NON LINEAR BUCKLING ANALYSIS OF HYPERBOLOID CONCRTE GRID

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ABSTRACT

Explanatory hyperboloid shells are most effective shell which permits an expansive number of elective pressure ways and gives the ideal structure for transmission of a wide range of burden types. They are broadly utilized as material unit for building and modern structures. Because of wide utilization of shells as material component it is important to break down a shell component all the more definitely utilizing realized strategy like limited component technique. In this investigation the endeavor has been made to break down hyperboloid solid lattice utilizing SAP2000 programming.

For the study, considered hyperboloid concrete grid with three different spans 18m, 50m and 100m with six different rise to span ratios (h/l= 0.05, h/l= 0.08, h/l= 0.12, h/l= 0.16, h/l= 0.33). The comparison of different span to rise ratios results is made by plotting the results in graphical form. It is concluded that the stresses of hyperboloid concrete grid has in considerable limit. Free vibration analysis is performed to find out the natural time period to avoid the resonance in earth quake.

INTRODUCTION:

Solid shell structures, frequently alluded to as 'meager shells' are reasonable auxiliary components for building roomy frameworks. They are regularly conservative and appropriate answer for various office structures, for example, water tanks, substantial range rooftops, regulation structures, and storehouses. Burdens following up on the outside of shell structures are chiefly conveyed by the alleged film activity. This is a general condition of pressure comprises of the in-plane typical and shear pressure resultants as it were. In examination, other basic structures, for example, pillars and plates convey loads following up on their surfaces by twisting activity, which can be said is fundamentally less proficient. Normally the in-plane worries in shells are low to such an extent that with a generally little thickness it is conceivable to range over substantial separations. What's more, solid shell structures can have different shapes and geometries and that has added to them regularly considered as outwardly alluring.

Shell structures are exceptionally intriguing because of their noteworthy solidarity to-weight proportions. They can length over vast territories, while having an especially less thickness. This is basically because of their structure based auxiliary conduct. The geometry, that is their underlying arch, alongside the limit conditions and sort of stacking, manages the manner in which they exchange load or the manner in which they bomb (in the event that the heap surpasses their heap conveying limit). Shells display film like conduct which will be clarified further in this theory. The excellence of shells lies in the way that an originator can structure the shell as meager as could be expected under the circumstances, even within the sight of burdens that upset its trademark film conduct. The shell can bind this unsettling influence to locales which can be structured or upgraded independently.

The properties referenced above are featured by the different shell structures in presence today. Shells give a way to acquire an aesthetical and fundamentally proficient structure. They can take a few shapes and structures, which lie helpless before the fashioner. Combined with the way that they take up less material for development, shells turned out to be progressively famous over the most recent seven decades. From that point forward there have been a few blocks in their development, however these challenges are a relic of days gone by. Improvements of cutting edge investigation techniques, and new inventive advancements in the development field, have prompted resurgence in shell plan. Thus, new plans for shells are picking up conspicuousness, some of which were incomprehensible before.

A shell can be characterized as a body that is limited by two surfaces parallel to its center surface, and is distorted in any self-assertive way. This is valid for shells of a steady thickness, which will for the most part be considered in this investigation. For the most part any surface which is bended in at least one bearings can be considered as a shell surface. This definition features the assorted variety of surfaces which can be portrayed as shells. Thus, there are distinctive methods for arranging shell surfaces. One specific method for characterizing shell surfaces is as indicated by their Gaussian ebb and flow. The Gaussian bend of a bended surface is a result of the two main ebbs and flows.

$$Kg = K_1 \cdot K_2 = (1/ r_1) \times (1/ r_2)$$

Where,

r1 and r2 are the relating radii of ebbs and flows.

The range of ebb and flow of a bend at a point is a proportion of the sweep of the roundabout circular segment that best approximates the bend by then [6]. The primary radii of arches are hence without a doubt the most extreme and least of the sweep of ebbs and flows.

In view of the result of the above equation shell surfaces can be classified into three sorts.

(a) A positive Gaussian arch portrays a great surface

(b) A negative Gaussian arch portrays an enemy of great surface

(c) While as round and hollow or plane surfaces have a Gaussian ebb and flow of zero.

