Lifting analysis of Mooring Support Structure (MSS) in offshore tower yoke by top panel stacking structure method

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Abstract. One indicator of the success of an offshore development project is its completion on time. Supporting factors of this time are the availability of lifting equipment that has a high capacity. Lifting the top panel on the MSS tower yoke system with all its main components is done by planning using crane tools that are improvised by the stacking structure method. The stacking structure method is done by doing all the installation of the primary and secondary structures on the top panel carried out at the bottom (ground) then lifted onto the tower yoke system by using several cranes lifting equipment. Whereas the determination of the center of gravity and the lifting point using SACS (Structural Analysis Computer System) software found that the top weight of the MSS Panel was 3705 KN with the center of gravity (x, y, z): (12.10 m, 9.43 m, 31.66 m) and MSS stacking top panel using four lifting points requires four cranes. The stacking structure method has a high potential used as a procedure for reducing offshore development costs.

1. Introduction
The utilization of marine resources requires improvisation in engineering offshore structures designed by the substance of their use. One of the building subsystems offshore is a characteristic of the building is its structure. An offshore platform structure is made and assembled on land and then used at sea. This indicates that the building design process not only pays attention to the way of installation but also the process of moving the building. A structure uses only one mooring rope (single line) to tether a shuttle tanker, the structure can be called a single point mooring (SPM) tower yoke systems function as an offshore terminal used to channel oil from the tanker to the site or otherwise. Single point mooring (SPM) can be applied at various depths without the need to build structures such as jetty (Indian Oil, SPM Terminal at Valdinar). With this advantage, it is possible for tankers with very large sizes (Very Large Crude Oil Carrier) having a draft size so high that it is impossible to move closer to the mainland. Therefore, we need a single point mooring (SPM) as a substitute for the function of the port on land that can be applied without having to build a jetty first, as shown in Figure 1 [2].
In the process of building installation, time plays an important role. One indicator of the success of an offshore development project is its completion on time. Supporting factors of this time are the availability of lifting equipment that has a high capacity. The greater the lifting capacity available, the lower the risk faced during the lifting process. One of the most critical parts of the mooring support structure (MSS) tower yoke system is the deck panel or top panel, which is the center of the worker's activities and installation of the system, such as electrical installations, piping, pumps and so on [3].

2. Crane

Crane is defined as the equipment used to move and lift cargo both material or goods or people vertically and or horizontally within a specified distance. In the offshore environment, cranes have an essential function, namely as a means of lifting all activities, including logistics needs, materials for operations, parts, installation of new facilities, repairs, transportation of employees, and others. Crane is included in the category of material transportation equipment because it can transport material vertically and then move it horizontally at a relatively small range. For the transportation of loose material with relatively long distances, the equipment used can be in the form of belts, trucks, and wagons. These tools require other tools that help load material into it, as shown in Figure 2. The operational characteristics of all moving cranes are, in principle, the same, with differences in the movers. Crane with movers means that the crane can mobilize from one place to another. The distance of the movement depends on the type of drive, the tire wheel, or the crawler wheel. Crane, which can move, consists of three types, namely crawler mounted crane; truck mounted crane, and wheel-mounted crane [4].
3. Stucking Structure Method

In principle, the removal of the top panel on the MSS tower yoke system that has been installed with all its main components is done by planning using a crane tool. The plan ensures that the available lifting equipment is capable of lifting heavy loads from the module. Top panel structure that has dimensions and a large system will produce an enormous, heavy burden as well. So it requires a crane that has a large capacity as well [6].

Cranes with large lifting capacities cannot be used throughout the project implementation due to high rental costs and are difficult to find in the field. So, to pursue time, offshore development needs improvisation. Improvisation is done by the method of stacking structure. The method of stacking structure is carried out by doing all the installation of the main structure, and secondary structure (grating, electrical and instrument, etc.) on the top panel carried out at the bottom (ground) then lifted onto the tower yoke system by using several crane lifting equipment. While determination the center of gravity and lifting points from the Top Panel will be analyzed using Structural Analysis Computer System (SACS) Software with the following display.
4. Result and Discussion

4.1. Determination of Center and Lifting points

The center of gravity and lifting point of MSS Top Panel is obtained from the analysis using SACS Offshore structure software.

4.1.1 Determination of center of gravity, there are several steps to get the center of gravity on the MSS structure top panel, namely:

- Model MSS structure top panel from Engineering drawing both Primary and Secondary Structure shown in the following Figure 4.

