more cautious from that point on. Concrete operations continued on into July and August, and temperatures soared into the 100's. We became concerned with plastic shrinkage, cracking and flash sets at this point which could result from high mix temperatures. As mentioned earlier, the curing compound was applied immediately after finishing, which eliminated the occurrence of plastic shrinkage cracks. To avoid flash sets, the contractor watered down his coarse aggregate pile to keep it cool and reduce the mix temperature of the concrete. We experienced no problems with flash sets.

The concrete operations were very successful and produced a concrete pavement of exceptionally high quality.

Asphalt

Asphalt had a very limited use on this project. It was used as a level-up to fill in low spots in the existing crushed stone base with asphalt surface which was to be overlaid. It was also used between the railroad tracks to allow crossing the tracks at any point. Finally, and primarily, it was used as the wearing surface over the soil-cement in the Northwest Lot, on which empty trailers were stored.

ASPHALT CONCRETE PAVED YARD FOR THE UNION PACIFIC IN SEATTLE

BY
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The Union Pacific Railroad Company's Seattle Intermodal Facility is located a short distance south of Spokane Street, roughly between 1st and 5th Avenues. A portion south of the 5th Avenue viaduct has been used as an intermodal facility for several years, but the yard needed to be expanded. The expanded area is about 3,300 feet long and up to about 500 feet wide, and extends from 6000 feet northerly from the 1st Avenue viaduct to 700 feet southerly from the 5th Avenue South viaduct. The expanded area has been used for tracks, but did not carry heavy vehicular traffic.

The facility is on the old Duwamish River floodplain. About 80 years ago, to improve the area for development, the river was channeled to its present location, leaving old meanders in the developed area. The old meanders cut through the northerly portion of the intermodal facility and were about 18 feet deep below the present ground surface. In addition, the floodplain was from 2 to 12 feet below the present ground surface.

Initial site investigations consisted of 19 hollow-stem auger borings with Standard Penetration Tests followed by 15 backhoe test pits and 53 Falling Weight Deflectometer tests. Fourteen field California Bearing Ratio (CBR) tests were conducted at selected locations and two plate-bearing tests were performed. Subsurface materials were found to be extremely variable. Until the early 1950's, the old river meanders had been used for disposing of trash consisting of cinders and ashes, glass, various kinds of metals, and chunks of concrete. The rest of the area had been filled with highly variable materials ranging from sand and gravelly sand to very soft clay. The water table was generally only 2 to 3 feet below the ground surface. The old meanders filled with trash were extremely soft, but the rest of the area was inconsistent. Extremely soft areas were found immediately adjacent to firm areas. Some CBR tests had essentially zero strength, and both plate-bearing tests actually failed with loads of less than 50 psi.

One consideration in the design was that the two viaducts restricted the headroom so the final grade could be raised only about 1 foot. This restriction prevented using an overlay of additional fill to solve the stability problem. Based on the subsurface explorations and tests, it became apparent that in certain areas, the pavement could be designed for existing conditions, but in other areas the poor quality material would have to be excavated and replaced with better material. Based on observations and test data, areas not requiring treatment were assigned values for pavement design of K = 100 psi and CRB = 15. The intent was to replace the poor material to the extent that these values could be used throughout the area.

Because it was impractical to delineate the boundaries of unsuitable areas from borings and test pits, it was decided to proof-roll the entire area with a fully loaded 50-ton pneumatic-tired roller with 50 psi tire pressure. This rolling was done after initial site grading was finished. The 50 psi tire pressure was selected because that pressure would approximate the pressure from a loaded Piggy-Packer for 2 feet below the final pavement surface, about the level to be proof-rolled. The roller was operated at a speed of 2 mph for at least 12 passes.

The first few passes did not always show up the soft areas, but by 12 passes the soft areas could be detected and their boundaries delineated. These boundaries were mapped for future excavation.

Two pavement designs were developed for the facility. It was assumed that to obtain a consistent K = 100 psi subgrade value, an average of 3 to 4 feet of material would need to be replaced in the soft areas. To obtain a consistent subgrade for asphalt pavements, 5 to 7 feet of soft material would have to be replaced. The pavement designs prepared were for portland cement concrete and asphaltic concrete (hardest grade) for areas to be used by Piggy-Packers, for trailer traffic, and for parking. No design was prepared for Roller Compacted Concrete (RCC) pavements because of the soft and deformable subgrade likely to be present during construction.

The Union Pacific Railroad Company secured bids from several contractors for both types of pavement (including excavation and replacement of soft areas). As so often happens, much of the work was done during wet fall weather and paving was done in January 1987. The new facility has now been in service about 1-1/2 years.

Frequently, soft spots were long, narrow strips where material has been dumped without compaction, but most often they were in large, irregular areas. Sometimes the very soft material could be removed to firmer soil, but in many places, such as old river meanders, the soft material continued down to greater depths than excavated. Generally, the deeper materials were soft at all locations. The original estimate of 5 to 7 feet of soft material to be removed turned out to be reasonable. In most places, excavation was close to 5 feet 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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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