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FRACTURE ANALYSIS OF STEEL PLATES SUBJECTED TO AXIAL FORCES AND BENDING MOMENTS

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ABSTRACT

Steel gusset plates are used commonly in steel buildings, steel bridges and truss joints with bolted or riveted connections. There may be instances when the crack develop on side of rivet or bolt holes while drilling the holes. Cracks may even develop due to static or fatigue loads. This paper adopts a fracture mechanics based approach to determine the crack propagation characteristics and the crack length versus number of cycles using Paris' law. FRANC2D has been adopted here for the analysis of steel gusset plate connecting members subjected to axial forces and bending moments.

Keywords: Crack propagation, Fatigue, Fracture mechanics, Steel gusset plate

I. INTRODUCTION

Steel gusset plates are thick sheets of steel that are used to connect bracing members to other structural members in the lateral force resisting system or to connect truss members with each other or for connecting beams with columns, etc. Bolting and riveting operations require drilling of bolt or rivet holes in the gusset plates in alignment with the holes in the tension or compression members. There is a very high possibility of micro or macro-cracks developing in the bolt holes, which would seriously hamper the performance of the joints.

Fracture mechanics is a branch of solid mechanics that deals with the study of stress and strain fields around existing cracks in a structure and tries to describe the behavior of the structure under effect of existing and propagating cracks. A structure may be subjected to static or repetitive or cyclic loads. A structural component may fail under the effect of repeated cyclic loads which may be of much smaller magnitude than the static failure loads. Such a failure of a component is termed as a fatigue failure. Fracture mechanics however has a drawback in that it requires an existence of a crack in the structure. Thus, if a new structure is required to be designed, a probable location and size of the crack must be anticipated in order to employ the principles of fracture mechanics; and thereby understand the crack propagation behavior.

II. CRACK PROPAGATION SIMULATION

A plate with bolt or rivet holes has been modelled to connect two members under tension and bending. The finite element mesh of the flat plate has been shown in fig.1.

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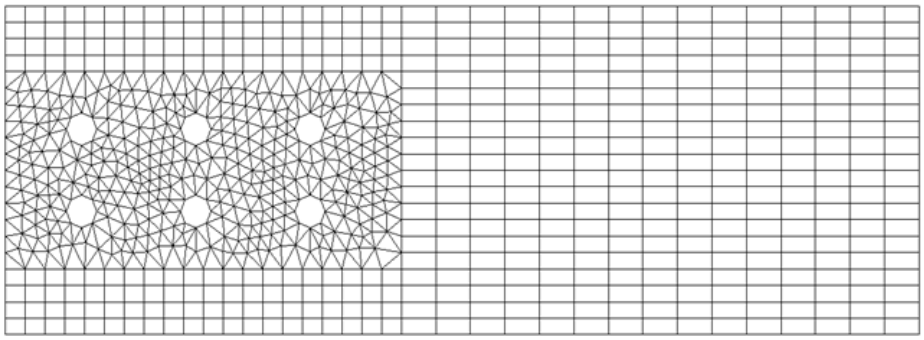

Figure 1: the finite element mesh of the flat plate

After analysis, initial cracks have been introduced at the hot-spots recognized from the von-mises stress plots. On subsequent application of loads, the crack propagation studied. The propagated cracks are shown in fig.2.

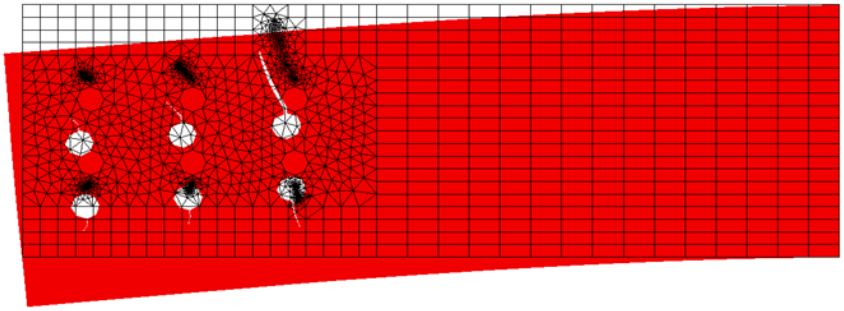

Figure 2: deformed steel plat after crack propagation

The effective stress (von-mises stress) in the plate after crack propagation have been obtained and depicted in fig.3. Figure 4 shows the fatigue life cycles of the plate for varying length of crack. It is observed that the fatigue life of the plate reduces significantly in presence of cracks and bending loads along with axial tension in connecting members.

