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# Comparative Study of Diagrid with Conventional Building Having Different Height

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**ABSTRACT** - Buildings in highly seismic areas must be designed with special attention to their lateral stability during extreme earthquakes. The modern concept of shifting the orientation of a vertical column to a diagonal column helps to transform all forces into axial forces. Diagrid (diagonal grid of columns) is a brand new structural system designed to improve the lateral stability of a building. The aesthetics and structural advantages of the diagrid structural system have made it a popular choice for many buildings around the world, including many major high-rise structures built in recent years. In this paper, the nonlinear behavior and design of medium to tall RCC diagrid structures are investigated. The results are compared with the corresponding moment-resisting frames and concentrically braced frames in terms of story drift, time span, base proportion and displacement in diagrids. Practical design guidelines are proposed using virtual work/energy diagrams and non-linear seismic analysis using ETAB for G+7, G+11 and G+16 to improve the non-linear behavior and increase the collapse load potential of diagrid structures in highly seismic areas with time history and Pushover analysis.

**KEYWORDS:** Diagrid building, earthquake forces, time history analysis, Pushover Analysis, ETABS

## I. INTRODUCTION

The word earthquake can be used to define any kind of seismic phenomenon that produces seismic waves, whether normal or man-made. Earthquakes are usually triggered by the rupture of seismic faults, although they can also be triggered by volcanic activity, mine explosions, landslides, and nuclear tests. Many structures have primary structural systems that do not meet current seismic standards and are severely damaged during earthquakes. India is divided into four zones based on seismic operations, as per 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 conduct extensive research before mass-producing thousands of similar systems that have been studied and engineered with test results in mind. Unfortunately, construction may not have this option, so creating on a large scale is not feasible. Many current buildings in India are built according to Indian Standard Code 456:2000, but to make the 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 design behavior. However, in the case of a strong earthquake, the system may be subjected to forces that exceed its elastic limit. After the last earthquake in the last four decades, in which several concrete structures were seriously weakened or destroyed, it became necessary to assess the seismic capacity of existing or planned structures. Consequently, the susceptibility of the structure to damage must be calculated. Simplistic linear elastic approaches are not ideal for achieving or achieving this goal. As a result, civil engineers have devised a new 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 suitable only when the system loads are minimal and the stress strains are below the elastic maximum. After an earthquake, the structural load may exceed the collapse pressure, causing the material stress to exceed the yield stress. To obtain successful results in this situation, material nonlinearity and geometric nonlinearity must be integrated into the study. Pushover analysis is the basic method for analyzing the non-linear static nature of a building. So using output thresholds, pushover curve and pushover analysis protocol discuss pushover analysis in this project.



### 1.1. Concept

Diagrid (portmanteau of diagonal grid) is a structure for the construction of buildings and roofs, which consists of diagonally intersecting metal, concrete or wooden beams. Compared to traditional RCC frame, it uses less structural RCC. A diagrid construction system can be defined as diagonal elements formed as a frame made by the intersection of different materials such as metals, concrete or wooden beams, which are used in the construction of buildings and roofs. Diagrid constructions of RCC members are effective in providing both strength and stiffness solutions. But currently, diagrid is widely used in large span and high-rise buildings, especially if they have complex geometries and curved shapes. The diagonal member of the diagrid carries both shear and moment. The optimal angle of placement of the diagonals therefore depends on the height of the building. The optimum column angle for maximum bending stiffness in a normal building is 90 degrees and for diagonals for shear stiffness it is 35 degrees. The optimal diagrid angle is assumed to fall between the two. The commonly used range is 60-70 degrees. As the height of the building increases, so does the optimal angle.

### 1.2. Benefits

The diagrid system has many advantages that can make it more advantageous to the designer than other systems. Some of these benefits are:

- Exterior and interior mostly without pillars.
- Plenty of daylight due to lack of internal columns and structure.
- Possible reduction of RCC by about 1/5.
- Simple construction techniques (although they still need to be perfected).
- Full use of construction material.
- Similar design/construction tolerances to typical moment frame construction (for example: a typ. column member would be made 1/8 inch longer than required to allow for compression in the final product in a M.F. project say for a Diagrid project).
- Free and clear, unique floor plans are possible.
- Aesthetically dominant and expressive.

### 1.3. Objectives

- To study the behavior of RC planar frames and diagrid structures under seismic loading (earthquake).
- Perform nonlinear analysis of diagrid structure with conventional in ETABS.
- To study the performance of Diagrid structure with respect to various parameters like storey displacement, storey displacement, base shear.
- To study the demand capacity curve of diagrid structure and conventional with pushover analysis.

