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PUSHOVER ANALYSIS OF BUILDING USING SOFT STORY AT DIFFERENT LEVEL

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Abstract: Buildings in high-seismic areas must be designed with particular attention to their lateral stability during extreme earthquakes. A modern concept of shifting the vertical column's orientation to a diagonal column aids in the transformation of all forces into axial forces. Diagrid (Diagonal Grid of Columns) is a brand new structural system designed to improve a building's lateral stability. The diagrid structural system's aesthetics and structural advantages have made it a popular option for many buildings around the world, including many prominent high-rise structures constructed in recent years. The nonlinear behaviour and design of mid-to-high-rise RCC diagrid structures are investigated in this paper. The results are compared to corresponding moment resisting frames and concentrically braced frames in terms of tale drift, time length, base share, and displacement in diagrids. Practical design guidelines are suggested using virtual work/energy diagrams and nonlinear seismic analysis using ETABs for G+7, G+11, and G+16 to improve nonlinear behaviour and increase collapse load potential of diagrid structures in high seismic regions with time history and Pushover analysis.

Keywords: Diagrid building, earthquake forces, time history analysis, Pushover Analysis

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I INTRODUCTION

The word earthquake may be used to define any kind of seismic phenomenon that produces seismic waves, whether normal or caused by humans. Earthquakes are usually induced by seismic fault rupture, although they may also be sparked by volcanic activities, mine explosions, landslides, and nuclear testing. Many structures have primary construction systems that do not fulfill existing seismic standards and are severely damaged during an earthquake. India is divided into four zones based on seismic operations, according to the Seismic Zoning Map of IS: 1893-2002. Zones II, III, IV, and V are the four zones. Some companies construct full-scale models and do extensive research before mass-producing thousands of similar systems that have been studied and engineered with test outcomes in mind. Unfortunately, the construction industry may not have this choice, making large-scale creation unfeasible. Many current structures in India are built according to Indian standard code 456:2000, but in order to render buildings earthquake prone, IS 1893-2002 should be included.

In certain cases, the only loads acting on these systems are gravity loads, resulting in elastomeric structural behavior. However, in the case of a strong earthquake, a system can be exposed to forces that exceed its elastic limit. After the last earthquake in the last four decades, in which several concrete structures were severely weakened or destroyed, it has been essential to assess the seismic suitability of existing or planned structures. As a result, the structure's susceptibility to harm must be calculated. Simplified linear elastic approaches are not ideal for achieving or achieving this goal. As a result, structural engineers have devised a novel modeling approach and seismic protocol that incorporates performance-based structures and nonlinear techniques.

Linear static, linear dynamic, nonlinear static, and nonlinear dynamic analysis are the four types of analysis. The first two are only suitable if the systemic loads are minimal and the stress strains are below the elastic maximum. After an earthquake, structural loading may exceed collapse pressure, causing material stresses to exceed yield stresses. To obtain successful results in this situation, material nonlinearity and geometrical nonlinearity must be integrated into the study. Pushover analysis is a basic method for analyzing a building's nonlinear static nature. So, using output thresholds, the pushover curve, and the pushover analysis protocol, discuss pushover analysis in this project.

A. Concept

The diagrid (a portmanteau of diagonal grid) is a structure for building and roof design that consists of diagonally intersecting metal, concrete, or wooden beams. In comparison to a traditional RCC frame, it uses less structural RCC. The diagrid structural system can be defined as a diagonal members formed as a framework made by the intersection of different materials like metals, concrete or wooden beams which is used in the construction of buildings and roofs. Diagrid structures of the RCC members are efficient in providing solution both in term of strength and stiffness. But nowadays a widespread application of diagrid is used in the large span and high rise buildings, particularly when they are complex geometries and curved shapes. The diagonal member of the diagrid carries both shear and moment. So the optimal angle of placing of the diagonals is dependent of building height. The optimal angle of the columns for maximum bending rigidity in the normal building is 90 degree and for the diagonals for shear rigidity is 35 degree. It is assumed that the optimal angle of the diagrid falls in between the both. Usually adopted range is 60 -70 degree. As the height of the building increases the optimal angle also increases.

B. Benefits

The diagrid system has a lot of benefits that can make it more favored be the designer against other systems. Some of those benefits are:

• Mostly column free exterior and interior.

