

Interlocking Concrete

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A New Berth Record *Port of Oakland Delivers Largest Paver Project in North America*



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Port of Oakland Places Largest Concrete Paver Project in North America



Berths 55/56 at the Port of Oakland utilizes a record breaking 39 acres (16 ha) of interlocking concrete pavement for container yards. The earth works in the right background (behind cranes) will see an additional 46 acres (19 ha) next year, soon to be another record breaker.

At the beginning of this summer, the Port of Oakland, California completed a massive, 1.7 million sf (170,000 m²) installation of concrete pavers for container handling and storage areas. The Port now holds the record as building the largest single project of concrete pavers in North America. (The Port of Freeport, Bahamas moves to second place with 1.2 million sf (120,000 m²) placed in a single project in 1995.) Manufactured and installed by ICPI members, the Oakland project represents the largest single mechanically installed paver project in the Western Hemisphere. Berth 55/56 represents significant progress for the concrete paver industry in the development of specifications, construction methods, and inspection processes for port paving projects.

Named for its location within the huge port complex, the Berth 55/56 project is the cornerstone effort to reconfigure and expand railroads, wharves, container storage, streets, and provide a waterfront park on about 1,110 acres (450 ha) next to the San Francisco Bay. Taken together, the projects comprise a \$600 million investment

as foreseen in the Port's "Vision 2000" master plan.

When completed, the Port of Oakland facility will simultaneously serve several post-Panamax container ships along a 6,000 ft (1,830 m) wharf with huge, fast cranes reaching across 22 containers and loading/unloading 34 per minute. The cranes are so tall that they cleared passing under the Golden Gate Bridge by a mere 2 ft. (0.6 m) on their delivery by ship to Oakland.

One Good Berth Deserves Another

The decision to use concrete pavers in Berth 55/56 was in part influenced by the success of the performance of 7.5 acres (3 ha) in nearby Berth 30. Constructed in 1993, the project was the cover story of the February 1994 issue, the first issue of this magazine. The project was a breakthrough for the concrete paver industry being the first of a significant size on a West Coast port in North America. Operated by Trans Pacific Container Leasing Corporation, the interlocking concrete pavement at Berth 30 supports shipping containers (transferred by reach-stackers) and truck chassis storage.

The driving reason for going with concrete pavers in the Port of Oakland's Vision 2000 plan was flexibility. At the plan's outset, no tenants were secured for the five-berth facility prescribed in the document. Therefore, the layout for the container terminals required



The Port of Oakland's first success with concrete pavers in 1993 in Berth 30 helped influence their use in much bigger projects slated for the next several years.



Container lift trucks readied for use at the port. Axle loads will be as high as 200,000 lbs (90,700 kg).

maximum flexibility since a tenant or tenants could lease any combination of berths. Jerry Serventi, P. E., the port's Principal Engineer, ultimately approved concrete pavers. His decision was due to many factors, with the main one being complete flexibility in the layout of the terminals.

Pavers also received a boost from a tenant, Hanjin Shipping, who entered the picture about a year into the project planning process. Pavers were presented to Hanjin as the preferred option for pavement. Bob Johansen, P.E., with JWD of Oakland are specialists in port planning and design. JWD developed the master plan for the port and design

for Berth 55/56. Mr. Johansen pointed out that, "Concrete pavers offered Hanjin flexibility to operate top pick and rubber-tired gantry (RTG) container handling equipment in any configuration and at different times throughout the year." He further noted that based upon Hanjin's positive response to pavers, the amount planned was actually increased for the site. The result was 39 acres (16 ha) extending 900 ft (275 m) from the back of the wharf into the container yard would be interlocking concrete pavement.

Pollution Containment and Recycling Save Money

Two million cubic yards of dredged

soils were stockpiled on the site and eventually used in the grading. Soils dredged from the San Francisco Bay were monitored for their toxic levels during the fill process. Most soils remained, while those with unacceptable toxic levels were removed from the site.

