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A Static Structural and Modal Analysis of Rectangular Plate by using ANSYS

[1] S. S. Kadam [2] Dr. G R. Gandhe [3] D. H. Tupe
Department of Civil Engineering,
Deogiri Institute of Engineering and Management Studies,
Dr. BAMU University, Aurangabad, Maharashtra, India

Abstract:-- **Finite element analysis is performed on quadrilateral rectangular plate by using finite element method based software ANSYS (version 15). And the comparison results are studied and compared out by using material properties of reinforced cement concrete and ferrocement and the appropriate loads acting on the structure and also compared with regression analysis on graphs by using static structural and modal analysis. Analysis results shows the effect of stress results with respect to their characteristics strength. Regression analysis are obtained very good agreement with the results obtained by finite element analysis based on software ANSYS- exact solutions. This job are very useful for obtaining the results are not only at node points but also the entire surfaces of the quadrilateral rectangular plate.**

Keywords: **Quadrilateral rectangular plate, Finite element method, Structural load, Static analysis, Modal analysis, Regression analysis.**

I. INTRODUCTION

In quadrilateral rectangular plates of this paper is to find the all sides of plates are fixed due to static loading. In the paper, How much deformation , von- misses stress, normal stress on X and Y directions are generated in static structural analysis and also in modal analysis how much frequency generated at the level of different modes of maximum deformation in thin rectangular plates of 4mx5m size dimensions by comparing reinforce cement concrete and ferrocement through finite element method of analysis. Thin plates because of they are higher strength to weight ratio are use in many structural design application. The act as principle load members and find variety of application ranging from stationary and moving components. These plates often subjected to static loads. These dynamic loads can be so severe that it can raise adverse conditions to such structures. Imposed loads basically results in the vibration of plates, that vibration under certain condition are causes resonance which can result in structural failure. It also result in high level of discomfort of user.

II. RELATED WORK

Khoa and Thinh (2007) are developed as a rectangular non-conforming element based on Reddy's higher order shear deformation plate theory to analyze the rectangular plates. A procedure for the reliability analysis of rectangular plate structures with large rotations but moderate deformation under random static loads was presented via a corotational total Lagrangian finite element formulation was based on the Von Karman assumption and first-order shear deformation theory [1].Zinno and Barbero (1995) developed a three-dimensional element with two-dimensional kinematic constraints for the geometric nonlinear analysis of rectangular plates using a total Lagrangian description and the principle of virtual displacements [2]. Civalek et al. (2011) presented the nonlinear static analysis of a rectangular thick plate resting on nonlinear two-parameter elastic foundation with cubic nonlinearity. They used the first-order shear deformation theory (FSDT) for rectangular plate formulation and investigated the effects of foundation and geometric parameters of plates on nonlinear deflections [3]. Dharma Raju and Suresh Kumar (2011) developed the analytical procedure to investigate the bending characteristics of anti-symmetric and rectangular plates based on a higher order shear displacement model with zig-zag function [4].

III. METHODOLOGY

Usual FEM equilibrium equations have been used in ANSYS software for analysing of the rectangular plate problems. RCC and FERROCEMENT plates of different aspect ratios and boundary conditions are modeled and analysed for comparison.

Description of element used in ANSYS Software: Validation check for selecting the proper element has been performed for SOLID186 and SURF154 has been selected for giving the most accurate results for deformation when

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compared to the results from Reinforce cement concrete with Ferrocement material also regression analysis on graphs. SHELL186 has in bending and as well as use in membrane capabilities. Both normal and in-plane loads are permitted. The element has six degrees of freedom at each node: translations in nodal x, y, and z directions and are rotations about the nodal x, y, and z-axes. Stress and large deflection are included.

IV ANALYTICAL ANALYSIS

A) Static Analysis-

Linear: Linear means straight line. 6 =ε E is equation of straight line (y = m x) passing through origin. "E" is the Elastic Modulus and is the slope of the curve & is a constant. In a real life after a crossing yield point material follows non liner curve but software follows same straight Line. Component brake into the two separate pieces are after crossing ultimate stress but this software based analysis never shows the failure in this fashion. It shows single unbroken part with red colour zone at the location of failure. Analyst has to concluded whether these component is safe or failed by comparing the maximum stress value with the yield or ultimate stress.

