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Effect of Element Size and Shape in Fem Analysis for Plate Element

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ABSTRACT

For the efficient design of structure it is necessary to do the exact analysis of the elements. There are several methods of analysis broadly classified into classical and approximate method classical methods give exact solution but has its own constraints like magnitude of structure & specific geometrical dimensions. To overcome this and for rapid processing approximate methods are adopted. One such method is finite element method. Even though the results are said to be approximate but with keen consideration the variance is as good as negligible. The aim of this dissertation work is to find out the factors like shape & size of elements for gaining more accurate analytical result. The work over here is done by considering a plate with various shape & size & comparative results are depicted in the observation tables. It is clear that accuracy in the result can be obtained with refined meshing and considering Triangular shape element.

1. INTRODUCTION

The finite element method provides a convenient and powerful technique for the analysis of problem of continuum mechanics. Since its original development during the early 1950's the method has been applied to a wide variety of problems with noteworthy success one of the greatest virtues of the method is its versatility the same general technique is employed in analyzing the stresses and deflection in any type of elastic continuum and both loading conditions and boundary conditions may be completely arbitrary.The general feature of the finite element analysis procedure is well known and need not be presented here in detail. Previous applications range from problems of plane stress and axially symmetric solids to the analysis of plates and shells. In addition to treatment of these two dimensional systems more limited investigations have been made with the analysis of general three dimensional solids by this technique.The essential feature of the finite element method is the means by which the differential equations of equilibrium of the elastic continuum are approximated by a set of algebraic equilibrium equations. This procedure is generally looked upon as the substitution for the actual continuum of an assemblage of discrete structural element interconnected at a finite no of nodal points. In effect the continuum may be visualized as being physically cut up into the finite element system the material properties of the original material being retained in the elements. The analysis involves as the evaluation of the element elastic properties which are represented by the stiffness matrix expressing the relationship between element nodal forces and displacements. By appropriate superposition of this element stiffness's, the stiffness matrix of the entire assemblage may be obtained. Finally the nodal force equilibrium equation expressed in terms of this structural stiffness matrix must be solved simultaneously for the nodal displacements of the complete system.

1.1. Need

The finite element method is a powerful and versatile analysis tool, but its usefulness is hampered by the need to generate a mesh, but can be very time consuming and error-prone if done manually. In recognition of this problem, a large number of methods have been devised to automate the mesh generation task. FEA is an analysis method in which a field variable is approximated by connecting simple interpolation functions, each defined over a small region. The region is called finite element. The interpolation function is adapted to the number of nodes in the element type, and amplitudes are determined by numerical values of the field quantity at specific points called nodes. Element are connected at nodes, where they share values of the field quantity (and may also share one or more of derivatives of the field quantity, depending on element type).

Nodes are also locations where loads are applied and boundary conditions are imposed. Many research works have been worked out to get solutions more near to exact solutions along with flexibility of molding calculations into computational program. And many of them knock out the success. But in spite of it, solutions we are getting are closer to exact solution and not the exact solution. Means there is a scope for more research in this direction. One question may arise in the mind "what is the need of to study finite element method when there are a number of uses friendly packages available in the market? This argument is not sound. The mathematicians continue to put the finite element method on sound theoretical ground whereas the engineers continue to find interesting extrusions in various branches of engineering ,Hence, the FE knowledge makes a good engineer better while just user without the knowledge of FE may produce more dangerous results.

2. LITERATURE REVIEW

A number of investigators have studied the effects of elements size on the accuracy of numerical results of different types of analysis and important conclusions have been drawn from previous research. Brocca and Bazant [1] presented a finite element study of the size effect of compressive failure of geometrically similar concrete columns of different sizes. It was observed from their analyses that the increasing

