

Finite Element Analysis of Cylindrical and Spherical Concrete Vaults

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ABSTRACT

Concrete shell structures, often cast as a monolithic dome or stressed ribbon bridge or saddle roof. The thin concrete shell structures are a lightweight construction composed of a relatively thin shell made of reinforced concrete, usually without the use of internal supports giving an open unobstructed interior. This project aims to investigate the displacement and to find the maximum shear stress of cylindrical and spherical concrete vaults subjected to pressure load and its self-weight. Boundary condition is given for the concrete vaults as simply supported. Concrete vaults of 3m, 6m and 9m span and of length 8m with same loading conditions were applied. If the shear stress is more it is easy to resist the more load on it. ANSYS results shows that the displacement values when compared with cylindrical and spherical shells, Spherical shells can resist more load.

KEYWORDS: Spherical vault, cylindrical vault, pressure load

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I. INTRODUCTION

Structural designers are an ewbreed of engineers, who act as bridges between conventional structural engineers and architects. Their role requires them to formulate the best possible design based on certain requirements, which depends on several factors. Thus, it is fair to say that they define the backbone of project. This causes a lot of responsibilities to fall on the designer. A good structural designer tries to incorporate several factors to make a complete design. This includes taking into account aesthetic, structural and constructional factors. This approach obviously causes several obstacles,

which can cause complications in the design process. This makes it imperative for a structural designer to have intuition and foresight, along with good structural knowledge to deal with these problems. It remains the primary responsibility of the structural designer to ensure that the structure performs all the functions, it was meant to perform before the start of the design process. The design process of any structure ultimately determines its 'structural life'. This motivates a designer to check the behaviour of the structure, when it is in a state of service. In the past, some shell structures have collapsed due to increasing influences of nonlinear parameters.

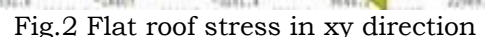
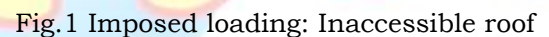
- The numerical investigations are to determine the confinement effects and behaviour of concrete vaults due to internal wall pressure load and to investigate and study by applying different available structural systems for minimizing the deflection under lateral loading.
- To estimate the ultimate strength and study the behaviour of concrete vaults and To develop stress plots for various span for different shapes of a concrete vaults subjected to pressure loading conditions.
- Responses of different structural systems are studied in terms of displacements due to cylindrical and spherical shapes.

For the analysis, ANSYS 15 was used for the concrete vaults having length 8m and height of the vaults varied between 2.4m and 6m.

Boundary condition is given for the concrete vaults as simply supported. To ensure the both ends are simply supported for the concrete vaults, all degree of freedom is selected. The inner wall of the concrete vaults pressure of 7890.73 MPa was applied and self-weight was applied on the concrete vaults.

Property Name	Symbol	Values	Units
Grade	f _{ck}	20	N/mm ²
Young's Modulus	E	22.36	GPa
Poisson ratio	ν	0.19	---
Density	ρ	2500	kg/m ³

Validation model consists of a steep catenary earth brick shells having particular dimension. The material and geometric properties for these finite element (FE) models are as follows: Young's modulus = 6,200 MPa, Poisson's ratio = 0.2, Density = 1,950 kg/m³, Thickness = 250mm, Span = 6m, When comparing these loads, that the steepest catenary vault (H/R= 2.0) carries approximately 40% of the load over a flat roof covering the same plan area by ANSYS and 35% according to the journal.



