



THE READY MIX USA COMPANIES
READY MIX USA | BLOCK USA | HARDSCAPES USA

A  **CEMEX** COMPANY

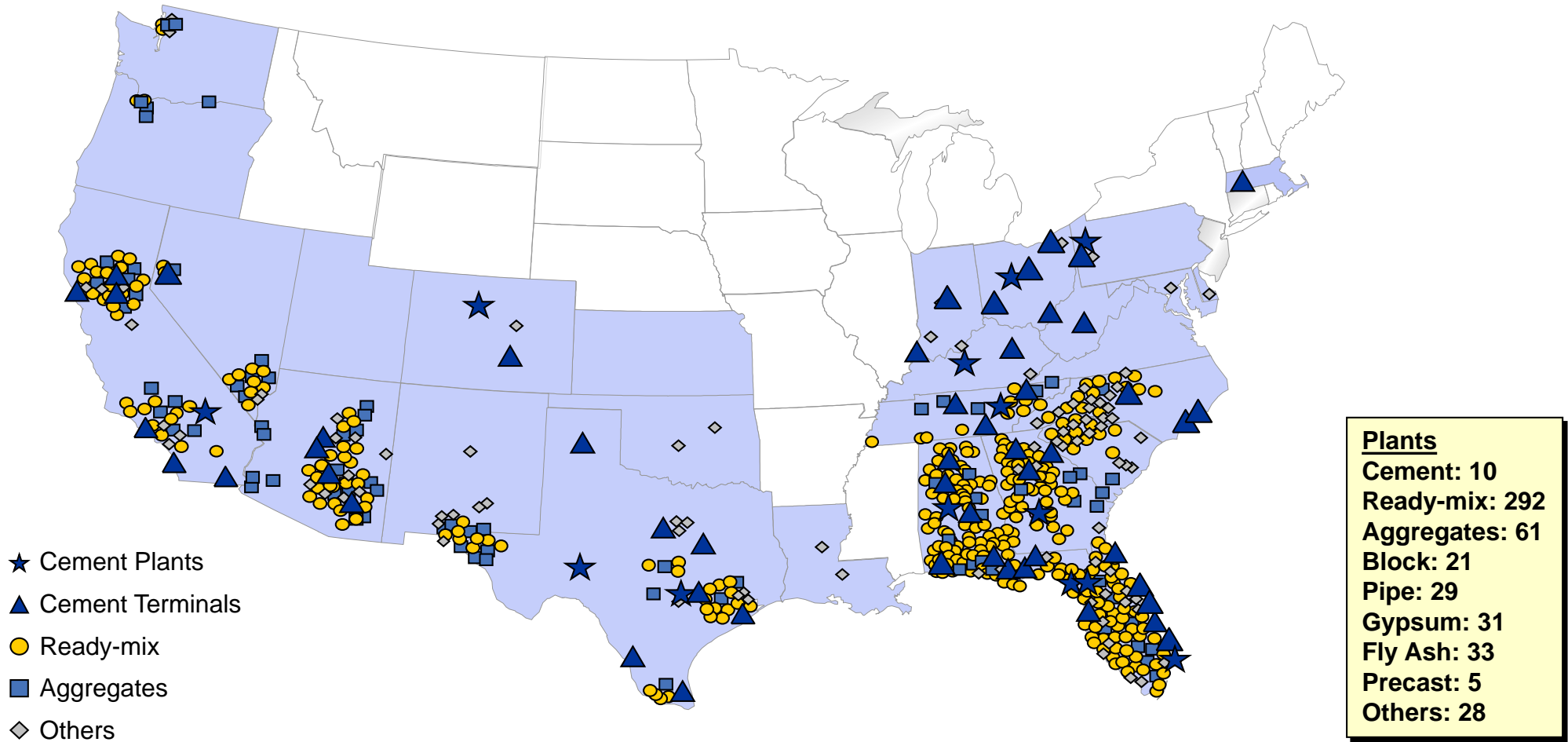
PROVIDING SOLUTIONS THROUGH PAVEMENT DESIGN



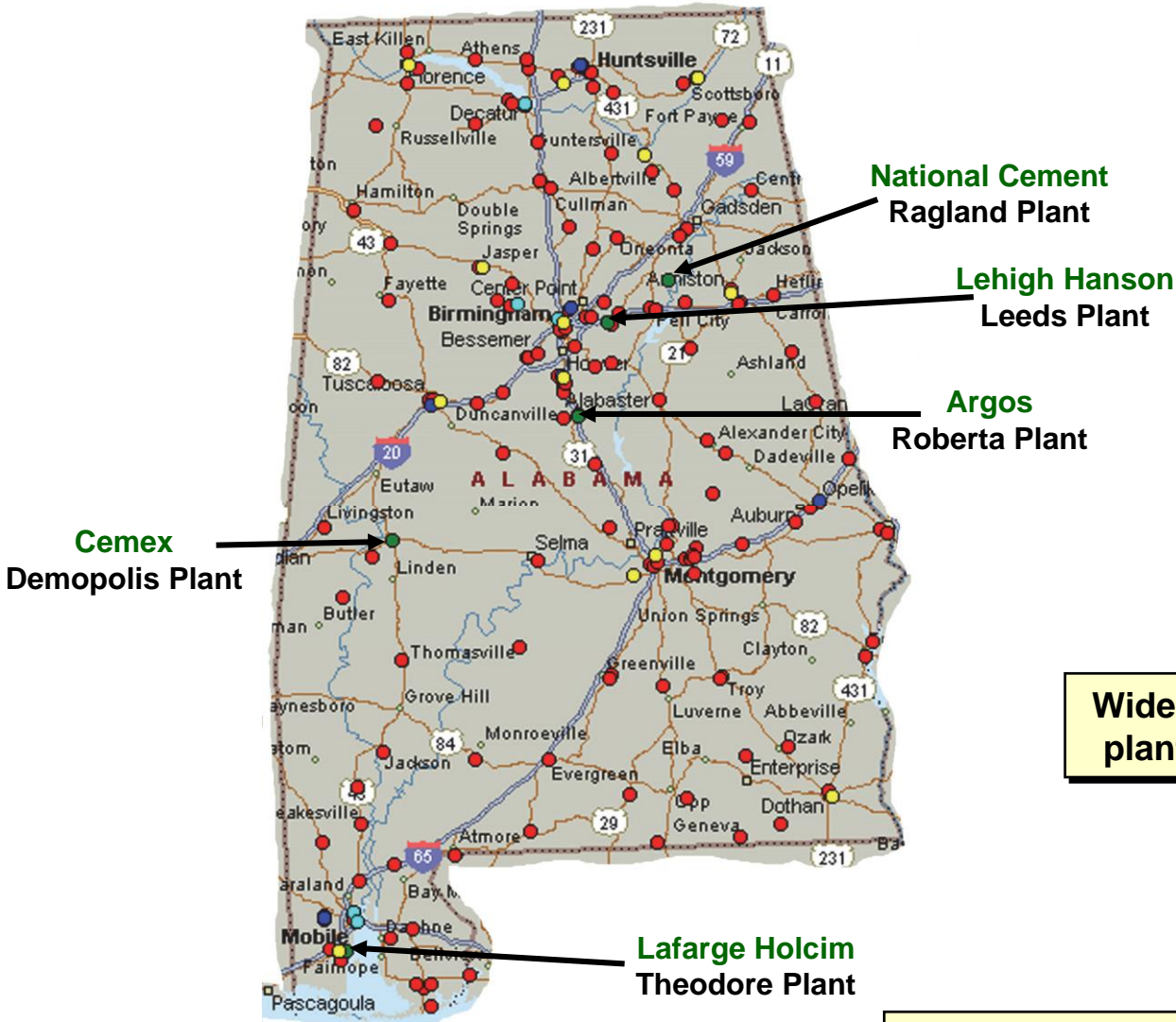
Cement-Based Pavement Solutions

Presented by Shadrack Mboya, P.E.

