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CALCULATION OF DYNAMIC AMPLIFICATION FACTOR FOR JACK-UP STRUCTURES

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Introduction

One of the common approaches to study the dynamic behavior of jack-up structure is using the dynamic amplification factor (DAF). DNV and ISO provided some approximate formulas to calculate DAF [1 & 2]. Accordingly, DAF will be studied whether is a need to perform dynamic analyses or not. In the case that dynamic analysis is demanded, an inertial load set can be determined from a dynamic amplification factor. Therefore, accurate calculation of DAF is crucial for any further studies on structural behavior. In this paper, DAF is directly calculated using the maximum dynamic response and the maximum quasi-static response of the jack up structure; and then they were compared with the values obtained by approximate formulas. Five soil-structure models are used to find the influence of the foundation model on DAF. The soil properties and load conditions are mainly based on the Persian Gulf characteristics.

Description of the structural and foundation models

A jack-up is a type of self-elevating mobile offshore platform composed of a hull, lattice legs and a jacking/lifting system. Each leg is supported in the seabed by a spudcan (fig.1).

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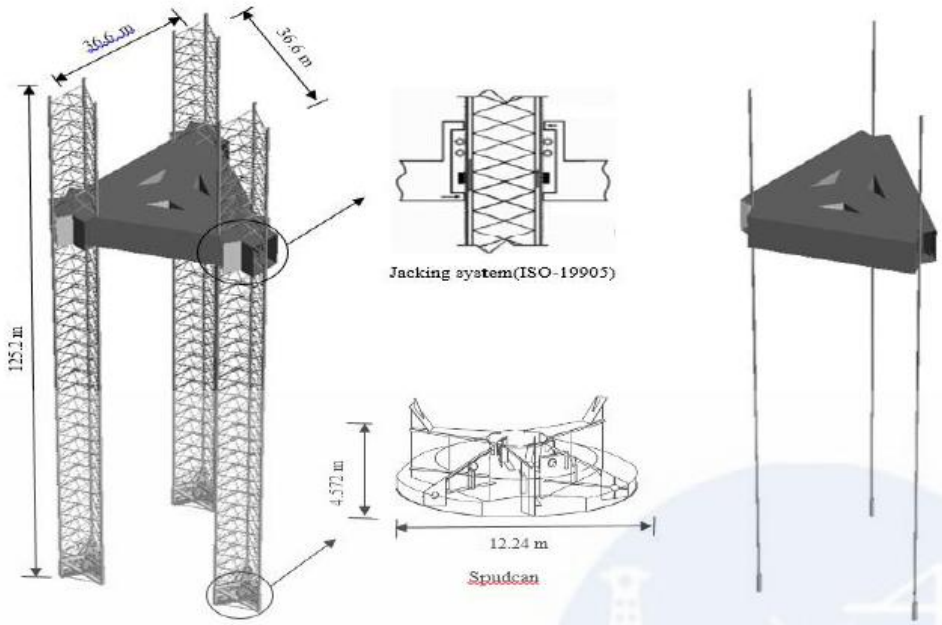

a)Detailed model **b)jacking system and spudcan.** **c)Stick model**

Fig.1) Structural model and schematic detailed view of jacking system and spudcan.

The geometry and structural configuration of the case study jack-up is similar to the rig that was first introduced by Friede & Goldman in early 80's called "Super m2".

The first step in the capacity check of the jack-up's foundation is estimating the required leg's penetration corresponding to the required preload. The SNAME's recommended equation for the capacity check is based on the traditional bearing capacity equation [3]. For this study, the bearing capacity versus depth has been plotted for the stiff clay.

