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Bending Analysis of Conoidal Shell Under Uniformly Distributed Load

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ABSTRACT

Engineering is manner of usage of technology for the society. There are various engineering field based totally on the vicinity of application. Civil engineering is subject which is used to constructed roads, bridges, dams, canals, building, and so on and also used for protection, but civil engineering performs essential role in growing infrastructure. On this challenge it is used for "Bending and Stress behaviour analysis of conoidal shell under uniformly distributed load".

Keywords: *:* Bending, conoidal shell, delaminated composite, Finite element method.

1. INTRODUCTION

Different forms of shell structures have been used as roofing units in civil engineering from very early days. The design and use of shell roofs have gradually undergone evolutionary changes with the focus changing with time. Shell structures are widely used in all industrial applications, especially those related to automobile, marine, nuclear, civil, aerospace and petrochemical engineering. In civil engineering construction cylindrical, conoid, hyperbolic and elliptic shells are commonly used as roofing units to cover large column-free areas. Conoidal shells provide ease of fabrication and allow sun light to come in. They are most suitable when greater rise is needed at one end.

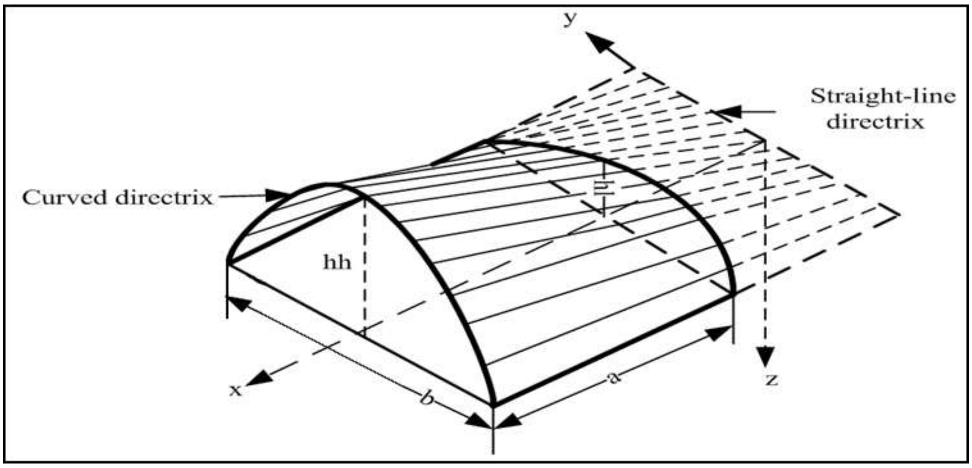


Figure 1.1 Geometry of conoidal shell

1.1 Conoidal Shells

A conoid surface is generated by a straight line moving parallel to a fixed plane. The moving line always intersects two different lines, one straight and one curved one. The curved directrix can be a parabola (or) catenary (or) part of a circle. It is assumed that both the straight line directrix and the plane containing the curved directrix are at right angles to the director plane, the curved directrix being moreover symmetric about its vertical axis, such conoids are called square conoids. A part of a conoid, known as a truncated conoid, is preferred to a full conoid, as otherwise large compressive and tensile stresses accompanied by bending and torsion will occur near the flat edge. Quite frequently, only a part of the surface that is truncated conoids is used for purpose of roofing. One of the greatest advantages in the use of conoidal shells is that a considerable amount of natural lighting is achieved at a minimum structural cost. Also the formwork for this ruled surface can be easily made from straight planks.

