinkage and reduced cracking from shrinkage-related stresses.
- RCC can be designed to have high flexural, compressive, and shear strengths, which allow it to support heavy, repetitive loads.
Potential Limitations of RCC

• Because of the type equipment used & placement practices, diamond grinding or asphalt surfacing typically needed for speeds greater than 30 mph

• The amount of RCC that can be mixed in a transit mixer or ready mix truck is typically lower than for conventional concrete, due to the dryness of the RCC mix

• Multiple horizontal lifts and adjacent slabs must be placed within an hour to ensure good bonding (unless adjacent cold joint is planned)

• Pavement edges are more difficult to compact
Typical RCC Costs

- Depends on contractor availability, material costs, site access and difficulty
- Typical In-Place cost (experienced local contractors) & does not include sawing
  - $2.25 to $3.25 / S.Y. per inch of depth
  - $15.75 to $22.75 / S.Y. for 7” depth