• Generous amounts of day lighting due to dearth of interior columns and structure.

• Roughly 1/5th reduction in RCC possible.

• Simple construction techniques (although they need to be perfected yet).

• Full exploitation of the structural material.

• Similar design/construction tolerances as a typical moment frame construct (for instance: a type. columnar element would be created 1/8th of an inch longer than called for to allow for compression in the final product in a M.F. project. The same can be said for a Diagrid project).

• Free and clear, unique floor plans are possible.

• Aesthetically dominate and expressive.

C. Objectives

• To study the performance of RC plane frames and Diagrid structure under seismic loads (Earthquake loads).

• To perform Non-Linear Analysis of diagrid structure with conventional in ETABS.

• To study the performance of Diagrid structure with respect to different parameters such as story drift, story displacement, base shear.

• To study demand capacity curve of diagrid structure and conventional with pushover analysis.

II. SYSTEM DEVELOPMENT

In this paper, three G+7, G+11, G+16 diagrid building models for RCC were created and analyzed in ETABs software for different positions of shear wall in zone V with subsoil Type medium -II. To confirm seismic activity with the same storey and storey height, both of the buildings are subjected to the same earthquake packing. Various seismic analysis techniques are used for the analysis of these simulations, but for this work, both linear static and non-linear static methods are used. The approaches are described in detail below.

A. Method of Analysis

Equivalent Static Method: The design lateral force due to earthquake is calculated as follow

- **Design horizontal seismic coefficient** :

The following expressions may be used to calculate the horizontal seismic coefficient Ah for a structure: - Ah = (Z/2) X (I/R) X (Sa/g) X (Z/2) X (Z/2) X (Z/2) X (Z/2) X (Z/2)

Assume that whatever the meaning of I/R, the value of Ah would not be less than Z/2 for any structure of T0.1 s.

What is the location?

Z is the zone aspect.

I = Importance factor, which is determined by the structure's practical application.

R=Response reduction factor, which varies based on the magnitude of the perceived seismic impact.

The structure's efficiency is a factor to consider.

Average reaction acceleration coefficient (Sa/g)

- **Design Seismic Base Shear** :

The total design lateral force or seismic base shear (Vh) along any principal direction is determined by the following expression:-

Vb = Ah .W

Where, W is the seismic weight of the building.

- **Distribution of design force** :

The design base shear (Vb) computed is distributed along the height of the building as below:

$Q_i = V_b (w_i h_i^2 / \sum w_i h_i^2)$

Where,

Q_i = Design lateral force at each floor level i

W_i = Seismic weight of floor i.

h_i = Height of floor i measured from the base.

❖ **Response Spectrum Method**

The modal form, or modal superposition method, is another name for this method. The approach may be used on structures where modes other than the fundamental one have a major impact on the structure's reaction. It's especially useful for analysing forces and deformations in multi-story buildings caused by medium-intensity ground shaking, which results in a moderately significant yet basically linear reaction in the structure. The reaction continuum approach of seismic analysis has analytical advantages for predicting displacements and component forces in structural structures. Using smooth design spectra that are the average of many earthquake movements, the approach includes calculating only the maximum values of displacements and participant forces in each mode. Just one mode of vibration was considered in the seismic coefficient system (single mode method). Without conducting a free vibration survey, the time span for this mode was calculated in a very crude manner.

III. METHODOLOGY

A. Problem Statement

The planned work's plan area is 18 x 18 m, with panels measuring 3x3 m for traditional with square diagrid buildings, and related areas considered for various levels. G+7, G+11, and G+16

Design parameters used for Study-

• Seismic Zones: III • Models: G+7, G+11, G+16

• 3.6 m floor height

• Both configurations have the same grid configuration: a square 3 x 3 grid.

• Diagrid angle: 67.4°

• The plan is 18X18 m in dimension.

• Column dimensions: 500mm x 500mm

• Beam dimensions: 300mm x 500mm

• Slab thickness: 125 mm

• Diagonals Dimensions: 300X500 mm

• M30 is the concrete grade.

