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Research Article

STUDY ON THE ANALYSIS OF TUBULAR JOINTS IN OFF SHORE STRUCTURES

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ABSTRACT

Steel circular hollow sections are used extensively in offshore structures such as platform jackets. In these structures, the hollow section members are joined together by welding the profiled ends of secondary members, the braces, onto the circumference of the main member, the chord. The behaviour of these welded tubular connections, even in their simplest configuration, is complex and their analysis is difficult. With sophisticated and powerful, yet user-friendly, software widely available and computational costs rapidly falling, the use of the finite element (FE) method for the analysis of tubular joints is now commonplace in both research and practice environments. The results of such research have significantly advanced the understanding of the behaviour of tubular joints under static, fatigue and fracture loading conditions.

INTRODUCTION

A. General characteristics

Steel circular hollow sections are used extensively in offshore structures such as platform jackets. In these structures, the hollow section members are joined together by welding the profiled ends of secondary members, the braces, onto the circumference of the main member, the chord. The behaviour of these welded tubular connections, even in their simplest configuration, is complex and their analysis is difficult. The analysis and design of tubular joints have received much attention in the past 30 years. Early efforts relied on simplified analytical techniques in obtaining elastic stress distributions. With the discovery of large oil and gas fields in offshore waters world-wide in the 1960s and 1970s, there was an urgent need in obtaining data for the development of design rules for jacket structures in hostile ocean environments. Consequently, many research programmes on tubular joints funded by oil and gas companies and national governments have been initiated. The majority of these activities involved laboratory testing of tubular joints under static and fatigue loading, e.g. references.

With sophisticated and powerful, yet user-friendly, software widely available and computational costs rapidly falling, the use of the finite element (FE) method for the analysis of tubular joints is now commonplace in both research and practice environments. Many extensive research programmes have been undertaken using numerical tools in the past 5–10 years to generate data in static strength, stress concentrations and stress intensity factors for tubular joints. The results of such research have significantly advanced the understanding of the behaviour of tubular joints under static, fatigue and fracture loading conditions (API, 1972; AWS, 1972; Bozhen, *et al*., 1990).

B. Objective of the study

To evaluate the stress distribution of tubular K-joint and Y-joint under static loading condition by using FEM software.

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C. **Scope of the project**

- To study the stress characteristics, strength and stress intensity.
- To analysis the joints under different loading conditions.

METHODOLOGY

General method

The methodology flow chart which explains the procedure follows in whole project that from start to end (Fig. 1).

A. **Modelling**

Modelling has been done in ANSYS 15.0, meshing and welding have been done in HYPERMESH 13.0.

The dimensions of sections are listed in Table 1 below.

The following (Fig. 2) shows the typical view of K-joint and (Fig. 3) shows the typical model of Y-joint.

B. Material property

1) Young Modulus: 2.1E5 Mpa

2) Density: 0.000000785 N/mm3

3) Poisson's Ratio (μ): 0.33

4) Maximum yield stress: 250 N/mm2

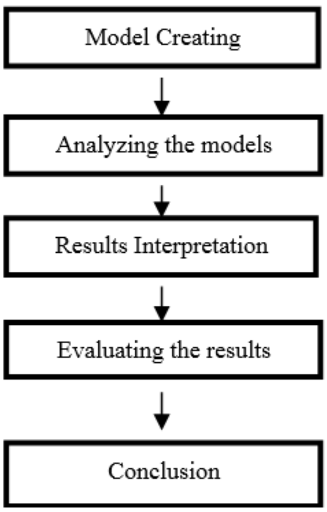

Fig. 1 Methodology flow chart

C. Element type

The tubular joint has been modelled in solid element 185. Solid 185 is used for 3-D modelling of solid structures. It is defined by eight nodes having three degrees of freedom at each node: translations in the nodal y, and z directions. The element has plasticity, hyper elasticity, stress stiffening, creep, large deflection, and large capabilities. It also has the mixed formulation capability for simulating deformations of nearly in compressible elastoplastic materials, and fully incompressible hyperelastic materials.

