

Liquefaction mitigation and slope stabilization using vibrocompaction and dry bottom feed stone columns are used to extend a wharf in a seismic zone.

WHARF CONSTRUCTION in a Seismic Zone

By Frederic Masse and Charles Spaulding

A wharf extension south of quay 24-4 at San Diego's National City Marine Terminal—in a seismic zone—required extending the quay wall some 1,100 ft, the creation of caissons by sheet-piles, filling them with sand, dredging the under-wharf slopes and building the wharf on piles.

Seismic analyses indicated that the majority of the bay deposits, and the sands in the caissons, had a high potential of liquefaction under earthquake loading to a depth of approximately 60 ft. Soil liquefaction means the strength and stiffness of a soil is greatly and suddenly reduced by earthquake shaking or rapid dynamic loading. Manifestations of soil liquefaction can include the loss of bearing and lateral capacity of foundations. Soil liquefaction also can result in instabilities and lateral movements in areas of sloping ground and lateral spreading in reclaimed areas.

Liquefaction occurs when soil is saturated, granular and loose. Ports and wharves are often in areas susceptible to liquefaction. Most wharves have retaining structures or quay walls at which ships moor. When the soil behind and beneath a wharf liquefies, the lateral pressure exerted on the wall increases enough to cause a major slide or tilting toward the sea; up to 10 ft in lateral movement has been recorded.

One of the most efficient methods of mitigating the risk of liquefaction is that of compacting the ground. On this project, improvements to the soil inside the caisson and at

the wharf slope consisted of combining vibrocompaction and vibroreplacement by the dry bottom feed method.

Vibrocompaction, also known as vibroflotation, compacts loose granular soils to depths of 100 ft. The equipment consists of a vibroprobe or vibroflot suspended to a crane or hydraulic excavator. The vibroflot, a cylindrical vibrator, 16- to 18-in dia., about 6 ft long and about 2 tons, penetrates the ground by use of vibration and high-pressure water jets at the tip of the vibrator. At the depth required, the vibrator vibrates laterally in amplitude a few inches, tending to compact the soil horizontally. As vibration continues and the vibroflot is raised slowly, sand is continuously dropped into the space around the vibrator to fill the created void. The in-situ sand also flows toward the vibroprobe as a result of the compaction process. Vibrocompaction is usually done on a grid pattern with compaction points at 6 to 12 ft apart in triangular or square spacing.

Vibrocompaction is limited to soils with a fine content under 12 to 15%. If fine content is too high (silty sands, sandy silts, silts and clays), the cohesive nature of the ground prevents improvement by this method. It is then necessary to use alternative techniques which basically consist of using compacted material inside the soft fine cohesive soils. Vibroreplacement is one of the best methods available to improve these fine cohesive soils.

The original wharf location and the extension are clearly visible on this view. The vibrocompaction crane is operating inside the caissons, on-shore. Vibroreplacement works will be performed to the right of the caissons in the sea.

Photos courtesy DGI-Memard, Inc.



