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STUDIES ON PARABOLIC CYLINDRICAL SHELL ROOF SUBJECTED TO SUPPORT SETTLEMENT

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***Abstract*— Concrete shells have been widely used for roofing large column-free areas and have been constructed in various countries for almost half a century. Any shell of given dimensions is normally designed for a given external loading under the assumption of unyielding corner supports. In cases where the shell is supported on flexible beams or when the soil conditions under the column supports are relatively poor and varying, the support points may be subjected to differential settlements. Changes in the supports can cause additional stresses in the structure, and local damage or total failure may occur if the new stress pattern is in excess of permissible values. Shell surfaces provide a structurally efficient solution to the problem of carrying roof loads over long spans. These three-dimensional forms owe their efficiency to the translation of applied loads into tensile and compressive stress, as well as shear stress, in the plane of their surface. These are termed membrane stresses. A shell can be defined as a curved slab whose thickness is very small compared to the other dimensions of the shell. Alternatively, a shell can also be defined as body that is bounded by two closely spaced curved surfaces. The middle surface, which is the locus of points that are equidistant from the two bounding surfaces, defines the shape of the shell. The purpose of the present work is to study the behavior of cylindrical shell roof due to support settlement under static loads. The characteristics of the cylindrical shell roof subjected to the support settlement suggest that additional measures for guiding the conception and condition of supports of these structures are needed.**

In order to achieve the objectives a cylindrical shell roof model is categorized under nine different support conditions having supports roller, hinged and fixed in different directions and are termed as A to I and are analyzed with settlement and without settlement having different rises that are 3m, 3.5m and 4m. For these various rises settlements considered are 0mm, 5mm, 10mm, 15mm and 20mm. STAAD Pro v8i software is used as a tool for analyzing the problem.

After the analysis it is observed that the overall performance of different support conditions as per objectives of the study, the support condition type B is very helpful in reduction of stresses and moments in case of supports settlement, and support condition type F and G are very detrimental. Present work provides a good source of information on the parameters membrane stresses, moments, shear stresses and deflection in a parabolic cylindrical shell roof.

***Keywords*— Parabolic Cylindrical Shell, Membrane Stresses, Moments, Shear Stresses, Deflection.**

I. INTRODUCTION

Concrete shells have been widely used for roofing large column-free areas and have been constructed in various countries for almost half a century. Any shell of given dimensions is normally designed for a given external loading under the assumption of unyielding corner supports. In cases where the shell is supported on flexible beams or when the soil conditions under the column supports are relatively poor and varying, the support points may be subjected to differential settlements. Changes in the supports can cause additional stresses in the structure, and local damage or total failure may occur if the new stress pattern is in excess of permissible values.

Fig. 1 Shell roof

The uppermost part of a constructed structure is called roof, provided to protect the building from rain, wind, snow, sun etc. It protects human beings, animals and also materials kept inside building. The roof should be strong, stable, weather proof and safe against fire and disaster.

The primary function of the roof system is to protect against and manage the weather elements, particularly precipitation, thereby protecting the interior and structural components of the home.

In addition to protecting the interior elements of the home the roof components should also be designed, in conjunction with the gutters and downspouts, to direct rainwater and runoff away from the foundation area, compaction and water entering the basement area.

