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COMPARATIVE ANALYSIS OF SQUARE & TRIANGULAR GRID PATTERN GRIDSHELL STRUCTURE

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ABSTRACT

Gridshell is a structure that gets its strength from its double curvature. A freeform shell structure comprised of a network of continuous pieces over its span is known as an elastically bent gridshell. Straight members are used to create a two-dimensional mat, which will then be twisted into a three-dimensional double curved shell. Gridshell designs are chosen not just for their performance, efficiency, or cost, but also for their architectural shape. A grid shell can be used to produce stunning patterns and unique structures. You've got the spatial characteristics in count, which are important for the building's usage. Gridshell has a self-bearing shape that allows for flexibility in the interior area. The meshes in a gridshell are first explored in the research to determine the structure's overall behavior. In gridshell design, the mesh approach is crucial because it provides the designer more control over the structural reaction.

Keywords: Gridshell Structure, Seismic Analysis, Time-History Analysis, Staad-Pro, Triangular Grid, Square Grid.

I. INTRODUCTION

A shell, to put it simply, is a form of structure that transmits loads using membrane forces, or in-plane stresses, instead of bending and shear forces. A gridshell is separated into a grid of smaller components, whereas a concrete shell is a consistent surface. The kinematic method is one approach to make gridshells. It involves flattening a rectangular or polynomial grid and then reshaping it into shape by pushing portions of the grid together or lifting them. The Gridshell are the most difficult form of the structure to analyses due to is complex behavior. As a results of which the Computer based design is the best tool.

Figure 1: Toledo gridshell 2.0, Naples, 2014.

Shells were formed using the hanging chain concept prior to the development of CAD techniques. The inverted shell shape is created using 3D chain, and the positions of the nodes are shot using stereo cameras to determine the location of the members, resulting in the final form (Happold & Liddell, 1975). Many tools may now be used to construct, locate, and even enhance gridshells with the assistance of CAD.

Mathematical representations of physics may be utilized to build gridshells or shells with confidence utilizing computers. Form finding can be more efficient and successful using computer-assisted procedures than with hanging chains. Boundary conditions, load cases, material characteristics, and displacement constraints are all taken into account in computer models to arrive at the appropriate geometry.

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II. OBJECTIVES

The project's main goal was to investigate the geometric compatibility of gridshell structures under dynamic loads. Stresses, Deflection, Displacement, Shear, Stiffness, Time history analysis, and other parameters were compared between gridshells. As previously stated, the project's goal is to_

1) The Gridshell along with the different grid patterns were compared under the Dynamic loadings (i.e. Seismic loading).

2) To analyze the Gridshells using Staad-Pro Connect Edition Software.

3) To increase the Stiffness of gridshell by diagonal stiffness, which can be modelled and achieved in various ways such as_

a. Adding diagonal bracing, either by adding cable elements or struts.
b. Smearing a continuous shear stiff covering onto the grid.

III. METHODOLOGY

1) Firstly modelling of Gridshell structure with different Grid Forms (Square & Triangular Grid, etc.) are created in Staad software.
2) Design load as per IS 875 and seismic forces as per Indian standard 1893 :(Part-1)-2016 are applied over the structure in Staad-Pro after modelling.
3) A FEM analysis is executed to confirm the general behavior of the Gridshell.
4) Relative study is done on the structures to realize its behavior in serving the reduction of lateral forces.
5) The results acquired from analysis are plotted in graph using MS word.

IV. MODELLING & ANALYSIS

The Gridshell Structure having the Following Geometric Properties_

- Plan Dimension = 10.00 m x 10.00 m (Square Plan)
- Height of Side Opening = 2.00 m
- Height of the Crown = 5.50 m
- Plate Thickness = 5.00 mm (Steel)
- Grid Pattern = Square & Triangular Grid.
- Trial Beam Property = PIP337M (Trial Properties)
- Live Load = 2 kN/m2
- Support Condition = Fixed Supports.

