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ORIGINAL ARTICLE

Perturbation nonlinear response of tension leg platform under regular wave excitation

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Abstract Conceptual discussion on highly nonlinear Duffing type equation of surge motion of TLP gives a deep view on structural response under environmental loads with some simplifications. Such analytical response is a simple form that clarifies important points in behavior of the structure. This paper presents the dynamic motion responses of a TLP in regular sea waves obtained by applying three methods in time domain using MATLAB software. Surge motion equation of TLP is highly nonlinear because of large displacement and it should be solved with large perturbation parameter in time domain. In this paper, homotopy perturbation method (HPM) is used to solve highly nonlinear differential equation of surge motion. Also the numerical methods such as modified Euler method (MEM) and MATLAB are used to solve the ordinary differential equation of motion. MEM is used for highly nonlinear Duffing type equation of surge motion of TLP, whereas the nonlinear part is not considered in MATLAB solution. Calculated responses by analytical HPM are compared with those obtained from both MEM and MATLAB responses.

Keywords Tension leg platform · Perturbation · Morison equation

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1 Introduction

TLPs are well-known structures for oil exploitation in deep water and are becoming increasingly popular for oil drilling at very deep water sites. In these structures, the maximum motion amplitude belongs to surge motion. Dynamic analysis of TLP modeled under wave is presented. Finding nonlinear equation of surge motion that contains geometrical nonlinear term, according to available methods to solve nonlinear equation, the surge motion equation should be solved with large parameter in time domain. When the motion amplitude is small motion equation is weakly nonlinear. Many close form methods are available to solve this nonlinear equation. Rising the motion amplitude due to wave force, the traditional methods are unused to solve motion equation with high nonlinear term. The perturbation method [4] is used that in contrast to the traditional methods [6, 8], this technique does not require a small parameter for finding surge motion of TLP. Therefore, the obtained results are valid not only for small parameter, but also for very large value of perturbation parameter. This effect is more important when the amplitude of vibration is large. Studies have been carried out to understand the structural behavior of moored structures to determine the effect of several parameters on the dynamic response and average life time of the structure Tabeshpour et al. [2, 5, 12].

An analytical solution of the tether response of TLP was presented by Golafshani et al. [3] for a continuous model, considering the buoyancy and the effect of added mass fluctuation under the load simulated as an ocean wave. The effect of added mass fluctuation on the heave motion of a TLP subjected to axial load at the top of the leg has been investigated by Tabeshpour et al. [13]. Chakrabarti et al. [1] analyzed the truss pontoon semi-submersible platform

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