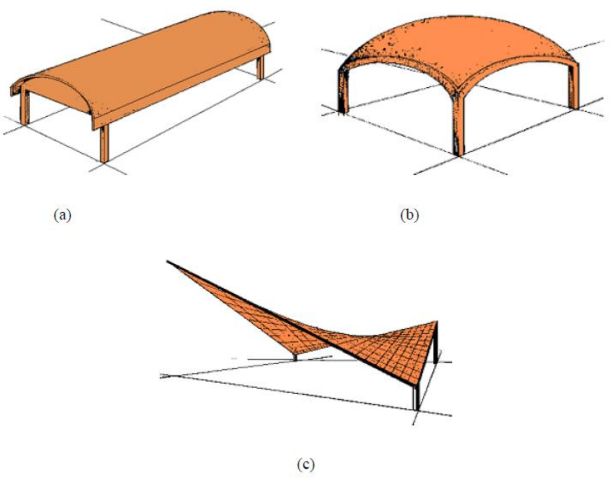


Fig. 2 Examples of shell roof

Shell surfaces provide a structurally efficient solution to the problem of carrying roof loads over long spans. These three-dimensional forms owe their efficiency to the translation of applied loads into tensile and compressive stress, as well as shear stress, in the plane of their surface. These are termed as membrane stresses. A shell can be defined as a curved slab whose thickness is very small compared to the other dimensions of the shell. Alternatively, a shell can also be defined as body that is bounded by two closely spaced curved surfaces. The middle surface, which is the locus of points that are equidistant from the two bounding surfaces, defines the shape of the shell. The thickness of the shell at a given point is the distance between the two bounding surfaces measured along the normal to the middle surface passing through a point.

II. Problem Formulation & Analysis

The purpose of the present work is to study the behaviour of cylindrical shell roof due to support settlement under static loads. The characteristics of the cylindrical shell roof subjected to the support settlement suggest that additional measures for guiding the conception and condition of supports of these structures are needed. For this purpose following details are used:

In this study the single bay, single span cylindrical shell roof is used.

Span of the shell roof is 12 m.

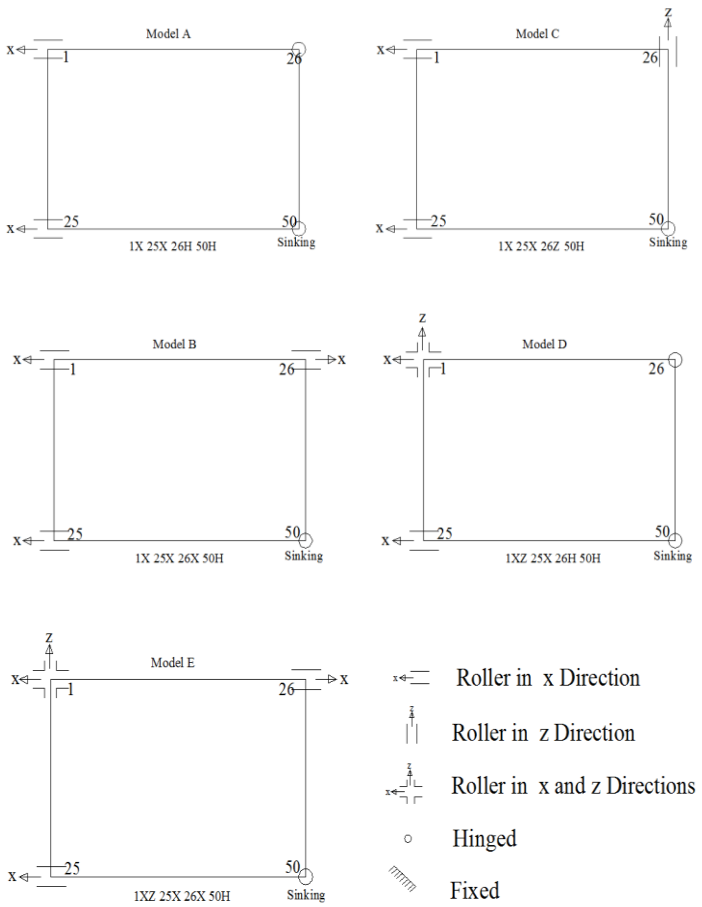
Length 18 m (i.e. plan area 12m X 18m).

Edge beam 400mm X 1000mm.

Thickness 200mm.

Shell is supported by four columns through edge beams.

The support conditions for allowing the transverse displacement of the supports in the horizontal plane due to the static loading and support settlement, in the different directions are shown in fig. 3.



