ESCSI

FEATURED PROJECT 03-2003

Marine Terminal - Port of Albany

PROJECT
Marine Terminal Expansion
Port of Albany

LOCATION
Albany, New York

OWNER
Albany Port District
Commission

ENGINEER
Childs Engineering, Inc.,
Medfield, Massachusetts

CONTRACTOR
Edward B. Fitzpatrick
Construction Corporation
Engineers and Contractors,
Williston Park, NY

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LIGHTWEIGHT FILL HELPS PORT OF ALBANY EXPAND

View of completed rehabilitation of the Port of Albany's marine terminal, now in operation.

LIGHTWEIGHT FILL HELPS RECLAIM, STABILIZE AND EXPAND THE MARINE TERMINAL AT THE PORT OF ALBANY

The modification of the Marine Terminal in the Port of Albany was designed to reclaim a functional area of approximately 1,500 x 80 feet (460 x 25 m) and provide increased dockside draft to allow large oil tankers to service the CIBRO Petroleum Products Distribution Terminal. In addition to increasing the draft from 26 to 32 feet (8 to 10 m) the reclamation program stabilized the area and provided for increased operating safety. Continuous operation of the facility during the expansion construction was an additional design constraint.

Figure 1 shows how the unusable existing slope into the Hudson River was reclaimed and the site rehabilitated by the sheet pile wall, lightweight fill and the use of tie backs to reinforce concrete dead men. The extreme southern portion of the site was developed through the use of cellular cofferdams that reached a shallow bedrock stratum. At the northern section, tied back piles and lightweight fill provided the solution. Fig. 2 shows a plan overview of the site.

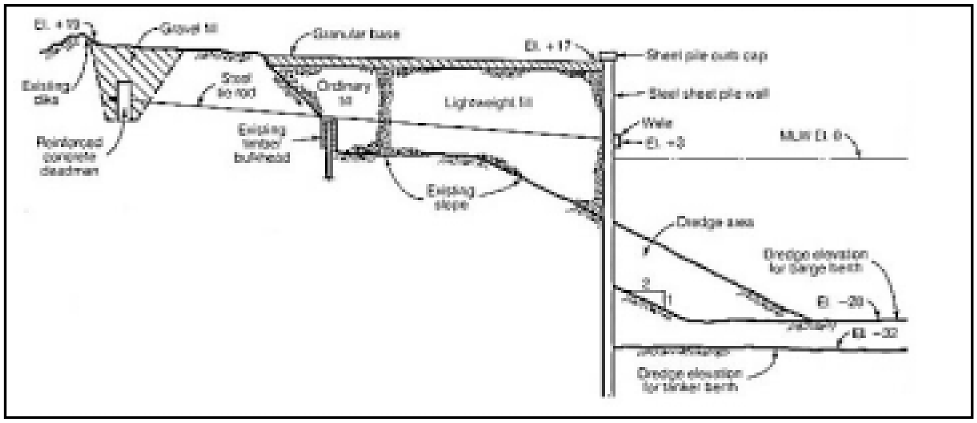

Fig. 1 Cross-section at Sheet Pile Wall

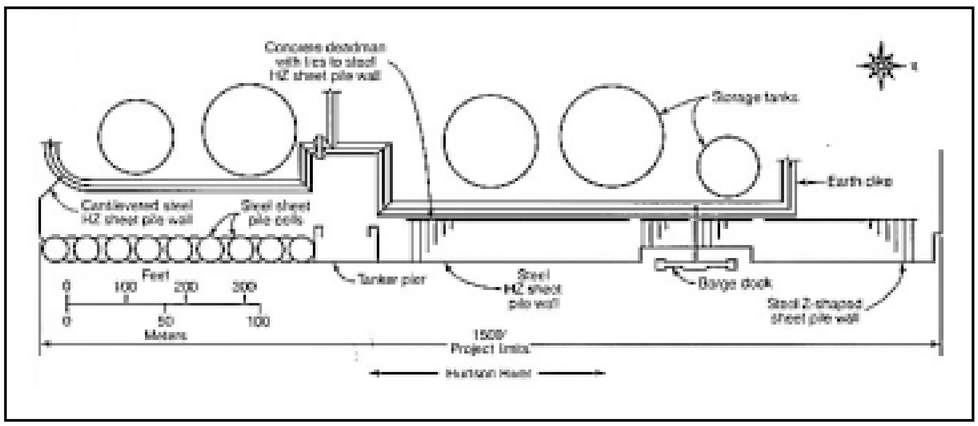

Fig. 2 Overview of Marine Terminal Modifications

During the design of the modifications it was determined that no one type of bulkhead structure would be cost effective over the entire length of the project. Relatively high bedrock (elevation -33.0 ft. [-10 m]) at the south end of the site and low bedrock (elevation -83.0 ft. [-25 m]) at the north end required a variation in the type of structure used to minimize cost.

