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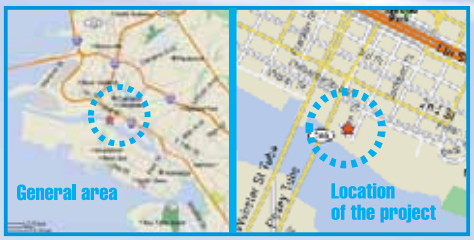


Seismic retrofit of Webster-Posey tubes

Oakland, CA- U.S.A.

Jet grouting

Cliente : *Owner*	CALTRANS
Contrattista principale : *Main Contractor :*	**West Coast Bridge**
Durata dei lavori : *Duration of work :*	**2002 - 2004**

Introduction

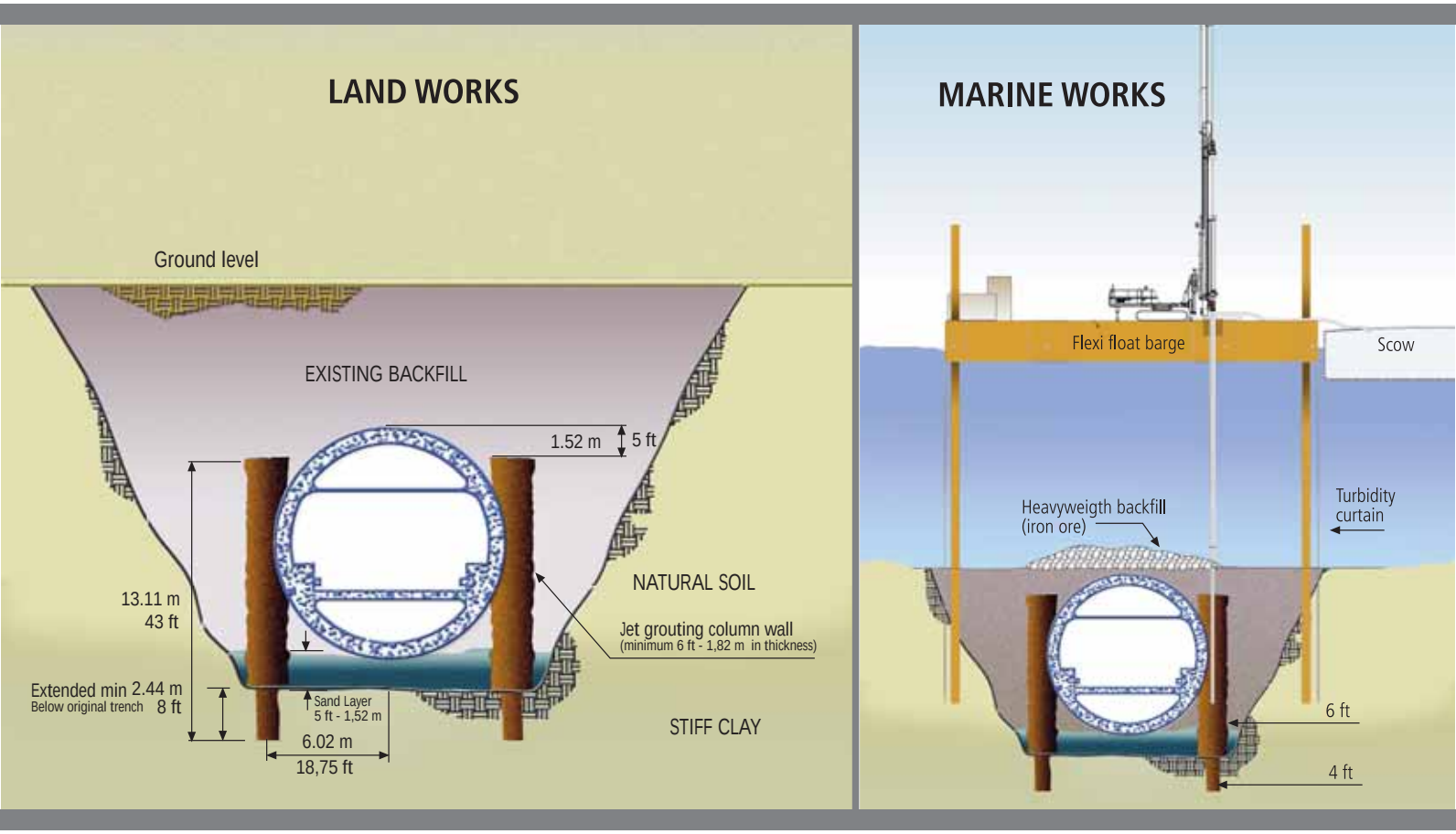
The Webster-Posey tubes connect Oakland to the island of Alameda, on the eastside of the San Francisco bay. *The Posey tube was constructed in 1928, designed by George A. Posey as the first highway immersed tube tunnel in the world, while the Webster tube was completed in 1963. Although built more than 30 years apart, the construction technique was practically identical.*