CEMEX IS ONE OF THE LEADING BUILDING MATERIALS SUPPLIERS IN THE INDUSTRY



ALABAMA IS THE FIFTH LARGEST PRODUCER OF CEMENT IN USA¹



- Cement Plants: 5
- Cement Terminals: 6
- Ready Mix Plants: 156
- Precast/Concrete Pipe Plants: 7
- Block Plants: 13

Cement Economic Data²
 Cement production: 4.3 million metric tons
 Cement consumption: 1 million metric tons

Widespread raw materials reach and portable batch plants allow our industry to supply most locations

Note: Asphalt industry has about 78 Hot Mix Plants in Alabama³

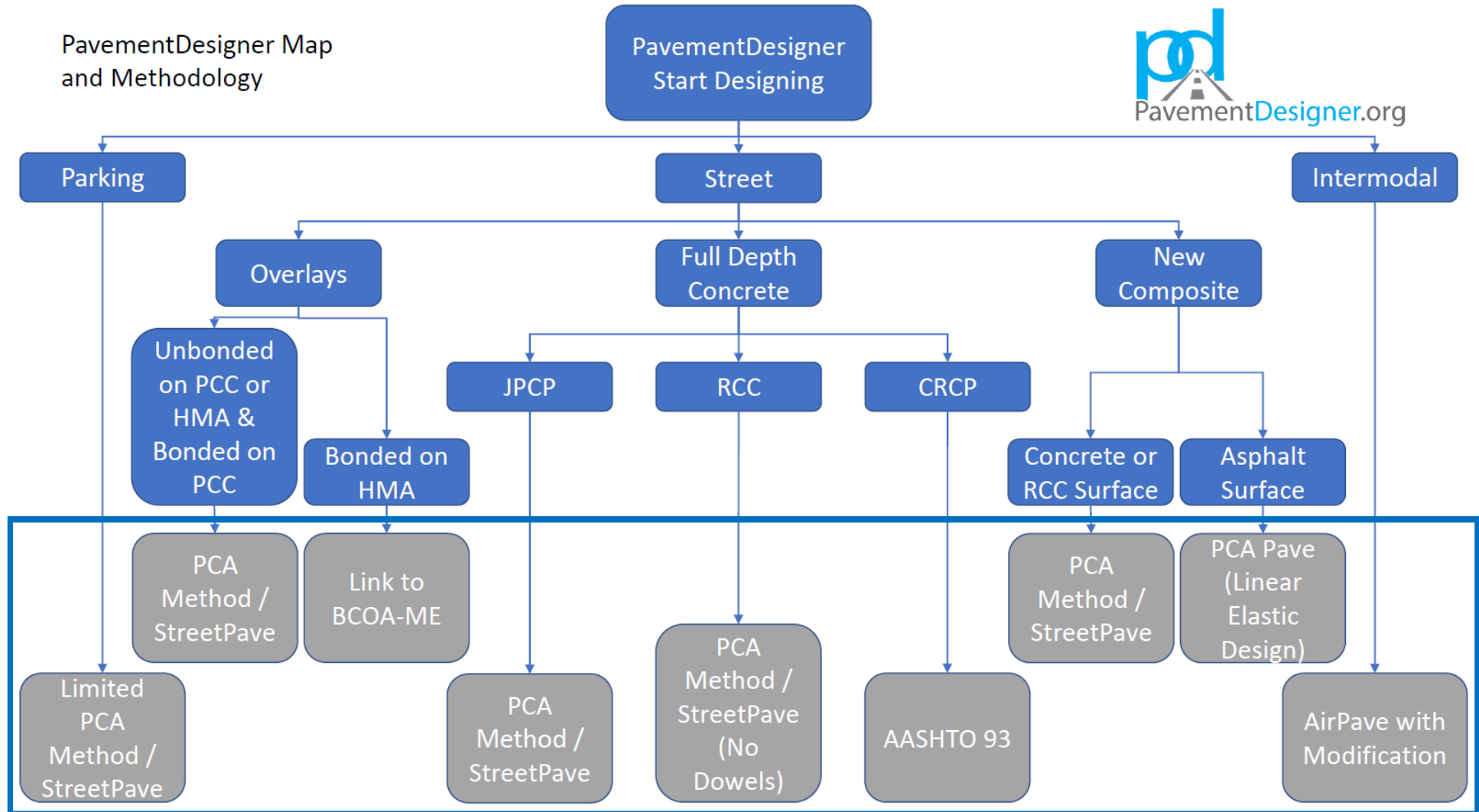
Sources:

1. Cement Industry in the United States, Wikipedia, 2013
2. Portland Cement Association, Alabama Cement Industry, 2015
3. Alabama Department of Transportation, Hot Mix Asphalt Plants, 2018



PavementDesigner.org

PavementDesigner Map and Methodology



A new, free online resource for the design of roadway, industrial, and parking area pavements



THE ADOPTION OF THESE ELEMENTS WILL INCREASE COMPETITION AND LOWER OVERALL COST OF PAVEMENT CONSTRUCTION

Elements that make Concrete Competitive

- ① **Adoption of Proper Pavement Design Procedure**
 - Removes over-design and lowers initial costs

- ② **Accounting for Maintenance Costs**
 - Most owners & engineers do not account for maintenance costs. Maintenance cost will help determine the best pavement alternative.

- ③ **Adoption of Alternate Design / Alternate Bid (ADAB) with Equivalent Design**
 - 90% of projects are designed with Asphalt only
 - Concrete may not even have the chance to bid....
 - ADAB has both asphalt and concrete designs and both are bid

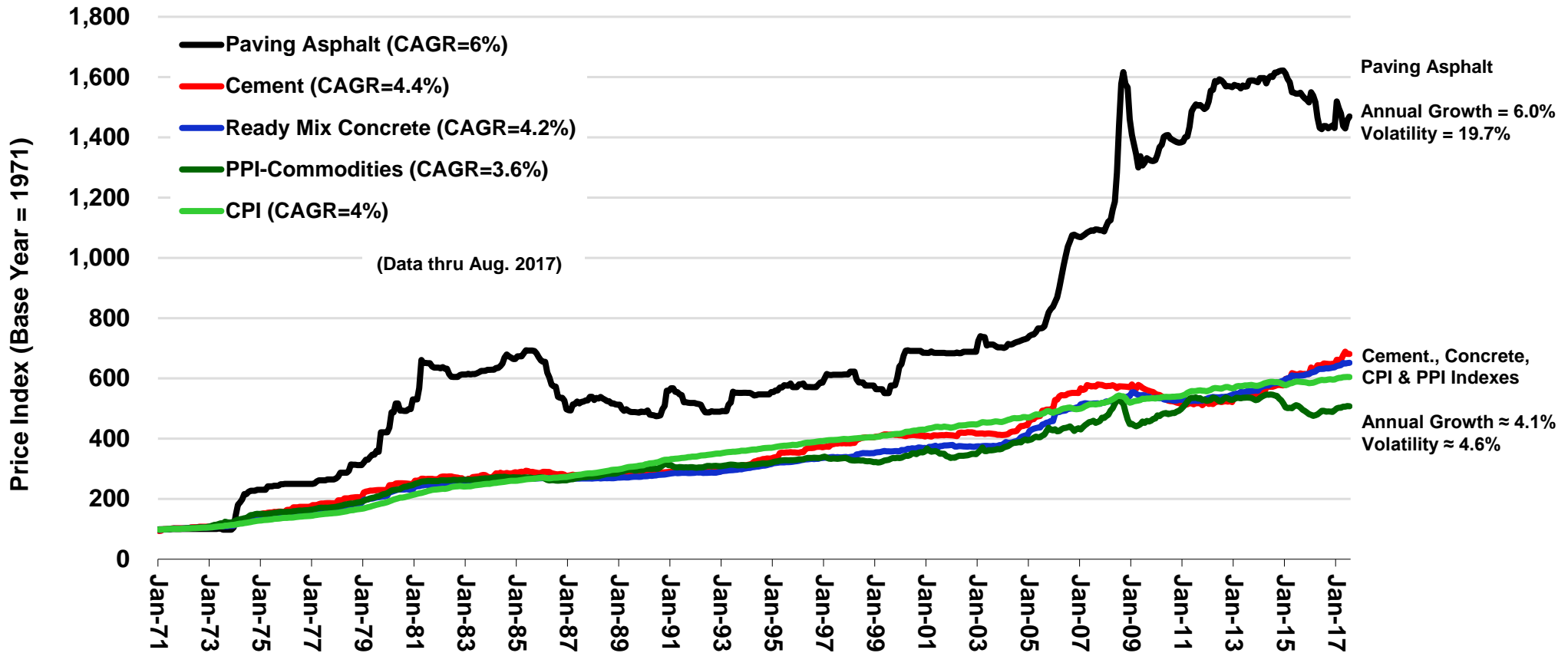
While there are benefits of each element, when COMBINED there are synergistic effects that have proven to make concrete pavements competitive