Consequently, five models for the simulation of the soil-structure interaction based on the stiff clay soil properties have been defined. For the sake of brevity, they are named with the alphabetical letters and are summarized in the Fig.2. The computer program "USFOS" [4] have been used for this study.

a) Perfect hinged **b) Linear springs** **c) A hinge base with linear rotational spring** **d) Nonlinear springs** **e) Fixed bases**

Fig.2) schematic soil-structure models

Deterministic nonlinear dynamic and quasi-static response to the extreme wave

The extreme wave seastate with the return period of 100 years for the Persian Gulf [5] has been used to study the influence of the soil-structure interaction modelling on the nonlinear dynamic and quasi-static response. Figures 3 to 5 show the time series responses for a jack-up with hinge foundation model.

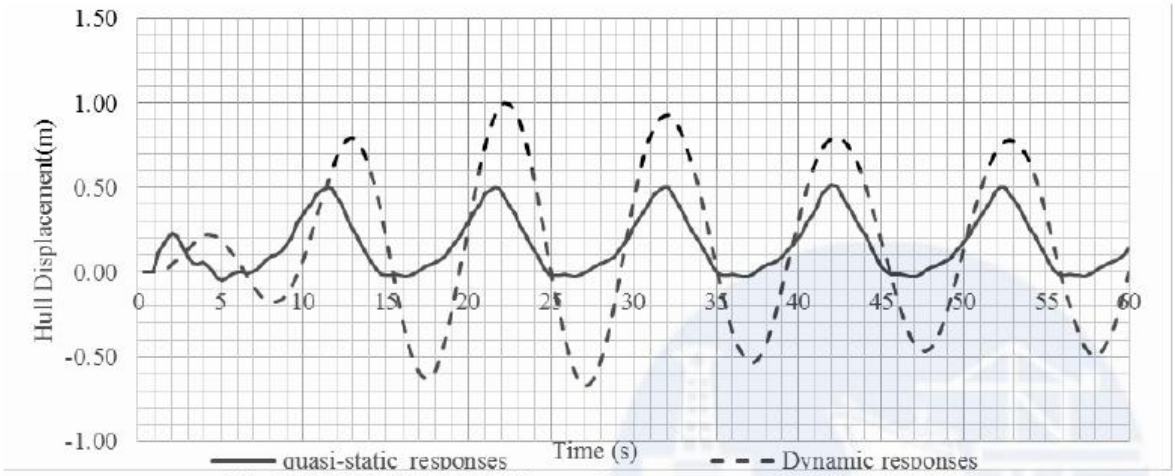

Fig.3 hull displacement time series responses for hinge model

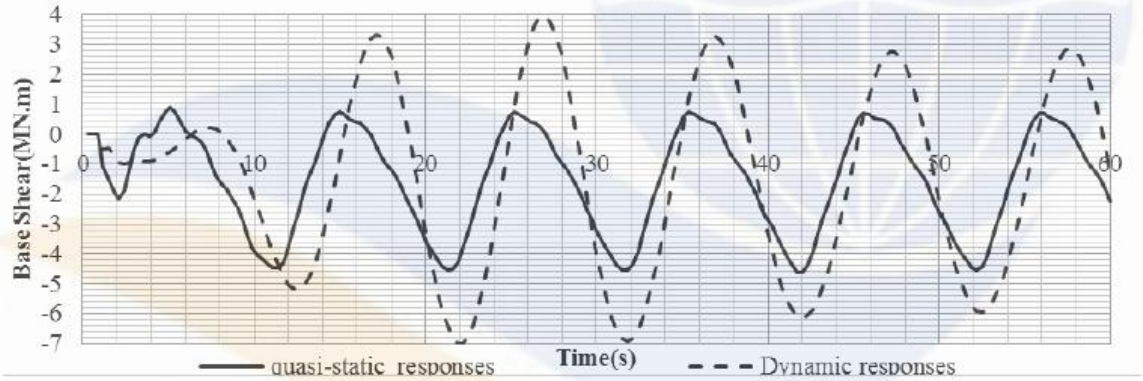

Fig.4 Base shear time series responses for hinge model

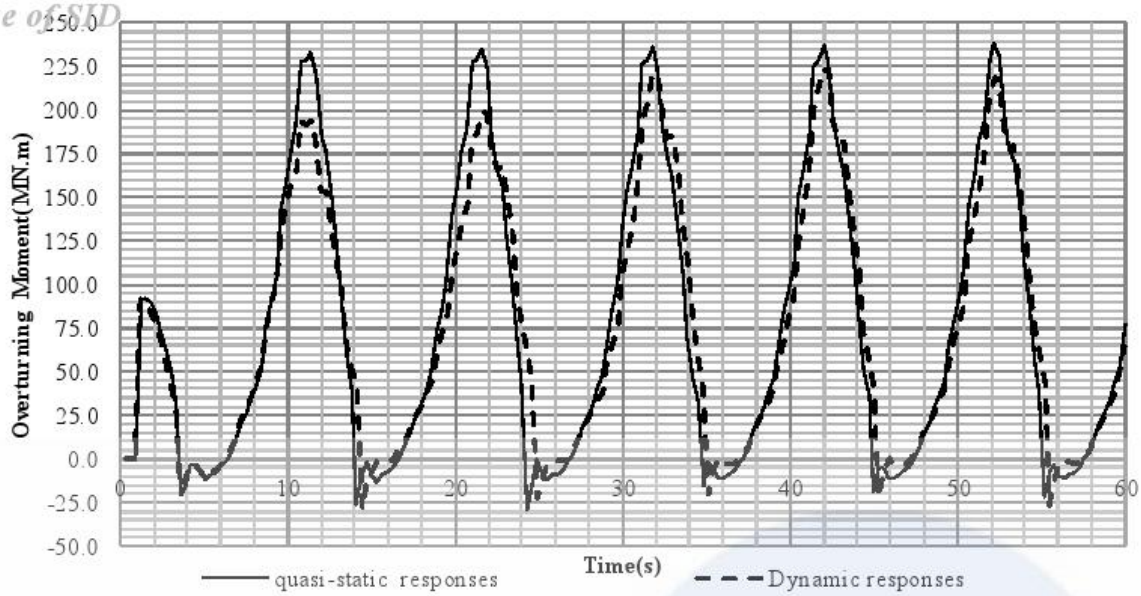

Fig.5 Overturning moment time series responses for hinge model

Calculation of DAF by using the results of the nonlinear dynamic and quasi-static response to the extreme wave

DAFs were calculated using the results of the nonlinear analyses. The effect of the foundation modeling and the difference between the DAF values according to the types of the structure responses were studied. Table.1 summarizes hull displacements DAFs obtained from analyses and approximate formulas for five foundation models.

