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Advanced Modeling and Analysis of Plate and Inverted Umbrella Roof Shell Using Ansys

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Abstract: ***In this objective paper a inverted umbrella roof shell and all sides fixed rectangular plate are designing and modeling for the static analysis in ANSYS Workbench (15) using finite element method. The finite element analysis is carried by using total deformation and normal stresses in longitudinal direction and on X and Y plane to determine respectively. Response of umbrella roof shell as well as rectangular plate subjected to uniformly distributed loads. Both results are linear and quadratic variation of the membrane displacements in the inverted direction are investigated and it is the found out by the quadratic variation is far superior. The effect of the large deformations is incorporated in that the present static analysis by including the first order normal stresses on X and Y plane. This present work material behavior is assumed to be isotropic elastic-plastic. Analytical investigations of the method are carried out by modeling and designing inverted umbrella roof shell and rectangular plate subjected to self weight or pressure load. These investigations compare the results for laterally loaded inverted umbrella roof shells with fixed all sides of rectangular plate with analytical and regression analysis on graphs results, by using two different materials like RCC and Ferrocement. The results how that employing less deformation generated in ferrocement as compared to RCC and also roof shell is better strength as compared to plate roof to yield engineering accuracy for design purposes.***

Keywords: Inverted umbrella roof shell, Hyperbolic Paraboloid, Finite Element Analysis, Static Structural analysis, Regression Analysis

1. Introduction

In this paper rectangular plate are only basic comparative study by HP shell. Shell are forms which becoming increasingly popular today are not the new type of the construction. The hyperbolic paraboloid of inverted umbrella roof shell is an infinite surface in three dimensions with the hyperbolic and parabolic cross-sections. Hyperbolic paraboloid shell roofs will be the especially useful of areas subject to earth quakes. There are different types of hyperbolic paraboloid shell roofs are include umbrella roof, inverted umbrella roof ,saddle-type hyperbolic paraboloid shell roof, gabled hyperbolic paraboloid shell roof, hipped hyperbolic paraboloid shell roof etc. That one doubly curved shell that cuts costs through easier forming is the hyperbolic paraboloid. The use of the reinforced concrete in the hyperbolic paraboloid offers that the same advantages inherent to all the shells of this material such as lightness, incombustibility, economy of materials, security against impact, and the little sensitiveness to foundation settlement. The Shells of this type have been used for the entrance canopies, churches, footings, warehouses roofs, gas stations, dwellings, factories, bowling lanes, and many other buildings. That is the simple beauty and many advantages of the hyperbolic paraboloid mark. it as the structure which will be progressively utilized in the future. The inverted umbrella roof shell benefits construction because of its the straight line generators. The membrane theory for this inverted umbrella roof shell predicted that the convex parabolas would be in the compression while the concave parabolas would be in the tension of an equal magnitude. In this membrane analysis, it is assumed that the inverted umbrella roof shell carry loads by in –plane stress resultants and the usually only deep doubly curved shells behave like a membranes. Thus, this type of shape would be the desirable since it would be less deformation than a form of a single curvature. In this paper the behaviour of a saddle type Inverted umbrella roof shell under increasing live load is studied using ANSYS Workbench (15) software

2. Problem Description

Modeling and Finite Element Analysis

Figure 1: Geometry of rectangular plate

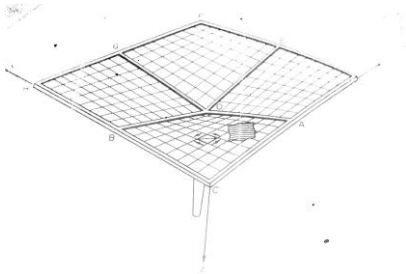

Figure 2: Geometry of Inverted Umbrella Roof Shell

In this paper above Fig.1 and Fig.2 shows the geometry of rectangular plate and inverted umbrella roof shell respectively.

In the project work comparison of the inverted umbrella roof shell and quadrilateral rectangular plate by using two different materials like reinforce cement concrete and ferrocement. Those results are found out by deformation and normal stresses on X and Y plane and those results are compared by using static analysis in ANSYS workbench (15).

