International Journal of Research
Available at https://pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 21
October 2018

Fracture Analysis of Crack Propagation Using Different Materials on Three Crack Modes of Failure

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ABSTRACT

In this thesis, the fracture mechanics of crack propagation using different materials Titanium, Nickel Alloy 718, Glass Fiber Reinforced Polymer, Carbon Fiber Reinforced Polymer is investigated for three modes of failure in a rectangular block. Fracture, Static analyses are done on all the three modes of failure to determine displacements, stresses, stress intensity factors, and vibrations. 3D modeling is done in Creo 2.0 and analysis is done in Ansys.

I.INTRODUCTION

The field of mechanics which concerns with the cracks propagation in materials study is Fracture Mechanics. It utilizes strategies for analytical solid mechanics for calculating the force on a crack & those of solid mechanics experiments to describe the resistance of material's to fracture.

There are 3 ways of force applying enabling propagation of a crack:

- **Mode I fracture** – Opening mode (a tensile stress normal to crack plane),
- **Mode II fracture** – Sliding mode (a shear stress acting parallel to crack plane & perpendicular to the crack front), &
- **Mode III fracture** – Tearing mode (a shear stress acting parallel to the plane of the crack and parallel to the crack front).

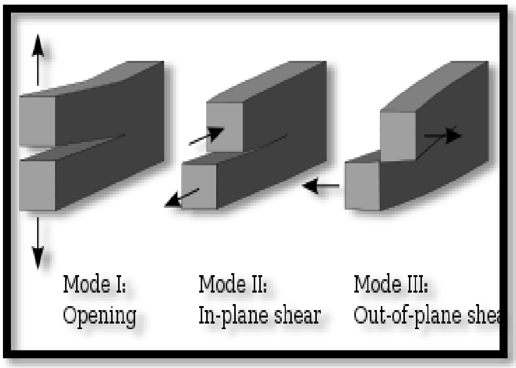

Fig 1:-Mode I, Mode II, and Mode III crack loading.

Fracture

A fracture is the detachment of a question or material into at least two pieces under the action of stress. The fracture of a solid more often than not happen because of the advancement of certain removal intermittence surfaces inside the solid.

II.LITERATURE SURVEY

M. D. Nikam[1], intended to satisfy this hole and produce more data along these lines expanded comprehension on fracture conduct in 3D Segments. The limited component investigation has been performed to help the outcomes on fracture parameters like Area and Size of Cracks and results has been contrasted and accessible hypothetical arrangements. It is presumed that the size of the basic Stress Intensity Factor can be utilized as a fracture rule for thin Plates. The same system has been adjusted for Investigation of interfacing pole to discover Stress Intensity Factor at different lengths of crack.

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M.Shohel[2], Three dimensional (3D) opening mode stress intensity factors (SIFs) for auxiliary steel welded 'T' points of interest were explored by the limited component strategy. A 3D shape dependent revision factor is proposed for semi elliptical surface cracks. The viewpoint proportion (a/c) of a semi elliptical crack assumes a key job in the guess of 3D-SIF qualities, and in the present investigation, it was evaluated for a 3D crack examination. The evaluated 3D-SIF was resolved through a relationship between's the a/c proportion and the two dimensional SIF for semi elliptical cracks in the thickness course adjoining the web flange intersection of a welded 'T'.

3D MODELS OF DIFFERENT CRACK MODES

In this thesis, 3 models of different crack modes are done in Creo 2.0. A rectangular block of 100mm*50mm*3mm is taken.

Crack Mode I

In the mode I, the loading is done on the body by tensile forces, such that surfaces of crack are pulled apart in thickness direction. The 3D model of rectangular block with Crack mode I is shown in below figure.

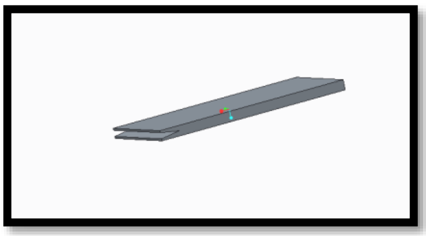

Fig 2:- 3D model of Crack Mode I

Crack Mode II

In the mode II, the loading is done on the body by shear forces parallel to surfaces of crack. The 3D model of rectangular block with Crack mode II is shown in below figure.

