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THE PLANNING, DESIGN, AND CONSTRUCTION OF THE LOS ANGELES EXPORT TERMINAL'S COAL TRANSPORTATION LINK TO JAPANESE POWER UTILITIES

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Cornerstone to an unprecedented Port of Los Angeles expansion program to the Year 2020 is the Los Angeles Export Terminal Project a.k.a. LAXT. This major steam coal and petroleum coke receiving, handling, and export transshipment terminal was completed in 1998 as hundreds of international guests attended its two Opening Dedication Ceremonies. The LAXT is by far the largest most advanced facility of its kind on the US West Coast. In a unique arrangement of domestic coal producers, a railroad company, and foreign coal purchasing and business interests, the Port has successfully arranged the integration of parties involved in the Pacific Rim coal chain link in developing this world class facility. Starting in the late 1980's, the Port of Los Angeles, which is the City of Los Angeles' Port Authority, determined that a large volume, state-of-the-art marine coal transshipment terminal would be highly desirable to increase Port export cargo volumes, replace the limited capacity existing coal facility, and take advantage of an ever increasing global demands for the US West's abundance of high grade, low sulfur steam coal on the world market. The Port thereafter actively led discussions with those involved in the sale, movement, and purchase of steam coal pursuant to forming a public/private sector joint venture development at the Port. By 1989 the Port received the interest from 35 firms including Western US coal producers, a US railroad company, all the major regional electric power utilities in Japan, Japanese banks, shipping companies, and trading companies. By 1990 the interested parties went forward with a comprehensive feasibility study.

Thereafter in 1993 a Shareholders Agreement was executed which established the tenant consortium called the Los Angeles Export Terminal, Inc. This Corporation, which also includes the Port of Los Angeles, consists of 51% US shareholders and 49% Japanese shareholders. The Port at the same time retained its normal public agency position as the facility's landlord. Later a formal Lease Agreement was issued between the Port and the Corporation. Under its terms, the design and construction of the facility was divided: the Port would provide the deep-draft wharf, railroad infrastructure, backland site improvements, and trunk line utilities; the Corporation would provide the materials handling system equipment and the buildings.

The LAXT consists of two basic terminal elements:

1. The deep draft wharf was designed and constructed to accommodate dry bulk vessels of up to 250,000 Dead Weight Tons in -22 meters MLLW (mean lower low water) at the pierhead. This wharf, which is now the largest and deepest in the Port's 92 year history, is supported by 193 polyethylene coated 54 inch diameter structural steel pipe piles. The wharf's design involved pseudo-static, slope stability, and soil-structure interaction analyses, state-of-the-art steel pile/concrete deck connection designs, and took into account both Operational Level Earthquake (OLE, 50% chance of exceedance in 50 years) and Contingency Level Earthquake (CLE, 10% chance of exceedance in 50 years) events. On top of the wharf, the modern rail mounted ship loader equipment can cleanly and quietly move up to 9,000 tons of product per hour into the vessel holds.

2. A 43 hectare backland receiving and storage facility is remotely located approximately two kilometers northeasterly of the wharf. This site features a triple loop (with crossovers) railroad track layout, a tandem rotary railcar dumper facility, underground and overhead stacker and reclaim equipment and infrastructure, a product stockpile area capable of 1,000,000 tons of storage, pole mounted water mister and rainbird directional spray systems for stockpile dust suppression, runoff water infiltration prevention HDPE (high density polyethylene) liners, giant settling ponds for water collection, clarification, and reuse, and a computerized railroad signal system. This area can receive and accommodate two even three 110 car unit coal trains at one time and can unload an entire unit train in less than two hours time. A Control House located within the railcar dumper building monitors and controls the entire LAXT facility via PC computers. An overhead, steel-enclosed, and high rate conveyor connects this backland to the wharf.

For the wharf, a concrete deck/steel pile structural system was determined to be the most appropriate and economical after comparisons with numerous alternatives. The major determining factor for the sizing of the wharf components was the very stringent seismic design criteria in the State of California (Zone 4, ICBO Uniform Building Code). The effects of berthing and mooring forces and wind were not significant in comparison with the seismic forces. The -22 meter water depth required that steel pipe piles, rather than the more traditional concrete piles, be utilized. The wharf structure consists of a cast-in-place reinforced concrete deck, 338 meters long and 31 meters wide. The deck consists of longitudinal and transverse beams (1.83 meters high and 1.22 to 1.83 meters wide)and a 0.302 meter thick concrete slab. The size of the longitudinal beams was in part governed by the vertical loads on the shiploader rails; however, seismic considerations still influenced the beam sizes in both directions.