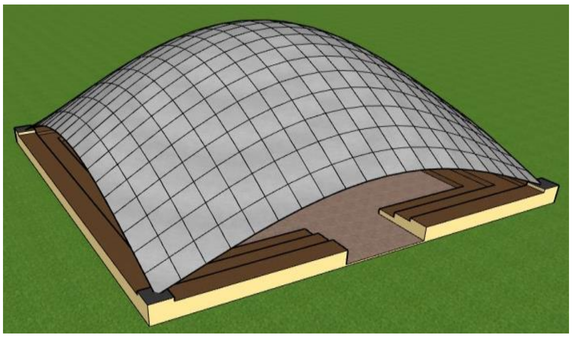

Figure 2: Gridshell Structure

Models are analysed for earthquake for different Seismic zones with Square & Triangular grid pattern depth in Staad-Pro software and results are compared.

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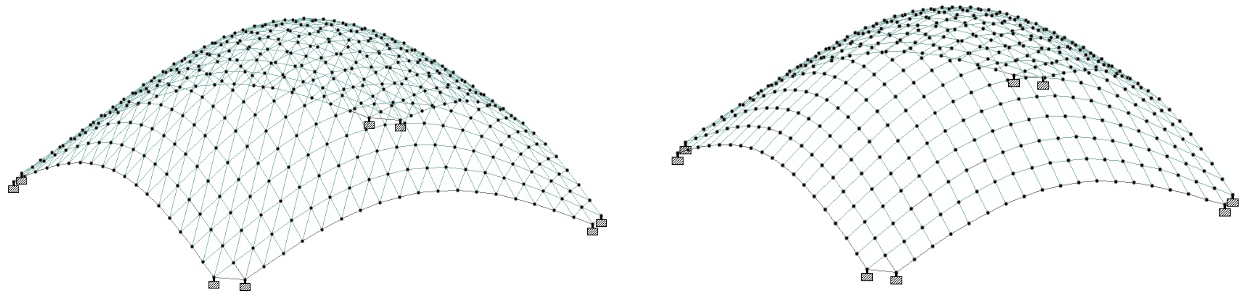

Figure 3: Staad Model with Square & Triangular Grid Pattern

V. ANALYSIS RESULTS

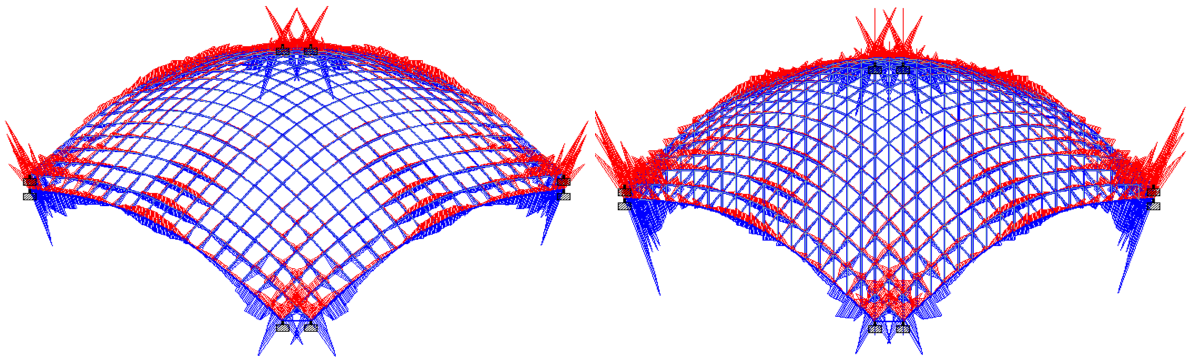

Figure 4: Beam Stresses (Bending Mz - N/mm^2)

