Volume 7 Issue 1 ISSN: 2456-7035

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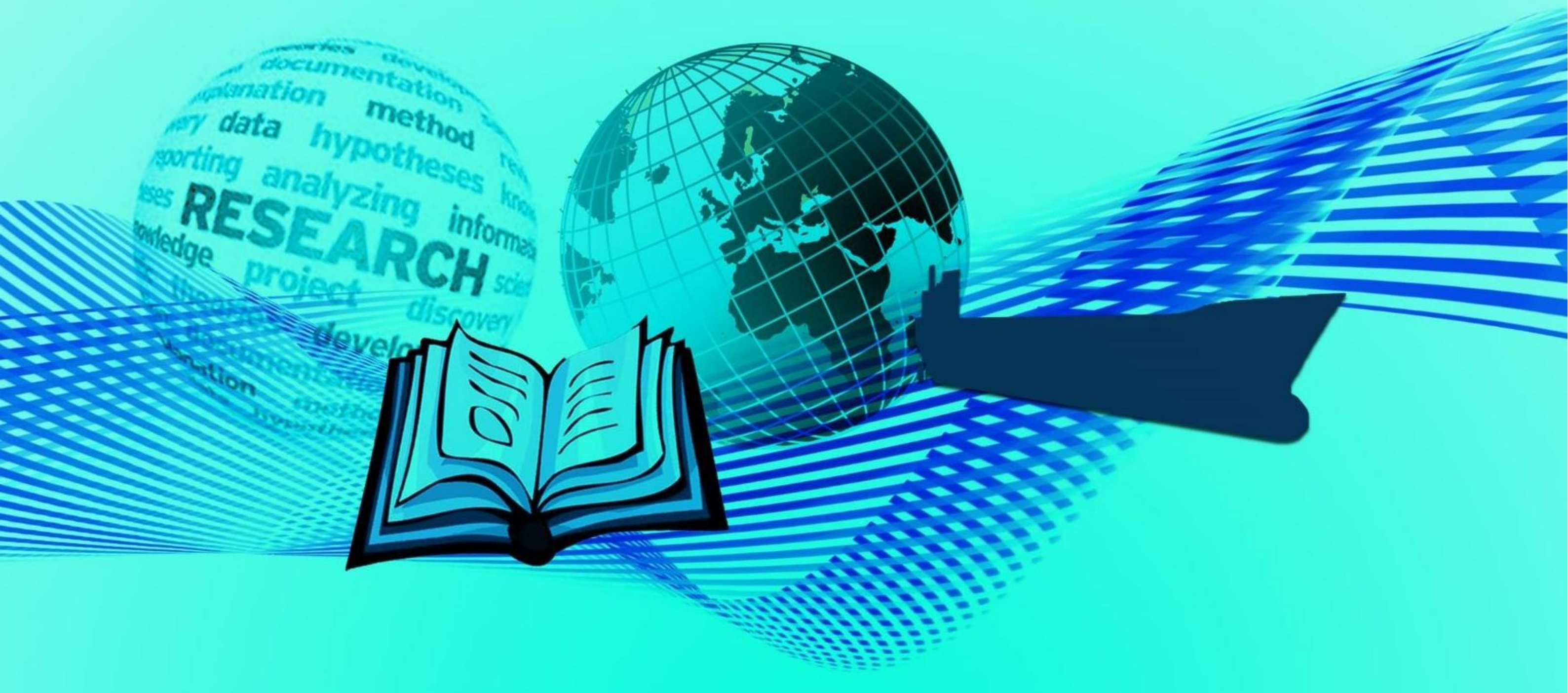
ISF Institution of Research and Education (IIRE)

IIRE JOURNAL
OF
MARITIME RESEARCH AND DEVELOPMENT
(IJMRD)

April 2023



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ISSN: 2456-7035

Published by:

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410, Gemstar Commercial Complex, Ramchandra Lane Ext, Kachpada,
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Website: www.iire.in, www.inner-search.org, www.isfgroup.in

Link of Publication: - https://ojsiire.com/index.php/IJMRD
Place of Publication: - Mumbai

IIRE Journal of Maritime Research and Development

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STRUCTURAL ENGINEERING CHALLENGES IN A MODU TO MOPU CONVERSION PROJECT

Mr Thomas Stephen, Ms Neethu Narayanan, Mr Tomin Mathew.

Abstract

A drilling rig is often chosen by the decision makers for a Mobile Offshore Drilling Unit (MODU) to Mobile Offshore Production Unit (MOPU) conversion project without having a proper pre-purchase engineering study to verify the suitability of the rig for the MOPU project. This decision is often governed by the purchase value of the drilling rig for conversion and the maximum operation limitations of the drilling rig as specified by the Marine Operation Manual (MOM) if the drilling rig. This could lead to sever engineering challenges during the project execution which require unusual remedial actions or sometimes even abandoning the project. In this paper, a detailed discussion is presented particularly with regards to the structural engineering aspects of a MODU to MOPU conversion project.