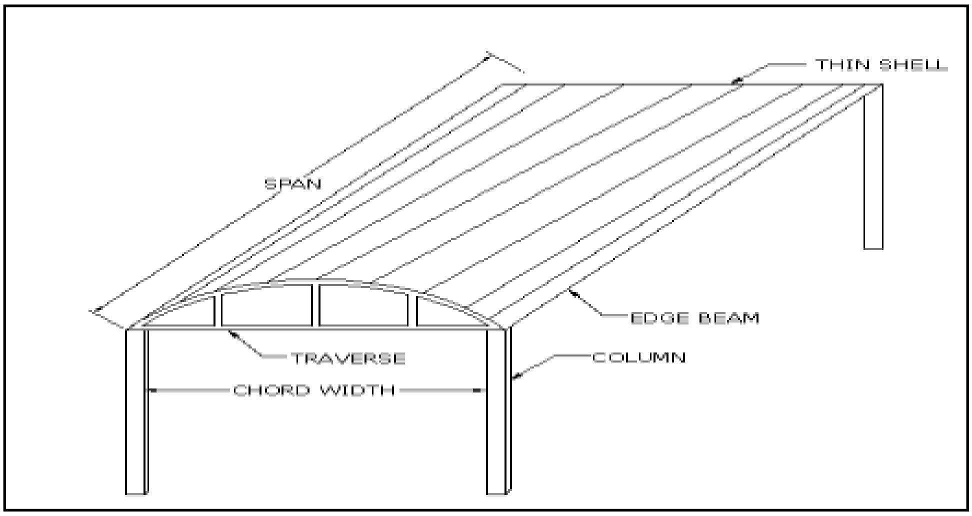


Figure1.3 Conoidal shell

1.3Objectives

1. Study the bending behaviour of conoidal shell for different aspect ratio, degree of truncation and different boundary condition under uniformly distributed load.
2. Study the bending behaviour of conoidal shell for different material under uniformly distributed load.
3. Study the stress behaviour of conoidal shell for different material under uniformly distributed load.

2.LITERATURE REVIEW

2.1 Introduction

The conoidal shell, usually in a truncated form, is most commonly used for factory type buildings, cantilevered canopies and dams. A conoid is a shell of complicated shape, singly ruled, anticlastic, non-developable conoidal shell configurations are aesthetically appealing, structurally stiff, and they may be used for covering large column free spaces. Naturally, these forms received importance from the engineers and research on conoidal shells.

2.2 Review of Literature

S. H. Das and D. Chakravorty [8] studied design aids and selection guidelines for composite conoidal shell roofs .The conoidal configuration has a special position due to the wide range of advantages it offers. These forms look aesthetically elegant, allow entry of north light, and may easily be cast and fabricated being single ruled surfaces. For the above reasons, civil engineers had been keen to use these forms to cover large column free areas in different industries. Research on these shells dates back to the second half of last century. For any given lamination, an increase in the number of support constraints decreases the maximum deflection, but if the lamination varies for two different shells then the one with less boundary constraints may exhibit less deflection than that with a high number of boundary restraints. The critical deflection, bending moment and in-plane compression normally govern the thickness requirement of a shell surface. The relative performance of the different shell choices in terms of the above three governing shell actions, combining different boundary conditions and stacking sequences.

A. A. Kota, U R Awari and P. R. Satarkar [1] discussed an effect of aspect ratio and degree of truncation on bending behaviour of laminated composite conoidal shell roof with using an eight noded isoparametric element with five degrees of freedom per node together with sanders' strain displacement relationships. Benchmark problems are solved to validate the present approach and a wide variety of composite conoidal shell problems with cross ply laminates are solved by varying aspect ratio and degree of truncation for different the stacking sequence and clamped boundary condition under uniformly distributed pressure. Results are presented for truncated and full conoid and a set of conclusions are arrived at based on a parametric study. The introduction of laminated composite as the structural material has provided the impetus to explore the different behavioural aspects of composite conoids. But the variation of curvature is the major difficulty encountered in the analysis of these shells. Aspect ratio and degree of truncation is the major factor leading to variation of curvature which might affect the bending stiffness of such shells. A study of the bending behaviour of laminated composite conoidal shells is carried out under uniformly distributed pressure with cross ply laminates having different anti-symmetric and symmetric stacking sequences by varying aspect ratio and degree of truncation for clamped boundary conditions. Clamped laminated composite conoidal shell, symmetric laminates are found to be stronger than the anti-symmetric laminates with respect to bending stiffness for different aspect ratio and degree of truncation. as design aids for structural engineers.

2.3 Summary of Literature Review and Research Gap

From the available research reports it is clear that, limited work on laminated and delaminated composite structures has been taken up by some researchers. But no work has been found on effect of aspect ratios and degree of truncations on isotropic conoidal shells. Hence, in this project, a study of the bending and stress behaviour analysis of conoidal shells is carried out for different aspect ratios, degree of truncations, boundary conditions and different material under uniformly distributed load.

