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# Public Works

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SPECIAL ISSUE



More state DOTs are using RCC  
page 6



## On a roll

**SPECIAL DIGITAL ISSUE:**  
Roller-compacted concrete  
is gaining in popularity.  
We have it covered with  
six feature stories.

May 2014 RCC project for the Yuma  
County Water Users' Association in  
Arizona. Photo: Corey Zollinger



## features

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Market growth and trends of roller-compacted concrete.

## Welcome to this special edition of PUBLIC WORKS

Look how far we've come. From limited uses in the Canadian logging industry in the 1970s to almost 200 U.S. projects over the last few years, roller-compacted concrete (RCC) continues to ascend from a niche product to the paving mainstream.

This dedicated edition of PUBLIC WORKS provides an in-depth look at RCC applications, placement techniques, and pavement performance.

A growing number of public agencies are saving money and lengthening the life of streets, bike paths, and parking and storage areas with RCC. The following six articles provide an in-depth look at public projects and research to educate you on the three Ws (when, where, why) of this pavement option.

After successfully completing an RCC demonstration at the World of Concrete in 2013 and 2014, this digital edition was made possible by the RCC Pavement Promotion and Research Council. Formed in early 2014, members include material suppliers, equipment vendors, and contractors with a common goal of sustainably expanding the market opportunities for RCC paving.

If you're considering specifying RCC for a paving project in your jurisdiction, the council is an excellent resource. We can answer questions on everything from what's the appropriate equipment to finding a qualified contractor.

If you have a question, or would like learn more about or join the RCC Pavement Promotion and Research Council, please contact us:

#### Chris Carwie

RCC Council, Promotion Committee Chairman  
Business Development Manager  
AG Peltz Group LLC  
ccarwie@agpeltz.com  
205-335-0579

#### Corey J. Zollinger, PE

RCC Council, Chairman of the Board of Directors  
Director, Paving Solutions  
CEMEX USA Inc.  
coreyj.zollinger@cemex.com  
713-722-6084

Thank you — and enjoy!



# ‘Alternative pavement’ stands the test of time

A roller-compacted concrete road in Nebraska provides two decades of durability.

In western Nebraska, a short stretch of pavement is one of the country’s longest-standing testaments to the durability of roller-compacted concrete (RCC).

The most remarkable thing about Big Horn Avenue in Alliance, Neb., may be how easy it is to forget, at least for those responsible for maintaining it. In 1994 the collector street for a residential subdivision was the city’s first road paved with RCC, and it has been virtually maintenance-free since.

“After 20 years, the road has held up very well and maintained its appearance,” says public works director Ron Perry. Although the project wasn’t completed during his tenure, Perry appreciates the pavement’s durability and cost savings.

*(continued)*



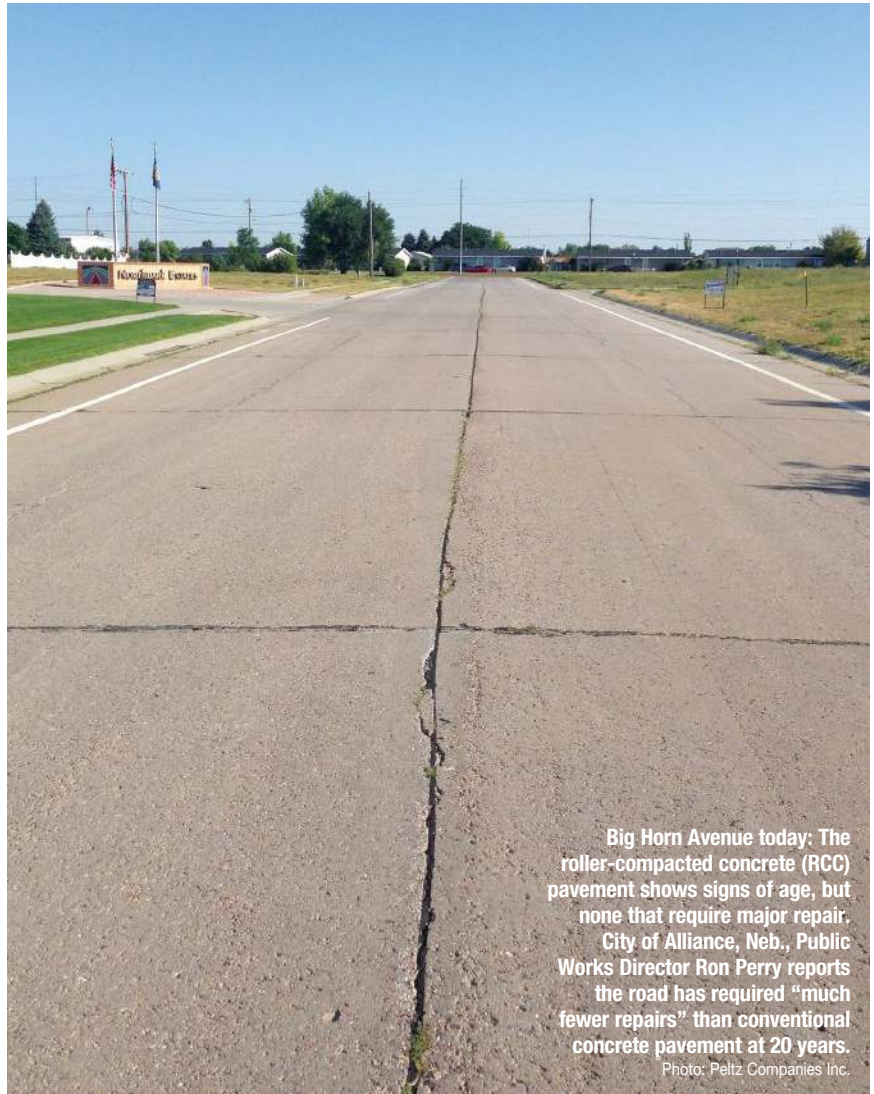
## PROJECT DETAILS

**Owner:** ATABRIT Partnership and City of Alliance, Neb.

**Contractor/concrete producer:** Peltz Companies Inc.

**Distance:** ¾ mile

**Project cost:** \$127,000 for roller-compacted concrete; \$202,500 total (including all subdivision pavement, curb, gutter, and sidewalks)



Big Horn Avenue today: The roller-compacted concrete (RCC) pavement shows signs of age, but none that require major repair. City of Alliance, Neb., Public Works Director Ron Perry reports the road has required “much fewer repairs” than conventional concrete pavement at 20 years.

Photo: Peltz Companies Inc.



**Big Horn Avenue 2005: Some cracks had been sealed before 2000, but the roller-compacted concrete (RCC) showed no signs of faulting or surface distress 11 years after placement.** Photo: Portland Cement Association

“The department has done crack sealing and a few cold patching of holes,” says Perry. “But for a 20-year-old road, it’s needed many fewer repairs than typical concrete.”

#### **An economical choice**

When the subdivision was under construction, the developer and landown-

er, ATABRIT Partnership, accepted a bid for RCC from Alliance-based Peltz Companies Inc. The developer was intrigued by the pavement’s projected 30-year lifespan, which made it a more economical choice for the long term.

At \$19 a square yard, RCC was considerably less expensive than conventional concrete, largely because it elim-

inated the need for steel reinforcement and associated material costs.

The project could also be completed more quickly due to RCC’s placement process and Peltz’s dedicated paving equipment. The contractor uses Volvo ABG high-density pavers instead of conventional asphalt pavers. “The RCC pavers achieve density so well that additional compacting isn’t always necessary,” says president Terry Peltz. “Often the surface meets smoothness and density specifications without the need for rolling, and projects can be completed with fewer steps. The goal in RCC construction is to provide a superior product as efficiently and cost effectively as possible. With the duo-tamp Volvo pavers, we’re able to accomplish both.”

“The speed of construction was certainly an attractive factor in selecting roller-compacted concrete,” says Barry Swanson, senior project supervisor for Baker & Associates Inc. of Scottsbluff, Neb., the project’s engineer of record.



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As project manager, Swanson designed and oversaw installing sewer and water systems as well as pavement in the new subdivision.

Under Baker's supervision, Peltz Companies placed the curb and gutter on Big Horn Avenue before returning to pave the main roadway. Installing the curb and gutter first provides the elevation and line controls for RCC paving, as well as a solid edge for compaction. The contractor considers this sequencing a best construction practice for RCC.

