PARAMETRIC STUDY OF FIXED JACKET PLATFORM UNDER VARYING JACKET CONFIGURATION AND ENVIRONMENTAL LOADS

Ayushi Nayak*, G.Augustine Maniraj Pandian**

* Mtech Structural Engineering, SRM Institute of Science and Technology, Chennai, Tamil Nadu, India

** Professor, Department of Civil Engineering, SRM Institute of Science and Technology, Chennai, Tamil Nadu, India

ABSTRACT

Offshore jackets are heavy steel structure subjected to harsh environmental forces. The work under this paper highlights the variation in parameters of fixed base wellhead platform due to change in leg batter and environmental forces. Static analysis has been carried out on models with leg batter of 1:5, 1:7 and 1:9 respectively for 3 sets of environmental load combination and maximum global deflection due critical load is found out. The analysis has been performed in an offshore software SACS (Structural analysis and computer system) and results are plotted in graph. Parametric study is done for wind and hydrodynamic (wave, current) loads acting in orthogonal direction i.e. South East, North East, North West and South West. Storm data for Bombay High basin, Norwegian Continental Shelf and South Pars field are used for comparative study. The results emphasized on behavioral change which shows decrement in Base shear, Overturning Moment and Forces with increasing leg batter.

Key Words: Jacket Platform, Static Analysis, SACS, Leg batter, Parametric study

1. INTRODUCTION

An offshore oil rig extricates crude oil from deep down the seabed. A rig consists of number of platforms performing various operations; these can be classified into different types depending on the circumstances. One among the type is Fixed Wellhead Platform. Its basic purpose is to shelter well, crane, escape system and other equipments for drilling. The tubular frame (Jacket) of the structure takes up maximum loading and hence need to have a stable design.

Some research has been carried out by Taha Nasseri et. al.(2014), Faseela & Dr Jayalekshmi (2015), and Mohammad Nejad (2010) who took weight as constraints and performed inplace analysis for optimization of structure whereas S Ishwarya et. al. (2016) did it by performing nonlinear pushover analysis. Performance and reliability check of a jacket platform in Mumbai high basin was carried out in softwares STRUCAD*3D and PILE19.4 OASYS by Ponam Mohan et al.(2013). R.G. Bea et al.(1995) observed behavior of 4 different
platform in gulf of Mexico under intense loading of hurricane Andrew. Fushun Liu et al. (2016), Kok Hon Chew et al. (2016), M. Zeinoddini et al. (2012), A. Mojtahedi et al. (2013) proposed newly designed methods by combining algorithm for analyzing and assessing response of the offshore structure.

In this paper a hypothetical wellhead jacket platform has been statically analyzed for a water depth of 70 meter. An offshore software SACS has been used for modeling and analyzing purpose. The basic need for this study is to understand the ultimate response of the structure experiencing change in configuration and loading condition to obtain integrity in design.

2. METHODOLOGY

Work under this study is initiated by modeling of jacket platforms for 3 different leg batter i.e. for 1:5, 1:7, and 1:9. Each platforms are then analyzed for 3 sets of environmental loading condition for extreme storm taken from three different sites; Bombay High basin (Set 1), Norwegian Continental Shelf (Set 2) and South Pars field (Set 3). Response of the structure is then compared considering parameters like Resulting Forces, Moment and Shear.

2.1 MODEL

An oil platform comprises of deck and jacket structure. The platform modeled in this study is 4 leged Wellhead platform with total height of 89 meter, standing on 70 meter water depth. Cross section of main deck is 24x17 meters where as for cellar deck 18x17 meters and a bracing type of X pattern is used. Altitudes of different levels from seabed are presented in figure 2.1 and an isometric view of the model in figure 2.2.
2.2 LOADS

Dead and Live loads are applied on surface in the form of pressure loads with a magnitude of 400T and 100T on Main deck and 250T and 50T on Cellar deck respectively. Weight of anode is also considered for tubular member. Environmental data including hydrodynamic loads with 100 year extreme storm are taken for geographical direction South East, North East, North West and South West representing 0, 90, 180 and 270 degree in SACS which can be seen in table 2.1 to table 2.3. Load combinations STM1, STM2, STM3, and STM4 are considered with a load factor of 0.75 for live load and 1.1 for environmental load.

Table 2.1 Wave data for 100 year extreme storm period

<table>
<thead>
<tr>
<th>Direction</th>
<th>Bombay High Basin</th>
<th>Norwegian Continental Shelf</th>
<th>South Pars field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical</td>
<td>SACS</td>
<td>Surface (m/s)</td>
<td>Bottom (m/s)</td>
</tr>
<tr>
<td>South East</td>
<td>0°</td>
<td>1.28</td>
<td>.304</td>
</tr>
<tr>
<td>North East</td>
<td>90°</td>
<td>1.249</td>
<td>.274</td>
</tr>
<tr>
<td>North West</td>
<td>180°</td>
<td>1.249</td>
<td>.335</td>
</tr>
<tr>
<td>South West</td>
<td>270°</td>
<td>1.249</td>
<td>.335</td>
</tr>
</tbody>
</table>

