CP ROAD MAP
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ROAD MAP TRACK 8
Long-Life Concrete Pavements

PRIMARY SOURCE
Guide for Roller-Compacted Concrete Pavements
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Portland Cement Association (PCA)

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Moving Advancements into Practice (MAP) Briefs describe promising technologies that can be used now to enhance concrete paving practices. MAP Brief 8-1 provides information relevant to Track 8 of the CP Road Map, Long-Life Concrete Pavements.

The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by TPF-5(185).

MAP Brief 8-1 is available at: http://www.cproadmap.org/publications/MAPbrief 8-1.pdf

"Moving Advancements into Practice"

MAP Brief 8-1:

Describing promising technologies that can be used now to enhance concrete paving practices

Roller-Compacted Concrete Pavements

What Is Roller-Compacted Concrete?

Roller-compacted concrete (RCC) gets its name from the heavy vibratory steel drum and rubber-tired rollers used to help compact it into its final form. RCC has similar strength properties and consists of the same basic ingredients as conventional concrete—well-graded aggregates, cementitious materials, and water—but has different mixture proportions.

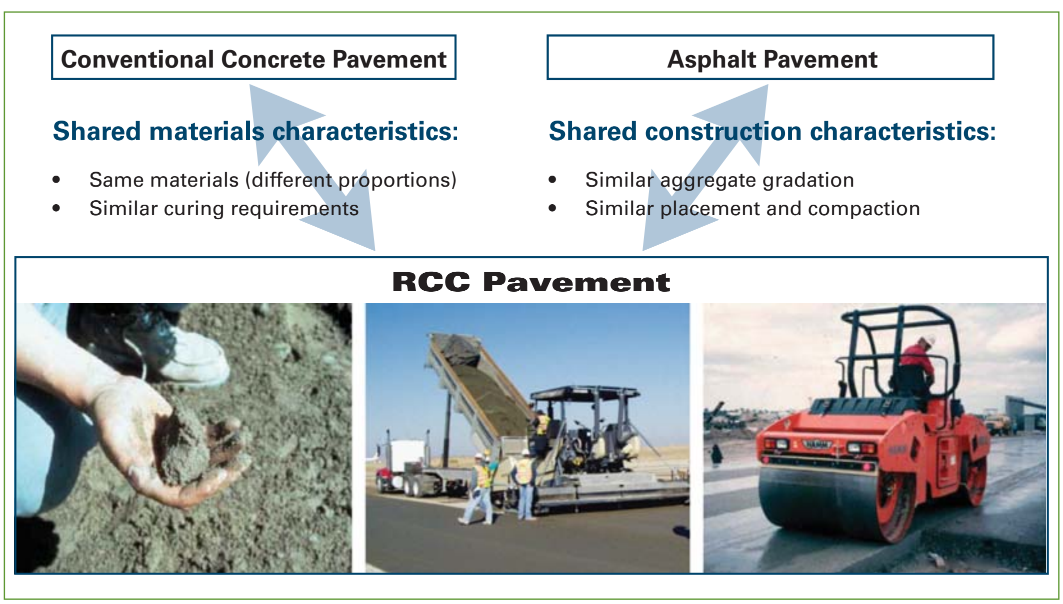
The major difference between RCC mixtures and conventional concrete mixtures is that RCC has a higher percentage of fine aggregates, which allows for tight packing and consolidation.

Fresh RCC is stiffer than typical zero-slump conventional concrete. Its consistency is stiff enough to remain stable under vibratory rollers, yet wet enough to permit adequate mixing and distribution of paste without segregation.

RCC is typically placed and initially compacted with an asphalt-type paver equipped with a standard or high-density screed, followed by a combination of passes with rollers for final compaction. Final compaction is generally achieved within one hour of mixing.

Unlike conventional concrete pavements, RCC pavements are constructed without forms, dowels, tie bars, or reinforcing steel. Joint sawing is not required, but when sawing is specified, transverse joints are spaced farther apart than with conventional concrete pavements.