Static: There are two conditions for static analysis

1) Force is static i.e. no variation with respect to time (dead weight).2) Equilibrium condition - 1 forces (Fx, Fy, Fz) and 1 Moments (Mx, My, Mz) = O. FE model fulfils this condition at each and every node. For complete model summation of external forces and moment is equal to reaction forces and moments as well as to found out the (6x,6y,6v, & w) normal stresses on X & Y axis, Von-misses stress and deflection.

Practical Applications: Most commonly used analysis. All Aerospace, Automobile as well as Offshore and also in Civil engineering industries perform linear static analysis.
Commonly used softwares: Nastran, Ansys, Abaqus, i- deas NX, Radioss, Cosmos, UG, Pro- Mechanica, Catia etc.

B) Modal Analysis-

In modal analysis the material of the plate is elastic, homogeneous and isotropic in nature. The plate is initially flat. The deflection of the mid plane of the plate is small as compared to its thickness. The straight line initially perpendicular to the mid plane of the plate will remain perpendicular even after bending of the plate. Normal component of the stress will be assumed small as compared to other component. Material properties are shown in following:

1)For RCC: E=2738Mpa; γ=0.2; ρ=2400Kg/m2; fck=30N/mm2; Ordinary mild steel=130N/mm2; High yield strength steel=190N/mm2

2)For Ferrocement: E=2738Mpa; γ=0.3; ρ=2000Kg/m2; fck=30N/mm2; 1/2" square welded mesh=0.235Kg/m2; 1" stucco wire=0.100Kg/m2; 1" chicken wire=0.190Kg/m2;1/2" chicken wire=0.126Kg/m2
Wire diameter=1mm; size of mesh=20mm.

V. RESULTS AND DISCUSSION

A) Static analysis For RCC

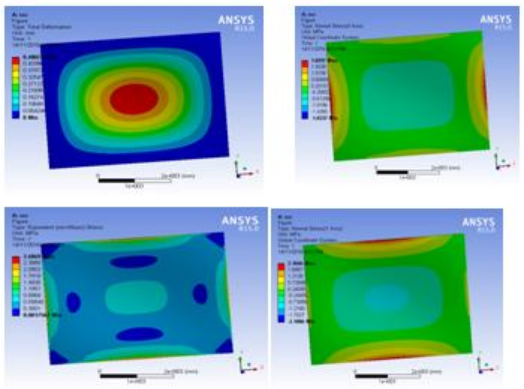
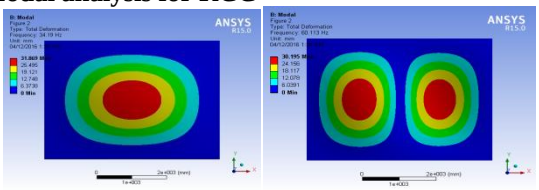


Fig. 1 shows the total deformation on RCC rectangular plate that is 0.48821mm, Fig. 2 shows the Equi. Stress (Von-misses stress) means the principal stress that is 2.6869Mpa, And Fig. 3 and Fig. 4 are shows the normal stresses on X-axis and Y-axis, that is 1.8297Mpa, 2.1846Mpa respectively. This results shows the static analysis for reinforce cement concrete.