Prior to filling areas with soil, each was covered with a network of geotextile wick drains. Dredged soil fill settled and de-watered from the surcharge from additional soil placed over it. After several months of de-watering and settlement, the soil fill was leveled and compacted and covered with an 20 in. (500 mm) thick layer of compacted aggregate base.

In addition, materials from many demolished buildings and pavements were incorporated into the fill, thereby sparing the expense and air pollution of hauling them offsite. These materials were from a former U.S. Navy base called the Naval Fleet Industrial Supply Center. The supply base was sold to the port as part of a national program of military base closures initiated in the 1990s.

While most dredge soils were kept on the site, measures were necessary to help contain leachate emissions. One of the techniques used for containing them was capping the soil and aggregate base with a 3 in. (75 mm) thick asphalt layer. The asphalt cap helps reduced the potential for leaching of materials from the soil. The asphalt also provided additional structural support for axle loads in excess of 200,000 lb. (90,700 kg) expected on the concrete pavers.



Pavers were made in a large, 14 sf (1.3 m²) herringbone pattern to help speed installation



Mechanized equipment lifts and places several paver layers per minute.



Straightening of pavers creates straight joint lines and consistent joint widths prior to compaction.

Design Rationalized Higher Cost of Concrete Pavers

Harza Engineers from Oakland provided geotechnical guidance on the project. According to Darius Abolhassani, P.E., with Harza and Mr. Johansen, the 3 in. (75 mm) thick asphalt layer helped reduce the aggregate base thickness and related excavation costs. The soils under the pavement have a high potential to shift during an earthquake (liquefaction) and may settle unevenly, especially after repeated wheel loads from container handling equipment. Concrete pavers allow a serviceable pavement even with some degree of subgrade movement.

Mr. Abolhassani and Mr. Johansen both noted that an advantage of the interlocking concrete pavement was that they allowed the use of RTGs without expensive, cast-in-place concrete runways that are typically used to support them. Like some shippers, Hanjin uses different kinds of container handling equipment depending on demand, yard layout, and operating costs. Hanjin chose top-pick

lift trucks and 8-wheeled RTGs to operate in Berth 55/56. The combined cost savings of not needing 5 ft (1.5 m) wide concrete runways, a reduced base thickness, plus the increased structural and environmental benefits from the asphalt layer provided sufficient savings to justify the expense of interlocking concrete pavement.

Once the asphalt cap was placed, an inch thick layer of bedding sand was placed over it using powered sand screeding equipment. The sand was regularly tested for gradation and degradation. Gradation specified was ASTM C 33 for concrete sand that essentially had 0% “fines” or material smaller than the No. 200 (0.075 mm) sieve. Experience has shown that it is important to restrict this material from the bedding sand so that water can drain and not allow the sand to become saturated. The absence of

No. 200 (0.075 mm) sized sand helps reduce the likelihood of saturation and instability under wheel loads.

Degradation of the sand was tested using the Lilley-Dowson bottle rolling test. Developed in 1988, this test procedure assesses the degradation of approximately one pound (0.4 kg) sample of bedding sand subjected to 6 hours of tumbling in a quart (liter) sized ceramic jar with two small steel balls. The ability of the sand to resist degradation is

assessed by measuring the increase of particles passing the No. 200 (0.075 mm) sieve (and others) after tumbling. The presence of too many of these small particles or “fines” was identified as a potential for creating instability in the pavement surface should the bedding sand become saturated. The ASTM C 33 gradation and hardness tests are recommended in the ICPI guide specifications for heavily loaded pavements, and the test has been specified in other port and airport pavement projects.

All of the 7.6 million, 4 in. (100 mm) thick concrete pavers for the port were manufactured in a herringbone pattern and stacked in large 14 sf (1.3 m²) layers ready for machine placement. In past port projects, layer sizes have been typically around 11 sf (1 m²) in area. So the slightly larger layers used at the Port of Oakland yielded some additional efficiency in installation production.