Gravel-filled steel sheet pile cells provided the best alternative at the south end of the site. The cell structures require little or no penetration into the overburden or bedrock to maintain stability. In addition the cells provide an environmentally acceptable containment area for dredge spoil disposal. The gravel fill provided a cleansing filter for dredge spoil leachates which might find their way back to the river.

The loose silt and clay layers were a major concern from the standpoint of overall slope stability and sheet pile wall kickout resistance. The combination of the lightweight backfill which minimized lateral earth pressures while also minimizing the over-burden pressures on the sensitive silts, together with the H-pile penetration to rock, caused the least disturbance to the existing soils. The HZ wall system provided a cost effective solution since the Z sheets could be terminated at elevations well above the bedrock (-42 ft or -13 m) while the H-piles could be driven to the rock where wall kickout resistance was established. In addition the HZ wall provided the required strength necessary for an exposed wall height of 49 ft. (15 m), between elevation -32.0 ft to +17.0 ft (-10 to + 5 m) without modification. A standard Z sheet pile wall would have required welding on steel plates to increase strength.

At the north end of the project where dredge depths were less (elevation -26.0 ft [-8 m] versus elevation -32.0 ft [-10 m]) a high-strength Z type sheet pile wall proved sufficient since a gravel layer above the bedrock was available to provide kickout resistance. Again lightweight fill was specified to reduce the lateral earth pressures.

Lightweight Aggregate

The specifications for the lightweight fill called for a rotary kiln-produced expanded slate or shale composed of inert, granular, inorganic material with a continuous coarse aggregate gradation and exhibiting a minimum angle of internal friction (ø) of 40 degrees.

The lightweight aggregate used has been successfully used in numerous other soil fill applications including a Boston waterfront project designed by Childs Engineering in 1972. The expanded aggregate is produced in several gradations available for masonry and structural concrete applications.

While the technology of structural lightweight concrete and lightweight concrete masonry is well documented, the physical properties appropriate to soil mechanics applications are less developed and under continuing research. Rotary kiln-produced lightweight aggregate is capable of producing concrete strength in excess of 5,000 psi (35 kPa); from the standpoint of individual particle strength and toughness, its mechanical and weathering performance in structures, including exposed bridge deck, is well know and fully documented. For this project a coarse aggregate (3/4-in. to #4) (20 to 4 mm) was selected for optimum combinations of low density and high stability, coupled with free draining characteristics. A typical delivered gradation was as follows:

Sieve size	Percent Passing
1 in. (25 mm)	100
3/4 in. (20 mm)	92
1/2 in. (12 mm)	46
3/8 in. (10 mm)	16
#4 (4 mm)	1

Laboratory tests have shown that granular materials do not have the well developed peak compacted density typical of cohesive materials. Practical variations of standard ASTM Proctor tests may, however, be conducted to evaluate in-place densities as a function of the compactive energy while also determining the degree of aggregate breakdown under compaction. A compacted moist build density of 70 lb/ft^3 (1,120 kg/m^3) was determined by Childs Engineering to be the appropriate design requirement that would reduce lateral pressures, provide a compacted substrate and develop in-place stability without excessive degradation of the aggregate.

In order to determine the resistance to lateral forces developed by the compacted aggregate, large-scale triaxial compression tests were conducted at Columbia University's Geotechnical Laboratory under the direction of Professor Robert D. Stoll (Fig. 3). A testing arrangement designed and fabricated by Dr. Stoll incorporated a representative test specimen 10 in. in diameter by 24 in. high (250 x 600 mm) encapsulated by an elastic membrane, which provided a sample size that minimized restraint of the platens. The failure surface developed during the course of the test was always easily visible.

The usual small scale triaxial compression test samples are appropriate for said size particles but not for coarse aggregate specimens. A comprehensive triaxial compression testing program conducted on a number of stockpile samples gave an assurance of repeatability in testing. Further tests evaluated the influence of the aggregate moisture conditions on the angle of internal friction (ø). Finally a two-year program was conducted on five lightweight aggregates from other rotary kiln plants in other geographic areas to determine the effects of differing aggregate properties (particle strength, shape and gradation) on the angle of internal friction. Based on this extensive series of tests, the angle of internal friction was determined to be in excess of 40 degrees in loose condition and slightly higher in compacted condition. Stress-strain curves developed in the triaxial compression testing program on various samples of lightweight aggregate under differing conditions of compaction were similar to test results on other granular materials.