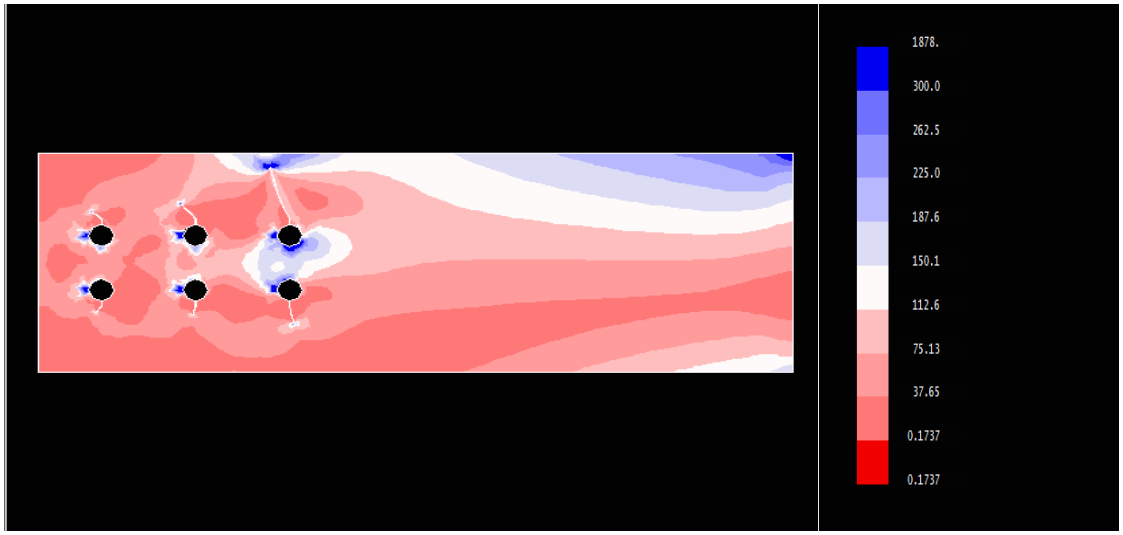

Figure 3: effective stresses in steel gusset plate after crack propagation

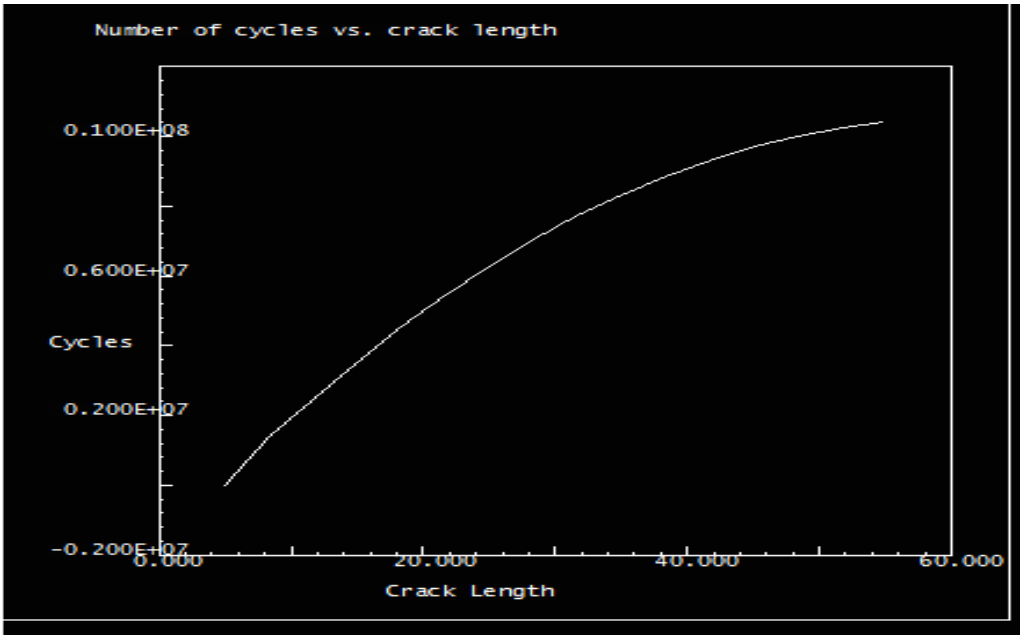

Figure 4: number of cycles versus crack length

III. CONCLUSION

Fracture analysis of a plate connecting members under tension and bending has been carried out. The members are considered to be connected by bolts or rivets. The fatigue life of the connection has been determined. A significant amount of information can be obtained from the study that enables more about design of connections.

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