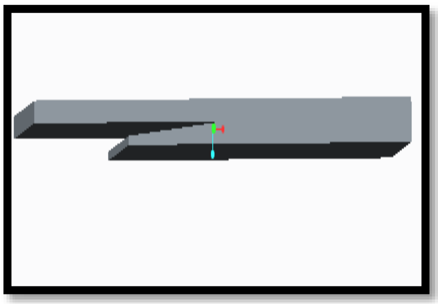

Fig 3:- 3D model of Crack Mode II

Crack Mode III

In the mode III, the loading is done on the body by shear forces parallel to crack's crack front. The 3D model of rectangular block with Crack mode II is shown in below figure.

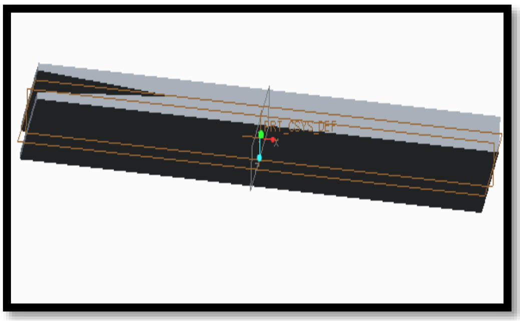

Fig 4:- 3D model of Crack Mode III

III.ANALYSIS ON DIFFERENT CRACK MODES

The fracture mechanics of crack propagation using different materials Titanium, Nickel Alloy 718, Glass Fiber Reinforced Polymer, Carbon Fiber Reinforced Polymer is investigated for three modes of failure in a rectangular block.

FRACTURE ANALYSIS

Fracture analysis is performed on the crack modes to determine stress intensity factors and J – Integral. A crack is applied at the edge of the crack mode.

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GLASS FIBER REINFORCED POLYMER (GFRP)

CRACK MODE I

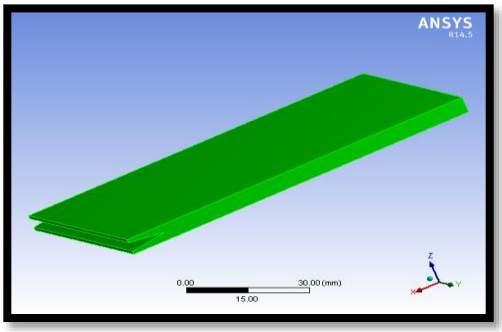

Fig 5:- Imported model of beam with crack mode I

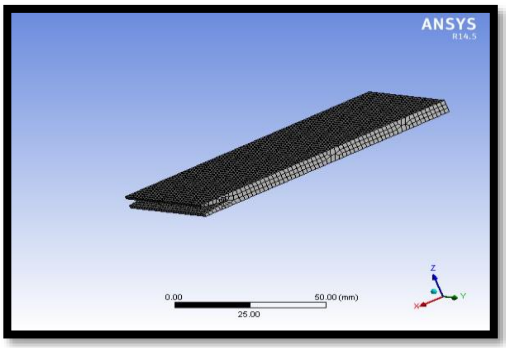

Fig 6:-meshed model of beam with crack mode I

Select fracture tool

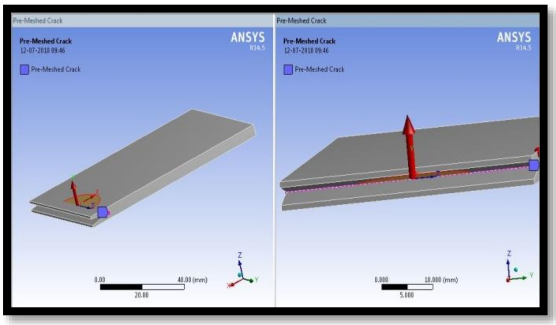

Fig 7:-Pre-meshed crack

Named Selection→ Crack→ Crack front, Select Crack Shape – Semi Elliptical, Enter major radius → 5 mm, Enter minor radius →2 mm, Enter Fracture affected zone Height – 13.55mm, Enter largest contour radius – 5 mm