![Figure 4. Engineering Drawing Top Panel MSS.](image-url)

![Figure 5. Top Panel by SACS Software.](image-url)
Installation weights, adding an additional load to the MSS top panel structure such as grating, electrical, instrument, etc. The MSS Top Panel weights are summarized, as shown in the table below.

**Table 1. Summary of Loading Condition**

| No. | Description                | MSS Module 1 (MT) |
|-----|----------------------------|-------------------|
| 1   | Dry Weight (MT)            | 197.900           |
| 2   | Padeye in Row 2            | 3.186             |
| 3   | Cleavis                    | 94.597            |
| 4   | Grating 1 (Row A)          | 1.713             |
| 5   | Grating 2 (Row B)          | 1.556             |
| 6   | Grating 3 (Lower Deck)     | 6.222             |
| 7   | Handrail1 (Row A)          | 1.0876            |
| 8   | Handrail2 (Lower Deck)     | 0.711             |
| 9   | Handrail3 (Upper Deck)     | 0.750             |
| 10  | Handrail4 (Upper to Row 2) | 0.318             |
| 11  | Handrail5 (Ladder)         | 0.255             |
| 12  | Handrail6 (Row B)          | 1.008             |
| 13  | Winch Foundation           | 1.434             |
| 14  | Switch Rack A              | 0.519             |
| 15  | Switch Rack B              | 0.889             |
|     | Total Net Weight           | 312.150           |
|     | Total Weight with Cont Factor(1.1) | 343.360    |
|     | Total weight with DAF (1,10 ) | 377.700    |

Analysis and Calculation Using SACS Software, after modeling and entering a combination load, calculations and analysis are carried out to obtain the center of gravity (CoG) and the total weight of the MSS Top Panel using SACS software. The location of the center of gravity of the MSS Top Panel can be seen in Figure 6.
Based on Figure 6, it can be seen that the weight of the MSS top panel after adding the combination load, Contingency Factor and Dynamic Amplification Factor is 3705 KN with the location of the center of gravity (x, y, z) (12.10 m, 9.43 m, 31.66 m).

4.1.2. Lifting Point, based on the weight and center point of gravity of the MSS Top Panel, a case study was conducted
to determine the location of the lifting point. As for who is concerned about determining the lifting point, namely:

- It is a concern of determining the number of lifting points, namely the number of cranes and the available crane capacity.
• The determination of the location of the lifting point is closely related to the strength of the structure (local check analysis) of the MSS Top Panel, where the members of the structure are still within safe limits when stacking is done.
• Rack Crane during the stacking process.

From the case study above, a calculation and analysis are carried out to get the lifting point from the MSS top panel, where the result is four lifting points with different weights for each lifting point. The results of the analysis and calculation can be seen in the image below.

![3D modeling of location and number of lifting points](image)

**Figure 9. 3D modeling of location and number of lifting points**

### 4.2. Equipment List

Equipment and facilities used during the top panel installation and removal process are described in the following table.

| No | Description       | Qty | Size            | Capacity (MT) | Remark                     |
|----|-------------------|-----|-----------------|---------------|----------------------------|
| 1  | Wire rope sling   | 2   | 4" x 15 M       | SWL = 120     |                            |
| 2  | Wire rope sling   | 2   | 2.5" x 15 M     | SWL = 60      |                            |
| 3  | Crawler Crane     | 2   | Kobelco SL 6000 (550 MT) | 280         | Boom crane:66.0 m       |
|    |                   |     |                 |               | Radius:14m, Double Drum, Pallet Weight 130 MT |
| 4  | Crawler Crane     | 2   | CKE 2500 (250 MT) | 53.5         | Boom crane:61 m           |
|    |                   |     |                 |               | Radius:16 m               |
| 5  | Carry picker      | 1   | -               | -             |                            |
| 6  | Plate             | 20  | -               | -             | For crane path            |
| 7  | Forklift          | 2   | -               | -             | Plate for crane path      |

### 5. Conclusion

Based on the results of the analysis and calculation of the MSS Panel stacking top can be concluded as follows:

1) The calculation process and analysis of the Panel top stacking using the SACS Offshore Structure software.
2) MSS top panel weight is 3705 KN with the location of the center of gravity \((x, y, z)\); (12.10 m, 9.43 m, 31.66 m).
3) The MSS Panel top stacking uses four lifting points, so it requires four cranes in the stacking process.

4) MSS top panel stacking process can speed up the project completion process but what is concerned about this is that proper engineering analysis is needed to determine the weight structure of the center of gravity, the strength of the structure, the number of lifting points and the number of cranes and other facilities so that the stacking process can run safely.

References

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