Central Freight Yard
Roller-Compacted Concrete Pavement

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Central Freight Yard
The Central Freight Terminal is located in Austin, Texas. It includes a maintenance shop, an office with dormitories, a 129-dock transfer facility, and parking for an additional 327 semi-trailers. The 14.5 acres (70,000 yd²) of pavement is constructed from roller-compacted concrete (RCC), placed in 1987 by the Peltz Companies of Alliance, Nebraska.

Design
RCC pavements were designed to be 7 inches thick in trailer parking areas and 8 inches thick in travel lanes. At free edges, the RCC pavement was thickened to 10 inches to provide additional support. The RCC was placed directly on 6 inches of lime-stabilized subgrade soil, which is a highly expansive fat clay, as shown in Figure 1. No aggregate base is present.

<table>
<thead>
<tr>
<th>Central Freight Yard Quick Facts:</th>
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<tbody>
<tr>
<td>Location</td>
<td>Austin, Texas</td>
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<tr>
<td>Pavement Area</td>
<td>14.5 Acres</td>
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<tr>
<td>Use</td>
<td>Freight Terminal</td>
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<tr>
<td>RCC Thickness</td>
<td>7-8 inches</td>
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<td>Initial Construction</td>
<td>1987</td>
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<tr>
<td>Design Life</td>
<td>20 years</td>
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<tr>
<td>Truck Movements</td>
<td>100+ per day</td>
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<td>Design Vehicle</td>
<td>Class 9 Truck</td>
</tr>
<tr>
<td>Trailer Parking Spaces</td>
<td>456</td>
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</tbody>
</table>

Figure 1. Expansive Soil Observed at Edge of Yard

The RCC mixture design is atypical, being a 50:50 blend of cement and fly ash, including 250 pounds per cubic yard of portland cement and 250 pounds per cubic yard of fly ash. This replacement level of fly ash is extremely high by industry standards and as a result, the 3,625 psi 28-day compressive strength of the RCC is relatively low compared to what is normally expected for conventional RCC mixtures. It is known that high volume fly ash mixtures such as this will continue to gain strength over long periods of time and it is quite possible that the in-place RCC strengths are significantly greater than that measured at 28 days contributing to the exceptional structural performance of the RCC at this site. The limestone
aggregate was well-graded, being produced from a combination of ¾ inch road base and manufactured sand produced in the Austin area. The percent passing the #200 sieve was in the range of 12% to 15%. The RCC was produced on-site using an ARAN ASR 2000 continuous mix pugmill, with two aggregate bins, a cement silo and a fly ash silo. It was noted that the resulting mix was harsh and difficult to work.

**Construction**

RCC paving was performed by Peltz Companies as a subcontractor to Billington Construction. The RCC was placed in a single, 28-ft wide lift using an ABG Titan 410 paver with tamping screeds. The RCC was transported from the pugmill to the paver using three-axle dump trucks. The truck drivers were experienced with RCC paving, having worked on previous jobs, allowing the RCC to be supplied to the paver at a rapid and constant rate. This expedited construction and prevented excessive starting and stopping of the paver creating a more uniform surface. Today, this would likely be accomplished through the use of a materials transfer vehicle. Final compaction was performed using 10-ton, smooth wheeled rollers without vibration.

After final compaction, but before curing was initiated, a cement slurry was applied to the edges of the mat using a squeegee with the intent to improve the appearance of the cold-joints and reduce spalling. The slurry did not contain fly ash and had a much whiter appearance than the 50:50 cement-fly ash RCC mixture. This difference in appearance is still easily observable today (Figure 2).

After application of the cement slurry, the RCC was wet-cured for seven days with water applied to the surface using water trucks.
Performance

A visual survey was conducted of the facility in October 2015, 28 years after construction. The RCC is in excellent condition, with little evidence of distress after nearly three decades of carrying heavy truck traffic. The minor distresses that were observed are having little to no impact on the ability of the RCC pavement to provide a high level of service and it is anticipated that this pavement will continue to perform for the foreseeable future. That being said, a few distresses and some repairs were noted during the visual assessment. One observation is that in most areas, a longitudinal crack is present at the center of the 28-ft wide paving lane. As shown in Figure 3, the longitudinal crack remains in good condition and appears as if it is a joint. In addition, transverse cracks have formed at approximately 10 to 40 foot intervals. These are also shown in Figure 3. For the first three years after construction, Central Freight routed and sealed the cracks that formed (shown in Figure 4). Cracks that formed subsequently have not been sealed, and the sealing has not been renewed.

