FATIGUE ANALYSIS OF OFFSHORE STEEL STRUCTURES

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Abstract - *Offshore construction is the installation of structures and facilities in a marine environment, usually for the production and transmission of electricity, oil, gas and other resources. The present study is thus an attempt to study the fatigue analysis of offshore steel structures. ANSYS software is used in this study for the finite element analysis (FEA) for fatigue analysis. In this study we check the fatigue analysis of offshore structures under various dynamic loads, effect of thermal loads and study on the welded joints in offshore structures. Fatigue is one of the failure mechanisms of offshore steel structures, which must be carefully checked during the design stage. The dynamic behaviour of structures become very important parameter in the overall design procedures. In this paper fatigue analysis of offshore steel structures in which the various dynamic loads, thermal loads on the structures and a study on the welded joints, also improve fatigue behaviour of offshore structures.*

Key Words: **Fatigue analysis, steel structures, thermal load, K- joints, 5 Box trick**

1. INTRODUCTION

Offshore structures are mostly used in petroleum industry as drilling, extraction or storage units for crude oil or natural gas. It has been in use for about 30 years. The first oil platform has been installed in North Sea in the Grand Lake St. Mary's in Ohio in 1891 by Phillips petroleum. Fatigue is one of the failure mechanisms of offshore steel structures, which must be carefully checked during the design stage. The dynamic behaviour of structures becomes very important parameter in the overall design procedures. In this paper fatigue analysis of offshore steel structures in which the various dynamic loads, thermal loads on the structures and also improve fatigue behaviour of offshore structures.

2. OBJECTIVE OF THE STUDY

1. Fatigue analysis of offshore structures under various dynamics loads such as ocean wave current loads, wind loads.
2. Effect of ocean surface thermal loads on the offshore structures.
3. Checking the fatigue life and fatigue damage of tubular K-joint.

3. METHODOLGY

Finite element analysis is methodology implemented on the study. It is the process of discretization of materials into finite elements where loads are applied on each element and analysed to obtain the overall performance of the fatigue analysis of offshore steel structures. This method is gaining in the modern research field as it yields accurate results for the given inputs, details and boundary conditions similar to realistic structure. ANSYS Mechanical Workbench 17.0is the software used to analyse the problem supported by explicit dynamics as platform. Thus with the aid of the computer software, computation efforts can be minimized and errors can be restricted to an extent for exact results conforming to realistic structure.

4. FIVE BOX TRICK

5 box tricks is the analysis procedure used for fatigue analysis of offshore steel structures. In this 5 steps used for analysising the problem. Fatigue element input we input geometry into the ANSYS, and then we add S-N curve details at material mapping stage. Load mapping means providing constant amplitude load is added to the analysis process. Fatigue analysis means the analysis carried out in fatigue tool in ANSYS that is, fatigue life, fatigue damage and safety factor. At last we evaluate the fatigue results obtained. Different stages in 5 box trick are shown in Figure 1.

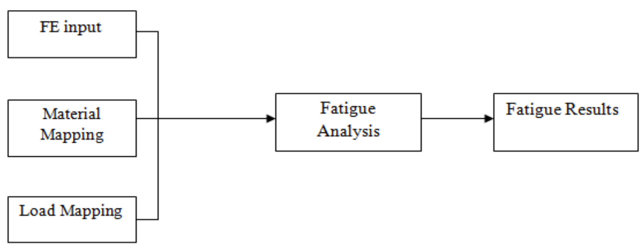

Figure 1 5 box trick

5. MODELING OF K-JOINT

For the modeling of tubular K-joint in SOLID WORKS 2016 the engineering data is assigned as shown in Table 1. The geometric model is shown in Figure.1. The detailed dimension of the geometric model is shown in Table 2. Analyzing the model in ANSYS WORKBENCH 17.0.

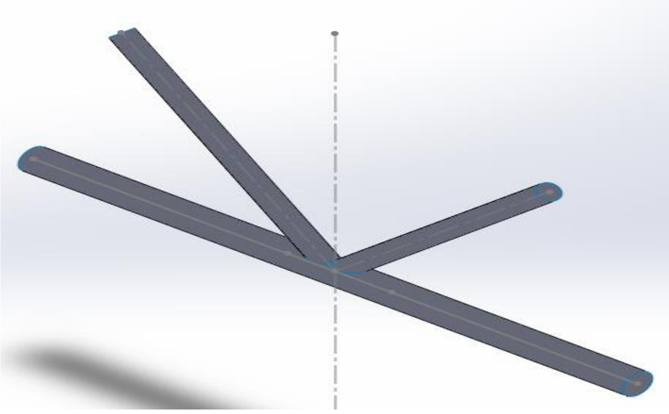

Figure 2 Geometric model before meshing

Table -1 Engineering data

Engineering data	Specifications
Material used	Structural steel
Density	7850 kgm^{-3}
Young's modulus	$2x10^5$ MPa
Poisson's Ratio	0.3
Bulk Modulus	$1.6667x10^5$ MPa
Shear Modulus	$0.76923x10^5$ MPa

Table 2- Geometric Dimensions

Geometric parameters	Chord	Brace
Diameter	100mm	70mm
Length	2000mm	1000mm
Thickness	10mm	10mm

5.1 Boundary Conditions

Two ends of the chords are held fixed.