## II. SYSTEM DEVELOPMENT

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

### 2.1 Method of Analysis

#### Response Spectrum Method

Modal form or modal superposition method is another name for this method. This approach can be used for structures where non-fundamental modes have a major influence on the response of the structure. It is particularly useful for the analysis of forces and deformations in multi-story buildings due to moderately intense ground shaking that results in a moderately significant but essentially linear response in the structure. The reaction continuum approach of seismic analysis has analytical advantages for predicting displacements and force components in structural structures. Using smooth design spectra that are the average of many earthquake motions, the approach involves calculating only the maximum values of the displacements and forces of the participants in each mode. In the system of seismic coefficients, only one vibration mode was considered (single mode method). Without performing a free vibration survey, the time span for this mode was calculated in a very rough manner.



### III. METHODOLOGY

#### 3.1. Problem Statement

The planned area of the work is 18 x 18 m, with 3 x 3 m panels for traditional square diagrid buildings and associated areas considered for different levels. G+7, G+11 and G+16

The design parameters used for the Study-

- Seismic zones: III
- Models: G+7, G+11, G+16
- 3.6 m floor height
- Both configurations have the same grid configuration: a 3 x 3 square grid.
- Cross grid angle: 67.4°
- The plan has dimensions of 18X18 m.
- Post dimensions: 500mm x 500mm
- Beam dimensions: 300mm x 500mm
- Plate thickness: 125 mm
- Diagonal dimensions: 300X500 mm
- M30 is a class of concrete.
- RCC class: Fe 500

The project survey had two phases. Primary data were collected based on a literature review that included online searches as well as a review of e-books, guides, passwords, and journal articles. After evaluation, a problem statement is created and the model is ready for detailed research and investigation. This research will be conducted according to the flow chart below:



#### 3.2 Software Analysis and Design Procedure

1. Define plan grids and story data
2. Define material properties
3. Define the frame parts
4. Define the slab sections
5. Define load cases



6. Drawing beam objects (frame members)
7. Drawing column objects (frame members)
8. Match the board cuts
9. Assign constraints
10. Assign the slab load
11. Display of input data in tabular form
12. Run the analysis
13. View the analysis results graphically
14. Design the concrete frame element

#### IV. MODELING IN ETABS

Model 1 – G+7	Normal Building
	Diagrid Building
Model 2 – G+11	Normal Building
	Diagrid Building
Model 3 – G+16	Normal Building
	Diagrid Building