Mechanized equipment especially designed to grab, move, and place each paver layer helped pave 5 to 6,000 sf (5 to 600 m²) per machine per day. This production rate includes compacting the concrete pavers, filling the joint sand, and doing the second compaction. The project saw up to seven mechanical installation machines working at the same time. Developed in Germany and sold in North America, the machines are specially designed to accelerate the installation of concrete pavers while managing crew fatigue.

Saw cutting was done to fit pavers against edges, drains, utility structures



Cutting pavers to fit at the drains used units no smaller than one third of a paver.





Initial compaction of the pavers in the bedding sand was done on large areas at one time.



Joint sand is swept across the paver surface and into the joints. A second compaction (not shown) with plate compactors help move the sand into the joints. The paver surface was later proof rolled with a large roller to further seat the units into the bedding sand.

and other structures located on the pavement. For areas subject to traffic, cut pavers were no smaller than one-third of a whole paver. Such areas included those against drains.

After placing an area of pavers, they were compacted into the bedding sand. Sweepers spread joint sand across the surface of the pavers and worked it into the joints. The joint sand was smaller in size than the bedding sand to facilitate fast entry and filling of the joints between the pavers. The concrete pavers were compacted again to work the sand into the joints. Additional sand was swept into the joints during the compaction process until the joints were filled.

The slope of the pavement is 1% to enable stable stacking of containers. The low slope means water will be slow draining from the surface. Therefore, a liquid polymer sealer was applied to the surface in order to attain early stabilization of the joint sand and reduce infiltration of water.

The sealer was applied after removal of excess sand from the surface. Re-application of the sealer is not expected as the sand at the surface of the joints will likely receive sediment and materials from tire wear to help maintain them in a sealed state.

The Port's specification required that pavers be sampled and tested regularly to ensure conformance with ASTM C 936.- Freeze-thaw testing was not required since Oakland does not see freezing temperatures. Compressive strengths were maintained at the required average of 8,000 psi (55 MPa).

Sample pavers were certified by ICPI as meeting ASTM requirements.

Smooth Operators

Tackling a project of this size involved moving quickly up a learning curve by all involved including the project inspectors, the general contractors, the paver installation subcontractors, and the paver manufacturer. There were many lessons learned during this project, all of which were worked through with the patience of the Port of Oakland staff and their construction management team, Parsons CMT. One of the most significant lessons was managing the placement of the layers and joint widths between them during mechanical installation.

The concrete paver installation contractors had the manufacturer number each package of pavers delivered to the site and, wherever possible, install them sequentially. This helped to some extent in reducing delays from force fitting layers together by grouping layers of similar widths.

In addition, the paver installation contractors also determined the average width of the layers. They then pulled string lines set at multiples of the average paver layer width. The string lines provided a framework for placing the layers while reducing shoehorning of layers to a minimum. This enabled an initially "loose" installation with wide joint widths. Layers were then adjusted and tightened together to the specified maximum joint width of 4 mm. Compaction of the pavers followed as described earlier.

The trip to the top of learning curve—and smooth installation productivity—were increased once these procedures were worked out. The Port of Oakland required method statements from the manufacturer and contractor in subsequent construction specifications. The objective of such an approach was

to establish working procedures to ensure a smooth operation on the job site.

Record Breaking Berths

As of late June 2001, the Port of Oakland approved contracts for the next major phase of construction, Berth 57/59. This project includes 2 million sf (200,000 m²) of concrete pavers in container yards. Completion is expected in 2002. When paved, it will be a *new* record for the largest interlocking concrete pavement installation in North America. Producer and contractor members of the Interlocking Concrete Pavement Institute will supply the materials and the installation. As the suppliers and installers for Berth 55/56, they've topped of the learning curve and should find a smoother ride while paving another record-breaking area of concrete pavers in Berths 57/59. ♡



At the Port of Oakland, 1.7 million sf (170,000 m²) of concrete pavers and huge cranes anticipate the arrival of shipping containers.