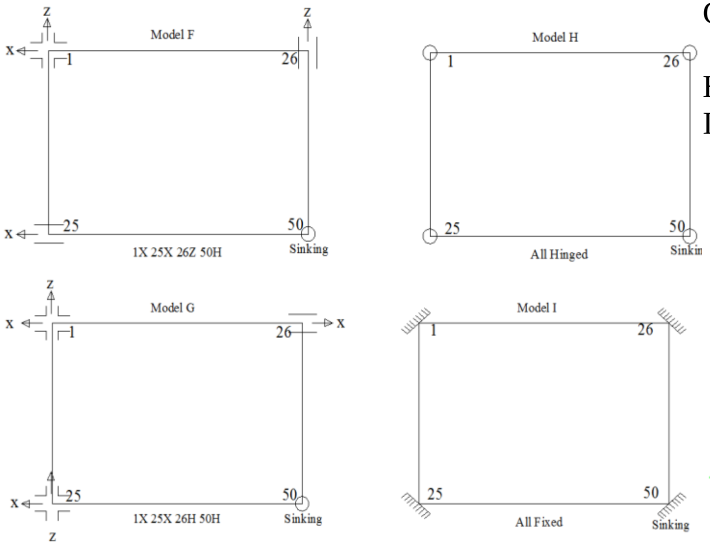


Fig. 3 Support conditions considered

For the analysis various settlements is considered in the cylindrical shell roof. Different values of settlement (sinking) provided are 5mm, 10mm, 15mm and 20mm.

Also the cylindrical shell is analyzed for different rises and the values of rises provided are 3m, 3.5m and 4m.

STAAD Pro v8i software is used as a tool for analyzing the problem.

In order to achieve the objectives of the study the following methodology is proposed:

In this attempt, a cylindrical shell roof model is categorized under nine different support conditions and is analyzed with settlement and without settlement having different rises, those support conditions are of following types:

A. Two supports roller in X direction and two supports hinged
B. Three supports roller in X direction and one support hinged
C. Two supports roller in X direction, one support roller in Z direction and one support hinged
D. One support roller in XZ direction, one support roller in X direction and two supports hinged
E. One support roller in XZ direction, two supports roller in X direction and one support hinged
F. One support roller in XZ direction, one support roller in X direction, one support roller in Z direction and one support hinged
G. Two supports roller in XZ direction and two supports hinged
H. All supports are fixed
I. All supports are hinged

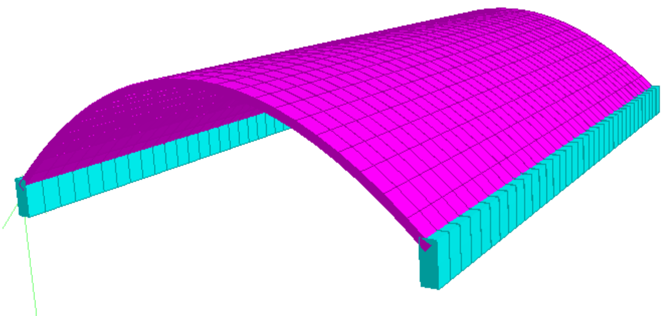


Fig. 4 Model of parabolic cylindrical shell roof

III. Results And Discussions

The study examines the performance of different types of shell roofs having different support conditions considered with and without settlement. As it is discussed earlier that use of rollers at the supports under settlement relaxes the extra moment and stresses, therefore, in present work ordinary supports are replaced by allowing the horizontal displacement in various directions and behaviour of these supports is studied with and without settlement.

To study the effectiveness of all these support conditions and the rise of shell the membrane stresses, moments, shear stresses, and deflections are worked out. The results organized in various tables and figures are discussed in detail.

The discussion are made by considering settlement of shell roof supports 20mm and those without settlement, from tables and graphs.