Peltz produced the RCC mix onsite using an Aran continuous-mix pug mill, and delivered it by dump truck to the paver. The developer provided two acres adjacent to the roadway as a staging area.

The paving was completed in a day, and saw-cut joints were constructed the next day, every 27 feet. No milling or surface treatment was needed aside from curing the surface with a white pigmented curing compound to avoid

*(continued)*

**(Right)** Over time, some raveling has occurred at construction joints, which have been sealed with hot pour sealant. Photo: Peltz Companies Inc.

**(Below)** The roller-compacted concrete (RCC) pavement surface has a tight matte and good finish, mainly due to the mix design and compaction provided by high-density Volvo (ABG) paving machines. Photo: Peltz Companies Inc.



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## RCC CONCRETE MIX DESIGN

**Thickness:** 6 inches

**Placement width:** 36 feet (in 18-foot strips)

**Cubic yards:** 1,100

**Total aggregate:** 3,324 lbs.

**Aggregate blend:**

- 30% coarse aggregate (3/4-inch #4 crushed limestone)
- 35% fine aggregate (crusher fines limestone)
- 35% NE 47-B sand gravel (North Platte River gravel)

**Cementitious material:** Type I-II cement, 564 lbs.

**Optimum moisture:** 7.4%



problems such as cracking, reduced strength, and dusting.

Depending on the type of traffic RCC pavement is designed for, curing times can range from two to four days, although in some cases pavement can

withstand light traffic on the same day of placement. Usually when the pavement has reached the required strength, it can be opened to traffic.

Big Horn Avenue reached compressive strengths of 4,200 to 4,500 psi at 28 days, exceeding the 3,500 psi performance specification.

Inside the subdivision, Peltz paved the streets with conventional concrete to accommodate varying widths and an inverted crown drainage system.

### Exceeding expectations

Swanson recalls being approached about using RCC pavement in 1994. "We weren't familiar with it, so we did some research to gain a better comfort level with the process," he says. "Our biggest concern was how the unsealed surface would endure Nebraska's weather. We thought freeze/thaw cycles could be a problem, but apparently they haven't been."

Impressed by the project's success, Baker & Associates began adding an alterna-

tive RCC option to its paving project bids.

Since paving Big Horn Avenue in its hometown, Peltz Companies has successfully completed high-profile RCC projects across the U.S. for clients, including Lowes, Cargill, U.S. Army Corps of Engineers, and municipalities. The contractor has used RCC on ports, distribution centers, highways, intermodal yards, and airports. Peltz is known for constructing Denver's Burlington Northern Railroad terminal in 1985 — one of the city's first RCC projects and the country's largest at the time.

Although the contractor's processes haven't changed considerably over the past 20 years, some design changes have taken place.

"To create a uniform riding surface on Big Horn Avenue, we used a standard mix design where the top size ¾-inch aggregate was evenly graded down to 200 mm sieve size," says Jim Peltz, vice president. "RCC gradations have changed over the years, lowering the top size 1 inch down to ¾ inch and sometimes ½ inch."

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The aggregate curve has also changed. “Years ago, specifications required up to 10% to 12% passing the #200 sieves. These excess fines often caused sticking problems with the screed and rollers,” he says. “Today, the specifications require 0-8% passing the #200.” (See the American Concrete Pavement Association’s Roller Compacted Guide Specification, 2014.)

When constructing RCC pavements, contractors often struggle with the proper construction of transverse and longitudinal construction joints. With much trial and error over the years, Peltz has refined its jointing processes to provide a superior pavement. (To read more about Peltz Companies, see “RCC: Then and Now,” CONCRETE CONSTRUCTION ROAD BUILDING with CONCRETE, April 2014.)

Their customers’ views have evolved as well.

“Many of our clients are taking the life-cycle cost analysis of RCC pavements into account when designing projects,” says

Terry Peltz. “They’re seeing the benefits of the discounted costs throughout the lifetime of the pavement.” **PW**

*T.J. Peltz is business development manager for Peltz Companies Inc. For questions regarding this project and other roller-compacted concrete applications, e-mail [tj@peltzco.com](mailto:tj@peltzco.com) or visit [www.peltzco.com](http://www.peltzco.com).*

**Ron Perry (left), public works director for the City of Alliance, Neb., meets with contractors Terry and Jim Peltz, president and vice president of Peltz Companies Inc., at Big Horn Avenue on the 20th anniversary of the roller-compacted concrete (RCC) project's completion.**

Photo: Peltz Companies Inc.



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# The new tool in the paving toolbox has arrived

More state DOTs are offsetting tight budgets and volatile commodity prices with roller-compacted concrete.

The virtues of roller-compacted concrete (RCC) for industrial applications were proven long ago, but public agencies have been slower to adopt the mixture.

That, however, is changing.

Experience and evolving technology are making the mix an increasingly feasible alternative to traditional materials for many paving applications. RCC is ideal for situations where high strength, rapid construction, and durability are desired at an economical price — four reasons state DOT use has grown rapidly over the last decade.

**Freshly placed roller-compacted concrete.** Photos: Andrew Johnson





### Benefits over traditional concrete

Developed in Canada for use in log-skidding yards in the 1970s, RCC is often referred to as “negative slump” concrete.

Unlike traditional concrete, which is relatively liquid and can be consolidated through internal vibration, RCC has a much lower water/cement ratio and must be compacted to attain its design strength. Once compacted, however, it’s comparable to traditional high-performance concrete, often achieving 28-day compressive strengths of more than 6,000 psi. High early strength of 2,000 psi within 24 hours is also possible.

Because it’s compacted, RCC can transmit loads as a granular solid before hydration of the portland cement. That means newly placed pavement can almost immediately carry limited loads. Because cars and trucks can cross within minutes instead of the hours required for traditional concrete, specifying RCC is an excellent way to minimize inconvenience to residences and businesses along sensitive roadways.

Depending on application, RCC is produced by a ready-mix concrete supplier in a portable central mix batch plant used for conventional concrete paving or in a continuous pugmill operation. Because placement resembles hot mix asphalt (HMA), aggregate gradations are generally similar to those of asphalt mixes.

Given its greater thickness, RCC should be placed by a high-density asphalt paver to ensure consistently satisfactory results. Conventional asphalt pavers can be used, but the outcomes have been mixed.

High-density pavers operate like conventional pavers but have tamper bars and other systems capable of producing 90% or greater modified Proctor compaction in lifts up to 9 inches. Several state DOTs use 90% compaction at the back of the machine as a performance requirement for defining “high-density paver.”



Existing pavement milled 2 inches below gutter.

### Multiple state DOT applications

Most state DOTs have at least experimented with RCC; see the table for project details by six states. Shoulders, industrial access, turn lanes, rest areas, and even highways have been paved throughout North America.

Shoulders that don’t have to be tied to the mainline for support are most common, followed by roadways capped with a layer of asphalt, diamond-ground, or left untreated.

The South Carolina DOT (SCDOT) is a particularly frequent user for urban reconstruction in areas of high truck traffic, having let more than 20 projects in the last five years. Between shoulder and reconstruction projects, the agency has placed 700,000 square yards since 2008.

Most projects involved highly deteriorated four- or five-lane curb-and-gutter sections. Many had 2 to 4 inches of asphalt over the original gutter, which ruled out resurfacing with a simple overlay. Here is how the projects were built:

- Mill asphalt to 2 inches below the gutter.
- Mill an additional 8 inches in one lane only.
- Fill deep-milled area with RCC to elevation of adjacent lane. Mainline traffic isn’t generally allowed until the next day, but property owners along the road may cross immediately.
- Cut transverse contraction joints using an early entry saw as soon as compaction is complete.

