

# The RIGHT Choice

FOR TOUGH DUTY



## Ready Mixed RCC

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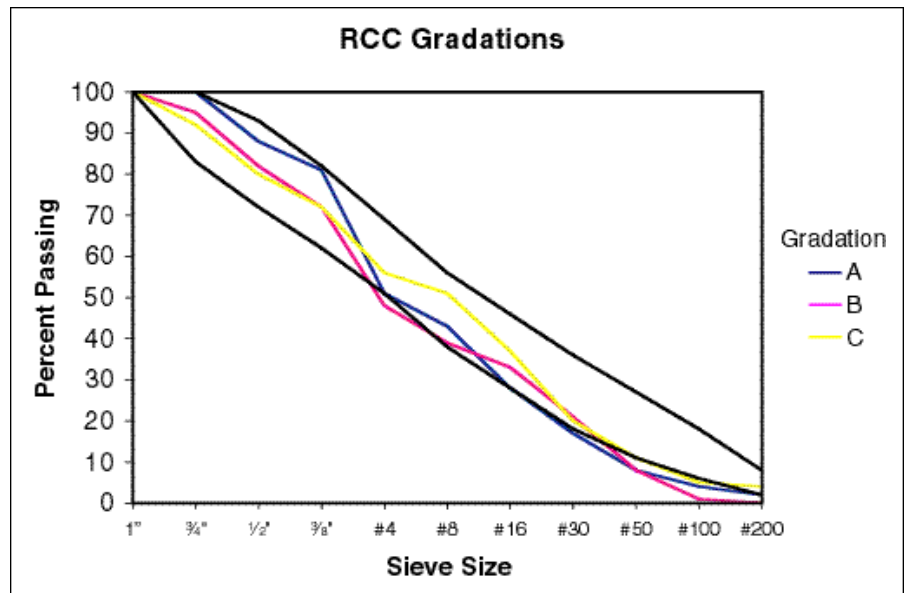
BY GREGORY E. HALSTED

When developing an effective introduction plan for a new product, the toughest challenge is to deliver the innovation at the right price and the highest quality from the start. When a contractor is deciding whether to approve concrete for use, all of the assurances of the best lab tech or mix design consultant take a back seat to the first look at the plant-produced product.

This is the challenge that the concrete producer faces over the next 18 months as NRMCA readies a promotion initiative to gain a greater share of parking areas, an effort in which roller-compacted concrete (RCC) will play a major role. It's important for ready-mixed concrete producers who are asked to supply this relatively dry and harsh product to know how to bid, batch, and produce the material efficiently and economically. It's one of the most important ways to support the concrete industry's massive marketing push that's intended to loosen the asphalt industry's grip on the small pavement market segment.

Many producers might be hesitant to produce RCC. This doesn't mean that they don't want to help grow the overall concrete market, but they might lack information and education on the subject.

The batching of quality RCC mixes at ready-mix facilities is a learning process that requires some initial planning and testing followed by repeated trial and error until the producer reaches a comfort level.



Selecting the proper gradation for designing roller-compacted concrete (RCC) mixes is the key to a successful project. The graph shows the gradations of three aggregates that were successfully used to batch high-quality RCC.

Today, with many agencies and owners looking for economic and durable alternatives to asphaltic concrete paving, the ready-mix producer who offers RCC can generate revenue in a relatively untapped market segment.

RCC is a stiff, zero-slump concrete that is placed and then compacted with rollers. Like conventional ready-mixed concrete, RCC uses the same basic materials of cement, aggregates, and water. But unlike ready-mix, RCC is a drier material that has the consistency and feel of damp gravel. It is this low water-cement ratio that gives

RCC its high strength and makes it an ideal construction material for applications ranging from dams and intermodal facilities to parking lots and city streets. However, from the producer's perspective, RCC raises some interesting production questions. Let me answer some of the most common questions that I receive.

Can RCC really be produced at ready-mix facilities? Although RCC normally is thought of as a material that must be produced in large quantities through some sort of continuous-flow system such as a pug mill, this is not necessarily the case. From the

# RCC and Producers:

loading and mixing equipment to the cement, water, and admixtures to the fine and coarse aggregates, the producer already has everything onsite to successfully produce a quality RCC mixture. Because of this fact, RCC becomes an economical construction material that can be successfully produced at ready-mix facilities, giving the producer an additional product to offer customers.

What type of mixing equipment is necessary for RCC? RCC can be produced from

a central-mixing concrete batch plant for medium- to large-sized projects, and even a transit mixer suits smaller jobs. The size and nature of the project dictate what production method to use.

■ Transit mixers. Although transit mixers can produce a quality product and provide more local RCC availability, their slower mixing and discharge times are not tailored for production on a large scale.

■ Tilt-drum mixers. By far the most common type of central-mixing units, tilt-drum mixers often are regionally located,

and this attribute, coupled with fast, quality-consistent production capabilities, makes them ideal for most RCC projects.

■ Horizontal paddle mixers. Whether single- or dual-shaft, portable or stationary, horizontal paddle mixers provide the most intense and fastest mixing action, making them a good choice for larger projects.

Whichever mixer apparatus the producer chooses, it must be noted that the producer should always transport RCC to the jobsite in covered dump trucks for efficient placement. Although the producer

can discharge RCC directly into dump trucks from tilt-drum or horizontal paddle mixers, the use of transit mixers involves the additional challenge of discharging from the transit mixer to a dump truck.

