



FHWA-NHI-131133

RCC Key Elements and Common Uses

Module 1




Tech Center

IOWA STATE
UNIVERSITY



Portland Cement Association



Continue 



Guide for Roller-Compacted Concrete Pavements

- Modules for this training were developed from guide
- Available from the Portland Cement Association website
www.cement.org/pavements.





Learning Objectives

Upon completion of this module, you will be able to:

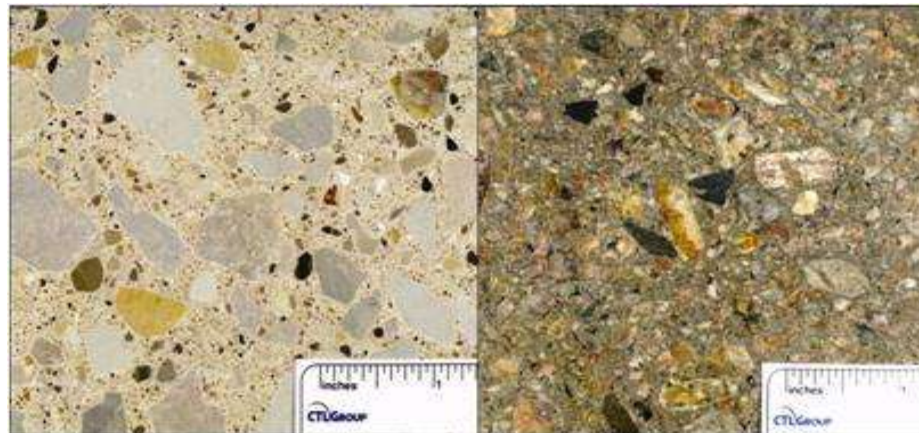
- Define what is RCC pavement
- Describe characteristics of RCC pavement
- Describe how RCC works
- Recognize the benefits of RCC
- Recognize the potential limitations of RCC pavement
- Understand the RCC pavement selection considerations
- Understand the typical uses of RCC pavement





What is Roller-Compacted Concrete (RCC) Pavement?

- Definition: “Roller-Compacted Concrete (RCC) is a no-slump concrete compacted by vibratory rollers”
- Materials are same as concrete—well-graded aggregates, cementitious materials, and water—but different mixture proportions
- Consolidated with paver and vibratory rollers
- After curing, RCC properties are similar to PCC

PCC**RCC**



What is Roller-Compacted Concrete (RCC) Pavement?

- Consistency is stiff enough to remain stable under vibratory rollers
- Wet enough to permit adequate mixing and distribution of paste
- Typically placed with asphalt-type paver equipped with standard or high-density screed
- Followed by a combination of passes with rollers for compaction





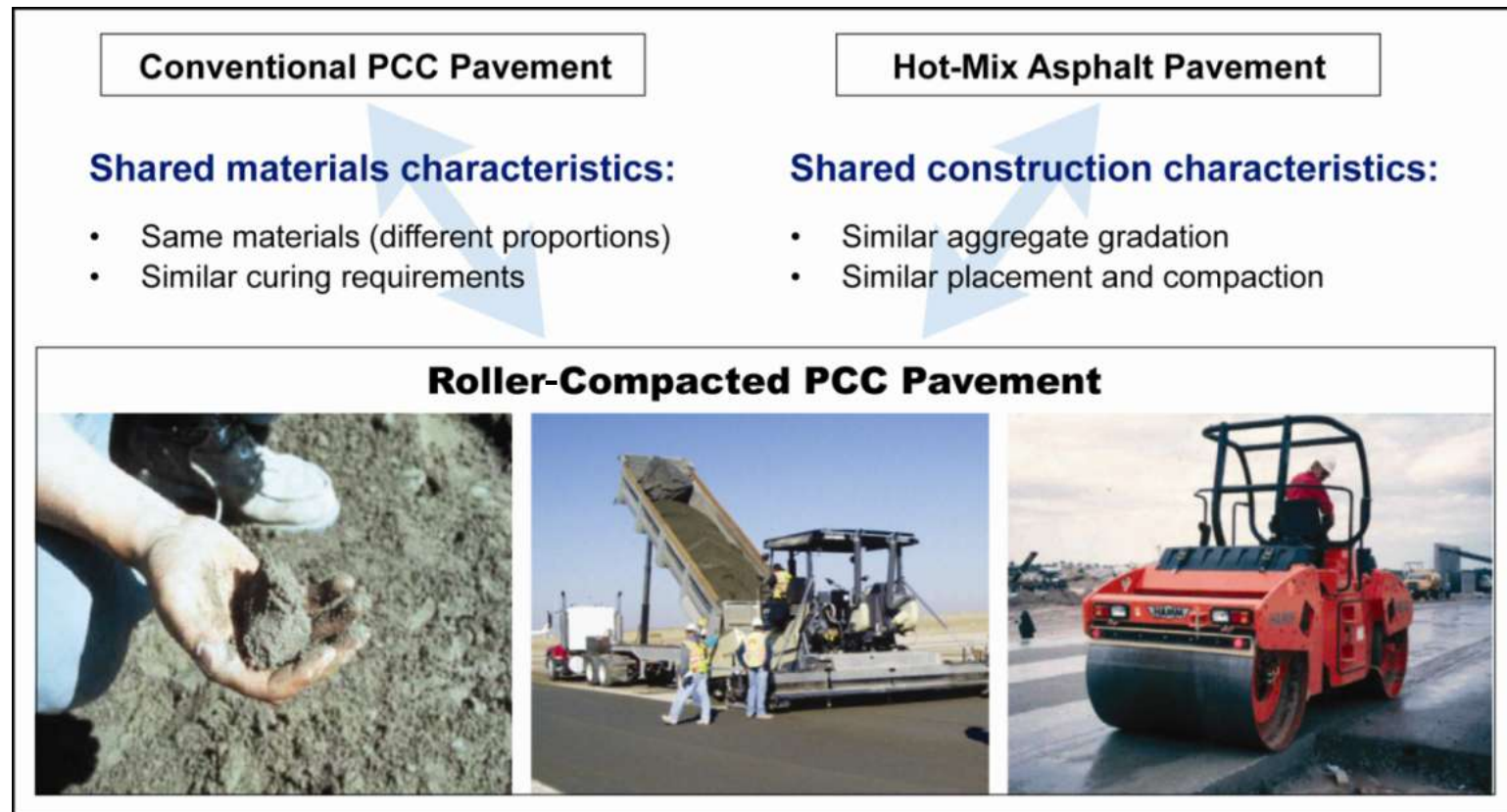
What is Roller-Compacted Concrete (RCC) Pavement?

