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FRACTURE STUDIES ON A NON-PRISMATIC STEEL GIRDER

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ABSTRACT

Haunched steel girders are often deployed due to the economy offered by them. The profile of haunched steel girders usually depend on bending moment and shear force diagrams.This violates a vital assumption in the Euler-Bernoulli's beam theory. Consequently, numerical analysis of the beam would be recommended over classical analysis. A haunched steel girder may further have holes in the web for further material saving. This makes it difficult to ascertain the failure loads and characteristics of such girders.One of the major reasons of failure in cantilever haunchedsteel girder is initiation and propagation of static and fatigue cracks at regions of high effective stresses. Cracksdeveloped are often observed to be periodic in nature. This paper tries to describe a study conducted on crack propagation in cantilever haunched steel girder with a hole in shear web. A fracture analysis code FRANC2D has been adopted to simulate the cantilever haunched steel girder having edge crack near the joint in finite element framework incorporating Linear Elastic Fracture Mechanics and Elastic Plastic Fracture Mechanics. Behavior of the crack and stress distribution around it has been studied taking into account the location and the mode of crack.

Keywords: Crack propagation behavior, Haunched steel girder, Fracture Mechanics, Finite element analysis, Fatigue crack, FRANC2D,

I. INTRODUCTION

To study the behavior of crack in cantilever haunched steel girder it is necessary to obtain length of crack, crack location, loading on cantilever haunched steel girder and location of hole near the support. This is usually achieved by non-destructive evaluation techniques.While designing members by Fracture Mechanics approach, a crack of small length is usually postulated.

In present study we are propagating a crack in cantilever haunched steel girder of variable thickness such as 3,5,8,10,12mm under uniformly distributed load. The study has been conducted to understand the propagation behavior of the crack.

A finite element model for simulating the propagation of crack in cantilever haunched steel girder has been developed in FRANC2D. A NON-cohesive edge crack of 1mm length has been introduced in the cantilever haunchedsteel girder to observe deformation and stresses. For varying thickness of the steel haunched girder the crack is studied as well as deformed shape has been observed. The direction of crack, mode of failure, crack tip location, length of cantilever haunched girder and a specified hole near support are taken into consideration while modeling and analyzing.

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II. FINITE ELEMENT MODEL

Dimension of the haunched girder consider for fracture analysis are shown in the schematic given in the figure below,

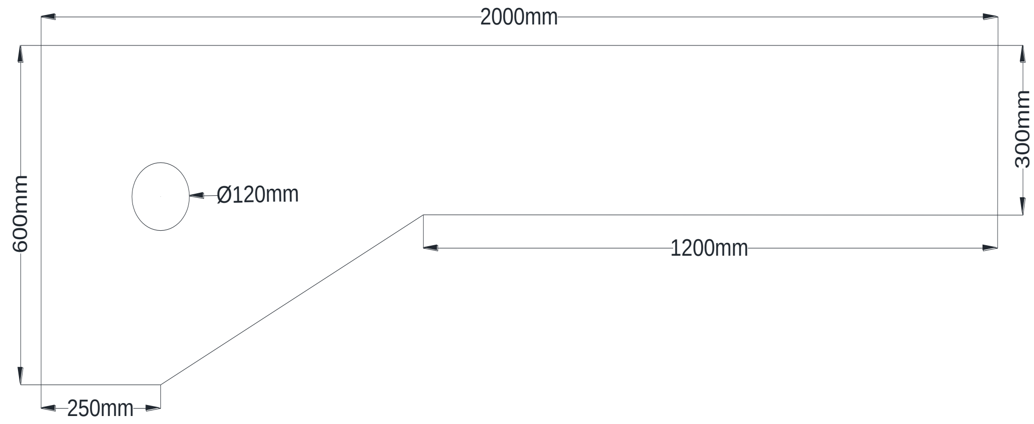

Fig 1 schematic of haunched steel girder

The girder is considered to be made of steel having properties as given intable

Type of material	Young's modulus of elasticity N/mm^2	Fracture toughness(K1c) $MPa \cdot m^{1/2}$	Poisson's Ratio
Steel	200000	45	0.33

Table 1 – mechanical properties of the steel adopted

Left bottom edge of cantilever hauchedsteel girder has been restrained in x and y . Uniformly distributed load of 100kN/m has been applied in downward direction at the upper portion of the cantilever haunch girder. Non-cohesive traction free edge crack of 1mm length was generated on upward left portion near the hole. The crack was introduced perpendicular to the longitudinal edge of cantilever haunched girder. The elongation and change in direction of the crack along with stress contours have been observed for various thickness of the girder.