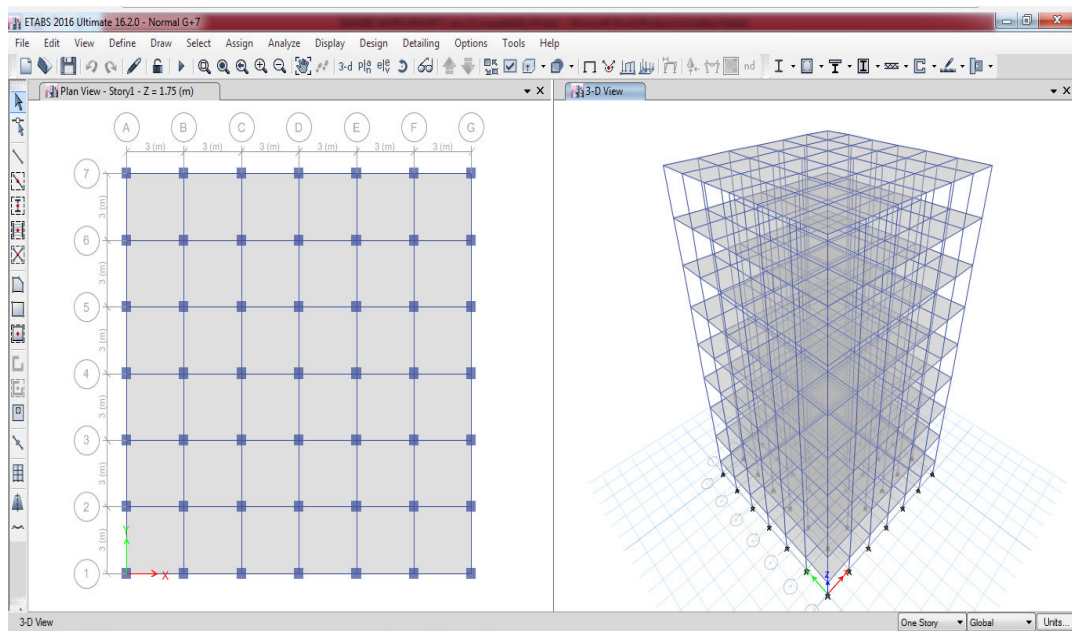


Fig 1 Normal Building G+7

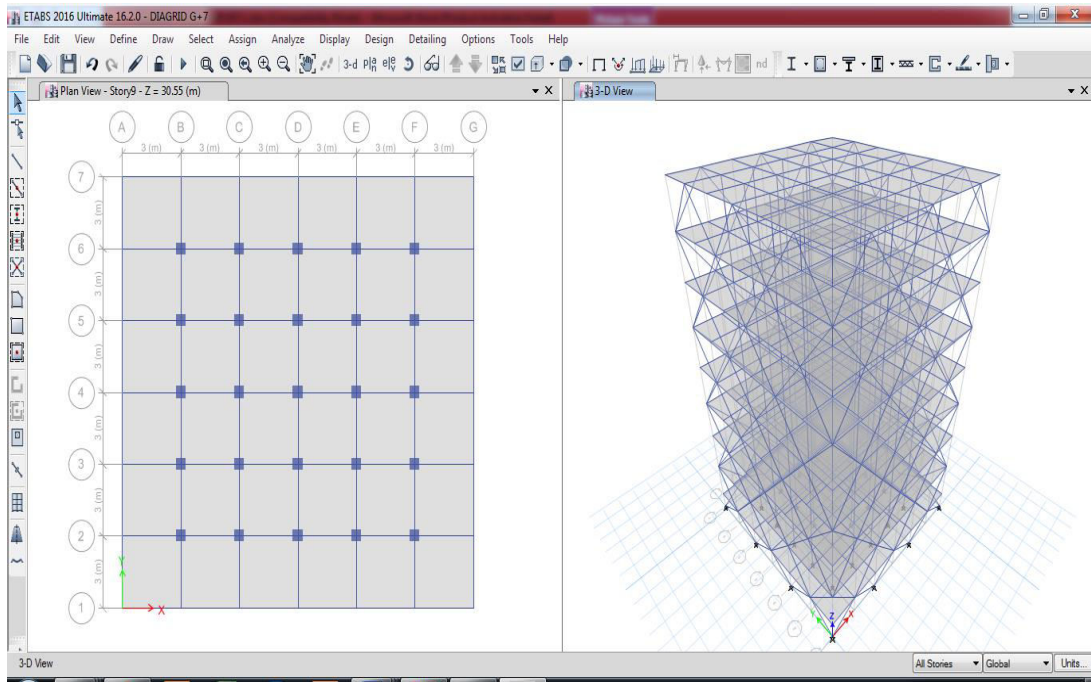


Fig 2 Diagrid Building G+7

V. RESULTS FOR THE MODEL

5.1 Results for G+7

- Time period

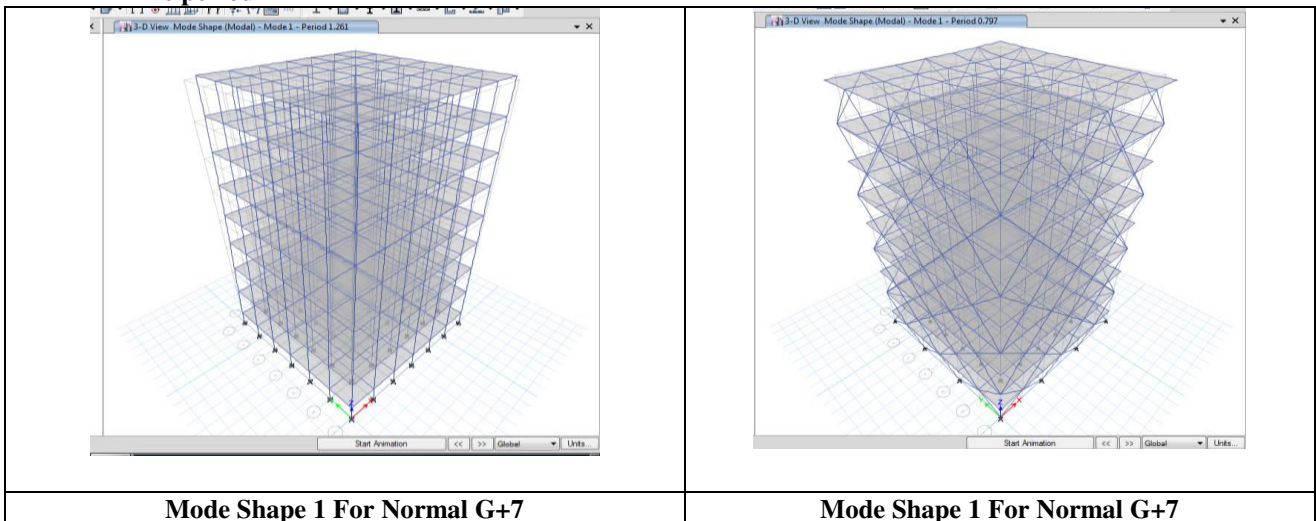




