iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** IX **Month of publication:** September 2015

DOI:

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Investigation of localized stresses and analysing the influence of hole in a finite width plate

Gaurav Dubey[*1], Shyam Singh Kanwar[2], Chandra Pal Chandra[3], Gouri Shankar Khanday[4]
[1*]Institute of Technology, Guru Ghasidas Vishwavidyalaya, Department of Industrial and Production Engineering, Koni, Bilaspur, Chhattisgarh 495009, India,
[2, 3, 4]Institute of Technology, Guru Ghasidas Vishwavidyalaya, Department of Mechanical Engineering, Koni, Bilaspur, Chhattisgarh 495009, India

Abstract— Several structures have holes in it for transmission of various units through it. These components are subjected to uniform pressure throughout the region and thereby generating higher stress around the hole. Since all the specimens with holes in it is also subjected to higher stresses due to the stress concentration factor involved in it which tends to increase the stresses nearby the holes. The aim of this paper is to show the variation of stresses due to a variety of holes. Also, the suggestions regarding the same have been given in order to improve the life of the specimen and the probable catastrophic failure can be avoided. The finite element solution has been determined and compared for the finite width plate.
Keywords— Finite element method, Stress concentration factor, Finite width plate, Failure, Stress.

I. INTRODUCTION

There are several components which require holes in it due to the passage of other components in it. The common example includes the aircraft panels for passing wire through them. Often these panels are having variety of holes and because of this the higher stresses are induced in these components, which causes the catastrophic failure of the components. Moreover the aircraft windows have holes to fit the glass in it. All these components are subjected to huge pressure from the surrounds. Hence it is necessary to analyze the induced stresses and take the corrective measures accordingly. Since a small flaw at those pressure is able to cause catastrophic failure. The investigation of isotropic plates was done by Peterson [1] and Heywood [2]. This work opens the new area in the field of elasticity. Further work in this area was done by Howland [3] as he analyzed the induced stresses near the holes when the specimen is subjected to uniform tension.

Dubey and Kumar [4] employed the numerical techniques to evaluate the results of stress intensity factor under mode-I type of loading. They also proposed modification in existing methods to evaluate the stress intensity factor with minimum number of iterations. Chung and Bin [5] came up with the analysis of isotropic as well as orthotropic specimens of plates and cylinders having circular holes in it which is subjected to various loading configurations. But it was Nueber [6] who came up with various theories pertaining to the notches and analyzed several system based on it. Till now the effect of circular hole was analyzed but Jones and Hozos [7] goes beyond this to analyze the elliptical holes and the corresponding stresses induced in the specimens. All the above discussed works are either experimental or analytical. But the stresses using the photo-elastic behaviour of material was obtained by the Seika and Ishii [8], who determined the maximum stresses generated in the rectangular and circular plate with reinforcement subjected to uniform tension. In this way they observed the photo-elastic fringes for their analysis. The analysis till this point of time was done by considering the single hole or notch in the specimen. But the work of Durelli [9], when the infinite width specimen is subjected to uniaxial loading opened the gateway for multiple notches and holes. By analyzing the previous works it can be concluded that the specimen with holes are necessary. But the stresses induced in those specimens are of higher magnitude. Hence the aim of this paper is to formulate and analyze the effect of various hole configurations and the corresponding stresses induced due to internal pressure. Also the methods to reduce the stress concentration factor can be easily suggested by knowing the reason of higher stresses.

II. MATHEMATICAL MODELLING OF SPECIMEN

The mathematical formulation for the two dimensional and three dimensional holes for finite width specimen were done by Wang [10]. This approach has been implanted to obtain the solution of finite element. Usually the mathematical formulation involves the usage of the theory of elasticity [11] so that the mechanical behavior can be analyzed analytically. For the purpose of analyzing the stress concentration factor the theoretical stress intensity factor is used [1, 10].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

$$K_T = \frac{\sigma_{\max}}{\sigma_{nom}} \quad \ldots(1)$$

where, σ_{max} is the maximum stresses acting over the plate, σ_{nom} is the nominal stress acting over the plate which can be expressed as:

$$\sigma_{nom} = \frac{P}{W * t} \quad \ldots(2)$$

where, *P* is the traction force acting over the plate, *W* is the width of the plate and t is the thickness of the plate.

But the case considered in the present study is the case of plate subjected to internal uniform pressure and thereby analyzing the effect of hole configuration. Fig.(1) shows the plate with arbitrary crack configuration which has been analyzed in the present study.