Keywords: Overturning Stability, Pinion Stiffness, Jack Up Rig, Mobile Offshore Drilling Unit (MODU), Mobile Offshore Production Unit (MOPU), Dynamic Amplification Factor (DAF).

1. INTRODUCTION

Converting a mobile offshore drilling unit to a production installation can be a cost-effective approach for the development of offshore fields especially for the marginal field where the operational life of the field is only a few years usually less than 10 years. One of the reasons for introducing a MOPU instead of a fixed offshore platform is because, the fixed platform is generally having a design life of 25 years and it is an immobile structure whereas the MOPU can be later deployed to a different site/project with minimum modification.

2. WEIGHT CONTROL ENGINEERING

Usually, a 3-legged drilling rig is chosen for MODU to MOPU conversions. Items such as Cantilever, Drill floor, Derrick Structure, Drilling equipment etc are removed from the drilling rig and process equipment required for the MOPU operation are added on to the main deck of the rig. One or two flare booms are also installed on to the side of the rig based on the project requirements. A gangway is connected to the nearby wellhead jacket, if any.

Weight control engineering is the prime and most important exercise that must be done with great accuracy in the FEED design itself for the smooth execution of the project. It is always beneficial to reduce the weight as much as possible for the MOPU. But this may not be possible all the time depends on the project requirement. Apart from the weight, the COG locations of the weights are crucial so as not to overload any of the legs in elevated conditions. Significant offset of COG from leg's centroid would need additional permanent ballast to correct COG which will further increase the overall weight which would directly affects the jacking system capacity and dynamics of the MOPU and thus wave excitation forces.

3. SITE SPECIFIC MET-OCEAN CONDITIONS

Usually drilling rigs are not designed for any particular site-specific environment as it is expected to operate in any part of the globe. Often a standard environment condition is chosen for the basic design of the drilling. For North Sea condition the standard environment conditions may look like below,

Maximum Wave Height: 13.5m, Wave Period: 15s

Current Velocity @ Surface: 1 knot, Current Velocity @ Seabed: 0 knots

Storm Wind Speed: 100 knots

However, when the same drilling rig must be deployed on to a particular site for the MOPU operations, the site-specific environmental loadings will come into play. Common scenarios are given below,

1. A lesser wave height, however, the wave period lies close to the natural period of MOPU which means more dynamic excitation.

2. A higher current velocity at location both at surface and at seabed. The average current speed for the original design is only 0.5 knots. However, sometimes the average current

velocity could be as high as 1.5knots or even more. This will imply that the current loading will be 9 times the original design loading as the current velocity is 3 times more. The dynamic amplification for MOPU is to be considered for a loading condition where both wave and current loads are present and therefore this current load will be further multiplied by the dynamic amplification factor (DAF).

3. Wind loads in the same order or lesser. However, because of the windage area might be increased because of the presence of process equipment on the main deck, flare booms, extra leg length above jacking system etc. This need to be considered in the revised analysis.

4. SOIL CONDITIONS AT INSTALLATION LOCATION

Drillings rigs are never designed for any soil data. During basic design of the rig, usually a 3m penetration is considered for the design and legs are assumed to be pinned at this penetration for the global leg in-place analysis.

However, when the vessel is deployed to a particular location for MOPU operation, the site-specific analysis is to be carried out to ensure that the vessel can be safely operated at the location. One of the important parameters is the soil strength at installation location.

If the soil strength is comparatively low, then the legs and spudcan would experience more penetration. This directly implies that the usable leg length is reduced by excessive penetration. For example, in Indonesian waters, a typical drilling rig designed for North Sea conditions (3m penetration) would have a penetration of more than 25m as the soil is very weak. So, the usable leg length is reduced by at least 22m compared to the original design.

5. DYNAMIC AMPLIFICATION FACTOR (DAF)

When a jack-up vessel is subjected to wave loading, it is subjected to dynamic excitation. The degree of the excitation depends on the natural frequency and the incident wave period. If they are close together, resonance might occur. In the basic design a standard wave period of 15s is used for the assessment.

The drilling rig's natural frequency may lie in the range of 5s in the storm loading condition as the rig normally has reduced weight for storm survival by reducing variable loads on board. Since the natural frequency and the wave incident frequency are far away, the DAF will be very less in the drilling rig design.

When it comes to the MOPU loading conditions, it has less freedom to reduce weight during storm case unlike drilling rig variable loads.

The weight of the MOPU stays almost the same during operational and storm cases. Therefore, MOPU has increased weight in storm condition and therefore the natural time period for MOPU in storm condition would shift towards 7s to 8s in some cases.