Various input data are required for a FE analysis to define (a) the model geometry and material properties, (b) the boundary and the loading conditions, (c) the solution methods and controls, and (d) the desired results to be output. The linear material behaviour is defined by Young's modulus of elasticity, E and Poisson's ratio n. For steel, it is generally assumed that the material would obey von Mises' yield criterion with the associated Prandtl–Reuss flow rule. In this paper, solid 185 is employed for three dimensional modelling of solid structures. The element is defined by eight nodes having three points of freedom at each node: translations in the nodal x, y, and managements. The element ha plasticity, stress stiffening, large deflection, and large strain capabilities (Dexter, 1996; Morgan, 1997; Lee, 1999).

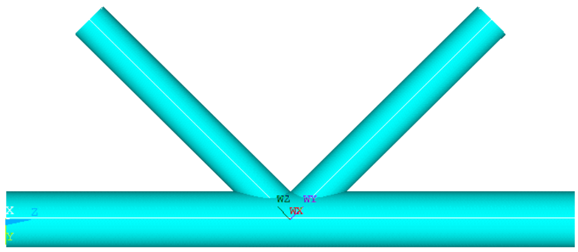

Fig. 2 Typical view of K-joint.

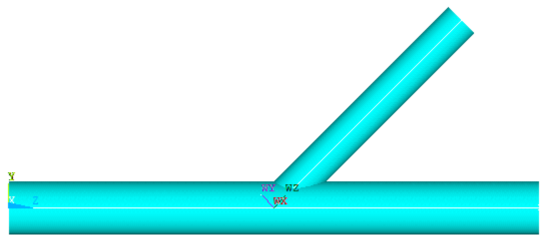

Fig. 3 Typical view of Y-joint.

Table 1. Dimensions of the K-joint and Y-joint

K/Y-Section	All dimensions are in mm				
	Width	Breadth	Thickness	Length	Weld thickness
Main member	100	90	10	2000	15
Brace	70	60	10	1000	

D. **Welding**

The weld geometry at the intersection of two tubular members is very complicated and difficult to model accurately. This is mainly because the weld profile is a function of the dihedral angle (c), which varies with the position around the intersection. An approximation to the actual weld profile can be obtained by using concentric cylinders to model the weld volume, the simplified weld geometry, as shown (Fig. 4 and Fig. 5). It is important to ensure that the weld profile at the expected hotspot stress site conforms to design specifications. In this paper, for the solid element, arc welding is being used to weld the joints. Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated. First developed in the late part of the 19th century, arc welding became commercially important in shipbuilding during the Second World War. Today it remains an important process for the manufacture of steel constructions (Inge, 2011; Hamid, *et al.*, 2011; Lozano-Minguez, *et al.*, 2014).

E. **Meshing**

Meshing is used for accurate presentation of complex geometry, easy representation of the entire solution, and capture of local effects. According to results requirement meshing can be increased (or) decrease. For accurate results the models have to be finely meshed so that the element discretization will be fine. Considerable time will be taken for meshing closely (Fig. 6 and 7).

F. **Loading**

(Fig. 8 and Fig. 9) shows the boundary condition applied at the ends of the main member and an axial load of 1000, 1150, 1250, 1300, 1350 N are applied at the top axis of the brace member (nodal points). A total of 20 nodes are formed (each side 10 nodes). Each node is given load equally to get an accurate

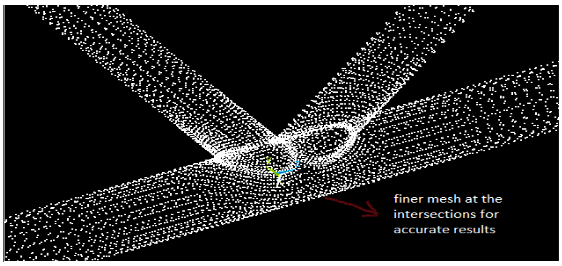

Fig. 4 Weld of K-joint.