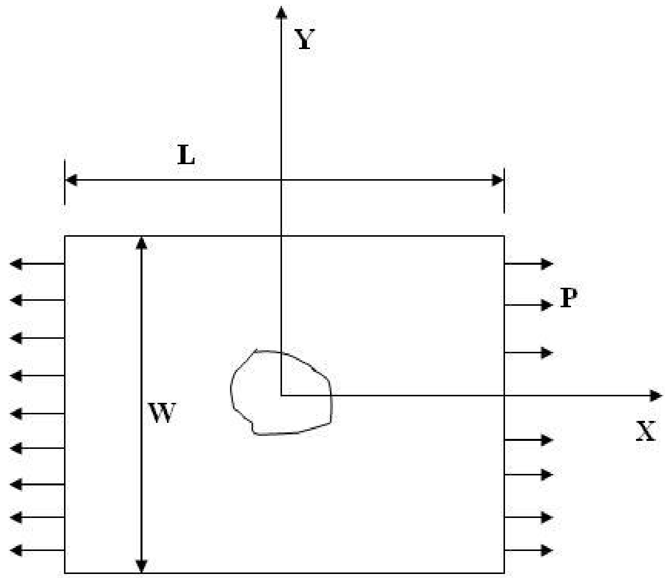


Fig. 1 Finite width plate with random whole configuration

III.FINITE ELEMENT MODELLING OF SPECIMEN

Finite element formulation [12] of the specimen includes the identification of values of the field variable computed at the nodes which will be used to approximate the values at non-nodal points (that is, in the element interior) by interpolation of the nodal values. For the three-node triangle example, the field variable is described by the approximate relation.

$$\varphi(x, y) = N_1(x, y)\,\varphi_1 + N_2(x, y)\,\varphi_2 + N_3(x, y)\,\varphi_3 \quad \ldots(3)$$

where φ_1, φ_2, and φ_3 are the values of the field variable at the nodes, and N_1, N_2, and N_3 are the interpolation.

$$\{F\} = [K]\,\{X\} \quad \ldots(4)$$

where, [K] is defined as the element stiffness matrix in the element coordinate system (or local system), $\{u\}$ is the column matrix (vector) of nodal displacements, and $\{f\}$ is the column matrix (vector) of element nodal forces.
The Eq.(4) is used to determine the unknown field variables i.e., {u}.
Once the displacement is known then corresponding values of strain can be determined by using the relation:

$$\varepsilon = \Delta u / L \quad \ldots(5)$$

and the corresponding value of stresses can be obtained from the stress-strain relation.

$$\sigma = E * \varepsilon \quad \ldots(6)$$

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

where, E is the modulus of elasticity.

The steps of using the FEM is represented by the Fig.(2). The plate of 150m length, 50m width, and 2m thickness has been selected which is then subjected to 1000Pa of uniform internal pressure while the external boundary of the plate has been fixed to resist end deformations. The area of 176.71m^2 has been taken uniform for all the specimens. The corresponding solution is discussed with explanation in the next section.