Apart from the shift in natural frequency, the incident wave period will be based on the actual met-ocean condition. Usually, each directional wave has different wave periods and heights as per the site-specific data.

Some of these wave periods might come close to the natural frequency of the structure which could cause DAF to be a much larger value which would directly amplify Wave and Current loading drastically which would result in structural failures.

6. VARIABLE LOADS

A drilling has the flexibility to reduce the variable load to move on to storm survival mode which would directly reduce the loads on to the legs, spudcan and jacking system and reduce the natural period of the rig which would further reduce the wave excitation forces.

But for a MOPU, the weight remains almost constant regardless of whether it is a 1 year operational environment or 100 year storm environment.

Therefore, the natural time period will be on a higher side and the wave excitation would be higher.

7. JACKING SYSTEM LIMITATIONS (PINION CAPACITIES)

Jacking system is specified with storm, operating, jacking and preload capacities for the drilling rig. Any of the loadings, weights, COG shifts mentioned above are towards unfavourable side, then this would result in jacking system failure which is generally indicated by the pinion ratings. There are chances that the pinion capacities exceed in either of these cases.

8. MARINE GROWTH & HYDRODYNAMIC COEFFICIENTS

In a drilling rig design, the basic designer usually does not consider any marine growth and consider that the leg members are always smooth. But when it comes to a MOPU design, a marine growth needs to be considered as per the project specification which would automatically increase the diameter of the legs members and thus attract more loads. Moreover, the hydrodynamic coefficients for the leg members will be changed from smooth to rough. For example, drag coefficient for smooth cylinder is 0.65 whereas it is 1.05 for rough cylinder. That is a 62% direct increase in drag force only because of the change from smooth to rough.

9. GLOBAL HULL STRENGTH & GLOBAL LEG STRENGTH

In general, because of the increase in loadings as specified in the above sections, the global strength of the vessel and the global in-place analysis need to be re-verified for the anticipated loading conditions. Often, the jacking structure might also need to be re-verified for these additional loadings.

10. CONCLUSION

There are other aspects of the MODU to MOPU conversion projects. But only the structural engineering problems are discussed in this paper.

It often happens that the project owner is deceived by the capacities & specifications listed in the approved operation manual of a drilling rigs while choosing a drilling rig for the MODU to MOPU conversion. If a proper, pre-purchase engineering is carried out to check the suitability of the rig for conversion, it could lead to a disaster during the execution of the project.

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AUTHORS

Thomas holds a dual degree in Naval Architecture and Ocean Engineering from IIT Madras. After completing degree in 2011, he worked with GL Noble Denton, DNV GL and ODL Engineering until he co-founded Ark2tech in 2016. Ark2tech is into FEED, Detail and Advanced Engineering consultancy services in Marine, Offshore & Oil/Gas Domains.

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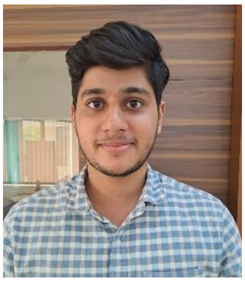

Tomin graduated from Toc H Institute of Science and Technology, Kerala and passed out in the year of 2019. He started his career with Ark2Tech as a structural engineer and picked up his skills in steel structure design, Finite Element Analysis and Offshore Structural Designs for Fixed and Mobile Platforms.