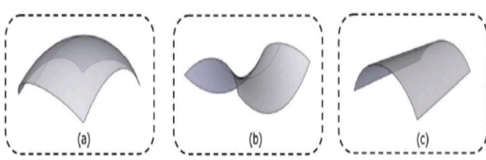


Fig.1.1 Typical Gaussian ebb and flow

` From Fig1.1 the viewpoint of auxiliary building, the primary contrast between these three sorts is the proliferation of limit impacts in the shell. The impacts will in general sodden snappiest for shells of positive Gaussian ebb and flow and slowest for shells of negative Gaussian ebb and flow.

Another method for depicting shell surfaces is as indicated by how the surfaces are created. Utilizing this technique, in 1980 Heinz Isler characterized shell surfaces into Geometric, Structural and Sculptural surfaces. Geometric shells are all around characterized numerically and which subsequently can decently be effectively determined systematically. These kind of shells were very noteworthy in the advancement of shell structures at the occasions where PC helped count were not accessible.

2.1. History of the previous research

Lobachevski [22] (1929) Hyperbolic structures have a negative Gaussian curvature, meaning they curve inward rather than outward or being straight. As doubly ruled surfaces, they can be made with a lattice of straight beams, hence are easier to build than curved surfaces that do not have a ruling and must instead be built with curved beams.

The lattice grid structure was a unique structure of its time, with an unprecedented shape and construction properties. According to Cooper, the idea of such a new structure came directly from an imaginary hyperboloid geometry, invented by him.

L Kollar et al [10] (1995) The buckling load of shells constructed in homogeneous elastic fabric sharply decreases with growing preliminary imperfection amplitude w0. This decrease is due to the value of the imperfection itself and the eccentricity e0 of the compressive force resulting from this imperfection. In the case of homogeneous material shells, the stiffness of the shell move segment is practically unbiased of the eccentricity, so it is sufficient to investigate only the lower of the buckling load with increasing imperfection alone. However, the plastic deformation; the load bearing potential furnished with the aid of the shell wall; and the stiffness of the cracked strengthened concrete cross phase are closely dependent on the eccentricity of the everyday pressure implemented. The have an impact on of the imperfection w0 and that of the eccentricity e0 of the normal pressure can be handled one after the other. However, a courting between both can be said.

Mehmet.H.Omurtag [7] (1996) Evolved an isoperimetric rectangular combined finite detail is for the evaluation of hypes. The principle of shallow skinny hyperbolic parabolic shells is based totally on Kirchhoff–Love's speculation and a new useful is obtained using the Gateaux differential. This functional is written in operator shape and is proven to be a capacity. Proper dynamic and geometric boundary situations are obtained. Applying version techniques to this useful, the HYP9 finite detail matrix is received in an express shape. Since most effective first-order derivatives arise in the purposeful, linear form features are used and a C0 conforming shell element is provided. Variation of the thickness is likewise blanketed into the system without spoiling the simplicity. The method is relevant to any boundary and loading condition. The HYP9 element has 4 nodes with 9 Degrees of Freedom (DOF) consistent with node—3 displacements, three in plane forces and bending, one torsional second (4 × nine). The overall performance of this easy, and elegant shell element, is established via making use of it to some check troubles existing inside the literature. Since the detail matrix is acquired explicitly, there's an crucial keep of computer time.

Ljubica Velimirovic [6] **(1998)** A hyperbolic paraboloid, handled from the constructional and mathematical components, is analyzed in his paper. In the constructional feel, it is a skinny shell of a superb bearing potential and wide usability in spatial systems, both as a complete shape or in parts. In the mathematical feel, it is handled as a geometrical floor on which it is viable to decide the rotation area and the field of infinitesimal deformations, and it's far inflexible.

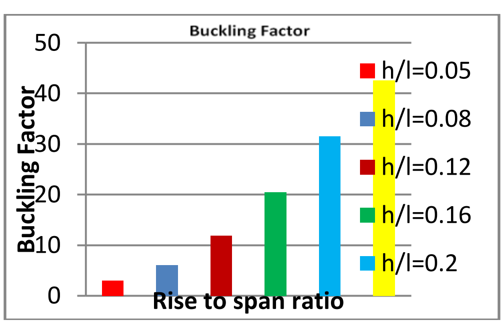
3.1 BUCKLING ANALYSIS OF CONCRETE GRID STRUCTURE OF HYPERBOLOID SHELL GRID 4.1 18 m SPAN CONCRTE GRID

Table 3.1 shows the buckling load of 18m span concrete grid structure of hyperboloid shape for different rise to span ratios for 18m span.

Table 3.1 Buckling factors of 18m span concrete grid structure for different h/l ratios.