3.METHODOLOGY AND MATHEMATICAL FORMULATION

In this chapter material property and problems to be analyzed by finite element method using SAP 2000NL software are given. Problems are divided into three parts for different aspect ratio and case I consist of numerical problem for clamped shells, case II consist of numerical problem simply supported shells.

3.1 Material Properties

a) Aluminum: i) weight density = 26 kN/m^3

ii) poissons ratio = 0.33

iii) Modulus of elasticity = $7x10^7$ kN/m^2

b) Glass: i) weight density = 24 kN/m^3

ii) poissons ratio = 0.26

iii) Modulus of elasticity = $6x10^7$ kN/m^2

3.1.1 Various Boundary Conditions

Case I: Clamped Conoidal Shell

(a) Maximum downward deflections ($\overline{w}$) clamped conoidal shells with aspect ratio = 1 under uniformly distributed load with different degree of truncation.

(b) Maximum downward deflections ($\overline{w}$) clamped conoidal shells with aspect ratio = 1.5 under uniformly distributed load with different degree of truncation.

(c) Maximum downward deflections ($\overline{w}$) clamped conoidal shells with aspect ratio = 2 under uniformly distributed load with different degree of truncation.

3.2 Methodology

In this chapter different methodology used in the project are explained.

1. Mathematical formulation using classical plate theory for analysis of plates using Navier's method is explained.
2. Finite element mathematical formulation for composite laminated conoidal shell using eight nodded isoperimetric curved quadratic shell elements with five degrees of freedom at each node.

3.3 Finite Element Using SAP2000NL Software

Clough was the first to use the terminology 'Finite Element'. Since then, tremendous advances have been made in the last 25 years both on the mathematical foundations and generalization of method to solve field problems in various areas of engineering analysis. During the same period rapid development in computer technology, large number of package programs has been developed such as ABAQUS, ANSYS, SAP, ETAB etc. for finite element analysis which made it possible for wider use of this technique in practice.

4.RESULTS AND DISCUSSION

4.1 Introduction

As we know that aspect ratio and degree of truncation are the major factors leading to variation of the curvature of conoidal shells which might affect bending stiffness. Hence in this project we have consider the shell with three aspect ratio (a/b) = 1, 1.5, 2 and different degree of truncation (hl/hh) is considered varying from 0 to 0.75. Deflection of the shell also depends upon boundary conditions hence two boundary conditions like clamped and simply supported are considered.

4.2 Deflection Results of Conoidal Shell

Deflection Results of Conoidal Shell For Aspect Ratio = 1

In this the results of conoidal shell with 1 aspect ratio and different degree of truncation as shown in Table 5.1 & 5.2 and graphical representation of deflection for conoidal shell with different boundary condition as shown in Graph 5.1 & 5.2. And the conoidal shell with aspect ratio and degree of truncation are shown in Figure 5.1