*(continued)*

**Table 1 - Selected State Highway Agency RCC Projects**

STATE	ROUTE	FACILITY TYPE	PAVEMENT STRUCTURE	YEAR	APPROXIMATE QUANTITY
AR	AR-213, Hattiesville	Arterial	7 and 8 inch RCC Diamond Grind	2012	28,000 sy
CO	SH66 at I-25, Longmont	Arterial	7.5 inch RCC	2007	41,000 sy
GA	I-85 Kia Interchange, West Point	Ramps and Shoulder	12 inch RCC	2008	19,000 sy
GA	I-285, Atlanta	Shoulders	6 and 8 inch RCC	2005	217,000 sy
GA	SR 6, Powder Springs GA	Shoulders, Center Turn Lane	7 inch	2006	84,850 sy
OH	I-80 Turnpike Service Plazas, Williams and Mahoning Counties	Truck and Auto Parking	6, 8, and 10 inch RCC 6 inch HMA Base	2010	73,000 sy
OH	I-80, MP 95 to 101	Shoulders	3.25 inch HMA 10 inch RCC 10 inch Aggregate Base	2011	59,000 sy
SC	US-78, Ladson	Arterial	2 inch HMA 10 inch RCC	2008	27,000 sy
SC	US-78, Aiken	Arterial	10 inch RCC Diamond Grind	2008	28,000 sy
SC	Route S-40-3020, Columbia	Arterial	2 inch HMA 10 inch RCC	2009	25,000 sy
SC	I-385, MP 0 to 14	Shoulders	10 inch RCC Existing HMA Shoulder	2010	131,000 sy
WV	US-221, Danville	Shoulders	9 inch RCC	2012	11,000 cy

- Once all lanes have been replaced, cap entire project with a layer of asphalt to provide a uniform surface and restore gutter. Because the RCC is only 2 inches below the gutter, this step can be delayed for several weeks.

**Major differences from traditional concrete**

For all of its benefits, RCC does have some issues that should be considered.

Raveling at joints caused by poor compaction can be minimized through careful construction techniques and carefully adhering to construction specifications.

Surface texture has been another objection.

Unlike conventional concrete, RCC can't be finished using floats and trowels. Mixes often contain pockets of coarse material or very shallow tension cracks (typically less than 1/8 inch.) But if placed correctly, the finished surface resembles well-graded asphalt. In fact,

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at least two SCDOT projects met standard rideability requirements after diamond grinding.

There have also been instances of scaling after two or three days (although the underlying RCC was sound) when roads were opened too soon. To prevent this, many DOTs cap projects with an asphalt wearing course.

### Future developments

Great strides have been made in RCC surface texture in the last few years. Better mix designs and construction techniques, and more experienced contractors have resulted in improved ride and surface textures on recent projects.

As the product continues to improve, RCC is poised to be a game-changing material for both project owners and contractors. **PW**

Second milling operation adjacent to RCC placed two days earlier.

*Andrew Johnson is pavement design engineer for the Portland Cement Association – Southeast Region. Telephone 803-556-2889 or e-mail [ajohnson@cement.org](mailto:ajohnson@cement.org).*



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# Township is first in state to use roller-compacted concrete

Township saves more than expected compared to conventional pavement.

**L**ike many townships, Upper Nazareth Township in Northampton County, Pa., has a lot of roads to fix and no budget to repair them all. In 2012, however, after discussions with Keystone Consulting Engineers, the township concluded that it had to reconstruct a 420-foot section.

After rejecting cold-in-place recycling, full-depth reclamation, and full-depth reconstruction using conventional blacktop, the township finally found an affordable option.

“Our research led us to roller-compacted concrete (RCC) because it had been in the various national trade publications,” says Keystone Project Manager Sean Dooley. “We found that RCC has been used in the Lehigh Valley by private

owners for warehouses and service yards subject to heavy loads.”

The material, which has been used for many years in other states but is just making inroads into Pennsylvania, is just what the name implies: concrete that’s placed and rolled like blacktop rather than troweled like a traditional concrete highway.

Keystone projected the concrete could save the township 15% to 20% on the initial cost compared to conventional pavement. It didn’t take much convincing to get township supervisors on board with the idea.

“When they approached us with the idea, they had enough information about RCC’s use in limited applications to convince us that it would be a good fit for our road program,” says supervisor Jim

Augustine. “We could do the project for less money and get the same or better result as blacktop.”

## No complaints

Although RCC can be applied with the same equipment as traditional pavement, there is a learning curve involved. Consequently, the bid specifications for the Upper Nazareth Township project required a third-party RCC supervisor to be onsite during the paving. Northampton County-based Livengood Excavators Inc., which has experience with RCC, placed the concrete.

RCC is not as forgiving as blacktop, so there’s a tight window for working with it.

“As soon as it hits the paver, you have about 20 minutes to get it down and rolled,” Dooley explains. “Then you have another 20 minutes to get it sealed in some way.”

Because RCC is rolled, rather than troweled, it doesn’t have the smooth appearance or feel of traditional concrete. Therefore, the township decided to add a 1½-inch layer of blacktop to finish the surface and make it blend smoothly with



Upper Nazareth Township in Northampton County, Pa., served as a test site for roller-compacted concrete (RCC), a low-cost paving option. Applied to a 420-foot section of road that’s been in use for about two months, an official says “it looks as good as the day we finished it.” Photo: Sean Dooley, Keystone Consulting Engineers



the rest of the road. The blacktop could have been put down right after the second tack coat, but Keystone decided to wait a few days to allow the concrete to cure completely.

“Because Keystone is considering it a pilot project, we wanted to let it go for several days to optimize the strength,” Dooley says.

The crew put down the RCC on a Thursday and applied the pavement overlay the following Tuesday. The road was opened to traffic later that day.

Augustine hasn't heard any negative comments from the public. So far, the material seems to be living up to its reputation. “We fully anticipate this will be a long-term solution to the issues with this road,” he says.

After two months, the blacktop overlay hadn't exhibited any signs of reflective cracking, which might be expected with the saw joints underneath. When

it does inevitably crack, as all blacktop roads do within three to five years, the cracks should be straight, predictable crevasses in line with the joints in the concrete. Thus, they can be easily routed and sealed, Dooley says.

### The savings add up

Using RCC instead of conventional pavement saved the township 30% on initial cost due to:

- The overall pavement depth is 10 ½ inches, compared to the 16 ½ inches it would have been with traditional asphalt pavement. This reduces the amount of excavation, the number of truck trips to remove and dispose of waste material, and the amount of new material and corresponding trucks needed to transport it.
- Concrete cost about \$40 per ton, compared to \$60 per ton for blacktop.
- The installed cost for the RCC on

this project was \$39 per square yard, compared to \$55 to \$64 per square yard for equivalent asphalt pavement. The overall cost was \$70,000, instead of \$99,000 to \$116,000 for 1,728 square yards.

RCC is not yet a PennDOT-approved product, although the department is developing specifications for its use. Consequently, the township couldn't use liquid fuels funds for the concrete but was able to use them for everything else on the project.

### A cost-effective alternative

With many townships and the commonwealth watching their roads deteriorate because they don't have the funds to repair or replace them, RCC offers a cost-effective alternative.

“This is so much cheaper, and we have such a deficit statewide to keep up with  
*(continued)*”



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our infrastructure that this material has to be part of the solution,” Dooley says.

Ken Crank of the Pennsylvania Aggregates and Concrete Association (PACA) says RCC has quite a bit of potential given the volatile economic status of liquid asphalt.

“When you start looking at trends in the industry, things seem to be conspiring to affect the supply of low-grade oil for asphalt,” he says. “That works to concrete’s advantage. RCC is a very durable, cost-effective alternative.”

### Developing a spec

PACA has been working with PennDOT to develop a specification for RCC, with the goal of getting it into the department’s Publication 408, Highway Specifications.

“Things are moving in a positive direction,” Crank says. “About two years ago, PennDOT placed an RCC shoulder

on a road in District 11 as a test project. The department is watching that closely and will look at the project in Upper Nazareth as it moves forward with a draft specification.”

Marcy Lucas, a research project manager in PennDOT’s New Products and Innovations Section, is leading the drive to get RCC approved. She anticipates a final specification for its use will come sometime in 2014.

One of the challenges with RCC is that few pavement companies use it.

“Anything that’s new has a learning curve,” Crank says. “As opportunities grow and more people use it, the number of vendors who’ve worked with it will expand.”

In the Lehigh Valley, where several RCC projects have been done, several contractors are familiar with the product. A large project was taking place in Greencastle, Franklin County, for Nor-

folk Southern Railroad when this issue went to press. PACA conducted an RCC Concrete Operations seminar for ready-mix producer members.