• RCC grade: Fe 500

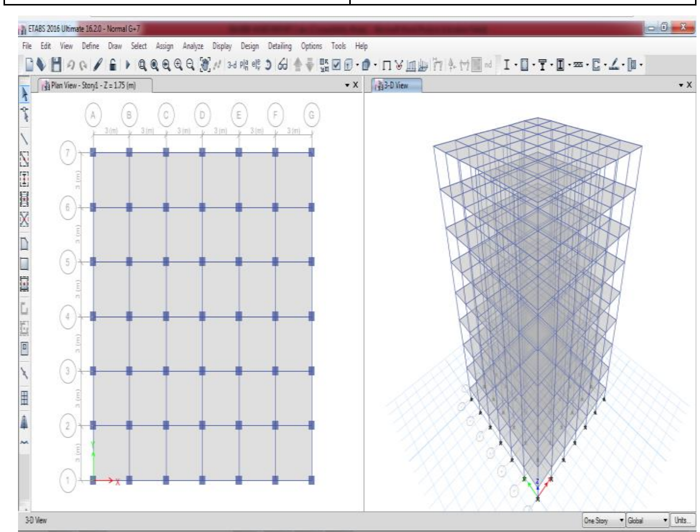
There were two phases of the project investigation. The primary data was collected by a literature review that included online searches as well as a review of eBooks, guides, passwords, and journal articles. Following the evaluation, the issue statement is established, and the model is prepared for detailed research and examination. This research will be carried out according to the flow map below:

Software Analysis And Design Procedure

1. Define Plan Grids and Story Data
2. Define Material Properties
3. Define Frame Sections
4. Define Slab Sections
5. Define Load Cases
6. Draw Beam Objects (Frame Members)
7. Draw Column Objects (Frame Members)
8. Assign Slab Sections
9. Assign Restrains
10. Assign Slab Loads
11. View Input Data in Tabular Form
12. Run the Analysis
13. View Analysis Results Graphically
14. Design Concrete Frame Element

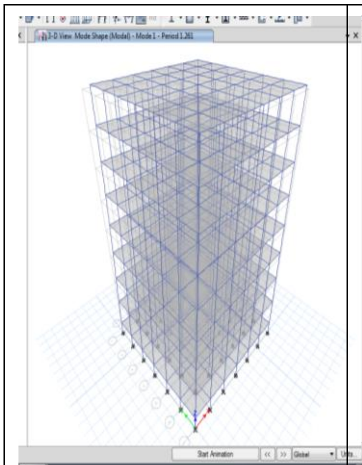
IV. MODELING IN ETABS

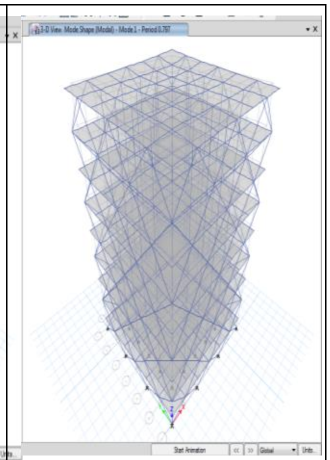
Modeling In Etabs	Modeling In Etabs
	Modeling In Etabs
Modeling In Etabs	Modeling In Etabs
	Modeling In Etabs
Modeling In Etabs	Modeling In Etabs
	Modeling In Etabs