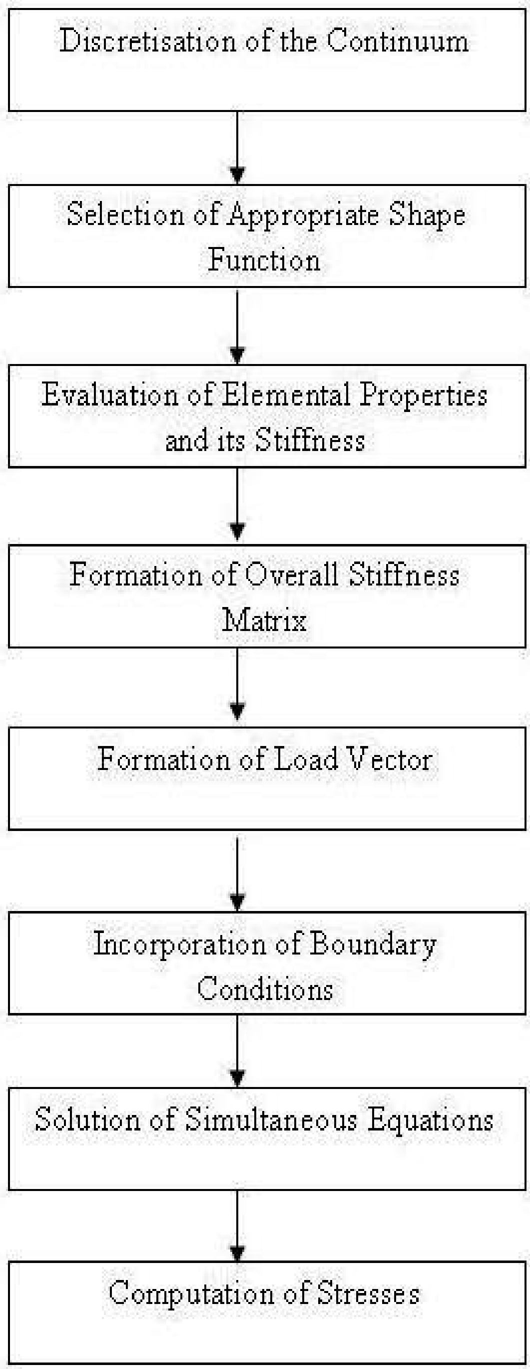


Fig. (2) Flow chart of Steps for using the FEM

Volume 3 Issue IX, September 2015
ISSN: 2321-9653

IV. RESULT AND DISCUSSION

The results presented below, Fig, [3-10] are obtained using Finite Element method and the results are compared with the results of ANSYS. The results shows that rectangular section has less stresses induced in it while circular section having maximum stresses in it. In the hexagonal section, the stresses are nearly same as circular section because of the fact that a circle can be represented approximately by the polygon of many sides. The reason of higher stresses in the circular and hexagonal sections despite of the fact that circular section will have lesser stress concentration as compared to rectangular section is because of less remaining area. The remaining areas to sustain those stresses are lesser in the case of circular section hence, the influence of boundary comes into picture.