Table 1 Time period result G + 7

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

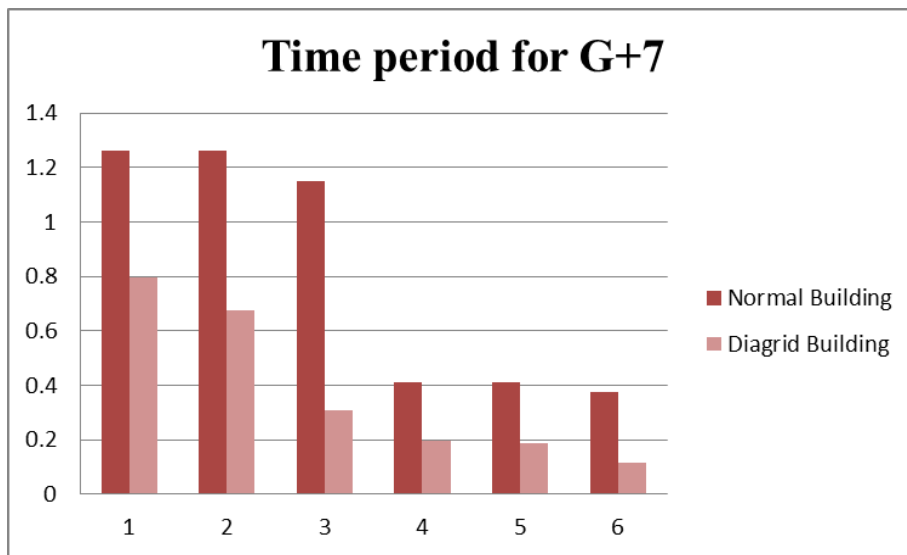


Fig 3 Time period for G + 7

The graph above shows the time period results for G+7 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 30-40%



