

“Computer Aided Analysis of Multiple Cylindrical Shell Structure Using Different Parameters”

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ABSTRACT

Shell structures are widely used in the field of civil, mechanical, , aeronautical and marine engineering. Shell technology has been enhanced by the development of new materials and prefabrication schemes. Despite the mechanical advantages and aesthetic values offered by the shell structures, the relative degree of un-acquaintance with shell behavior and design is high. The construction of a reinforced concrete shell involves many problems, the design and construction of form work, reinforcement selection etc. More than almost any other structural system, shells depend upon the ability of the engineer to foresee the design problems. Most of the early shells built were single or multi-barrel cylindrical shells. The work provides analysis comparison of multiple cylindrical shells with varying parameters of radius and thickness.

1. INTRODUCTION

A Shell in the technical language may be defined as a curved structural member in which the thickness is small compared to the radius and other dimension. Shell or skin space roof are preferable to plane roofs since they can be used to cover large floor spaces with economical use of materials of construction. The use of curved space roofs requires 25 to 40% less materials than that of the plane elements. Structurally the shell roofs are superior since the whole cross section is uniformly stressed due to the direct forces with negligible effects & due to this aspect the thickness of shells is usually very small in the range of 75 mm to 150 mm. Shell structures are very broad topic. Shells differ in their shape (cylindrical, spherical, parabolic, etc.), in the way in which their walls are stiffened (laterally, longitudinally, with orthogonal stiffeners),

by type of load action, by type of material used (concrete, steel), etc. This great variability and range of shell performance presents many practical difficulties in their design. In the work one type of concrete multi cylindrical shell loaded with live (snow load) and dead load only. It has been considered that thin shell structures transfer their loading by means of the membrane tensional and compression forces that act in the walls of the shell. Also it is known that shells have very high efficiency under symmetrical loading and support. Transfer of asymmetrical loading and local load is not desirable. In real life, shell structures are used mainly as chimneys, tanks, pipelines, silos, hangers, sports auditoriums, exhibition halls, industrial buildings and a variety of other large span structures where uninterrupted floor space is required. Shell roofs are architecturally very expressive and have been used for domes by Romans Recent advances include the construction of shell structures using prefabricated shell elements.

2. SOFTWARE USED

Among the features introduced by the analysis engine of SAP2000 are modal analysis, static and dynamic analysis, linear and nonlinear analysis, and pushover analysis. The analytical modeling used in this software is the member type model which means that beams or columns are modeled using single elements. The layered shell modeling can be possible in SAP2000 which allows any number of layers to be defined in the thickness direction, each with an independent location, 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 relationship.

SAP2000 can specify for each material one or more stress-strain curves that are used to generate 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 typically only specify one stress-strain curve. A variety of cross sections are available in SAP2000 element library. These sections include rectangular sections as used for modeling the beams and columns of the RC buildings. SAP2000 provides the tools needed for pushover analysis as material nonlinearity at discrete, user-defined hinges in frame elements. The hinge properties are created based on pushover analysis regulations found in performance-based guidelines. Default hinge properties are provided based on FEMA-356 criteria. Display capabilities in the graphical user interface to generate and plot pushover curves, including demand and capacity curves in spectral ordinates. Capabilities in the graphical user interface to plot and get information about the state of every hinge formed at each step in the pushover analysis.

3. METHODS OF ANALYSIS

3.1 Membrane Theory

The shells whose L/R ratio is less than 0.5 can be analysed reasonably accurately by 'Membrane theory' provided the edges of such shells are afforded unyielding supports.

3.2 Beam Method

The shell whose L/R ratio is greater than or equal to π can be analysed accurately by 'Beam method'.

3.3 Analytical method

The shells not falling in the above mentioned two categories have to be analysed by any accepted 'Analytical method'. After determining the dimensions L i.e. span, R i.e. radius and (2h) i.e. thickness of the shell, the two mutually independent ratios are obtained. These ratios viz. ρ and k being known as parameters were first introduced by Aas-Jakobsen, in order to make all computations dimensionless and of the same order of magnitude. The stress distribution in a shell is a function of these two parameters.