Although Upper Nazareth Township doesn’t plan to use RCC in the foreseeable future, concentrating instead on surface treatments to save as many road miles as possible, the township wants to tell people about RCC so others can consider it.

“Everyone’s trying to do more with less,” Augustine says. “Hopefully, this is something other townships can use to save money when addressing their road repair issues.” **PW**

*This article originally appeared in the October 2012 issue of Pennsylvania Township News, the monthly magazine of the Pennsylvania State Association of Township Supervisors, which represents 1,454 townships of the second class.*



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# Sure bet

A city engineer's gamble on roller-compacted concrete (RCC) is paying off with other municipalities and the state DOT.

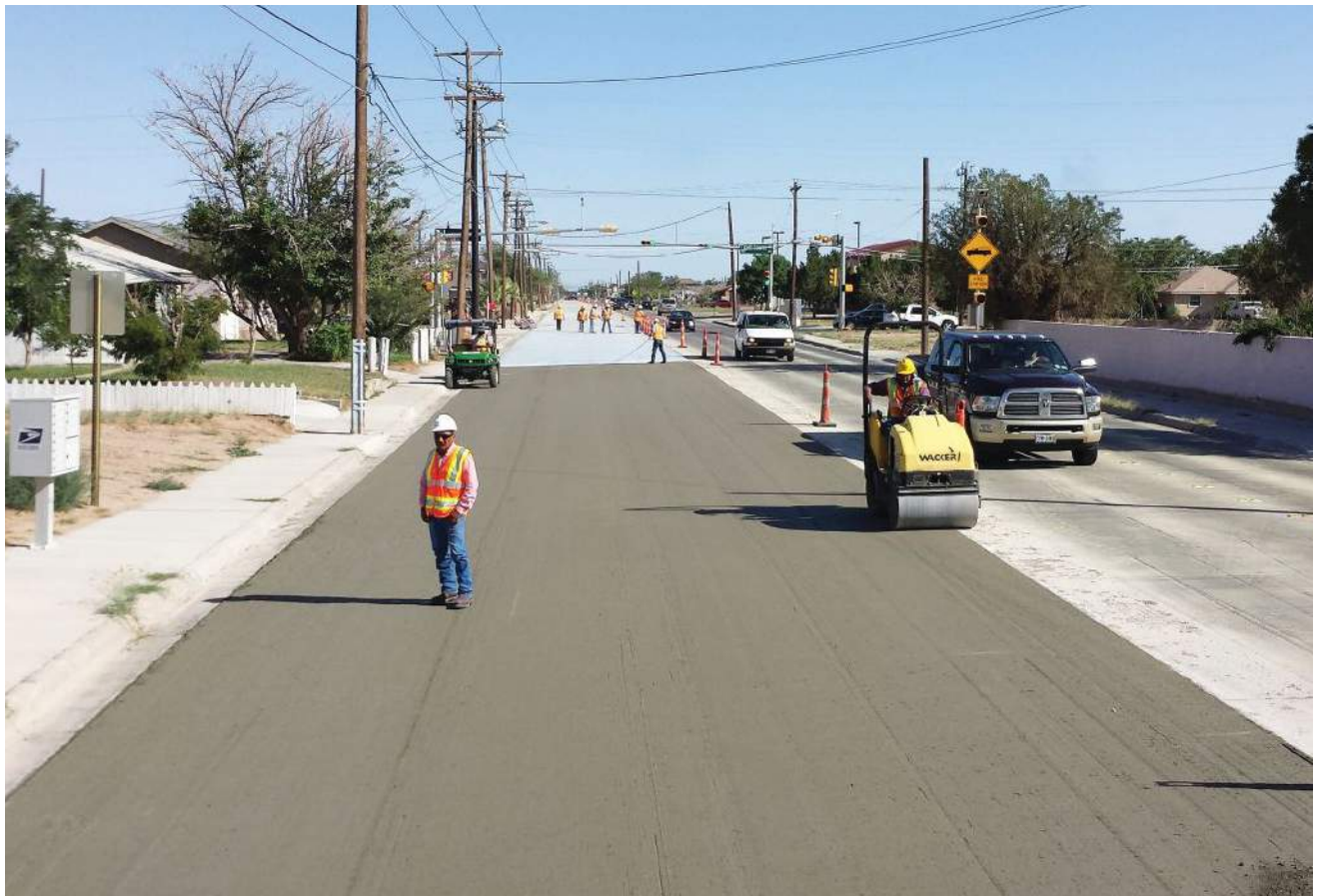
It's not often that public works asks a contractor for a change order. But when he saw how well his first roller-compacted concrete (RCC) pavement project went, asking the city council to spend \$150,000 now to save millions on future maintenance was a no-brainer for former San Angelo, Texas, City Engineer Clinton Bailey.

His gamble apparently paid off. The following year the city council tripled public works' budget to \$1.68 million. Although it was a drop in the bucket compared to the estimated \$150 million needed to fully rebuild 30% of the city's streets and roads, it was still enough to kick-start maintenance that had been postponed during the Great Recession.

**In 2014, the City of Midland, Texas, reconstructed 1.5 miles of arterial roadway by milling up and replacing 6.5 inches of asphalt with 6.5 inches of roller-compacted concrete (RCC). Like the City of San Angelo, Midland's engineering department had the RCC pavement diamond-ground to improve ride and stopping resistance.** All photos:

Corey Zollinger

*(continued)*





Midland's engineering department specified roller-compacted concrete (RCC) to open Lamesa Road as quickly as possible for business owners frustrated by what they considered inexplicable delays over three years. Repaving the 1.5-mile section was done in two phases, each lasting about a week, by San Angelo contractor Reece Albert Inc. The road opened to traffic 48 hours after placement.

"RCC makes sense financially," Bailey said in an interview on the city's in-house news program. He's now public works director for the City of Fredericksburg, Texas. "We won't see the potholes and cracks that need sealing; these roads will never need a sealcoat. We can take the streets we're rebuilding with RCC off our maintenance schedule and allocate those dollars elsewhere."

Since those two 2011 projects, the Texas DOT developed a special specification and is overseeing its first RCC project, a safety rest area (the alternative was continuously reinforced concrete pavement).

When Jerry Morales became the City of Midland's first Hispanic mayor in late 2013, one of his top priorities was finishing a road rebuild that business owners had long grown weary of. Almost two miles of a cracked, pitted, and potholed four-lane asphalt arterial required complete reconstruction.



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While that's the ideal opportunity to fix and install other public works assets like water and wastewater mains, manholes, sidewalks, and traffic lights, all that work takes time.

By the time the final paving phase rolled around almost three years later, Morales wanted Lamesa Road open to traffic ASAP. Reece Albert Inc., the same RCC contractor San Angelo used, completed the job in two phases between May and June 2014. Each phase lasted about a week and the pavement was carrying traffic 48 hours after placement.

The first publicly owned road in Texas paved with roller-compacted concrete (RCC) was this 3,400-foot stretch of Grape Creek Road in 2011 for the City of San Angelo. It was also the contractor's first RCC project. In five days, Reece Albert Inc. milled up and replaced 6 inches of asphalt with 8 inches of subgrade stabilized with lime and cement followed by 6 inches of RCC.

*(continued)*



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The City of San Angelo specified diamond grinding to improve rideability and increase friction. At \$3 to \$5/square yard, diamond grinding costs less than an asphalt overlay and produces a surface that's virtually maintenance-free. Grinding was performed by Penhall Co. Inc. of Anaheim, Calif.

### Risky project

Taking a chance on a new process or product is risky for public works. San Angelo elected officials may have known they were approving the first use in Texas of RCC for a public road. But they may not have known that it was also the contractor's first experience with the pavement.

This made it doubly risky for Bailey. He had three things going for him, though: the contract document, a collaborative relationship with his contractor, and an excellent ability to reduce complex engineering concepts into layman's terms.

Reece Albert is a family-owned highway contractor and aggregates producer founded in San Angelo in 1940. In 2006, the company bought a Vögele 2100 paver with high-density screed for asphalt paving jobs with tight tolerance specifications. Having invested \$750,000 in a machine that processes 1,200 tons of

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material an hour, business development manager Chris Cornell went looking for other ways to put it to work.