Figure 3. Longitudinal and Transverse Cracks
Figure 4. Routed and Filled Cracks

In addition, approximately 5% of the pavement surface has been patched with conventional portland cement concrete (PCC), as shown in Figure 5. The predominant reason for this patching was to repair areas that heaved due to the expansive soils. Patching of some areas was also required during construction when a water line broke, resulting in substantial subgrade heave as it became inundated. Isolated areas of heaving continue to occur where water is able to penetrate the surface, such as at construction joints as shown in Figure 6.
Figure 5. Conventional PCC Patch

Figure 6. Heaving at Longitudinal Construction Joint Due to Expansive Soil (unrepaired)
Overall, the surface of the RCC looks very similar to that of a hot-mix asphalt (HMA) surface, other than color. There are areas where the surface texture appears to be raveled, but are instead indicative of localized segregation or less than ideal compaction. This is shown in Figures 2, 4, and 5. Another surface feature that is similar to HMA are small surface tears that generally align perpendicular to the direction of paving as shown in Figures 6 and 7. Their appearance is very similar to “heat-checking” that is often seen in newly paved hot-mix asphalt (HMA). In HMA, traffic will knead most of these tears out over time, however this kneading does not occur in RCC. But performance at the Central Freight facility, as well as other RCC facilities of similar age, demonstrates that these tears do not progress or become more severe over time, or otherwise compromise the strength or durability of the surface, being purely cosmetic in nature.

The only other distress observed is an artifact of design, being primarily limited to areas where paving lanes intersect at acute angles resulting in cracking and minor displacement (Figure 8). The angle between paving lanes resulted in irregularly-shaped slabs, which, as with conventional concrete can result in corner breaks and re-entrant cracking. In addition, as the paver has to be stopped and re-positioned to begin the new paving lane, a cold joint is formed providing an opportunity for segregation and low density of the mix to occur, resulting in reduced durability and longevity.
Ideally, the site design and paving plan should be optimized so that most, if not all, of the paving is performed in straight “pulls”. This will increase the efficiency of the paving operation, resulting in cost savings, as well as resulting in a more consistent and higher quality product. Where paving lanes must intersect, particularly at acute angles, consideration should be given to include isolation joints between intersecting paving lanes to minimize the potential mechanical conflict developing at the joint resulting is spalling and blowups. Another option may be to use reinforced conventional concrete immediately in the vicinity of the intersection to control cracking. The reinforcement is not expected to prevent cracking, but it will keep any cracks that form tight and easily maintainable. Further, the use of conventional concrete at these intersections with acute angles will eliminate the presence of segregation and poor density that can occur in RCC at these locations.

**Life Cycle Costs**

The initial cost of the RCC paving in 1987 was $13 per square yard for the 7-inch thick areas and $15 per square yard for the 8-inch thick areas, for a total paving cost of $996,500. Maintenance performed to date has included minor routing and filling of cracks, performed early in the pavement’s life, and patching of approximately 5% of the surface area, predominantly due to repairing areas that heaved due to swelling soil. Assuming $10,000 was spent on crack sealing for each of the first two years, and 1% of the surface area was patched with conventional concrete every six years at a cost of $28 per square foot in 1987 dollars, the total life cycle cost comes to $1.31 million in non-discounted dollars for the 29 year life of the facility. This is illustrated in figure 9, and results in a total life cycle cost of $1.11 million in 1987 dollars, using the OMB nominal rate of 5.7% for the period of 1987 to 2016. It is noted that this OMB nominal rate is higher than the discount rate typically used for public agency life cycle cost analyses, as those analyses typically do not use inflated future costs.
Summary

The RCC pavement at the Central Freight yard has provided 29 years of good service with low maintenance under heavy traffic on highly challenging soils. Most of the patching that has occurred was done to address heaving of the expansive soil. The remaining small areas of structural distress are primarily limited to places where paving lanes intersected at acute angles. As discussed, this occurrence is preventable through the use of good site design and in the development a paving plan that minimize acute angles and ensures that most of the paving is performed in straight “pulls”. In those locations where acute angles cannot be avoided, the use of reinforced conventional concrete has been found to create a long lasting solution. Aside from the small number of distresses identified, the RCC pavement at the Central Freight yard has performed exceptionally well for 29 years of service, and it is expected that many more years of service are in store without the need for major repair or rehabilitation.