4. 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 multiple shell structure. For analysis two parameter have been change first one is thickness and second is radius, on the basis of different radius and thickness for same chord width, length and material of shell, following results are formed and compare the results for different models.

5. PROPERTY AND DIMENSIONS OF MODELS

Span in X direction	11 m
Span in Y direction	11 m
Live load	0.6 kN/m ²
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°
Semi central angle (Type-B)	31°
Semi central angle (Type-C)	57°
Radius of model (Type-A)	10.83m
Radius of model (Type-B)	8.56m
Radius of model (Type-C)	6.53m

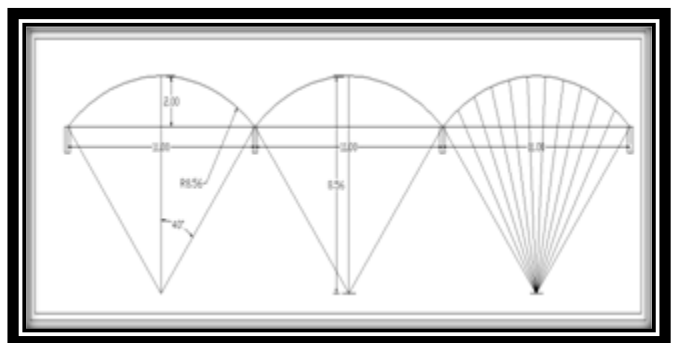


Fig. 1.1 basic dimensions of multi-bay cylindrical shell

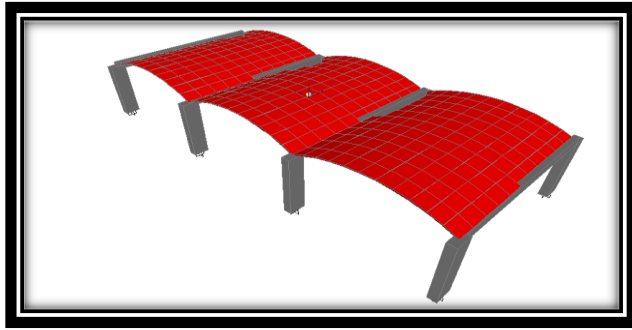


Fig.1.2 3D- model of multi-bay cylindrical shell Structure

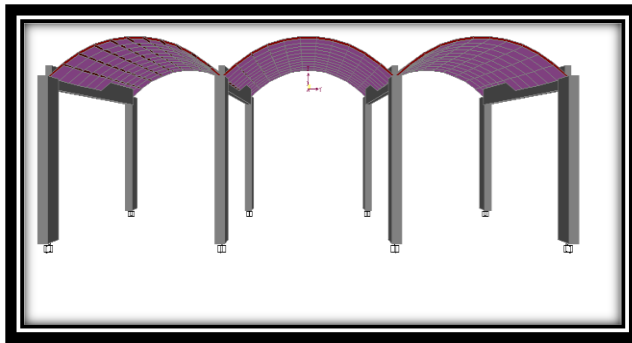


Fig.1.3 Front perspective view of modeled multiple shell structure

6. ANALYSIS RESULT

The linear static analysis is adopted for analysis of multiple 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 varying thickness and radius for fixed length and chord width of the model which are presented below.

6.1 RESULT COMPARISON BETWEEN MODEL TYPE A , B and C

For showing comparison between all the models consider following conditions.

1. Take all models having same thickness with different radius.
2. Take a single model having same radius with different thickness of shell element.

The analyses of all the models of shell is done only for dead load of the structure and result of support reaction obtain from analysis are listed in table below.

6.2 Model Type (A)

with central rise is 1.5m and 120 mm thickness of shell value of maximum moment portion is shown in fig 1.4 and max. moment of particular member shown in table.1.

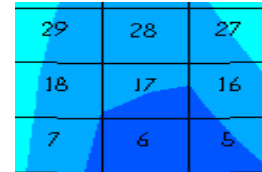


Fig.1.4:- Portion of Maximum Moment(A)

Table 1:- Element Max. Moments		
Area	OutputCase	Mmax
Text	Text	KN-m/m
5	DEAD LOAD	12.67
6	DEAD LOAD	12.71
7	DEAD LOAD	11.96
16	DEAD LOAD	11.94
17	DEAD LOAD	11.93
18	DEAD LOAD	11.48
27	DEAD LOAD	11.04
28	DEAD LOAD	11.05
29	DEAD LOAD	10.97

6.3 Model Type (B)

with central rise is 2m and 120 mm thickness of shell value of maximum moment portion is shown in fig 1.5 and max. moment of particular member shown in table.2.



