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Critical trigger condition of seabed liquefaction under ocean waves

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Soil liquefaction in seabed not only drives vertical sediment transportation but also weakens coastal infrastructures such as pipeline or underwater foundation. The damage of seabed liquefaction events had been documented in literature. Due to the threat to lives and environment, it is important to have an exhaustive analysis on the risk assessment of seabed liquefaction subjected to ocean waves. The objective of this study is to assess the critical wave condition triggering seabed liquefaction in oceanic environment through theoretical modelling. Our investigation focused on the wave condition of momentary liquefaction induced by periodic wave loading. The scenario considers a permeable seabed on which a wide range of ocean waves propagates, and the critical wave parameters of wave height and wavelength causing liquefaction are examined. A two-dimensional analytical solution of seabed response based on Biot's consolidation theory is applied with nonlinear water wave theory to predict the soil response and the consequence of liquefaction. In contrast to the previous studies of seabed response applying the analytical solutions which only valid for a restricted wave range, we use a numerical approach of finite-amplitude wave to reflect the nonlinearity effect in a wide range of water wave from deep water to shallow water. The present assessment of liquefaction is compared with the extant solution of seabed response under Stokes wave and cnoidal wave for validation. In additional, the potential of liquefaction instability is performed by a critical curve of wave condition covering the range of ocean waves from deep water to shallow water. Our study provides advanced theoretical framework and robust mathematical model for the assessment of wave-induced seabed instability under water waves, and the detailed analysis sheds insight into the impact of ocean waves on the seabed liquefaction.