USING APPROPRIATE CONCRETE PAVEMENT FEATURES WILL OPTIMIZE THE DESIGN AND CAN MAKE CONCRETE MORE COMPETITIVE

Element	Objective	Recommendation	Impact
<p>Pavement Thickness</p>	<ul style="list-style-type: none"> ➤ Design thickness to match expected traffic ➤ Most of the design loads are carried by concrete 	<ul style="list-style-type: none"> ➤ Do not use artificial minimums ➤ Use of latest design guidelines 	<ul style="list-style-type: none"> ➤ Increases initial cost of pavement
<p>Concrete Mix Design</p>	<ul style="list-style-type: none"> ➤ Determine mix proportion to yield minimum strength and durability 	<ul style="list-style-type: none"> ➤ Use cost effective local material that yield similar design performance period (performance based mixes) 	<ul style="list-style-type: none"> ➤ Increases initial cost of pavement
<p>Base Material</p>	<ul style="list-style-type: none"> ➤ Used to prevent pumping ➤ Used as construction platform 	<ul style="list-style-type: none"> ➤ Use appropriate base material based on pavement applications ➤ Use cost effective base material and proper thickness that will yield similar design performance period 	<ul style="list-style-type: none"> ➤ Increases initial cost of pavement
<p>Dowels</p>	<ul style="list-style-type: none"> ➤ Used to improve load transfer between slabs 	<ul style="list-style-type: none"> ➤ Typical use on high truck traffic volume and high traffic speed ➤ Use cost effective dowels 	<ul style="list-style-type: none"> ➤ Increases initial cost of pavement
<p>Fibers</p>	<ul style="list-style-type: none"> ➤ To add impact resistance ➤ Increase durability 	<ul style="list-style-type: none"> ➤ Most effective for thickness < 6 inches ➤ Most pavement design do not use fibers 	<ul style="list-style-type: none"> ➤ Increases initial cost of pavement
<p>Joint Spacing/ Wide Lanes</p>	<ul style="list-style-type: none"> ➤ Control crack formation ➤ Increase durability 	<ul style="list-style-type: none"> ➤ Use shorter joint spacing ≤ 15 feet ➤ Consider widening of design lane (13 feet typical) in lieu of increasing pavement thickness 	<ul style="list-style-type: none"> ➤ Pavement performance

CONCRETE PRICES HAVE BEEN MUCH MORE STABLE THAN ASPHALT PRICES

Bureau of Labor Statistics Inflation Indexes since Jan 1971



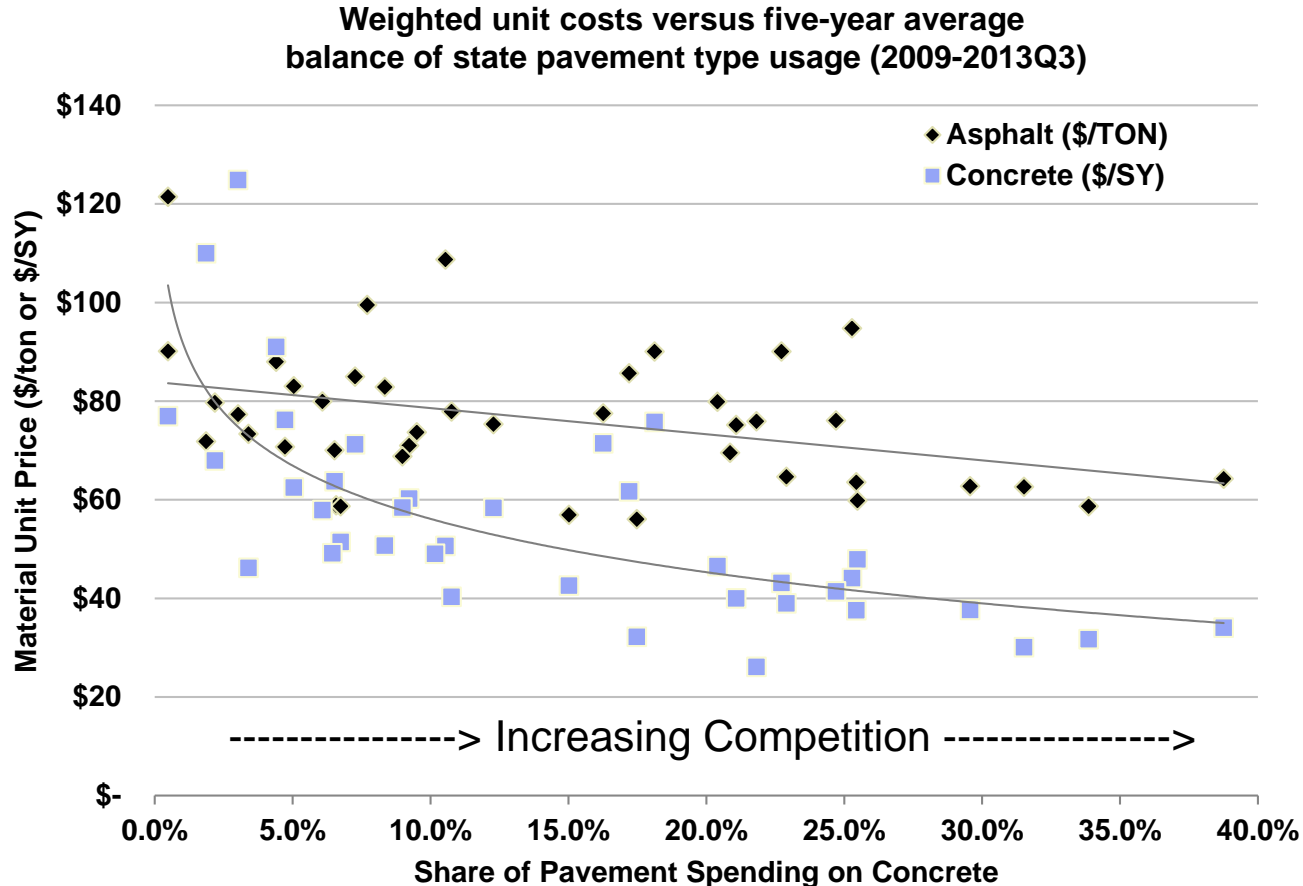
**Asphalt Inflation Rates are significantly higher than Concrete
Not accounting for inflation experience will bias the cost estimates and lead to costly overruns**

1. U.S. Department of Labor, Bureau of Labor Statistics, <http://www.bls.gov/ppi/home.htm>
 2. CAGR = Compound Annual Growth Rate



SUSTAINED COMPETITION BETWEEN THE PAVING MATERIALS INDUSTRIES BRINGS VALUE TO THE TAX PAYERS

- No state spends more than 40% of paving dollar on concrete – on average
- MAJORITY of states spend less than 15% of paving dollars on concrete pavement
- As competition increases between industries
 - Prices decrease
 - Innovation increases
 - Quality improves
- Allows agencies to build more pavements for same investment!



CEMENT-BASED PAVEMENT SOLUTIONS

Application	Conventional Concrete Pavements	Thin Concrete Pavements	Roller Compacted Concrete (RCC)	Concrete Overlays	Full-Depth Reclamation (FDR) with Cement	Soil Stabilization with Cement	Pervious Concrete
Interstate/Highways	●		●	●	●	●	
Local Streets	●	●	●	●	●	●	●
County/Rural Roads	●		●	●	●	●	
Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

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Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

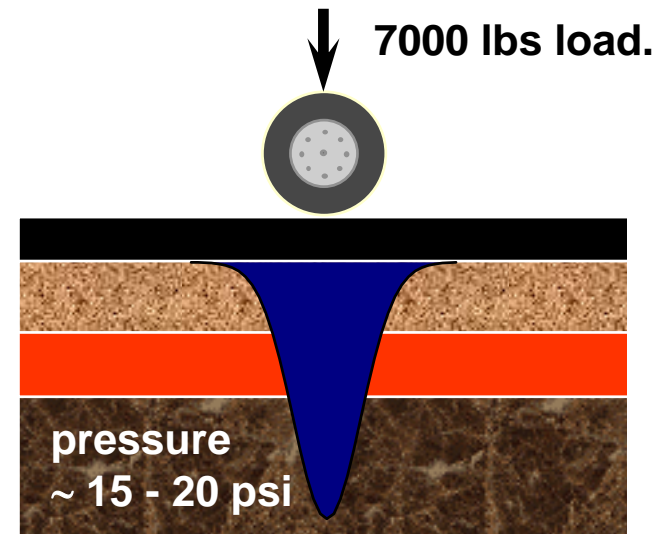
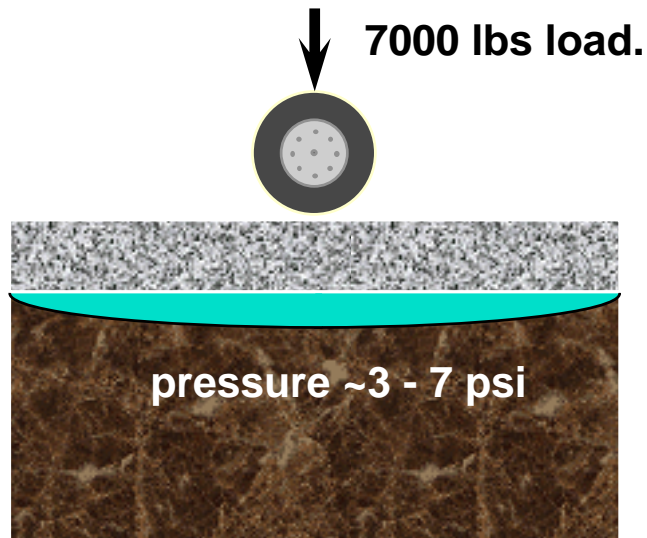
CONCRETE AND ASPHALT PAVEMENTS ARE DIFFERENT BASED ON HOW THEY DELIVER LOADS TO THE SUBGRADE

Concrete Pavements are rigid

- Loads are distributed over a large area through slab action.
- Minor deflections.
- Low subgrade contact pressures.
- Subgrade uniformity is more important than strength.