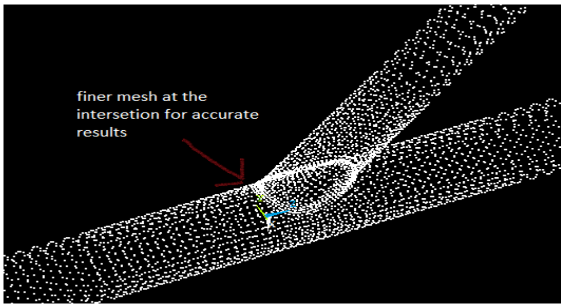

Fig. 5 Weld of Y-joint.

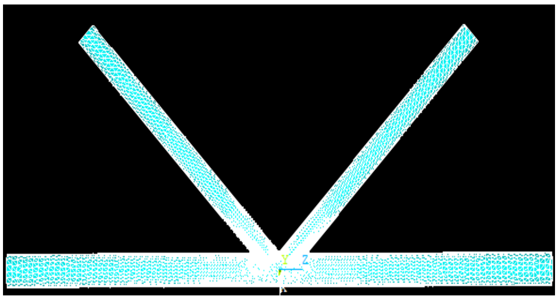

Fig. 6 Meshing of K-joint.

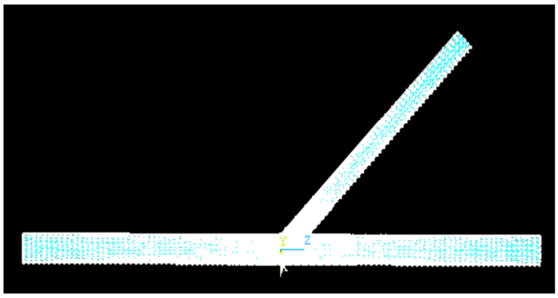

Fig. 7 Meshing of Y-joint.

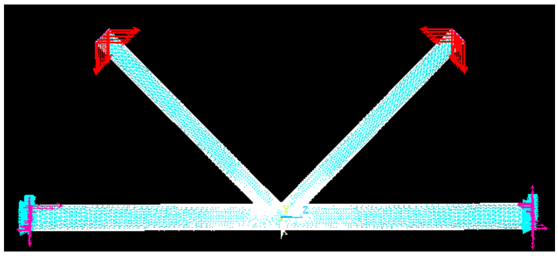

Fig. 8 Loading of Y-joint.

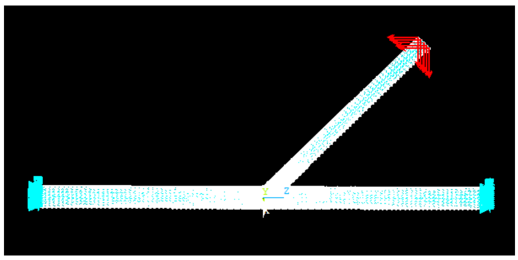

Fig. 9 Loading of Y-joint.

value of stress and deformation (Altair engineering Inc, 2012; Ansys Inc, 2014).

RESULTS AND DISCUSSION

A. General model

A single model is being created for the dimensions provided in the Table 1 above and has applied 5 different sets of loads to represent the behaviour of the joint. The result shows the displacement behaviour and stress behaviour of the K-joint and Y-joint. The values are plotted in a chart.

B. Displacement behavior

Analysis of the tubular joints has been carried out in the ANSYS software to run a complete model with all the required data's for analysing. After the joints has been analysed, the results are taken from the post processing, where the results are stored. Now the displacement result has to be taken from the nodal solution. The maximum displacement will be plotted in this solution. Maximum displacements are recorded in the (Fig. 10) of K-joint and (Fig.11) of Y-joint. Displacements are shown for the given load of 1000 N.

C. Stress behavior

Analysis of the tubular joints has been carried out in the ANSYS software to run a complete model with all the required data's for analysing. After the joints has been analysed, the results are taken from the post processing, where the results are stored. Right away the stress result has to be considered from the nodal solution. The maximum stresses will be plotted in this solution. Maximum stresses are presented in the (Fig. 12) of K-joint and (Fig. 13) of Y-joint. Stresses are shown for the given load of 1000 N.

