NON-LINEAR ANALYSIS APPROACH FOR TOPSIDES PLATFORM SKIDDED LOADOUT

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Loadout operation is one of the key operations in offshore industry of fabrication and construction of the topsides or jacket module. One of the successful keys in this operation is on how to design efficiently the support foundation and the selection of the correct vessel to carry the module to the installation field. The challenge has arisen on how to obtain accurate support reactions which will be used for foundation design and the basis for the vessel selection. Overprediction of support reactions on the design will lead to expensive decision of the foundation as well as the vessel selection.

The objective of this paper is to present the non-linear approach for topsides skidded loadout analysis. The non-linear analysis approach will utilize timber material with stress-strained curve compared to the stiff dummy member / linear approach which is normally as general practice in the industry. With the said approach, it would produce more reliable and optimized skidded loadout reactions for the further analysis checks. The optimized and reliable reactions against actual behavior of the structures is very important to avoid any excessive design of the foundations and unnecessary strengthening of the vessel which can result in cost optimization of the project.

By implementing the non-linear analysis approach on the skidded loadout analysis, the effective and reliable reactions will be achieved to avoid unnecessary strengthening or conservatism in design which will lead to efficient design of the LSF foundations such as quayside pile, skid beam, vessel strength check, and many more potential savings compared to traditional method where the boundary conditions is modelled as rigid or with linear spring. The same method also can be implemented to the other pre-service stage analysis.

Keywords: Non-Linear Analysis; Loadout; Topsides; Timber; Stiffness.

1 Introduction

Loadout operation is one of the important phases in the fabrication and installation of offshore platform (jacket and topsides). The activity includes transferring the structure module (jacket and topsides) from quayside of the fabrication to the transportation vessel. The transportation vessel further transports this complete structure module to the installation field.

There are two types of loadout operations which are commonly used in the industry. First, the module is put into the trailer and the trailer slowly moves to the transportation vessel. This method is widely used if the transported module is within the trailer capacity. However, as per current demand, the module of the offshore platform is getting heavier. Hence, the loadout by using trailer currently has some limitations due to huge and heavy module.

Proceedings of the 17th International Symposium on Tubular Structures.
Editors: X.D. Qian and Y.S. Choo

Published by Research Publishing, Singapore.
ISBN: 978-981-11-0745-0; doi:10.3850/978-981-11-0745-0_140-cd

The second method of the loadout operation is by skidding the topsides from the quay side to the vessel side. This skidding method is done by putting the topsides onto the skidway which normally will have sliding pad on-top of it (i.e. Teflon). The module is slowly pulled by the strain jack to the location of the vessel before sea-fastening is installed and ready for transportation. The illustration of this topsides skidding is depicted by the following figure.