B) Modal analysis for RCC



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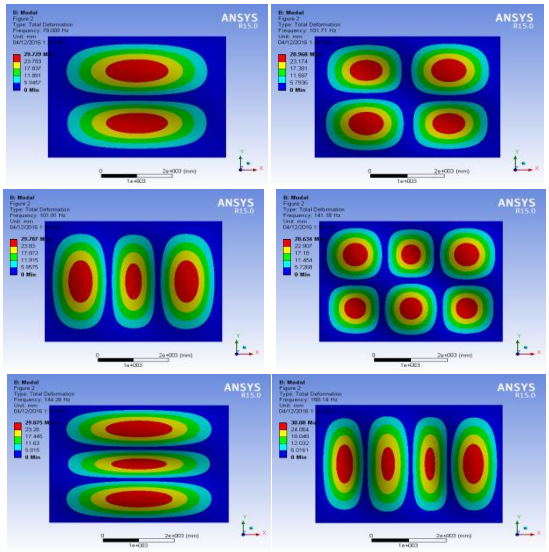


These all figures are 8 mode shapes of the rectangular RCC plate. Which are located to how many frequency generated on RCC plate and how many deflection at each mode shape or each node point of the RCC plate.

C) Static analysis of Ferrocement plate

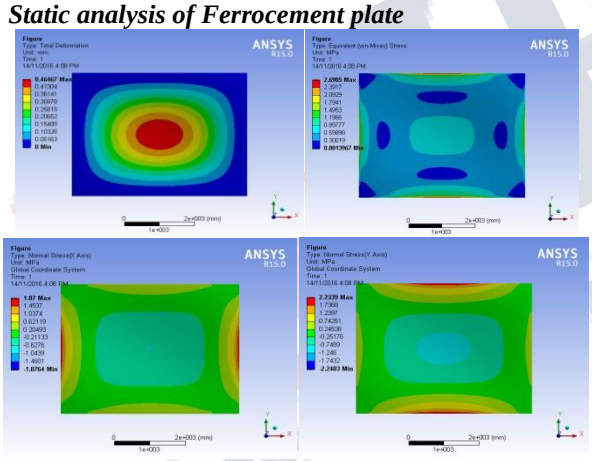
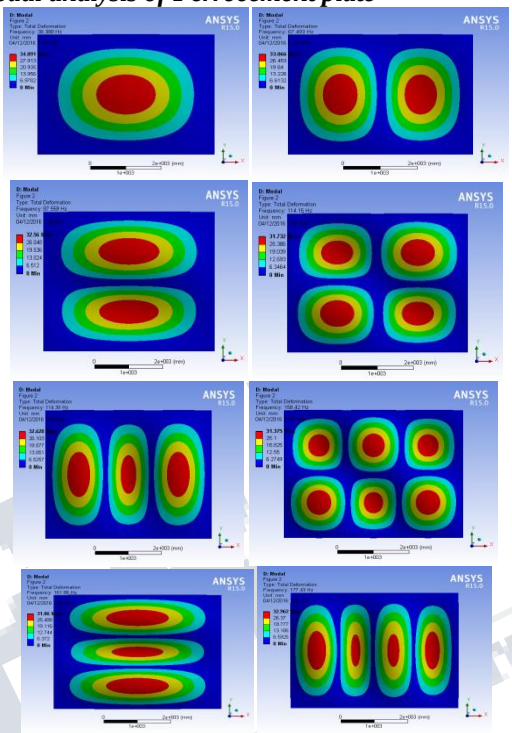
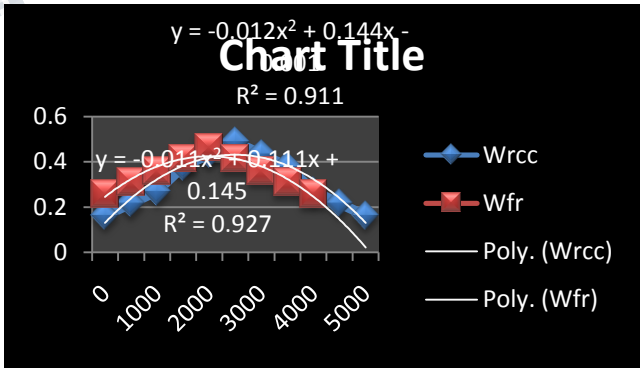


Fig. 1 shows the total deformation on RCC rectangular plate that is 0.46467mm, Fig. 2 shows the Equi. Stress (Von-misses stress) means the principal stress that is 2.6905Mpa, And Fig. 3 and Fig. 4 are shows the normal stresses on X-axis and Y-axis, that is 1.87Mpa, 2.2339Mpa respectively. This results shows the static analysis for Ferrocement.