D. Load v/s Displacement Curve (K-Joint)

In (Fig. 14), it explains the displacement of 5 different models of K-joint. This line shows the non-linear curve between the load and displacement.

E. Load Vs Stress Curve (K-Joint)

In (Fig. 15), it explains the stresses of 5 different

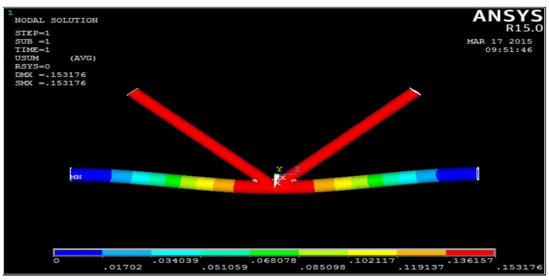

Fig. 10 Displacement of K-joint.

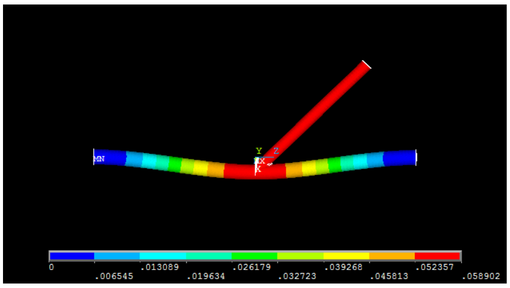

Fig. 11 Displacement of Y-joint.

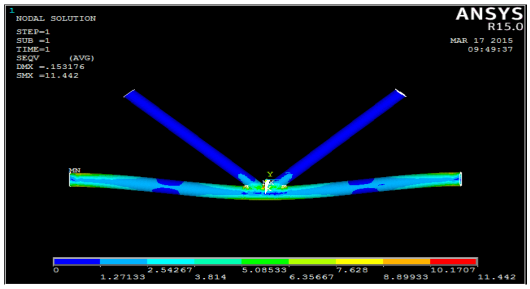

Fig. 12 Stress distribution of K-joint.

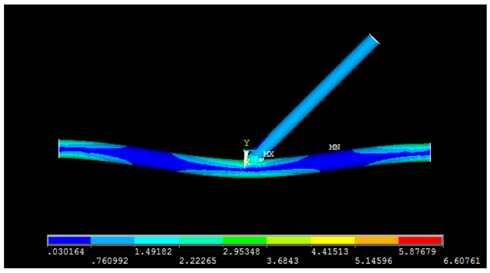

Fig. 13 Stress distribution of Y-joint.

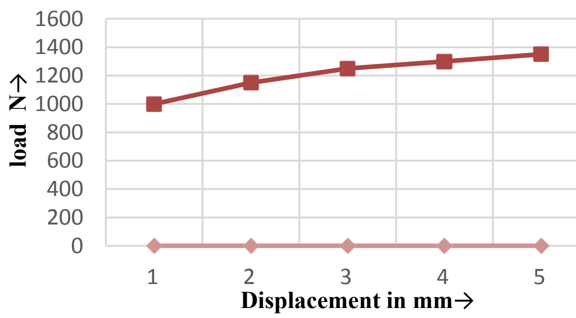

Fig. 14 Load v/s displacement curve (K-joint).

models of K-joint. This will show the graph for the stress vs load. This line shows the non-linear curve between the load and stress.

F. Load v/s Displacement Curve (Y-Joint)

In (Fig. 16), it explains the displacement of 5 different models of Y-joint. This line shows the non-linear curve between the load and displacement.

G. Load Vs Stress Curve (Y-Joint)

In (Fig. 17), it explains the stresses of 5 different

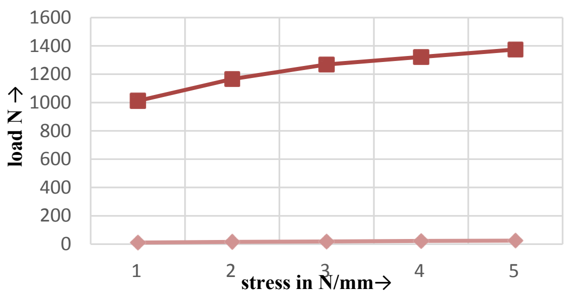

Fig. 15 Load v/s stress curve (K-joint).