Effect of settlement on different types of support conditions:

From the results observed for all the nine models considered with settlement is compared to without settlement models and the observations are discussed:

In case of membrane stresses Nx, in models B, C, E, F and G there is observed percent increase with 2, 7.5, 0.8, 10.47 and 0.39 respectively. Whereas, in models A, D, H and I there is percent decrease with 55, 1.07, 39.75 and 19.61 respectively.

In case of membrane stresses Ny, in models A, B, C, F, G, and I there is observed percent increase with 5.73, 4.81, 7.88, 27.5, 8.3 and 18.02 respectively. Whereas, in models D, E and H there is percent decrease with 1.67, 12.08 and 29.23 respectively.

In case of membrane stresses Nxy, in models B, C, E and G there is observed percent increase with 1.89, 7.52, 0.5 and 7.96 respectively. Whereas, in models A, D, F, H and I there is percent decrease with 1.38, 1.38, 2.23, 39.58 and 17.8 respectively.

In case of moments Mx, in models A, B, D, E and F there is observed percent increase with 212.6, 3.71, 5.02, 1.4 and 3.68 respectively. Whereas, in models C, G, H and I there is percent decrease with 8.61, 0.51, 75.43 and 10.8 respectively.

In case of moments My, in models A, D, E and F there is observed percent increase with 178.2, 4.69, 0.27 and 1.71 respectively. Whereas, in models B, C, G, H and I there is percent decrease with 8.65, 16.11, 0.96, 35.82 and 0.57 respectively.

In case of shear stresses Qx, in models A, C, E, F and G there is observed percent increase with 80.67, 9.29, 0.13, 3.26 and 0.13 respectively. Whereas, in models B, D, H and I there is percent decrease with 2.35, 5.78, 53.77 and 15.13 respectively.

In case of shear stresses Qy, in models A, C, E and F there is observed percent increase with 124.5, 7.58, 0.21 and 4.61 respectively. Whereas, in models B, D, G, H and I there is percent decrease with 6.02, 11.24, 0.18, 62.91 and 28.66 respectively.

In case of deflection S, in models A, B, D, E, F and G there is observed percent increase with 1.03, 4.55, 42.14, 7.99, 8.14 and 6.19 respectively. Whereas, in models C, H and I there is percent decrease with 23.43, 52.38 and 17.29 respectively.

Effect of 3m rise on shell roof having different settlements:

It is observed that as the settlement increases from 0mm to 20 mm the values of all the different study parameter membrane stresses, moments, shear stresses and deflection also increases. The results observed are discussed in detail:

For the shell roof having 3m rise membrane stresses Nx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 3.98, 5.65, 7.28, 8.92 and 10.6 respectively. In case of membrane stresses Ny these results are observed as 1.89, 1.41, 1.87, 2.34 and 2.81 respectively. In case of membrane stresses Nxy these results are observed as 1.3, 1.84, 2.36, 2.89 and 3.42 respectively.

For the shell roof having 3m rise moments Mx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 13.12, 38.66, 63.69, 89.03 and 111.6 respectively. In case of moments My these results are observed as 7.93, 10.42, 13.72, 17.06 and 20.44 respectively.

For the shell roof having 3m rise shear stresses Qx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 0.32, 0.56, 0.78, 1.01 and 1.25 respectively. In case of shear stresses Qy these results are observed as 0.89, 0.18, 0.28, 0.39 and 0.5 respectively.

For the shell roof having 3m rise deflection S for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 7.71, 10.21, 15.26, 22.99 and 30.83 respectively.

Effect of 3.5m rise on shell roof having different settlements:

It is observed that as the settlement increases from 0mm to 20 mm the values of all the different study parameter membrane stresses, moments, shear stresses and deflection also increases. The results observed are discussed in detail:

For the shell roof having 3.5m rise membrane stresses Nx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 4.17, 5.93, 7.6, 9.25 and 10.9 respectively. In case of membrane stresses Ny these results are observed as 1.33, 1.45, 1.91, 2.36 and 2.8 respectively. In case of membrane stresses Nxy these results are observed as 1.36, 1.93, 2.46, 2.98 and 3.49 respectively.