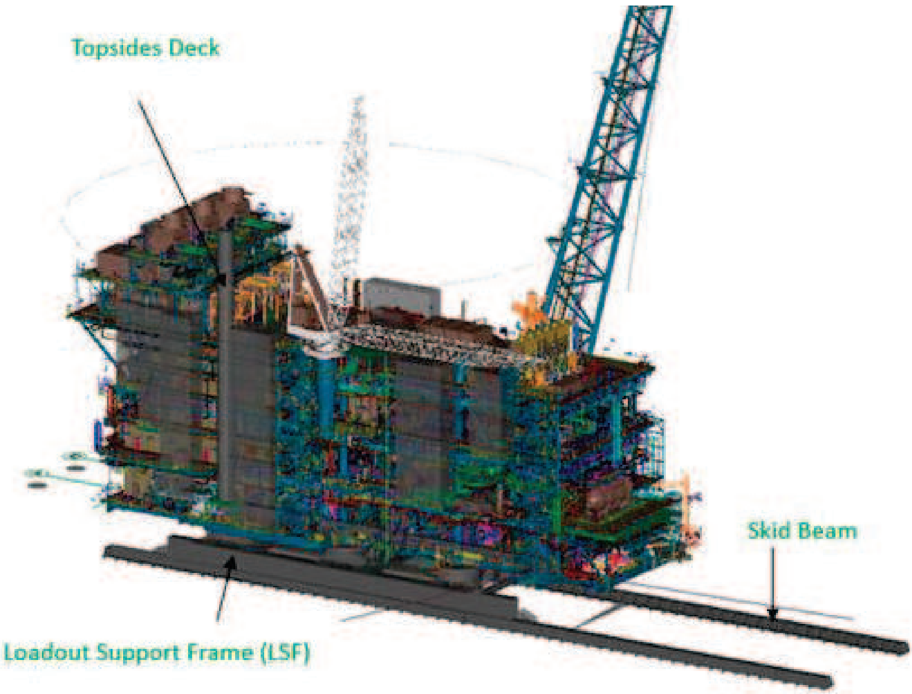

Figure 1. Loadout Skidding Operation Illustration

By using loadout skidding method, quayside foundation design and vessel strength selection needs to be assessed carefully in order not to be overly conservative which can lead to expensive decision and lost time for the project. In order to simulate the actual behavior which will lead to accurate reactions for further design stage, the non-linear approach of this loadout analysis is adopted. A scientific study has been made on the real project where the topsides of 17,000 MT is skidded into the skid beam from the quayside to the vessel side by using pulling method.

2 Component of Loadout Skidding Operations

As shown on the Figure 1 for the loadout skidding operations, the topsides deck will be placed on top of the skid beam where the Teflon is provided to buffer for small friction between the topsides and the skid beam where loading operations is in place. In addition, the timber has been secured underneath the Loadout Support Frame (LSF) to act as a cushion for better load transfer from the LSF to skid beam and from the skid beam to the foundation or vessel. Each component of this loadout skidding operation is presented by the following figure.

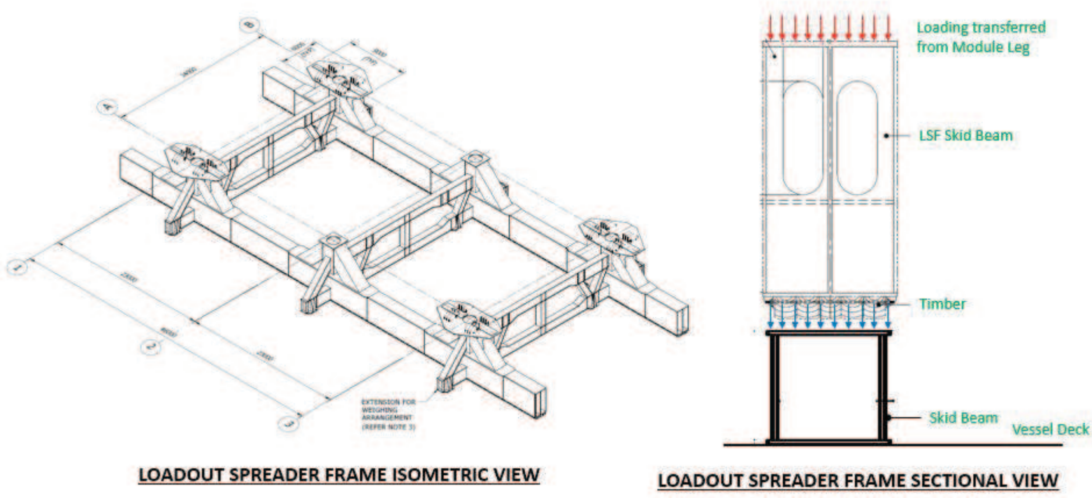

Figure 2. Loadout Spreader Frame Isometric and Sectional View

3 Stress-Strained Curve for Timber

The timber placed underneath the LSF will distributes the load in accordance with its properties. Testing of timber used for the project shall be performed to obtain force and displacement curve of the timber. The non-linear force displacement curve from this timber on the later part will be used as an input in the SACS software to perform the non-linear analysis of the loadout. The stress displacement curve on the said timber is presented by the figure below for various specimen. To obtain conservative reactions, the stiffer section modulus of the timber needs to be assumed and used in the analysis.