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elements size caused reduction in nominal strength. However, a quantitative analysis showing the relationship between the elements size and the nominal strength was still needed. Shasshikant T. More, Dr. Mrs. R. S. Bindu [2] the objective of this paper is to present guidelines for choosing optimal element size for different types of finite element analyses. In order to achieve that goal, in this study, a series of static, and buckling analyses were performed on a structure model made up of plates to reveal the effects of the element size on the accuracy of the FEA results. The solver NX-Nastran and Femap pre and post-possessor, used for modeling and analyses involved in this work. Nagsen B. Nagrale, Dr.R.N.Baxi [3]. This paper deals with, the solution of problem occurred for reciprocating screw of Injection molding machine. The main work was to model the components of machine with dimensions assemble those components and then simulate the whole assembly for rotation of the screw. The modeling software used is PRO-E wildfire 4.0 for modeling the machine components like body, movable platen, fixed platen, barrel, screw, nozzle, etc. WaiCheeMun, Ahmad Rivai, Omar Bapokutty [4] The aim of this paper is to investigate the factors influencing the selection of elements in FEA by considering the effects of different types of elements on the results of FEA. A simple case study of an I-beam subjected to an asymmetric load is carried out by FEA. Three different models of the I-beam were prepared and analyzed separately using 1D elements, 2D elements, and 3D elements. The results of these models were compared with the mathematical model of the I-beam. The FEA results of these models showed good agreement with the theoretical calculation despite the small and negligible errors in the analysis. Satish D. Watsar, Prof. Ajay Bharule [5] The main objective of this paper is for stress analysis of finite plate with special shaped cut out for stress distribution and Stress Concentration Factor (SCF). An Experimental investigation is taken to study the stress analysis of plate with special shaped cut out.The results based on Experimental analysis are compared with result obtained using finite element analysis (FEA).

3. OBSERVATION AND REMARKS

Analysis by using STADD PRO:

Case I :- Rectangular plate of size 4.5 X 3.6 m subjected to dead load & imposed load for the mesh size of 3 X 3 rectangular elements

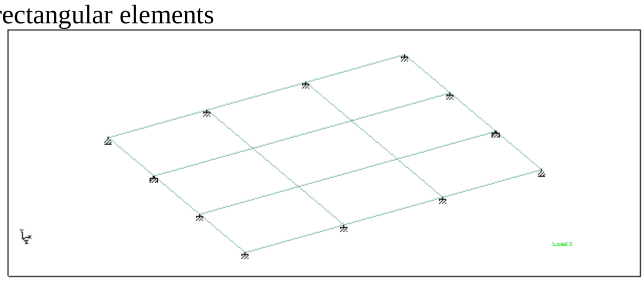


Fig No. 1. Plate fix support (3X3 Rectangular).

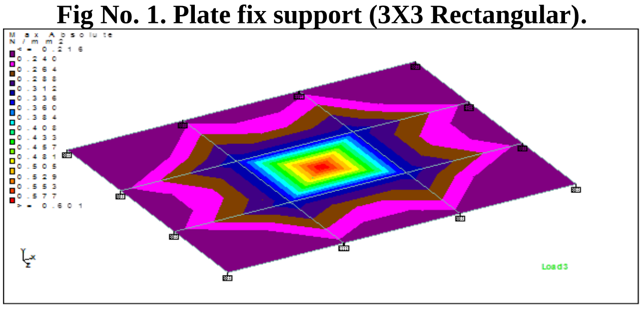


Fig No. 2 - STRESS DEVELOPMENT CONTOUR (3X3 Rectangular)

Case II :-Rectangular Plate of size 4.5 X 3.6 m subjected to dead load & imposed load for the mesh size of 3 X 3 Triangular elements.

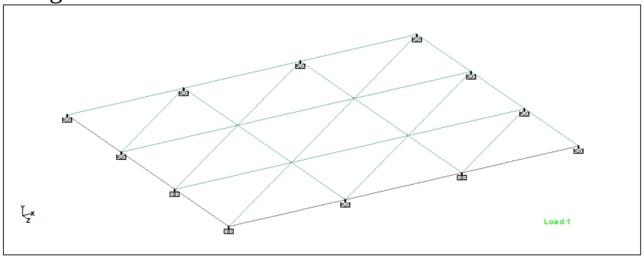


Fig No. 3. Plate fix support (3X3 Triangular).

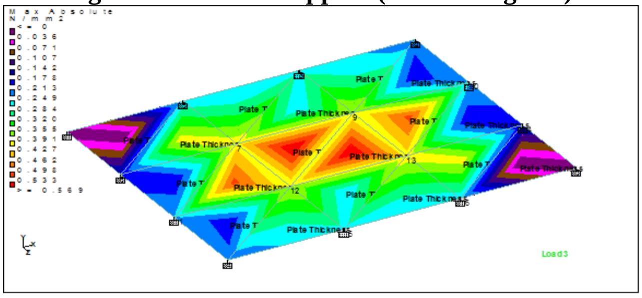


Fig No. 4. STRESS DEVELOPMENT CONTOUR (3X3 Triangular).