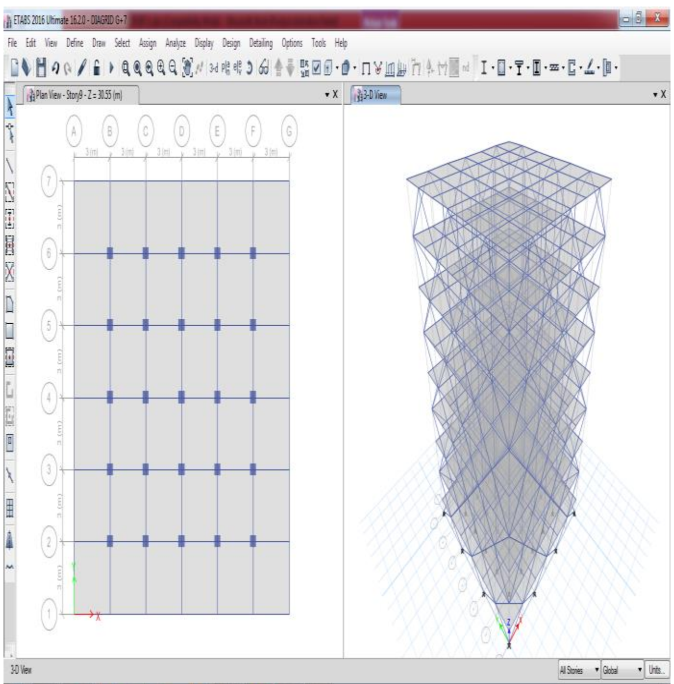
Normal Building G+7

V. RESULTS FOR THE MODEL



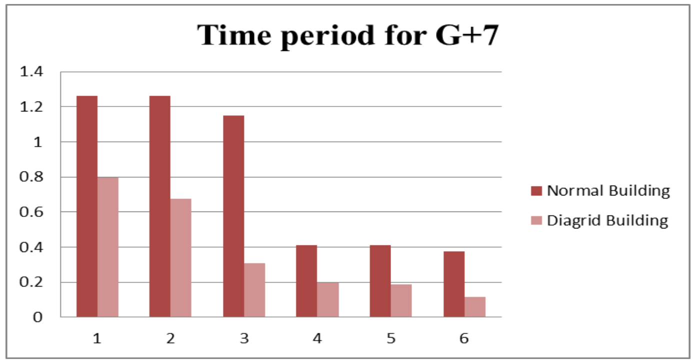


Mode Shape 1 For Normal G+7	Mode Shape 1 For Normal G+7

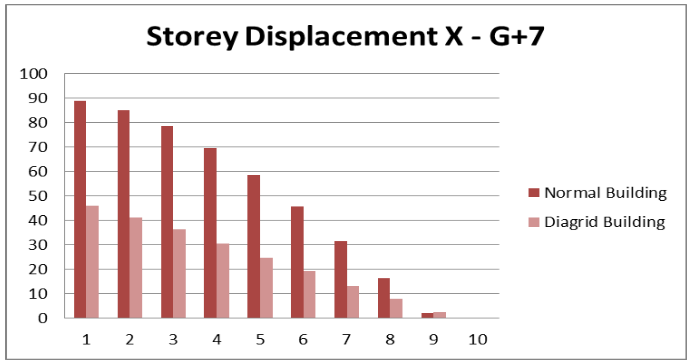


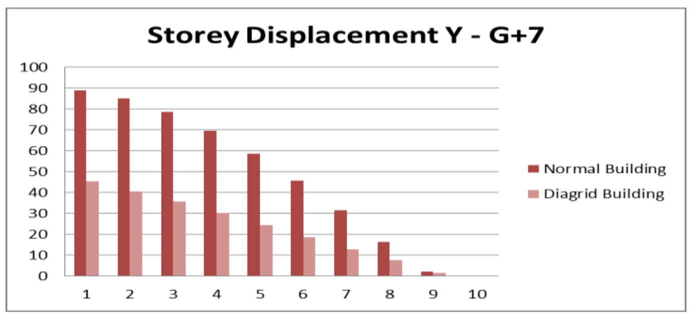
Mode	Normal Building	Diagrid Building
1	1.261	0.797
2	1.261	0.677
3	1.149	0.306
4	0.41	0.196
5	0.41	0.189
6	0.376	0.116