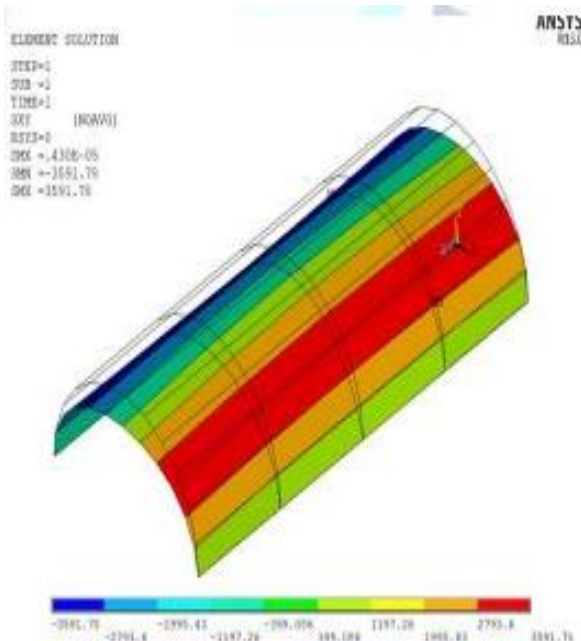


Fig 3 Cylindrical stress at xy direction vault roof

V. RESULTS AND DISCUSSIONS

For the simulations carried out, we found shear stress and displacement in x direction, y direction and xy direction having span 3m, 6m and 9m for cylindrical and spherical concrete vaults, among these xy direction shown the better results.

A. For span 3m

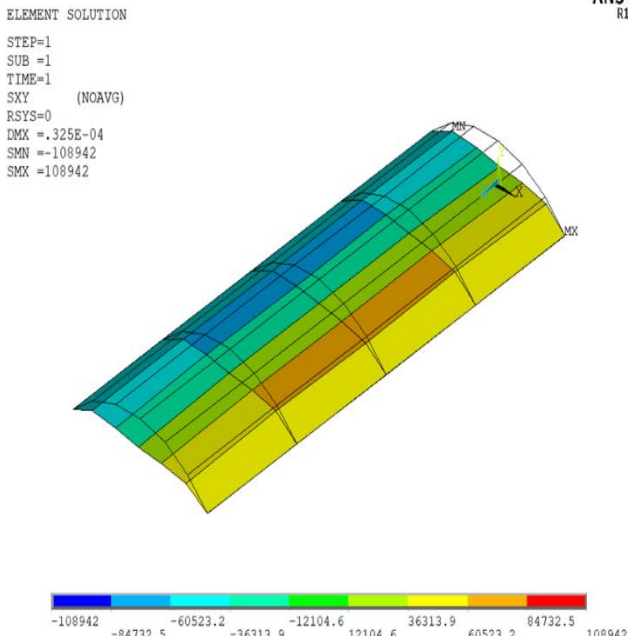


Fig.4 Cylindrical shell of 3m span; XY shear stress

Fig.4 shows a concrete cylindrical shell of 3m span and length 8m. From ANSYS software, there is a displacement of 0.325×10^{-4} mm in a cylindrical shell and shear stress is equal to 108942 N/m^2

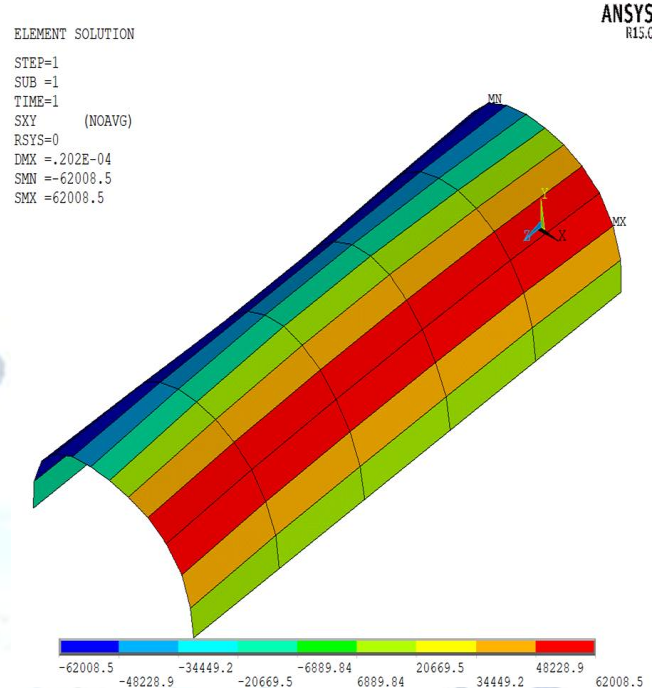


Fig.5 Spherical shell of 3m span; XY shear stress

Fig.5 shows a concrete spherical shell of 3m span and length 8m. From ANSYS software, there is a displacement of 0.202×10^{-4} mm in a spherical shell and shear stress for 3m span is equal to 62008.5 N/m^2