He began talking to and working with cement supplier Cemex USA Inc. and the Cement Council of Texas; and invited engineers from the state DOT, west Texas communities, and consulting firms to a two-day open house/demonstration of RCC.

RCC is a low-moisture mix that gets its strength from compaction rather than reinforcement with steel rods. It's placed via high-density pavers, and then compacted, so roads can be opened much

*(continued)*



Built in 2011 by San Angelo contractor Reece Albert Inc., Texas' first publicly owned roller-compacted concrete (RCC) street is performing well, as illustrated by this photo taken in fall 2014.

NO.	DESCRIPTION	PRICE CONSTRUCTION INC.	REECE ALBERT INC.
1	50th St and Grape Creek Rd Base Bid	\$2,267,261.73	\$2,353,428.01
2	Alternate A: Asphalt Pavement – Grape Creek Rd	\$1,431,937.80	\$1,174,201.99
	<b>Total Base Bid + Alternate A =</b>	<b>\$3,699,199.53</b>	<b>\$3,527,630.00</b>
3	Alternate B: Roller Compacted Concrete – Grape Creek Rd	\$1,352,668.32	\$1,193,184.85
	<b>Total Base Bid + Alternate B =</b>	<b>\$3,619,930.05</b>	<b>\$3,546,612.86</b>



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sooner than with traditional concrete. Not having to form or reinforce the pavement also saves time and money.

Subgrade preparation is no different than conventional concrete. In fact, Cornell advises conducting a subgrade analysis for any concrete road project, RCC or otherwise. In addition to ensuring a durable mix and design, the relatively minor investment could avoid costs from overdesigning the pavement.

### Trucking to the jobsite

RCC mixes are trucked to the jobsite from a concrete producer or the paving contractor (for details on mix design and production, see “Planning makes perfect” on page 19).

Many public works departments overlay with asphalt for a smoother ride, but diamond grinding is becoming increasingly popular. Diamond grinding is a pavement preservation technique used to improve ride, reduce noise, and increase texture of concrete pavements. The process removes about 1/8 inch to 1/4 inch of the pavement surface using closely spaced diamond saw blades.

At \$3 to \$5/square yard, the surface treatment costs less than an asphalt overlay and produces pavement that’s virtually maintenance-free. All of the projects referred to in this article were diamond-ground.

“Typical uses are only small areas of the pavement surface,” says Corey Zollinger, PE, paving solutions director for CEMEX USA Inc. “With RCC, the entire surface

is ground, which reduces the typical price per square yard. The larger the job, the less your square yard cost will be.”

“The benefit of RCC is the cost of ownership over time,” Cornell told *Texas Contractor*. “Asphalt requires periodic maintenance, a seven- to 10-year cycle, whereas roller-compacted concrete might go 20 to 25 years before any significant maintenance takes place.”

“Construction is much like concrete and creates a very low-maintenance, very long-lasting roadway,” Bailey says. “Maybe a crack here and there, a little differential movement, replacing small sections, possibly a diamond grinding for surface treatment, but very low-maintenance.”

**Asphalt street useful life: 25 years; roller-compacted concrete street useful life: 50 years.**

### Asphalt alternative

Bailey was one of the Reece Albert open house attendees. That, and the city’s relationship with Reece Albert, prompted him to ask the city council for permission to include RCC as an alternative to asphalt for the first of two economic-development projects that were packaged into a single contract (see bid tabulation on page 17).

Cornell asked that the contract’s asphalt section use an RCC design equivalent of 40 years. Because this was the

**Initially bid as asphalt, the City of San Angelo requested a change order to use roller-compacted concrete (RCC) to build a long-planned economic development project linking a state highway with fairgrounds which hosts the nation’s second-largest rodeo every February. Contractor Reece Albert Inc. placed 4,400 feet in in four days. Grinding was done by Southeast Grinding and Grooving LLC of Marietta, Ga. Homes and other new development are now springing up along the road.**

first time the city had bid RCC, public works decided to alternate bid RCC and a traditional asphalt pavement structure. Upon developing the pavement design for Grape Creek Road, it was important that both pavement types were designed equivalently. This meant that both pavements were designed to carry the same loads, with same soil conditions, over the same lifespan.

Once this was completed, the city decided to award the project based on best value to account for factors such as lower maintenance costs the RCC pavement would provide as well as the historical quality of work performed by the contractor.

Grape Creek Road, a full reconstruction, was finished in October 2011. Pleased with both the process and the result, Bailey asked Reece Albert for a change order to build a new road, Lake View Heroes Drive, as well. That project was completed in April 2012.

“He took a chance by including us,” Cornell says. It was a chance that paid off. **PW**



# Planning makes perfect

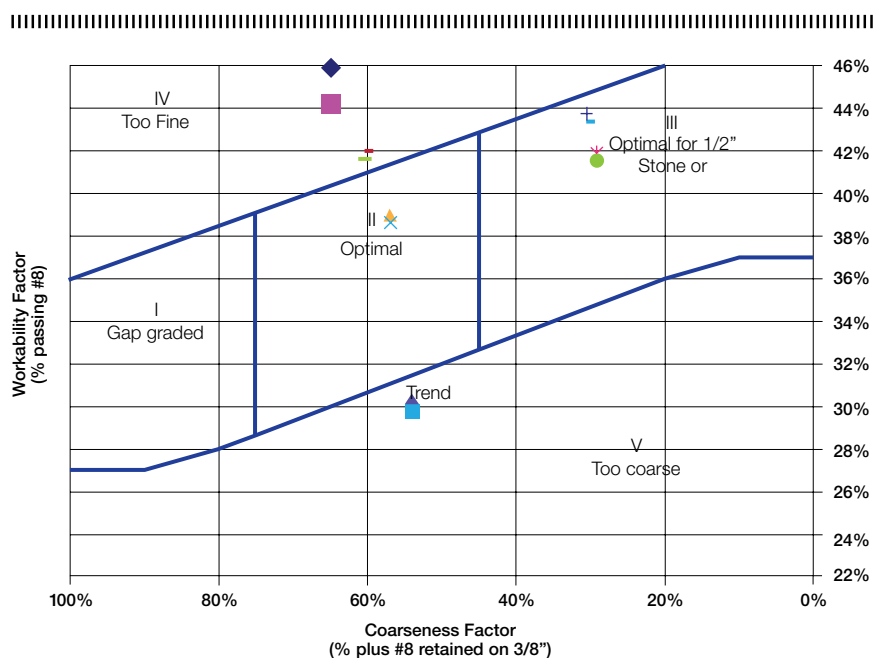
Improperly formulated and placed roller-compacted concrete is subject to surface raveling and vulnerable to freeze-thaw cycles. Use a test strip to show government customers you know what you're doing.

**R**egardless of the sport, the best players are the ones who continually prepare. Just watch the all-pro quarterback double- and triple-checking items to make sure everything is good to go before game time.

Successful roller-compacted concrete (RCC) contractors are the same. No matter how many jobs they've done, they install a test strip before each project to:

- Ensure the concrete production and construction techniques produce the same results (within tolerances) as those of the submitted mix.
- Develop correlations between lab-cured specimens and field-cast cored cylinders or sawed beams.
- Determine the amount of roll down.
- Confirm that the owner is satisfied with aesthetics.
- Work out any process issues before in-place work begins.

(continued)



Plotting the aggregates on a coarseness factor chart is useful.

They do this every single time because RCC, more than any other mix, “lives” at the intersection of soil mechanics and cement. The mixture’s unique science presents challenges that, if not addressed up front, will compromise long-term pavement performance.

Follow these six steps to plan and place a test strip that instills your customer’s confidence.

## RCC TEST STRIP CHECKLIST

### PRODUCTION

- Large project: pugmill
- Medium project: central mix plant
- Small project: twin-shaft RCC mixer under a dry-batch plant

### DELIVERY

- Dump trucks
- Arrange delivery with producer

### PAVING

- Thick, high-tolerance pavements, exposed surface: high-density paver
- Thinner, asphalt-capped pavements: conventional paver

### COMPACTION

- Roller size and type based on test sections results
- Pneumatic-tire rollers often used to seal and knead the surface

### CURING

- Compound
- Application equipment

### QUALITY CONTROL

- Nuclear gage for testing density
- Equipment (molds, hammer drill, round bit for the drill) for making ASTM C1435 cylinders
- Hand-held moisture gage
- Drill for taking cores
- Laboratory access for specimen testing

### Step 1: Well-graded aggregates required

Many first-time concrete producers use readily available crusher-run materials, which are generally too variable to produce consistent RCC.

