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Influence of Existing Tunnel - Surface Structure Interaction under Repeated Dynamic Loading Conditions.

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Abstract

According to past studies, subsurface spaces induce variation in ground response during an earthquake incidence and directly impacts the surface structures' seismic behaviour. Though, these subsurface structures (tunnels) are less susceptible to deformation than superstructures; its interaction with the surface structures during dynamic loading needs to be assessed carefully. Especially when these tunnels are located in partially saturated sand deposits, the interaction between soil-tunnel-structure is more complicated. The generation of pore water pressures, acceleration response during dynamic conditions may induce soil deformation and create deformations in the tunnel and superstructure system. Recently, repeated shaking events (i.e., continuous foreshock/aftershock associated events during earthquake incidence) posing a serious threat to the safety of significant infra-structures (Christ church earthquake 2011, Japan earthquake 2011, etc.) Hence, it is crucial to con-sider the response of surface structures with an existing tunnel under multi-seismic events where the studies were very limited. Considering the above, this study aims to understand the dynamic interaction behaviour between the surface structure with a shallow tunnel under repeated dynamic loading conditions. The experimental studies were conducted on a 1-g uniaxial shaking table with ground having 25% saturation replicating partially saturated conditions. A scaled-down structural member fixed on a pile foundation was used for simulating surface structure. Similarly, a scaled-down square tunnel of dimension 280×280×750 mm embedded at 420 mm depth was used for simulating shallow tunnel system. The tunnel-structure embedded ground was then subjected to repeated incremental sinusoidal acceleration loading of 0.1g, 0.2g, 0.3g, 0.4g and 0.5g with 5 Hz frequency. The effects of acceleration response, structural displacement, soil displacement, and pore water pressure were compared and analysed. The tunnel and structural displacement during testing were monitored and estimated using 2-D digital image correlation. The parameters influencing tunnel-soil-surface structure interaction under repeated seismic loading conditions were analysed and presented. The results show that, the irrespective of improved soil reinforcement induced by the pile foundation, occurrence of repeated shaking with longer duration affects the performance of the surface structure and its interaction with the tunnel embedded ground.

Keywords: Tunnel-soil-surface structure interaction, Partially saturated sand, 2-D Digital image correlation, 1-g Shaking table, Repeated seismic events