Table 1: Material Configuration Data

Properties	RCC	Ferrocement
Young's modulus	27386Mpa	79056Mpa
Density	2400Kg/m^3	2000Kg/m^3
Tensile ultimate strength	30Mpa	250Mpa
Poisson's ratio	0.2	0.3
Ordinary mild steel	130 N/mm^2	
High yield strength steel	190 N/mm^2	
½" Sq. welded mesh		0.235Kg/m^2
1" Stucco wire		0.10Kg/m^2
1" Chicken wire		0.190Kg/m^2
1mm size of mesh		20mm

In this paper ANSYS software used based on finite element method. Results compared by static analysis with regression analysis on graph equation.

3. Analysis

Finite Element Analysis

Finite element analysis (FEA) has become a common place of in recent years, and the now basis of a multibillion dollar per year industry. Numerical solutions of even very complicated stress problems can now be the obtained routinely using FEA, and the method is so far important that even the introductory treatments of Mechanics of the Materials such as these modules should outline its the principal features.

Ansys

ANSYS is the software based on finite element method as well as commercial packages of the compatibilities ranging from a linear, static, simple, modal analysis to complex, non linear, dynamic analysis. In ANSYS each module is applicable in particular problem. For the example; Ansys/civil, for any type of a structure to analyse in ANSYS as well as Workbench. Various softwares are use for analyse the various structure and tools like, CFD, CAD,STAAD,ABACUS etc;

Static Analysis

In static analysis by using ANSYS software the results found out the deformation, Normal stresses on X and Y plane for quadrilateral rectangular plate and inverted umbrella roof shell that is the HP shell means hyperbolic paraboloid shell roof.

Regression analysis

In regression analysis the results found by using static analysis results on plotted graph obtain the parabolic curve and in parabolic curve to obtain the equation in equation to found out by the static results nearly equal or less than one or equal to one value of R^2.

4. Results

A] Static Analysis for RCC

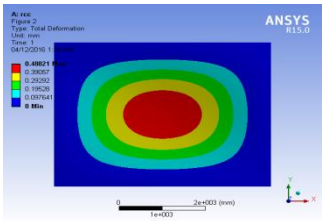

Figure 3: Total deformation of RCC plate

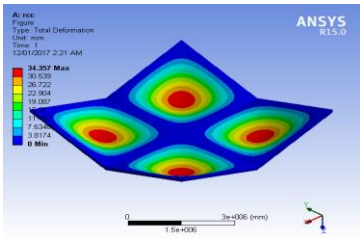

Figure 4: Total deformation of RCC inverted umbrella roof shell

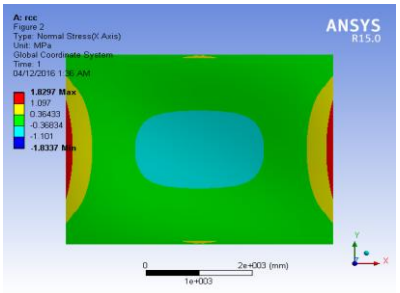

Figure 5: Normal stress on X for plate

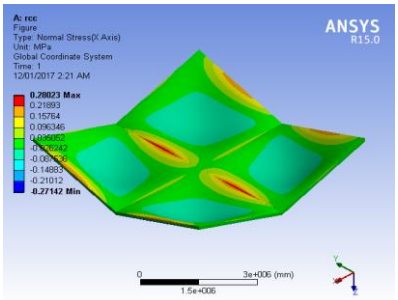

Figure 6: Normal stress on X for inverted umbrella roof shell

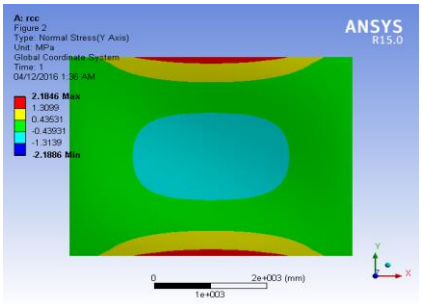

Figure 7: Normal stress on Y for plate

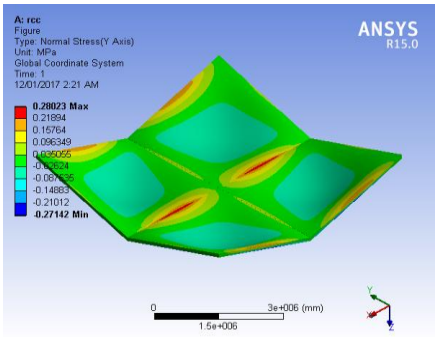

Figure 8: Normal stress on Y for inverted umbrella roof shell

B] Static Analysis for Ferrocement

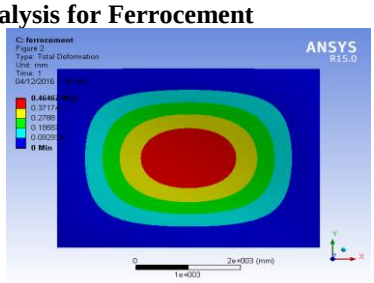

Figure 9: Total deformation of Ferrocement plate

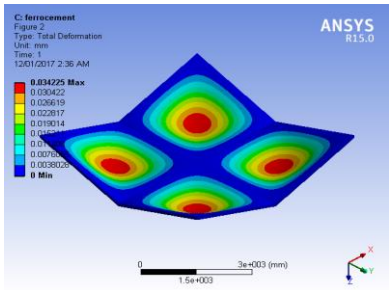

Figure 10: Total deformation of Ferrocement inverted umbrella roof shell

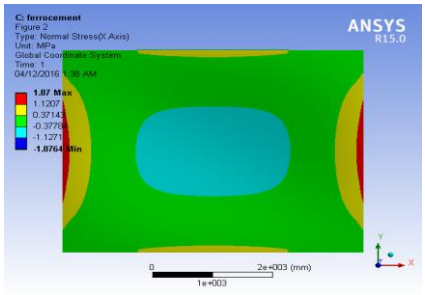

Figure 11: Normal stress on X for plate

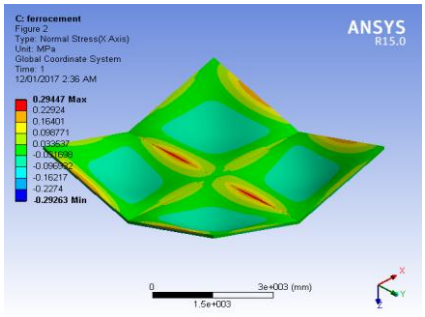

Figure 12: Normal stress on X for inverted umbrella roof shell

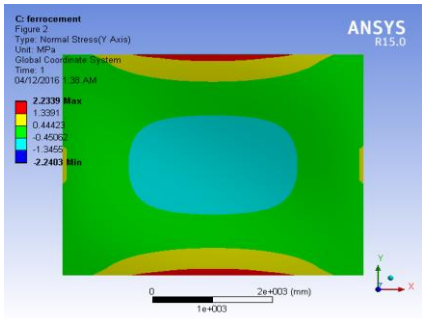

Figure 13: Normal stress on Y for plate

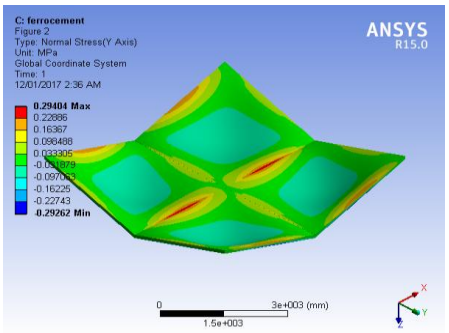

Figure 14: Normal stress on Y for inverted umbrella roof shell

For RCC Fig.3 and Fig.4 are shown result the total deformation of RCC that is, 0.48821mm and 34.357mm for plate and inverted umbrella roof shell respectively. Fig.5, Fig.6, Fig.7 and Fig.8 are shown result the Normal stresses on X and Y plane of RCC that is, 1.8297Mpa, 0.28023Mpa, 2.1846Mpa and 0.28023Mpa for plate and inverted umbrella roof shell respectively.

For Ferrocement Fig.9 and Fig.10 are shown result the Total deformation of Ferrocement that is, 0.46467mm and 0.034225mm for plate and inverted umbrella roof shell respectively. Fig.11, Fig.12, Fig.13 and Fig.14 are shown result the Normal stresses on X and Y plane of Ferrocement that is, 1.87Mpa, 0.29447Mpa, 2.2339Mpa and 0.29404Mpa for plate and inverted umbrella roof shell respectively.

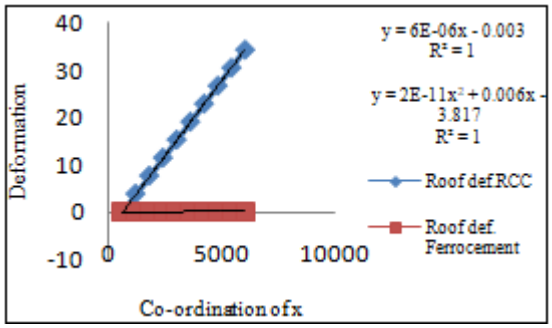

Figure 15: Variation of total deformation for inverted umbrella roof

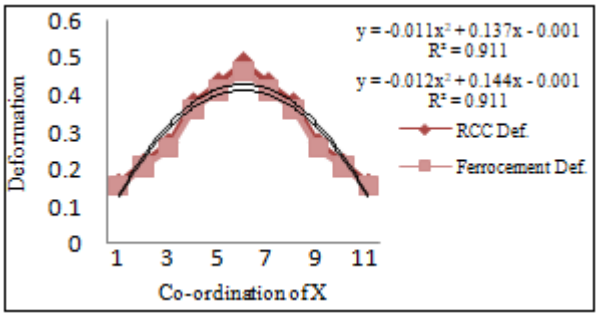

Figure 16: Variation of Total deformation for plate

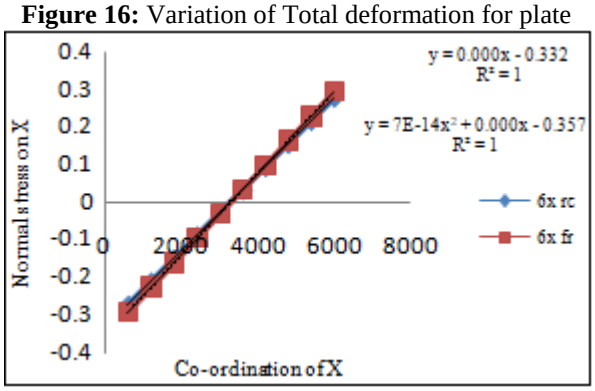

Figure 17: Variation of Normal stress on X for inverted umbrella roof shell

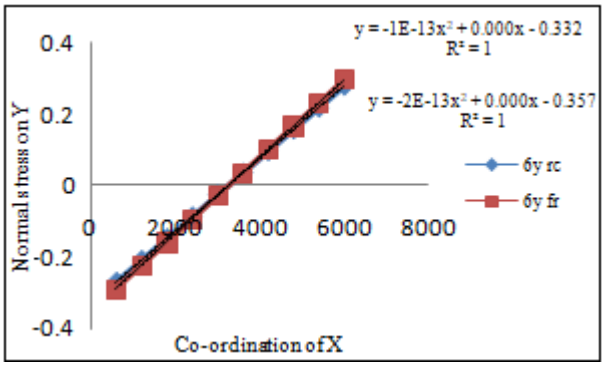

Figure 18: Variation of Normal stress on Y for inverted umbrella roof shell

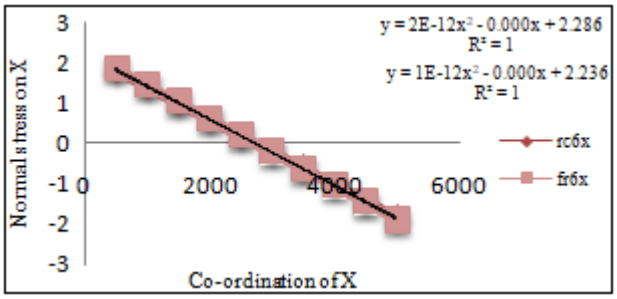

Figure 19: Variation of Normal stress on X for plate

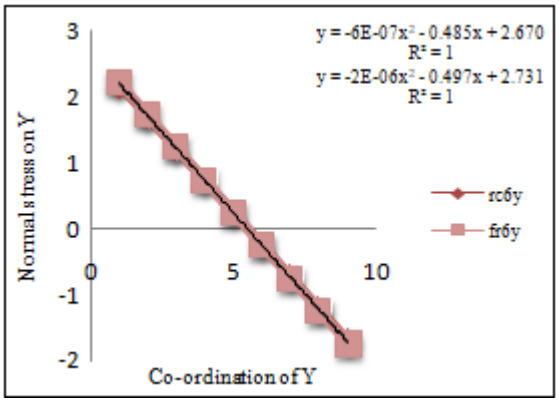

Figure 20: Variation of Normal stress on Y for plate

Table 2: Comparison by Total def. of RCC and Ferrocement for static and regression analysis of inverted umbrella roof shell

X	Total def. RCC ANSYS	Total def. RCC Reg.	Total def. Ferro. ANSYS	Total def. Ferro. Reg.
600	0	0	0	0
1200	3.8174	3.3830	0.003803	0.0042
1800	7.6348	6.9830	0.007606	0.0078
2400	11.452	10.5831	0.011408	0.0114
3000	15.27	14.1831	0.015211	0.015
3600	19.087	17.7832	0.019014	0.0186
4200	22.904	21.3833	0.022817	0.0222
4800	26.722	24.9834	0.026619	0.0258
5400	30.539	28.5835	0.030422	0.0294
6000	34.357	32.1837	0.034225	0.033

Table3 Comparison by Total def. of RCC and Ferrocement For static analysis Regression analysis of plate

X	Total def. RCC ANSYS	Total def. RCC Reg.	Total def. Ferro. ANSYS	Total def. Ferro. Reg.
0.5	0.16274	0.068	0.15489	0.064
1	0.21698	0.131	0.20652	0.125
1.5	0.27123	0.188	0.25815	0.179
2	0.37972	0.239	0.36141	0.229
2.5	0.43396	0.289	0.41304	0.272
3	0.48821	0.323	0.46467	0.311
3.5	0.43396	0.356	0.41304	0.343
4	0.37972	0.383	0.36141	0.371
4.5	0.27123	0.404	0.25815	0.392
5	0.21698	0.419	0.20652	0.409
5.5	0.16274	0.428	0.15489	0.419

Table 4: Comparison by Normal stress on X plane of RCC and Ferrocement for static and Regression analysis of inverted umbrella roof shell

X	Ns RCC ANSYS	Ns RCC Reg.	Ns Ferro. ANSYS	Ns Ferro. Reg.
600	-0.2714	-0.2727	-0.2926	-0.2969
1200	-0.2101	-0.2127	-0.2274	-0.2369
1800	-0.1488	-0.1527	-0.1621	-0.1769
2400	-0.0875	-0.0927	-0.0969	-0.1169
3000	-0.0262	-0.0327	-0.0317	-0.0569
3600	0.0350	0.0273	0.0335	0.0300
4200	0.0963	0.0873	0.0987	0.0630
4800	0.1576	0.1473	0.1640	0.1230
5400	0.2189	0.2073	0.2292	0.1830
6000	0.2802	0.2673	0.2944	0.2430

Table 5: Comparison by Normal stress on Y plane of RCC Ferrocement for static and regression analysis of inverted umbrella roof shell