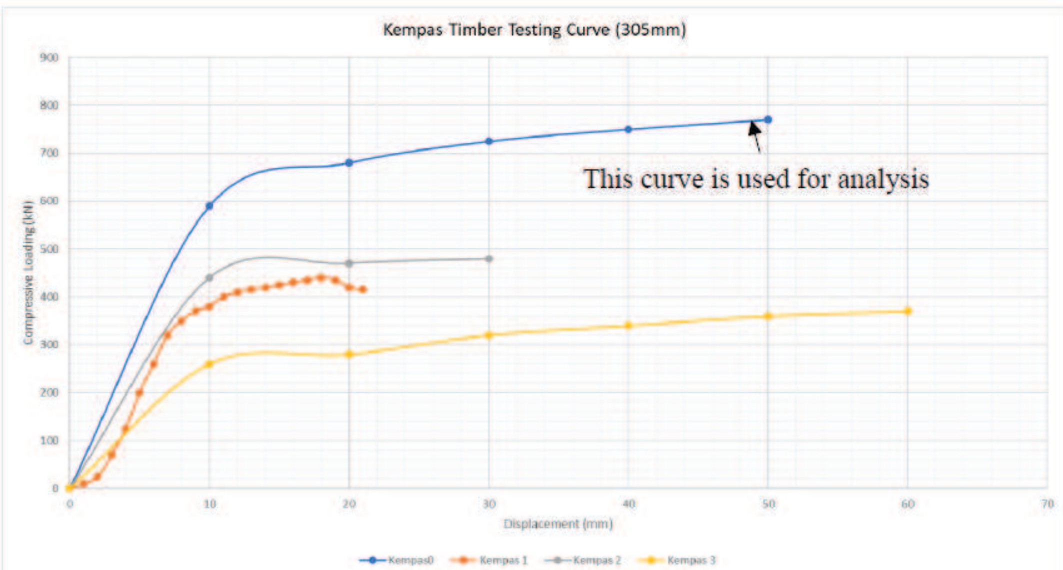

Figure 3. Timber Force Displacement Curve from Timber Testing

4 Non-Linear Analysis Methodology

This section covers analysis methodology to perform the non-linear analysis of the topsides skidded loadout analysis. SACS non-linear GAP element module analysis is used in the study. The timber's non-linear properties are modeled as the boundary conditions underneath the LSF to simulate the deformation that occurs in accordance to the timber stiffness. The global analysis model of this non-linear analysis model is depicted by the following Figure.

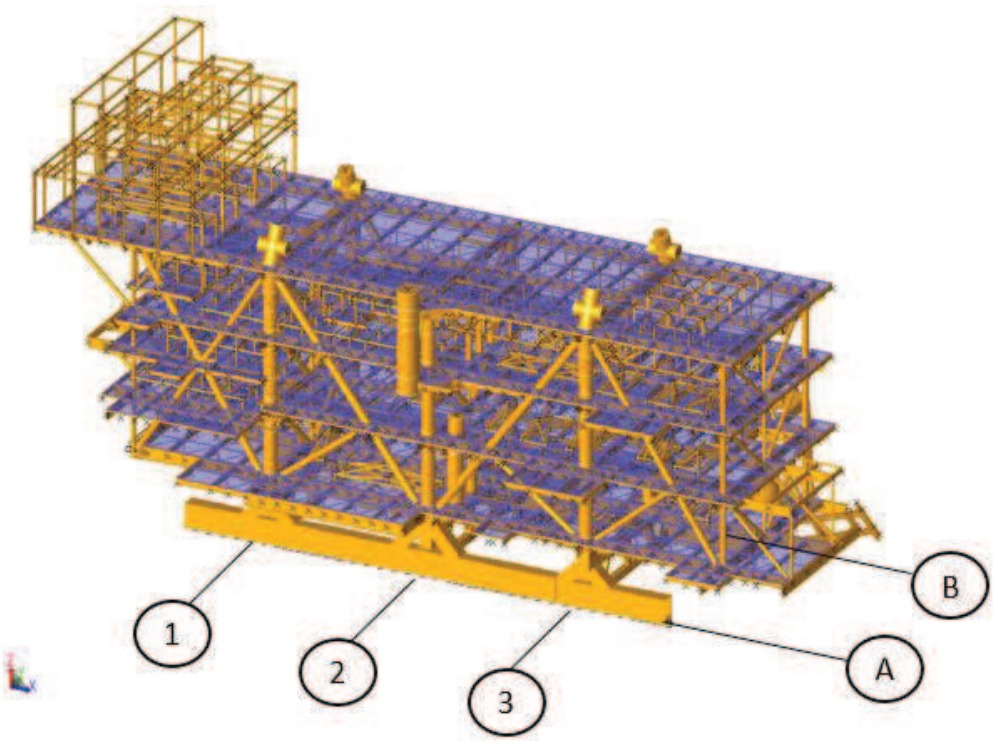

Figure 4. SACS Computer Model for Loadout Non-linear analysis

Topsides gravity load as per NTE of 17,000 MT combined with possible Raking and Breaking with the operational wind load is performed. Complete LSF member unity checks is also being evaluated to ensure all member properties used on the this LSF are safe. The joint reactions is also extracted which is eventually used as design input for quayside foundation design and vessel strength check evaluation.