RCC pavements combine various aspects of conventional concrete pavement materials practices with some construction practices typical of asphalt pavements. However, while RCC pavements are compacted in the same manner and have similar aggregate gradation as asphalt pavements, the materials and structural performance properties of RCC are similar to those of conventional concrete pavements.



Comparison of RCC materials and construction practices with conventional concrete and asphalt pavements

Basic Differences between RCC and Conventional Concrete Pavements

The following table shows a comparison of materials and construction practices for conventional concrete and RCC pavements.

Type of Pavement		
General Materials and Practices	**Conventional Concrete Pavements**	**RCC Pavements**
Mix materials proportions	Well-graded coarse and fine aggregates typically account for 60 to 75 percent of the mixture by volume. A typical water-to-cementitious materials (w/cm) ratio is 0.40 to 0.45, which makes a cement paste wet enough to thoroughly coat the aggregate particles and fill spaces between the particles. Typical proportions of water, cementitious materials, and coarse and fine aggregates for conventional concrete and RCC mixtures are compared in Figure1-5.	Dense- and well-graded coarse and fine aggregates typically comprise 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. See Figure 1-5 for typical materials proportions for RCC and conventional concrete mixtures.
Workability	The mixture is plastic and flowable, so that it can be manipulated by the paving machine, and relatively stiff (slump is generally about 2 in. [5.1 cm]) to hold shape after being extruded from the paving machine.	The mixture has the consistency of damp, dense-graded aggregates. RCC's relatively dry and stiff (less than zero slump) mixture is not fluid enough to be manipulated by traditional concrete paving machines.
Paving	The mixture is placed ahead of a slipform paving machine, which then spreads, levels, consolidates through vibration, and extrudes the concrete. Forms may be used with small hand pours. Conventional concrete pavements are typically 6 to 12 in. (15.2 to 30.5 cm) thick and are placed, consolidated, and finished in a single pass.	Typically the RCC mixture is placed with a heavy-duty, self-propelled asphalt paving machine, utilizing a high-density single- or double- tamper bar screed to initially consolidate the mixture to a slab of uniform thickness. These types of pavers are essential to high-quality placement, especially in thick pavement applications. Forms are not required. RCC is usually placed in lifts of 6 to 8 in. (15.2 to 20.3 cm) (4 in [10.2 cm] minimum and 10 in. [25.4 cm] maximum).
Consolidation (primarily the removal of non-entrained air)	Consolidation occurs internally. Initially, internal vibrators and surface vibrators on the paving machine fluidize the plastic concrete, releasing air. After the concrete is extruded from the machine and before initial set occurs, some additional consolidation occurs through the settlement of solids (cements and aggregates) and the upward movement of water to the surface (bleeding).	Consolidation is accomplished externally by compacting the concrete with rollers, typically within the first 60 minutes after mixing (before the paste begins to harden).
Finishing	Finishing is conducted before initial set occurs. Conventional concrete is usually mechanically textured to improve friction.	Although the surface of the RCC pavement typically has an open texture (similar to asphalt), use of smaller aggregates and/or additional cement can create a denser surface (closer to conventional concrete). RCC can be textured through diamond grinding.
Hydration	Proper hydration of the concrete mixture is critical to the long-term durability of the concrete pavement. To assist in the hydration, curing of the concrete is an important requirement.	Proper hydration of the RCC mixture is critical to the long-term durability of the pavement. To assist in the hydration, curing of the concrete is an important requirement.
Curing	Thorough curing is required as soon as possible after finishing. This is critical for controlling water evaporation from the concrete surface so that it is available for cement-water hydration, which results in strong hardened paste filling voids and binding aggregate particles together.	Thorough curing is required as soon as possible after roller compacting. This controls water evaporation from the concrete surface so that it is available for cement-water hydration, which results in strong hardened paste binding the aggregate particles together.
Cracking, load transfer, and reinforcement	In conventional jointed pavements, the location of cracks is controlled by cutting joints, across which transverse dowel bars are used for load transfer (for pavements 8 in. [20.3 cm] or thicker), and longitudinal tiebars are used to help ensure aggregate interlock. In continuously reinforced pavements, tight cracks are allowed to occur in a naturally closely spaced pattern, and the steel reinforcement, together with aggregate interlock, assists in load transfer.	Joints are not usually sawed in RCC industrial applications. When sawing is not specified, random cracks 15 to 30 ft (4.6 to 9.1 m) apart are normally tight, enabling load transfer through aggregate interlock. When sawing is specified to control random cracks, it is typically in applications with car and truck traffic. Fewer joints are sawed in RCC than in conventional concrete pavements, and they are spaced farther apart (15 to 30 ft [4.6 to 9.1 m] transversely). Because of the way RCC is consolidated, it is not possible to place dowels or tiebars in RCC pavements.