For the shell roof having 3.5m rise moments Mx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 14.55, 42.04, 69.91, 97.31 and 124.2 respectively. In case of moments My these results are observed as 8.85, 11.76, 15.47, 19.15 and 22.77 respectively.

For the shell roof having 3.5m rise shear stresses Qx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 0.32, 0.58, 0.82, 1.06 and

1.29 respectively. In case of shear stresses Qy these results are observed as 0.09, 0.21, 0.33, 0.45 and 0.46 respectively.

For the shell roof having 3.5m rise deflection S for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 8.19, 11.31, 18.18, 26.84 and 35.29 respectively.

Effect of 4m rise on shell roof having different settlements:

It is observed that as the settlement increases from 0mm to 20 mm the values of all the different study parameter membrane stresses, moments, shear stresses and deflection also increases. The results observed are discussed in detail:

For the shell roof having 4m rise membrane stresses Nx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 3.96, 5.65, 7.21, 8.61 and 10.11 respectively. In case of membrane stresses Ny these results are observed as 1.33, 1.37, 1.78, 2.15 and 2.51 respectively. In case of membrane stresses Nxy these results are observed as 1.3, 1.83, 2.32, 2.75 and 3.18 respectively.

For the shell roof having 4m rise moments Mx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 14.54, 40.23, 67.97, 92.89 and 117.1 respectively. In case of moments My these results are observed as 9.23, 12.25, 16.03, 19.43 and 22.74 respectively.

For the shell roof having 4m rise shear stresses Qx for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 0.29, 0.54, 0.77, 0.98 and 1.18 respectively. In case of shear stresses Qy these results are observed as 0.08, 0.22, 0.34, 0.45 and 0.56 respectively.

For the shell roof having 4m rise deflection S for settlements 0mm, 5mm, 10mm, 15mm and 20mm are observed as 7.96, 11.32, 19.07, 26.99 and 34.63 respectively.

IV. CONCLUSIONS

Within the scope of present work following conclusions are drawn:

1. If we allow the displacement in horizontal plane, membrane stresses in x direction decreases in support conditions type B, F, and G and in other support conditions it increases.
2. If we allow the displacement in horizontal plane, membrane stresses in y direction increases in all types of support conditions except type B.
3. If we allow the displacement in horizontal plane, membrane stresses in xy plane increases in support conditions type A, C, D, E and G but in support conditions type B and type F it decreases.
4. When we allow the displacement in horizontal plane, moment along the curve increases in support conditions type C, D, E, F and G but in support conditions type A and type B it decreases.
5. When we allow the displacement in horizontal plane, bending moment along the axis increases in all types of support conditions but increases insignificant for support conditions type A and B while it is considerable for support conditions type C and D. For support conditions type E, F and G, moment along axis increases tremendously.
6. When we allow the displacement in horizontal plane, shear stresses in x and y directions both increases for support conditions type C, D, E, F and G but in support conditions type A and type B it decreases.
7. If we allow the displacement in horizontal direction, the deflection of the shell roof increases in all the types of support conditions.

After observing the overall performance of different support conditions as per objectives of the study, it is observed that the support condition type B is very helpful in reduction of stresses and moments in case of supports settlement, and support condition type F and G are very detrimental.

REFERENCES

1. Ancy Francis, Ramadass S, Nimya Rose Joshuva, 8 August, (2016), "*Influence of Increasing Live Load in Stress on Hyperbolic Paraboloid Shell Roof*", Volume 5, Issue 8, Paper ID: ART20161252, International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064.
2. Syed Jalaludeen Shah, Sameena Khalid, 10-11 June, (2015), "*Seismic Behavior of Inverted Spherical Shell Foundations*", International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue International Conference on Technological Advancements in Structures and Construction "TASC- 15",
3. Hien Luong T. Nguyen, 6 August, (2009), "*Buckling under external pressure of cylindrical shells with variable thickness*", International Journal of Solids and Structures 46 (2009) 4163–4168, Elsevier.
4. Anders M. Hagglund, Peter D. Folkow, (2008), "*Dynamic cylindrical shell equations by power series expansions*", Proceedings of the 6th International Conference on Computation of Shell and Spatial Structures

IASS-IACM 2008: “Spanning Nano to Mega”, Cornell University, Ithaca, NY, USA, John F. ABEL and J. Robert COOKE (eds.).

