

# Treasure Island -- stabilization would protect soil

David Perlman, San Francisco Chronicle, 4-17-11

Treasure Island was built in the 1930s atop a broad underwater shoal by dumping tons and tons more sand onto the area - sand that was dredged from other parts of the bay and carried to the rapidly growing island by barge, or pumped there through hydraulic pipelines.

Now, the developers seeking to build a high-rise neighborhood in a location susceptible to earthquakes, tsunamis and sea-level rise have drawn up an engineering plan that in essence creates a new island atop the sandy fill.

As risky as this might sound, engineers say the approach being proposed draws on stabilization methods that are commonly used to solidify landfills around the world.

"Soil engineers over the past 50 years have developed and applied many techniques to improve the properties of low-lying, artificially filled ground that's subject to the danger of liquefaction," said Thomas Holzer, an engineering geologist with the U.S. Geological Survey in Menlo Park. "Applying those techniques properly can either minimize or stop liquefaction from happening."

## Saturated sand

When a severe earthquake shakes the sand of any filled-in land close to water, the water - even many feet down - rises into the spaces between each individual grain of sand, Holzer said. As the water pressure increases, the sand becomes saturated and loses all its strength. That's liquefaction.

The same kind of liquefaction buckled roads and damaged buildings on Treasure Island when the Loma Prieta earthquake struck in 1989. The same seismic phenomenon proved even more disastrous in San Francisco's Marina district, where much of the land was unstable; liquefaction destroyed at least 35 houses and helped set gas mains ablaze.

To prevent such a scenario - or something much worse in the next big earthquake - Treasure Island's developers have retained Engeo Inc., a geotechnical engineering firm based in San Ramon. Its task is to plan and oversee the varied technologies designed to protect the roughly 100 acres eyed for high-density development on the island.

The main change would affect the surface sand, which ranges from 30 to 50 feet thick. Below it lies a layer of what engineers call "young bay mud," like wet clay. Below that is solid clay that poses no liquefaction problem.

"The solution at Treasure Island is to make its sandy soil so dense that water won't penetrate it," said Engeo's president, Uri Eliahu. "Where layers of claylike young bay mud lie beneath the sand, the trick is to squeeze all the water out of that mud to solidify it."

The deep surface layer of sand would be made dense by high-tech methods that are very old school. Plans call for huge, muscular tools to work their power wherever the land is to be developed.

"Densifying" the loose sand surface can involve what engineers call "deep dynamic compaction." It's a little like a small boy stomping hard on a patch of beach - except that in this case the approach would call for a crane 80

to 90 feet high to drop 45,000 pounds of thick steel plate again and again onto a single patch of surface about 10 by 12 feet wide. Each patch then would be tamped down with an 8-ton weight plunging from a crane 50 to 60 feet high.

"The cranes will make thousands of drops to densify the sand" in all the areas slated for development, Eliahu said.

Afterward, tons of heavy rubble known as surcharge would be piled on top of the surface for months or years, to make the compacted surface permanent, and squeeze the water out of the lower claylike bay mud.

### **'Vibro replacement'**

Then there's a technique the engineers call "vibro replacement." Cranes would lower huge torpedo-shaped vibrating probes, with water jets at their tips, that would power their way deep into the sand. At the same time, earth movers would push piles of pebbles into each deepening hole to create stone columns that would increase the soil's stability - not only against the threat of liquefaction, but also to strengthen the island against powerful shaking from an earthquake.

In some parts of the island, Eliahu foresees, those columns might need to be as huge as 30 feet in diameter and 75 feet deep.

The goal is to avert the threat of quake-induced liquefaction that could tilt and topple buildings, rip apart underground power lines and sewers, and churn up roads.

Protective measures would also be taken for areas of Treasure Island envisioned as parkland.

If development proceeds, one of the first steps would be to encircle the island perimeter with a new rock berm. The intent is not only to protect against a possible tsunami, but also to ward off the threat of sea-level rise in the future.