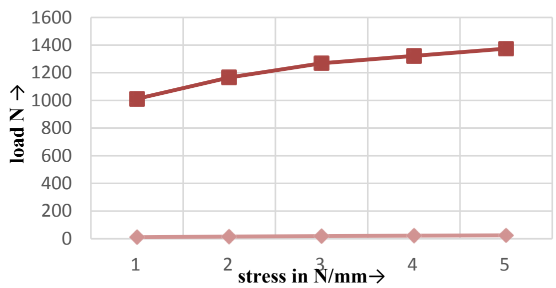

Fig. 16 Load v/s displacement curve (Y-joint).

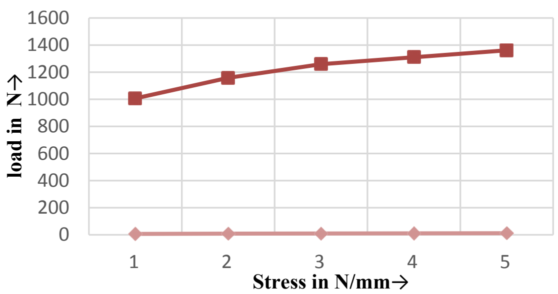

Fig. 17 Load v/s displacement curve (Y-joint).

models of Y-joint. This will show the graph for the stress vs load. This line shows the non-linear curve between the load and stress.

CONCLUSIONS

1) The natural period of the system increases up to 10%

2) By using the welded joints, the strength of the element is increased by 10-15% percentage in total.

3) Stress and displacement are reduced by 10% percent when the elements are welded by arc welding.

4) Usage of this arc welding under the water requires minimal welding fume or arc light is emitted.

5) Welds produced are sound, uniform, ductile, and corrosion resistant and have good impact value. 50% to 90% of the flux is recoverable, recycled and reused.

6) The results acquired from this paper reveals that the provision of K-joints in the tubular structure provides more adoptable than using Y-joints in the tubular structures.

7) Introduction of K-joints proved to be more effective in retaining stresses within the structure than Y- joints.

8) Welding of K-joint creates a rigid part around the welded surfaces than in Y-joint because the chord member is fixed at both ends and the braces from both sides provides symmetry to the element where the as Y-joint doesn't satisfy the criteria.

REFERENCES

Altair Engineering Inc. (2012). Hyper mesh 13.0 user guide.

Ansys Inc. (2014). 15.0 user manual.

API, American Petroleum Institute. (1972). API RP 2A-Recommended practice for planning, designing and constructing fixed offshore platforms.

AWS, American Welding Society. (1972). Structural welding code-steel AWS D1.1-72.

Bozhen, C., Yuren, H. and Minjie, T. (1990). Local joint flexibility of tubular joints of offshore structures. *Marine Structures*. 3 : 177-197.

Dexter, E.M. (1996). Effects of overlap on behaviour and strength of steel circular hollow section joints. PhD thesis, University of Wales Swansea. 172-187.

Hamid, A., Mohammad A.L.Y. and Mohammad, H.A. (2011). Effect of stress concentration factors on the structural integrity assessment of multi-planar offshore tubular DKT-joints based on the fracture mechanics fatigue reliability approach. *Ocean Engineering*. 38 : 1883-1893.

Inge, L. (2011). On stress concentration factors for tubular Y- and T-Joints in frame structures. *Marine Structures*. 24 : 60-69.

Lee, M.M.K. (1999). Strength, stress and fracture analyses of offshore tubular joints using finite elements. *Journal of Constructional Steel Research*. 51 : 265-286.

Lozano-Minguez, E., Brennan, F.P. and Kolios, A.J. (2014). Reanalysis of offshore T-joint fatigue life predictions based on a complete weld profile model. *Renewable Energy*. 71 : 486-494.

Morgan, M.R. (1997). Stress fields in tubular K-joints for fatigue analysis of offshore structures. PhD thesis, University of Wales, Swansea. 85-99.