RCC Pavement Applications

RCC is an economical, fast-construction candidate for many pavement applications. It has traditionally been used for pavements carrying heavy loads in low-speed areas because of its relatively coarse surface. However, in recent years its use in commercial areas and for local streets and highways has been increasing.

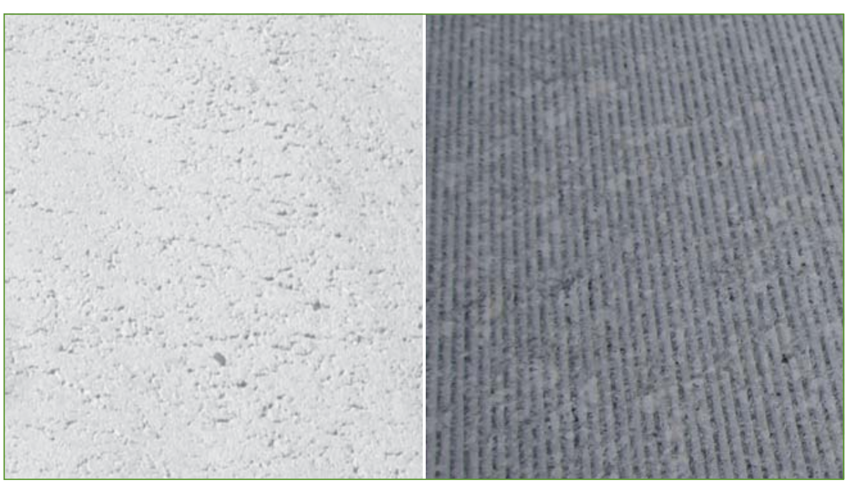
The following are typical applications:

- Industrial plant access roads and parking lots
- Intermodal shipping yards, ports, and loading docks
- Truck/freight terminals, bulk commodity storage, and distribution centers
- Low-speed urban and rural roads+
- Aircraft parking areas
- Military loading zones, forward or rearward bases of operation, and airfields
- Recreational vehicle pad storage
- Vehicle maintenance areas
- Large commercial parking lots
- Roadways in public parks
- Roadways for timber and logging operations
- Highway shoulders
- Temporary travel lanes that must be constructed quickly to divert traffic

RCC can be used in pavement systems serving higher traffic speeds when the surface is diamond ground. It can also be used as a base for a thin conventional concrete pavement surface, with a separation layer.

RCC Materials

RCC contains the same basic materials as conventional concrete—coarse and fine aggregates, cementitious materials (cement, fly ash, silica fume, etc.), water, and, when appropriate, chemical admixtures—but they are used in different proportions.



RCC before (left) and after (right) diamond grinding

RCC applications

Port terminal, Houston, TX

Residential street, Columbus, OH

Commercial parking lot

Interstate highway shoulder, Atlanta, GA

The primary differences in proportions between RCC mixtures and conventional concrete mixtures are as follows:

- RCC is generally not air-entrained.
- RCC has lower water and paste contents.
- RCC generally requires a greater amount of fine aggregates in order to produce a combined aggregate that is well graded and stable under the action of a vibratory roller.
- RCC usually has a nominal maximum size of aggregate (NMSA) not greater than 3/4 in. (19 mm) in order to minimize segregation and produce a relatively smooth surface texture.

