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THERMAL ANALYSIS OF PLATE BY USING FINITE ELEMENT METHOD

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ABSTRACT

Thermal analysis of isotropic square plate made up of various materials with thermal load application and different boundary conditions is analyzed in this research. Finite element formulation is carried out in the analysis and the FEM formulation is done in the analysis section of the ABAQUS. In this study, flat Square plate without cut-out which can be assumed as perfect plates which are made up steel, aluminium materials are analysed. Finally comparison has been done between the results obtained from ABAQUS results for isotropic square plate without cutout. A study on the structural properties such as deflections and thermal behaviour of different materials has been conducted during the analysis which will be helpful in various fields of engineering.

Keywords: Thermal, FEM, ABAQUS.

I. INTRODUCTION

Plates and beam are extensively used in many engineering works like buildings, bridges, tunnels, and other infrastructure. Plates and beams are used in such application are generally subjected to lateral loads, which causes bending in plate. The structural components used in the aeronautical and aerospace vehicles, as well as civil and mechanical structures often encounter severe thermal environment. If the temperature variation is sufficiently high, these stresses can reach levels that may lead to structural failure, especially for brittle materials. Thus, for many problems involving high temperature variation, the knowledge of thermal stress analysis can be very important. In structural mechanics and in many branches of engineering mechanics and aeronautics, the widespread use of plates and beams are made to deal with thermal stresses, deformations, buckling and vibrations of plates and shells for which there arises the need for reliance upon different methods of analysis. Analytical techniques in dealing with such problems have serious limitations because of difficulties in deriving closed-form solutions of nonlinear differential equations. Hence the analyses on various thermal plates have attracted many researchers since the early of 20th century. With conventional analytical methods, the deflection of plate is expressed in the form of series. However, there are some challenge problems in obtaining the analytical solutions with different thermal environments and boundary conditions. Therefore, finite element method is employed to analyze the thermal plate problems in this study. The analysis of isotropic thin thermal plate is fundamental for analyzing other more complicated thermal plates. Hence the elementary stiffness matrix and equivalent loading vector are derived and consequently the finite element solution procedure is formulated for the analysis of isotropic thin thermal plates in this paper. The obtained numerical results from finite element analysis are compared with available exact solutions. The problems in the finite element analysis are pointed out which need being noticed in the numerical analysis of thermal plates.

II. ANALYSIS

Thermal analysis for plates the first case is a flat square plate having all sides fixed. The deflection and Equivalent stress due to thermal loading are now evaluated using the finite element software,abaqus .First steady state thermal analysis is performed on plate. Model is generated with all the dimensions being unity, the generated model using ABAQUS.

After generatng model, material properties of steel material are assigned as described in table as follows ,

Property	Steel
Density(kg m^-3)	7850
Co. of Thermal Expansion	1.2x10^-5
Young's Modulus (Mpa)	2x10^5
Poisson's Ratio	0.3
Thermal Conductivity	60.5(W m^-1 C^-1)

Table.1 Properties of Material

Once the model is generated the next step is to mesh the whole geometry so that further loading and the boundary conditions are specified. Meshing looks as in figure 1

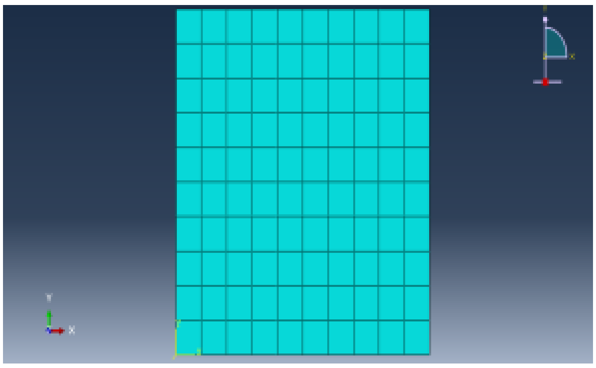

Fig. 1 Plate with mesh areas

Once the model is meshed, the next is specifying the boundary conditions. 100 ° C Temperature is applied on top side and 0 °C on remaining sides as shown in

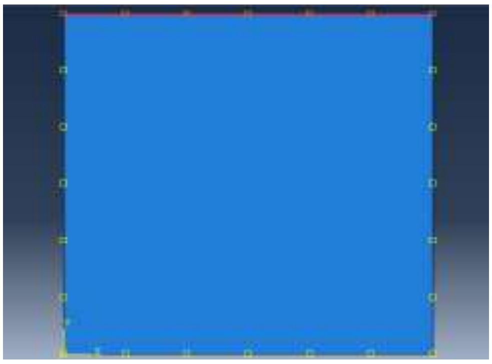

Fig.2 Boundary Condition

Once the boundary conditions are specified, the model is selected and the solution option solves for all possible results. Here temperature distribution is result. The temperature distribution is as in figure no 3,