Case III :-Rectangular plate of size 4.5 X 3.6 m subject to dead load & imposed load for the mesh size of 6 X 6 rectangular elements.

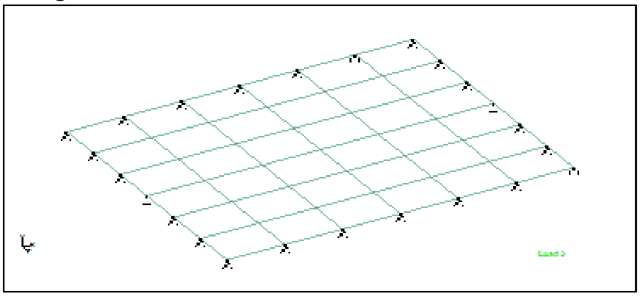


Fig No. 5. Whole Structure (6X6 Rectangular).

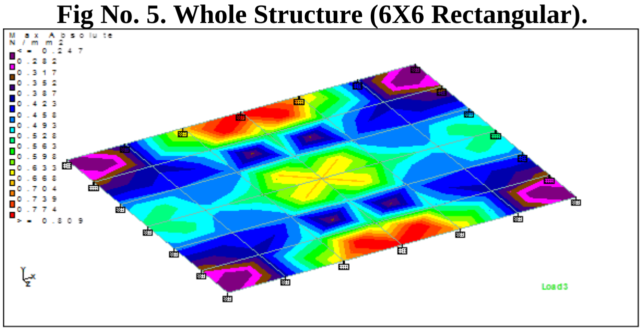
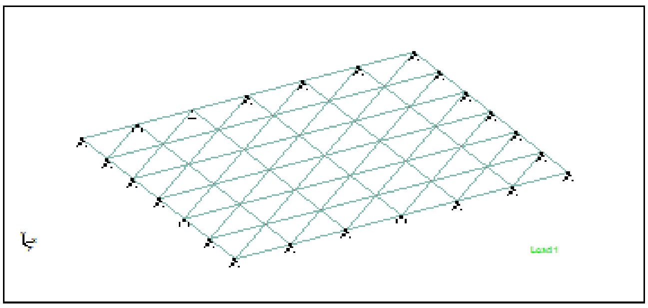


Fig No. 6. Stress Development Contour (6X6 Rectangular).

Case IV :-Rectangular plate of size 4.5 X 3.6 m subject to dead load & imposed load for the mesh size of 6 X 6 Triangular elements.



FigNo. 7. Whole Structure (6X6 Triangular).

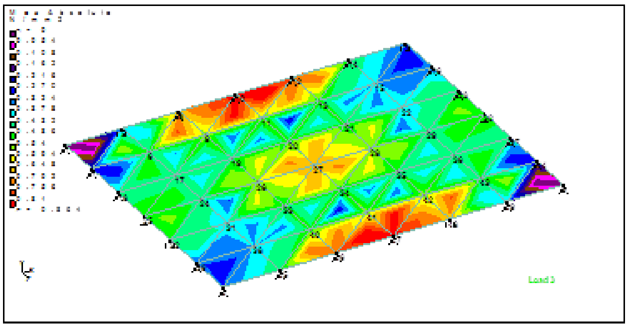


Fig No. 8. Stress Development Contour (6X6 Triangular).

Case V :-Rectangular plate of size 4.5 X 3.6 m subject to dead load & imposed load for the mesh size of 12 X 12 rectangular elements.

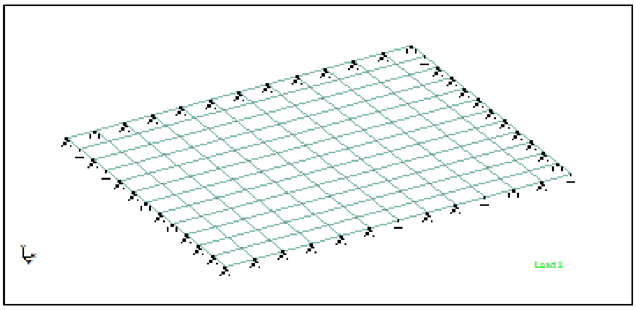


Fig No. 9. Whole Structure (12X12 Rectangular).

