and 7 feet was the maximum depth excavated.

In many areas, the soft material was covered by sandy material. This material was stockpiled and used for backfill. Additional pit-run gravel backfill was obtained from a pit located near Kent. That pit generally had a maximum size of about 3 inches and was reasonably well-graded to fine sand sizes. About 35 or 40 percent was finer than the No. 4 sieve; the more silty materials were eliminated by selection at the pit. The same material was used for the gravel base. To keep the backfill from being contaminated, soft areas were covered with a geotextile which made a "sausage" of the backfill.

One problem that developed during construction was that many of the manholes extended downward into the very soft and deep materials, so the weight of the Piggy-Packer or loaded trailer could cause excessive settlement. This problem was solved by constructing concrete slabs about 10 feet by 10 feet in the bottom of excavations to support the manholes.

Since the facility was completed, it has been subjected to high Piggy-Packer and trailer usage. The only known pavement failure has been a small section at the trailer entrance where there was insufficient removal of soft material. Detailed observations have revealed no other failed areas, or even areas that suggest potential failure. Only in the trailer parking areas has there been any distress. In most cases, portland cement concrete strips were constructed to support the trailer dolly pads. These strips were 5-feet wide (except one 3-foot wide pad near the west side of the parking area). Trailers parked 90 degrees to the concrete strips generally have their pads setting on the concrete strips (except many miss on the 3-foot strip), but where angle parking is used a large percent of the pads rest on the asphalt pavement. When the project was first opened, it was quite common for the round pads to sink into the asphalt pavement about 1/4-inch, but since the facility has been in use and the pavement hardened, none of the dolly pads now appear to be causing compression of the pavement. Concrete strips 8 feet wide would solve most of the problem.

Adjacent to some of the manholes, the pavement has settled up to about 1-inch as a result of poor subgrade and base compaction, probably because the roller operated lengthwise over the areas to be paved. At the manholes, the rollers passed outside of the structures leaving V-shaped areas with insufficient compaction.

## CONSTRUCTION, PERFORMANCE AND MAINTENANCE OF ROLLER COMPACTED AND OF POURED CONCRETE IN INTERMODAL YARDS AT THE PORT OF TACOMA

BY

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Port of Tacoma

The Port of Tacoma has a North and a South intermodal rail yard. The South yard was constructed in 1985 and was made exclusively of Roller Compacted Concrete (RCC). It covers about 13 acres and was constructed in 120 calendar days and cost $2 million. This was our first experience with RCC. It uses an aggregate with 450 pounds of cement and 100 pounds of flyash.

The North intermodal yard covers 23 acres. We spent $4 million to construct the yard. It has both RCC and cast-in-place surfaces that have performed well.

The two yards are operated differently. Our South yard uses top picks and the North yard uses straddle carriers.

Both RCC and cast-in-place surfaces are extremely different and have their pluses and minuses. In the South yard, the RCC was placed just as you would place asphalt. The contractor had a batch plant on site. We placed crushed rock over the site so we could run machinery on it without rutting the ground surface. We then placed 17 inches of asphalt, 8-1/2 inches at a time. A problem with RCC is the surface. It is subject to cracking at construction joints mainly. A problem we had at these transverse joints is that the cracks are uncontrolled and always occur at a catch-basin. The way that the yard is designed is that the drainage valley is down the center, and the paving machines do not adjust to the valley in the RCC.

The RCC in the South intermodal yard is presently wearing fairly well. At first, we had some dusting problems, but use of the facility and grinding down some of the RCC surface helped create a good lock on the surface.

An apperance problem, is the edges of the South yard. We were not sure how to handle this during construction, but when you run a straight edge off the paving machine and then roll the surface, then the edge tends to break down at an angle. We had no way to compact the edge, so it is a little loose. Our stopping point is back from the edge, so the condition should not be a problem.

When we first started having problems with the cracks in the joints, we put liquid asphalt in them. This was not pliable, and in the cold weather, it would shrink up and come out. In hot weather, we would patch it. There were places where rubber tires actually picked up the asphalt, but it worked pretty well.

In some joints where the cracks opened up quite a bit, we placed a fine asphalt in the cracks and put the liquid asphalt around them. That has held up pretty well. The North intermodal yard is served mainly by straddle carriers. The "strads" have a tire pressure of 130 psi, and they are abusive to any type of surface.

The RCC on the North yard was placed in 1985. The paving machine used on this project had self-tamping bars which provided 95 percent compaction. The mix of the RCC in the North yard was the same as that in the South yard. The surface was a lot tighter than using traditional methods of pouring concrete. We have not had the cracking in the North yard as we had in the South yard. The machine gave a tighter surface on the edge and produced a sloped edge of about 15 percent.

The RCC was placed in the North yard during the hot season, and I believe that the contractor did not water properly, so the surface dried out. When that occurs, you do not get any matrix on the top of the surface. As tires start running over the RCC, it abrades and self-destructs. This caused quite an alarm at first.

One fix for the problem was to place a coal tar emulsion on the areas that were abraded, along the tracks and where the strads come into the train and turn. We placed two or three coats to see how it held up. The coal tar emulsion has since wore off, but it did its job in preventing cracking.

There are some maintenance problems with RCC, due to the uncontrolled cracking. All things being equal, I would choose cast-in-place over RCC due to the fact that you get a tighter matrix on the surface, better control over cracking and better control over your grade.

## RCC EQUIPMENT DEVELOPMENTS AND CONSTRUCTION TECHNIQUES

BY
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Portland Cement Association

Roller Compacted Concrete (RCC) is providing an interesting alternative to many agencies that are in the business of providing hard surfaced areas. It overcomes some of the problems of asphalt while providing the benefits of conventional concrete at a reduced price.

Knowledge of RCC has expanded considerably from the time of its first use in the mid-1970's, but there still is a need for experimentation and more research to make this product even better.

RCC is essentially the same material as conventional concrete. The difference is that it is backed a bit differently and placed differently. RCC typically has a little less cement content than conventional concrete and is rolled into place instead of being cast into place. Because it is a dry mixture, the water content is less. So, RCC is basically a non-plastic or dry mix.

RCC pavement thickness design methods are generally accepted to be the same as conventional concrete. RCC has the idiosyncracy that the initial cracking occurs at very long joint spacing. This produces, as far as cracks go, a very wide or open crack, any where from 1/4 to 1/2 inch.

This poses a problem with pavement design. The criteria for conventional concrete is based on the fact that, at a joint or edge of a crack, we have load transfer across that joint and support by the adjacent panels in all directions. If we take an RCC crack, we have essentially a free edge, and the pavement has to be thicker to sustain the increased stress. To account for the stress, design methods dictate or require that design loads be increased by as much as 20 percent.

If the RCC is batched and constructed properly, the flexible strength of RCC tends to be anywhere from 10 to 30 percent stronger than conventional concrete. So the increase in stress is offset by the increased flexible