Plotting aggregates on a coarseness factor chart is useful (see figure on page 19). For larger aggregates, the mix should plot in Zone II. For the small maximum coarse aggregate sizes used in today’s mixes, plot the mix in Zone III.

Most specifications recommend a minimum two coarse aggregates blend, typically smaller than 3/4-inch top size, as well as ASTM C33 natural concrete sand or manufactured sand. This new American Concrete Paving Association specification is an excellent guideline.

The concrete and engineering industries want to know what water-cementitious materials (w/cm) ratio to specify. The answer is simple: You don’t need to.

First, RCC gets 35% to 40% of water content from free moisture in the aggregates, compared to 25% for conventional mixtures.

Second, proper moisture content is both a strength and a density issue. Mixes are delivered in dump trucks, so you can’t tweak them after batching. If water content is too far above or below optimal, the mixture will be strong enough but lack the required density — and you won’t be able to fix that. RCC pavements without proper density are subject to issues such as surface raveling and freeze-thaw vulnerability.

Thus, water volume is based on the amount needed to achieve the required compaction. The concrete producer or RCC contractor sends all mix materials to a lab that performs a modified proctor according to ASTM D1557 to identify the optimal water content (a percentage of the total dry weight of all the materials) that corresponds with the maximum density.

Concrete technicians must have the skills to mathematically convert the optimal water content into SSD (saturated surface dry) batch weights for a computerized concrete batch panel or pull

weights for manual batching.

When the mix design has been finalized, test a trial batch by molding cylinders according to ASTM C1435. Mold enough to plot a history curve, which will be useful when comparing strength gain to tests taken from the test strip.

Currently, there is no ASTM method for molding RCC beams. Breaking cylinders in split tensile may be useful for determining bending strength.

### Step 2: Pair equipment to the project

Most large U.S. projects have been placed with a high-production pugmill and high-density paver. The latter is especially critical for both thick lift pavements (more than 8 inches) or if the surface is going to be left exposed.

For city streets and other projects that may be capped with hot mix asphalt (HMA), more conventional pavement and mixing equipment is often utilized.

### Step 3: Select test strip location

The test strip can be incorporated into the project. The area should be large enough so that all facets of the job, including fresh joints, can be installed.

Most test strips are a minimum of four loads.

### Step 4: Manufacture the mix

The production facility that will be used for the project should manufacture the RCC for the test strip.

If the material supplier and installation contractor are different companies, require the supplier to mold cylinder specimens according to ASTM C1435 to document that the mixture was properly batched.

Batch within tolerance but slightly above the optimal moisture content to account for any moisture loss during transportation.

Don’t install the test strip with RCC made from a local ready-mix plant when a pugmill will be used for the project.

### Step 5: Install the test strip

Test strip placement is the perfect time



to make sure the paver you're going to use on the job is operating properly. Spot check for proper thickness as paving progresses.

If the project is too wide to place in a single pass, place at least two loads on one pass. Then back up and do the second pass. About 12 inches of the first pass won't be rolled. When the adjacent RCC is placed, those 12 inches are rolled with the subsequent pass to produce a homogeneous pavement.

The intersection of the two passes is a longitudinal joint. There are three types with RCC: fresh, cold, and horizontal.

A joint is considered **fresh** if RCC is placed against previously placed RCC within 60 minutes and the joint remains moist. If not correctly constructed, cracks will occur.

Density is critical for **cold joints**, which are any joints that don't qualify as fresh joints. Most contractors use

#### DEVELOPING A TARGETED ROLLING PATTERN

STATION	# OF ROLLING PASSES	WET DENSITY (PCF)	MOISTURE CONTENT (%)	CALCULATED DRY DENSITY (PCF)	% OF MAXIMUM DENSITY
1000+00	0	118.7	6.0%	112.0	75.6%
1000+00	1	143.1	5.8%	135.3	91.3%
1000+00	2	154.1	6.1%	145.2	98.0%
1000+25	0	119.1	6.1%	112.3	75.7%
1000+25	1	144.0	5.9%	136.0	91.7%
1000+25	2	155.1	6.3%	145.9	98.4%

edging shoes within 10 degrees of vertical to meet density requirements. Cold joints that don't should be cut using a full-depth saw beginning at least 6 inches from the exposed edge.

Remove loose and foreign material before placing fresh mixture against a

compacted cold joint. Wet the vertical face immediately before placing the adjacent lane.

**Horizontal joints** are lifts of more than single-pass maximum of 10 inches. Place subsequent lifts within 60 minutes  
*(continued)*

## Trust your RCC Project to the Experts

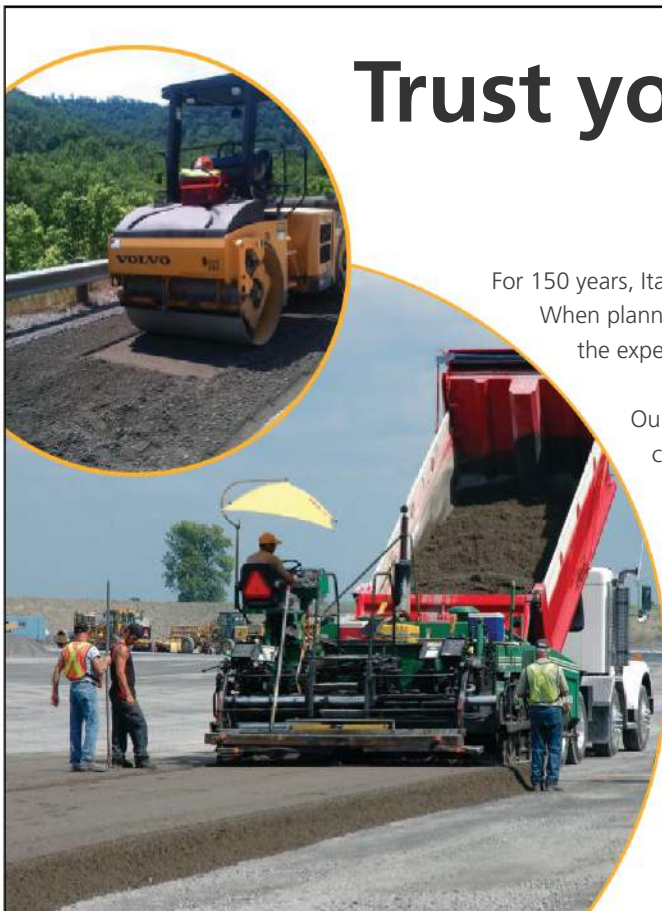
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to ensure adequate bonding and create a monolithic slab. If that deadline can't be met, the engineer can require that supplementary bonding materials be utilized. Keep the bottom lift's surface moist and apply the materials right before placing the subsequent lift.

A test strip also ensures the project achieves proper elevation.



**The amount of water required is based on the amount needed for the required compaction, so there is no need to specify a water-cementitious materials (w/cm) ratio.**

RCC is often used on local streets and roads, where it's placed between concrete curbs. If it's the finished surface, pavement and curb elevations must match. If the RCC will receive an asphalt wearing surface, the amount of roll down must be predictable for the thickness of the asphalt surface to be uniform.

Predictable roll down is also important at joints. If the roll down is underestimated, a lack of compaction can occur at the joint and lead to future durability issues. If the pavement doesn't roll down as much as anticipated, there won't be uniform elevation between placements.

Finally, curing is critical. Due to the large areas quickly being placed, the proper equipment must be used to cure the surface before it has a chance to dry out. A test strip enables the contractor to dial in the required curing compound application rate to properly cover the pavement's surface.

**Step 6: Quality control/assurance**

As previously noted, pavement strength and durability are affected by both mix design and density. Thus, verifying moisture content is absolutely critical.

Density and moisture content are monitored via the nuclear gage calibrated to the modified proctor of the approved mix. Wet density should be used because the cement's hydrogen ions can provide misleading nuclear density results.