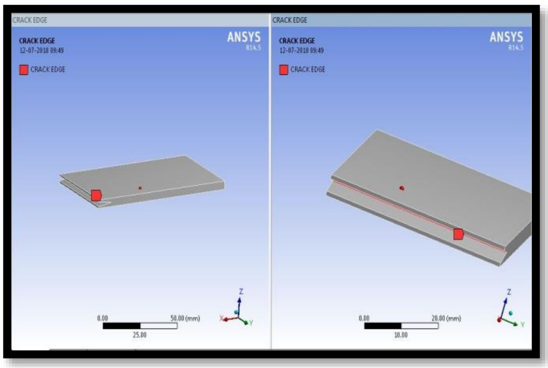

Fig 8: - Crack on edge

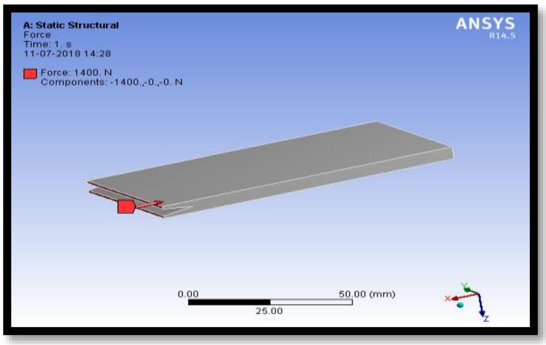

Fig 9:- Load of 1400N is applied at crack tip

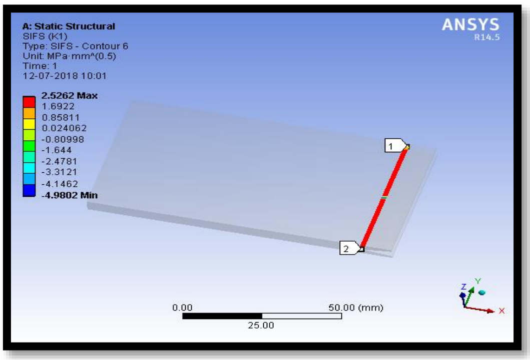

Fig 10:- Stress intensity factor of crack mode I by using GFRP

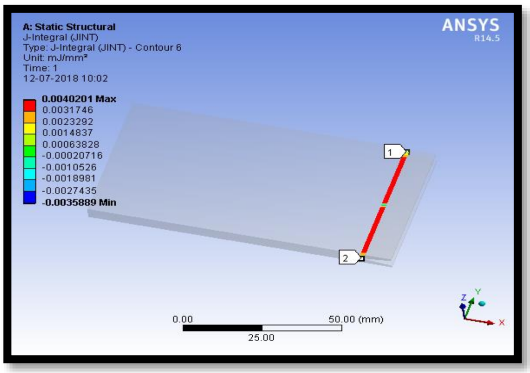

Fig 11:- J- integral of crack mode I by using GFRP

CRACK MODE II

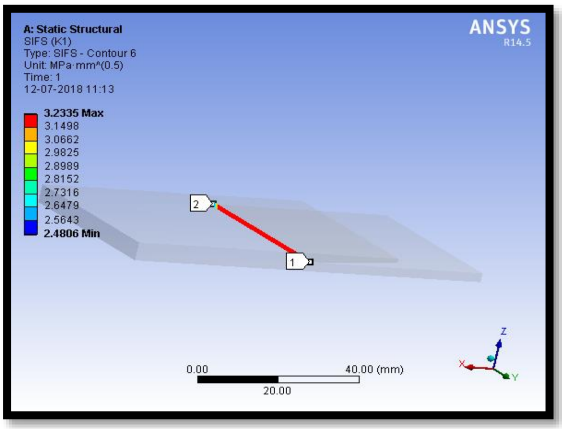

Fig 12:-Stress intensity factor of crack mode II by using GFRP

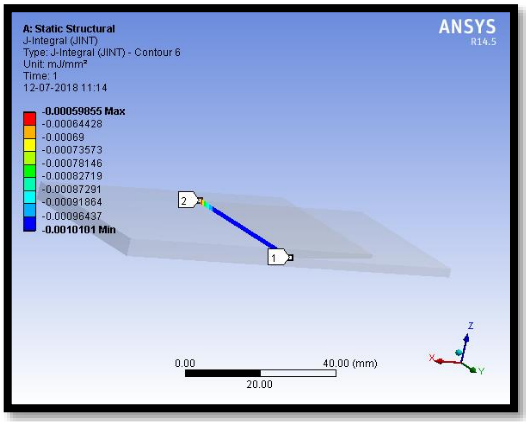

Fig 13:- J – Integral of crack mode II by using GFRP

CRACK MODE III

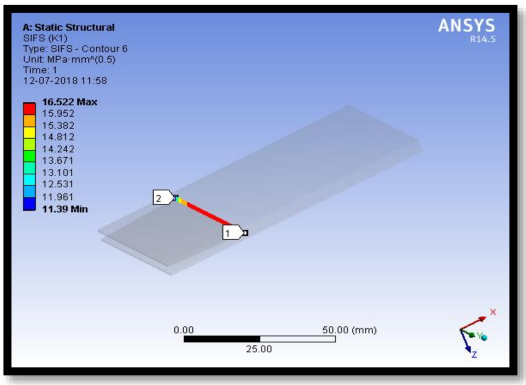

Fig 14:- Stress intensity factor of crack mode III by using GFRP

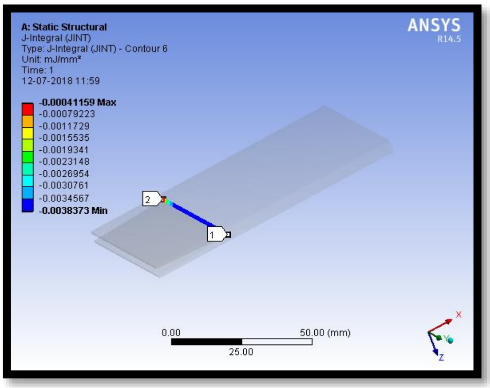

Fig 15:-J- integral of crack mode III by using GFRP

IV.RESULTS & DISCUSSIONS FRACTURE ANALYSIS

The table below shows the stress intensity factors and J – Integral for 3 crack modes and different materials.

CRACK MODE	MATERIAL	SIFS K1 (MPa.mm^0.5)	JINT (mJ/mm^2)
I	TITANIUM	2.7413	0.001043
	NICKEL 718	2.5502	0.00055147
	GFRP	2.5262	0.0040201
	CFRP	2.5262	0.069681

II	**TITANIUM**	3.3737	-0.00013731
	NICKEL	3.2485	$-8.0691e^{-5}$
	GFRP	3.2335	-0.00059855
	CFRP	3.2335	-0.010375
III	**TITANIUM**	17.031	$-4.5185e^{-5}$
	NICKEL 718	16.579	$-5.0582e^{-5}$
	GFRP	16.522	-0.00041159
	CFRP	16.522	-0.0071343

From the above table, the following observations can be made:

- For Titanium material, the stress intensity factor is increasing for Crack Mode II by about 18% when compared with Crack Mode I. The stress intensity factor is increasing for Crack Mode III by about 85% when compared with Crack Mode I.
- For Nickel 718 material, the stress intensity factor is increasing for Crack Mode II by about 21% when compared with Crack Mode I. The stress intensity factor is increasing for Crack Mode III by about 83.7% when compared with Crack Mode I.
- For Glass Fiber Reinforced Polymer, the stress intensity factor is increasing for Crack Mode II by about 21 % when compared with Crack Mode I. The stress intensity factor is increasing for Crack Mode III by about 84% when compared with Crack Mode I.
- For Carbon Fiber Reinforced Polymer, the stress intensity factor is increasing for Crack Mode II by about 22 % when compared with Crack Mode I. The stress intensity factor is increasing for Crack Mode III by about 85% when compared with Crack Mode I.