Time period result



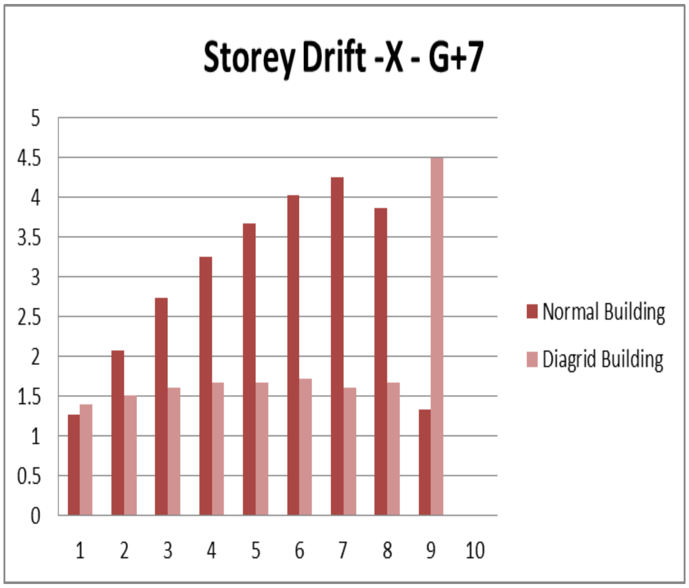
time period for G + 7



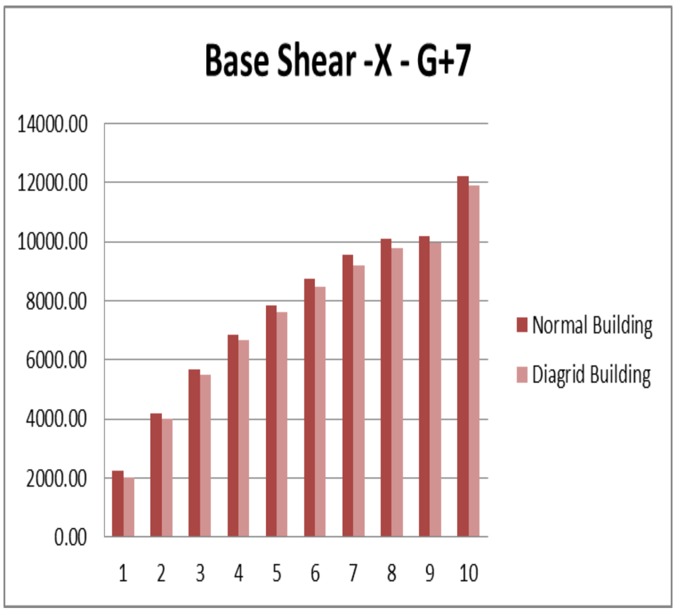


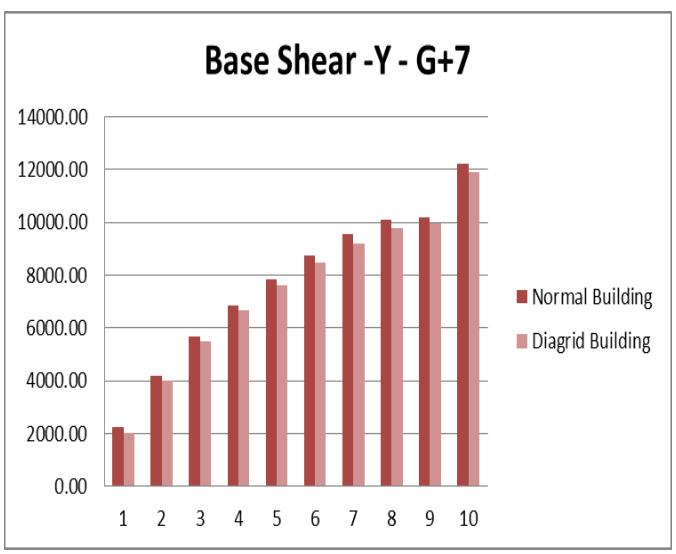
❖ **Storey Drift**

Story	Normal Building	Diagrid Building
9	1.276	1.405
8	2.078	1.507
7	2.74	1.617
6	3.256	1.678
5	3.674	1.667
4	4.024	1.722
3	4.251	1.611
2	3.871	1.677
1	1.33	4.493
Base	0	0