Once the wet density and moisture content are known, the dry density and percentage of maximum dry density can be calculated. One note: Density gauges can be excellent indicators, but they're prone to inaccuracies. Consequently, many concrete producers calibrate hand-held moisture meters and use burn backs to provide a mixture at the proper moisture content.

As the test strip progresses, routinely test density directly behind the paver

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and after each rolling pass. Use this data to develop a targeted rolling pattern. Then density-test to verify proper compaction throughout the project.

Most specifications require in-place strength be verified. Do this by sawing specimens from the pavement. The test strip is an excellent opportunity to verify that the mixture and construction techniques produced results similar to those determined during the mix development stage.

Remember that temperature substantially impacts strength gain. Cylinders tested during the mix development phase were cured at 73° F. If the pavement is placed in warmer conditions, it will gain strength faster than the lab-cured specimens. Conversely, a colder placement environment will slow the rate of strength gain.

During the test strip, the relationship between lab-cured specimens and in-

## Having the correct moisture content (within tolerances) is not only a strength issue — it's also a density issue.

place cored cylinders or sawed beams can be developed.

A lab-cured ASTM C1435 cylinder should be made. Nuclear density testing can be performed on the pavement made with the same load of RCC sampled and tested. Cores taken from the pavement can be tested in compression or split tensile. Sawed beams can be tested for flexural strength.

By weighing and measuring each core and sawed beam, the density of the in-place pavement can be calculated and compared to the nuclear gage density results. The quality control team can then analyze all of the data to fully understand the pavement's in-place strength.

The construction team can also implement maturity methods based on forecasted weather. This information will be valuable when they're working long hours to complete a project before cold weather sets in. **PW**

*Written by Christopher Tull of CRT Concrete Consulting LLC, this article originally appeared in the May 2013 issue of CONCRETE CONSTRUCTION and was updated by Chris Carwie of A.G. Peltz Group LLC. E-mail ccarwie@agpeltz.com or chris@crtconcreteconsulting.com.*

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# On a roll

The rise of roller-compacted concrete (RCC).

**R**oller-compacted concrete (RCC) is a no-slump concrete that is placed by an asphalt-type paver and compacted with vibratory rollers. RCC got its start in the 1970s, when the Canadian logging industry needed a durable, economical pavement to withstand the heavy loads and equipment utilized in sorting yards. The use of RCC helped eliminate many of the traditional problems associated with hot-mix asphalt pavements, including rutting, pavement punctures, and surface spalling, which significantly reduced maintenance costs over time.

## Smaller projects becoming more common

Figure 1 shows that RCC placement vol-



umes, project numbers, and applications in the U.S. are clearly increasing. Since the beginning of the decade, utilization has expanded into many other applications such as hike and bike trails, local streets and roads, and commercial parking lots, while continuing to be used in traditional industrial-type applications. Between 2011 and 2013, more than 172 projects have been paved, covering more than 4.9 million square yards.

Figure 2 combines the data with historical studies and illustrates that as the number of annual projects grows, median project size is coming down. The reduction is due to a change in applications; while RCC continues to be used on large projects, smaller projects such as roadways, access roads, and parking lots are becoming more common.



Surface appearance from different RCC aggregate blends. All photos: Corey Zollinger

The projects were classified as commercial, industrial, intermodal, port, and roadways. For clarification, industrial projects are classified as distribution centers, equipment yards, etc. While intermodal yards and ports could also be classified as industrial, the large amount of RCC they're using justifies separating them. Table 1 summarizes the statistics for the different applications.

As has been the case since 2000, the primary user of RCC is private industry, followed by public agencies. Even though it was the first user of RCC in the U.S., military use has fallen substantially. I'm still collecting data on military use, so there are probably projects that are not accounted for in this study. Table 2 summarizes the data by owner type.

## Mix design enhancements

Aggregate and sand type selection is a major factor in final placement characteristics, finished surface texture, and engineering properties such as flexural strength.

Historically, aggregate size has varied widely, with nominal maximum aggregate size ranging from ¾ inch to 1.5 inches. Mixes were often "gap graded," producing "open" or "coarse" surfaces that, despite high strength results, tended to spall or ravel.

Today's gradation bands followed by experienced designers and contractors are much better, and mixes are custom-blended to provide "tighter" surface textures while still meeting strength requirements. Although each mix is job- and material-specific, nominal maximum aggregate sizes typically don't exceed ¾ inch and sometimes ½ inch.



ASTM C-33 manufactured and natural sands mixed with coarse aggregates to form well-graded combined aggregates can make excellent RCC. As the photos on page 24 show, these newer mixes are smoother and exhibit less surface deterioration.

End-user requirements are the key component in determining appropriate surface texture. From heavy industrial projects to residential city streets, each project owner has different needs and expectations. It's the pavement engineer's and contractor's responsibility to learn what these are, communicate RCC's limitations, and design the mix accordingly.

Admixtures are improving workability and increasing placement time. Traditional RCC consists of aggregate, sand, cement, and water. Most specifications give the contractor 45 minutes to place and finish the concrete, a deadline that's easy to meet on large industrial projects with onsite pugmill plants.

But as RCC spreads to more diverse projects, this time limit needs to be extended.

In November 2012, CEMEX Inc. and Grace Admixtures conducted tests to see if hauling time could be increased without sacrificing workability (moisture content). Laboratory results indicated placement time could be extended without compromising compressive strength or long-term durability. Six 200-foot strips of the control mix and admixture were then placed. The field study not only confirmed the lab results, but showed acceptable results with a lower dosage of admixture.

### Production advancements

RCC has historically been produced onsite in easily transportable twin-shaft pugmill mixers that can be set up in one day by two or three workers and generate 300 to 800 short tons per hour (see photo on page 27).

(continued)

### RCC SY PAVED BY YEAR

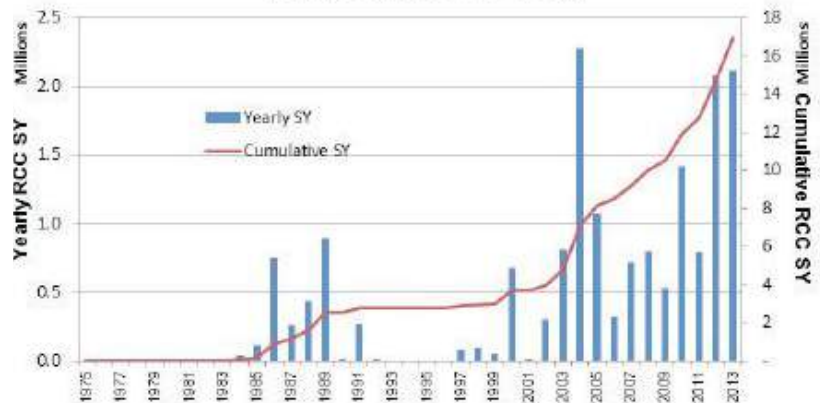


Figure 1: RCC square yards paved by year. Chart courtesy of Gary Anderton, David Pittman, and Corey Zollinger

### RCC PROJECT SUMMARY

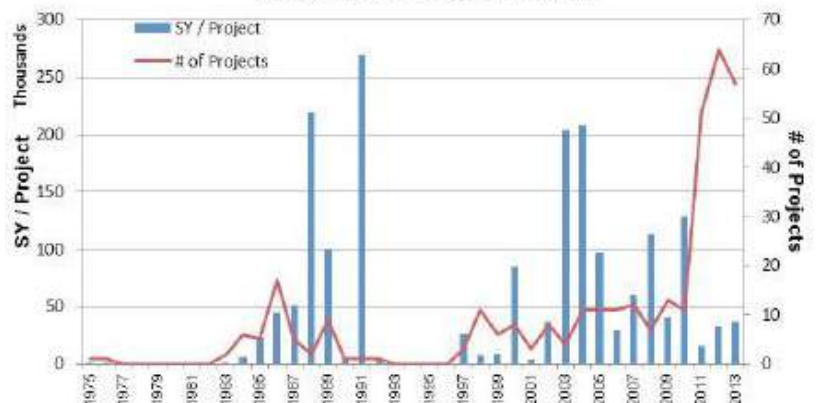


Figure 2: RCC projects in the U.S. Chart courtesy of Gary Anderton, David Pittman, and Corey Zollinger

Table 1 – RCC Summary by Application Type 2011 – 2013

Application Type	Square Yards	% Area	Projects	% Projects
Commercial	114,342	2%	19	11%
Industrial	1,986,135	40%	65	38%
Intermodal	1,522,215	30%	25	15%
Port	572,400	11%	9	5%
Roadway	798,204	16%	54	31%
Total	4,993,296		172	

RCC Summary by Application Type 2011 – 2013 Table: Corey Zollinger

Table 2 – RCC Summary by Owner Type 2011 – 2013

Owner Type	Square Yards	% Area	Projects	% Projects
Military	50,000	1%	1	<1%
Private	3,735,485	75%	124	72%
Public	1,165,240	23%	47	27%
Unknown	92,571	2%	1	1%

RCC Summary by Owner Type 2011 – 2013 Table: Corey Zollinger



(From top to bottom) RCC natural surface, diamond ground, and overlaid with asphalt.