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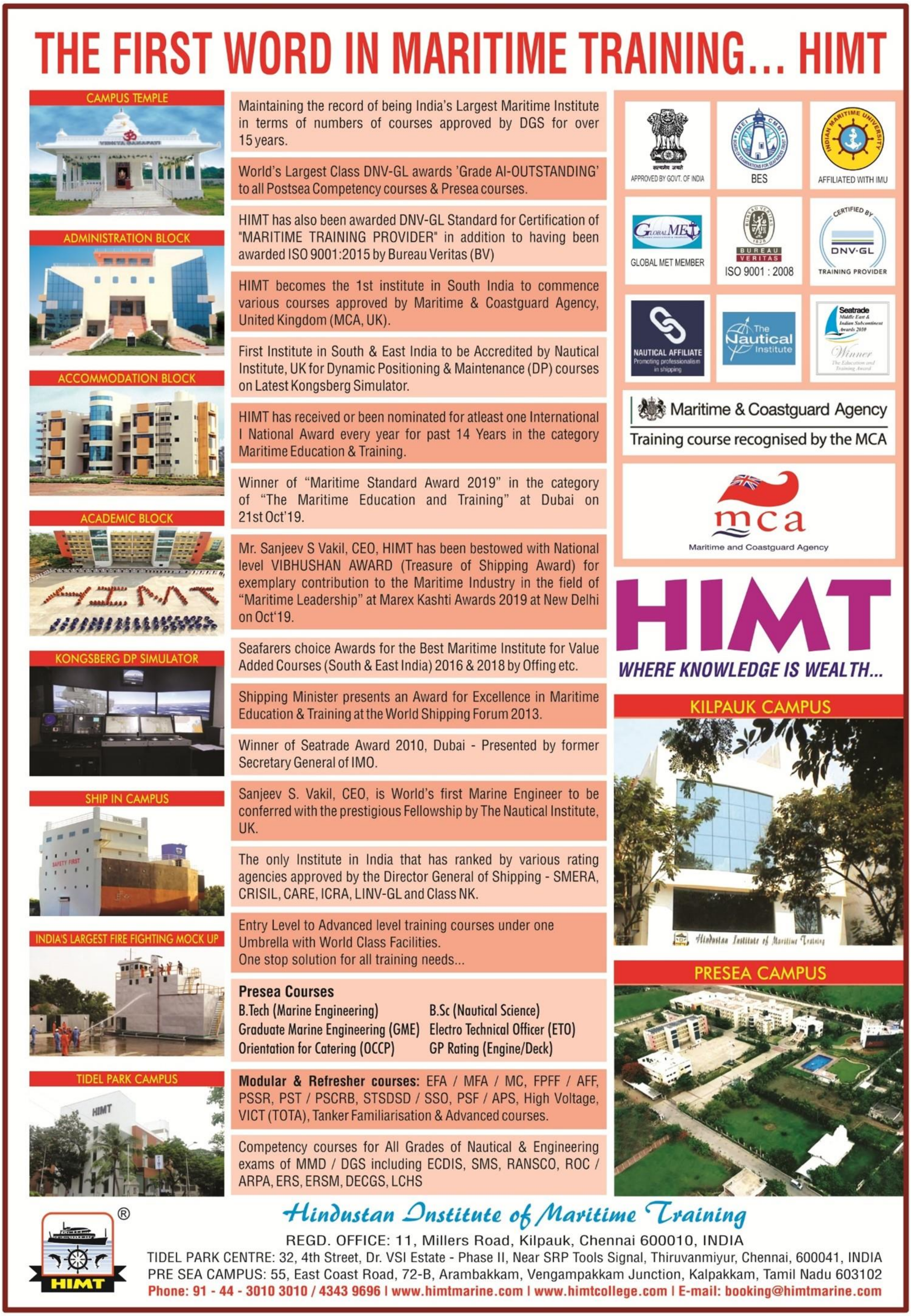

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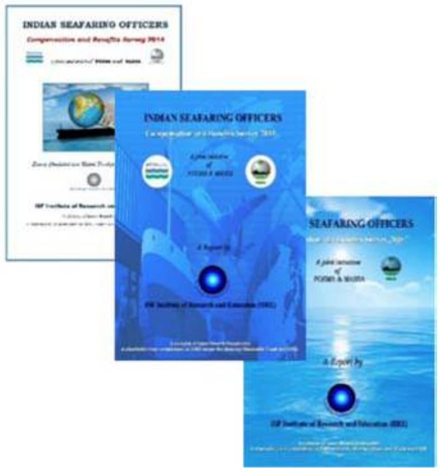

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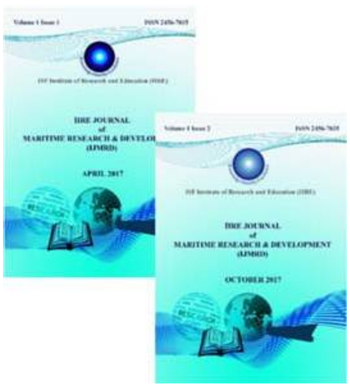

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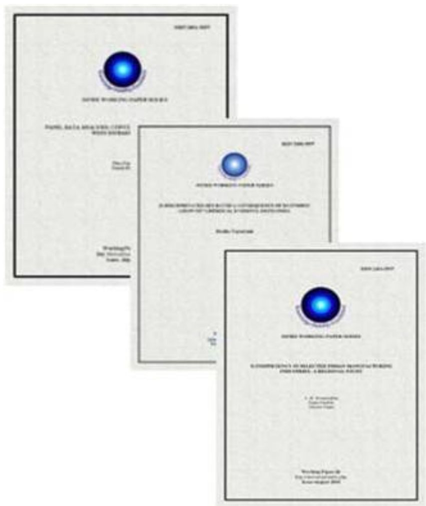

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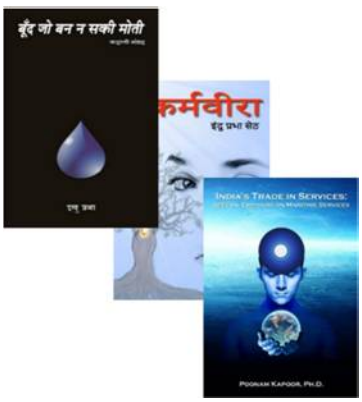

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