A trench was dug at the bottom of the Oakland Estuary and pre-cast tunnel segments were sunk in position and connected under water. The 200 feet long, 37 feet in diameter, pre-cast, reinforced concrete segments were 2.5 feet thick and were laid on a layer of loose sand bedding. Once the connections were made, the trench was backfilled with soft clay and loose sand, dredged from the bay and dumped from barges upon the tubes to protect them and to prevent flotation.

Tube & jet grouting columns

In 2001 Phase 1 of the project was carried out by Wagner JV (a Trevi Group company), using double fluid jet grouting techniques to seal Tube joints Number 1 and 14 at both Posey and Webster Streets.
Finally, early in 2002 Phase 2 was let out for bid. Once again, Wagner JV was the contractor chosen for the jet grouting portion of the retrofit.

The design for the retrofit of the tubes contemplated the installation of a continuous row of triple fluid jet grouted columns forming a wall of the minimum thickness of 6 feet on each side of the tubes for their whole length, from above the spring-line of the tubes down to the underlying natural clay stratum in order to contain the material under the tubes and preventing its flowing during earthquakes.



When the Estuary was deepened in the 1950s, and cover over the tunnel was reduced, heavy iron ore mixed with sand was dumped over the Posey tube to stabilize it.
The construction of the Webster tube was identical in all respects, including the use of iron ore to prevent flotation.

The probability that the loose sands surrounding the tubes would liquefy in the event of a severe earthquake and that the tubes would become buoyant and possibly fail, prompted Caltrans to study ways to seismically retrofit the structures.
In the event of liquefaction, material winflow under the tubes to pushing them to move upwards; if the tubes are isolated by two parallel walls composed by material that does no liquefy and that can resist the lateral differential pressure, then the structures would not move even if the soil beneath them liquefies.

In plan view the rows of jet grouted columns formed two parallel walls on each side of the tubes, restraining the liquefiable material underneath and preventing it from flowing, thus guaranteeing the structural integrity of the tubes in the event of an earthquake. Wagner JV conducted an extensive testing program that lasted several months, in the course of which construction criteria for production work were established allowing jet grouting work to begin in the fall of 2002.

Many techniques were considered to reach that objective and when jet grouting and stone columns seemed to be the most suitable methods, a demonstration program was implemented in 2002 to verify the design assumptions, schedule and constructability for the confirmation program.

At the Posey tube a row of twelve, 6 feet diameter jet grouted columns was used, while at the Webster tube stone columns were installed by the pipe pile method and by vibroflottation.

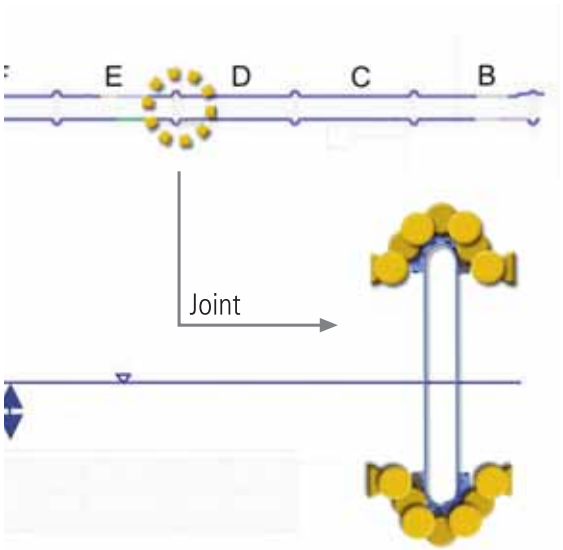
The project was completed in the early part of 2004. It involved the installation of jet grouted columns, 7.5 to 8 feet in diameter, built by the triple fluid method, spaced 4.5 feet center to center resulting in a continuous wall on each side of the tubes both on land and on water.

