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Seismic History and Liquefaction Resistance: A Comparative Study of Sites in California

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Abstract : Introduction: Liquefaction of soils during earthquakes can have significant consequences on the stability of structures and infrastructure. This study focuses on comparing two liquefaction case histories in California, namely the response of the Wildlife site in the Imperial Valley to the 2010 El-Mayor Cucapah earthquake (Mw = 7.2, amax = 0.15g) and the response of the Treasure Island Fire Station (F.S.) site in the San Francisco Bay area to the 1989 Loma Prieta Earthquake (Mw = 6.9, amax = 0.16g). Both case histories involve liquefiable layers of silty sand with non-plastic fines, similar shear wave velocities, low CPT cone penetration resistances, and groundwater tables at similar depths. The liquefaction charts based on shear wave velocity field predict liquefaction at both sites. However, a significant difference arises in their pore pressure responses during the earthquakes. The Wildlife site did not experience liquefaction, as evidenced by piezometer data, while the Treasure Island F.S. site did liquefy during the shaking. Objective: The primary objective of this study is to investigate and understand the reason for the contrasting pore pressure responses observed at the Wildlife site and the Treasure Island F.S. site despite their similar geological characteristics and predicted liquefaction potential. By conducting a detailed analysis of similarities and differences between the two case histories, the objective is to identify the factors that contributed to the higher liquefaction resistance exhibited by the Wildlife site. Methodology: To achieve this objective, the geological and seismic data available for both sites were gathered and analyzed. Then their soil profiles, seismic characteristics, and liquefaction potential as predicted by shear wave velocity-based liquefaction charts were analyzed. Furthermore, the seismic histories of both regions were examined. The number of previous earthquakes capable of generating significant excess pore pressures for each critical layer was assessed. This analysis involved estimating the total seismic activity that the Wildlife and Treasure Island F.S. critical layers experienced over time. In addition to historical data, centrifuge and large-scale experiments were conducted to explore the impact of prior seismic activity on liquefaction resistance. These findings served as supporting evidence for the investigation. Conclusions: The higher liquefaction resistance observed at the Wildlife site and other sites in the Imperial Valley can be attributed to preshaking by previous earthquakes. The Wildlife critical layer was subjected to a substantially greater number of seismic events capable of generating significant excess pore pressures over time compared to the Treasure Island F.S. layer. This crucial disparity arises from the difference in seismic activity between the two regions in the past century. In conclusion, this research sheds light on the complex interplay between geological characteristics, seismic history, and liquefaction behavior. It emphasizes the significant impact of past seismic activity on liquefaction resistance and can provide valuable insights for evaluating the stability of sandy sites in other seismic regions.

Keywords : liquefaction, case histories, centrifuge, preshaking
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