Building it Right the First Time: Integrated Paving Solutions at the Port of Houston

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The Port of Houston is a complex of shipping and cargo-handling facilities that spans 25 miles along the Houston Ship Channel. In 2009, the Port ranked first in U.S. import tonnage and second in export tonnage, with 220 million tons of cargo serviced. It has traditionally been a bulk carrier facility, but in recent years has significantly expanded its container-handling capacity. This growth will continue and even accelerate, because of the anticipated 2014 completion of the Panama Canal expansion.

RCC placement at the Port of Houston

Solving Problems

At the Bayport Terminal, integrated concrete and cement pavement options are solving some difficult problems faced at many ports: poor soils, high water tables, no locally available aggregates, huge loading requirements, and a need for fast construction. Low maintenance is also essential, as pavement closures reduce handling capacity and profitability.

When the first phase of the Terminal was in final design, Jim McQueen, the Port of Houston Authority's (PHA) chief construction manager, learned of roller-compacted concrete (RCC) as a cost-effective pavement option. He allowed RCC bid alternates for the two container yard expansions. In addition, he specified cement/lime stabilization of the subgrade, and cement-treated base (CTB), to reduce cost and ensure 30-year durability.

The Savings

Bids on the most recent project, Bayport Phase 1, Stage 2 Container Yard, provided nearly a 15% savings compared to the non-RCC alternate, for a final bid price of $34.7 million. The unit costs were $38.89/square yard and $48.46/square yard for the 14- and 18-inch thick RCC pavements, respectively. The RCC alternate was awarded to McCarthy Building Companies, with Interstate Highway Construction (IHC) being the RCC subcontractor.

Heavy-Duty Designs

Intermodal container pavements have to withstand heavy loads, including gantry cranes carrying shipping containers, which are then stacked five-high. Three loading environments were considered for the most recent expansion: Grounded container storage, wheeled container storage, and the circulation roads. The designer, Klotz Associates of Houston, developed multiple pavement options for a 30-year design life. The RCC pavement sections consisted of 1) cement/lime stabilized subgrade, 2) a geotextile