Asphalt pavements are flexible

- Loads are more concentrated.
- Deflections are higher
- Subgrade, base and subbase strength are very important.
- Usually require more layers and greater thickness for optimally transmitting load to the subgrade



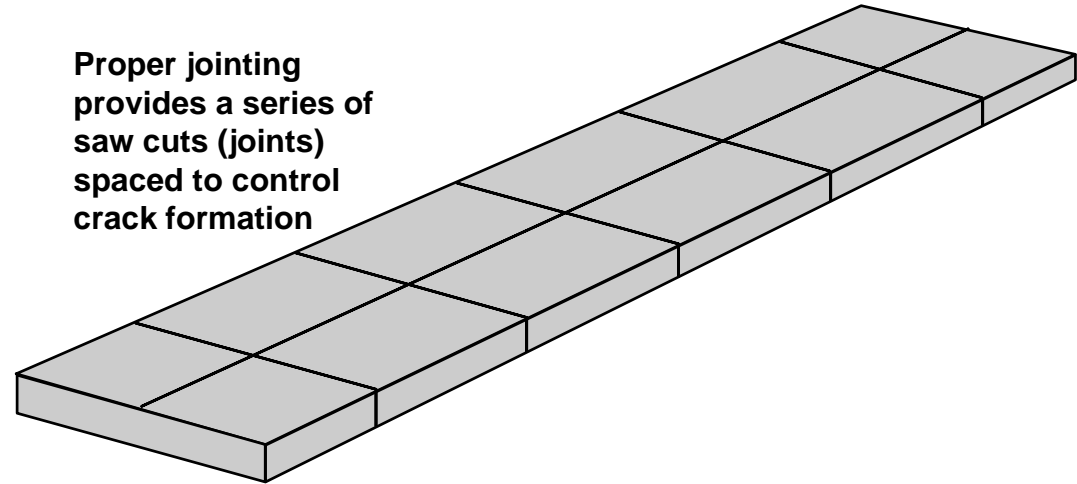
Concrete's Rigidity spreads the load over a large area & keeps pressures on the subgrade low

WHY ARE JOINTS NECESSARY?

- The concrete will crack after placement
 - Joints tell the concrete where to crack
- Why does concrete crack after placement?
 - Concrete drying shrinkage
 - Changes in temperature and moisture
 - Ambient (contraction)
 - Gradient (curling)
 - Subbase restraint (friction or bond)
 - First applied loads



Proper jointing provides a series of saw cuts (joints) spaced to control crack formation

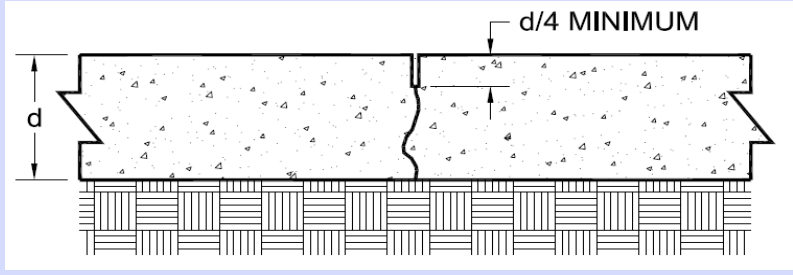
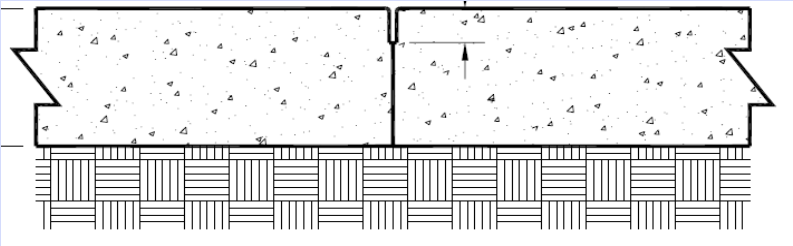
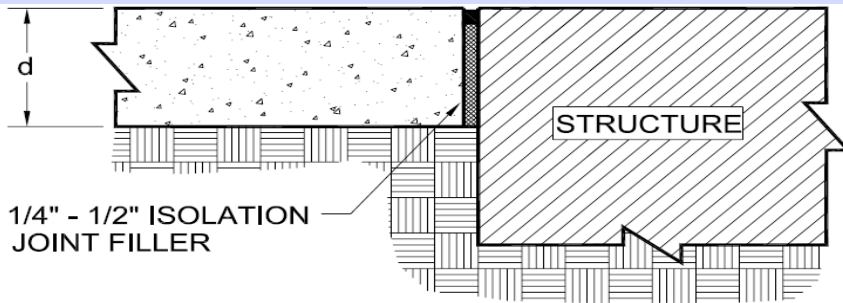


Erratic crack patterns due to no joints

Recommended Maximum Joint Spacing (2 x thickness in ft)

Pavement thickness, in.	Spacing range, ft
4 to 4.5	6-10
5 to 5.5	7.5 -12.5
6 or greater	10-15

TYPES OF JOINTS IN CONCRETE PAVEMENTS

	Details For Use	Typical Detail
<p>Contraction (Control) Joint</p>	<ul style="list-style-type: none"> ➤ Use at short joint spacing ➤ Made by saw cut, or tooled ➤ Early entry cuts = 1" deep ➤ Saw cut within 2 to 6 hours of paving 	
<p>Construction Joint</p>	<ul style="list-style-type: none"> ➤ Use at end of construction day ➤ Use thickened edge for heavy duty applications ➤ Keyways not recommended 	
<p>Isolation (Expansion) Joint</p>	<ul style="list-style-type: none"> ➤ Isolate pavement features with differential movements ➤ Do not use at regular spaced joints in paving lane ➤ Full thickness, vertical joint, sealed with compressible material 	

1) Jointing recommendations should be based on ACI 330

STEEL REINFORCEMENT IS NOT NECESSARY FOR CONCRETE PAVEMENTS

- Steel reinforcement has minor effect on a pavement's load-carrying capacity or thickness
- It does effect the joint design of the pavement
- Joints are placed according to the system selected and identifies the "concrete pavement type"
- For all paving applications, industry does not recommend using mesh reinforcing steel
- Not enough mesh to add strength
- It is rarely placed at the correct depth
- Cost impact – 7 to 12%
- Save money with tighter joint spacing instead of spending money on reinforcing for similar performance



DO I NEED DOWELS?

Dowels are used to improve Load Transfer

A slabs ability to share its load with neighboring slabs

1. Dowels

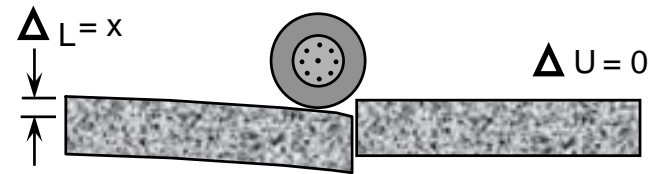


2. Aggregate Interlock

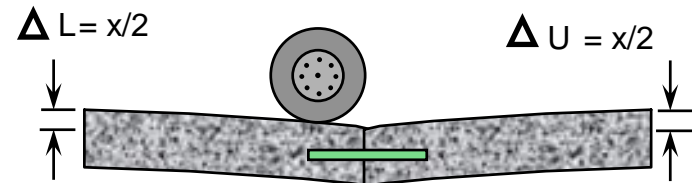
- Shear between aggregate particles below the initial saw cut



3. Concrete shoulders, extended lane, & curb and gutter aid load transfer



Poor Load Transfer



Good Load Transfer

Trucks Control Thickness and Deflections

- Include dowels if:
 - Slab thickness > 8.0 inches
- Exclude dowels if:
 - Slab thickness < 7.0 inches

Other issues:

- Speed of Traffic (Speeds >~30 mph more apt to need dowels)
- Channelized traffic (more apt to need dowels)
- Direction (single direction more apt to need dowels)

A SUBBASE IS PRIMARILY USED TO PREVENT PUMPING/EROSION OF SUBGRADE

- Purposes of the subbase are:
 - To minimize or eliminate the potential for pumping, subgrade expansion due to clay or frost
 - Provide construction platform
- Use a subbase if:
 - Category C, k – value less than 200
 - Multiple truck semi-trailer daily applications
 - Non-uniform soil conditions
 - Wet soil that might hamper construction
- Exclude subbase if:
 - Non-pumpable subgrade soil (< 45% passing #200 sieve & PI <6)
 - It is not economical to use thick subbases to increase structural capacity
 - Cost impact – 15 to 25%



Pumping is the forceful displacement of soil and water from underneath a concrete slab