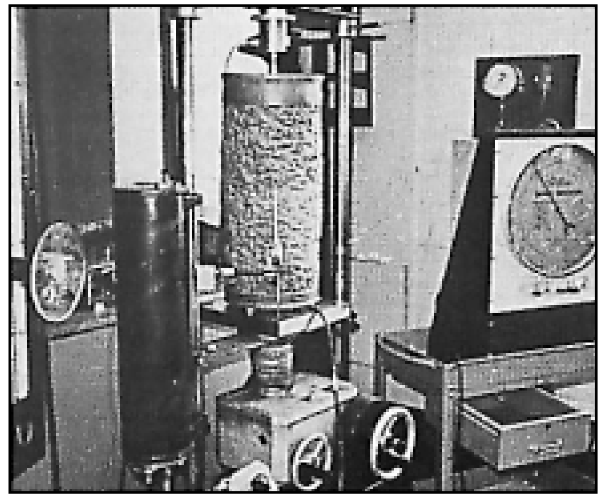

Fig. 3 Apparatus for determining the angle of internal friction for coarse lightweight aggregate

CONSTRUCTION

The contractor had little difficulty in transporting, placing and compacting the lightweight aggregate soil fill. Peak shipment reached 1,300 tons (1,170 mt) per day (55 truck deliveries) without logistical difficulties or overtime requirements on the part of the contractor's personnel. At first the material was moved with a Michigan 75B loader, while later a Caterpillar 966C front end loader was used because of its larger bucket and the room to move a greater volume. The project was organized with telescoping belts for aggregate handling in some areas, while in other areas two trucks were arranged for tandem dumping followed by movement of the material by front end loader (Fig. 4). Lightweight aggregate shipments started in July 1981 and were virtually completed by October.

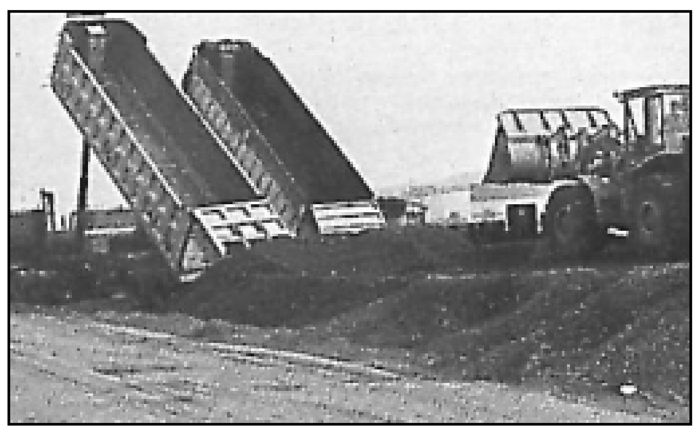

Fig. 4 Trucks dumping lightweight behind sheet piling wall

During the course of the project, 215 test samples were taken on the lightweight aggregate with detailed information reported on gradation, bulk and particle density, moisture content, and in-place density. Test samples were taken by aggregate producer's quality control and field service personnel as well as by an independent testing lab hired by the owner.

Dry loose delivered bulk density was specified not to exceed 55 lb/ft^3 (880 kg/m^3) with in-place, compacted bulk density not to exceed 70 lb/ft^3 (1,120 kg/m^3). Field tests indicated the delivered moist build density was less than 55 lb/ft^3 (880 kg/m^3) and in-place compacted bulk density averaged approximately 65 lb/ft^3 (1,040 kg/m^3).

While laboratory tests on small samples are necessary and instructive, the best measure of accuracy in predicting in-place density is when the contractor's estimates of quantities, based upon cross-sectional volume calculations, are realized by actual shipments to the project. This was the case on this job as the estimated quantity of 23,700 tons (21,500 mt) – approximately 27,000 yds^3 (20,600 m^3) in place – was realized within 1%. The project has performed as expected and is currently off-loading large tankers serving the upstate area.

Acknowledgements

The project is noteworthy for the cooperative efforts whereby private sector capital was matched by local government funding for the overall rehabilitation of the Port area, which is considered a cornerstone of economic recovery for the entire Capital District region.

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