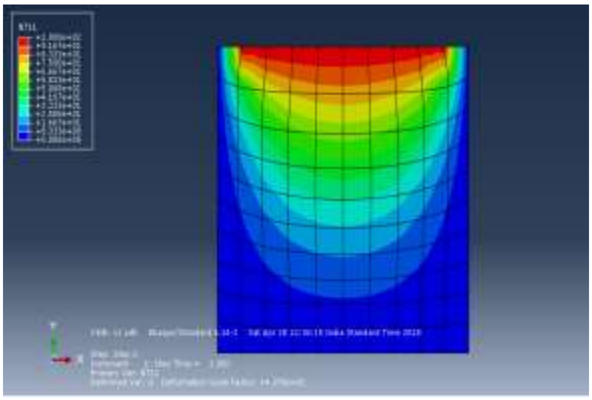

Fig. 3 Temperature distribution

This completes steady state thermal analysis. Then coupled static thermal and displacement is performed on same plate. Here two cases are considered. In first case all sides of plate are fixed and in second case opposite two sides are fixed and remaining are simply supported. Geometry and material properties are taken from steady state thermal analysis. Then further is done. Using same model, meshing is done. Then boundary conditions are applied as follows.

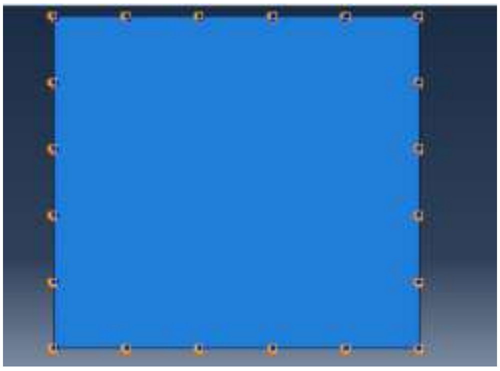

Fig. 4 Boundary condition in first case

Once the boundary conditions are specified, the model is selected and the solution job option solves for all possible results. Then all the results including the stresses and deformations are viewed. Equivalent stress, total deformation for steel for first case is described in figure 5 & 6.

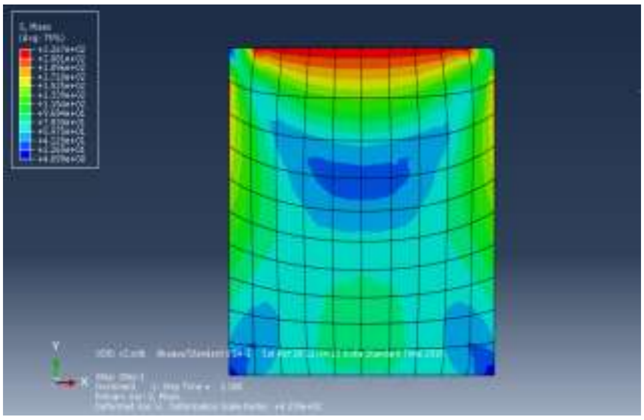

Fig.5 Stress in plate first case in steel

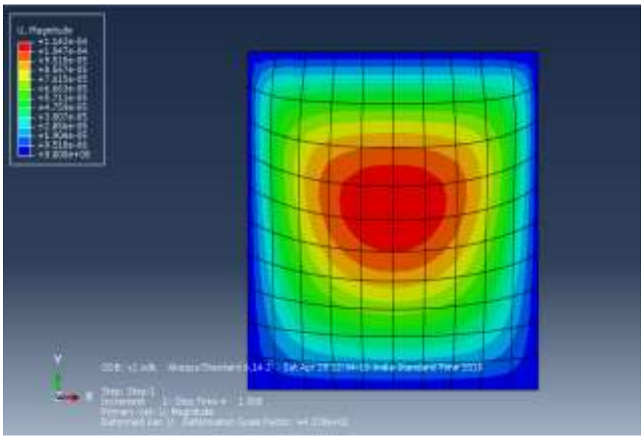

Fig. 6 Deformation in steel first case for steel

Now model is solved for the second case two opposite sides are fixed and remaining side are simply supported. With thermal analysis to it meshing is done then boundary conditions for second case are applied.

Fig. 7 Boundary condition for second case

Once the boundary conditions are specified the model is selected and the solution option solves for all possible results. The coupled temperature displacement option is given then the results including the stresses and deformations for case second are described as follows.