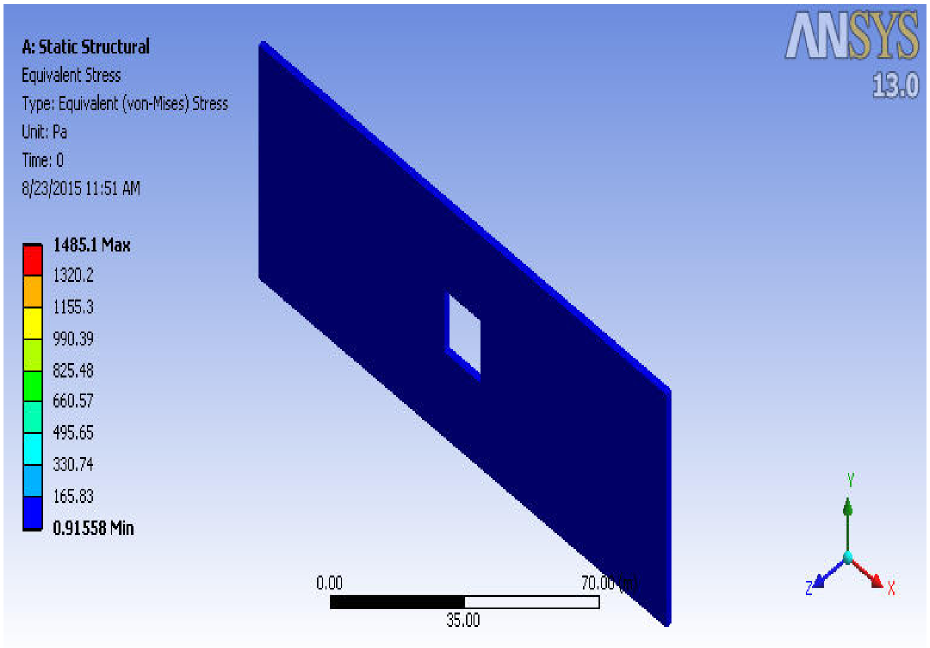


Fig. (3) Undeformed geometry for the finite width plate with square hole

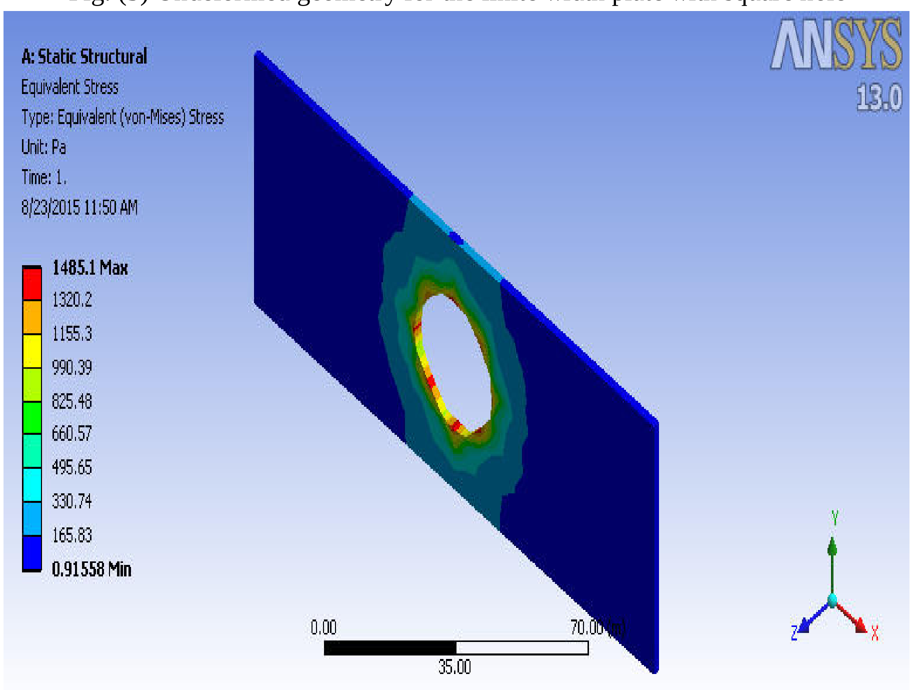


Fig. (4) Deformed geometry for the finite width plate with square hole

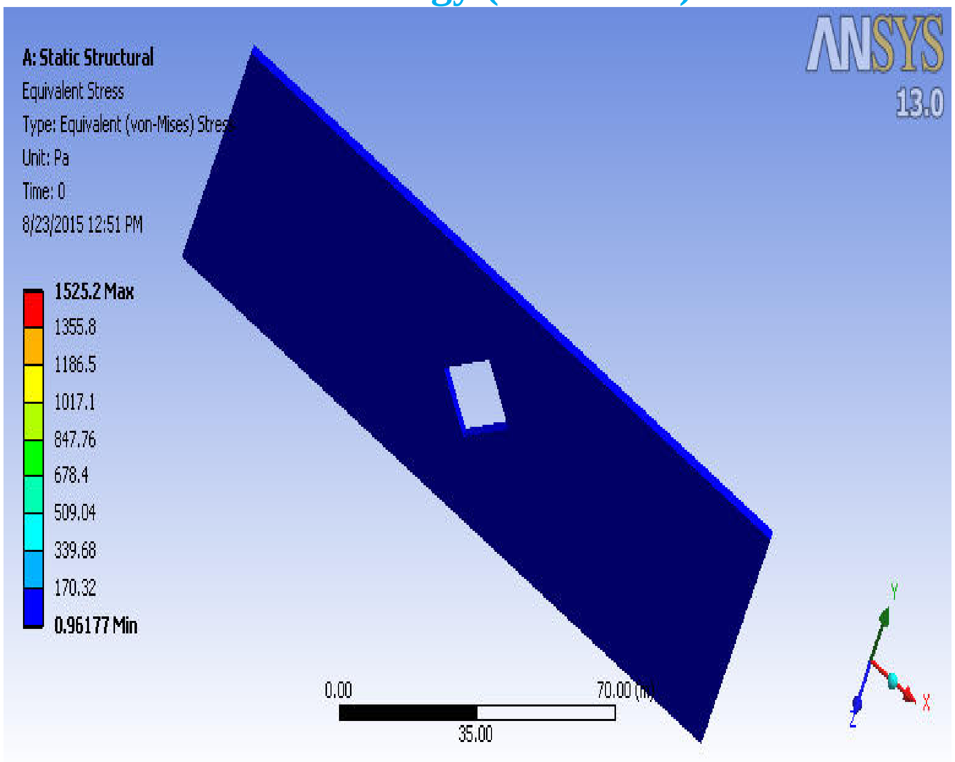


Fig. (5) Undeformed geometry for the finite width plate with square hole rotated by45 degrees