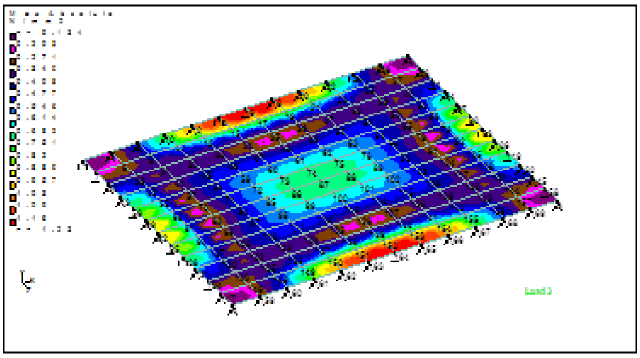


Fig No. 10. Stress Development contours (12X12 Rectangular).

Case VI :-Rectangular plate of size 4.5 X 3.6 m subject to dead load & imposed load for the mesh size of 12 X 12 triangular elements.

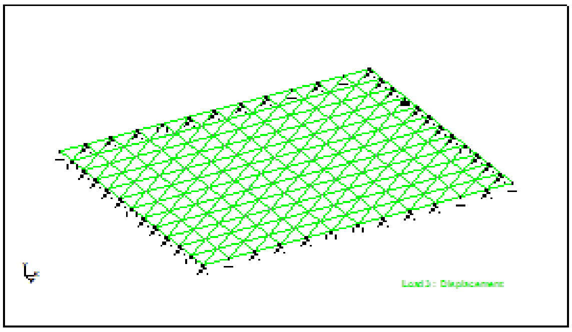


Fig No. 11. Whole Structure (12X12Triangular).

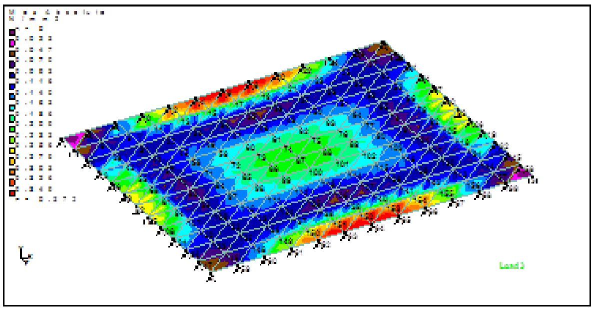


Fig. 12. Stress Development Contour(12X12Triangular).

OBSERVATIONS AND REMARK

Table 1. Along X Direction.

Case 3 x 3	**Nodal Location (m)**	**0**	**1.5**	**3**	**4.5**
Rect. Element	Row no. 1 Node displacment	0	0	0	0
Triangular Element	Row no. 1 Node displacment	0	0	0	0
Rect. Element	Row no. 2 Node displacment	0	0.234	0.234	0
Triangular Element	Row no. 2 Node displacment	0	0.354	0.321	0

Table 2. Along Z Direction.

Case 3 x 3	**Nodal Location (m)**	**0**	**1.2**	**2.4**	**3.6**
Rect. Element	Row no. 1 Node displacment	0	0	0	0
Triangular Element	Row no. 1 Node displacment	0	0	0	0
Rect. Element	Row no. 2 Node displacment	0	0.234	0.234	0
Triangular Element	Row no. 2 Node displacment	0	0.354	0.321	0

Table 3. Along X Direction.

Case 6 x 6	**Nodal Location (m)**	**0**	**0.75**	**1.5**	**2.25**	**3**	**3.75**	**4.5**
Rect. Element	Row no. 1 Node displacement	0	0	0	0	0	0	0
Triangular Element	Row no. 1 Node displacement	0	0	0	0	0	0	0
Rect. Element	Row no. 2 Node displacement	0	0.044	0.101	0.12	0.101	0.044	0
Triangular Element	Row no. 2 Node displacement	0	0.66	0.123	0.14	0.115	0.052	0
Rect. Element	Row no. 3 Node displacement	0	0.107	0.244	0.259	0.244	0.107	0
Triangular Element	Row no. 3 Node displacement	0	0.137	0.276	0.325	0.271	0.128	0
Rect. Element	Row no. 4 Node displacement	0	0.132	0.303	0.368	0.303	0.132	0
Triangular Element	Row no. 4 Node displacement	0	0.162	0.337	0.401	0.337	0.162	0

Table 4. Along Z Direction.