B. For span 6m

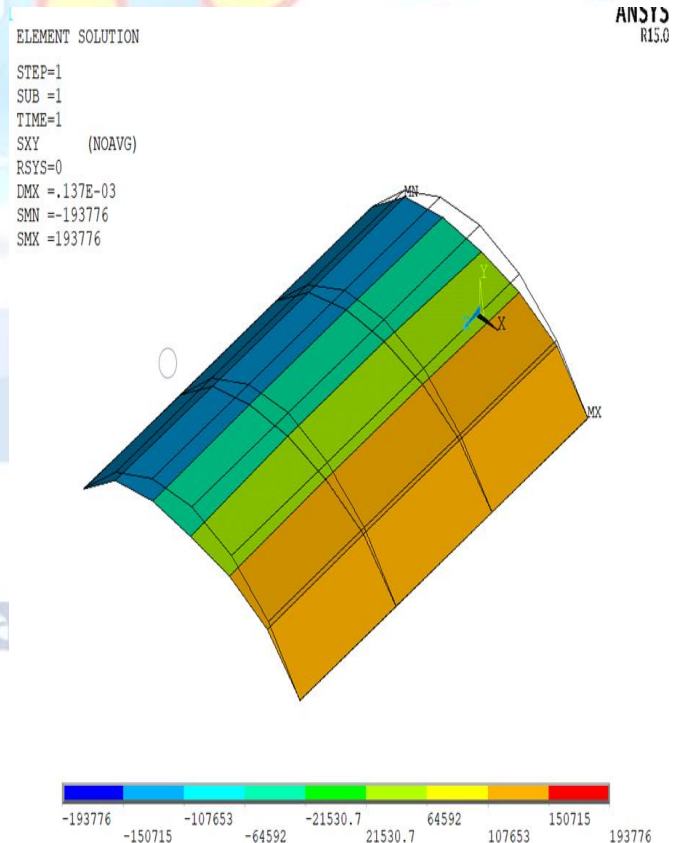


Fig.6 Cylindrical shell of 6m span; XY shear stress

Fig.6 shows a concrete cylindrical shell of 6m span and length 8m. From ANSYS software,

there is a displacement of 0.137×10^{-3} mm in a cylindrical shell and shear stress for 6m span is equal to 193776 N/m^2

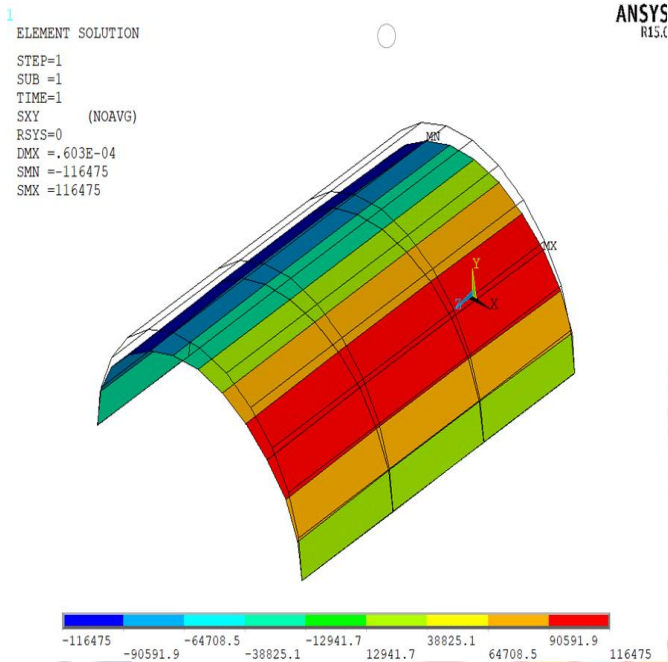


Fig.7 Spherical shell of 6m span; XY shear stress

Fig.7 shows a concrete spherical shell of 6m span and length 8m. From ANSYS software, there is a displacement of 0.603×10^{-4} mm in a spherical shell and shear stress for 6m span is equal to 116475 N/m^2

