Seismic, Geochemical, and Compaction Innovations for Urban Tunneling

Construction of Los Angeles County's subway tunnels was challenged by their location in a seismically active region, hydrocarbon deposits, and the necessity to tunnel under 20 major skyscrapers. The following methods accelerated the construction schedule and saved the project millions of dollars. Seismic Innovations: To withstand the effects of southern California's earthquakes by allowing the tunnels to move with the ground, construction standards were established to create ductile tunnel structures that would tolerate displacements, localize and minimize damage, and provide means to facilitate repairs. The choice was to use a relatively thin tunnel lining. Additionally, the tunnels were constructed with an average overlying ground cover of 60 feet. Geochemical Innovations: To prevent seepage of volatile methane and hydrogen sulfide gases into the subway, construction included installation of a 100 mil-thick, high density polyethylene (HDPE) membrane around all underground structures. This was coupled with a ventilation system capable of purging any gas that might find its way into the tunnels. Although previously used for waterproofing, this is believed to be the first use of HDPE to impede gases from entering subway structures. Compaction Grouting Innovation: An alluvium formation of sandy soil complicated the construction with expected ground movement and settlements affecting downtown buildings. The depth of the building foundations negated the use of underpinning to protect the buildings, so a specialized grouting technique was developed to control movement of the soil above the tunnels. This compaction grouting technique required the installation of 2 to 3 inch diameter steel pipes above the subway's alignment in advance of tunnel construction. During tunneling, a stiff grout mixture of cement, sandy loam, and water was pumped under high pressure through the steel pipes to solidify the soil and control settlement. In several places chemical grouting, using a sodium silicate grout, was needed to fill the voids in the soil.

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