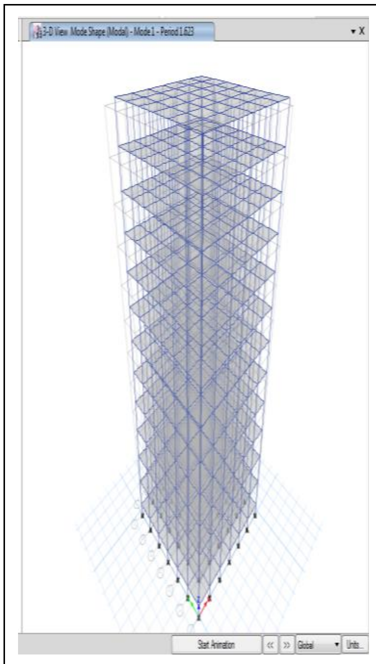


storey drift X for G + 7

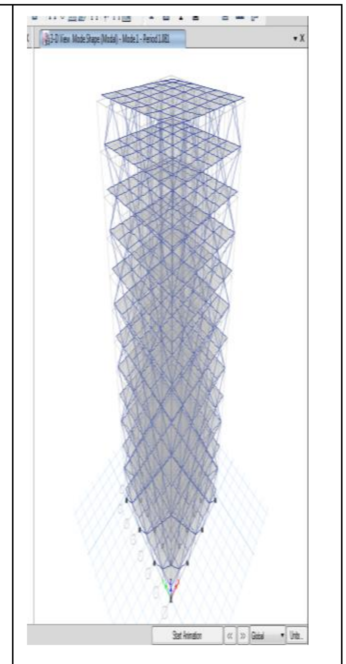




RESULTS FOR THE MODEL 2 – G+11

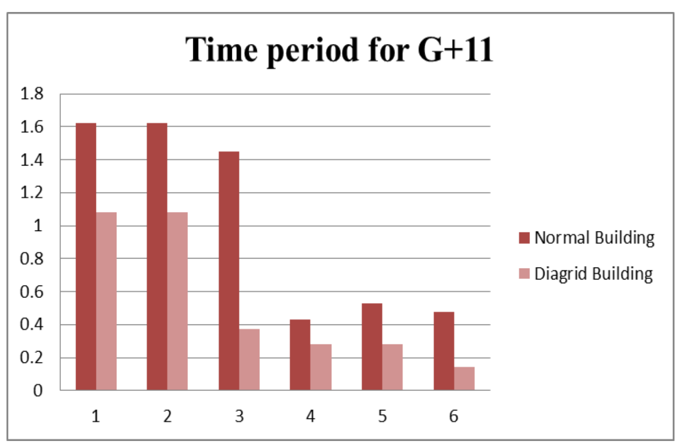


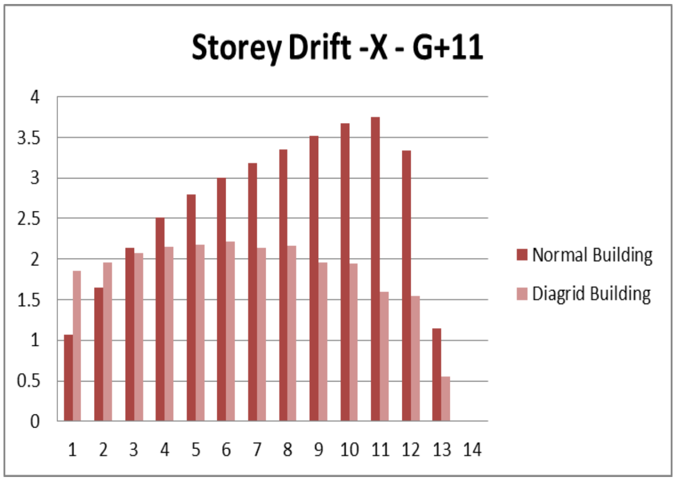
Mode Shape 1 For Normal G+11

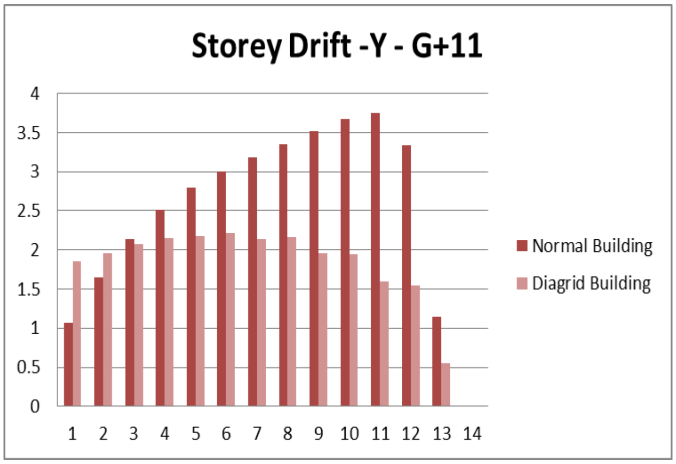


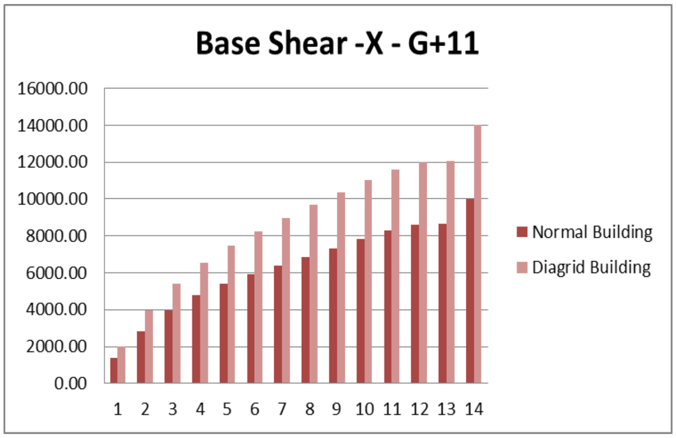
Mode Shape 1 For Normal G+11

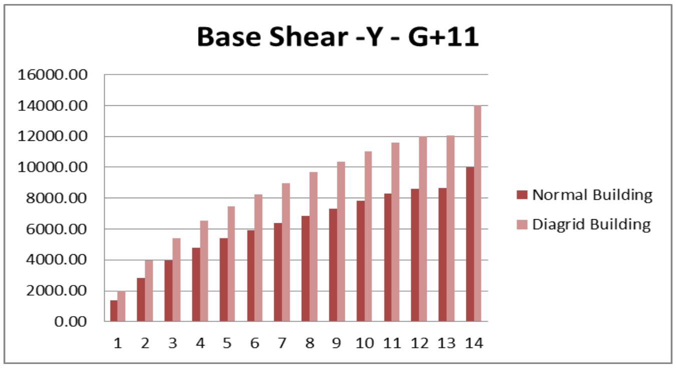
Mode	Normal Building	Diagrid Building
1	1.623	1.081
2	1.623	1.081
3	1.449	0.372
4	0.43	0.28
5	0.53	0.28
6	0.478	0.14











VI. CONCLUSIONS

Based on the empirical review conducted in this test work, the diagrid and normal building structures are compared for nonlinear analysis of response spectrums for G+7, G+11, and G+16. The analysis concludes that the diagrid structure is more economical than normal structures up to the 11th floor, but G+16 less economical than the G+7 and G+11 structures. To ensure consistency in this study, we analyze G+16 for pushover analysis to determine the structure's capability. The analysis concludes that the diagrid structure has a greater capacity resisting force than the normal structure.

- Time Period for G+7 for normal and diagrid structure for the responcs spectrum analysis , the time period reduces of diagrid structure than normal structure by 30-40%
- results for storey displacement X for G+7 for normal and diagrid structure for the responcs spectrum analysis , the storey displacement reduces of diagrid structure than normal structure by 40-50%
- results for storey displacement Y for G+7 for normal and diagrid structure for the responcs spectrum analysis , the storey displacement reduces of diagrid structure than normal structure by 20-30%