Conditions for Pumping

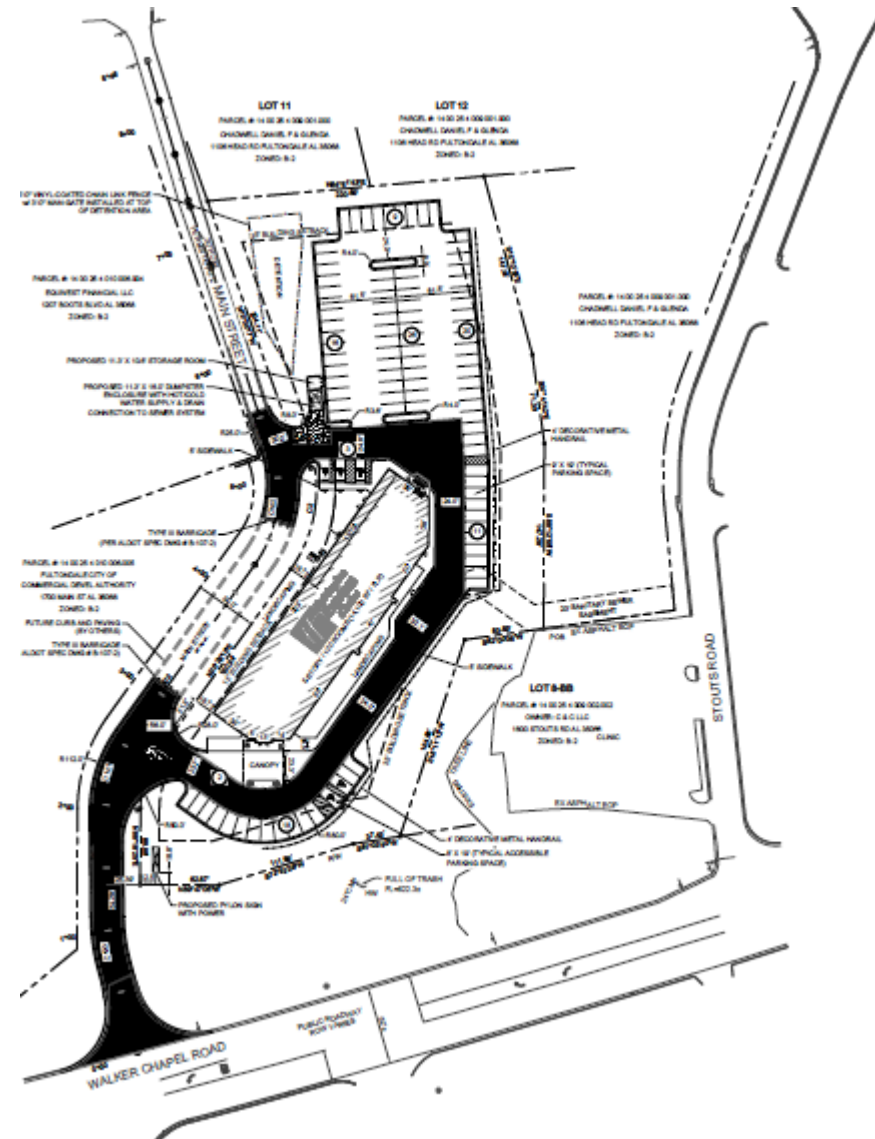
1. Subgrade soils that are erodible
2. Free water between slab and subgrade
3. Frequent heavy wheel loads

For parking lots, bases are not usually required, however if required use a Granular Base (or a Cement Stabilized Subgrade)

PROJECT SUCCESS

Holiday Inn Express & Suites – Fultondale, AL (2016)

- Contractor was competing with 3 inches of asphalt and 6 inches of base and wanted the design for concrete
- Design for 5-inches of concrete on subgrade soils
- The owner awarded the project as concrete to the contractor
- Contractor awarded the project to Ready Mix USA with 900 CY of concrete paving



Paved in November, 2016



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Local Streets	●	●	●	●	●	●	●
County/Rural Roads	●		●	●	●	●	
Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

ROLLER COMPACTED CONCRETE HAS LONG HISTORY OF GOOD PERFORMANCE ON HEAVY DUTY PAVEMENTS

Roller Compacted Concrete (RCC) Pavements

- No Slump
- Consistency of damp gravel
- Placed by asphalt pavers
- Compacted with vibratory rollers
- No forms
- No reinforcing steel
- No finishing
- Max lift thick – 8 to 10 in
- Low W/C ratio = limited shrinkage cracks
- High-production rate (typ. 1900 LF/day)
- Typical Traffic Opening within 24 hours
- Typically 5 to 15% cheaper than conventional concrete



Honda Automotive Facility – Lincoln, AL
1.5M Square Yards/ 5" and 7" RCC /4" CTB



Willow Lane – Hayesville, KS (2011)
5" RCC / 6" recycled base / clay



Birmingham Regional Intermodal Facility
60,000 CY of 9" and 16" RCC

RCC have been successfully used for intermodal Port / freight / manufacturing yards Its is also used on city streets and Residential subdivisions. Go to rcc.acpa.org for projects examples

RCC EXPLORER DATABASE SHOWS WHERE RCC HAS BEEN DONE

rcc.acpa.org

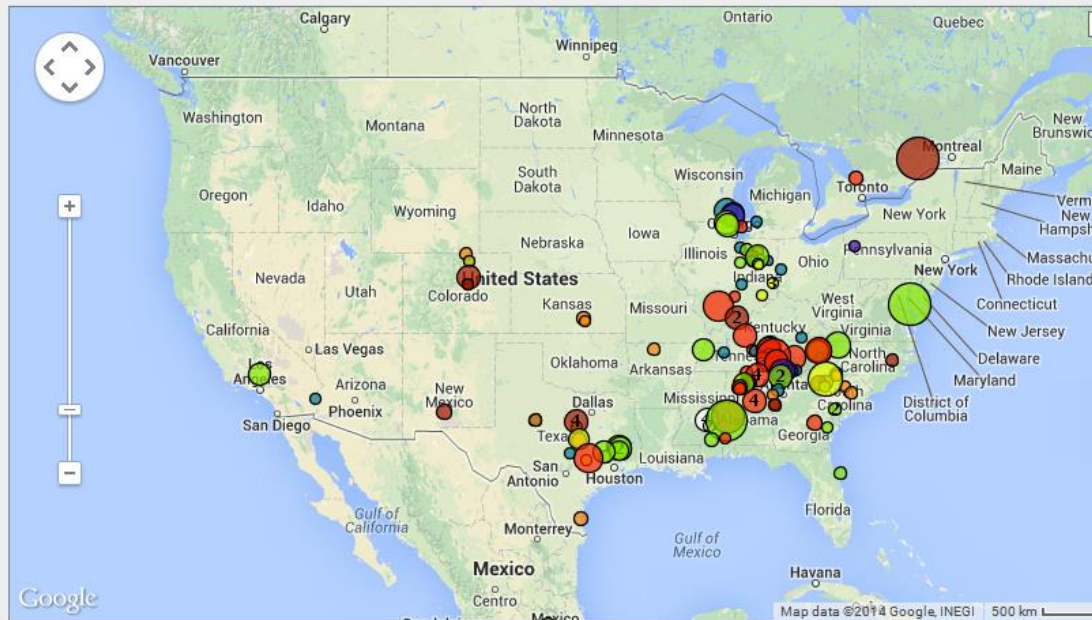
 The National RCC Explorer

[Instructions](#)

264 items

MAP VIEW • TABLE VIEW • DETAILS VIEW

[98 results](#) out of 264 cannot be plotted.