Rise to span Ratio(h/l)	Buckling factor	Applied load kN/m^2	Critical load kN/m^2
0.05	3.028	3	9.084
0.08	4.026	3	12.078
0.12	5.934	3	17.802
0.16	7.842	3	23.526
0.2	9.521	3	28.563
0.33	10.631	3	31.893

Graph 4.1 Buckling Factor of hyperboloid concrete grid shell of span 18m with differential h/l ratio.



Graph 4.1 shows the buckling factor of the hyperboloid concrete grid shell of span 18m with different rise to span ratios. From the graph 4.1, it is observed that hyperboloid concrete grid shell with h/l=0.33 having higher buckling factor when compare to other considered h/l ratios. Observed an increase in buckling factor by 1.3, 2, 2.6, 3.1 and 3.5 times for h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to buckling factor of hyperboloid shell with h/l=0.05.

4.2 BUCKLING ANALYSIS OF CONCRETE GRID STRUCTURE OF HYPERBOLOID SHELL GRID

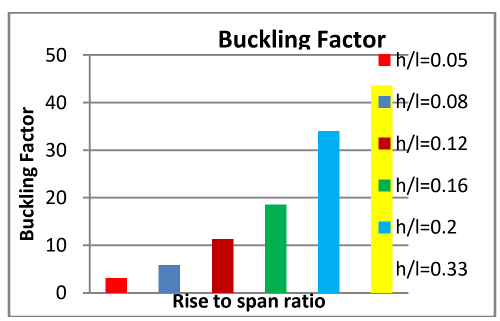
4.2 50m SPAN CONCRETE GRID

Table 4.2 shows the buckling load of 50m span hyperboloid concrete grid structure of hyperboloid shape for different rise to span ratios for 50m span.

Table 4.2 Buckling factors of 50m span concrete grid structure for different h/l ratios.

Rise to span Ratio(h/l)	Buckling factor	Applied load kN/m^2	Critical load kN/m^2
0.05	3.029	3	9.087
0.08	4.905	3	14.715
0.12	7.021	3	21.063
0.16	9.93	3	29.79
0.2	11.44	3	34.32
0.33	12.42	3	37.26

Graph 4.2 Buckling Factor of hyperboloid concrete grid shell of span 50m with differential h/l ratio



Graph 4.2 shows the buckling factor of the hyperboloid shell of span 50m with different rise t o span ratios. From the Graph 4.2, it is observed that hyperboloid shell with h/l=0.33 having higher buckling factor when compare to other considered h/l

ratios. Observed an increase in buckling factor by 1.6, 2, 2.8, 3.4 and 3.7 times for h/l=0.08, h/l=0.12, h/l=0.16, h/l=0.20 and h/l=0.33 respectively when compared to buckling factor of hyperboloid shell with h/l=0.05.

4.3 BUCKLING ANALYSIS OF CONCRETE GRID STRUCTURE OF HYPERBOLOID SHELL GRID

4.3 100m SPAN CONCRETE GRID

Table 4.3 shows the buckling load of 100m span concrete grid structure of hyperboloid shape for different rise to span ratios for 100m span.

Table 4.3 Buckling factors of 100m span concrete grid structure for different h/l ratios.

Rise to span Ratio(h/l)	Buckling factor	Applied load kN/m^2	Critical load kN/m^2
0.05	3.084	3	9.252
0.08	4.807	3	14.421
0.12	6.212	3	18.636
0.16	8.551	3	25.653
0.2	10.34	3	31.02
0.33	11.365	3	34.095

4.4 COMPARISON OF NORMALIZED FACTOR FOR DIFFERENT SPAN

Table 4.4 shows the critical load information about concrete grid structure different rise to span ratio for 18m, 50m, and 100m span respectively. Here 'n' loads are divided by initial buckling load. This is useful to find out the critical load improvement in the structure.

Table 4.4 Critical load of structure with rise to span ratio for 18 m span

Rise to span ratio	Buckling factor	Applied load	Critical load	Normalized
0.05	3.028	3	9.084	1.0
0.08	4.026	3	12.078	1.3
0.12	5.934	3	17.802	2.0
0.16	7.842	3	23.526	3.0
0.2	9.521	3	28.563	3.1
0.33	10.631	3	31.893	3.5

