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ANALYSIS OF FATIGUE LIFE AND STRESS INTENSITY FACTORS IN GUSSET PLATES

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ABSTRACT

A gusset plate is the stiffener used at the joint between two or more steel structural components. It is a simple plate with which members are connected. Connection is done with help of mechanicals fastener like bolt connection, rivet connection or welding. In the process of drilling holes for bolt or rivet there may be some crack induced in plate. This crack plays a vital role in fatigue life of the plate. So in this paper a fatigue analysis is carried out with existing crack and its fatigue life is obtained. Along with it stress intensity factors which are very important for crack propagation are evaluated and graphs are plotted for different thickness of plate. The results obtained will be useful in calculating the number of reserved load cycle of an element with a crack or defect present. FEM based software ANSYS workbench 15 has been adopted for performing fracture mechanic based finite element simulation.

Keywords: fatigue life, fracture mechanics, gusset plates, stress intensity factor, Goodman theory, ANSYS

I. INTRODUCTION

Truss is a structure that consist of axial force members only. Truss are used when large spans need to be covered,As a result, they are designed to carry larger amount of load in structures like bridges, industrial building, and integrity of framing structures in tall buildings. Truss members are connected with thick steel plates known as gusset plates. Truss members consist of direct tension and compression. The member transfer force to the gusset plates so it becomes the important part of design. Design of gusset plates depend upon the number of members connected to it and amount of force exerted on it. Gusset plate may be fastened to each member using mechanical fasteners like bolts, rivet bolts or permanent bonds, such as welding. In connection consisting of bolt and rivet bolt hole is to be drilled in the members as well as gusset plate. This process may induce some micro or macro cracks in the gusset plates which in future propagates with increasing amount of stress. [1]This strongly affects the joint behavior and reduces its load bearing capacity. Therefore we need to simulate the propagation of the crack and for that we require stress intensity factors K1, K2, K3 these values depend on the crack length and the dimensions of plates. [4] Due to the repetitive load cycle crack propagates further which is because of fatigue.[2] The fatigue life can be found out by various methods however Goodman's theory is usually found to be in agreement with experimental observation and hence is adopted in the present analysis.

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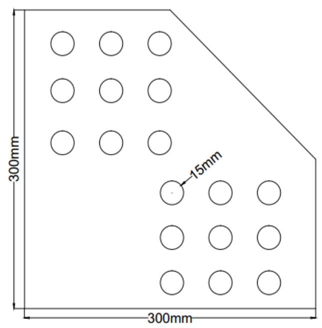
II. ANYLYSIS OF GUSSET PLATES

A Gusset plate used in simple Pratt truss is used for analysis. Schematic of the same is shown in fig. 2(a). Two members are connected to the plate one horizontal and other vertical both are connected with bolt connection having 9 holes per members.[3]Different thickness of plates are taken into account which are 10 mm, 12 mm, and 15 mm. respectively. Vertical member induced compressive force of 50 KN and the horizontal induced tensile force as well as the torsion of 50 KN and 20 KN respectively. Fig. 2(b)shows type of loading.



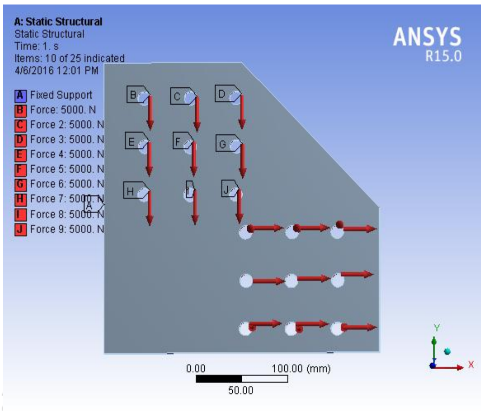


Fig. 2(a) schematic of gusset plate

Fig. 2(b) loading

2.1 Determining Location of Crack

To determine the location of the crack, preliminary analysis has been carried out and location of maximum equivalent von-mises stress is determined which gives us the probable location of the crack. The co-ordinates of the anticipated crack were found to be [0,-90, 40]. As crack will propagate perpendicular to the direction of principal stresses, it is oriented at an inclination of 60^*

2.2 Crack Inputs

A crack of 10 mm was introduced at a co-ordinate of [0,-90, 40] and inclination of 60^* as sown in fig.2(d). A semi elliptical crack was used with maximum radius 10mm and minimum radius be 1 mm. Crack was meshed with fine 10 noded tetrahedron elements.

