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Site Response Analysis and Liquefaction Potential of a Calcareous Sand Site from Puerto Rico



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ABSTRACT

Assessing the liquefaction potential of calcareous sands is quite challenging given their unique mineralogy, high content of calcium carbonate, brittleness, particle shape, crushing susceptibility and very high intraparticle porosity. This type of soil in uncemented state is susceptible to liquefy under cyclic loading. Puerto Rico has a great amount of calcareous sands, especially in the coastal areas and is located in a very high seismic zone with frequent tectonic activity. The island is exposed to frequent dynamic events like high magnitude earthquakes, landslides, and tsunamis. Historical cases of liquefaction have been registered in the western side of the island, such as the M 7.3 seismic event in 1918 that was followed by a tsunami.

This study presents a site response analysis and an assessment of the liquefaction potential of a loose, uncemented calcareous sand site located in the south-west area of the island, more specifically Cabo Rojo, Puerto Rico. As part of the investigation a series of field tests such as Cone Penetration Tests (CPT) and Dilatometer Tests (DMT) with shear wave velocity measurements were performed at the site of study. The field tests results were used to estimate the cyclic resistance ratio (CRR) of the calcareous sand. Given the fact that liquefaction potential depends on specific site conditions, a site response analysis was made to determine the seismic demand (CSR) of the site. The site response analysis entails of an equivalent linear one-dimensional analysis incorporated in the program EERA. Also, a seismic design spectrum that considers site effects is proposed starting from the design spectrum of the IBC-12 code for a site classification B. A way to define a design spectrum is through the smooth envelope from the response spectra of various acceleration records. In this study seven historical records were adapted, each one with different characteristics like frequency content and peak ground acceleration. The factor of safety against liquefaction indicates that the calcareous sands at the study site are potentially liquefiable. This study raises questions about the assessment of liquefaction potential of calcareous sands because of the site effects obtained in the response analysis. This can be attributed to the substantial differences in the seismic behavior of calcareous sands compared with terrigenous sands.

Keywords: calcareous sands, liquefaction resistance, site response analysis.