A Study of Load Carrying Capacity of Cracked Weld Joint using Finite Element Analysis

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Abstract:- Static Stress and dynamic modal analysis gives the idea for strength of the joints. Any failure in the analysis is catastrophic to the functioning of the structure/machine. This can be eliminated by proper stress and dynamic analysis. Cracks will happen in the welds after certain cycles of working. The present study is to find the effect of crack on load carrying capacity of the joint and its stress behaviour in the joint. The results shows parabolic reduction of strength with the propagation of crack which indicates failure propagation is more with increased cracking. Also stress behaviour across the cross section also changes with the crack propagation and results shows maximum concentration at the bottom region which is totally different from the full contact problem.

1. INTRODUCTION:
A reliable structural design of welded structures requires the accurate assessment of the behaviour of the welded connections. Although welds are conventionally designed to be statically stronger than the components they connect, in practice, a large number of fracture failures occur in the weld. The structural behaviour of welded plate girders is relatively unaffected by large cracks for a substantial proportion of life. The essential of adopting the finite element method for determining the design stresses for fatigue life calculations has been increased recently especially when utilizing the advanced fatigue assessment methods for welded steel structures.

2. LITERATURE SURVEY:
Fracture is very important parameter of reducing the strength of the welded structures. Lot of literature has been done to find the fatigue crack life on welded configurations. J.J. Janosch¹ in his article "Welded Assemblies of E-36-4 Steel as a function of the penetration of the Weld subjected to tensile and bending loads” has conducted tests to reveal degree of incomplete fusion below by which discontinuity will be created has no effect on fatigue strength after certain limits. In his study, he mainly concentrated on effect improper penetration on weld strength. He has applied finite element method for finding the propagation of micro cracks with further loading. He has represented graphs for fatigue life with depth improper weld continuity. T. BNykanen² has analysed one sided fillet welded T-joints for strength using fracture mechanics parameters. Plane strain Linear elastic fracture modeling is considered for results. Paris crack growth model is considered for crack propagation and stress flow lines. The strength reduction with improper penetration of weld has been analysed. Weld length, height and plate thickness effects are analysed. Drazan Cozak³ has studied the effect of fracture parameters on weld strength and cracking. Single edge notch, three point bend specimens are considered for analysis. The comparison has been done between experimental analysis techniques to numerical techniques. The finite element analysis has been used for finding the threshold crack loads. Nenad Gubeljak⁴ has discussed causes of the brittle fracture of the welds. He has concluded the brittle regions in the welds are the potential sources for cracking. Unstable fracture component was analysed for which different hardness is observed two brittle weld regions. The formation of different hardness is attributed to multipass welds also attributed to AC welding. Even the metallic inclusions or alloying of the materials are also the source for weld brittleness. Peter Bernasovsky⁵ has analysed various types of cracks in the welds. Mainly they are classified to hot cracks, cold cracks, Lamellar tearing and reheat cracks. They are mainly found in the heat affected Zone (HAZ) from where they propagate to the parent metal. He has selected the cracks on real structures to find the fatigue fracture effect experimentally. Teppel Okawa⁶ in his article discussed methods to improve fatigue crack life with opening and closing of cracks and resulting residual stresses on the system. Further fatigue life improvement techniques like UIT has been discussed. The analysis has been done for variable loads. A comparison has been done with the calculated values with experimental values. Slight variation is observed between the results.

3. Methodology:
A plate of 75 mm X 75 mm with 25 mm thickness is considered for analysis. The geometry is built in Ansys and split to ease the map mesh. Plane42 element is used for analysis. Different material properties are assigned for mild steel plates and the weld geometry. A triangular type weld is created using ansys mixed approach. Map mesh is carried out for obtaining the better results. A nonlinear material behaviour is considered by specifying the yield stress for the member. A load increment approach is considered by specifying ramped option for execution. The safe loads are calculated and represented. Crack simulation is carried out by demerging the nodes and a nonlinear analysis with newton raphson mixed approach is used for finding the safe loads.

Fig: Geometrical Details of the problem
4. Results:
Analysis has been carried out in the nonlinear domain and safe the loads for the given condition is represented. Both static condition and dynamic conditions are represented. Initially full contact or without crack analysis is carried out and safe load is estimated. Further by demerging the nodes, crack simulation is carried out and results are represented as follows.

| Material Details of the Mild Steel and Weld Material. |
|-----------------|-----------------|-----------------|
| Young’s Modulus (GPa) | 200 | 120 |
| Poison’s ratio | 0.3 | 0.22 |
| Tangent Modulus (Mpa) | 250 | 200 |

5. Conclusions:
The Finite element analysis has been carried out to find the structural strength and dynamic ability of the welded joints with complete and with cracked configurations. The results drastic drop of structural strength and dynamic ability as shown in the figure. Almost 80% of structural strength drop can be observed with 60% crack propagation and a drop of 45% dynamic strength can be observed from the dynamic results for fundamental natural frequency. So complete weld of the joint is essential to prevent any possible failure and also to maintain design load carrying capacity for which weld has been created. Even the stress variations can be predicted across the weld Geometry which helps in identifying the higher stress regions by which crack propagation propagates further. Finite element analysis is a good tool for finding the regions of stress concentrations and variations through virtual simulation.
6. References