Table 1) Calculated DAF for hull displacements

Soil structure models					
Hull displacement	a	b	c	d	e
DAF(analyses)	1.55	1.53	1.53	1.88	1.31
DAF(approximate formulas)	2.17	1.22	1.22	1.22	1.17

Conclusion

In the design process and assessment of jack-up structure, it is necessary to perform a set of analyses. Using simplified methods decrease this time consuming process. There are some approximate methods in which the dynamic loads are mainly calculated based on DAF. Studying DAF gives us understanding of the dynamic effect on the jack-up behavior. In addition, it can be used as an index to show the necessity for performing dynamic analyses.

Comparing the DAFs obtained from the nonlinear analyses with approximate formulas shows that the approximate equation for calculating DAF cannot be used for further analyses of the jack-up structure responses. Because the natural period of the structure, the period of the wave and damping are the only parameters that are considered in the approximate formulas. Therefore, neither the current speed and wave height nor the effect of the nonlinearity are involved in the calculation. Using five models for simulating soil-structure interaction shows the significant effect of the soil-structure model on the natural period and consequently DAF estimation. Therefore, the accurate procedure for using DAF can be summarized as follows: by performing dynamic analysis and comparing the results, the more accurate and simple foundation model could be found. Then DAFs are calculated from the analyses responses.

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