Table 4.5 Critical load of structure with rise to span ratio for 50 m span

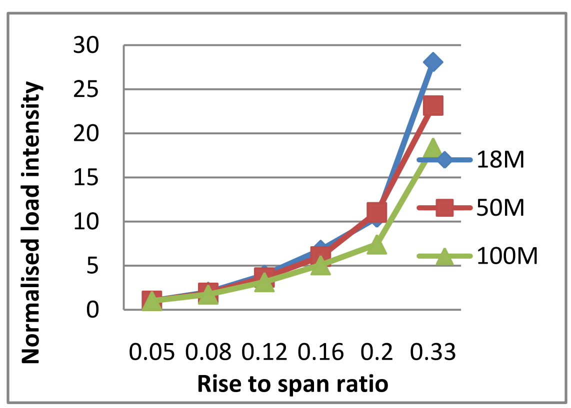
Rise to span ratio	Buckling factor	Applied load	Critical load	Normalized
0.05	3.084	3	9.252	1
0.08	4.807	3	14.421	1.5
0.12	6.212	3	18.636	2.0
0.16	8.551	3	25.653	2.8
0.2	10.34	3	31.02	3.3
0.33	11.365	3	34.095	3.7

Table 4.6 Critical load of structure with rise to span ratio for 100 m span

Rise to span ratio	Buckling factor	Applied load	Critical load	Normalized
0.05	3.029	3	9.087	1
0.08	4.905	3	14.715	1.6
0.12	7.021	3	21.063	2.3
0.16	9.93	3	29.79	3.3
0.2	11.44	3	34.32	3.8
0.33	12.42	3	37.26	4.1

The Graph 4.4 shows the comparison of normalized factors for hyperboloid concrete grid structure for different rise to span ratios

Fig 4.4 Comparison of Normalized load intensities and Rise to span ratio

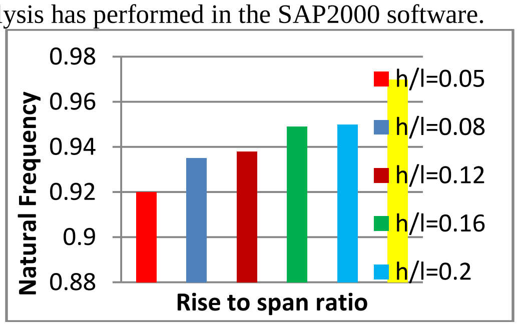


Graph 4.4 shows the Normalized load intensities Vs Rise to span ratios for different spans of hyperboloid concrete grid structure.

From the Graph 4.4 it is observed maximum normalized load intensity at higher rise to span ratio (h/l=0.33) for all the considered spans of hyperbolic concrete grid structure. Observed increase in normalized load intensities by 3.5, 3.7 and 4.1 times at h/l = 0.33 for 18m, 50m, 100m spans respectively when compare to normalized load intensities at h/l = 0.05 span.

4. 5 NATURAL FREQUENCY RESULTS FROM 18m SPAN CONCRETE GRID SHELL

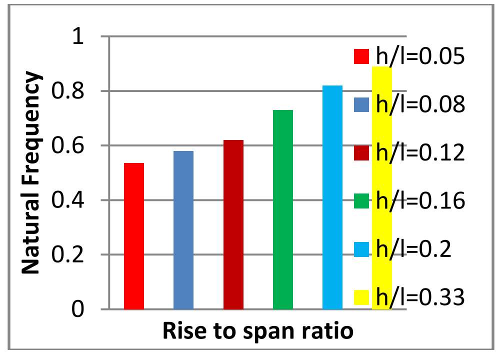
Resonance is a main parameter in steel or concrete structures. If the natural frequencies are equal to artificial frequencies such as seismic condition, the structure may be failure due to resonance. That's way finding the natural frequency is main thing in steel or concrete structures. To find the natural frequencies modal analysis has performed in the SAP2000 software.



Graph 4.5 Natural Frequency of hyperboloid concrete grid shell of span 18m with differential h/l ratio.

Graph 4.5 shows the natural frequency of the hyperboloid concrete grid shell of span 18m with different rise to span ratios. From graph 4.5, it is observed that hyperbolic concrete grid shell with h/l=0.08 having higher natural frequency when compare to other considered h/l ratios. Observed an increase in the natural frequency by 5.4, 3.7, 3.4, 2.2 and 2.1 times for h/l=0.05, h/l=0.08 h/l=0.12,h/l=0.16 and h/l=0.20, respectively when compared to natural frequency of hyperboloid shell with h/l=0.33

