FIXED OFFSHORE PLATFORM DESIGN AND STRUCTURAL STRENGTH EVALUATION CONSIDERING SEA BED CONDITION

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1. Introduction

In this study, structural design and strength evaluation of the platform structure, which is a typical fixed offshore platform, was performed as part of the structural design study for acquiring the structural safety evaluation technology of the offshore plant. The basic geometry of the platform structure is designed in accordance with the classification rules and general platform design guidelines. General guidelines for designing steel offshore structures are given in ANSI/AISC [1] and Euro Code 3 [2]. The detailed guidelines for the design of steel offshore structures are applied in the API RP 2A WSD [3]. For the designed platform, the structural strength was evaluated by performing the in-place analysis. The sea bed boundary condition suitable for the platform design and strength evaluation was proposed by analysing the effect of the platform structural strength and deformation according to the sea bed boundary condition of the pile fixed platform.

2. Platform structure design

The platform installation target sea is set to 130m water depth in the South China Sea near Malaysia. The platform with 20,000 ton superstructure was designed by rule scantling technique. The 8-leg type platform was selected considering the size of the superstructure and the spacing of the coupling part between superstructure and platform leg. The specific dimensions of legs and members of the platform were designed to meet material strength standards such as slenderness, buckling, and hydrostatic pressure collapse. The slenderness ratio of 80 on the U.S. coastal standard was applied to ensure sufficient safety. The ratio of diameter to thickness (D/t ratio) was less than 60 to prevent local buckling, and finally the designed platform weighed 5,300 tons.

3. Global structural analysis

The in-place analysis of platform was carried out using SACS (v.11.0), a structural analysis software for offshore structures. The extreme environmental condition (100-year repetition period) was applied to the platform load condition and the pinned joints were applied to the boundary condition between the platform and the sea bed. The platform had the highest stress in the beam sea condition, and the unity check ratio of 0.995 at the lowermost leg was caused by the self-weight of the superstructure and the bending moment due to the horizontal marine environment loads (Fig. 1). Unity check ratio was measured to be less than 1 to ensure structural integrity of the designed platform. And analytical results were verified by obtaining almost the same strength results through structural analysis using the in-house code based on the beam element.

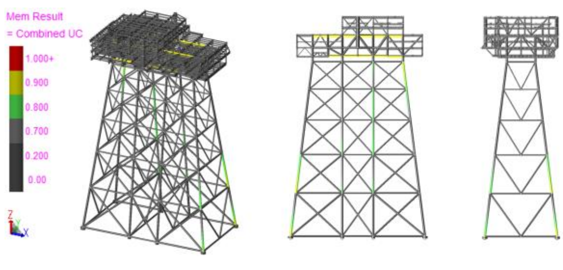

Figure 1: Analysis results of platform model (Combined unity check).

4. Sea bed boundary condition effect

The effect of sea bed boundary conditions between the bottom pile member of the platform and the sea bed was analysed. When the fixed boundary condition was applied to the bottom pile joints, the +y moment due to the horizontal environment loads occurred at the lowermost leg as the rotational deformation of the pile was constrained. In the case of the pinned boundary condition where horizontal displacement of the platform influences the rotational deformation of the pile, the –y axis moment due to the pile member rotational deformation occurred at the lowermost leg (Fig. 2). The axial stress of the leg due to weight of the superstructure is almost the same in both cases, but the moment due to the horizontal loads is opposite to the direction and the magnitude of the stress is quite different (Table 1). Fixed joint is not suitable sea bed boundary condition for platform global structural analysis because leg stress can be underestimated for it predicts deformation behaviour of piles differently from actual behaviour.

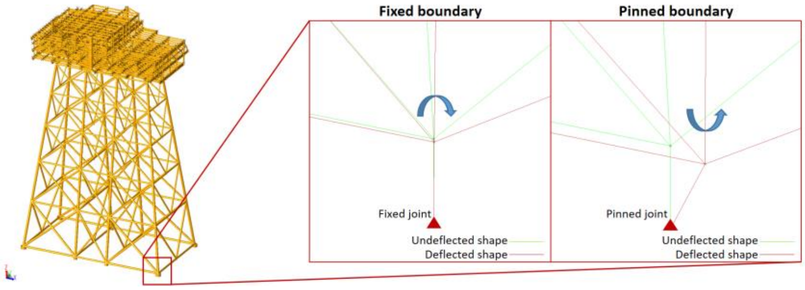

Figure 2: Structural deformation results of platform by sea bed boundary condition.

Joint condition	Unity check ratio				Applied stress (N/mm^2)			
	Max. U.C.	Axial U.C.	Bend-Y U.C.	Bend-Z U.C.	Axial stress	Bending Y-Y	Bending Z-Z	Com. Stress
Pinned	0.995	0.696	0.258	0.040	-114.01	-55.34	21.76	-173.47
Fixed	0.759	0.702	0.019	0.039	-114.88	6.50	-9.46	-126.35

Table 1: Comparison of U.C. ratio and stress of the lowermost leg (Pinned vs. Fixed).

5. Conclusions

A 5,300 ton platform structure satisfying the related design guidelines was designed and the structural integrity of the platform was evaluated for environmental loads and superstructure loads. The maximum stress occurred at the lowermost leg and was evaluated as U.C. ratio of 0.995, confirming the structural integrity. Prior to the Pile-Soil interaction analysis including the actual sea bed geological property, pinned boundary condition was found to be suitable for platform global structural analysis by analysing platform behaviour and stress characteristics according to boundary conditions at the end of piles.

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