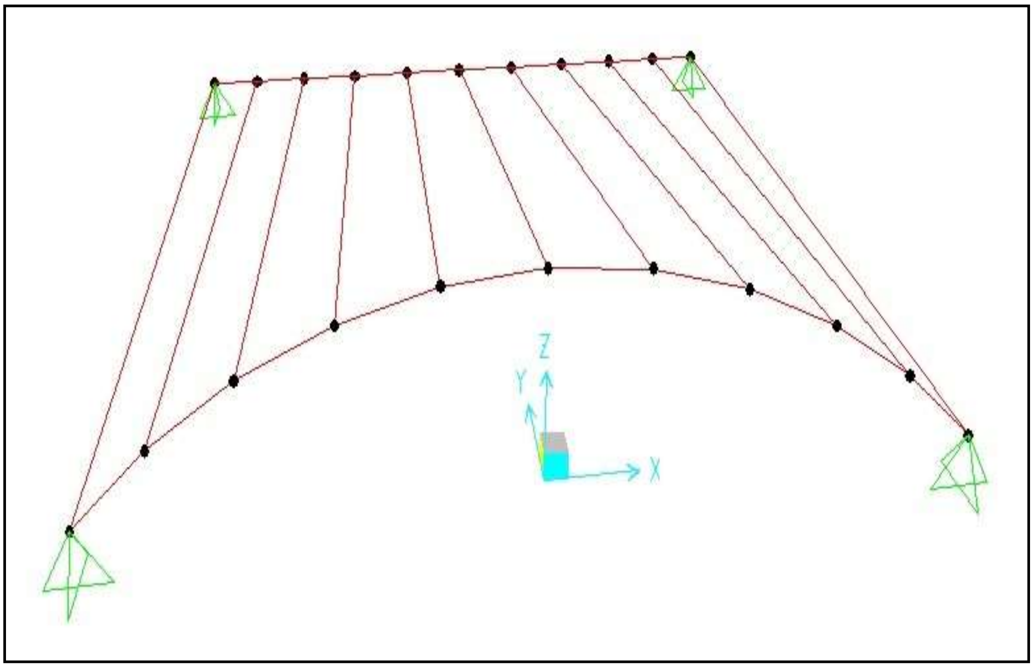
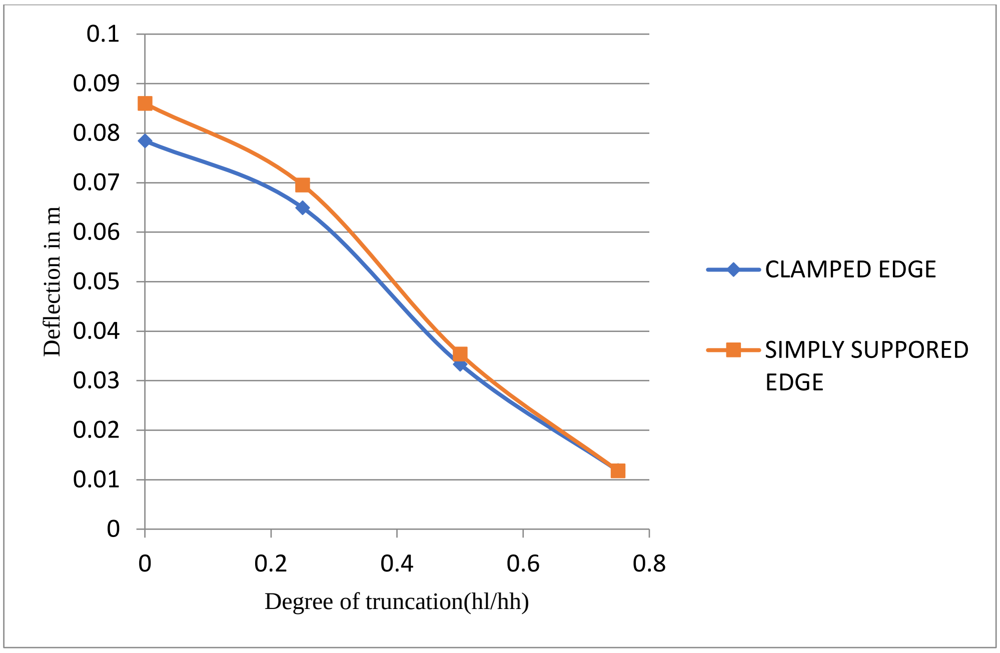


Figure 5.1 SAP2000NL Model for Aspect Ratio =1 & Degree of Truncation = 0.00

Table 5.1 - Maximum downward deflections for conoidal shell with aspect ratio = 1 of aluminum materials

Sr.No.	Material	Boundary Condition	Degree of truncation	Deflection in m
1	Aluminum	Clamped edge	0.00	0.07846
2			0.25	0.06494
3			0.50	0.03331
4			0.75	0.01182
5		Simply supported edge	0.00	0.08598
6			0.25	0.06954
7			0.50	0.03536
8			0.75	0.01180

Note- a/b=1, a/h=500, h=0.02m, a/hh=5, hh= 2 m.



Graph 1.1 Graphical representation of deflection for conoidal shell with aspect ratio = 1 for aluminum material

6.FUTURE SCOPE

i. There is scope of carrying out similar investigations on laminated composite conoidal shell roofs for different aspect ratios, stacking sequences, boundary conditions & various loading.

ii. There is scope of carrying out similar investigations on delaminated composite conoidal shell roofs for different aspect ratios, stacking sequences, Boundary conditions & various loading conditions.

7.CONCLUSION

Following concluding points are drawn from the present study,

i. The results of finite element using SAP2000NL software are compared with those obtained by classical plate theory. It shows greater deflection values because of the elimination of transverse stresses in the classical plate theory.

ii. The results of bending stiffness of clamped shells are more than the simply supported shells.

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