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Computational Analysis of Natural Rubber with Toughened GFRP

Divyabarathi P*, Adikeshavan P, Syedhaleem M
Department of Aeronautical Engineering, Bharath University, Chennai – 600073
***Corresponding author: E-Mail: divyabarathi.aero@bharathuniv.ac.in**

ABSTRACT

In this paper, the glass fiber Stress intensity factor has been estimated through a numerical investigation of the composite with different ply orientations. To find the fracture parameter K with the help of crack mouth opening displacement method (CMOD) the specimen was modeled and meshed using ANSYS workbench. The six layers of laminate were modeled with the fiber orientation of 0° and 90° (angle ply & cross ply). One end of the composite specimen was given pinned boundary condition and other end was subjected to static displacement control loading condition. Stress intensity factor was given as a output parameter and the stress intensity contour plots were obtained for the different cases. From these results we known strength of cross ply laminates are lower than the unidirectional laminate.

KEY WORDS: Stress Intensity factor, strength, natural rubber, glass fiber, GFRP

1. INTRODUCTION

Composite materials are gaining importance due to their good mechanical properties. In many structural applications even a small crack under critical conditions can cause complete failure of the structure. Hence, an understanding of the state of stress near a crack and the crack propagation will enable us to design a better structure such that it will withstand even after the formation of a crack. Recently developed numerical analyses software is very helpful in the analyses of composites. Though the results cannot be taken as accurate, it helps in eliminating the number of cases to be subjected to experimental analyses; thus, saving material and time.

Model: To compare with the results obtained from an experimental analysis, a computational model of the composite made of toughened GFRP along with natural rubber is analyzed using the ANSYS multiphysics software. The problem is solved using the Crack Tip Opening Displacement method to find out the stress intensity factor that will be helpful in predicting the stress state near a crack tip due to remote loads or residual stresses.

Laminate measurements: The laminate measurements according to ASTM (D 5045) standard are as follows for the different cases that were analyzed.

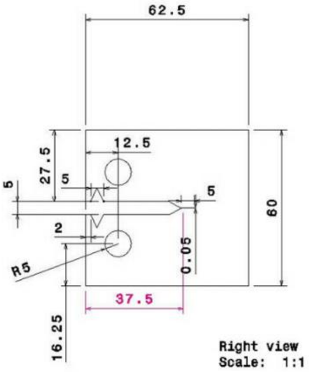

Figure.1. CTOD Specimen Dimensions

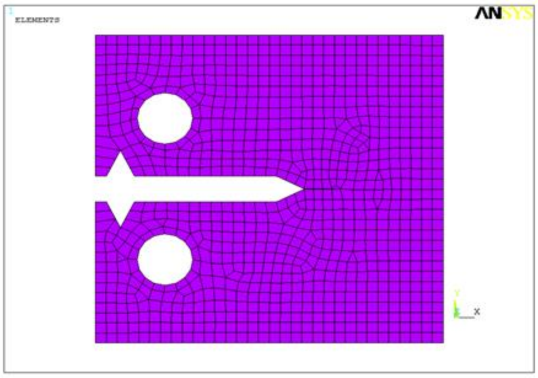

Figure.2. Meshed View of the Model

Boundary conditions: There are two ends in the model. One end is given the pinned end condition while static displacement under controlled loading is used for the other end. Boundary conditions are applied with the help of the following key points,

Table.1. List of key points to apply boundary conditions

Key points for Boundary Conditions		
k, 40, 27.5	k, 41, 32.5	k, 42,2,32.5
k, 43, 4.5,37.5	k, 44,7,32.5	k, 45,32.5,32.5
k, 46, 37.5,29.75	k, 47, 42.5,29.75	k, 48,42.5,29.25
k, 49, 37.5,29.25	k, 50, 32.5,27.5	

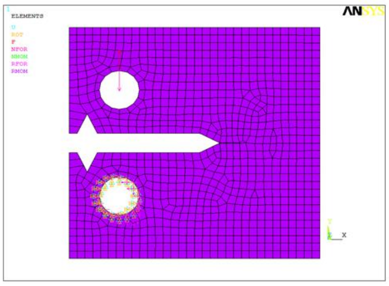

Figure.3. Loading and Boundary Conditions

2. RESULTS

The loading conditions and other calculations are with respect to the standards specified by the ASTM. After specifying the boundary conditions, the solution procedure is carried out and after post processing; the results obtained have been shown below.

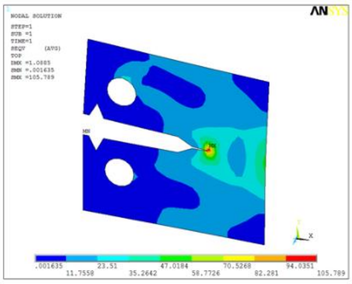

Figure.4. Stress Intensity Plot – Unidirectional Ply Case

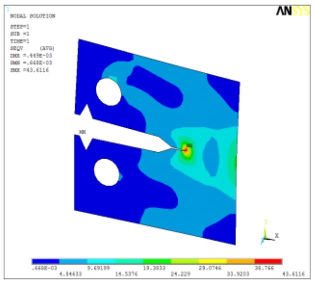

Figure.5. Stress Intensity Plot – Cross Ply Case

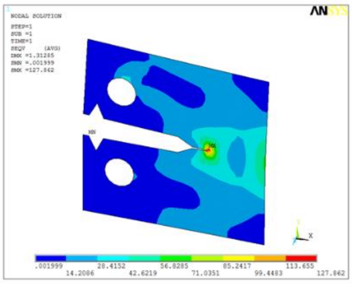

Figure.6. Stress Intensity Plot – Unidirectional Ply with 1 % Natural Rubber Case

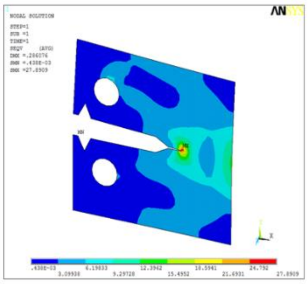

Figure.7. Stress Intensity Plot – Cross Ply with 1 % Natural Rubber Case

Table.2. Stress Intensity Factor for Different Cases

Material	Theoretical values of stress intensity factor
Fiber unidirectional	105.7Mpa√m
Fiber crossply	44Mpa√m
1% natural rubber unidirectional	127.8Mpa√m
1% Natural Rubber Crossply	27.8Mpa√m

3. CONCLUSION

The analysis was done by using natural rubber with fiber and resin with different directions. From the results, it is clear that the stress intensity factor has improved on the addition of natural rubber for the unidirectional case. However, in the case of cross ply orientation, the stress intensity factor has decreased. Since, natural rubber is hyper elastic; it has improved the stress intensity factor. However, this is not working out for the case of cross ply orientation that has to be studied in detail in future works.

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