DYNAMIC RESIDUAL SEABED RESPONSE AROUND A MOVABLE PILE FOUNDATOIN

Titi Sui, Hohai University, ttsui@hhu.edu.cn
Chi Zhang, Hohai University, zhangchi@hhu.edu.cn
Jinhai Zheng, Hohai University, jhzheng@hhu.edu.cn
Dong-Sheng Jeng, Griffith University, d.jeng@griffith.edu.au

Wave-induced seabed soil response and its resultant liquefaction is common observed in a silt seabed with relative poor drainage condition, which poses a great threaten to the foundation safety of marine structures. Regarding the governing equations, three different approaches namely the Fully-dynamic (FD), Partial-dynamic (PD) and Quasi-static (QS) model, have been used in the previous studies. Among these, both PD and FD approaches consider the effect of the inertial terms of soil skeleton/fluid. It has been reported in the literature that effects of the inertial terms on the seabed response could not be neglected, especially for the seabed around a movable structure (Ulker et al., 2010). However, these studies only focused on the oscillatory mechanism which are probably seen in a sandy seabed with high permeability. Recently, Zhao et al. (2017) investigated the residual soil response around a pile foundation by integrating a RANS wave model and a QS seabed model. In their study, the inertial terms of soil skeleton and pore water were neglected. To the authors' best knowledge, up to now, effects of the inertial terms on the residual response of a silt seabed have not been investigated.

In this study, a 3D numerical model for wave-induced seabed residual response with FD approximation is developed, which is an extended version of the model for oscillatory seabed response by Sui et al. (2016). The governing equations for oscillatory mechanism are shown in eq. 1-3 where the inertial forces of soil skeleton/fluid is highlighted (red rectangle) (definition of the symbol refers to Sui et al. 2016).

$$\sigma_{ij,j} + \rho g_i = \rho \ddot{u}_i + \rho_f \ddot{w}_i \quad (1)$$

$$-p_{,i} + \rho_f g_i = \rho_f \ddot{u}_i + \frac{\rho_f \ddot{w}_i}{n} + \frac{\rho_f g_i}{k_i}\dot{w}_i \quad (2)$$

$$\dot{u}_{i,i} + \dot{w}_{i,i} = -n\beta\dot{p} \quad (3)$$

A new definition of 3D source term f_3 (for residual mechanism) is proposed which are based on the resultant force concept of shear stresses. The pile is allowed movable ($u_{soil}=u_{pile}$, $\sigma'_{pile}=\sigma'_{soil}-p$, $\tau_{pile}=\tau_{soil}$) at seabed/structure interface. Fully-nonlinear Bossinesq wave model (FUNWAVE) is used to provide wave pressure. The present model is validated with the flume tests available in the literature. An overall good agreement between the measurements and numerical simulation is obtained, as shown in Fig. 1a.

As an example, wave-induced seabed response around a mono-pile, based on three approximations (FD, PD and QS), is illustrated in Fig. 1. It is found that (1) seabed residual response would be enhanced if the inertial terms of pore fluid and soil skeleton are considered, and the latter plays a more important role (Fig. 1b); (2) significance of the inertial effects increases with the decrease of seabed permeability (*k*) and the increase of wave height (*H*), as shown in Figs. 1c and 1d; and (3) influence of inertial terms on the seabed residual liquefaction is minor that can be neglected for the engineering practice (not presented here).

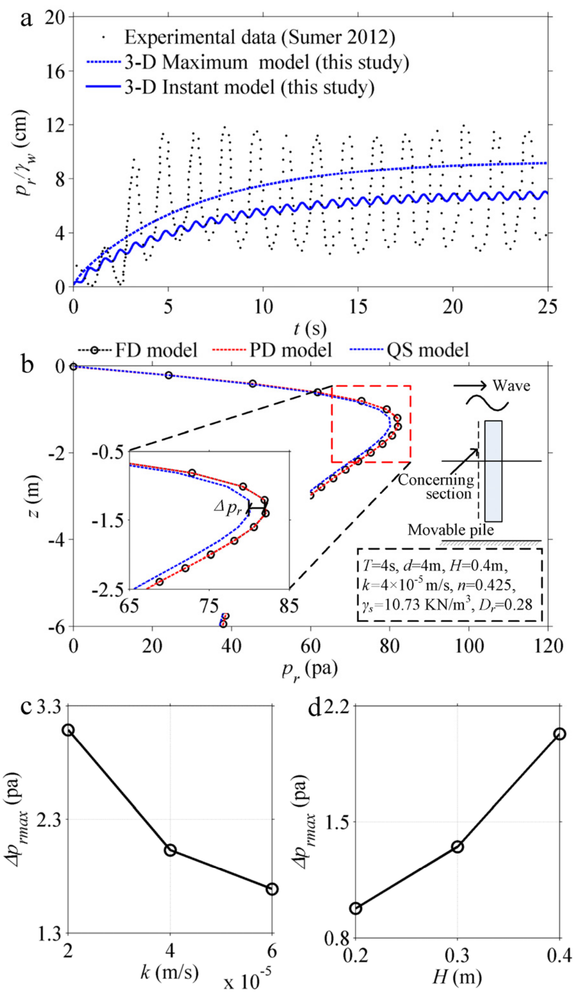

Figure 1 Numerical cases for (a) model validation with flume tests by Sumer et al. (2012), (b) effects of inertial terms on the residual response of seabed around the vicinity of pile, and significance of inertial terms with various (c) seabed permeabilities (*k*) and (d) wave heights (*H*).

REFERENCES

Sumer, Kirca, Fredsøe (2012): Experimental validation of a mathematical model for seabed liquefaction under waves, International Journal of Offshore and Polar Engineering, ISOPE, vol. 22, pp. 133-141.

Sui, Zhang, Guo, Zheng, Jeng, Zhang, Zhang (2016): Three-dimensional numerical model for wave-induced seabed response around mono-pile, Ships & Offshore Structures, TAYLOR & FRANSIS, vol. 11, pp. 667-678.

Ulker, Rahman, Guddati (2010): Wave-induced dynamic response and instability of seabed around caisson breakwater, Ocean Engineering, ELSEVIER, vol. 37, pp. 1522-1545.

Zhao, Jeng, Liao, Zhu (2017): Three-dimensional modeling of wave-induced residual seabed response around a mono-pile foundation, Coastal Engineering, ELSEVIER, vol. 128, pp. 1-21.