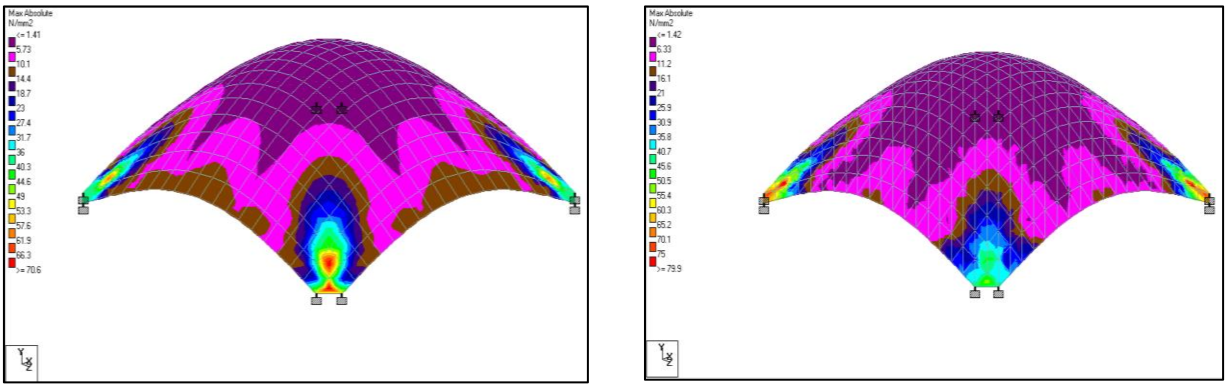

Figure 5: Plate Stresses (Maximum Absolute- N/mm^2)

MAXIMUM STORY DISPLACEMENT (in mm)

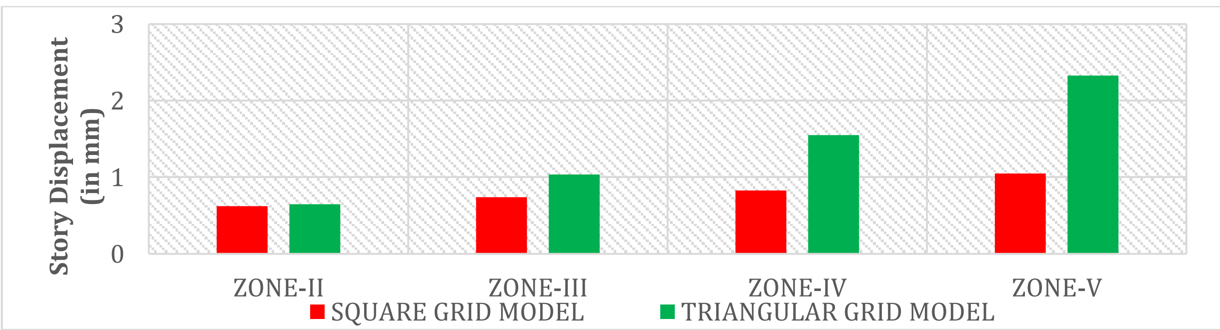

Figure 6: Comparison of Maximum Story Displacement under all Seismic Zone.

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MAXIMUM STORY DRIFT (in mm)

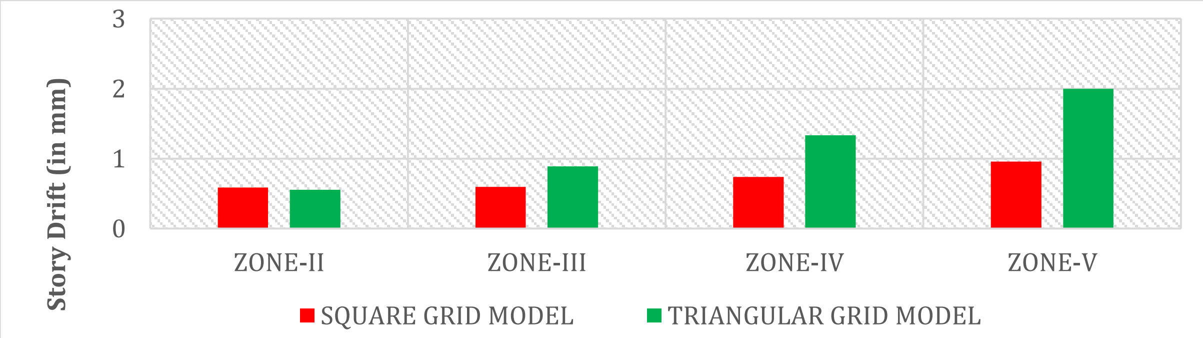

Figure 7: Comparison of Maximum Story Drift.