- Final compaction is generally achieved within one hour of mixing
- RCC pavements are constructed without forms, dowels, or reinforcing steel
- Joint sawing is not always required, but when sawing is specified, transverse joints are spaced farther apart than with conventional concrete pavements





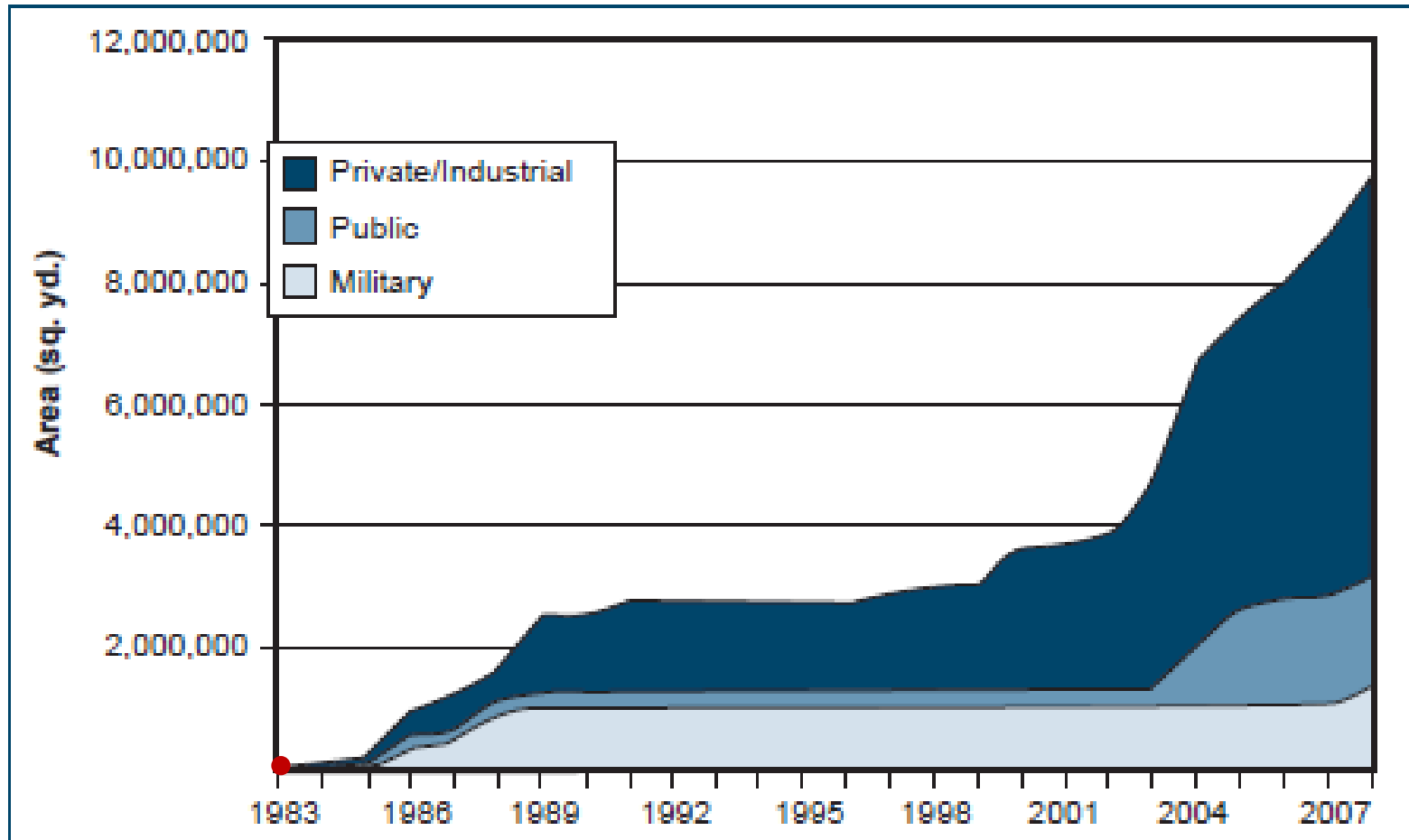
How Does it Work?



RCC combines aspects of conventional concrete pavement with construction practices similar to HMA pavement.