D) Modal analysis of Ferrocement plate



These all figures are 8 mode shapes of the rectangular Ferrocement plate. Which are located to how many frequency generated on Ferrocement plate and how many deflection at each mode shape or each node point of the Ferrocement plate.



This graph represent the difference between total deformation on RCC and Ferrocement Rectangular plate using static analysis. And on graph these equations are shown this is the regression analysis of parabolic curve.

Table 1. Comparison by T.D of RCC & Ferrocement for static analysis and regression analysis

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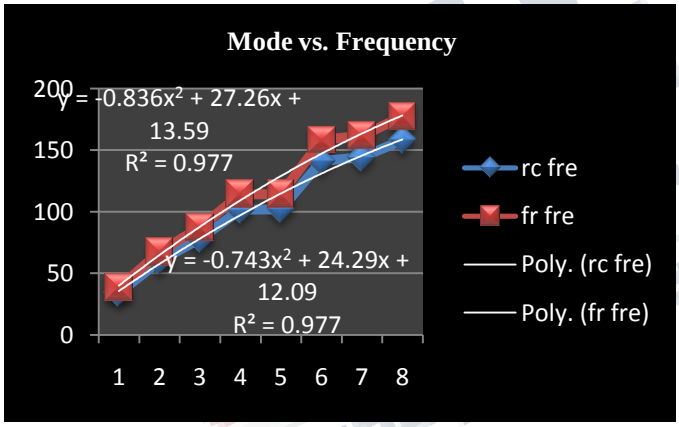
A	W_{RCC} by Ansys	W_{RCC} by regression	W_{FR} by Ansys	W_{FR} by regression
500	0.48821	0.4929	0.46467	0.4663
1000	0.43396	0.4004	0.41304	0.4163
1500	0.37972	0.3129	0.36141	0.3663
2000	0.27123	0.2304	0.30978	0.3163
2500	0.21698	0.1529	0.25815	0.2663
3000	0.16274	0.0804	0.20652	0.2163
3500	0.10849	0.0129	0.15489	0.1663
4000	0.054245	-0.0496	0.10326	0.1163
4500	0	-0.1071	0.05163	0.0663
5000	0	-0.1596	0	0.0163

Representing this table shows the value of total deformation of RCC and Ferrocement plate by ANSYS comparing with regression analysis by appropriate results.



This graph shows the difference between Mode vs Frequency to locate at each mode shape how many frequency generated on RCC & Ferrocement plate.

Table 2. Comparison by Frequency of RCC & Ferrocement for modal analysis and regression analysis

Mode	RC Freq. by ansys	RC Freq. by regression	FR Freq. by ansys	FR Freq. by regression
1	34.19	35.64	38.388	40.023
2	60.113	57.703	67.493	64.780
3	78.009	78.27	87.559	87.863
4	101.71	97.362	114.15	109.273
5	101.91	114.96	114.39	129.010
6	141.18	131.070	158.42	147.073
7	144.28	145.692	161.86	163.463
8	158.14	158.827	177.43	178.180

Representing this table shows the value of Frequency of RCC and Ferrocement plate by ANSYS comparing with regression analysis by appropriate results.

VI. CONCLUSION

In this study, The finite element analysis of static structural analysis were performed for all sides of fixed quadrilateral rectangular plate of reinforce cement concrete with ferrocement material. Some of main conclusion as follow.

- The total deformation of RCC plate is higher than the ferrocement plate by static structural analysis and also by regression analysis.
- The total deformation of RCC plate is less than the ferrocement plate by modal (Vibrational) analysis and also by regression analysis.
- The higher frequency found in ferrocement plate is 177.43Hz by ANSYS and 178.180Hz by regression analysis as compared to the RCC plate is 158.14Hz by ANSYS and 158.827Hz by regression analysis.
- It means that to shows overall results to be concluded that the ferrocement rectangular plate is better than RCC rectangular plate. Because, to produce minimum total deformation as well as ,minimum cost, less labour are required.

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