STATIC STRUCTURAL ANALYSIS

CRACK MODE	MATERIAL	Deformation (mm)	Stress (MPa)	Strain
I	**TITANIUM**	0.008799	18.926	0.00018555
	NICKEL	0.0048136	18.975	$9.987e^{-5}$
	GFRP	0.035259	18.979	0.00072998
	CFRP	0.61116	18.979	0.012653
II	**TITANIUM**	0.032306	13.549	0.00013284
	NICKEL	0.017639	12.42	$6.537e^{-5}$
	GFRP	0.12917	12.263	0.00047166
	CFRP	2.2389	12.263	0.0081755
III	**TITANIUM**	0.04581	18.934	0.00018563
	NICKEL	0.025389	18.963	$9.9807e^{-5}$
	GFRP	0.18624	18.964	0.0007294
	CFRP	3.2282	18.964	0.012643

From the above table, the following observations can be made:

- For Titanium material, the stress is increasing for Crack Mode I by about 28% when compared with Crack Mode II. The stress is increasing for Crack Mode III by about 28.4% when compared with Crack Mode II.
- For Nickel 718 material, the stress is increasing for Crack Mode I by about 34% when compared with Crack Mode II. The stress is increasing for Crack Mode III by about 34.5% when compared with Crack Mode II.
- For Glass Fiber Reinforced Polymer, the stress is increasing for Crack Mode

I by about 35.38% when compared with Crack Mode II. The stress is increasing for Crack Mode III by about 35.33% when compared with Crack Mode II.

- For Carbon Fiber Reinforced Polymer, the stress is increasing for Crack Mode I by about 35% when compared with Crack Mode II. The stress is increasing for Crack Mode III by about 35% when compared with Crack Mode II.

V.CONCLUSION

By observing fracture analysis results, the stress intensity factors are less for crack at mode I and when Polymers are used. The stress intensity factors are decreasing for crack at mode I by about 21.8% when compared with that of crack at mode II and by 84.7% when compared with that of crack at mode III when GFRP and CFRP are used. By observing static structural analysis results, the stress are less for crack at mode II and when Glass Fiber Reinforced Polymer is used. The stresses are decreasing for crack at mode II by about 54.76% when compared with that of crack at mode I and by 35.33% when compared with that of crack at mode III.

REFERENCES

1. **M. D. Nikam, G. V. Patil, G. N. Thokal, V. H. Khatawate,** Estimation of stress intensity factor (sif) on crack component by using finite element analysis, International Journal of Mechanical Engineering and Technology, Volume 5, Issue 1, January 2014.
2. **M. Shohel, C. Menzemer, G.A. Arthur, Estimation** of three-dimensional stress intensity factor for structural 'T' details, Fatigue and fracture of engineering materials and structures, volume 39, issue 9, September 2016.
3. **Djamila Benarbia, Mohamed Benguediab**, Determination of Stress Intensity Factor in Concrete Material Under Brazilian Disc and Three-Point Bending Tests Using Finite Element Method, University of Sidi Bel Abbes, Sidi Bel Abbes , City BenMhidi. B.P. 89, Algeria, 03 September 2015.
4. **J. C. Passieux, A. Gravouil, J. R´ethor´e and M.C. Baietto,** Direct estimation of generalized stress intensity factors using a three-scale concurrent multigrid X-FEM, International Journal for Numerical Methods in Engineering, 2011.
5. **F. Khelil, M. Belhouari**, A Numerical Approach for the Determination of Mode I Stress Intensity Factors in PMMA Materials, Engineering, Technology & Applied Science Research Volume 4, Issue No. 3, 2014.
6. **Abdelkader Boulenouar, Noureddine Benseddiq,** Fe Model For Linear-Elastic Mixed Mode Loading: Estimation Of Sifs And Crack Propagation, Journal Of Theoretical And Applied Mechanics, 2014.
7. **J.Caicedo and A.Portela,** Direct Computation Of Stress Intensity Factors In Finite Element Method**,** European Journal Of Computational Mechanics, 10 July 2017.
8. **M.L. HATTALI, H. AURADOU, M. FRANCOIS, V. LAZARUS,** Numerical and experimental approaches for the determination of two-parameter fracture mechanics in wedge splitting loading, 21st Congress Francis the Technique, 2013.
9. **Akash S. Ingle, S.J.Parihar,** Determination of Stress Intensity Factor for a crack in thin plate under Mode-I loading using Finite Element Analysis, International Journal of Innovative and Emerging Research in Engineering Volume 2, Issue 4, 2015.
10. **Zhuang He, Andrei Kotousov,** Estimation of Stress Intensity Factors from Near Crack Tip Field, International Journal of Aerospace and Mechanical Engineering Vol:9, No:7, 2015.