Increased Use of RCC





History of Roller-Compacted Concrete

1930s



1970s



Late 1980s-Early 1990s



Timeline



1940s



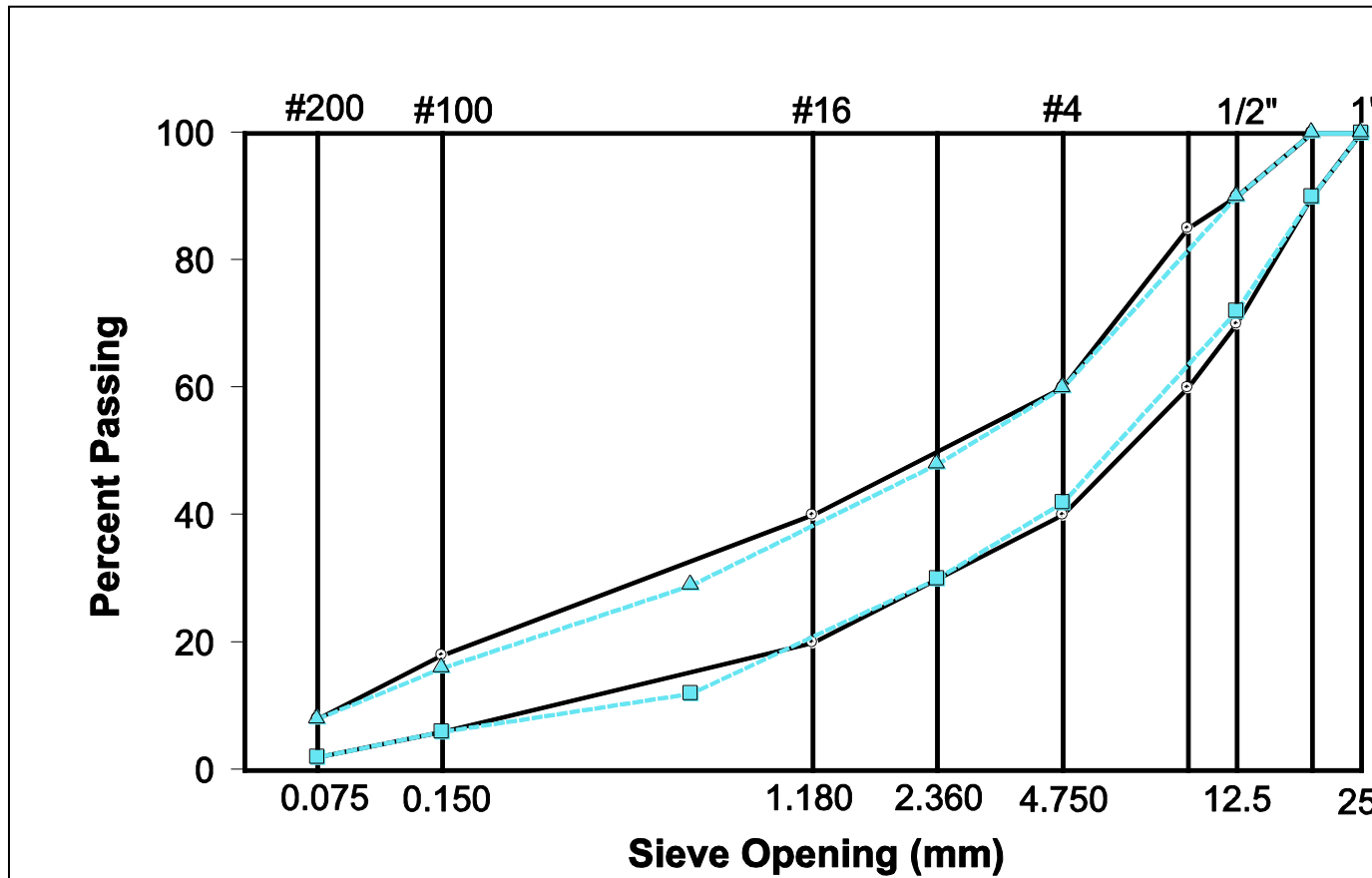
Early 1980s



2000s



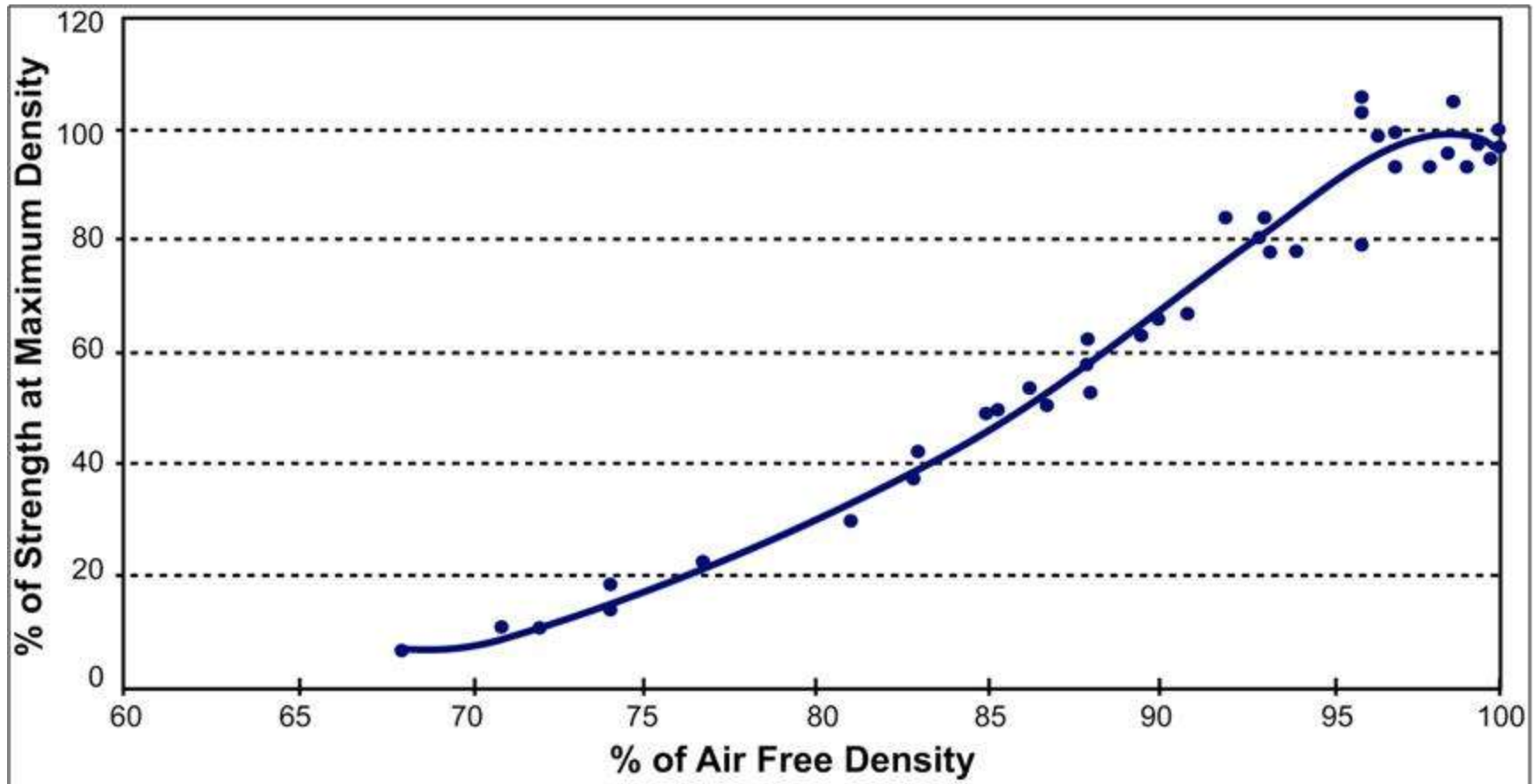
Gradation and Density



Typical aggregate gradation of RCC, depicted by the solid black lines, is similar to aggregate gradation of an intermediate asphalt layer, depicted by the dashed blue line.



Compaction



The strength of RCC drops appreciably as its density drops.



Compaction





Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Consolidation

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.



Basic Differences Between RCC and PCC

Mix materials proportions

Conventional Concrete Pavements

- Aggregates typically account for 60 to 75 percent of the mixture by volume
- w/cm ratio is typically 0.40 to 0.45

RCC Pavements

- Aggregates compose 75 to 85 percent of RCC mixtures by volume
- RCC mixtures are drier than conventional concrete due to their higher fines content and lower cement and water contents

Workability

Paving

Consolidation

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.



Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Conventional Concrete Pavements

- Manipulated by the paving machine (slump is generally about 2 in.)

RCC Pavements

- Consistency of damp aggregates
- RCC's relatively dry and stiff mixture is not fluid enough to be manipulated by traditional concrete paving machines

Paving

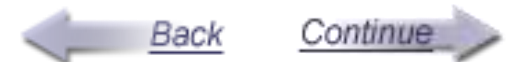
Consolidation

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.





Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Conventional Concrete Pavements

- Mixture is placed ahead of a slipform paving machine, which then spreads, levels, consolidates through vibration

RCC Pavements

- Typically placed with a conventional or heavy-duty, self-propelled asphalt paving machine

Consolidation

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.



Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Consolidation

Conventional Concrete Pavements

- Consolidation occurs internally
- Internal vibrators and surface vibrators on the paving machine fluidize the plastic concrete, releasing air

RCC Pavements

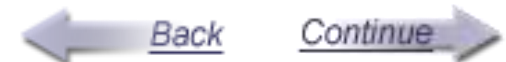
- Consolidation is typically accomplished externally by compaction of the concrete with pavers and rollers

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.





Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Consolidation

Finishing

Conventional Concrete Pavements

- Conducted before initial set occurs
- Usually mechanically textured to improve friction

RCC Pavements

- Typically has an open texture (similar to HMA)
- Can be textured through diamond grinding

Hydration and curing

Cracking, load transfer, and reinforcement

Select each one to learn more.



Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Consolidation

Finishing

Hydration and curing

Conventional Concrete Pavements

- Proper hydration and curing of the concrete pavement is critical to the long-term durability.

RCC Pavements

- Proper hydration and curing of the RCC mixture is critical to the long-term durability.

Cracking, load transfer, and reinforcement

Select each one to learn more.





Basic Differences Between RCC and PCC

Mix materials proportions

Workability

Paving

Consolidation

Finishing

Hydration and curing

Cracking, load transfer, and reinforcement

Conventional Concrete Pavements

- Load transfer is principally accomplished through dowel bars and tie bars
- Aggregate interlock assists with load transfer
- Location of cracks is controlled by cutting joints

RCC Pavements

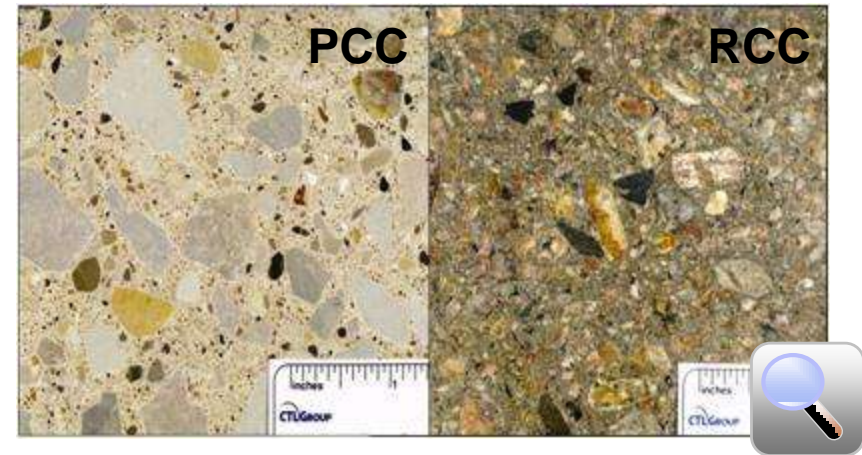
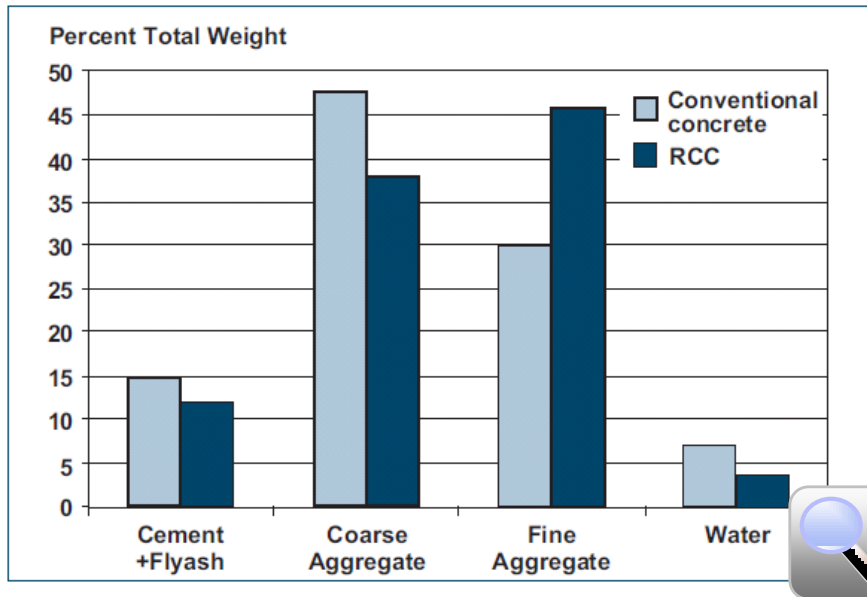
- Joints usually not sawed in RCC industrial applications
- Fewer joints are sawed and they are spaced farther apart
- No dowel bars or tie bars are used
- Load transfer is accomplished through aggregate interlock

Select each one to learn more.