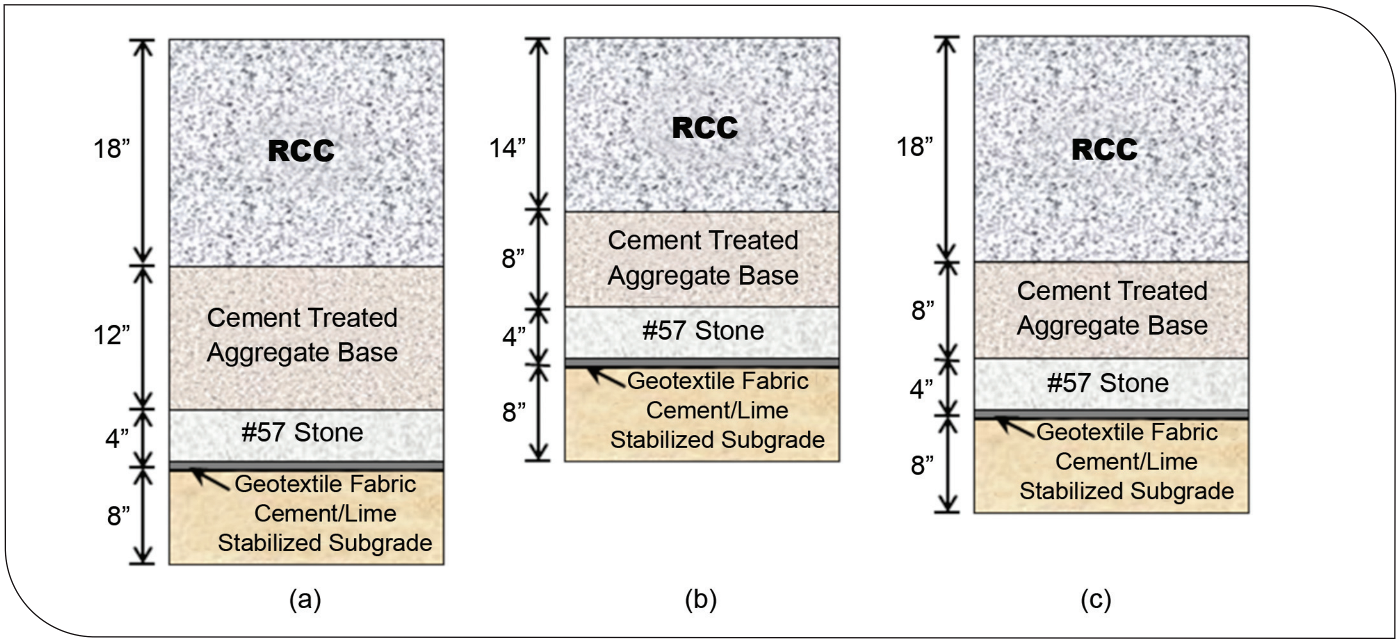


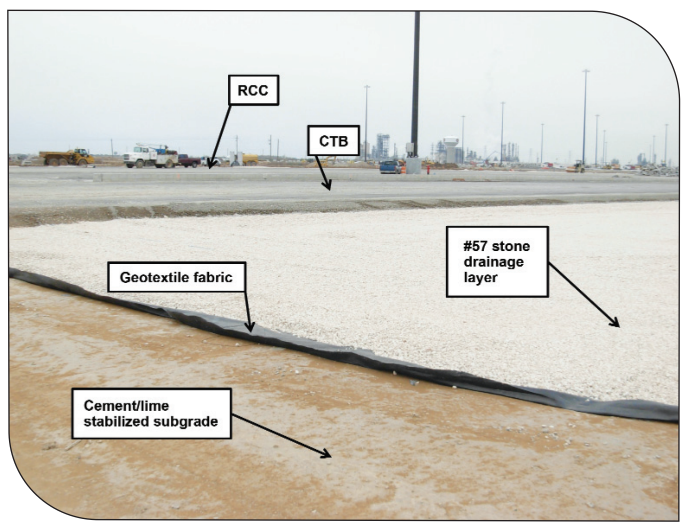
Figure 1- Pavement sections: (a) Grounded container storage; (b) Wheeled container storage; and (c) Circulation roads

fabric, 3) an open-graded drainage layer, 4) cement-treated recycled concrete aggregate subbase, and 5) an RCC surface layer (Fig. 1).

RCC Pavement

RCC production/placement rates are very high, making this an ideal concrete paving material for large, thick industrial pavements. Additionally, no steel (neither dowels nor reinforcing) is needed, further speeding placement and reducing cost. Wide allowable joint spacing and thin saw cut joints keep long-term maintenance to a minimum. The 14- and 18-inch pavement thicknesses required two-lift placements to allow full compaction, but this is quickly and easily achieved with RCC.

The RCC mixture was an optimized blend of Type I/II portland cement, washed concrete sand, manufactured sand/crusher screenings, and coarse aggregate. The specified flexural strength of the RCC was 550 psi at seven days. In addition, project specifications dictated quality control testing for density and compressive strength. The required minimum average density was 98%, with no test falling below 95% of maximum wet density as determined by the modified Proctor method (ASTM C1557).



General view of pavement layers

Table 1 – Summary of RCC test results

Test	Test Section	Production
Average flexural strength at 7 days, psi	570	---
Average compressive strength of cylinders at 7 days, psi	4,030	5,050
Average compressive strength of cores at 7 days, psi	3,430	4,440

RABA Kistner Consultants (Houston) performed the RCC testing. IHC constructed a test section prior to production placement. Results of the test and production RCC are summarized in Table 1.

Compacted CTB ready to receive RCC surface

"Green" Cement-Treated Base

The subbase for the RCC needed to be uniform and resilient, even under saturated conditions. It also had to be non-pumping under heavy, repeated loads. The designer chose CTB, as it fulfilled all these requirements at an economical cost.

Houston is an aggregate-poor locale, so the CTB supplier, Southern Crushed Concrete, suggested the use of recycled crushed concrete to serve as the CTB aggregate. This saved trucking aggregate from over 100 miles away, and the cement treatment helped improve the durability of this marginal material. The CTB also served as an all-weather work platform that provided a stiff surface for effective RCC compaction.