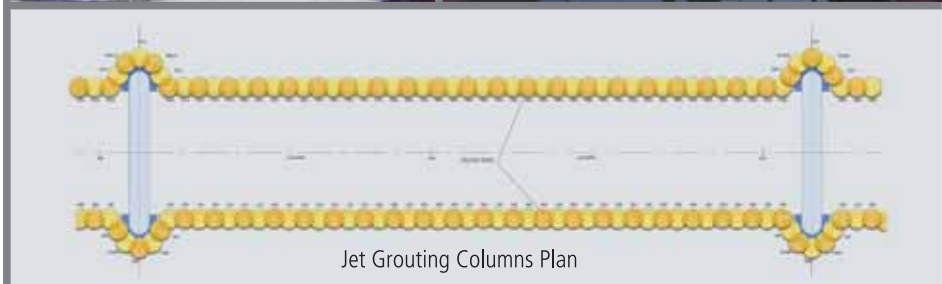
The principal pieces of equipment needed to perform the job were two jet grouting rigs, a Soilmec Euro 40 and a Soilmec SM525, and a grout plant with 4 high pressure pumps.

The work on water was done from a dedicated barge, equipped with silt curtains to avoid polluting the harbor.

• It is environmentally friendly.
• It produces very limited ground heave or movement on the existing ground.
• It causes limited disturbance in crowded utilities areas.
• It offers the possibility of treating different, difficult and variable soil conditions.
• It offers the possibility of forming large embracing and irregular consolidating columns around the structures to be retrofitted (tubes in this case) both from land and water.
• It does not present any type of vibrations that might damage existing nearby superficial and underground structures and utilities.

This triple fluid jet grouting project was a unique construction challenge: for its complexity, its size, the unexpected soil behavior,





Problems

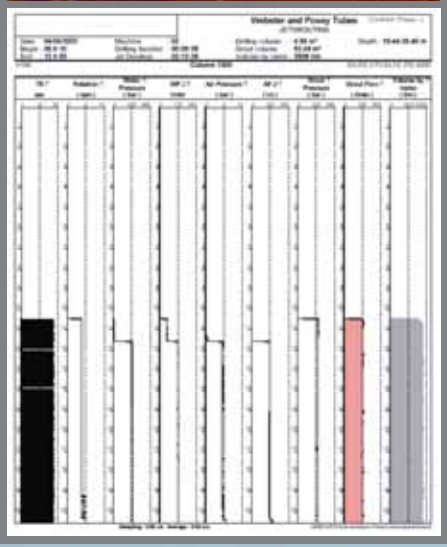
This contract encountered a slew of problems, some caused by the characteristics of the ground, some by the application of a technique in previously untested conditions and some were "man made". Unfortunately the latter exacerbated the formers to the detriment of the work.

Conclusions

For its versatility the jet grouting system proves to be a powerful tool that can be used in a marine environment to selectively treat liquefiable soils, as well as stiff clays and soft bay muds. It can use cheap stabilization agents, i.e. Portland cement, pozzolan, etc; with no need for expensive chemical agents to stabilize heterogeneous soils
It allows work to be done around sensitive structures founded in liquefiable soils without damaging and or causing any movement.

heterogeneity and variability of the soil conditions, the presence of underlying stiff clays, hydro-fracturing, voids, reduced overburden in the bay mud, obstructions and exigent strength and permeability requirements that caused several problems that were successfully solve both during drilling and grouting.
The schedule was met and the jet grouting work was finished three months earlier than the baseline schedule.
Through the ingenuity of the jet grouting contractor all the difficult challenges caused by uniqueness of the project were met and overcome to successfully complete the largest triple fluid project over water ever made in USA and around the world.

Quality Control



Jet grouting columns - Plan

Type of treatment	triple fluid jet grouting
N° of jet grouted columns on land	**860**
N° of jet grouted columns on water	**560**
Average diameter of columns	**7.5'** (2200 mm) **- 8'** (2500 mm)
Spacing of colums	**4.5'** (1,35 m)
Average compressive strength of columns required	
WEBSTER	**600 PSI (4130 kpa)** @ days
POSEY	**1000 PSI (6895 kpa)** @ days
Permeability	**<1 lugeon**

This is the first time in the US, and possibly in the world, where jet grouting under water was used to seismically retrofit a structure.

Regardless of the many problems encountered, the successful performance of the work is opening a new avenue of design to clients needing to intervene on submerged structures.

TREVI
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TREVIICOS

5819, via Dismano - 47522 **Cesena** (FC) - **I**taly
Tel. +39.0547.319311 - Fax +39.0547.318542
e-mail: **intdept@trevispa.com**
www.trevispa.com