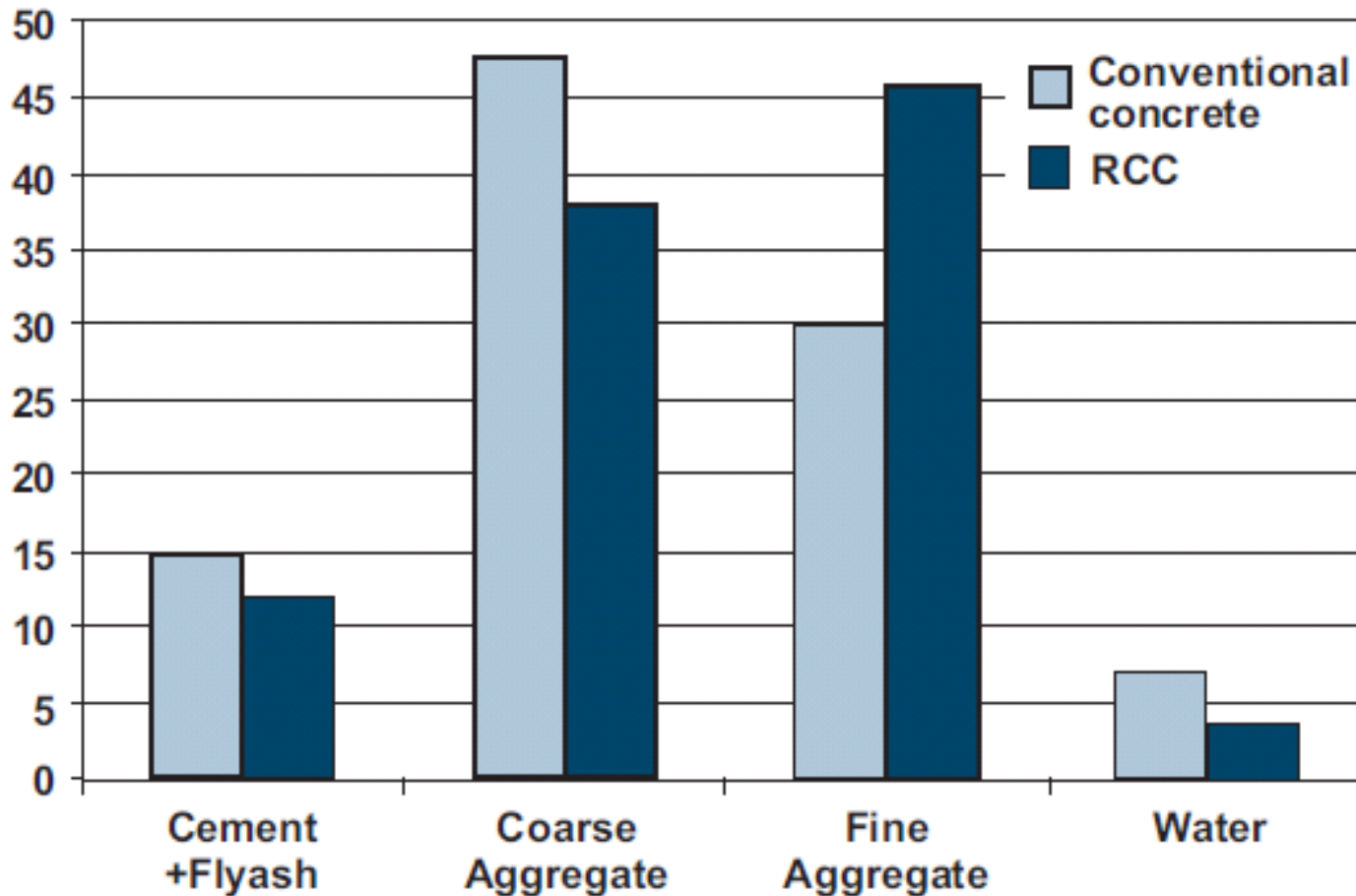
Basic Differences Between RCC and PCC

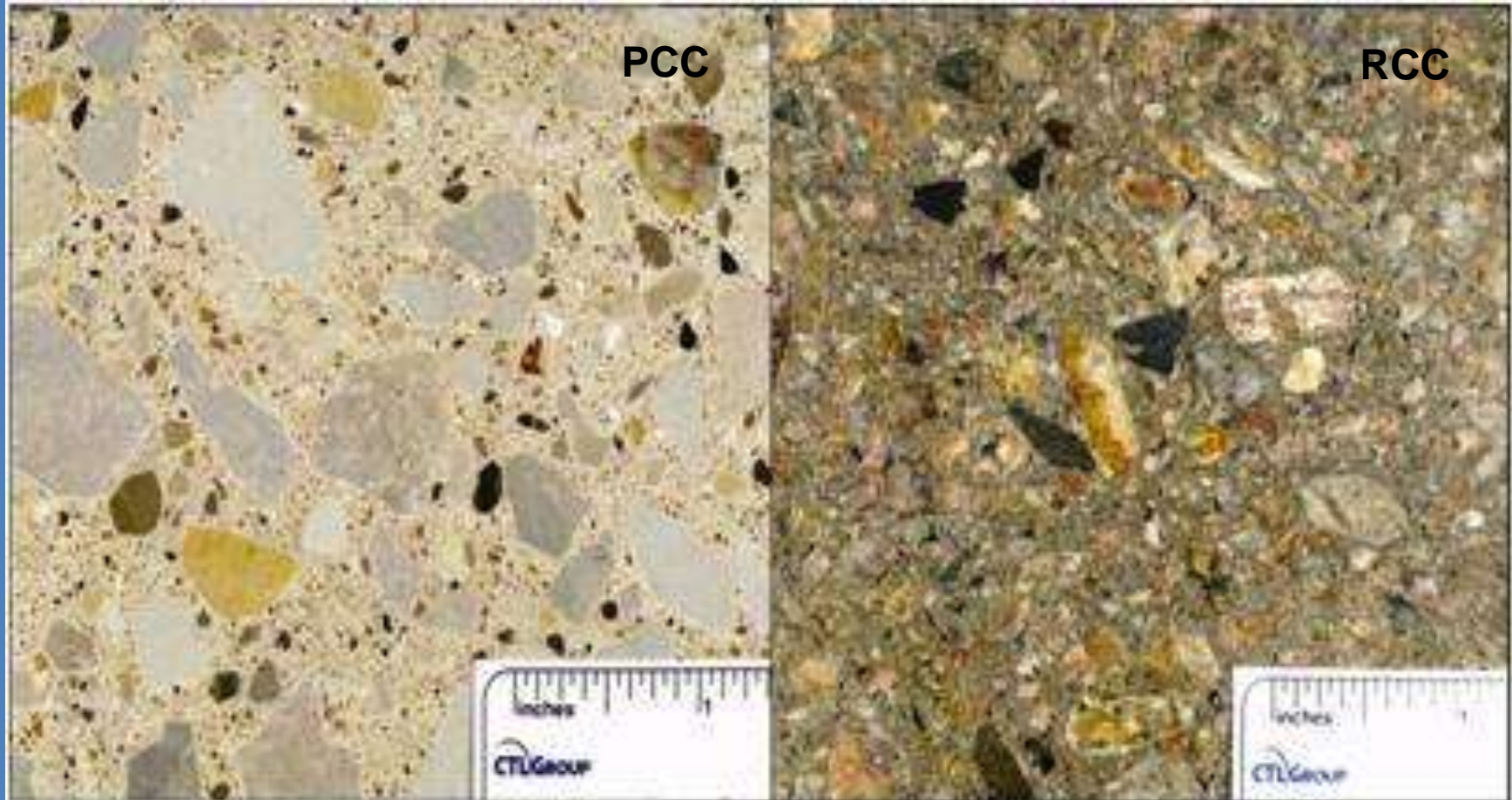


Select each image to zoom in and learn more.