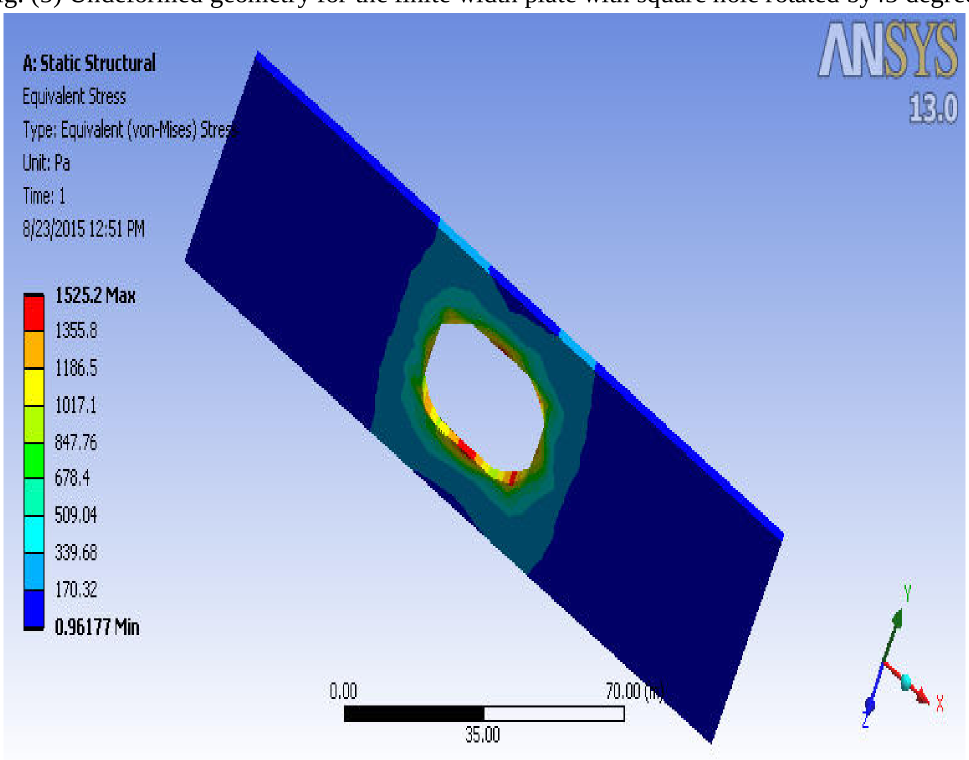


Fig. (6) Deformed geometry for the finite width plate with square hole rotated by45 degrees