5.2 Results For The Model 2 – G+11

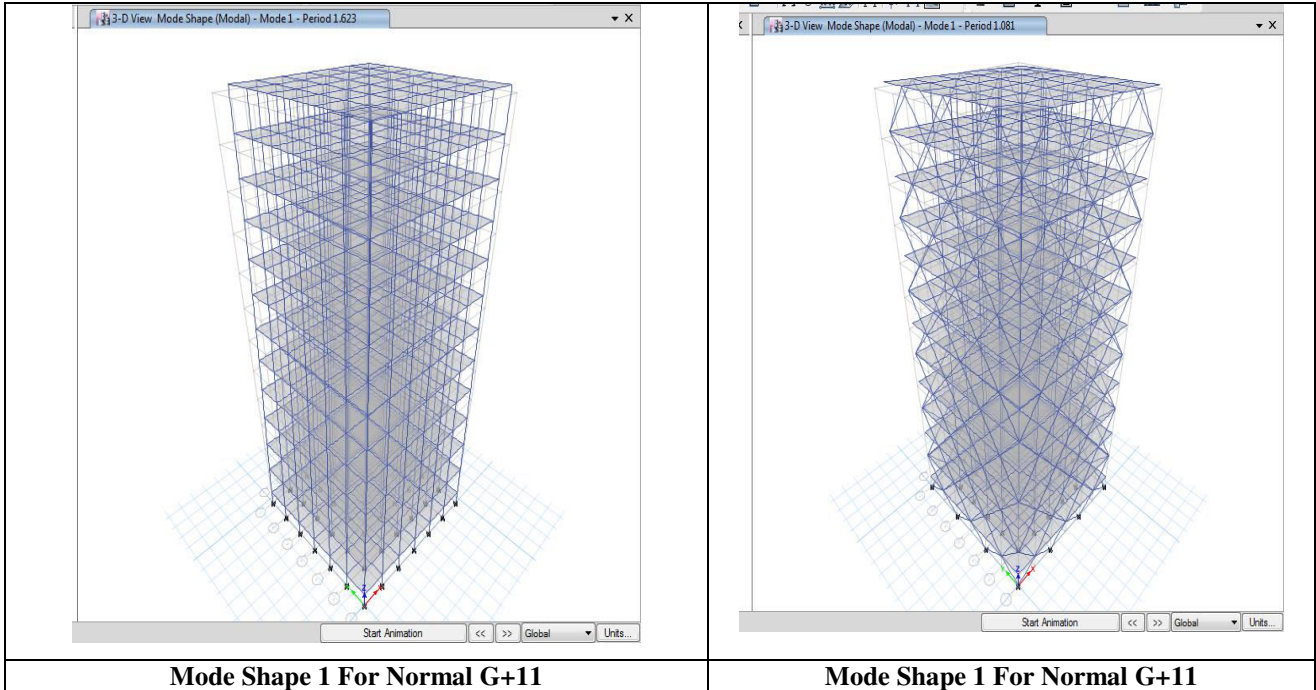


Table 2 Time period result G + 11

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



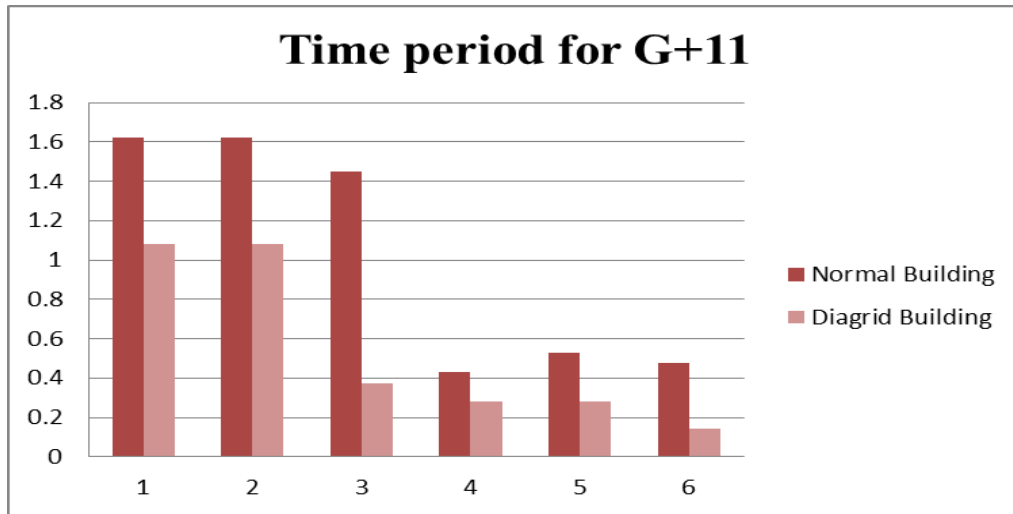


Fig 4 Time period for G + 11

The graph above shows the time period results for G+11 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 35-40%