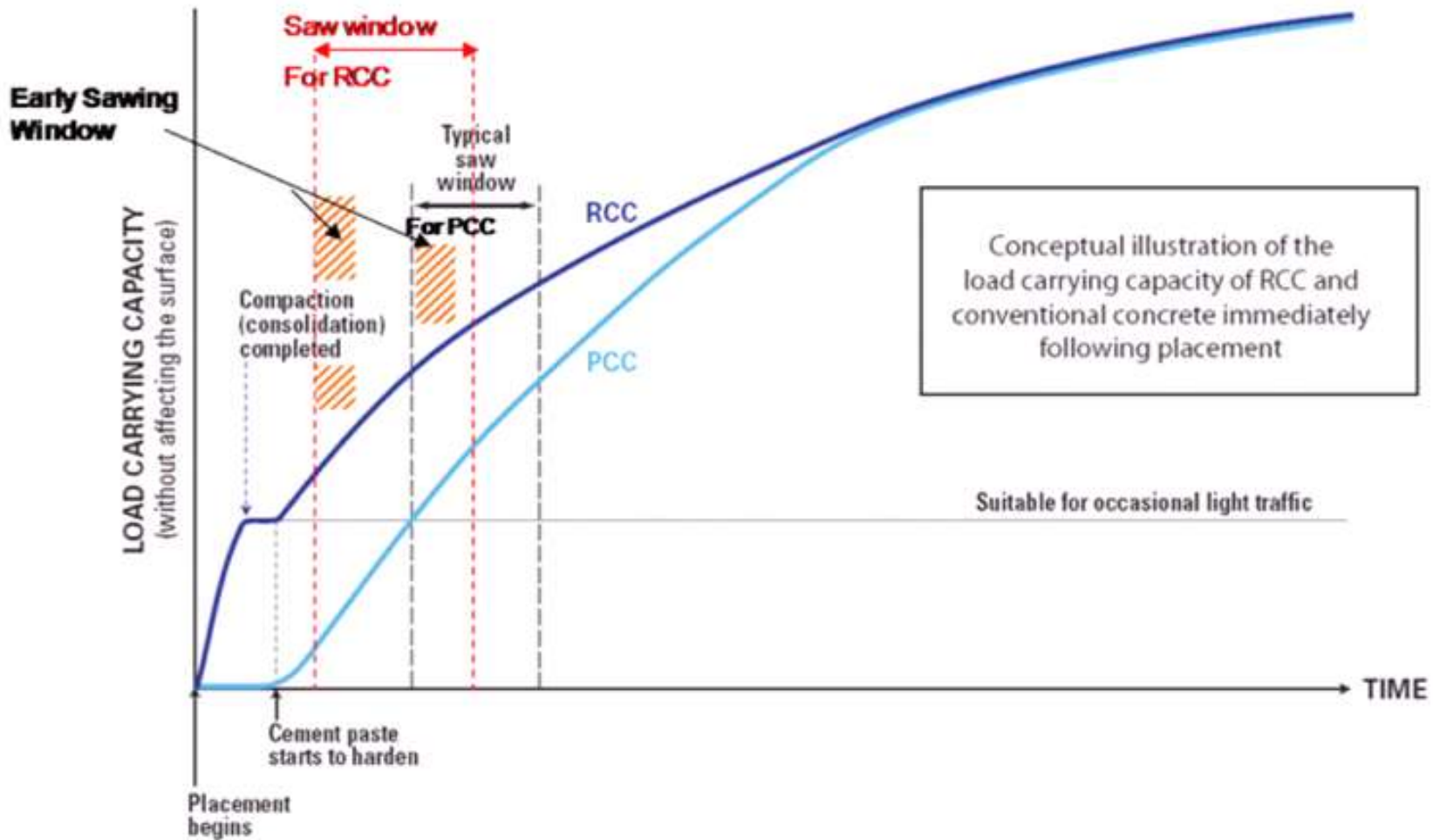
Percent Total Weight





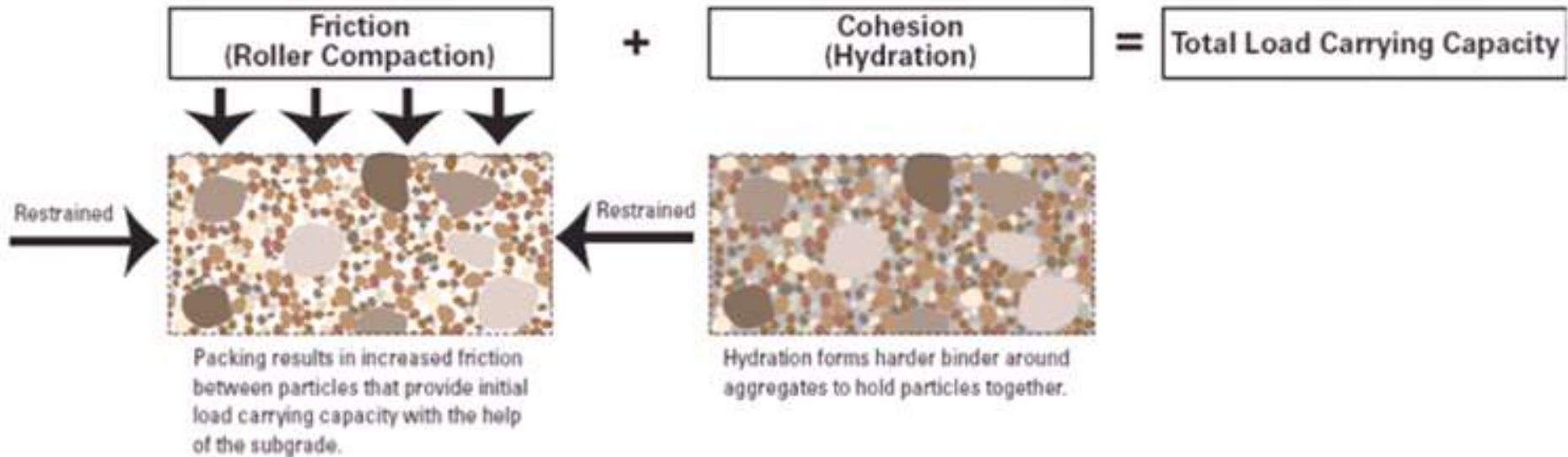


Early Load Carrying Capacity of RCC and PCC





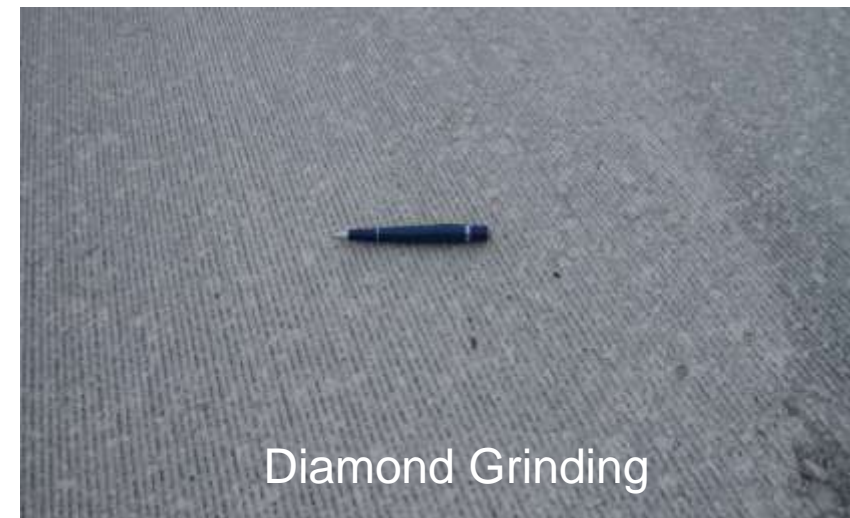
Early Load Carrying Capacity of RCC and PCC





Surface of RCC

- More of an open surface texture after rolling similar to an asphalt pavement surface
- Quiet pavement due to “negative texture”
- Can lose fine aggregate from their surface within two to four years service
 - Surface is treated by diamond grinding or an overlay when posted speeds exceed 30 mph





Benefits of RCC

- 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 and placement
 - Reduced construction times
- Can be designed to have high flexural, compressive, and shear strengths, which allow it to support heavy, repetitive loads
- RCC needs no forms or finishing
- No dowels, tie rods, or steel reinforcement





Benefits of RCC (cont.)

- Less concrete shrinkage and thus less cracking
- Low permeability
- Provides excellent durability and resistance to chemical attack, even under freeze-thaw conditions
- Eliminates rutting and subsequent repairs





Benefits of RCC (cont.)

- Provides enough structure capacity to allow early opening to light traffic
- RCC can be placed in lifts as thick as 10 inches
- Light-colored surface improves night vision
- RCC pavements have solar reflectance index (SRI) greater than 29
- Freeze-thaw durability of RCC is high even without the use of air entrainment.





Potential Limitations of RCC

- Diamond grinding or asphalt surfacing typically needed for speeds greater than 30 mph
- Amount of RCC that can be mixed in a transit mixer or ready mix truck typically lower than amount for conventional concrete
- Multiple horizontal lifts and adjacent slabs must be placed within an hour to ensure good bonding



Potential Limitations of RCC (cont.)

- Pavement edges are more difficult to compact
- Due to relatively low water content, hot-weather RCC paving requires extra vigilance to minimize water loss to evaporation
- Due to the dryness of the RCC mixture, admixture dosage requirements can be higher for RCC than for conventional concrete