2.3 Fatigue Inputs

A totally reversed load case is considered with the fatigue inputs value of mild steel and Goodman theory was used to determine the damage and the remaining life of plate both in terms of number of load cycle and the number of days were found out.

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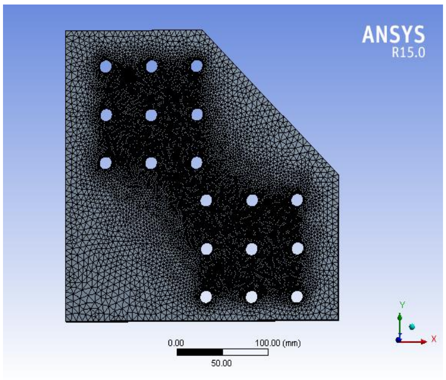

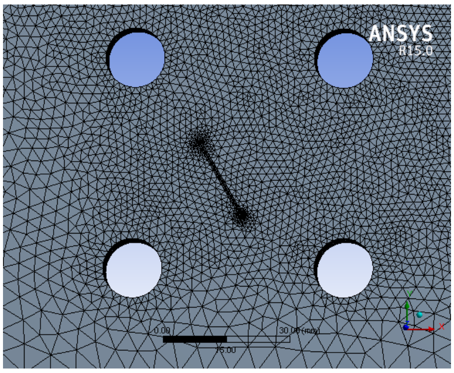

Fig. 2(c): Meshing Fig. 2(d): Meshing on crack

III. RESULTS

The results obtained has been shown in the fig.ure which are for all different thickness. As expected stresses and strains were observed maximum at the crack tip and the fatigue life was minimum at the crack tip. Graphs were plotted between the stress intensity factor in mode 1(K1), mode 2(K2), and mode3 (K3) against the various thickness. Second graph was plotted between the J-integral against the thickness and third graph between fatigue life against the thickness of the plate**.**