Mineral aggregates constitute up to 85 percent of the volume of RCC and play an influential role in achieving the required workability, specified density in the field under vibratory compaction, compressive and flexural strengths, thermal properties, long-term performance, and durability.

Type I and II portland cements are commonly used in RCC pavements. Chemical admixtures commonly used in conventional concrete can be incorporated into RCC mixtures; however, higher dosages may be required. An air-entraining agent may be used; however, it is typically not required.

Design of RCC Pavements

For design purposes, RCC pavements fall into two main categories—heavy-duty industrial pavements (e.g., ports and multimodal terminals) and conventional roadway pavements (e.g., pavements carrying different sizes and weights of roadway-licensed trucks and lighter vehicles).

The following table illustrates the design procedures that can be used for RCC pavements.

Design procedures for RCC pavements

Design Procedure	Heavy-duty industrial applications	Conventional roadway applications
RCC-PAVE software (PCA)	√	
U.S. Army Corps of Engineers	√	
StreetPave (ACPA)		√
Guide for Design of Jointed Concrete Pavements for Streets and Local Roads (ACI 325.12R-02)		√
Guide for the Design and Construction of Concrete Parking Lots (ACI 330R-08)		√

Construction of RCC Pavements

RCC pavements are constructed as plain, undoweled, and unreinforced pavements. The structural behavior of RCC pavements is similar to that of equivalent conventional concrete pavements.

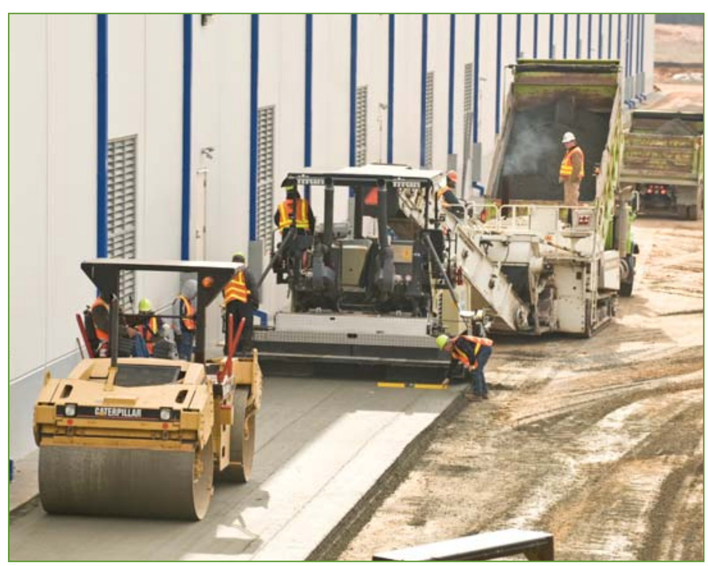
RCC is placed and initially compacted with an asphalt-type paver, and final compaction is achieved using vibratory steel drum and rubber-tired rollers. The timing of the placement and compaction is critical to obtaining adequate density, strength, and smoothness of the finished RCC pavement. The concrete is placed and compacted while it is still fresh and workable, usually within 60 min of delivery.

Joint sawing is typically not required for RCC pavements; however, sawed joints can be used to prevent random cracking or to maintain the highest possible load transfer efficiency, particularly if the pavement is subjected to cold weather or repeated heavy loads.

For More Information

The recently released *Guide for Roller-Compacted Concrete Pavements* provides owner-agencies, contractors, materials suppliers, and others with a thorough introduction to and updated review of RCC and its many paving applications. It includes detailed overviews of RCC properties and materials, mixture proportioning, structural design issues, and production and construction considerations, plus troubleshooting guidelines and an extensive reference list.

For more information, contact Dale Harrington, 515-964-2020, dharrington@snyder-associates.com.



RCC paving train