Fig.1.5:- Portion of Maximum Moment(B)

Area	OutputCase	Mmax
Text	Text	KN-m/m
5	DEAD LOAD	10.21
6	DEAD LOAD	10.26
7	DEAD LOAD	9.87
16	DEAD LOAD	9.78
17	DEAD LOAD	9.78
18	DEAD LOAD	9.64
27	DEAD LOAD	9.18
28	DEAD LOAD	9.31
29	DEAD LOAD	9.34

6.4 Model Type (c)

With central rise is 3m and 120 mm thickness of shell value of maximum moment portion is shown in fig below and max. Moment of particular member shown in table

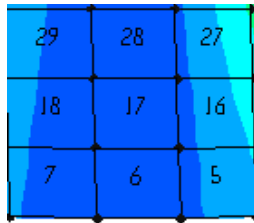


Fig.1.6:- Portion of Maximum Moment(C)

Area	Output Case	Mmax
Text	Text	KN-m/m
5	DEAD LOAD	6.89
6	DEAD LOAD	7.41
7	DEAD LOAD	7.41
16	DEAD LOAD	6.99
17	DEAD LOAD	7.44
18	DEAD LOAD	7.43
27	DEAD LOAD	6.96
28	DEAD LOAD	7.45
29	DEAD LOAD	7.45

6.5 MAXIMUM ELEMENT FORCES

The portion of max. force for different shell models are shown in tabulated below with their element number.

6.5.a Model Type (A): 1.5 m rise 120mm thick

Area	OutputCase	Fmax
Text	Text	KN/m
44	DEAD LOAD	140.33
66	DEAD LOAD	155.93
77	DEAD LOAD	153.58

6.5.b Model Type (B) : 2.0 m rise 120mm thick

Area	Output Case	Fmax
Text	Text	KN/m
44	DEAD LOAD	127.31
66	DEAD LOAD	140.62
77	DEAD LOAD	138.75

6.5.c Model Type (C) : 3.0 m rise 120mm thick

Area	OutputCase	Fmax
Text	Text	KN/m
44	DEAD LOAD	114.57
66	DEAD LOAD	125.43
77	DEAD LOAD	124.08

6.6 MAXIMUM STRESSES

The portion of maximum stress in shell models are present by element having maxi. value show below in table.

6.6.a Model Type (A)

1.5 m rise 120mm thick

Table7:- Element Max. Stresses		
Area	Output Case	Smax Top
Text	Text	KN/m2
1	DEAD LOAD	19371.36
12	DEAD LOAD	12772.05
2	DEAD LOAD	7366.47
13	DEAD LOAD	5992.26

6.6.b Model Type (B)
2.0 m rise 120mm thick

Table 8:- Element Max. Stresses		
Area	Output Case	Smax Top
Text	Text	KN/m2
1	DEAD LOAD	17055.73
12	DEAD LOAD	11302.02
2	DEAD LOAD	6917.11
13	DEAD LOAD	5633.65

6.6.c Model Type (C)
3.0 m rise 120mm thick

Table7.11:- Element Max. Stresses		
Area	Output Case	Smax Top
Text	Text	KN/m2
1	DEAD LOAD	12603.79
12	DEAD LOAD	8594.11
2	DEAD LOAD	1785.91
13	DEAD LOAD	5078.41

6.7 TAKE A SINGLE MODEL HAVING DIFFERENT THICKNESS OF SHELL ELEMENT:

Now show the result for varying thickness we consider shell element with central rise is 1.5m having thickness of element 120mm and 80 mm respectively for two different model and the result obtained from the analysis for max. moment ,max. force and max. stress. In the shell element are shown below.