5. Karl Mauritsson, Anders Bostro M., Peter D. Folkow, (2008), “*Dynamic equations for a homogenous, fully anisotropic, elastic plate*”, Proceedings of the 6th International Conference on Computation of Shell and Spatial Structures IASS-IACM 2008: “Spanning Nano to Mega”, Cornell University, Ithaca, NY, USA, John F. ABEL and J. Robert COOKE (eds.).
6. Pierino Lestuzzi, Souad Sellami, Youssef Belmouden, 28-31 May, (2008), “*A seismic analysis of a modular shell system*”, Proceedings of the 6th International Conference on Computation of Shell and Spatial Structures IASS-IACM 2008: “Spanning Nano to Mega”, Cornell University, Ithaca, NY, USA, John F. ABEL and J. Robert COOKE (eds.).
7. R. Lo Frano and G. Forasassi, 7 February, (2008), “*Buckling of Imperfect Thin Cylindrical Shell under Lateral Pressure*”, Hindawi Publishing Corporation Science and Technology of Nuclear Installations Volume 2008, Article ID 685805, 8 pages.
8. Shadi Ostovari Dailamani, James G. A. Croll, (2008), “*Earthquake analysis of cylindrical roof shells*”, Proceedings of the 6th International Conference on Computation of Shell and Spatial Structures IASS-IACM 2008: “Spanning Nano to Mega”, Cornell University, Ithaca, NY, USA, John F. ABEL and J. Robert COOKE (eds.).
9. Shadi Ostovari Dailamani, James G. A. Croll, (2008), “*Interpretation of seismic response of cylindrical roof shells*”, Proceedings of the 6th International Conference on Computation of Shell and Spatial Structures IASS-IACM 2008: “Spanning Nano to Mega”, Cornell University, Ithaca, NY, USA, John F. ABEL and J. Robert COOKE (eds.).
10. George P. Kouretzisa, George D. Bouckovalasa, Charis J. Gantes, 5 February, (2006), “*3-D shell analysis of cylindrical underground structures under seismic shear* (S) wave action”. Soil Dynamics and Earthquake Engineering, Elsevier.
11. L. Zhang and Y. Xiang, (2005), “*Vibration of Open Cylindrical Shells with Stepped Thickness Variations*”, International Journal of Solids and Structures 43 (2006) 3705–3722, Elsevier.
12. Maloy K. Singha, L. S. Ramachandra, and J. N. Bandyopadhyay, (2004), “*Nonlinear Response of Laminated Cylindrical Shell Panels Subjected to Thermo Mechanical Loads*”.
13. M. Pircher, (2000), “*Medium-Length Thin-Walled Cylinder Under Wind Loading—Case*”.
14. P. R. Heyliger, and A. Jflani, (1992), “*Free Vibrations of Laminated Anisotropic Cylindrical Shells*”.
15. B. Moradi and I. D. Parsons, (1992), “*Dimensional Analysis of Buckling of Stiffened Composite Shells*”.
16. Sidney H. Simmonds, (1989),” *Effect of Support Movement on Hyperbolic Paraboloid Shells*”.
17. S. Bosniakowski and R. Bergmann, (1988), “*Analysis of Continuous Circular Cylindrical Shells”*.
18. Demetres Briassoulis, (1988). “*Integrated Physical Model for Closed Thin-Walled Cylindrical Shells*”.