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

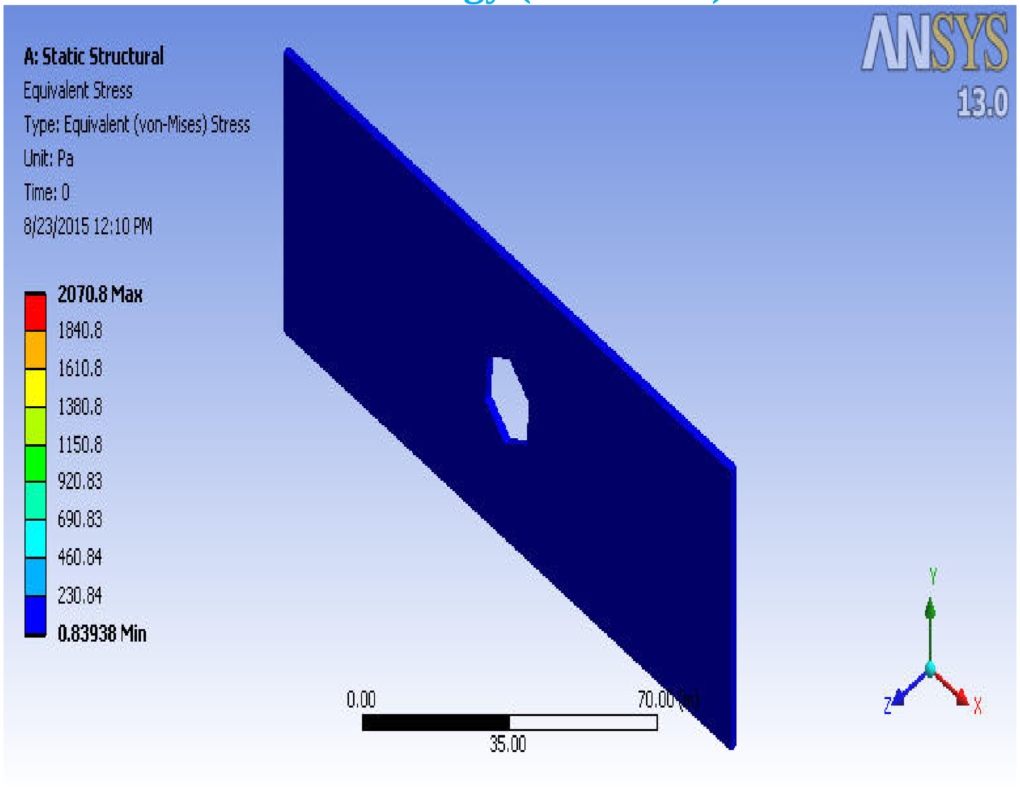


Fig. (7) Uneformed geometry for the finite width plate with hexagonal hole

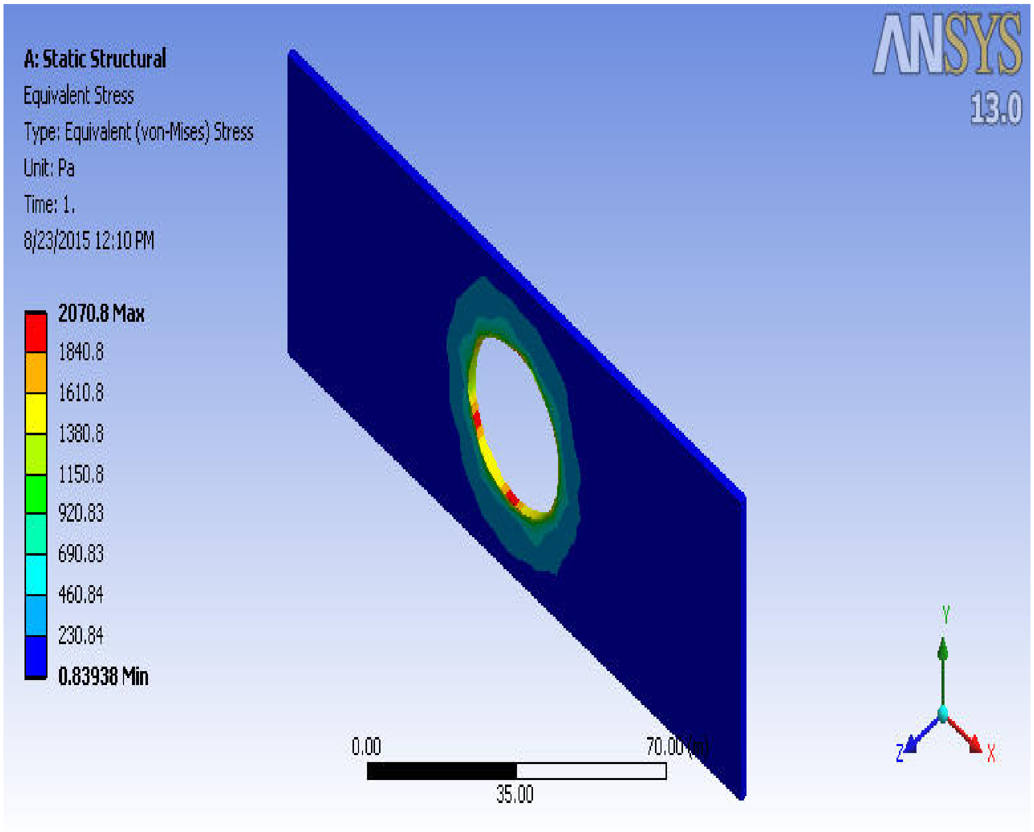


Fig. (8) Deformed geometry for the finite width plate with hexagonal hole

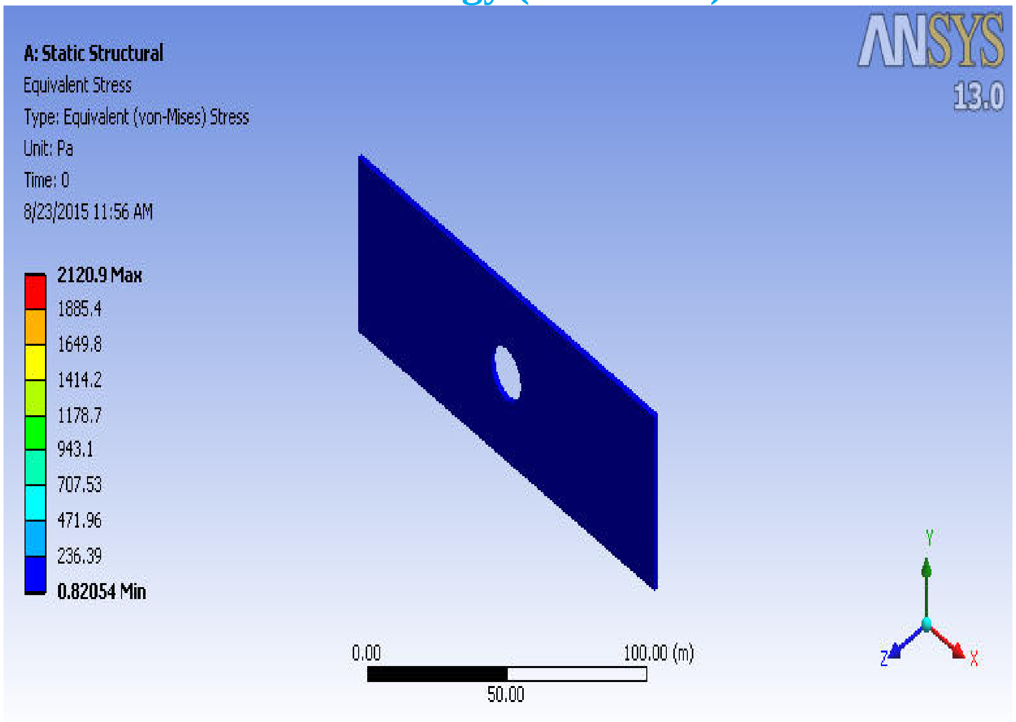


Fig. (9) Undeformed geometry for the finite width plate with circular hole

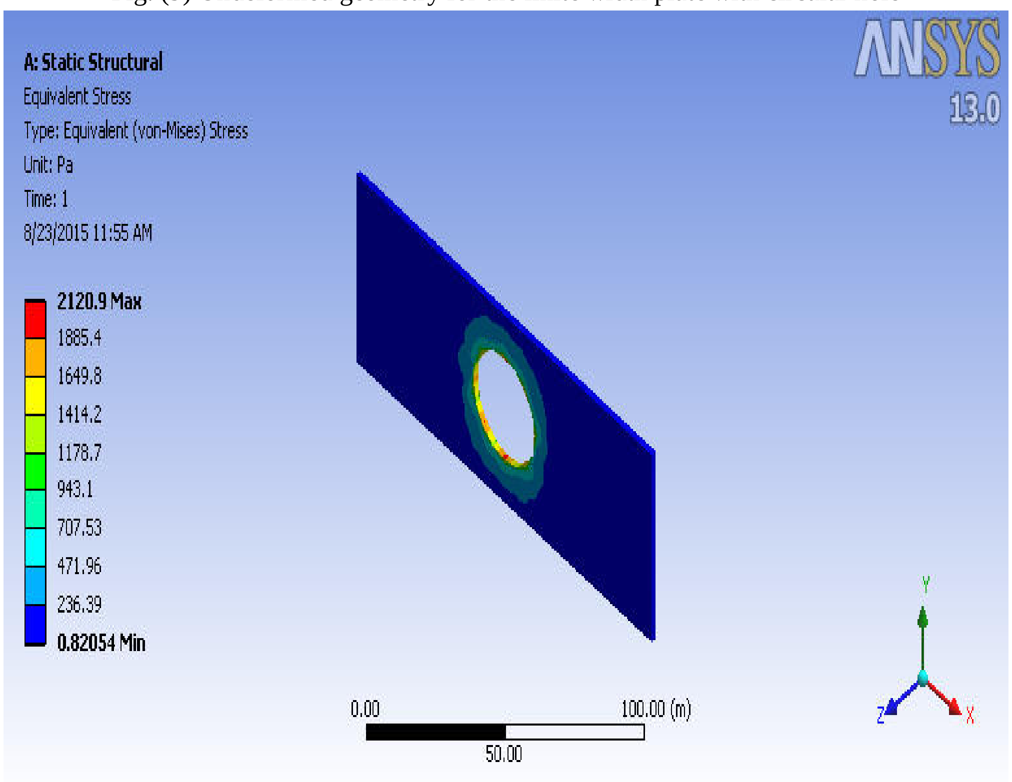


Fig. (10) Deformed geometry for the finite width plate with circular hole

The Table 1 shows the value of stresses obtained by the FEA and compared by the results of ANSYS. The comparison shows the influence of various geometrical parameters on stress distribution.

Volume 3 Issue IX, September 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table. 1 Stresses induced in the specimens with varying the hole configuration

S. No.	Plate with	Maximum Stress	
		FEA	ANSYS
1.	Square hole	1485.36	1485.1
2.	Square hole rotated by 45 degrees	1526.1	1525.2
3.	Hexagonal hole	2071.03	2070.8
4.	Circular hole	2120.78	2120.90

V. CONCLUSIONS

By observing the results the following conclusions can be drawn:

A. The stresses in the circular hole specimen is observed to be of higher magnitude because of the reason that it left lesser area in the lateral direction of the specimen.

B. The stress concentration is more in the hexagonal hole as compared to rectangular and circular holes. But higher stresses are generated in the circular sections. Hence the stresses concentration factor is also function of the available area.