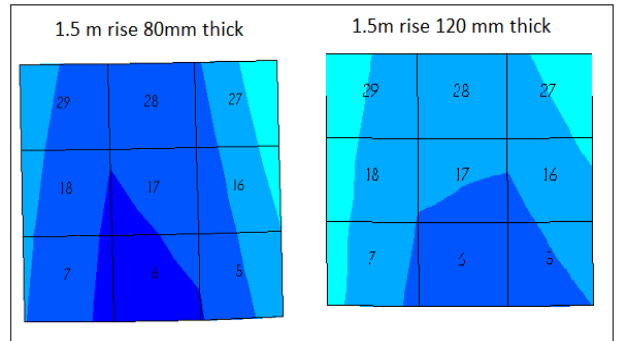


Fig 1.7:- comparison between max. moment contour

Table 9: Element Forces - Area Shells		
Area	Output Case	% difference between both model
Text	Text	
5	Self weight	41.39
6	Self weight	42.50
7	Self weight	45.29
16	Self weight	42.80
17	Self weight	44.54
18	Self weight	46.37
27	Self weight	44.37
28	Self weight	46.72
29	Self weight	47.14

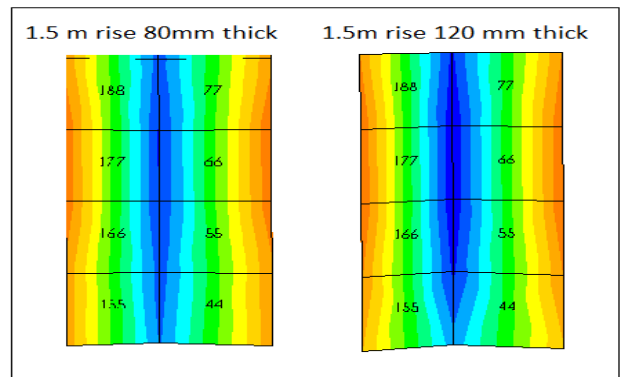


Fig 1.8: comparison between elements force Contour

Table 10: Element Forces - Area Shells		
Area	Output Case	% difference between both model
Text	Text	
44	Self weight	39.16
55	Self weight	38.96
66	Self weight	38.86
77	Self weight	38.96

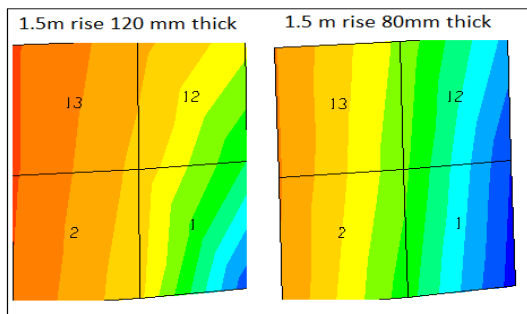


Fig 1.9 comparison b/w elements max. stresses of element

Table 11: Element Stresses - Area Shells		
Area	Output Case	% difference between both model
Text	Text	
1	Self weight	28.67
12	Self weight	3.54
2	Self weight	12.10
13	Self weight	13.22

7. CONCLUSION :

Considered all model having different radius and same thickness.

- From the analysis of all the model it is find out the portion of max. element moment , max. element forces and max. stresses due to self weight of structure and reach the following conclusion.
- The portion of max. moment formed at the middle (end and start) element of the end shell.

- In all models of having same thickness and different radius the portion of max. moment is same but the magnitude of max. moment reduced when the rise of shell will be increase or radius will be decrease.
- The portion of max. forces is lies at that portion where two shells are join with each other.
- The forces formed in the shell elements is reduced when increase the size of the shell.
- The portion of max. stresses in multiple shell is lies at the corner of shell where it connect with the column .
- The stresses formed in the shell models will be reduced when the rise of shell increased.
- In the simply way when we increased the rise of shell moment ,forces and stresses in the shell element will be increased but the portion of all the result will be different.

Considered models having same radius with different thickness:

When worked on the above condition and compare the result for model having radius 10.56m with rise 1.5m and varies thicknesses 120mm to 80mm. It is found that the portion of maxi. Moment, maxi. Forces and maxi. Stresses is remaining same but due to reduction in thickness all moment ,forces and stresses reduced. and now we reach to following conclusion that for shell construction always use liter section.

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