Analysis and simplified formula for seaquake-induced hydrodynamic forces on Floating Offshore Platform in finite water depth

Yiming. Shen [(1)], Yang. Qu [(2)], Piguang. Wang [(3)]

[(1)] *Ph.D. candidate, College of Architecture and Civil Engineering of BJUT,* shenyiminghue@outlook.com
[(2)] *Associate Professor, College of Architecture and Civil Engineering of BJUT,* *yangqu@bjut.edu.cn*
[(3)] *Ph.D. candidate, College of Architecture and Civil Engineering of BJUT,* *wangpiguang1985@bjut.edu.cn*

Extended Abstract

In this study, a simplified calculation formula is proposed to determine the hydrodynamic loads acting on floating bridge platforms with different cross-sectional shapes, sizes, and submergence depths under seaquake excitation. The platform structure is assumed to behave as a rigid body based on potential flow theory, and the water is treated as an incompressible fluid, while the effects of free-surface waves are neglected, as shown in Fig. 1. The seabed is assumed to be flat and treated as a rigid boundary, and the seaquake excitation is numerically simulated by applying prescribed vertical ground acceleration at the seabed.

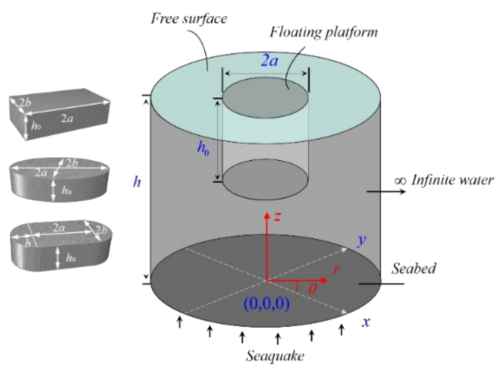


Fig.1 Schematic diagram of the theoretical model

In order to establish an efficient numerical model, a precise artificial boundary is introduced to truncate the infinite water domain. Based on the boundaries at the water surface, the water–structure interface, the seabed, and at infinity, the hydrodynamic pressure within the finite water domain is solved using numerical analysis methods.

Using this efficient numerical model, the hydrodynamic pressures and forces from seaquakes on circular, rectangular, round-ended, and elliptical cross-sections are analyzed for various sizes and submergence ratios. A distributed fitting method is used to relate the effects of cross-section shape (b/a), size (L), and submergence (H), introducing a force coefficient C to quantify the hydrodynamic response. A simplified expression is then derived to estimate seaquake-induced forces for different cross-sectional geometries.

$$C^{circular} = P_1(H)L + P_2(H) \tag{1}$$

$$C^{Rectangular}(\frac{b}{a}, L, H) = P_1(L,H)(\frac{b}{a})^2 + P_2(L,H)(\frac{b}{a}) + P_3(L,H) \tag{2}$$

$$C^{Elliptical}(\frac{b}{a}, L, H) = P_1(L,H)(\frac{b}{a})^2 + P_2(L,H)(\frac{b}{a}) + P_3(L,H) \tag{3}$$

$$C^{Round-ended}(\frac{b}{a}, L, H) = P_1(L,H)(\frac{b}{a})^2 + P_2(L,H)(\frac{b}{a}) + P_3(L,H) \tag{4}$$

A three-dimensional case study of a floating bridge was conducted, with the Bjørnafjorden floating bridge in Norway selected as the primary research subject. The bridge consists of the main beam, columns, pontoons, and mooring system, with the structural arrangement illustrated in Fig. 2. The hydrodynamic forces induced by the seaquake were applied as concentrated loads at the nodal points on the bottom of the pontoons. Hydrodynamic loads are divided into two types: for the rigid round-ended pontoon, static water stiffness is modeled with springs, radiation forces with added-mass elements, and drag with the Morrison equation; for the anchor cables, inertia and drag forces are both described by the Morrison equation.

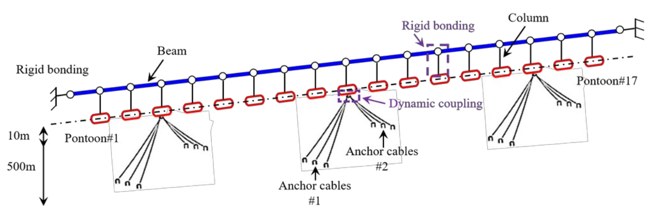
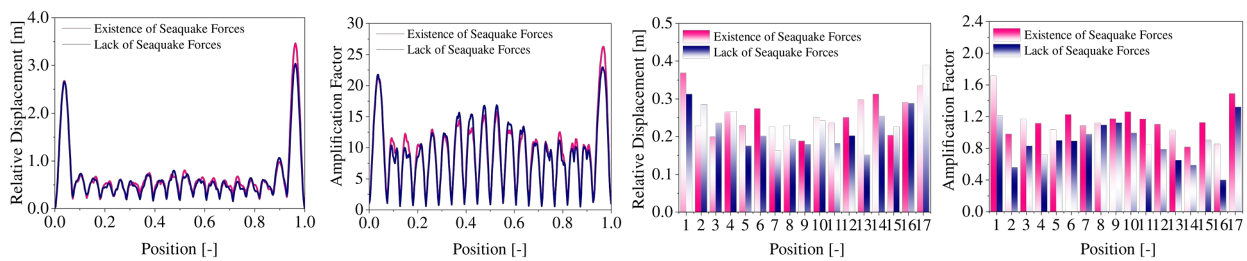


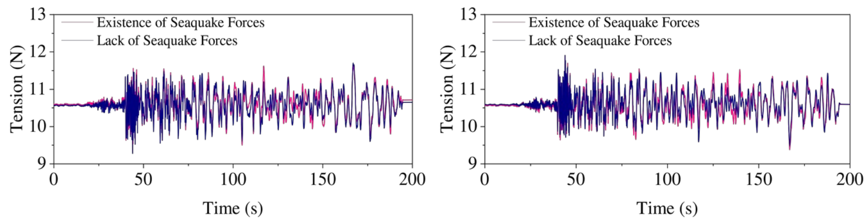
Fig.2 Finite element model information of the floating bridge

Figs. 3-4 show that seaquake forces notably increase the vertical displacement and acceleration of the main beam and pontoons, and also amplify anchor cable tension. In short, seaquake excitation significantly affects the floating bridge's dynamic response, especially in the vertical direction, and should be fully considered in design.



(a) z-direction(beam) (b) z-direction(beam) (a) z-direction(pontoon) (b) z-direction(pontoon)

Fig.3 Maximum displacement/ acceleration at various points along the beam/ pontoon



(a) anchor cable#1 (b) anchor cable#2

Fig.4 Time history curve of anchor cable tension

Keywords: *Seaquake Hydrodynamic force; Simplified formula; Parameter analysis; Floating bridge*