- results for storey drift X for G+7 for normal and diagrid structure for the responcs spectrum analysis , the storey drift reduces of diagrid structure than normal structure by 30-40%
- results for Base Shear X for G+7 for normal and diagrid structure for the responcs spectrum analysis , the base shear reduces of diagrid structure than normal structure by 30-40%
- results for Base Shear Y for G+7 for normal and diagrid structure for the responcs spectrum analysis , the base shear reduces of diagrid structure than normal structure by 20-40%
- results for Time Period for G+11 for normal and diagrid structure for the responcs spectrum analysis , the time period reduces of diagrid structure than normal structure by 30-40%
- results for Storey Displacement X for G+11 for normal and diagrid structure for the responcs spectrum analysis , the storey displacement reduces of diagrid structure than normal structure by 20-30%
- results for Storey Displacement Y for G+11 for normal and diagrid structure for the responcs spectrum analysis , the Storey Displacement reduces of diagrid structure than normal structure by 10-30%
- results for Storey Drift X for G+11 for normal and diagrid structure for the responcs spectrum analysis ,

the Storey Drift reduces of diagrid structure than normal structure by 20-30%

- results for Storey Drift Y for G+11 for normal and diagrid structure for the responcs spectrum analysis , the Storey Drift reduces of diagrid structure than normal structure by 30-40%
- results for Base Shear X for G+11 for normal and diagrid structure for the responcs spectrum analysis , the base shear reduces of diagrid structure than normal structure by 30-40%

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