With their limited space and air permit restrictions, smaller projects have to rely on ready-mix concrete suppliers instead. Producing consistent zero-slump mix results with batch plants and ready-mix trucks has been a challenge. That's changing, however, thanks to the development of portable twin-shaft RCC mixers that are inserted directly below existing batch plants and produce about 200 yards per hour (varies by batch plant speed).

### Final surface types

RCC is placed by asphalt-type paving equipment and finished with heavy dual steel drum rollers, which leaves a final surface appearance similar to asphalt. Over the last 10 years, owners have begun to specify diamond grinding or asphalt overlays to improve smoothness or increase stopping resistance as shown in photo B on pages 29.

Since 2011, 2% of projects have been diamond-ground, 30% received an asphalt overlay, 60% remained as natural RCC, and data is unavailable for 8%.

In terms of the RCC surface area placed, 1% of the projects have been diamond-ground, 9% received an asphalt overlay, 82% remained as natural RCC, and 8% of the surface-type data is unavailable.

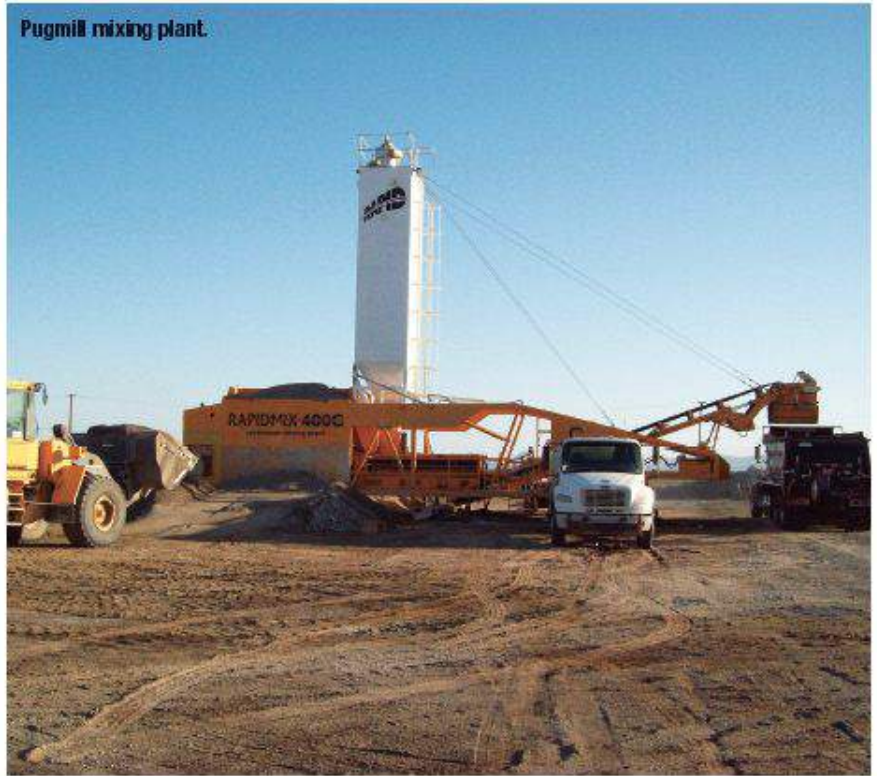
RCC continues to increase in utilization around the U.S. into many different project types. The past two



years has seen more than 2 million square yards of RCC placed annually, the highest yearly total since 2004. As RCC continues to grow in utilization and application type, the technology is developing along with it. This includes advancements to mix designs, production methodologies, and surface smoothness. RCC has now been used for building bonded concrete overlays of asphalt pavements, for unsurfaced roadways, and for national chain distribution centers. As this cycle continues, expect RCC to continue its rapid growth and provide end-users with a cost-effective durable pavement alternate. **PW**

*Corey Zollinger is director of paving solutions for CEMEX Inc. in Houston. E-mail coreyj.zollinger@cemex.com.*

Pugmill mixing plant.



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## RCC: VERSATILE AND DURABLE

Four new applications for roller compacted concrete (RCC) pavement.

**A** Admixtures make inconveniently located projects possible by extending placement times beyond 45 minutes. A 12-foot-wide East Wetlands hike and bike trail was built by CEMEX in 2013 in the City of Yuma, Ariz., which required the delivery truck to back up a quarter-mile. The arid climate and hauling time would have compromised traditional RCC mixes, but the mile-long installation of 5-inch RCC shows no random cracking a year later thanks to the addition of GRACE V-MAR VSC500, which was dosed at a rate of 3 to 5 cwt depending on the ambient conditions and the expected haul time. The mix design included 520 pounds of cement; 805 pounds of coarse aggregate; 1,675 pounds of intermediate aggregate; 805 pounds of sand; and 6.5% water. The maximum aggregate size was ½ inch, which provided the tight surface texture required for this application. Photo: Corey Zollinger

**B** The first diamond-ground RCC road is performing well five years after placement. Built in August 2009 by Morgan Corp. for the South Carolina DOT, the project entailed milling 10 inches of asphalt, recompacting the subgrade, and placing 10 inches of RCC in one lift. The mile-long, four-lane project was completed in 15 days. Material was mixed in a Rapid International USA Inc. Rapidmix 600C pugmill near the jobsite in the city of Aiken, transported in dump trucks, and delivered to a Gomaco Corp. Inc. RTP-500 rubber-track placer that conveyed it to an ABG Titan 7820 paver. The pavement was cured and sawcut for control joints every 20 feet. Traffic was allowed 24 hours later. With a speed limit of 45 mph, the desired International Roughness Index (IRI) was 85 inches/mile. Pre-grind IRI was 100 to 120 inches/mile in areas with stiffer subgrades and up to

200 inches/mile in areas of softer subgrades. The average post-grind IRI for each lane was 58.1, 73.6, 65.2, and 72.1 inches/mile with an overall average of 67.2. Photo: Chris Carwie, AG Peltz Group

**C** Despite carrying 400 tractor-trailers a day, a 69-acre RCC parking lot in Rome, Ga., displays only minimally visible random and mid-panel cracks after three years. Lowe's Home Improvement bid RCC instead of asphalt with conventional concrete dolly pads after touring facilities with RCC and weighing upfront costs. Seven inches of RCC were placed on top of 6 inches of aggregate base in 30-foot sections using an ABG Titan 7820 paver and Aran ASR 500 continuous pugmill mixing 280 to 300 cubic yards/hour. Transverse and longitudinal control joints were sawcut on a 15-by-15-foot pattern and sealed with Sika Corp.'s Sikaflex. The project was built in two months and 11 days by AG Peltz Group LLC and Peltz Companies Inc. in fall 2011. Photo: Chris Carwie, AG Peltz Group

**D** In summer 2013, the Southern Tier Catholic School in Olean, N.Y., needed a new pavement surface for the parking lot. The local contractor proposed to the school board a conventional concrete overlay as well as an RCC overlay. Due to the speed of installation, as well as the ability to open the pavement to traffic the following day, the board chose RCC. This became the first documented RCC-bonded concrete overlay. RCC was placed 5 inches thick over 5,600 square yards of asphalt pavement using a standard VT LeeBoy asphalt paving machine. The RCC was sawcut at 10-foot joint spacing. While New York has experienced a severe winter, the parking lot is reportedly performing well so far. Photo: Wayne Stevens

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**A**



**C**



**B**



**D**

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