Case 6 x 6	**Nodal Location (m)**	**0**	**0.6**	**1.2**	**1.8**	**2.4**	**3**	**3.6**
Rect. Element	Row no. 1 Node displacment	0	0	0	0	0	0	0
Triangular Element	Row no. 1 Node displacment	0	0	0	0	0	0	0
Rect. Element	Row no. 2 Node displacment	0	0.044	0.107	0.132	0.107	0.044	0
Triangular Element	Row no. 2 Node displacment	0	0.066	0.137	0.162	0.128	0.052	0
Rect. Element	Row no. 3 Node displacment	0	0.101	0.244	0.303	0.244	0.101	0
Triangular Element	Row no. 3 Node displacment	0	0.123	0.276	0.337	0.271	0.115	0
Rect. Element	Row no. 4 Node displacment	0	0.12	0.195	0.368	0.295	0.14	0
Triangular Element	Row no. 4 Node displacment	0	0.14	0.325	0.401	0.325	0.14	0

Table 5. Plate Center Stress Development Chart.

Force		Shear Force X	Shear Force Y	Mx	MY	MXY
Case 3 x 3 Rect. Element		0.007	-0.0124	1.54	2.25	-1.39
Case 3 x 3 Tria. Element		0.04	0.002	2.132	1.39	-0.004
Case 6 x 6 Rect. Element		-0.005	0.012	2.043	3.1	-0.152
Case 6 x 6 Tria. Element		-0.008	0.007	2.471	2.154	-0.114
Case 12 x 12 Rect. Element		-0.003	0.006	1.907	2.94	-0.038
Case 12 x 12 Tria. Element		0.001	0.001			

Table 6. Along X Direction.

Case 12 x 12	Nodal Location (m)	0	0.375	0.75	1.125	1.5	1.875	2.25	2.625	3	3.375	3.75	4.125	4.5
Rect. Element	Row no. 1 Node displacment	0	0	0	0	0	0	0	0	0	0	0	0	0
Triangular Element	Row no. 1 Node displacment	0	0	0	0	0	0	0	0	0	0	0	0	0
Rect. Element	Row no. 2 Node displacment	0	0.005	0.016	0.026	0.033	0.038	0.039	0.038	0.033	0.026	0.016	0.005	0
Triangular Element	Row no. 2 Node displacment	0	0.005	0.019	0.029	0.037	0.041	0.042	0.04	0.035	0.027	0.016	0.005	0
Rect. Element	Row no. 3 Node displacment	0	0.016	0.048	0.08	0.104	0.119	0.124	0.119	0.104	0.08	0.048	0.016	0
Triangular Element	Row no. 3 Node displacment	0	0.017	0.053	0.085	0.11	0.124	0.129	0.123	0.108	0.082	0.05	0.017	0
Rect. Element	Row no. 4 Node displacment	0	0.028	0.083	0.139	0.182	0.209	0.218	0.209	0.182	0.139	0.083	0.028	0
Triangular Element	Row no. 4 Node displacment	0	0.03	0.09	0.146	0.19	0.216	0.225	0.215	0.188	0.144	0.087	0.03	0
Rect. Element	Row no. 5 Node displacment	0	0.038	0.113	0.189	0.25	0.287	0.3	0.287	0.25	0.189	0.113	0.038	0
Triangular Element	Row no. 5 Node displacment	0	0.042	0.121	0.198	0.258	0.295	0.308	0.295	0.257	0.196	0.119	0.042	0
Rect. Element	Row no. 6 Node displacment	0	0.044	0.133	0.223	0.294	0.339	0.354	0.339	0.294	0.223	0.133	0.044	0
Triangular Element	Row no. 6 Node displacment	0	0.049	0.141	0.231	0.303	0.348	0.363	0.347	0.302	0.23	0.14	0.049	0
Rect. Element	Row no. 7 Node displacment	0	0.047	0.139	0.234	0.31	0.357	0.373	0.357	0.31	0.234	0.139	0.047	0
Triangular Element	Row no. 7 Node displacment	0	0.052	0.147	0.243	0.318	0.366	0.382	0.366	0.318	0.243	0.147	0.052	0

Table 7. Along Z Direction.