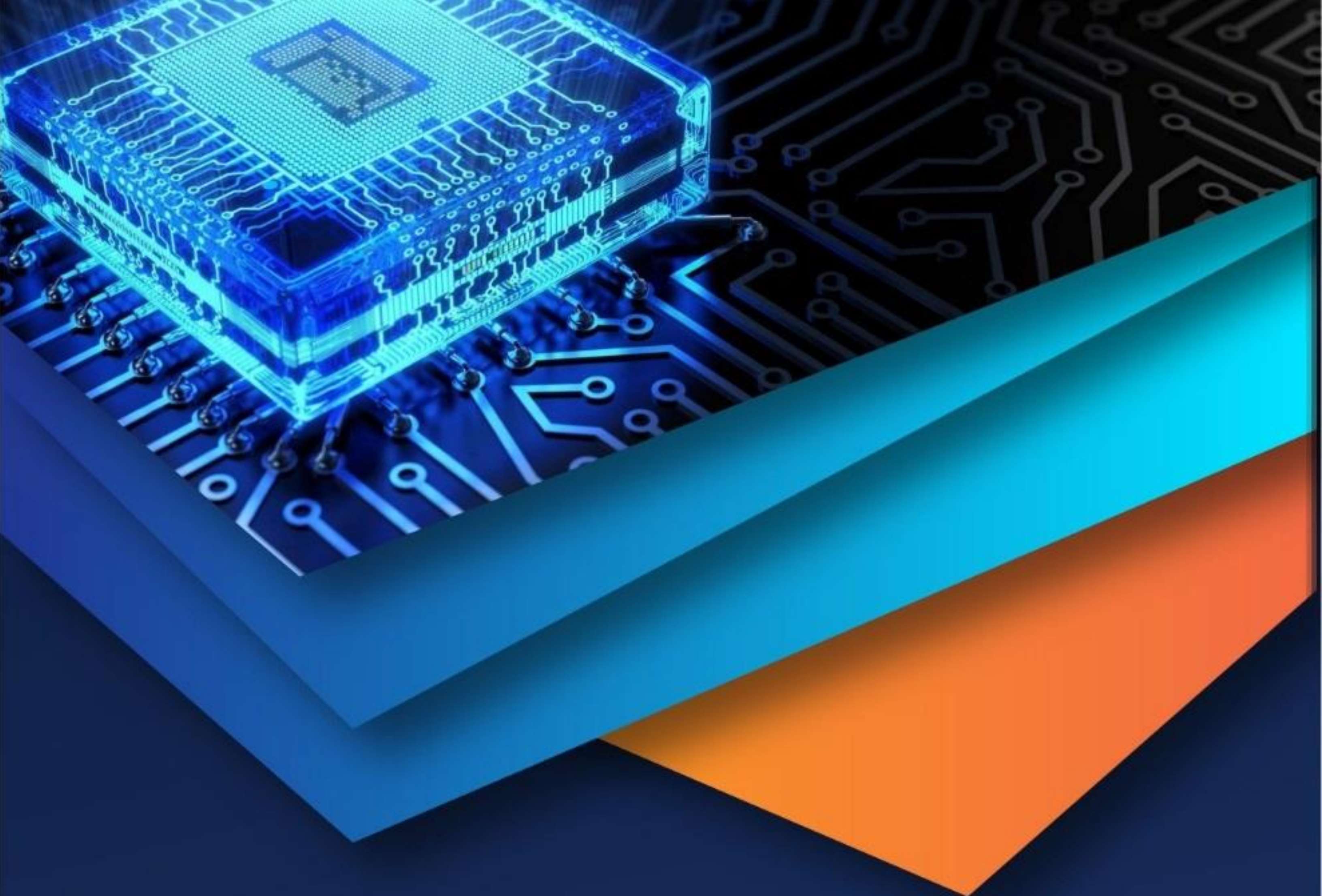
C. The rectangular hole rotated by 45 degrees generates more stress than rectangular section without rotation which is again due to the fact that lesser area for fracture is available in prior case.

D. By observing the current result, it will be easy to suggest the methods of reducing the stress concentration factor corresponding to level of stress for the respective hole configuration.

All these facts also show the influence of finite boundary in the specimen.

REFERENCES

[1] Peterson, R.E., “Stress concentration factors”, John Wiley & Sons, 1974.
[2] Heywood, R.B., “Designing by photoelasticity”, Chapman and Hall, 1952.
[3] Howland, R.C.J., “On the stresses in the neighborhood of circular hole in a strip under tension”, Phil. Trans. Roj. Soc.,Vol. 229, pp. 49-86, 1929.
[4] Dubey, G., and Kumar, S., “Efficient methods for integrating weight function: a comparative analysis”, Structural Engineering and Mechanics, Technopress, pp. 885-900, 2015.
[5] Hwai-Chung,W., and Bin, M., “On stress concentrations for isotropic/orthotropic plates and cylinders with circular hole”, J. of Composites, Part B: engineering, 34, pp. 127-134, 2003.
[6] Neuber, H., “Theory of Notch Stresses”, Office of Technical Services, U.S. Department of Commerce, Washington, DC, 1961.
[7] Jones, N., and Hozos, D., “A Study of the stress around elliptical holes in flat plates”, Trans. ASME, J. Eng. Ind., Vol. 93, Ser. B, 1971.
[8] Seika, M., and Ishii, M., “Photoelastic investigation of the maximum stress in a plate with a reinforced circular hole under uniaxial tension”, Trans. ASME, J. Appl. Mech., Vol. 86, Ser. E, pp. 701–703, 1964.
[9] Durelli, A. J., Lake, R. L., and Phillips, E., “Stress concentrations produced by multiple semicircular notches in infinite plates under uniaxial state of stress”, Proc. SESA, Vol. 10, No. 1, 1952.
[10] Wang, Q.Z., “Simple formulae for the stress concentration factor for two–and three-dimensional holes in finite domain”, J. of strain analysis, 37, pp. 259-264, 2002.
[11] Timoshenko, S. P., and Goodier, J. N., “Theory of Elasticity”, 3rd ed., McGraw-Hill, New York, 1970.
[12] Reddy, J.N., “Mechanics of laminated composite plates and shells: Theory and analysis:, 2nd Edition. New York: CRC Press, 2004.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY