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Analysis of Parabolic Shell by Different Models Using Software: SAP 2000

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ABSTRACT

The shell structure consists of a thin reinforced concrete shell without the use of internal columns to create an internal opening., parabolic or spherical cross section. On the other hand, warehouses and playgrounds are conventional concrete frame structures, on the other hand, they can be difficult to design as the exact shape required for the stability of the structure depends on the material used, the dimensions of the enclosure, external or internal loads and other chamfers.. .. Thus, by changing the shell parameter, the performance of the shell will also change. The main goal of this work is to parametrically analyze different designs of cylindrical shells of different lengths in order to analyze two different lengths of taken cylindrical shells, and then change two parameters, first the radius and then the thickness, based on the radii. and the difference in thickness for the same width, length and material of the frame, we will evaluate the behavior of the frame for different models.

KEYWORDS: *Multiple cylindrical shells, Analysis, Different Parameter, shell structures, parametric analysis Transient dynamics analysis, Time-History Analysis, modeling, analysis, design, and reporting*

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INTRODUCTION

Concrete circular cylindrical shells have been widely used for roofing large column-free areas and have been constructed in various countries for almost half a century. From architectural and functional points of view, shells have their applicability as roofing units in many of the public buildings. These roofs are used where full-size floor areas are required to be covered without obstruction from columns. There are many situations where skew shells are required to cover rather than the plot area having unsymmetrical plot size, inclined corridors verandas, etc. connecting the straight areas are such common situations. Due to architectural and structural point of view it is required to use skew shell in so many situations. some time it is essential to used in ships, sub marines, etc.

The objectives of the present work are:
- To study the behavior of the parabolic cylindrical shell subjected to Dynamic loading conditions.
- Comparison between the behaviors of straight parabolic cylindrical shell vs. skewed parabolic cylindrical shell.
- To conduct parametric studies on such parabolic cylindrical shell roofs having different rises, thicknesses and Skew Angle of shells.
- Plotting the graphs and tables on the behavior of shell (moment, stress, strain, deflection), which will provide the ready to use data for practicing engineers planning to use such type of shells.

SOFTWARE USED

Among the features introduced by the analysis of SAP2000 are modal examination, static and dynamic analysis, linear and nonlinear analysis, and easy analysis. The investigative modeling used in this software is the member type model which means that beams or columns are model using single fundamentals. The layered shell modeling can be possible in SAP2000 which permit any number of layers to be defined in the thickness direction, each with an independent position, thickness, behavior, and material. Material behavior may be non linear. The hysteretic response of the concentrated plasticity at ends of a member can be described by a moment curvature association. SAP2000 can specify for each material one or more stress-strain curves that are used to produce nonlinear hinge properties in frame elements. The different curves can be used for different parts of a frame cross section. For steel and other metal materials, SAP2000 usually only specify one stress-strain curve. A multiplicity of cross sections are available in SAP2000 element library. These sections include rectangular sections as used for modeling the beams and columns of the **Reinforced concrete** (**RC**) buildings. SAP2000 provides the tools required for easy target analysis as material nonlinearity at discrete, user-defined hinges in frame elements. The hinge properties are created based on easy target analysis regulations found in performance-based procedure. Default hinge properties are provided based on FEMA- 356 criteria. Display capabilities in the graphical user interface to generate and plot easy target curves, including demand and capacity curves in spectral ordinates. Capabilities in the graphical user interface to plot and get information regarding the state of every hinge formed at each step in the easy target analysis.

PROPOSED METHODOLOGY:

For this proposed work single bay cylindrical shell roof having Span 10 m, Length 18 m (i.e. plan area 10m X 18m), rise are 1.5, 2.25 & 3m and Thickness 200,150 & 100 mm with Edge beam 0.300m X. 8m taken. Different Models are studied (for dead load, live load and time history analyses) with variation in rise, thickness & skew angle by using SAP-2000. The results of shells are presented in the form of tables and graphs.

METHODOLOGY:

- Finite element method has been used for the numerical analysis.
- Shell is discretised by 9 noded Quadrilateral elements.
- Sap software has been used for analysis.
- Study of Variation in skew angle has been done keeping rise & thickness constant.
- Study of Variation in rise has been done keeping skew angle & thickness constant.
- Study of Variation in thickness has been done keeping skew angle & rise constant.

MODELING

For the analysis of multiple cylindrical shell following dimension are considered which is tabulated in table In the current study main goal is parametric analysis of the shell structure. Following results are formed and compare the results for different models.

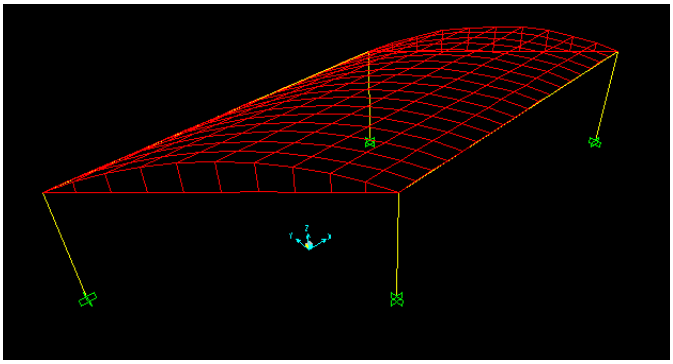


Fig 1.1 Isometric view of skewed parabolic cylindrical shell structure

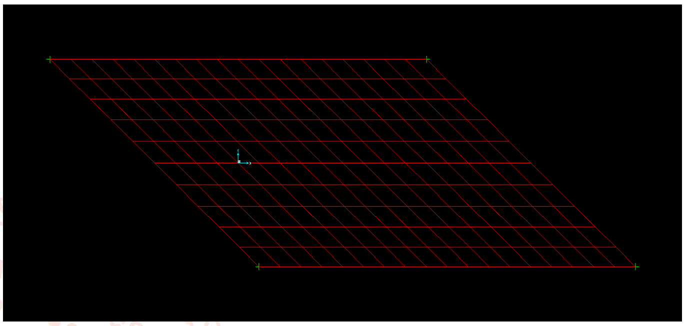


Fig 1.2 Top view of skewed parabolic cylindrical shell structure

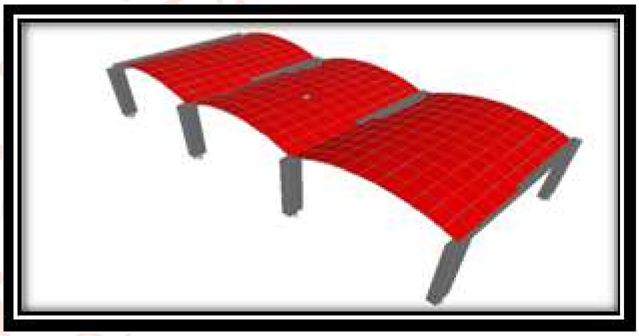


Fig.1.3- model of multi-bay cylindrical shell Structure

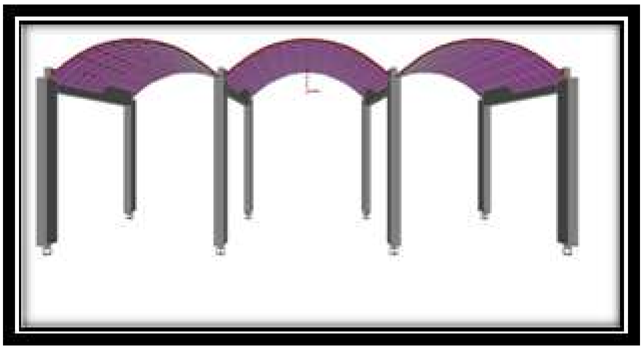


Fig.1.4 Front perspective view of modeled multiple shell structure

PROPERTY AND DIMENSIONS OFMODELS

Span in X direction	11 m
Span in Y direction	11 m
Live load	0.6 kN/m2
Grade of Concrete	M-25
Type of Steel	HYSD bars
Column Height	5.0 m
Column Size	0.3 m X 1.0 m
Column Support condition	Fixed
Beam Size	0.30 m x 0.50 m
Varying Thicknesses for Radius =	0.08m, 0.12m
Number of bay	3 bay
Semi central angle (Type-A)	40^o
Semi central angle (Type-B)	31^0
Semi central angle (Type-C)	57^0
Radius of model (Type-A)	10.83m
Radius of model (Type-B)	8.56m
Radius of model (Type-C)	6.53m

ANALYSIS RESULT

As mentioned in the objective of the study, the behavior of skewed parabolic cylindrical shells under dynamic loading have been analyzed with varying parameters. The results obtain from the analysis are represent by tables and graphs. Comparison between various Skewed parabolic cylindrical shell and non-skewed parabolic cylindrical shell has been done for different rise, thickness and skew angles in tables and graphs.The linear static analysis is adopted for analysis of various cylindrical shell using structural engineering software SAP-2000 due to static load only. the following analysis result, stresses and force contour are obtain from the analysis for changing thickness and radius for fixed length and chord width of the model which are presented below

Stresses in longitudinal direction S11 (Nx)

Table No. 4.7 Rise3 m & Thickness 200mm

S11 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
7	0	0.385	1.605	25.842	33.972
16	30	0.844	1.636	26.809	34.431
25	45	0.774	1.4	26.031	36.038

Table No. 4.8 Rise3 m & Thickness 150mm

S11 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
8	0	0.672	1.774	21.412	39.757
17	30	1.321	1.979	22.607	35.431
26	45	1.216	1.736	23.138	33.878

Table No.4.9 Rise3 m & Thickness 100mm

S11 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
9	0	1.516	2.412	16.706	51.011
18	30	2.095	2.538	17.552	37.342
27	45	1.991	2.29	18.384	29.569

Stresses in Transverse direction S22 (Nɵ)

Table No. 4.16 Rise3 m & Thickness 200mm

S22 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
7	0	0.31	1.184	1.044	25.068
16	30	1.284	1.77	3.061	36.322
25	45	2.352	2.311	7.842	57.52

Table No. 4.17 Rise3 m & Thickness 150mm

S22 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
8	0	0.366	1.564	1.184	24.961
17	30	1.519	2.306	3.073	33.482
26	45	3.077	2.98	8.312	49.954

Table No. 4.18 Rise3 m & Thickness 100mm

S22 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
9	0	0.626	2.396	1.283	19.271
18	30	1.559	3.296	2.782	26.545
27	45	3.767	4.09	9.223	48.011

In plane shear stress S12 (Nxɵ)

Table No. 4.25 Rise3 m & Thickness 200mm

S12 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
7	0	0.266	0.689	10.097	12.504
16	30	0.773	1.286	16.22	18.862
25	45	0.874	1.56	19.899	26.247

Table No. 4.26 Rise3 m & Thickness 150mm

S12 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
8	0	0.476	0.969	9.058	13.547
17	30	1.108	1.635	14.995	18.248
26	45	0.378	1.063	7.303	10.516

Table No. 4.27 Rise3 m & Thickness 100mm

S12 (N/mm²)					
Model	skew angle	Mode			
		1	2	3	4
9	0	0.899	1.389	8.549	15.203
18	30	1.668	2.202	14.089	18.87
27	45	1.819	2.745	19.646	18.963

Graphs for the stresses

Fig. 4.15

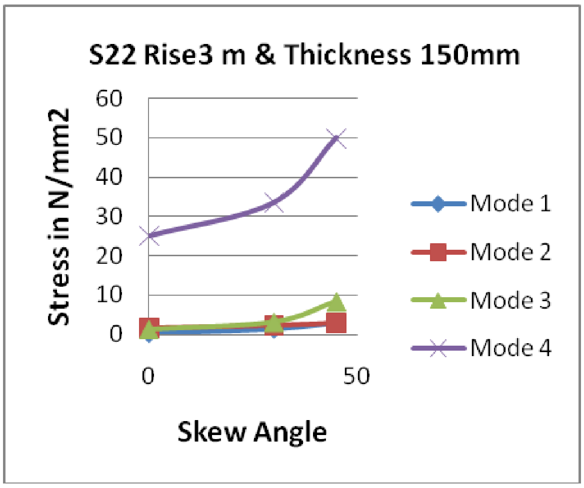


Fig. 4.16

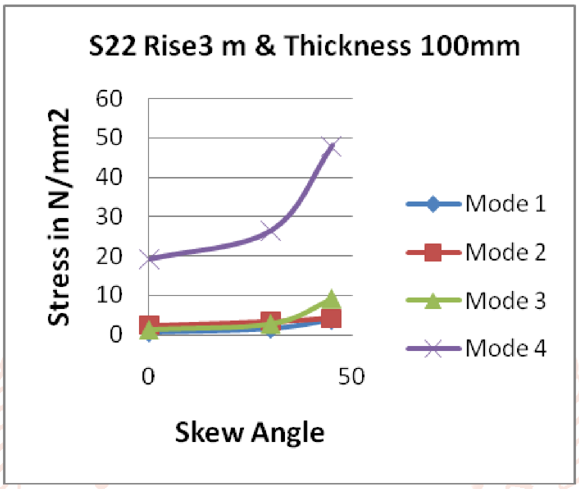


Fig. 4.17

Longitudinal moment M11 (Mx)

Table No. 4.34 Rise3 m & Thickness 200mm

M11 (KN/m)					
Model	skew angle	Mode			
		1	2	3	4
7	0	14.0883	27.7392	104.1938	432.981
16	30	18.9146	26.8797	102.9506	420.7515
25	45	19.1589	24.3558	99.2122	389.0721

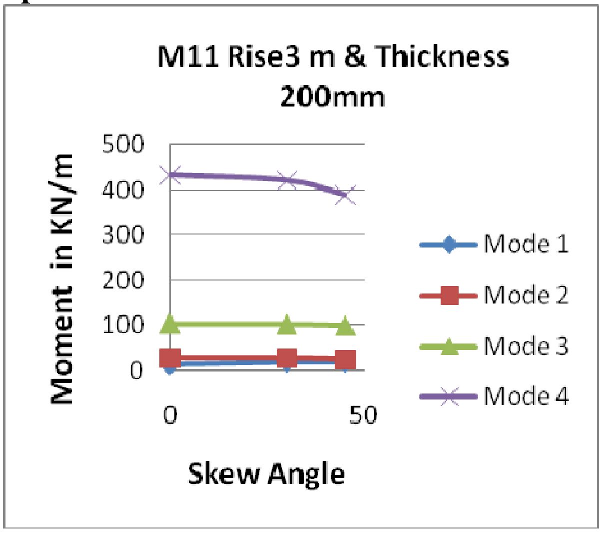
Table No. 4.35 Rise3 m & Thickness 150mm

M11 (KN/m)					
Model	skew angle	Mode			
		1	2	3	4
8	0	11.4395	16.1881	57.9523	219.0174
17	30	13.297	15.6892	58.0957	213.9864
26	45	13.0929	14.3925	56.7519	201.1809

Table No. 4.36 Rise3 m & Thickness 100mm

M11 (KN/m)					
Model	skew angle	Mode			
		1	2	3	4
9	0	7.2557	7.3388	25.6174	84.6964
18	30	6.9833	7.0818	25.9891	78.3767
27	45	7.0291	6.6433	26.0607	86.6395

Graphs for Moments



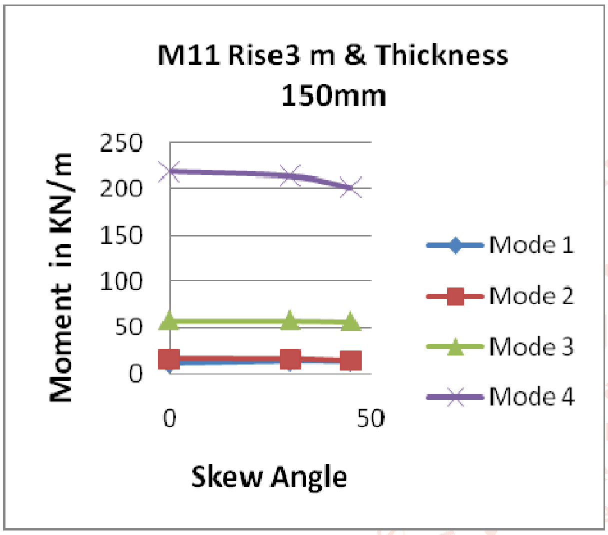


Fig. 4.34

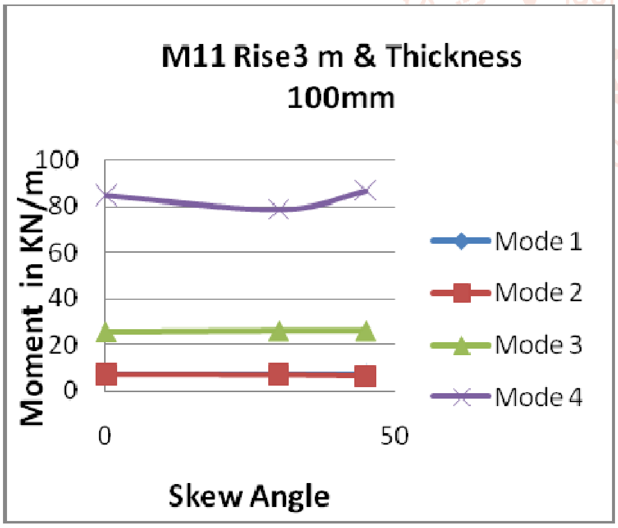


Fig. 4.35

Result for rise variation

Tables No4.52. Skew angle 45' & Thickness 200mm

Model	Rise	Stress N/mm²		
		S11	S22	S12
19	1.5	18.645	9.489	14.352
22	2.25	24.786	9.538	18.666
25	3	26.031	7.842	19.899

Tables No.4.54 Skew angle 45' & Thickness 100mm

Model	Rise	Stress N/mm²		
		S11	S22	S12
21	1.5	16.414	13.457	19.337
24	2.25	8.701	14.252	7.381
27	3	18.384	9.223	19.646

Tables No4.53. Skew angle 45' & Thickness 150mm

Model	Rise	Stress N/mm²		
		S11	S22	S12
20	1.5	18.223	10.903	16.419
23	2.25	7.712	16.503	7.648
26	3	23.138	8.312	-2.336

Graphs for stresses

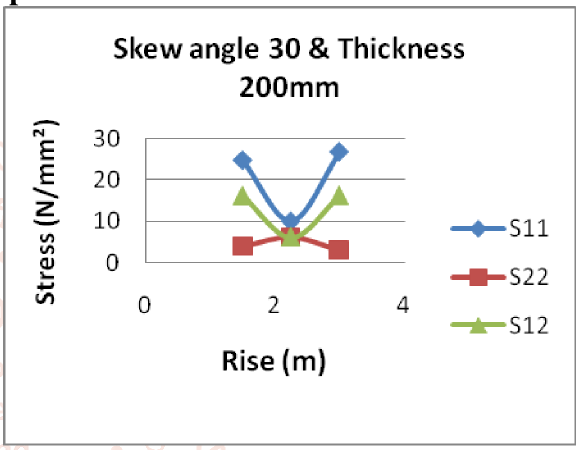


Fig. 4.48

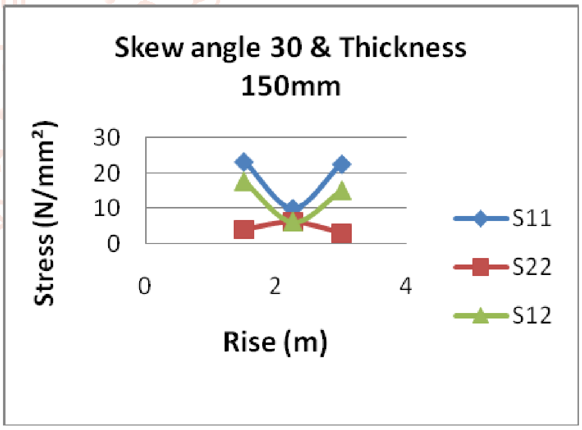


Fig. 4.49

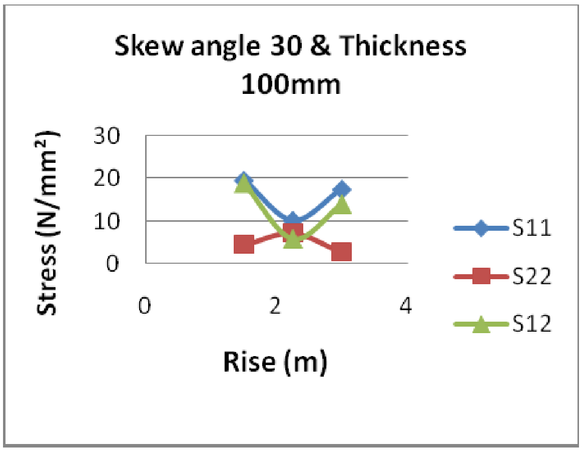


Fig.4.50

CONCLUSIONS:

The observations of the study are as follows:

The effect of rise: By increasing the rise stresses are minimum for 2.25m rise, for shallow and deep shell the loads are resisted by stresses as compare to intermediate rise. Shells with intermediate rise moment plays major role. Transverse normal shear is played negligible part in loads resistance.

The effect of thickness: longitudinal stresses plays major role in resisting the loads compare to other two stresses, the transverse normal stress is negligible with thickness. Moments are increasing with thickness. Transverse moment increases more in comparison of longitudinal moments.

The effect of skew angle: The longitudinal stress decrease as the skew angle increase, transverse stress increase as the skew angle increases. The in plane shear stress almost remain constraint there for it can be concluded that the role of resistance to load shift from longitudinal stress to transverse as skew angle increases.

Longitudinal Moment does not varies much the transverse moment increases for skew angle in 30, 45 but more increases in 30.Further the transverse moment has more than double in all cases which shows transverse moment plays the major role in resisting the load.

REFRENCES

Books

[1] Ramaswamy, G. S. "Design and construction of concrete shell roofs". *Cbs Publishers & Distributors Pvt. Ltd., New Delhi, , India.*

[2] Timoshenko, S. and Krieger, S. "Theory of plates and shells". *Tata McGraw Hill Education Pvt ltd., New Delhi, India, 429-575.*

[3] Agrawal P. and shrikhande M. "Earthquake resistant design of structures". PHI learning pvt. ltd. New Delhi-110001, India.

Thesis and dissertation

[1] Kandasamy, S. and Singh, A. V., (2010). "Free Vibration Analysis of Cylindrical Shells Supported on Parts of the Edges". *Journal of aerospace engineering, ASCE, 33-43.*

[2] Rao, G. (1983). "A study of funicular shell". *M. E. dissertation, Shree Govindram Seksaria Institute of Technology and Science Indore.*

[3] Reddy, E. S. (1978). "Optimum design of stiffened cylindrical and conical shells". *M. Tech., department of mechanical engg., Indian Institute of technology, Kanpur.*

[4] Rode, V. (1984). "Bending analysis of conoidal shell panels for hydrostatic loads". *M. E. dissertation, Shree Govindram Seksaria Institute of Technology and Science Indore.*

[5] Singh, L. (1971). "Experimental and analytical study of the design of reinforcement in folded plates and cylindrical shell structure". *M. Tech., department of civil engg., Indian Institute of technology, Kanpur.*

Papers

[1] Arciniega, R. A. and Reddy, J. N. (2006). "Large deformation analysis of functionally graded shells". *International Journal of Solids and Structures, 44, 2036–2052.*

[2] Haldar s. Majumdar A. Manna M. C. "Bending of Skewed Cylindrical Shell Panels" (2010) International Journal of Computer Applications (0975 – 8887)Volume1 – No. 8

[3] Halder, S. (2008). "Free vibration of composite skewed cylindrical shell panel by finite element method". *Journal of Sound and Vibration, 311, 9–19.*

[4] Wang C. and Lai J. C. S. (1999) "Prediction of natural frequencies of finite length circular cylindrical shells "Elsevier Applied Acoustics 59 385±400

[5] Bathe, K. J. and E. N. Dvorkin. 1986. "A Formulation of Genera l Shell Elements -- The Use of Mixed Interpolation of Tonsorial Components". Int. Journal for Numerical Methods in Engineering, Vo l. 22, No. 3. pp. 697- 722.

[6] Zienkiewicz, O. C. 1977. The Finite Element Method. Mc Gra w-Hill Book Company.

[7] N. Krishna Raju " Advanced Reinforced Concrete Design " based on IS-456-2000 (2nd Edition).

[8] "Membrane theory of cylindrical shells", K. C. Roy, Indian concrete journal, Vol. 23, 1949.

[9] "An Analytical and Experimental Investigation of the Behavior of thin Cylindrical Shell Roof Structures" –M. Smolira, University of London Ph. D. Thesis Part 1 and 2, 1949.

[10] "Theory and Design of Cylindrical Shell Structures" by R. S. Jenkins, Lund and Humphries and Co. Ltd. London 1947.

[11] Timoshenko, S. P., Woinowsky-Krieger, S. 1959. "Theory of Plates and Shells" 2d ed.,

McGraw-Hill Book Company, New York.

[12] Dr. Umesh Pendharkar, Ravindra Rai, 2012. "Computer Aided Analysis of Multiple Cylindrical Shell Structure Using Different Parameters". (IJERT) Vol. 1 Issue 3, May - 2012 ISSN: 2278- 0181

[13] Srinivasan Chandrasekaran1*, S. K. Gupta2, Federico Carannante3, 2009. "Design aids for fixed support reinforced concrete cylindrical shells under uniformly distributed loads". International Journal of Engineering, Science and Technology Vol. 1, No. 1, 2009, pp. 148-171

[14] Varghese P. C. 2014. "Design of Reinforced Concrete Shells and Folded Plates" First Edition, PHI Learning Private Limited, Delhi.

[15] IS-2210-1988, "Criteria for Design of Reinforced Concrete Shell Structures and Folded Plates", B. I. S., New Delhi.

[16] Bandyopadhyay J. N., 1998. "Thin Shell Structures Classical and Modern Analysis", New Age International Publishers, New Delhi.

[17] Chandrashekara K., 1986. "Analysis of Thin Concrete Shells", Tata McGraw Hill, New Delhi.

[18] "Design of Cylindrical Concrete Shell Roof", Manual No. 31, ASCE, New York, 1952

[19] Chandrasekaran S., Ashutosh Srivastava, Parijat Naha. 2005. "Computational tools for shell structures" Proc. of Intl. conf. on structures and road transport (START-2005), IIT-Kharagpur, India, pp. 167-175.

[20] Ramaswamy G. S. 1968. "Design and construction of concrete shell roof" First Edition, Mc-Graw Hill.

[21] "Distribution method for Circular Cylindrical Shell Roofs" by Yit zhaki North Holland Publishing Co., A msterdam, Holland

[22] Cylindrical Thin Concrete Shells Jose Antonio Lozano Ga lant May 2009, TRITA-BKN. Master Thesis 277, 2009 ISSN 1103-4297, ISRN KTH/BKN/EX-277-SE.

[23] Design aids for fixed support reinforced concrete cylindrical shells under uniformly distributed loads Dept. of Ocean Engineering, Indian Institute of Technology Madras, Chennai 600 036, India.

[24] "Design of cylindrical concrete shell roofs" prepared by the committee masonry and reinforced concrete of the structural division through its subcommittee on thin shell design. R. F. Bleich, Mario G. salvadori., Alfred 1 Prame.

[25] Thin Shell Concrete Structure Design and Construction, Jessica Mandrick, E90 Project Proposal Swarthmore College, Department of Engineering.

[26] Integrated Modeling, Finite -Element Analysis, and Engineering Design for Thin-Shell Structures using Subdivision Fehmi Cirak,

[27] Michael J. Scott, Erik K. Antonsson, Michael Ortiz and Peter Schr¨oder.

[28] "Practical design of cylindrical shell roofs" V. K. Chavan.

[29] Rohit Sahu, Barun Kumar, Deeksha Shrotriya "Dynamic Study of Parabolic Cylindrical Shell: A Parametric Study" Volume 5 Issue 4, May-June 2021 Available Online: www. ijtsrd. com e-ISSN: 2456 – 6470

[30] Dr. Umesh Pendharkar, Ravindra Rai, 2012. "Computer Aided Analysis of Multiple Cylindrical Shell Structure Using Different Parameters". (IJERT) Vol. 1 Issue 3, May - 2012 ISSN: 2278- 0181

[31] Srinivasan Chandrasekaran1*, S. K. Gupta2, Federico Carannante3, 2009. "Design aids for fixed support reinforced concrete cylindrical shells under uniformly distributed loads". International Journal of Engineering, Science and Technology Vol. 1, No. 1, 2009, pp. 148-171

[32] Varghese P. C. 2014. "Design of Reinforced Concrete Shells and Folded Plates" First Edition, PHI Learning Private Limited, Delhi.

[33] IS-2210-1988, "Criteria for Design of Reinforced Concrete Shell Structures and Folded Plates", B. I. S., New Delhi.

[34] Bandyopadhyay J. N., 1998. "Thin Shell Structures Classical and Modern Analysis", New Age International Publishers, New Delhi.

[35] Chandrashekara K., 1986. "Analysis of Thin Concrete Shells", Tata McGraw Hill, New Delhi.