III. RESULTS AND DISCUSSION

A finite element mesh showing steel cantilever haunched girder

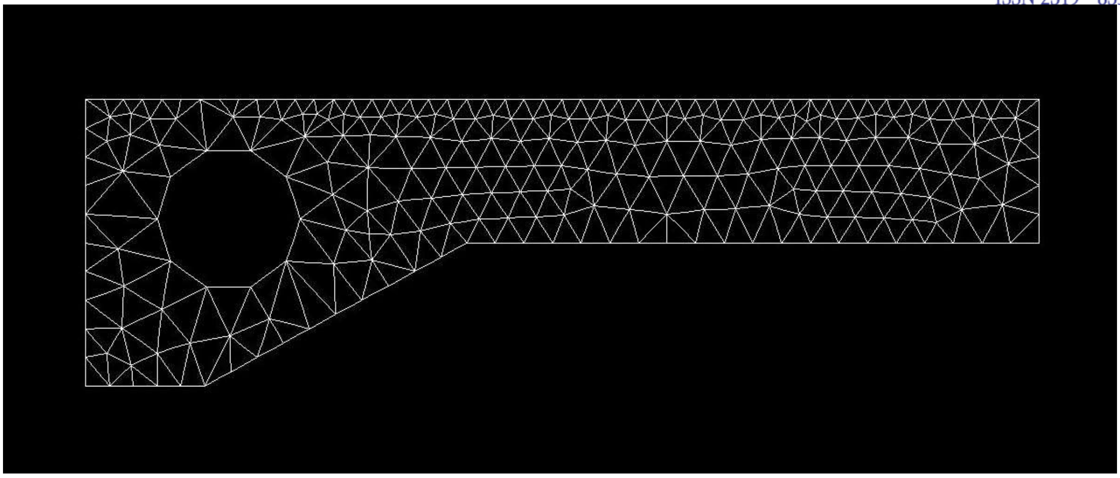

Fig1.1Schematic of finite element mesh

Uniformly distributed load of 100kN/m was applied for 3mm thickness plate and crack is propagated at the edge the propagation is shown in the fig. 1.2

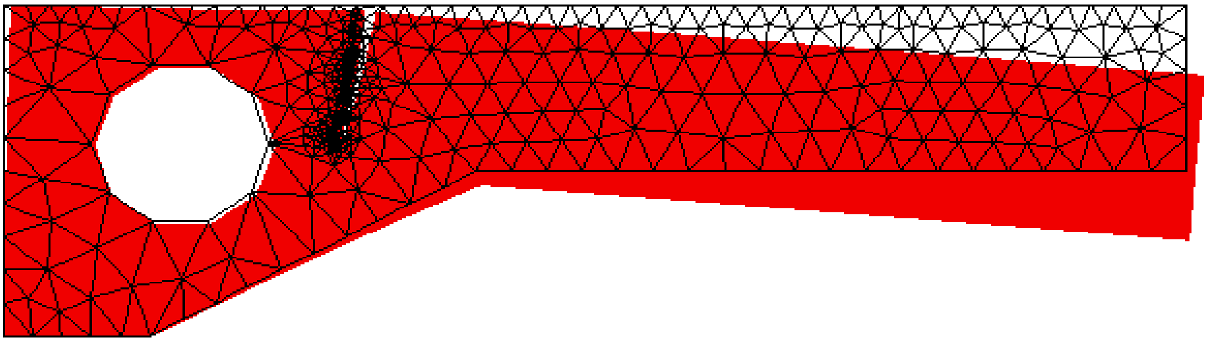

Fig. 1.2 Deformed shape of cantilever haunched steel girder

Uniformly distributed load of 100kN/m was applied for 5mm thickness plate and crack is propagated at the edge the propagation is shown in the fig. 1.3