Dummy member at the bottom of the LSF which presents the timber is also modeled in analysis. The dummy member stiffness properties are not important in this non-linear analysis as the real stiffness will be written in GAP compression module. Boundary conditions illustration to reflect timber underneath the LSF in the model is presented by figure below.

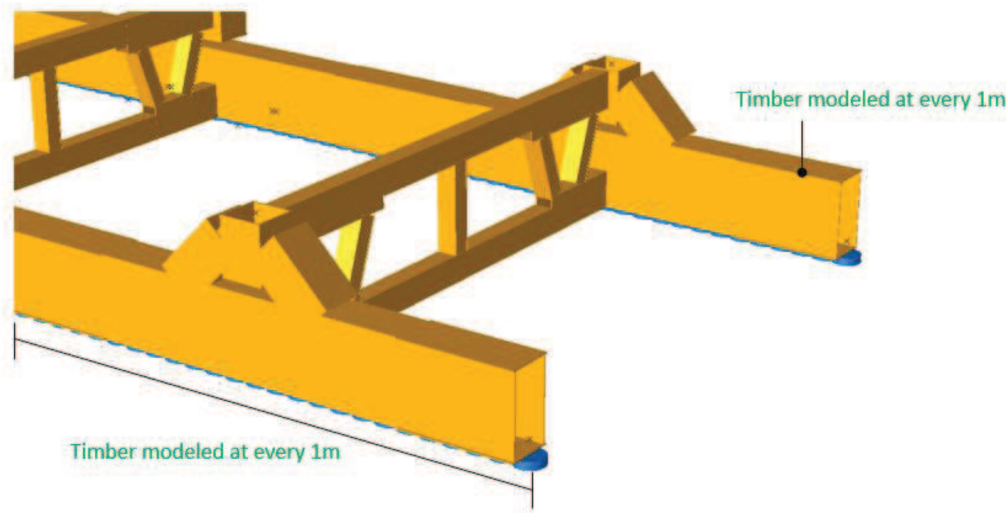

Figure 5. Boundary Conditions and Non-Linear Material Modeled in Timber

Timber's non-linear material is modeled accordingly based on timber test results from laboratory. This property is written in GAP element module as non-linear element for SACS program to calculates the displacement based on the load-displacement curve inputted into the module. Non-linear stiffness of the timber material is presented by the following Figure.

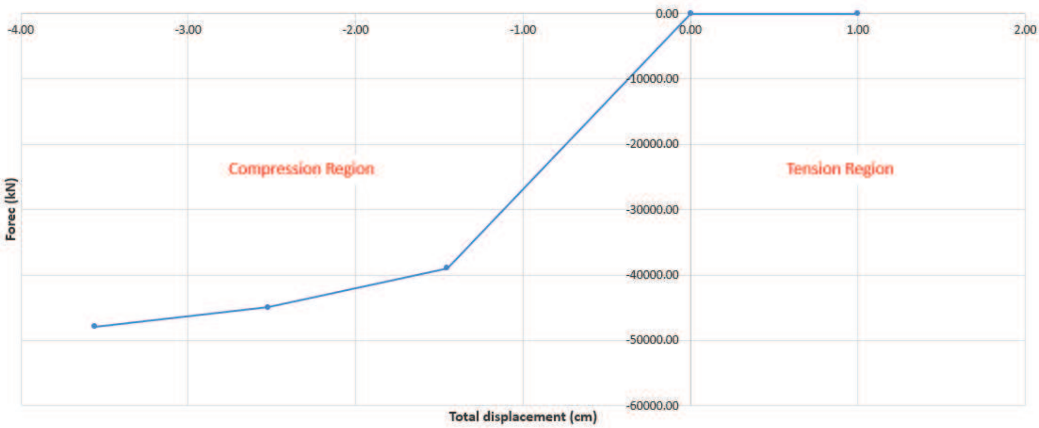

Figure 6. Non-Linear Material Timber Properties Modeled in GAP module

5 Analysis Results

Joint reactions comparison has been made to compare the output results from the non-linear method compared to the normal method where the boundary conditions is modeled with linear timber properties. The joint reactions curve is depicted by Figure 7.