Application

● Airport
 ● Arterial Street
 ● Industrial/Trucking Facility
 ● Local Street
 ● Military
 ● Other (e.g., Logging Facility, Composting Area, Storage Yard)
 ● Port or Intermodal Facility
 ● Widening or Shoulder
 ○ mixed

Search

Application

- 74 Industrial/Trucking Facility
- 52 Local Street
- 43 Port or Intermodal Facility
- 31 Military

Paving Machine: High Compaction/Density (1 Tamper and 2 Pressure Bars or 2 Tamper Bars)
 Pavement Jointed: Yes
 Joint Spacing: 15 ft



RCC and PCC Installation
Image 1 of 3

CLOSE X

Pavement Jointed: Yes
 Joint Spacing: 12.5-15 ft
 Joints Sealed: Yes

165 0 - 50000

28 50000 - 100000

8 100000 - 150000

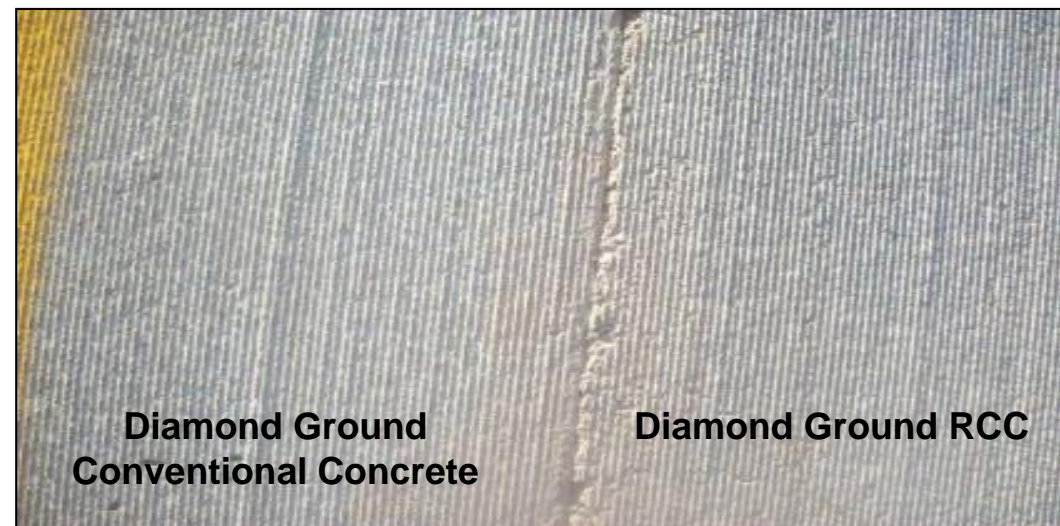
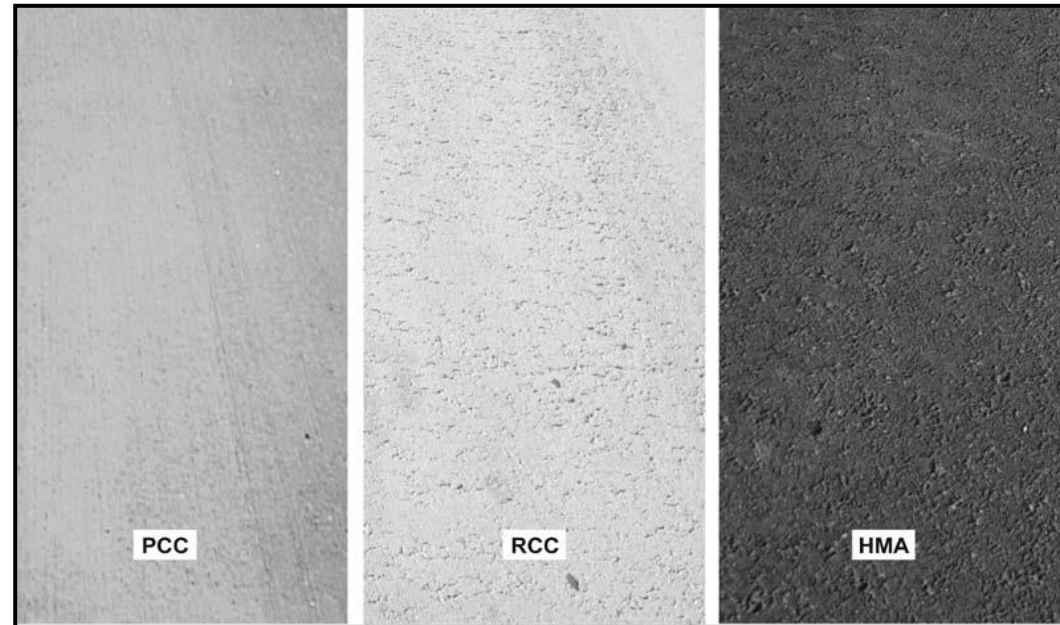
7 150000 - 200000

Nominal Maximum Size Aggregate



THE SURFACE APPEARANCE AND TEXTURE OF RCC IS SIMILAR TO ASPHALT PAVEMENT

- Similar appearance & texture as asphalt only light grey instead of black
- Surface texture depends on aggregate gradation and paste content
- Diamond ground RCC is similar to diamond ground concrete
- Trowelled RCC similar appearance as conventional concrete



PORTS, INTERMODALS & DISTRIBUTION CENTERS ARE USING RCC FOR DURABILITY, SPEED OF CONSTRUCTION, & COST SAVINGS

Project Information

- Owner: Walmart
- Contractor: Morgan Corp
- Use Type: Distribution Center
- Year Built: 2018
- Size: 73 acres
- Volume: 113,000 CY



Additional Details

- Thickness: 10" RCC / 4" Aggregate Base
- Joint Spacing: 15 ft
- Traffic: 20,000,000 ESALs (2,700 Trucks / day)
- Paved 30 ft wide, about 1 acre per day (73 production days)
- RCC paving was about one acre per day and completed in 73 production days (late October 2017 to April 2018)



Walmart Distribution Center Mobile, AL

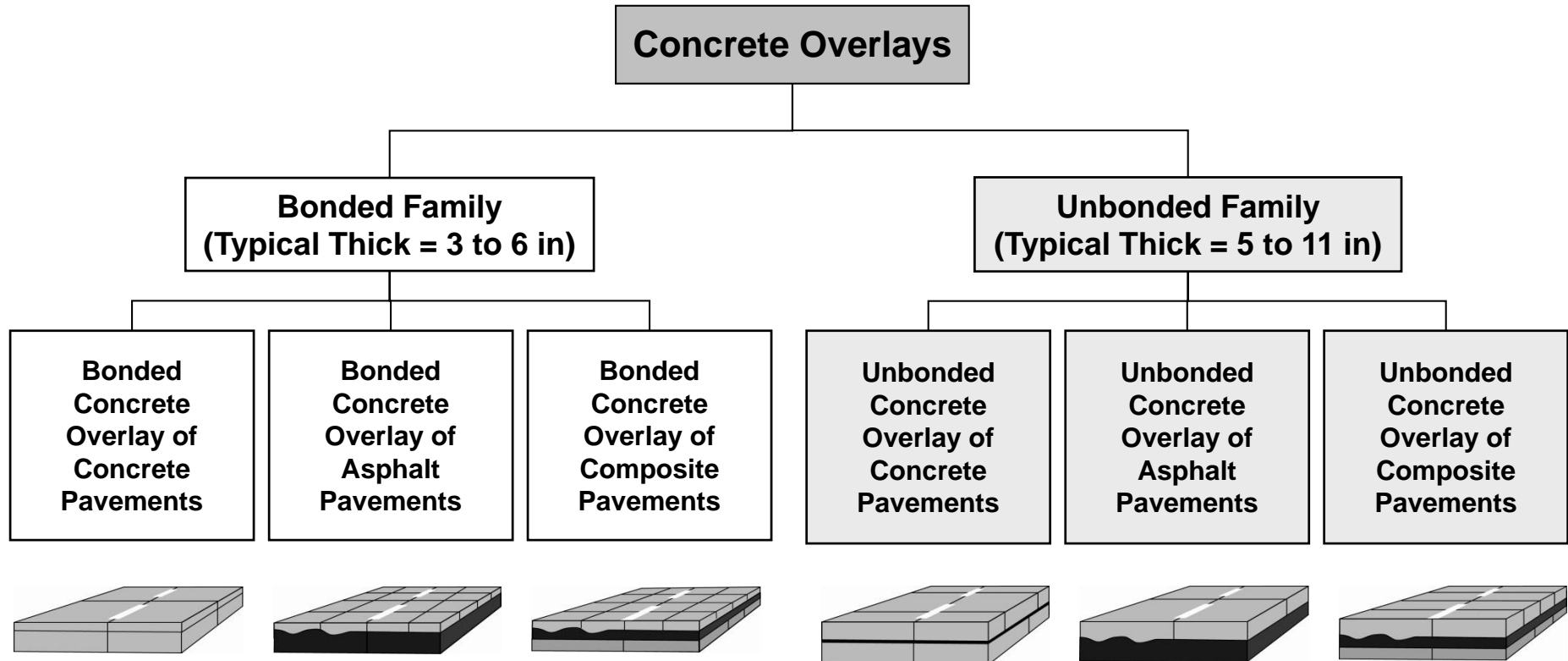


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Local Streets	●	●	●	●	●	●	●
County/Rural Roads	●		●	●	●	●	
Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

CONCRETE OVERLAYS FALL INTO TWO FAMILIES

Overlay family is dependent on how the interface between layers is treated



Bond is integral to design
(Existing pavement is in relatively good shape)

Old pavement is base
(Existing pavement is in poor condition)

CONCRETE OVERLAYS HAVE SIMILAR LONG-TERM DURABILITY AND COST ADVANTAGES OF TRADITIONAL CONCRETE PAVEMENTS

Durability & Costs Advantages

Add strength and durability to an existing pavement

- Can restore or add design life to existing pavement

Competitive on Initial & Life Cycle Cost

- Dollar for dollar, one of most effective long-term options
- A wide range of thicknesses can be used
- Can be designed to last from 10 to 40+ years

Can be placed on both concrete and asphalt pavements.