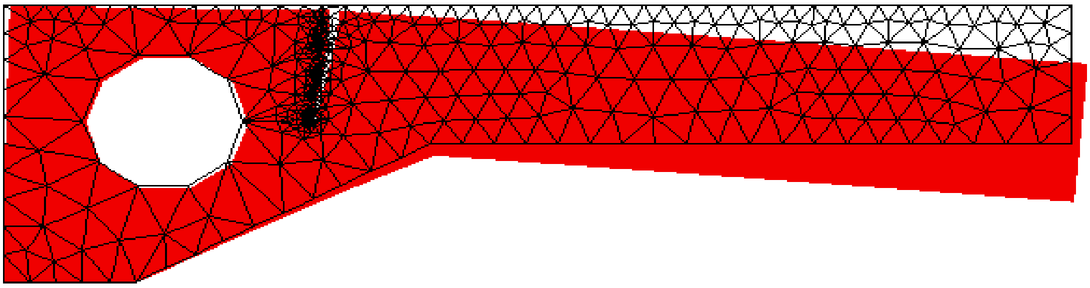

Fig. 1.3Deformed shape of cantilever haunched steel girder

Uniformly distributed load of 100kN/m was applied for 8mm thickness plate and crack is propagated at the edge the propagation is shown in the fig. 1.4

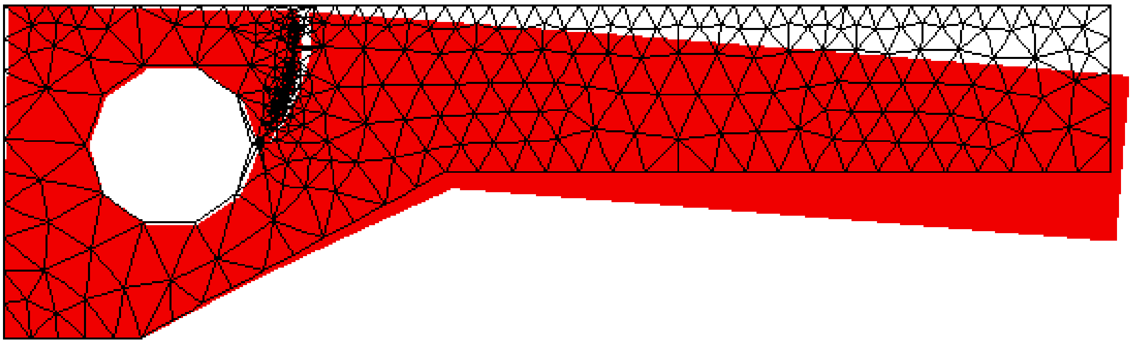

Fig. 1.4Deformed shape of cantilever haunched steel girder

Uniformly distributed load of 100kN/m was applied for 10mm thickness plate and crack is propagated at the edge the propagation is shown in the fig. 1.5

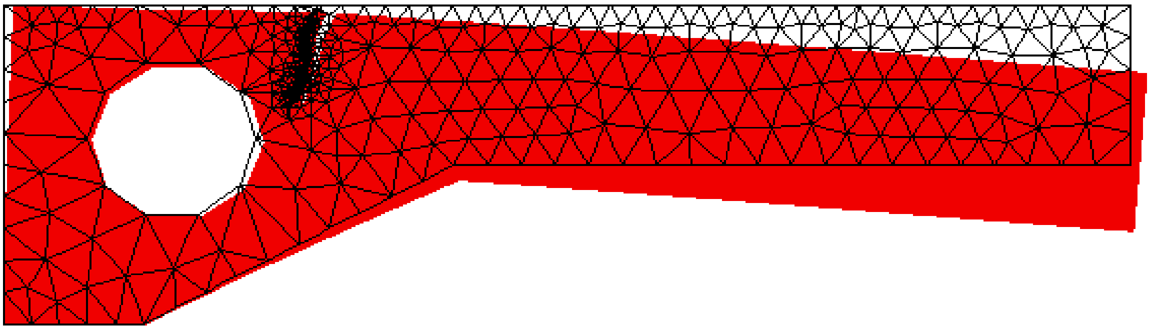

Fig. 1.5Deformed shape of cantilever haunched steel girder

Uniformly distributed load of 100KN/m was applied for 12mm thickness plate and crack is propagated at the edge the propagation is shown in the fig. 1.6