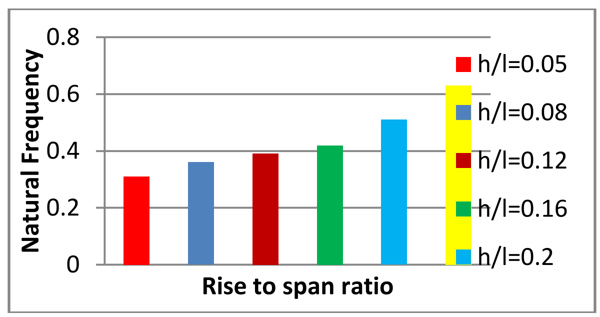
4.6 NATURAL FREQUENCY RESULTS FROM 50 m SPAN CONCRETE GRID SHELL



Graph 4.6 Natural Frequency of hyperboloid concrete grid shell of span 50m with differential h/l ratio.

Graph 4.6 shows the natural frequency of the hyperboloid concrete grid shell of span 50m with different rise to span ratios. From Graph 4.6, it is observed that hyperbolic concrete grid shell with h/l=0.33 having higher natural frequency when compare to other considered h/l ratios. Observed an increase in the natural frequency by 8.9, 6.7, 5.6, 3.2 and 1.8 times for h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to natural frequency of hyperboloid shell with h/l=0.33.

4.7 NATURAL FREQUENCY RESULTS FROM 100 m SPAN CONCRETE GRID SHELL



Graph 4.7 Natural Frequency of hyperboloid concrete grid shell of span 100m with differential h/l ratio.

Graph 4.7 shows the natural frequency of the hyperboloid concrete grid shell of span 100m with different rise to span ratios. From Graph 4.7, it is observed that hyperbolic concrete grid shell with h/l=0.33 having higher natural frequency when compare to other considered h/l ratios. Observe an increase in the natural frequency by 10.3, 7.5, 6.1, 5.0 and 2.3 times for h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to natural frequency of hyperboloid shell with h/l=0.33.

5. CONCLUSIONS

Analysis is performed on hyperboloid shell concrete grid structure of three different spans (i.e., 18, 50 and 100) with six different rise to span ratios (h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16, h/l=0.33). Following are the conclusions drawn from the study.

1. For 18m span, hyperboloid shell grid of h/l ratio 0.33 is performed well when compare to other considered h/l ratios. Observed an increase in buckling factor by 1.3, 2, 2.6, 3.1 and 3.5 times for h/l=0.08, h/l=0.12, h/l=0.16, h/l=0.20 and h/l=0.33 respectively when compared to buckling factor of hyperboloid shell with h/l=0.05.

2. For 50m span, hyperboloid shell grid of h/l ratio 0.33 is performed well when compare to other considered h/l ratios. Observed an increase in buckling factor by 1.6, 2, 2.8, 3.4, and 3.7 times for h/l=0.08, h/l=0.12, h/l=0.16, h/l=0.20 and h/l=0.33 respectively when compared to buckling factor of hyperboloid shell with h/l=0.05.

3. For 100m span, hyperboloid shell grid of h/l ratio 0.33 is performed well when compare to other considered h/l ratios. Observed an increase in buckling factor by 1.6, 2.3, 3.3, 3.8, and 4.1 times for h/l=0.08, h/l=0.12, h/l=0.16, h/l=0.20 and h/l=0.33 respectively when compared to buckling factor of hyperboloid shell with h/l=0.05.

4. The natural frequency of the hyperboloid shell of span 18m with different rise to span ratios. It is observed that hyperbolic shell with h/l=0.33 having higher natural frequency when compare to other considered h/l ratios. Observed an increase in the natural frequency by 5.4, 3.7, 3.4, 2.2 and 2.1 times for h/l=0.05, h/l=0.08 h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to natural frequency of hyperboloid shell with h/l=0.33.

5. The natural frequency of the hyperboloid shell of span 50m with different rise to span ratios. It is observed that hyperbolic shell with h/l=0.33 having higher natural frequency when compare to other considered h/l ratios. Observed an increase in the natural frequency by 8.9, 6.7, 5.6, 3.2 and 1.8 times for h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to natural frequency of hyperboloid shell with h/l=0.33.

6. The natural frequency of the hyperboloid shell of span 100m with different rise to span ratios. It is observed that hyperbolic shell with h/l=0.33 having higher natural frequency when compare to other considered h/l ratios. Observed an increase in the natural frequency by 8.9, 6.7, 5.6, 3.2 and 1.8 times for h/l=0.05, h/l=0.08, h/l=0.12, h/l=0.16 and h/l=0.20 respectively when compared to natural frequency of hyperboloid shell with h/l=0.33.