- Existing pavement does not have to be removed
- Few pre-overlay repairs are necessary
- Use normal concrete pavement construction practices

Have good safety and sustainability characteristics

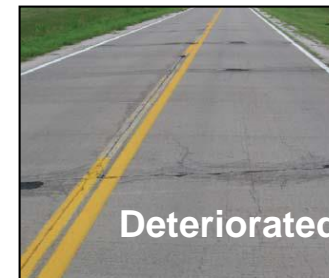
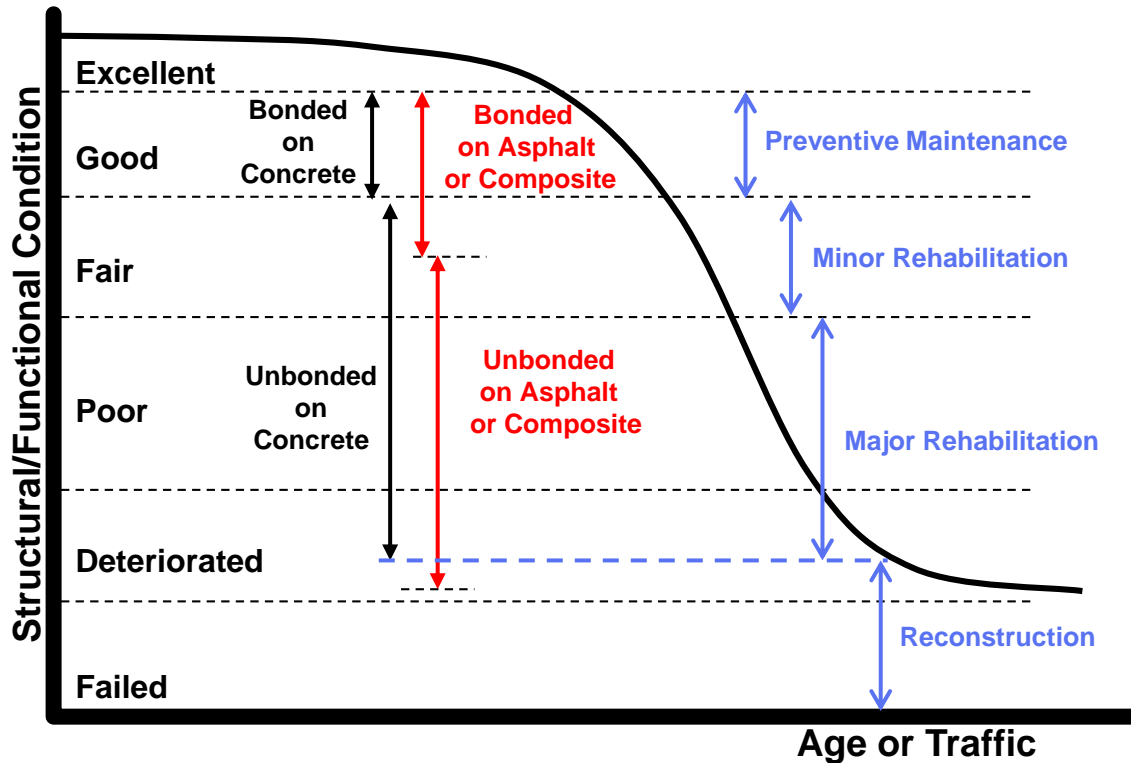
- Reduced pavement removal / use existing structure
- Uses fewer virgin materials
- High skid resistance and non-rutting
- High reflectivity = greater visibility, lower surface temperature
- Stiff system = better fuel efficiency
- Fewer construction emissions



Coolidge Road, Michigan
5 inch (125 mm) concrete overlay &
widening, built September 1983
Picture circa 2001
First Rehabilitation done in 2015
after 32 years

THE CHOICE BETWEEN BONDED OR UNBONDED OVERLAY IS PRIMARILY BASED ON THE EXISTING PAVEMENT CONDITIONS

Pavement Deterioration Curve



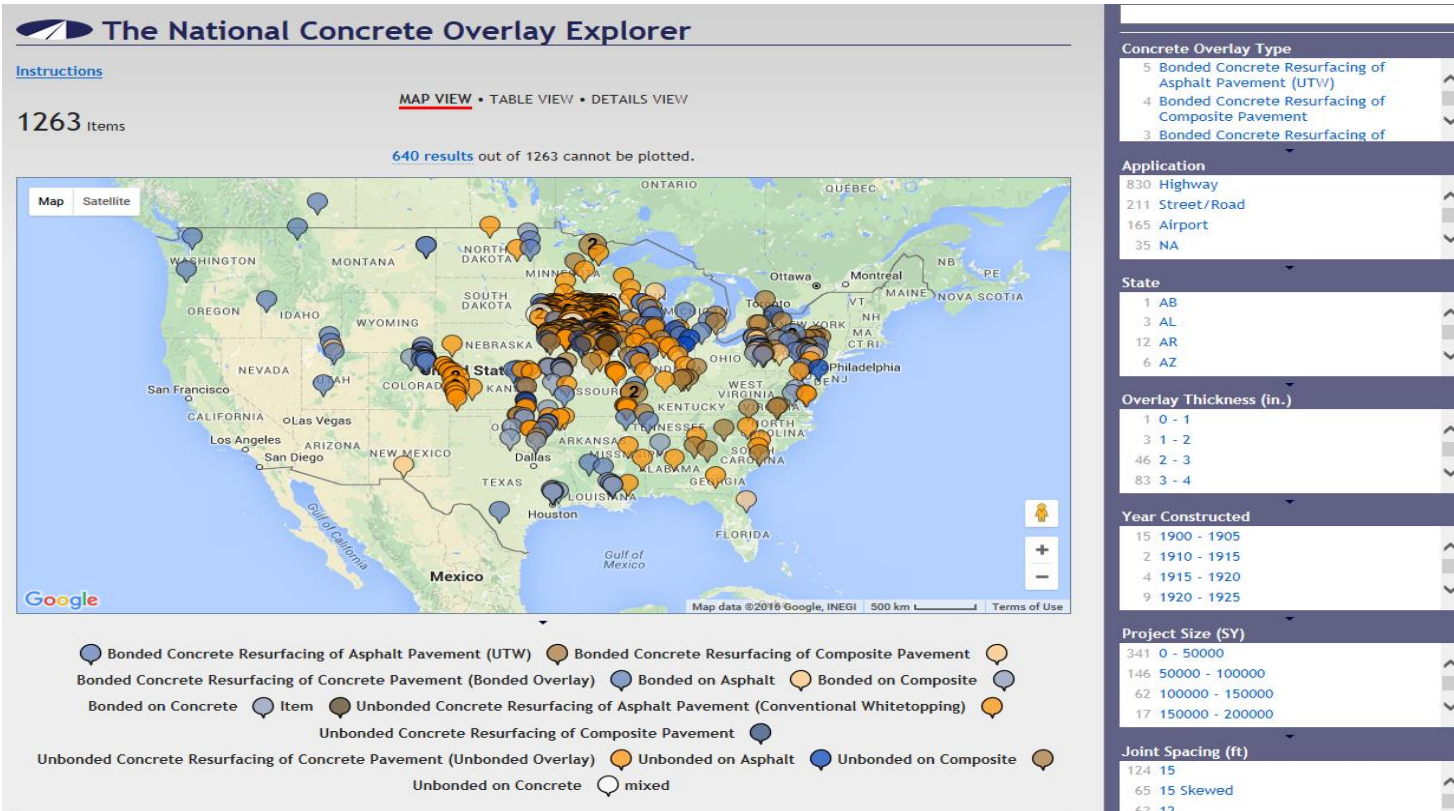
Other Issues that dictate viability of an overlay

- Roadway type (Interstate vs Arterial vs Collectors)
- Urban vs Rural
- Site specific considerations
 - shoulder, bridges, and other vertical clearance issues
- Traffic control options & Time to open

MOST STATES HAVE SOME CONCRETE OVERLAY EXPERIENCE

ACPA Concrete Explorer database provides details on over 1200 projects

States with Concrete Overlay Experience



<http://overlays.acpa.org/webapps/overlayexplorer/index.html>

Iowa ^{1,2}

- Over 500 different overlay projects
- First project in 1960
- Most projects on county road system

Missouri

- Using Alternate Bid/Alternate Designs (concrete vs Asphalt) for high volume highways
- Majority of overlay projects have gone concrete

Colorado

- Has pioneered the use of thin concrete overlays

Michigan

- Over 18 projects of 6 to 8 in. (150 to 200 mm) concrete overlays on interstate applications

Illinois

- Has constructed 81 overlays since 1974.
- 65 been over asphalt or composite pavement

1. Iowa Concrete Pavement Association
2. National Concrete Pavement Technology Center (CPTech Center)



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Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

WHAT IS PERVIOUS CONCRETE?