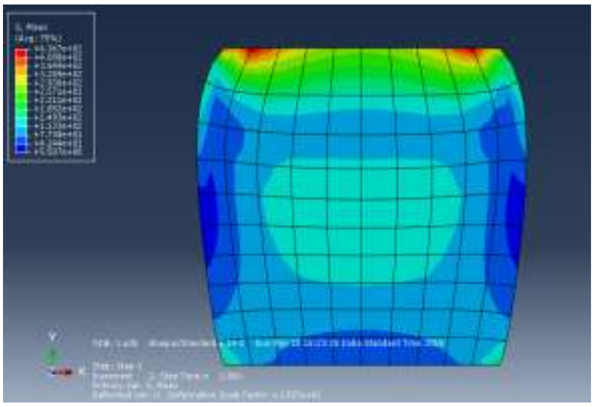

Fig. 8 Stress for second case in steel

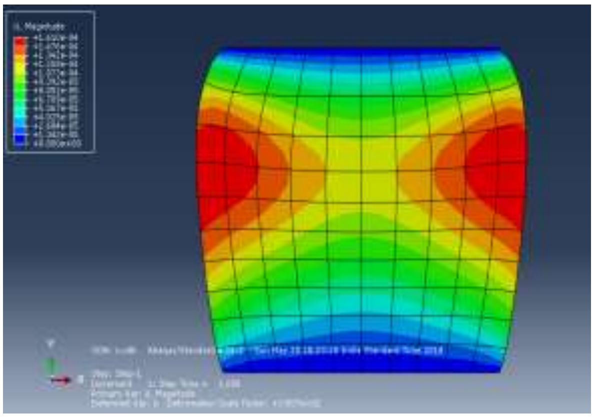

Fig.9 Deformation for second case in steel

III. RESULTS AND DISCUSSION

The thermal analysis performed on square plate. Temperature variation along length and width are described with comparison of the results in ABAQUS and ANSYS software. The fig. 10 shows the temperature variation for steel.

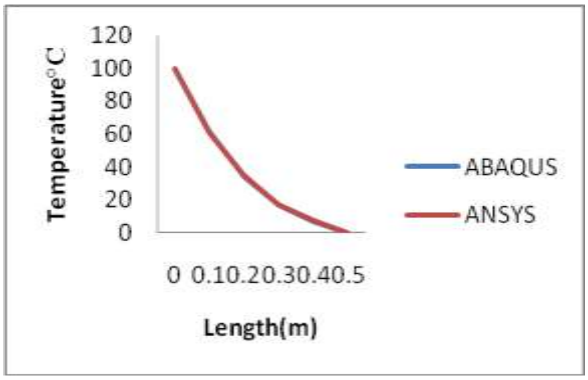

Fig 10 Temperature variation along Y axis

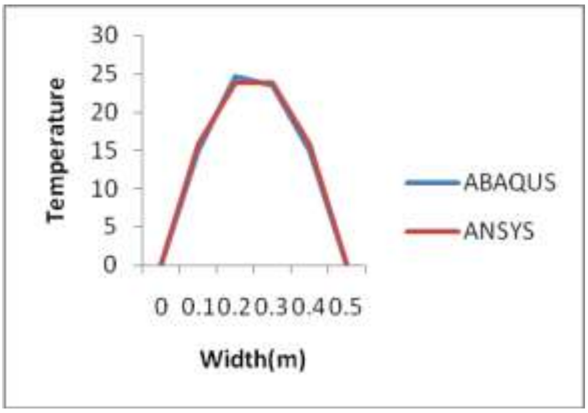

Fig 11 Temperature variation along X axis

Then coupled temperature displacement analysis performed on plate. In first case i.e. all sides fixed, stress in ABAQUS software and ANSYS software are described in fig 12,13,14 and total deformation as described in,fig15,16.