5.2 Load assigning

Load assigned as constant amplitude loading.

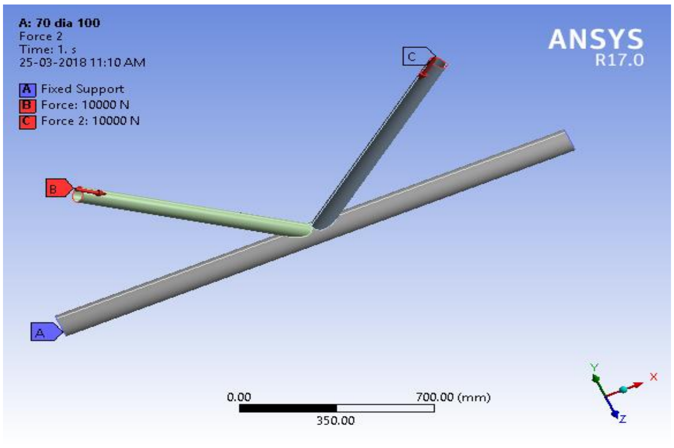

Figure 3 Fixed support and force

6. ANALYSIS USING ANSYS

6.1 Maximum stresses and deformation

Constant amplitude loading is applied and the stresses and deformation corresponding to loads are obtained. Maximum occurred when 10000N are provided. The corresponding stress values and total deformation are shown in Figure 4 and Figure 5.

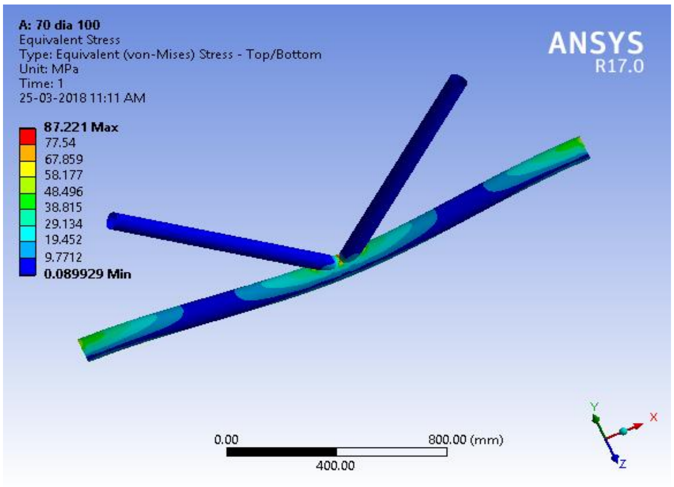

Figure 4 Equivalent stress

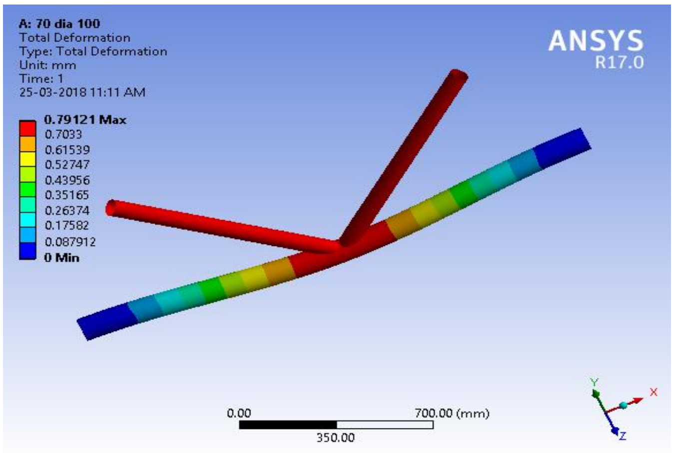

Figure 5 Total deformation

7. PARAMETRIC STUDY

Parametric study is done for tubular K-joints by varying the diameter of both chord and brace corresponding to brace to chord diameter ratio β and corresponding stress, deformation, fatigue life and fatigue damage.

$$\beta = d/D \quad [21]$$

where, β is brace to chord diameter ratio,
d is the brace diameter,
D is the chord diameter.

8. CONCLUSIONS

The following conclusions were drawn from numerical and mathematical analyses' results gathered during this research project:

- The expected results focused on the fatigue life of tubular joints.
- It is proved that deformation obtained for tubular joints are less as the diameter varies.
- Von-Mises stress as well as safety factor for tubular joints are decreases as the diameter increases.
- Fatigue life for tubular joints are increases as the diameter increases.
- Proposed tubular joints were also compared with the varying thickness of chord and brace.
- Thickness of tubular joints has much influence in the fatigue life of structures.
- Tubular joint with d=450mm and D=500mm is the best model after analysising.
- Fatigue damage for tubular joints were also decreases as diameter ratio changes.

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