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Consultants Corner

Engineering for the future

An Innovative Solution To Mitigating Liquefaction Hazard

The skyrocketing value of land in southern California in recent years has caused developers to take a second look at properties once deemed difficult for development due to adverse soil conditions. Such was the case of a parcel in the Reseda area of the San Fernando Valley. Although ideally suited in many respects for commercial development, the site was located in an area designated by the State of California as a "liquefaction hazard zone."

The term "liquefaction" refers to the liquefied condition and loss of soil strength that can occur when certain types of soil are subjected to a sudden shock, such as that generated during an earthquake. Soil will behave as a viscous liquid, settling unevenly and temporarily losing the ability to support foundations. Although this site was located within an already existing medical center, today's stringent seismic requirements rendered construction of a proposed two-story commercial building potentially cost prohibitive.

Located along the south bank of the Los Angeles River channel, the area surrounding the site had experienced severe damage during the 1994 Northridge earthquake, primarily due to liquefaction. The challenge facing the project owner was how to construct the building to meet current building code requirements and mitigate potential damage in the event of a liquefaction-producing earthquake, while maintaining the economic viability of the project. Other restrictions imposed by the local municipality included limits on noise and vibration during construction, due to adjacent residential neighborhoods and an active five-story medical building located within 20 feet of the site.

Pictured above is the Los Angeles Channel, just to the south of the property.

The site was covered with asphalt before beginning the grouting process.

The grout injection equipment with manometers for level survey.

Onsite portable batch plant used with the generator to mix grout.

The client retained Earth Systems Southern California to conduct a subsurface exploration and develop recommendations for mitigation of liquefaction potential. Borings revealed that the southern part of the site was underlain by silts and clays, while the northern part was underlain by loose sandy sediments deposited by past meandering of the Los Angeles River. Groundwater was present at a depth of approximately 20 feet, with a potential to rise to within 10 feet of the ground surface. Due to the loose, sandy, saturated nature of the soil in this part of the site, the site was determined

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to have significant potentials for liquefaction-induced settlement, ground damage, and lateral spreading (slumping of the soil toward the adjacent channel) in the event of another sizable earthquake.

The soils engineering report prepared by Earth Systems Southern California presented several options for site development, along with a discussion of the advantages and disadvantages of each approach. After review and comparison of all of the options, it was determined that compaction grouting would provide the most appropriate mitigation, based upon the site conditions, noise and vibration restrictions. In compaction grouting, grout is injected into the soil under pressure. The grout displaces the soil, increasing its density to a point where the potential for liquefaction-induced settlement and associated lateral spreading are reduced to acceptable levels.

The compaction grouting was performed by Moore and Taber Geotechnical Constructors. A small portable batch plant was set up at the site to mix the grout, which consisted of a fine- to medium-grained sand that was combined with Type II Portland cement and water to achieve a pumpable consistency. A grid was laid out on the site, and the grout was injected into the ground through a casing/pipe beginning at a depth of 55 feet. The grout was injected under pressures of up to 1200 pounds per square inch (psi).

The casing was elevated a few feet, and the process repeated until the desired density was achieved. The strength of the grout was tested periodically throughout the grouting period. A total of 73,289 cubic feet (approximately 2,700 cubic yards) of grout were injected into the subsurface over a period of about five months. Based upon the area and depth of the treated zone, the volume of soil treated by compaction grouting was estimated to be approximately 1,440,000 cubic feet. At the completion of the grouting operations, the engineer estimated the grout had increased the density of the treated soil volume by about five percent.

As the process of grout injection creates an increase in pressure within the soil in all directions, the ground surface of the property can sometimes uplift, or "heave," if the procedure is not carefully controlled. The site was continuously monitored throughout the grouting process by means of visual observation and manometers within the grout influence zones. A surveyor was retained to establish a grid of temporary survey monuments and provide continuous real-time monitoring during the grouting. Nearby utilities were also monitored using in-pipe cameras to verify that no displacement or damage occurred.

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Before-and-after testing was performed using Standard Penetration Tests, cone penetrometers, and laboratory density tests. Based upon the test data, the compaction grouting process was effective in mitigating the liquefaction and lateral spreading hazards. The potential for lateral spreading was essentially eliminated, and the estimated potential for liquefaction-related ground settlement was reduced from more than ten inches to less than one inch. The reduced settlement estimates fell within limits accepted by the City of Los Angeles Department of Building and Safety, and allowed the project to be designed using a conventional continuous and spread footing foundation system.

Substantial portions of urban areas within California lie within seismic risk zones and are subject to earthquake-related hazards. By employing innovative geotechnical methods such as compaction grouting, such hazards can be mitigated for a reasonable cost, and properties formerly considered marginal or unbuildable can be successfully developed.

—Mark Russell and Dave Murray

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