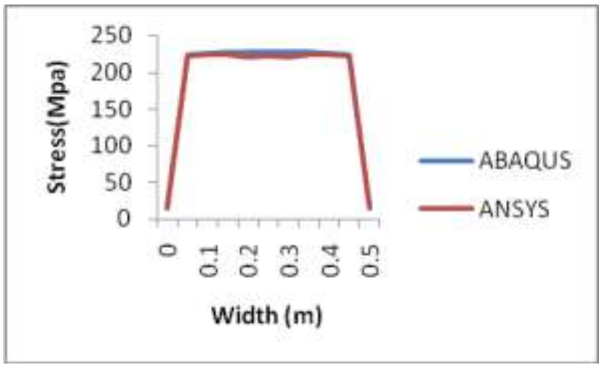

Fig 12 Stress along top edge

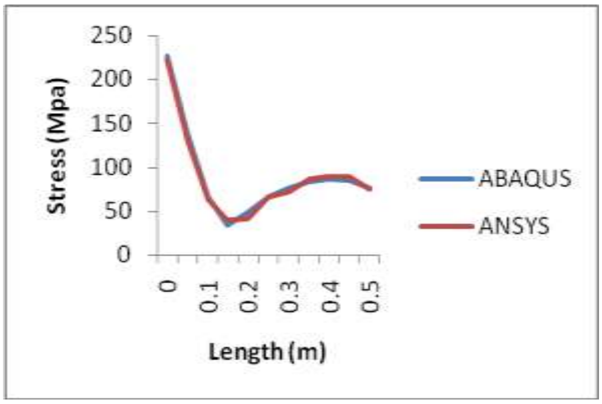

Fig 13 Stress long Y axis [all sides fixed]

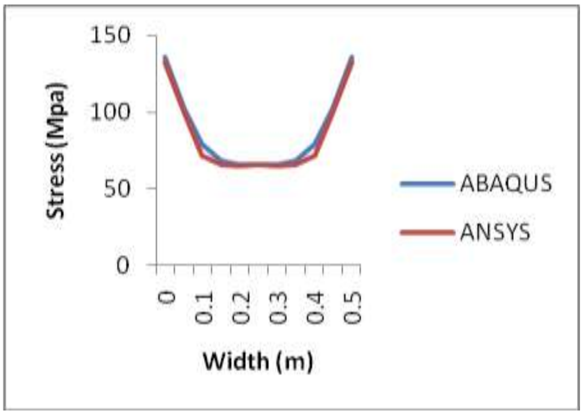

Fig 14 Stress along X axis [all sides fixed]

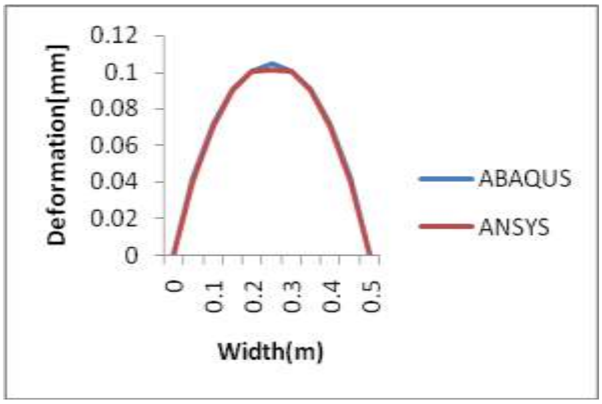

Fig 15 Deformation along X axis [all sides fixed]

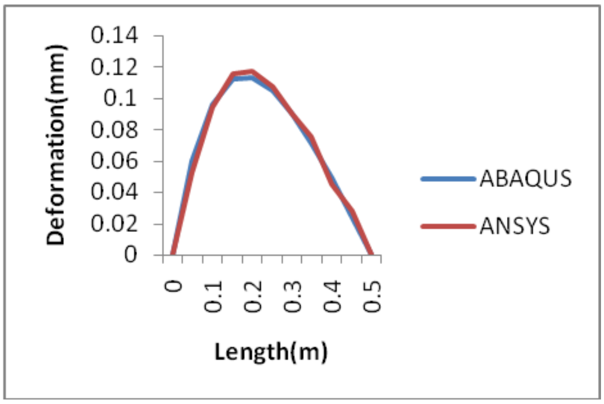

Fig 16 Deformation along Y axis [all sides fixed]

Coupled thermal displacement analysis performed on plate. In second case two opposite sides are fixed and remaining are simply supported, stress in ABAQUS and ANSYS are described in fig 17, 18, 19 and deformation described in fig 20, 21.