Table 2.2 Current data for 100 year extreme storm period

<table>
<thead>
<tr>
<th>Direction</th>
<th>Bombay High Basin</th>
<th>Norwegian Continental Shelf</th>
<th>South Pars field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical</td>
<td>SACS</td>
<td>Height (m)</td>
<td>Period (sec)</td>
</tr>
<tr>
<td>South East</td>
<td>0°</td>
<td>11.64</td>
<td>12.7</td>
</tr>
<tr>
<td>North East</td>
<td>90°</td>
<td>11.03</td>
<td>12.2</td>
</tr>
<tr>
<td>North West</td>
<td>180°</td>
<td>15.88</td>
<td>13.45</td>
</tr>
<tr>
<td>South West</td>
<td>270°</td>
<td>17.1</td>
<td>13.9</td>
</tr>
</tbody>
</table>

Table 2.3 Wind data for 100 year extreme storm period

<table>
<thead>
<tr>
<th>Direction</th>
<th>Bombay High Basin</th>
<th>Norwegian Continental Shelf</th>
<th>South Pars field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical</td>
<td>SACS</td>
<td>Velocity (m/s)</td>
<td>Velocity (m/s)</td>
</tr>
<tr>
<td>South East</td>
<td>0°</td>
<td>44.83</td>
<td>33</td>
</tr>
<tr>
<td>North East</td>
<td>90°</td>
<td>44.83</td>
<td>31</td>
</tr>
<tr>
<td>North West</td>
<td>180°</td>
<td>41.84</td>
<td>30</td>
</tr>
<tr>
<td>South West</td>
<td>270°</td>
<td>42.59</td>
<td>35</td>
</tr>
</tbody>
</table>
3. RESULTA AND DISCUSSION

Linear static analysis has been performed to compare behavior of structure under varying configuration. Codes referred throughout the process are API-RP-2A 21st edition and WSD AISC 9th and 13th edition. Maximum upward and downward forces and associated moment and shear relative to mud line due to change in leg batter and sea state loading are graphically portrayed. Basic joint design and unity check has also been done to ensure stability of structure against premature failure.

The effect of wave loading is pre dominant in offshore structure; wind action dominates more above the water level especially on the deck. Curved surface of tubular member reduces area to be exposed improving performance of the structure against wind effect. On the other side prediction of waves is only probabilistic hence to retain structure’s stability its natural period is kept below the period of wave.

Lateral forces by wind and wave generates hydrostatic force which disrupt the linearity of structure by shifting center of buoyancy from the center of gravity causing overturning at the base. Thus shape and weight of the structure plays an essential role for generating stability against overturning. Transformation in the moment with respect to the base area can be seen from figure 3.1 which shows a similar 2-3% reduction in moment with increasing slope for the South East and North West waves. An increase in moment for 0.2-0.6% can also be seen while the legs change its slope from 1:5 to 1:7 for the other two directions.

![Overturning Moment](image_url)

**Figure 3.1: Variation in moment relative to mudline**
The comparison from the figure 3.2 shows that maximum expected lateral force at the base of the structure due to environmental and hydrodynamic effect is 7750 kN for jacket in Bombay high basin whereas jacket in Norwegian shelf and South pars field faced worst waves at 90° and 180° generating highest shear respectively. But it can also be noted that an identical change of 2-4% reduction in shear is observed for the loads coming in lateral direction hence longitudinal side of the structure is much more affected by the steepness change than the lateral side. Jacket with leg batter 1:9 is most suitable since it experience least base shear due to reduced base area.

**Figure 3.2: Variation in shear relative to mudline**

Maximum upward and downward force presented in figure 3.3 and figure 3.4 are the reaction generated with respect to mud line level in response to sea state loading in order to balance forces coming on the structure to prevent it from overturning. As the steepness of leg increase magnitude of resisting force decreases by 5-10%. Set 1 loading condition gives maximum upward force of 1520 kN for the waves coming from south west direction, whereas for other two sets of load waves from North East and South East directions were critical respectively.

From the above study we can be observed that the jacket in Bombay high basin is subjected to high overturning moment and base shear for given sea state loading hence a jacket with leg batter 1:9 leg will be most suitable.
Figure 3.3: Variation in maximum upward force

Figure 3.4: Variation in Maximum downward force
4. CONCLUSION

A hypothetical jacket platform has been modeled for 3 leg configuration, its performance against wind and wave forces from 3 different regions are then compared performing static analysis in SACS. The possible conclusions drawn from the above study are reported below:

- Critical load combination for platform in Bombay High basin is STM4, Norwegian Continental Shelf is STM2 and for South Pars field is STM3.
- Critical member whose value exceeds one in unity check has been re-designed for the exceeding value of bending stress in order to assure stability of the structure.
- Wave moving parallel to the diagonal of the structure generates greater forces on the vertical member whereas for the waves parallel to the face greater forces are observed on the bracing.
- Axial Stresses acting on the structure are under allowable limit.
- The wave forces generated are also evaluated by manual calculation using Morison equation for the same jacket with zero batter and comparing it with jacket with 1:5 leg slope.
- In order to maintain structure’s integrity under the service year final responses has been carefully studied and are highlighted in this paper.

5. ACKNOLODEGEMENT

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6. REFERENCES


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