Is a concrete pavement:

- Has 15-35% air voids to allow water to percolate
- Has minimum or no fines in the mix
- Typically uses single size aggregate
- Has rough surface texture
- Has unit weight less than conventional concrete
- Has typical permeability rate of 3.5 gal/ft²/min (infiltration rate in excess of 340 in/h)
- Provide savings to site owners through storm water management, increased land area use, decrease construction costs, minimal maintenance



Cemex has pervious concrete brand called Pervia



Pervia
Permeable by design



WHERE HAS PERVIOUS CONCRETE BEING USED?

Streets and Roads



Parking Lots



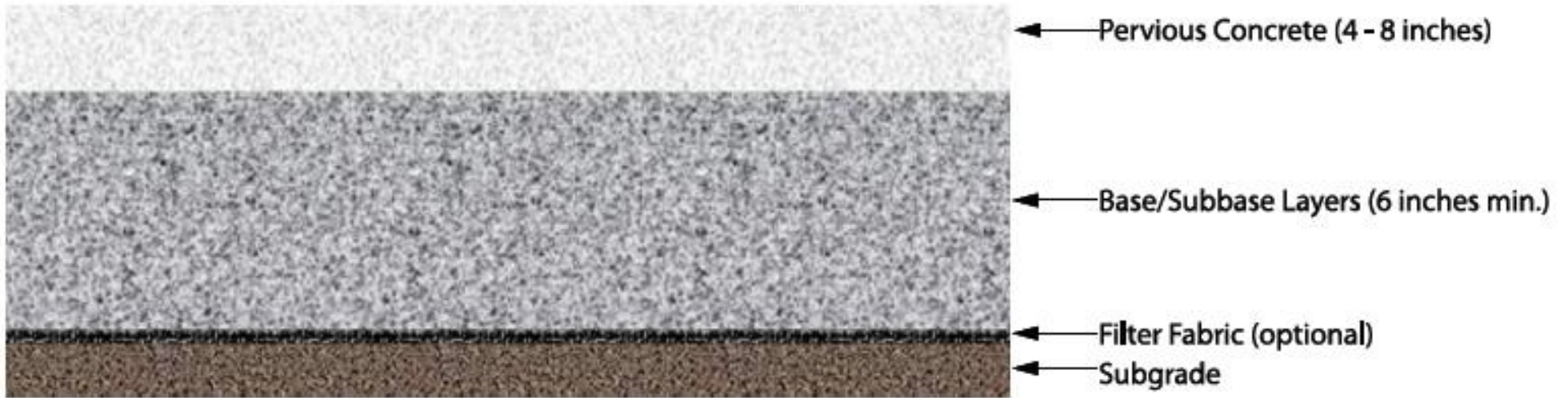
Sidewalks



Others



TYPICAL PERVIOUS CONCRETE PROFILE



Adopted from United States Environmental Protection Agency (EPA) 2010

PERVIOUS CONCRETE DESIGN CONSIDERATIONS

Traffic:

- Pedestrian/Sidewalk (typically 4 inches min.)
- Standard Duty Traffic (typically 6 inches min.)
- Heavy Duty Pavement (typically 8 inches min.)



Sidewalk Pavement



Standard Duty Pavement



Heavy Duty Pavement

WHERE HAS PERVIOUS CONCRETE BEING USED? ALABAMA PROJECTS

- O'Reilly Auto Parts (4675 Pinson Boulevard, Pinson, AL)



WHERE HAS PERVIOUS CONCRETE BEING USED? ALABAMA PROJECTS

➤ Sanders & Williams, LLC (4501 Pine Tree Circle, Birmingham, AL



6-inch pervious concrete with 6-inch base, built in 2010

WHERE HAS PERVIOUS CONCRETE BEING USED? ALABAMA PROJECTS

- Publix Super Market at The Shoppes at Fairhope Village (22530 US-98, Suite 100, Fairhope, AL)



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Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

SOIL STABILIZATION IS A COST EFFECTIVE TREATMENT OF POOR SOILS THAT ARE INADEQUATE FOR CONSTRUCTION

1. What is it?

- Treatment of soil using portland cement
- Soils include gravel, sand, silt, clay, and manufactured sand and aggregate
- Typical cement content is between 2 to 6 percent of soil dry weight

2. What does it do?

- Increases workability, strength, compaction of soils
- Reduces moisture susceptibility, mitigating subgrade expansion due to clay or frost
- Provide construction platform
- Provide uniform, stable support
- Eliminating the potential for pumping of the subgrade

3. Cost Comparison

- Typically cost less than half of aggregate base materials.

When soil stabilization is used under light to medium duty pavements, soil erodibility is reduced eliminating the need for granular bases



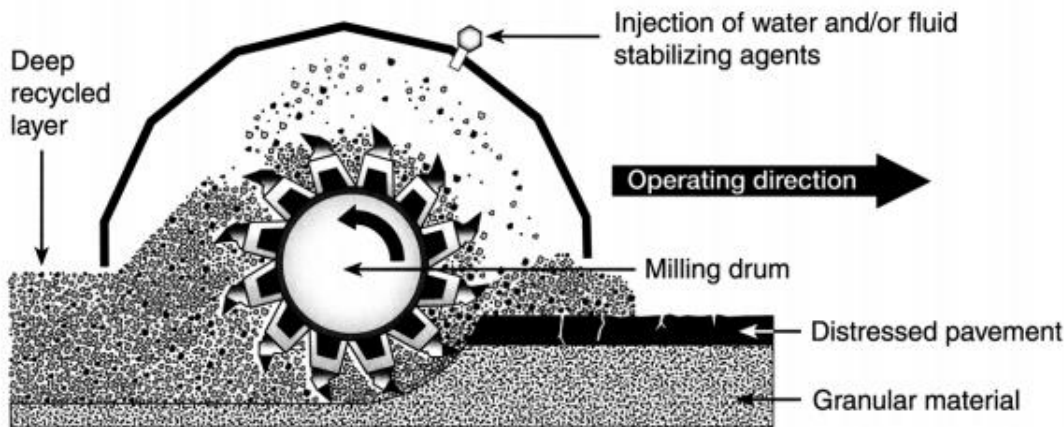
(1) PI – Plasticity index – measure of soil plasticity. Low PI = Sand, High PI = Clay
(2) Majority of soil stabilization is done on mid to high PI soils

CEMENT-BASED PAVEMENT SOLUTIONS

Application	Conventional Concrete Pavements	Thin Concrete Pavements	Roller Compacted Concrete	Concrete Overlays	Full-Depth Reclamation (FDR) with Cement	Soil Stabilization with Cement	Pervious Concrete
Interstate/Highways	●		●	●	●	●	
Local Streets	●	●	●	●	●	●	●
County/Rural Roads	●		●	●	●	●	
Parking Lots	●	●	●	●	●	●	●
Base Course			●		●	●	●
Industrial	●		●	●	●	●	●
Airport Runways & Aprons	●			●	●	●	

FULL-DEPTH RECLAMATION (FDR) WITH CEMENT

- Pulverizing or recycling of an existing distressed or deteriorated asphalt pavement and its underlying layers with Portland cement to form a new base.
- Underling layers include base, subbase, and/or subgrade (soil)
- Typical pulverized depth is between 6 and 12 inches
- Typical cement content is between 2 to 8 percent of recycled material dry weight
- Typically a rigid or flexible pavement is placed over FDR base material



Bituminous Surfacing				New Surfacing
Granular Base	Pulverized	Pulverized	Stabilized	Stabilized
Subgrade	Subgrade	Subgrade	Subgrade	Subgrade
Existing road	Pulverization to desired depth	Removal of excess material (if necessary) and shaping	Add agents/select material, mixing, reshaping and compaction	Final surface treatment

FDR WITH CEMENT IS A TRIED AND TRUE REHABILITATION METHOD

- **Low cost: Typical cost savings between 30 and 60% compare to alternative reconstruction such as removal and replace¹**
- **Can be performed in a short time, benefiting owners or general public**
 - **Typical production rates range from 5,000 to 10,000 square yards depending on contractors experience**
- **Can be performed in airports, residential, industrial, parking lots, streets & local roads, and interstate and highways**
- **Increases structural capacity of the pavement**
- **Reduce carbon footprint**



1. Design of Full-Depth Reclamation with Portland Cement (FDR-PC) Pavements (Halsted 2007)

INTERSECTION OF US HWY 43 & COUNTY ROAD 148 GREENE COUNTY, AL

Project:

- Begins at US Highway 43 and runs east to Dollar Hide Camp
- Currently two-lane roadway in a rural setting

Condition:

- Severe distress of the pavement
- Major rutting
- Alligator cracking

FDR:

- Total length of 2.665 miles
- Cement treatment of approximately 10" deep and 20' wide
 - 31,270 SY of FDR
 - 782 tons of Portland cement
- Contractor: Pozzolanic Construction, TN
- Total Cost: \$459,193.93





Thank You

& Any Questions?

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