C. For span 9m

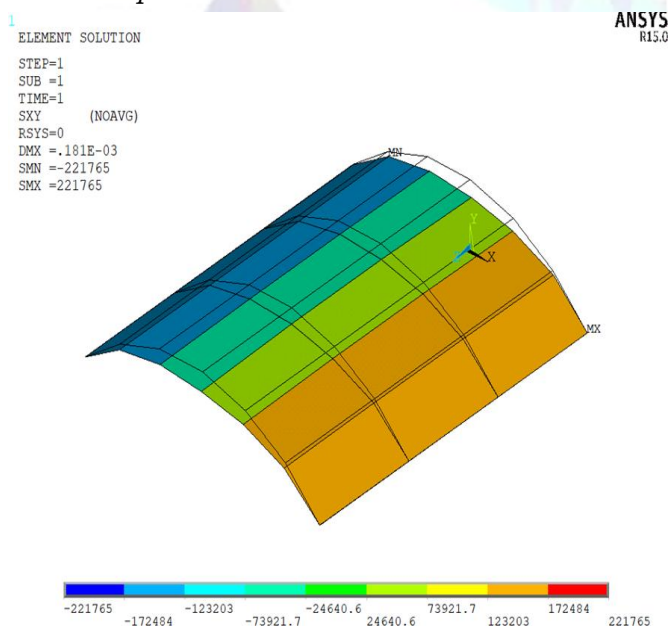


Fig.8 Cylindrical shell of 9m span; XY shear stress

Fig.8 shows a concrete cylindrical shell of 9m span and length 8m. From ANSYS software, there is a displacement of 0.181×10^{-3} mm in a cylindrical

shell and shear stress for 9m span is equal to 221765 N/m^2

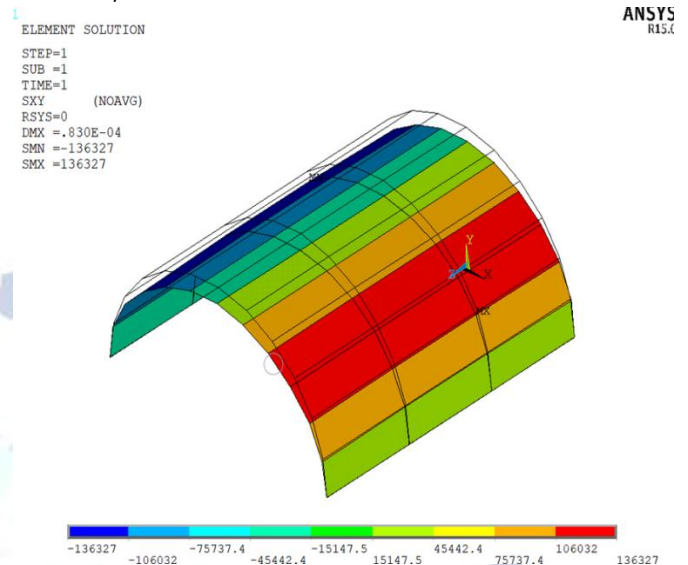


Fig.9 Spherical shell of 9m span; XY shear stress

Fig.9 shows a concrete spherical shell of 9m span and length 8m. From ANSYS software, there is a displacement of 0.830×10^{-4} mm in a spherical shell and shear stress for 9m span is equal to 136327 N/m^2

VI. CONCLUSION

Based on above discussions, it can be concluded that the designed roof is a esthetically pleasing, structurally efficient and easy to construct.

- ANSYS results shows that the displacement values when compared with cylindrical and spherical shells. Spherical shells can resist more load.
- Shear stress is zero, indicates no forces are acting in Y direction for both cylindrical and spherical shells.
- While comparing Shear stress acting in X direction for both cylindrical and spherical shells. Cylindrical shells has less stress values.
- Von Mises criterion is one which states the equivalent distortion of energy of a stress, body attributes to yielding. The cylindrical shells yield more when compared with spherical shell.
- By comparing with 3m, 6m, 9m span and same H/R ratio, the use of cylindrical shells with increase in span, Von Mises stress increases in yielding value.
- Results of the analysis showed that shear stress is maximum along XY direction and along this direction it is able to resist the pressure load for a cylindrical shell.
- The spherical shell has captured the

imagination of generations of builders proving the timeless beauty of the simplest of shapes. Cylindrical shell is an attempt to enhance the aesthetical efficiency of the roof system.

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