Case 12 x 12	Nodal Location (m)	0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3	3.3	3.6
Rect. Element	Row no. 1 Node displacment	0	0.005	0.016	0.028	0.038	0.044	0.047	0.44	0.038	0.028	0.016	0.005	0
Triangular Element	Row no. 1 Node displacment	0	0.005	0.017	0.03	0.042	0.049	0.052	0.049	0.042	0.03	0.017	0.005	0
Rect. Element	Row no. 2 Node displacment	0	0.016	0.048	0.083	0.113	0.133	0.139	0.133	0.133	0.083	0.048	0.016	0
Triangular Element	Row no. 2 Node displacment	0	0.019	0.053	0.09	0.121	0.141	0.147	0.141	0.121	0.09	0.053	0.019	0
Rect. Element	Row no. 3 Node displacment	0	0.026	0.08	0.139	0.189	0.223	0.234	0.223	0.189	0.139	0.08	0.026	0
Triangular Element	Row no. 3 Node displacment	0	0.029	0.085	0.146	0.198	0.231	0.243	0.231	0.198	0.146	0.085	0.029	0
Rect. Element	Row no. 4 Node displacment	0	0.033	0.104	0.182	0.25	0.294	0.31	0.294	0.25	0.182	0.104	0.033	0
Triangular Element	Row no. 4 Node displacment	0	0.037	0.11	0.19	0.258	0.303	0.318	0.303	0.258	0.19	0.11	0.037	0
Rect. Element	Row no. 5 Node displacment	0	0.038	0.119	0.209	0.287	0.339	0.357	0.339	0.287	0.209	0.119	0.038	0
Triangular Element	Row no. 5 Node displacment	0	0.041	0.124	0.216	0.295	0.348	0.366	0.348	0.295	0.216	0.124	0.041	0
Rect. Element	Row no. 6 Node displacment	0	0.039	0.124	0.218	0.3	0.354	0.373	0.354	0.3	0.218	0.124	0.039	0
Triangular Element	Row no. 6 Node displacment	0	0.042	0.129	0.225	0.308	0.363	0.382	0.363	0.308	0.225	0.129	0.042	0
Rect. Element	Row no. 7 Node displacment	0	0.038	0.119	0.209	0.287	0.339	0.357	0.339	0.287	0.209	0.119	0.038	0
Triangular Element	Row no. 7 Node displacment	0	0.04	0.123	0.215	0.295	0.347	0.366	0.347	0.295	0.215	0.123	0.04	0

In each of this table the values reflects for the same mapping size but with different element shape. As in table no. 1 row no. 1 indicate support edge & edge & thus the values are zero. Row no. 2 is at a dist. of 1.2 m from considered origin. The displacement values for the same plate at same nodal location shows variations is decimal values e.g. in table no. 1 nodal row no. 2 for the location of 1.5 m the value are 0.234 & 0.354 for rectangular & triangular element resp. The similar display values are tabulated in all tables, along the x & z direction.

Then the comparison is made for the row at a dist. of 1.2 m along z direction & the nodal location at 0, 1.5, 3, 4.5 along x-direction, the values shows convergence with increase in density size e.g. for the nodal location at dist. 1.5 in table no. 1,3,5 the dispnt. Values are 0.234, 0.244 & 0.25 resp.

Similarly when the comparison for the mesh density is done consideration triangular element shape, like as in table no. 2,4 & 6 at location no. 1.5 the values are 0.354, 0.276, 0.258 resp. All these values reflect the convergence with increase in mesh density size.

When the comparison is done for same nodal location as in for eg. Table no.5 row no. 5 nodal displacements the values shows defense in decimals at distance 0.375 the values are 0.038 & 0.042 for rectangular and triangular element resp. & this is true for all nodal location.

The Table no.7 tabulates the shear force & bending moment values at the plate centre on the basis of this observation, the conclusion is drawn in next chapter.

4. CONCLUSION

For determining the effect of mesh density & element shape, the plate is analysis for various cases in this dissertation work the rectangular plate with fixed support & of 3 X 3, 6 X 6, 12 X 12 similarly the element shapes are rectangular and triangular in all cases. The observations are drawn on the basis of analysis as in chapter no. 6. From the various observation & remarks, it is clearly seen that the mapping & density plays vital role to achieve convergence.

It is seen that when the mesh density increase the nodal displacement curves gets finer shapes & get refined values.

Similarly the displacement values for triangular element depit more exact displacement as that compare to rectangular elements.

Thus from the work done in this dissertation it can be learnt that the accuracy & the convergent in finite element method is dependent upon the mesh density and element shape consideration.

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