The wharf structure is supported on 1.372 meter diameter vertical steel piles driven to depths of approximately 16.8 to 21 meters below the seabed. The steel piles are spaced at 6.7 meters along the length of the wharf. The approach ramp and the mooring dolphins are supported by 0.910 meter diameter steel piles. All piles were driven "open ended." The piles are protected with a shop

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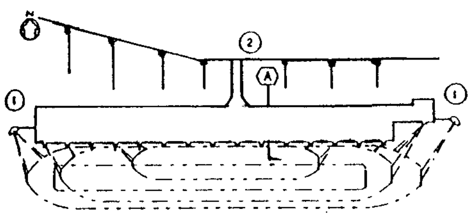
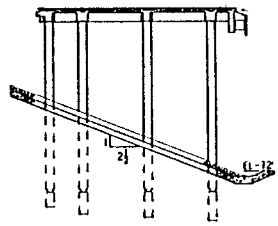
applied polyethylene coating extending from the tops of the piles to the ocean floor rock line. In addition, a sacrificial anode cathodic protection system was installed to provide additional corrosion protection.



WHARF PLAN



SECTION "A"

The preliminary design was performed using pseudo-static methods for seismic design. The preliminary design for the pile supported wharf structure was based on a 5% damped response for the CLE event and a response modification factor of 3. The pseudo static analysis was performed according to AASHTO (American Association of State Highway and Transportation Officials). For seismic motion in the transverse direction, 1/3 of the earthquake forces are applied simultaneously to the longitudinal direction. Calculations for the OLE earthquake were performed with a Response Modification factor Rw of 1.

The final design was verified by a three dimensional seismic soil-structure interaction analysis originally developed by Professor John Lysmer and others at the University of California, Berkeley. In this analysis, which was performed in the frequency domain, the soil was modeled as a semi-infinite viscoelastic layered media in both OLE and CLE events. The structure was modeled using standard finite elements. This method of analysis was developed for the nuclear industry and has been validated by the US Nuclear Regulatory Commission. A detailed discussion of this analysis is available.

One of the most important design features is the pile to deck joint connection detail. This connection, which is considered fixed, features three meter long concrete plugs installed inside the tops of the piles. The force transfer is effected by 16 No. 18 reinforcing bars extending from the concrete plugs into the concrete deck beams. Additional information on this is available.

A comprehensive geotechnical investigation took place consisting of four offshore borings, four landside boring, and a number of cone penetrometer tests. The results indicated that the piles would develop most of their axial capacities in the lower stratum which consists of dense to very dense silty sand.

The stability of the 2.5:1 slope embankment was studied using finite element procedures. A detailed analysis was performed to compute the response of the slope to the CLE ground motions using "equivalent linear" soil properties, and then using the simplified procedure suggested by Newmark to obtain estimates of the displacements that might result from such shaking. The failure surfaces were a deep circular failure plane and two shallow sliding block failure surfaces within the weak stratum above Elevation -4.6 meters. The anticipated deformations resulting from CLE condition range between 0.26 and 1.5 meters.

Under Port planning, management, and/or oversight, an international array of designers and builders took part in this world class facility. For example, the over 8,000 tons of steel pipe piles were unprecedentedly supplied by the **Kawasaki Steel Corporation.** The wharf itself was constructed by **Kajima Engineering and Construction, Inc.** via competitive (low bid) public tender. This was the first time that a Japanese general contractor won a major Port project. In the backland, thousands of geotechnical stone columns were installed for ground improvement to prevent seismic liquefaction, particularly in the areas of support for the large (32 meters high) and sensitive overhead stacker equipment. The Japanese firm, **Shimizu Corporation**, was heavily involved in the liquefaction/stone column analysis and design effort given their world renown knowledge and research reputation in this area. Administrative, technical and other information of these particular efforts are also available.

The overall design and construction cost of this international overseas project was $200 million assessed between the Port and the LAXT Corporation in accordance with the Lease Agreement demarcation.

This project provided many additional design and construction breakthroughs. For example, the large diameter steel pipe piles required unique handling, field fabrication, and pile driving methodologies. An interesting and innovative pile design modification took place during pile driving construction upon the results of the concurrent indicator pile program. The massive underground railcar dumper pit (46 meters long by 18 meters wide) is fully 15 meters deep into the ground water table (20 meters total height) which presented design and construction de-watering challenges. Also, the fully signalized triple loop rail track layout design has provided unusually quick unit train turnarounds favorable to the railroad company.

LAXT also represents major planning and transportation breakthroughs as well. By bringing together and linking the very business players that are involved in the US/Pacific Rim coal trade business (i.e. "the Pacific coal chain"), including a transcontinental railroad company, LAXT has finally created an effective instrument by which to mitigate the high land transportation costs of hauling coal the approximately 1,600 kilometer distance to the Pacific Coast. It also provides an efficient world class marine transshipment facility. Well over 30 mines in the entire US Central Rocky Mountain area can now deliver their valuable high grade, low sulfur steam coal product in large quantities to expanding markets in Japan, the Far East, and in Central and South America. Before LAXT, only limited quantities of coal could be transshipped through the US Pacific Coast.

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