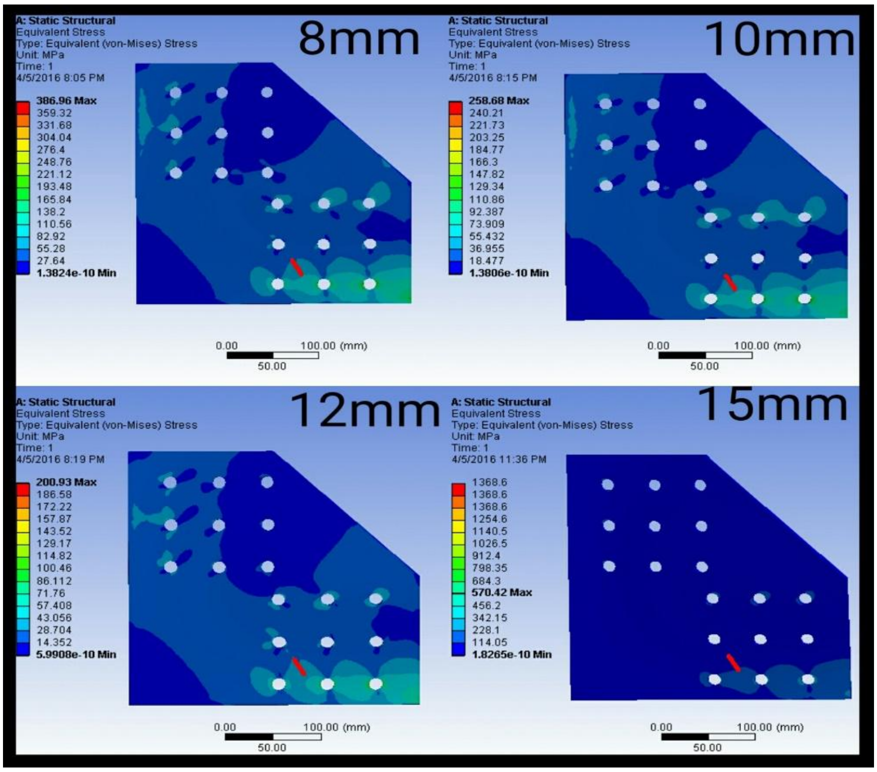

Fig. 3(a): EQUIVALENT VON-MISES STRES

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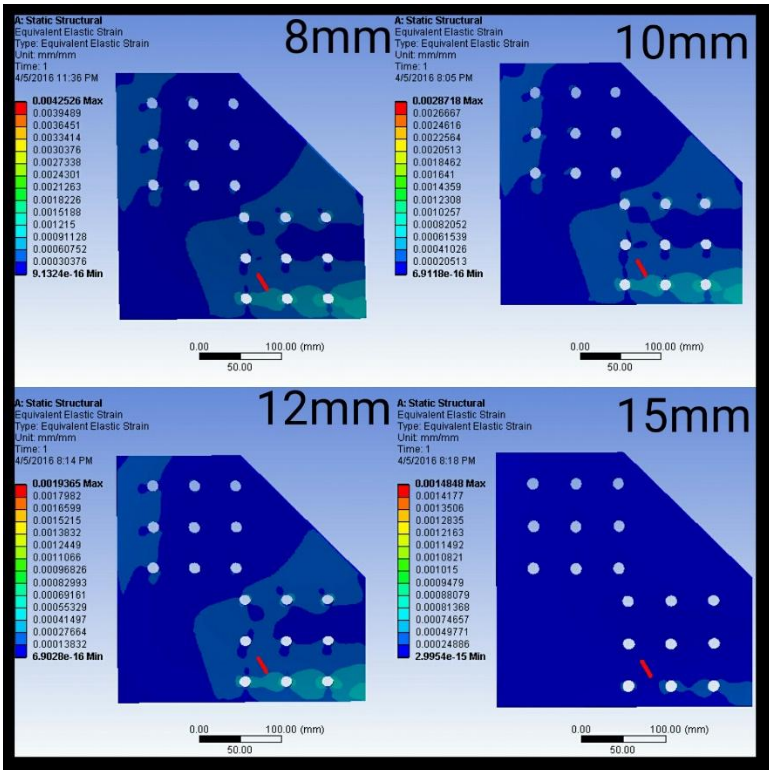