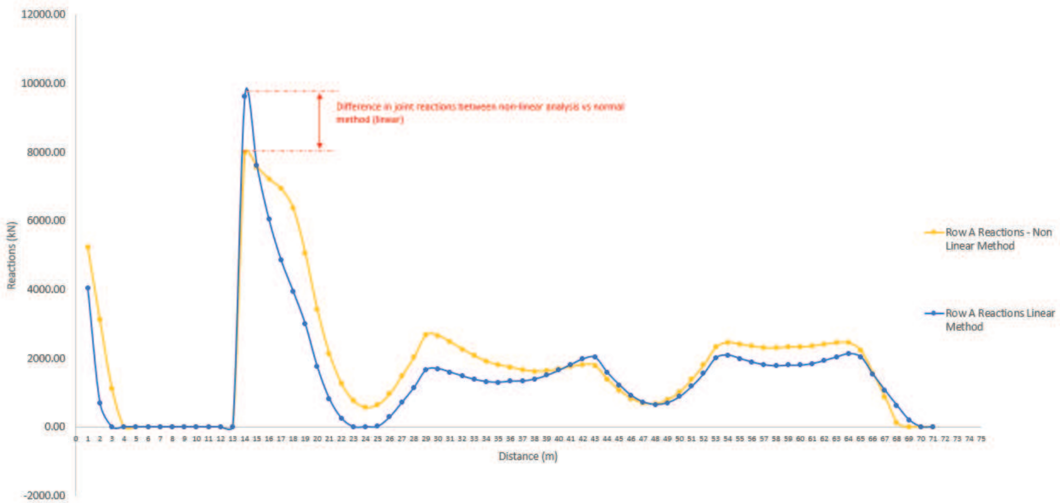

Figure 7. Boundary Conditions and Non-Linear Material Modeled in Timber

From the analysis above, it is shown that the joint reactions output from non-linear method is more efficient compared to the linear method where timber elasticity is modeled as linear material. This efficient joint reaction will give more benefit especially for the design of foundations as well as the vessel selection strength checks which will lead into cost savings.

6 Conclusions

From the real project study performed above, it is proven that the non-linear method analysis showing joint reactions lesser compared to analysis run where timber is modeled with linear method. The non-linear timber material properties used in GAP element module can perform well to distribute the load as per actual displacement with reference with its timber test results. This behavior further will give efficient joint reactions which will lead into cost saving in vessel selection as well as for provision of the foundation on the quayside. The same method also can be used for other analysis where timber properties can be used to generate real behavior of the structure.

References

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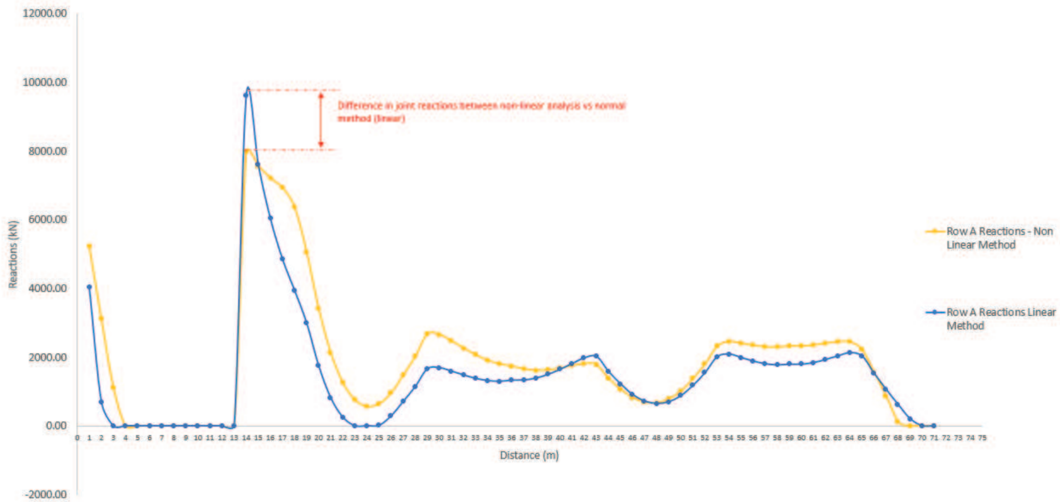

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