MAXIMUM BASE SHEAR (in N)

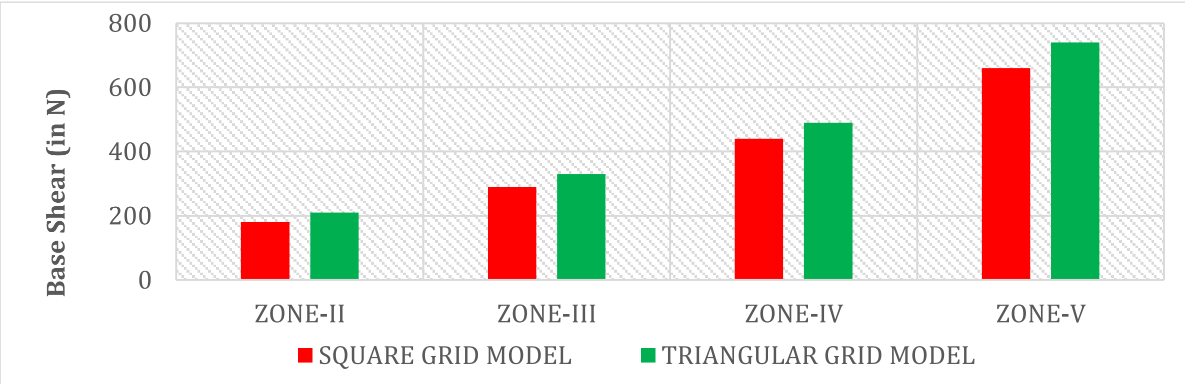

Figure 8: Comparison of Base Shear.

Table 1. Comparison of Analysis Results.

S. No.	Parameters	Units	Square Grid Gridshell				Triangular Grid Gridshell			
			Zone-II	Zone-III	Zone-IV	Zone-V	Zone-II	Zone-III	Zone-IV	Zone-V
1	Nodal Displacement (Absolute)	mm	15.595	15.595	15.595	15.595	14.193	14.193	15.194	17.462
2	Maximum Sectional displacement	mm	1.304	1.304	1.304	1.304	1.333	1.333	1.333	1.359
3	Maximum Axial Force in member	kN	25.113	25.113	25.113	25.113	19.374	19.374	19.374	19.374
4	Maximum Shear Y in Beam Member	kN	1.659	1.659	1.659	1.659	2.312	2.312	2.312	2.312
5	Maximum Moment Z in Beam Member	KNm	0.667	0.667	0.667	0.667	0.832	0.832	0.832	0.832
6	Beam Sterss Bending Mz	N/mm^2	312.421	312.421	312.421	312.421	389.241	389.241	389.241	389.241
7	Beam Axial	N/mm	81.802	81.802	81.802	81.802	63.109	63.109	63.109	63.109

	Stress	**2**								
8	**Max. Plate Stress_Bending My**	**kNm/m**	**0.041**	**0.041**	**0.041**	**0.041**	**0.100**	**0.100**	**0.100**	**0.100**
9	**Max. Plate Stress_Bending Mx**	**kNm/m**	**0.051**	**0.051**	**0.051**	**0.051**	**0.083**	**0.083**	**0.083**	**0.083**
10	**Maximum Base Shear**	**kN**	**0.180**	**0.290**	**0.440**	**0.660**	**0.210**	**0.330**	**0.490**	**0.740**
11	**Maximum Story Displacement**	**cm**	**0.062**	**0.074**	**0.083**	**0.105**	**0.065**	**0.103**	**0.155**	**0.233**
12	**Maximum Story Drift**	**cm**	**0.059**	**0.060**	**0.074**	**0.096**	**0.056**	**0.089**	**0.133**	**0.200**

VI. CONCLUSION

1) The FEM results concluded that the singularity can improve stiffness and buckling load of a Gridshell.
2) A dynamic analysis was performed in the samples and it is concluded that the introduction of the singularity makes the beams less likely to bend.
3) It has been observed that for Earthquake Analysis of Gridshell structure Storey Displacement and Drift is more in Triangular Grid Pattern than Square Grid Pattern Gridshell structure.
4) The Effect of Seismic forces are not found severe as generally found in Building structures.
5) The Base shear is more in triangular grid pattern gridshell than Square grid pattern and also it increases as the Seismic zone changes from Lower to Higher zone.
6) The Gridshell structure with Triangular Grid Pattern is less more responsive than Square grid pattern Gridshell.

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