Fig. 3(b): equivalent strain

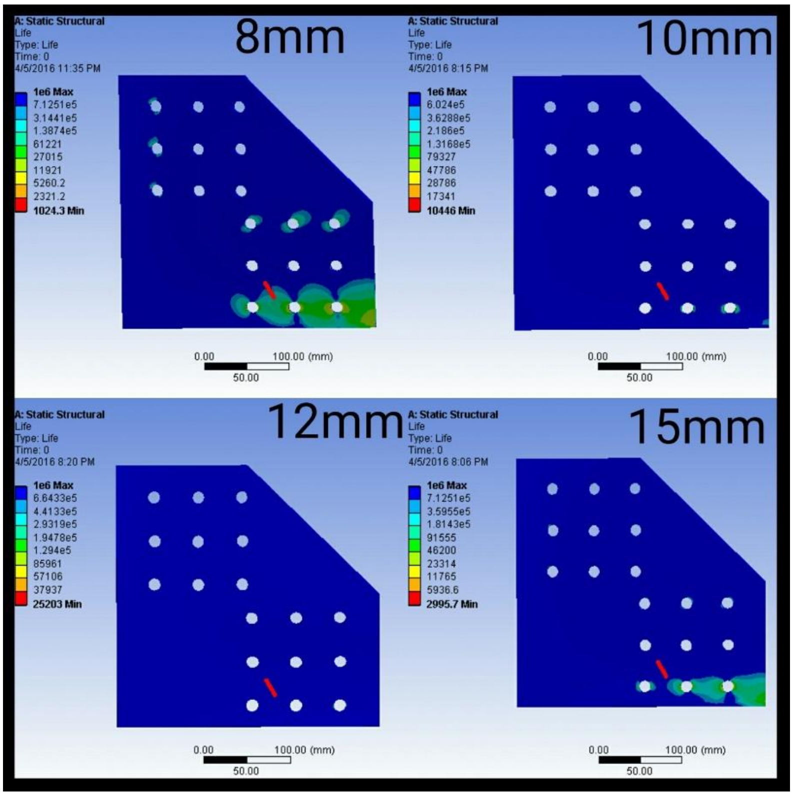


Fig. 3(c): Fatigue life

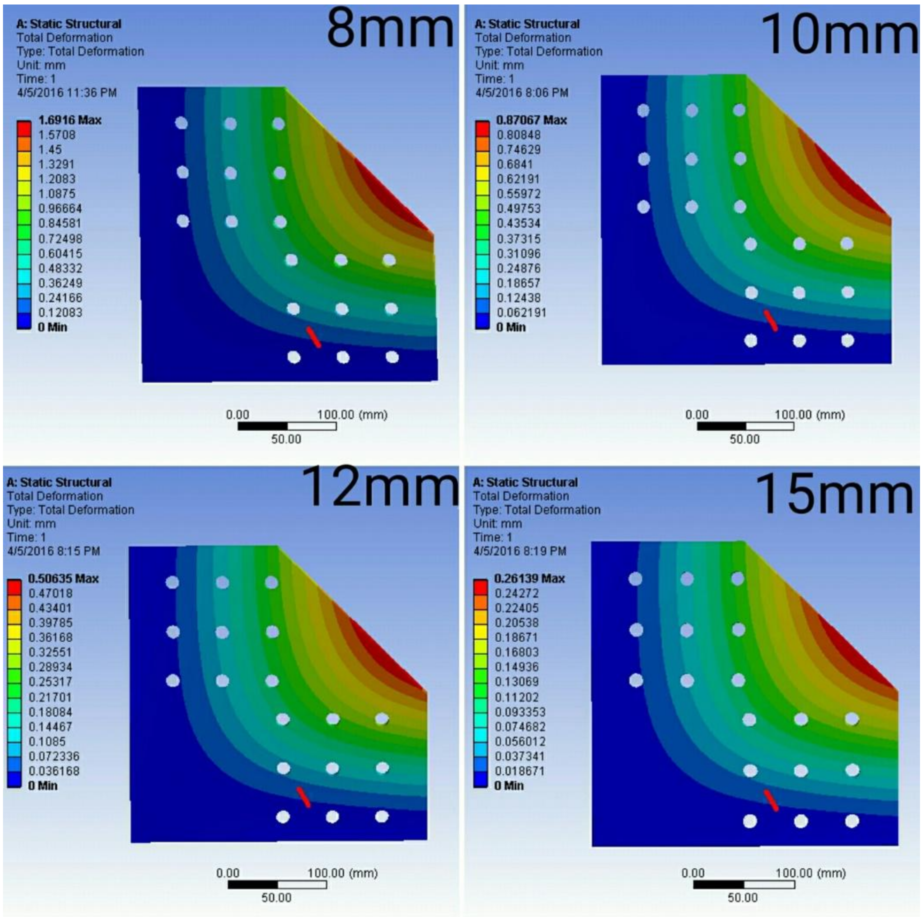
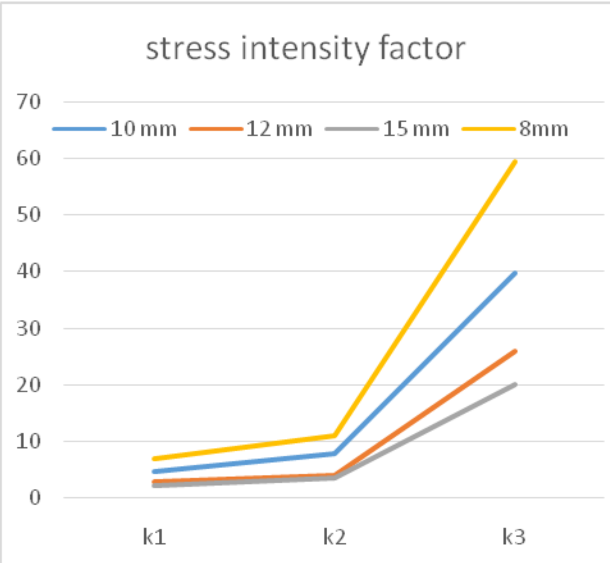