The CTB was produced using a pugmill plant. Southern Crushed Concrete utilized its existing plant, four miles away, eliminating plant mobilization costs. Jim Miller of Southern states, "CTB is a great product at an affordable price. In the Houston market, you commonly realize a 20 to 25 percent material cost savings using recycled concrete over virgin aggregate."

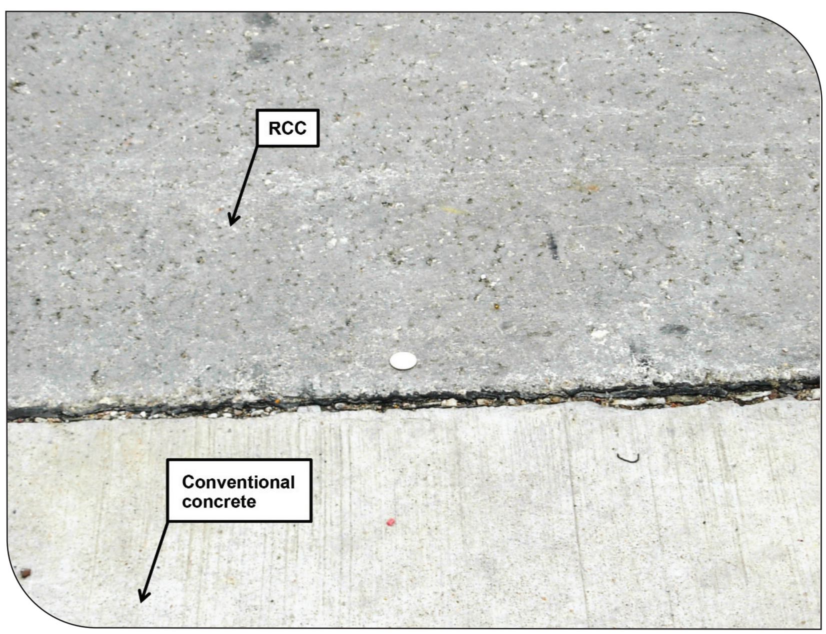
Subgrade Treatments

A stable and durable subgrade is another key to long-term pavement performance. Due to the complex, poor quality soils encountered (mostly dredged fill material), the geotechnical consultant called for 5% lime to modify soil characteristics, followed by 5% cement to ensure long-term strength and reduced moisture susceptibility. The cement/lime treatment eliminated the need to remove and replace thousands of tons of subgrade with select fill. This work was performed by Laguna Construction Company of Laguna Pueblo, New Mexico.

Impressive Results

By using RCC pavement, the Port estimated that it reduced the project construction schedule by four months while keeping maintenance to a minimum. The ability to open for business earlier, while minimizing maintenance "down-time," continues to reinforce the Port's decision to select RCC for the Port of Houston pavements.

Since 2007, nearly 100 acres have been paved with RCC (along with CTB subbase, and cement/lime subgrade treatment). Additional expansions at Bayport are planned



Surface appearance of RCC placed adjacent to conventional concrete to continue until the 1,043 acre complex reaches completion. The RCC paving in Stage 1, Phase 2, the most recent section, encompassed 44 acres. IHC began the RCC placement in January 2010, and paving was finished by early May, less than 5 months later.

Customer Satisfaction

PHA's Jim McQueen is convinced that RCC, combined with the CTB and cement/lime stabilized subgrade, was the right solution for the Port. "I have been very pleased with the excellent job performed by the McCarthy/IHC team and the professional nature in which they both operate. The Port of Houston is hoping that the success of these projects will inspire future RCC projects across Texas."

Extracted RCC core for quality control observations and testing

Credits

Owner: Port of Houston Authority, Houston, TX

General Contractor: McCarthy Construction Company, Houston, TX

RCC Contractor: Interstate Highway Construction, Mansfield, TX

Civil Engineer: Klotz Associates, Houston, TX

Materials & Testing: Raba Kistner Consultants, Houston, TX

PCA

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