5.2 Results For The Model 2 – G+16

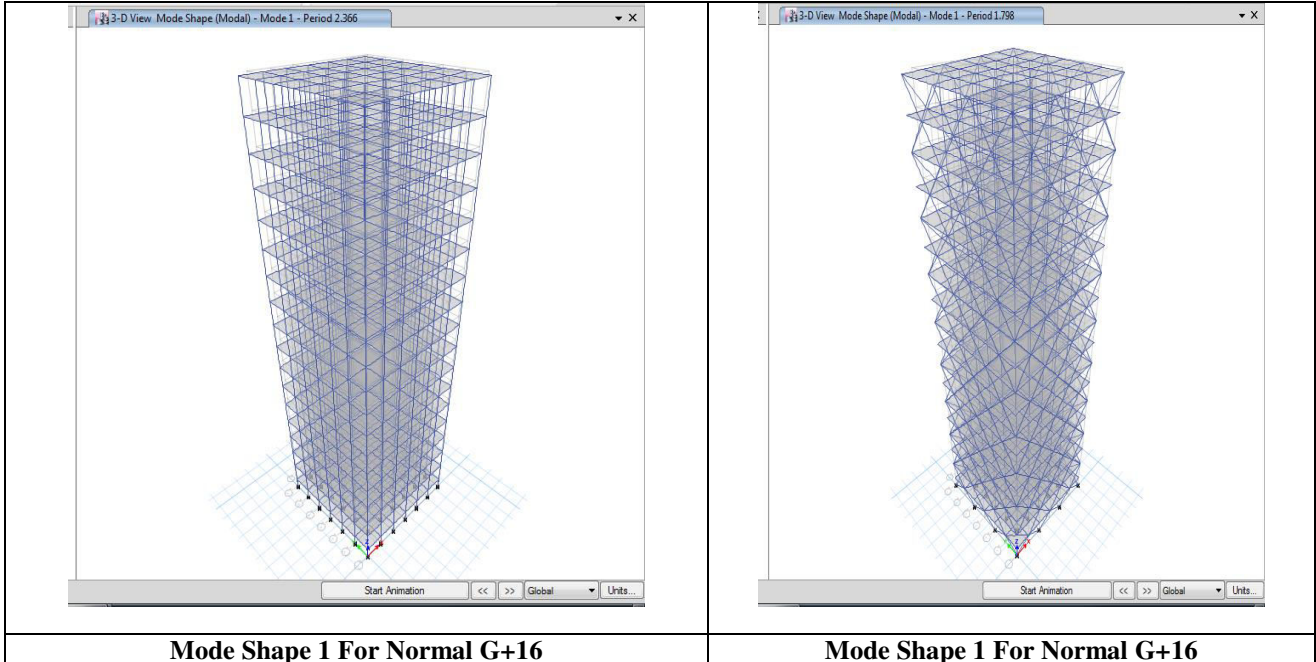




Table 2 Time period result

Mode	Normal Building	Diagrid Building
1	2.366	1.798
2	2.366	1.798
3	2.048	0.519
4	0.769	0.44
5	0.769	0.44
6	0.677	0.21

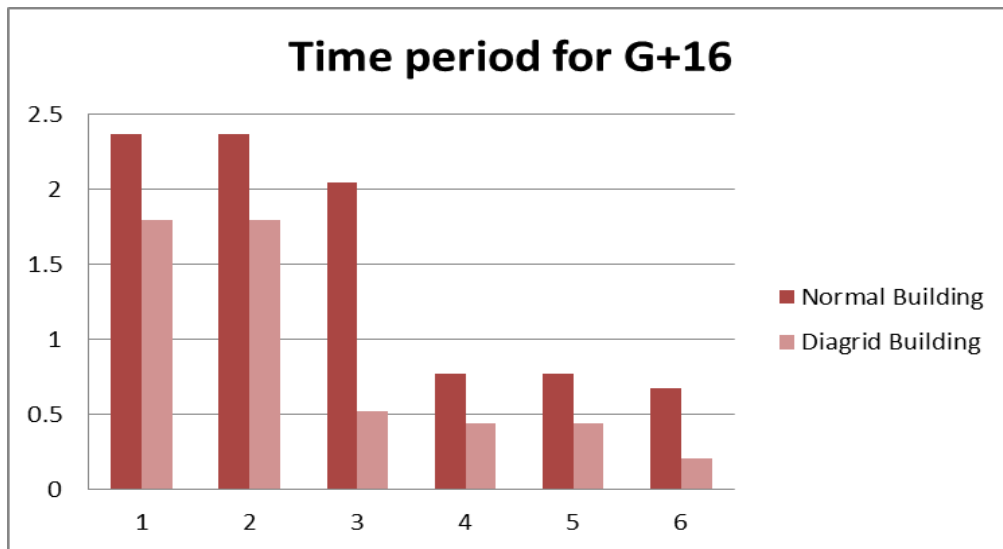


Fig 4 Time period for G + 11

The graph above shows the time period results for G+16 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 30-35%

### VI. CONCLUSION

Based on the empirical review carried out in this test work, diagrid and normal building structures are compared for nonlinear analysis of response spectra for G+7, G+11 and G+16. The analysis concludes that diagrid construction is more economical than normal construction up to the 11th floor, but G+16 less economical than G+7 and G+11 constructions. To ensure consistency in this study, we analyze G+16 for displacement analysis to determine the capability of the structure. The analysis concludes that the diagrid structure has a larger force-resisting capacity than the normal structure.

- The graph above shows the time period results for G+7 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 30-40%
- The graph above shows the time period results for G+11 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 35-40%
- The graph above shows the time period results for G+16 for normal and diagrid structure for spectral response analysis, the time period reduces diagrid structure than normal structure by 30-35%



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#### IS CODES:

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- ii. **IS Code 1893:2002** - Criteria For Earthquake Design of Structures



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