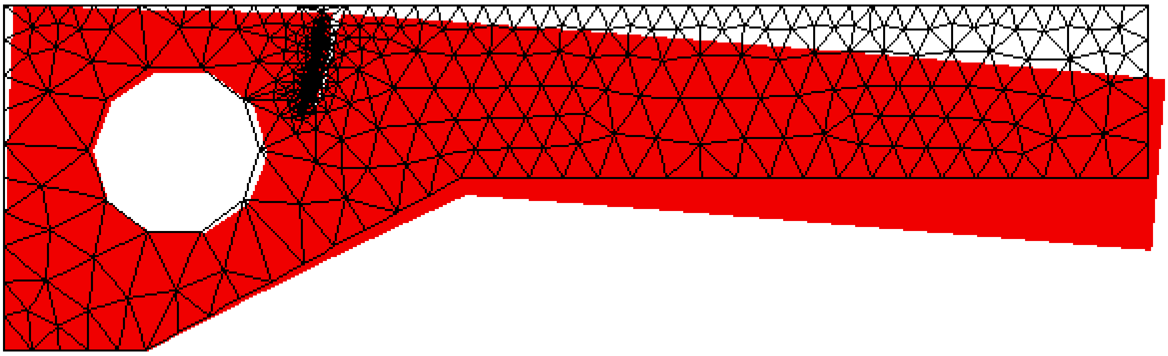

Fig. 1.6Deformed shape of cantilever haunched steel girder

Due to the large loads imposed on the girder the observed fatigue life is very short, then the girder is under cyclic load must be controlled or appropriate thickness must be provided .Fatigue life of the girder is shown in fig 1.7

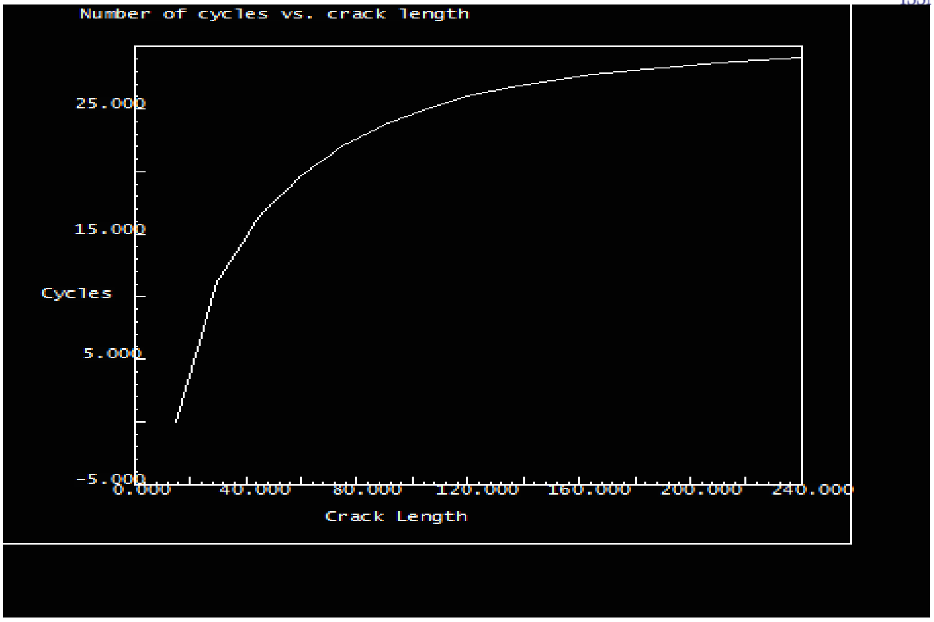

Fig.1.7 Fatigue life of the girder

IV. CONCLUSION

Fracture and fatigue studies on a haunched steel girder with hole and initial cracks have been carried out. FRANC2D proves to be immensely useful tool to perform the simulations. The crack propagates predominantly in mode 1 considering the maximum permissible crack length and fatigue life ,the girder may be effectively designed .

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