Fig. 3(d): Total deformation



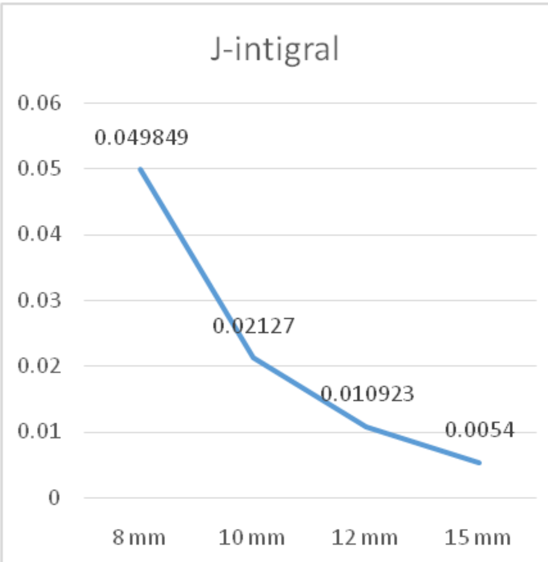


Fig. 3(E): Graph Of Stress Intensity Fig. 3(F): Graph Of J-Intigrual

Factorvs Thickness Of Plate:Vs Thicikness Of Plate

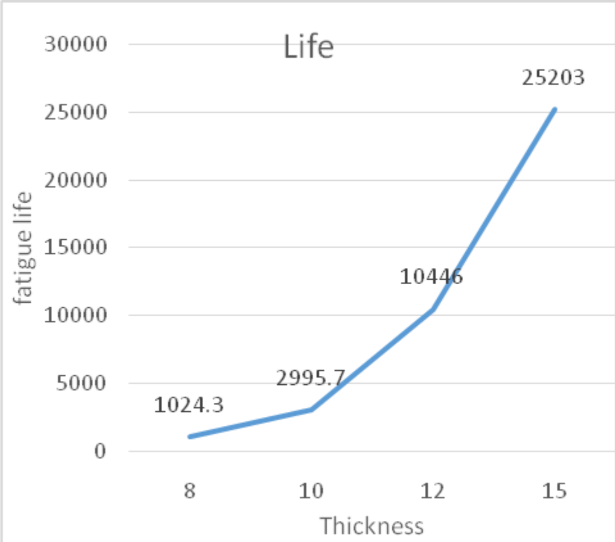


Fig. 3(G): Graph Of Fatigue Life Vs Thickness Of Plate:

IV. CONCLUSION

Finite element based fatigue analysis has been carried out here and the relation of stress intensity factor, fatigue life of gusset plate with varying thickness has been studied using ANSYS. This results will further be useful in designing the gusset plats. As the thickness of the plate increases the life increases and stress intensity factor decreases. Adoption of fracture based design methodology appears to be promising for safe and economical design of gusset plats. Fracture mechanics coupled with finite element analysis offers a complete description of crack propagation and estimation of life of the gusset plates.

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