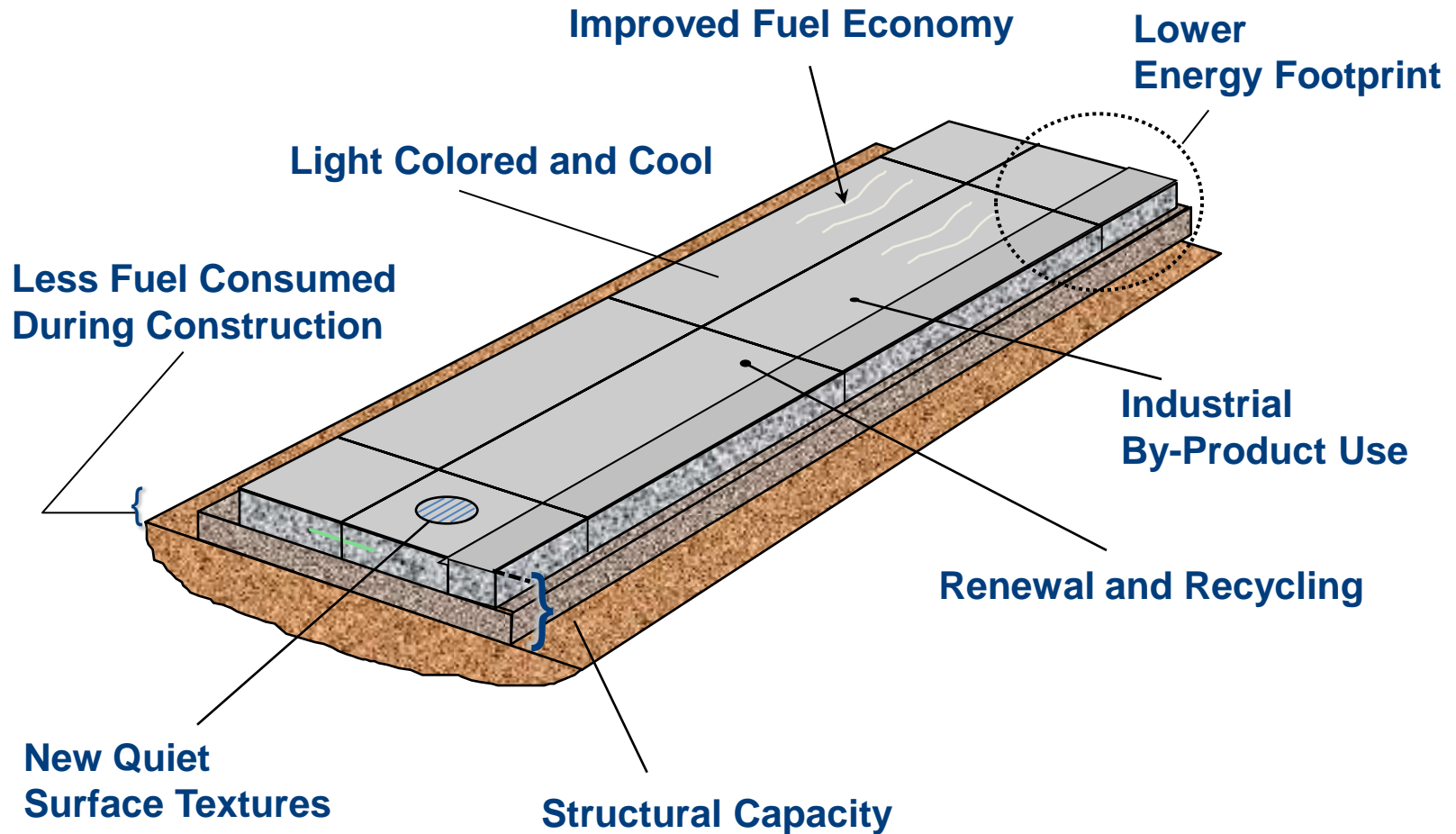
Common Uses of RCC Pavements

- Ports/Heavy Industry
- Light Industry
- Airports
- Local Streets
- Arterial Streets
- Shoulders/Widening
- Base for Overlays





Sustainability





Light Industry and Access Roads

- Warehouse facilities and auto manufacturing facilities
- Traffic speeds typically are 30 mph or less
- Typical loadings are from semi-trucks
- Edge loading should be considered in the analysis
- Multiple lifts are seldom used





Light Industry and Access Roads

- Type of Traffic
 - High Volume of Trucks
- Design
 - StreetPave
 - WinPAS
 - RCCPave
 - USACE Method
 - ACI 325.12R Table
 - ACI 330R-08 Table
- Surface Treatment
 - None for Speed < 30 mph
- Jointing
 - Typically None
 - Lane Traffic – Jointing done to improve load transfer



Select the photo for additional information.



- Large areas use square jointing pattern
- Early entry saws very effective
- Need to saw within 1 to 4 hours
- Saw 1/3 to 1/4 depth

RCC Thickness	Transverse Spacing	Longitudinal Spacing
<8 inches	15-20 ft.	15-20 ft.
≥8 inches*	3-4 (in feet) times the thickness (in inches) *maximum 30 ft.	2.5 (in feet) times the thickness (in inches)



Arterial Streets

- Maintaining traffic during construction is a major concern
- Traffic constraints and construction time is reduced using a single lift RCC pavement





Arterial Streets

- Type of Traffic
 - Buses, Passenger Cars
 - Trucks
- Design
 - StreetPave
 - WinPAS
 - ACI 325.12R Table
- Surface Treatment
 - Diamond Grinding
 - RCC Base with Overlay (High Speed Facilities)
- Jointing
 - Typically Required



Select the photo for construction examples.

- Placement
 - High Density Paver (for thicker pavements)
 - Conventional Paver



1st Example

- Reconstruction of Lane Avenue pavement in Columbus, Ohio
- Consists of 8 in. of RCC base
- 3 in. of asphalt to provide smoothness for higher speed traffic
- RCC pavement constructed under traffic for this four-to-six lane arterial street



2nd Example

- Reconstruction of US 78 in Aiken, South Carolina
- 10 in. RCC pavement replaced existing full-depth asphalt pavement
- RCC surface diamond ground for this four-lane section to improve smoothness and provide surface texture at affordable cost



Local Streets and Roadways

- RCC for new residential developments
- Provides strong working platform during site-work and construction
- Surface treatments can be applied once the development nears completion





Local Streets and Roadways

- Type of Traffic
 - Passenger Cars
 - Delivery Trucks
- Design
 - StreetPave
 - WinPAS
 - ACI 325.12R Table
- Surface Treatment
 - Speeds > 30 mph surface smoothness important
 - Diamond grinding
- Jointing
 - To control random cracking



Shoulders and Widening

- Meets new lane and drop off criteria
- Strength and speed of construction make it suitable for road-widening applications
- Material provides a stable foundation





Shoulders and Widening

- Type of Traffic
 - Buses, Passenger Cars
 - Trucks
- Design
 - Thickness typically established by standards
 - For widening:
 - WinPAS
 - StreetPave
 - ACI 325.12R Table
- Surface Treatment for Widening
 - Rumble Strips
 - Diamond Grinding
 - Overlays
- Jointing
 - Match Existing Jointing



Select the photo for a construction example.



Shoulders and Widening

- Type of Traffic
 - Buses, Passenger Cars
 - Trucks
- Design
 - Thickness typically established by standards
 - For widening:
 - WinPAS
 - StreetPave
 - ACI 325.12R Table
- Surface Treatment for Widening
 - Rumble Strips
 - Diamond Grinding
 - Overlays
- Jointing
 - Match Existing Jointing



Select the photo for a construction example.

Example: Georgia DOT to reconstruct shoulders on I-285

- Existing asphalt shoulders were badly distressed
- Existing shoulder milled out and replaced with 10 ft. wide and 6 to 8 in. deep section of RCC
- Rumble strips ground into the surface to conform to Interstate Highway safety requirements
- Project included 34 shoulder miles of RCC
- Northbound and southbound outside shoulders replaced for 17 centerline miles
- No surfacing was placed on the RCC





Multi-Layer Systems for High-Speed Roadways

- Can be used as a base under a thin asphalt wearing course for rideability
- Can be used as a base under unbounded conventional concrete overlay to reduce pavement thickness
- Allows for reduction in pavement thickness provides long term performance
- Provides an excellent construction platform
- Example – Design a long-term pavement > 10 in. thick with a surface renewal limited to a 30 – 40 yr. cycle
 - Use a conventional concrete surface over an RCC pavement
 - System could be a wet-on-dry multi-lift system that would consist of an RCC base with a thin (4 in. to 6 in.) unbonded concrete overlay
 - Separation layer would be required





Multi-Layer Systems for High-Speed Roadways

- Type of Traffic
 - Highways: High-volume truck, bus
- Design
 - AASHTO Design Guide (1993, 1998)
 - AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG)
 - StreetPave or WinPAS computer programs for mixed-vehicle traffic
- Surface Treatment (above interlayer)
 - Conventional concrete
 - Asphalt wearing course
- Typically RCC joints not sawed when an unbonded concrete overlay is used





Module Summary

You have learned how to:

- Define what is RCC pavement
- Describe characteristics of RCC pavement
- Describe how RCC works
- Identify the benefits of RCC
- Identify the potential limitations of RCC pavement
- Describe RCC pavement selection considerations
- Describe the typical uses of RCC pavement