What types of aggregates should be used for RCC? Because RCC uses the same aggregate sizes found in conventional concrete, the producer will discover that the necessary coarse and fine aggregates for RCC are already stored in his bins or stockpiles. Coarse aggregates consist of crushed or uncrushed gravel or crushed stone and



The concrete industry is gearing up to make a major push for the small pavement market segment. The producer who plans to start producing roller-compacted concrete (RCC) should know how it varies from conventional concrete.

# The Right Mix

► The producer should know about a few unique attributes of the material before pursuing the small pavement market.

the fine aggregates consist of natural or manufactured sand. Crushed aggregates typically work better in RCC mixes due to the sharp, interlocking edges of the particles, which help to reduce segregation and provide higher strength.

ACI has established aggregate gradation limits that have proven to produce quality RCC pavement mixtures. These limits recommend the use of dense, well-graded

gradations with a nominal maximum size aggregate (NMSA) not to exceed 3/4 inch (19 mm). Additionally, the ACI gradation ranges allow for a fines content that is typically higher than that of conventional concrete (2%–8% passing the #200 [75 µm] sieve), thus eliminating the need for washed aggregates in many cases. These ACI gradation limits effectively allow the use of standard-sized stone—most commonly #57s, #67s, #7s, #8s, and #89s—to be used in RCC pavement mixes.

How much cementitious material is in RCC? The cementitious materials used in RCC mixes include Type I or Type II portland cement or blended hydraulic cement, Class F or Class C fly ash, and ground granulated blast-furnace slag. The typical total amount of cementitious material for an RCC mix is 300–600 pounds per cubic yard in a wide range of proportions of these materials. The selection of the proper type and amount of cementitious materials should be based on their availability to the producer as well as the required design strength of the finished RCC project. In some cases, the addition of retarding admixtures to delay the setting time of the cementitious materials may also be useful, as when there exists a long haul time between the point of production and the project location.

How much water should be used in RCC? Although the quantity of mixing water is considerably reduced for RCC, its quality should meet the same requirements as for conventional concrete mixes. Water to total cementitious ratios, or  $W/(C+P)$ , for RCC mixes generally fall between 0.33 and 0.43. In other words, these mixes require 150–200 pounds of water per cubic yard.  $W/(C+P)$  ratios in this range have the greatest positive influence on the final strength of RCC, with 28-day unconfined compressive strengths typically exceeding 6000 psi.

What are the mixing times and batch sizes for RCC? The required mixing time for RCC depends on a number of factors, including the size of the batch, the gradation of the mix, the  $W/(C+P)$  ratio, and

the type of mixing equipment employed. The recommended mixing times and maximum batch sizes for the three types of mixing units discussed in this article are summarized in the tables.

Keep in mind that because RCC is transported to projects in dump trucks, the maximum amount of RCC safely hauled is around 8 or 9 cubic yards—assuming that each yard weighs 2000 pounds. Whichever mixing method is employed, vigorous mixing is imperative to evenly distribute the small amount of water present in the mix. The key to producing a strong, durable RCC mix rests in the careful proportioning and mixing of the materials.

— GREGORY E. HALSTED worked for the Georgia DOT for 17 years and has participated in numerous speaking engagements, including training and construction workshops. He recently joined the Portland Cement Association as a pavements engineer.

**Table 1: RCC Mixing Guidelines**

Mixer type	Mixing time	Batch size
Transit	4–5 minutes*	up to 3 cy
Tilt-drum	2–4 minutes	up to 5 cy
Horizontal paddle	20–60 seconds	up to 12 cy

\*Assumes a mixing speed of 20 revolutions per minute

## RCC Test Mix Designs

The materials, mixer employed, and water-cementitious materials ratio can vary widely for RCC mixes.

### Producer A

- Coarse aggregate per cubic yard (cy): 1056 pounds #67 stone, 1055 pounds #89 stone
- Fine aggregate/cy: 1734 pounds manufactured sand
- Cementitious materials: 300 pounds Type I portland cement, 100 pounds Class C fly ash
- Water: 149 pounds
- Batch size: 8.0 cubic yards
- Mixer: single-shaft horizontal paddle
- Mixing time: 40 seconds

### Producer B

- Coarse aggregate/cy: 1039 pounds #57 stone, 1039 pounds #8 stone
- Fine aggregate/cy: 1369 pounds manufactured sand
- Cementitious materials/cy: 300 pounds Type I portland cement, 250 pounds ground granulated blast-furnace slag
- Water/cy: 200 pounds
- Batch size: 4½ cubic yards
- Mixer: tilt-drum
- Mixing time: 2 minutes

### Producer C

- Coarse aggregate/cy: 1400 pounds #57 stone, 600 pounds #89 stone
- Fine aggregate/cy: 2000 pounds natural sand
- Cementitious materials/cy: 250 pounds Type I portland cement, 70 pounds Class F fly ash, 150 pounds ground granulated blast-furnace slag
- Water/cy: 191 pounds
- Batch size: 2.7 cubic yards
- Mixer: transit
- Mixing time: 4 minutes

**Table 2: ACI Aggregate Gradation Ranges for RCC**

ACI recommends the use of a 3/4-inch top size aggregate and a relatively high fines content.

Sieve size		Percent passing	
Inch basis	mm basis	Minimum	Maximum
1"	25.000	100	100
3/4"	19.000	83	100
1/2"	12.500	72	93
3/8"	9.500	62	82
#4	4.750	51	69
#8	2.360	38	56
#16	1.180	28	46
#30	0.600	18	36
#50	0.300	11	27
#100	0.150	6	18
#200	0.075	2	8