A Simplified Structural Safety Assessment Procedure for a Sea Water Caisson Attached to FPSO

Min Ju Gam1, Beom Seon Jang2,*, Dong Beom Lee1, Sung Gun Park3, Min Sung Chun4, Bon Yong Koo5
1: Department of Naval Architecture and Ocean Engineering, Seoul National University
Seoul, Korea
2: RIMSE, Department of Naval Architecture and Ocean Engineering, Seoul National University
Seoul, Korea
3: Structure R&D Group, Ship & Ocean R&D Institute, Daewoo Shipbuilding & Marine Engineering Co., Ltd.
Seoul, Korea
4: Structure Research Part, Central Research Institute, Samsung Heavy Industries Co., Ltd.
Daejeon, Korea
5: Korea Energy Technology Center, American Bureau of Shipping
Busan, Korea

ABSTRACT
The subject of this study is a sea water caisson attached to FPSO. The caisson is exposed to Morison load and global load simultaneously. Drag term in Morison load has nonlinearity due to relative velocity squared. Due to this nonlinearity, analysis should be conducted in time domain. However, time for calculation in time domain is much longer than that in frequency domain. Therefore, development of a simplified method is necessary to get a result which is similar to an exact solution easily and quickly in frequency domain. In this paper, calculation procedure for the exact solution about floating structure like the caisson is suggested. Several techniques are used to get the exact solution in time domain; superposition of response, stretching method, and expression for response in complex plane.

KEY WORDS: Sea water caisson; Morison load; Nonlinearity; Simplified method; Floating structure; Superposition; Stretching method; Complex plane.

INTRODUCTION
Generally cylinder-type offshore structure attached to a large hull such as a sea water caisson attached to FPSO is subject to Morison load from wave and global load from hull at the same time. Therefore, local stress and global stress should be considered together in structural safety assessment. If Morison load is assumed as linear in calculating fatigue damage ratio of offshore structure, the results may be underestimated in some part and overestimated in other part (Lee, et al., 1999). Thus, nonlinear wave load should be used instead of the linear wave load to prevent this phenomenon. Normally, structural safety assessment can be done in two domains; frequency domain and time domain. In frequency domain, the time used for calculation is short, but the calculation is only available under an assumption that the applied load is linear. Whereas, in time domain, the nonlinear wave load can be considered, but the required time for the calculation becomes much longer, which makes it difficult to be used in early design stage. Hence, combining advantages of both domains is needed. That is to say, it is important suggesting a new method to get a result exactly and simply.

This study has two levels as show in figure 1. Level 2 is performed in time domain to get the exact solution. This is used to verify the result of the new method. Level 1 is carried out in frequency domain, and the simplified method is developed in level 1. Level 2 is usually more complicated and time-consuming than level 1. Both level 2 and level 1 start from motion analysis to get RAOs (Response Amplitude Operator) fluid particle velocity for each depth, 6 DOF (Degree of Freedom) motion, and global stress. In level 2, time history of combined stress is generated from these RAOs and it is used to calculate fatigue damage ratio. In level 1, result can be obtained conducting spectral method for combined stress. Combined stress spectrum is generated by the sum of local stress and global stress spectrum. To get a local stress spectrum, linearization of Morison equation is performed using stochastic method and equivalent method.

This paper only covers level 2; analysis in time domain.

PROCEDURE IN TIME DOMAIN (LEVEL 2)

Overall Procedure in Time Domain

Fig. 1 Structural safety assessment procedures in different domains