X	Ns RCC ANSYS	Ns RCC Reg.	Ns Ferro. ANSYS	Ns Ferro. Reg.
600	-0.27142	-0.3320	-0.29262	-0.2970
1200	-0.21012	-0.2120	-0.22743	-0.2370
1800	-0.14883	-0.1520	-0.16225	-0.1770
2400	-0.08754	-0.0920	-0.09706	-0.1170
3000	-0.02624	-0.0320	-0.03188	-0.0570
3600	0.035055	0.0279	0.033305	0.0299
4200	0.096349	0.0879	0.098488	0.0629
4800	0.15764	0.1479	0.16367	0.1229
5400	0.21894	0.2079	0.22886	0.1829
6000	0.28023	0.2679	0.29404	0.2429

Table 6: Comparison by Normal stress on X plane of RCC and Ferrocement for static and regression analysis of plate

X	Ns RCC ANSYS	Ns RCC Reg.	Ns Ferro. ANSYS	Ns Ferro. Reg.
500	1.8297	1.8367	1.87	1.88
1000	1.4226	1.4367	1.4537	1.4862
1500	1.0156	1.0367	1.0374	1.0862
2000	0.6085	0.6367	0.62119	0.6862
2500	0.2015	0.2367	0.20493	0.2862
3000	-0.2055	-0.1632	-0.21133	-0.1137
3500	-0.61256	-0.5632	-0.6276	-0.5137
4000	-1.0196	-0.9632	-1.0439	-0.9137
4500	-1.4266	-1.3632	-1.4601	-1.3137
5000	-1.8337	-1.7632	-1.8764	-1.7137

Table 7: Comparison by Normal stress on Y plane of RCC and Ferrocement for static and regression analysis of plate

X	Ns RCC ANSYS	Ns RCC Reg.	Ns Ferro. ANSYS	Ns Ferro. Reg.
0	2.1846	2.1846	2.2339	2.2339
500	1.6987	1.6845	1.7368	1.7338
1000	1.2128	1.1845	1.2397	1.2338
1500	0.7268	0.6845	0.74251	0.7338
2000	0.2409	0.1845	0.24538	0.2338
2500	-0.2449	-0.3154	-0.25176	-0.2661
3000	-0.7308	-0.8154	-0.7489	-0.7661
3500	-1.2168	-1.3154	-1.246	-1.2661
4000	-1.7027	-1.8154	-1.7432	-1.7662

Above Fig.15 and Fig.16 are shown the results of Total deformation of plate and inverted umbrella roof shell in static analysis using RCC and Ferrocement. In graphs two equation are found out by parabolic curve shown on equation to found out the nearly equal to value of total deformation of plate and umbrella roof are shown in Table2 and Table3 are called as Regression analysis

Fig.17, Fig.18, Fig.19 and Fig.20 are shown the results of Normal stress on X and Y plane of plate and inverted umbrella roof shell in static analysis using RCC and Ferrocement. In graphs two equation found by parabolic curve shown on equation to found out the nearly equal to value of Normal stress of plate and umbrella roof are shown in Table4, Table5, Table6 and Table7 respectively are called as regression analysis.

5. Conclusions

In this paper to shows the comparison of inverted umbrella roof shell with quadrilateral rectangular plate by using two different material like Reinforcement and Ferrocement. Finite element method based software ANSYS are used in this paper.

In inverted umbrella roof shell Total deformation is 34.357mm in RCC and 0.003422mm in Ferrocement, it means that the Ferrocement material is less deformation generate in static analysis as compare to RCC and also in regression analysis 32.1837mm for RCC and 0.033mm for Ferrocement is nearly equal to static in ANSYS.

In quadrilateral rectangular plate Total deformation is0.48821mm in RCC and 0.46467mm in Ferrocement, it means that the also for plate Ferrocement material is less as compare to RCC and in regression analysis 0.323mm for RCC and 0.311mm for Ferrocement.

Overall, in case of analysis is to shows the Ferrocement material is better as compare to RCC, Also in future better use to activate and also in this paper to shows the comparison of plate and umbrella roof to shows the shell is better strength compared to plate roof to better activate and shell also generate significant stresses.

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