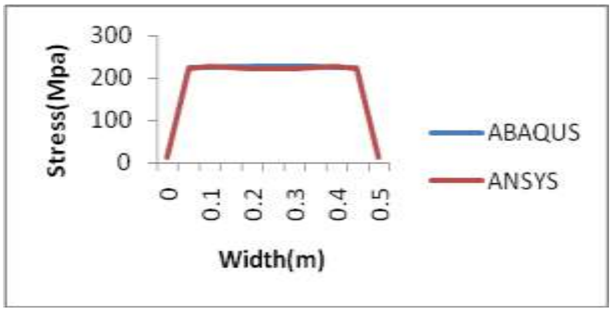

Fig 17 Stress [two sides fixed, two simply supported]

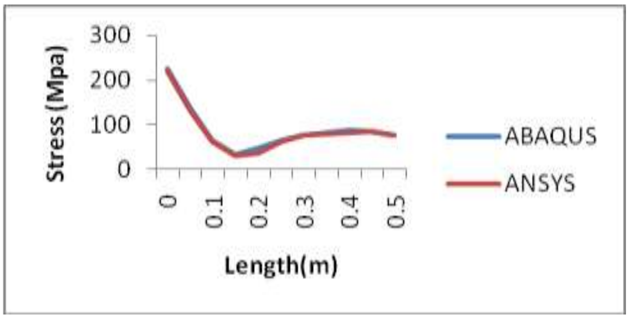

Fig 18 Stress along Y axis [two sides fixed, two simply supported]

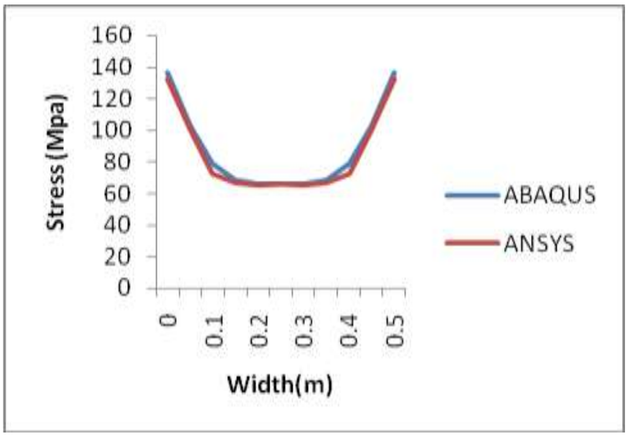

Fig 19 Stress along X axis [two sides fixed, two simply supported]

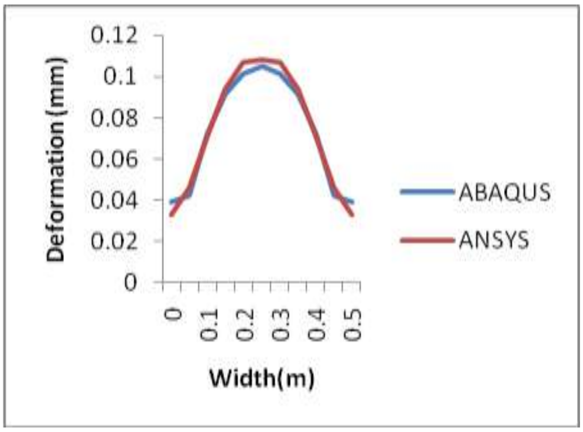

Fig 20 Deformation along X axis [two sides fixed, two simply supported]

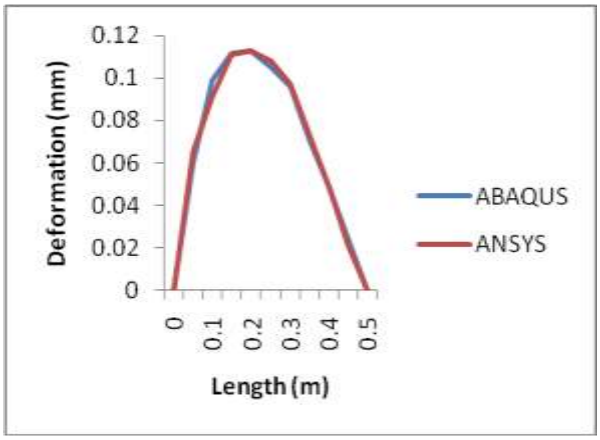

Fig 21 Deformation along Y axis [two sides fixed, two simply supported].

IV. CONCLUSION

In this study, the conventional finite element method is used and it is done by using FEM software ABAQUS, the detailed conclusions on the structural behavior of plates that can be plotted from the present study are summarized. The major advantage is changing the traditional steel design for plates. In this study, thermal and displacement analysis is performed on plate of steel material for different boundary conditions, by using ABAQUS and ANSYS software's comparison is done, structural behavior of plate is concluded as fallows,

1. In all sides of plate fixed condition, Stresses obtained in ABAQUS software and ANSYS software is almost same.
2. In all sides of plate fixed condition, Deformation in ABAQUS and ANSYS when compared are same.
3. In two opposite sides of plate fixed and remaining simply supported condition, stress and deformation in steel plate ABAQUS is almost same as ANSYS therefore it is conventional to use ABAQUS software.

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