INVESTIGATION ON G+20 AND G+30 DIAGRID STRUCTURES WITH VARIED DIAGRID ANGLES AND MODULES

Mr.Dheekshith K[1], Mrs. Shwetha Sankesh[2], Mr.Bhavani Shankar[3]

[1]Assistant Professor, Srinivas University College of Engineering and Technology, Mangalore, Karnataka, India
[2]P.G Student Srinivas University College of Engineering and Technology, Mangalore, Karnataka, India
[3]Assistant Professor, Srinivas University College of Engineering and Technology, Mangalore, Karnataka, India

---***---

Abstract - *In this project, the comparison between diagrids of different diagrid angles, different storey heights and different number of modules are made. Parameters like the top storey displacement, the storey drift and the base shear are analysed and compared for all the four models. Two models are modelled which has G+20 and G+30 storeys. Regular square plan of 18m*18m is chosen and 3m intervals both in X and Y direction is taken as room dimensions.Angles of diagrids are varied and executed. Linear static analysis for zone 3 is done. Results obtained from the analysis is compared. Tabular and graphical representation of results is carried out. Discussions related to the obtained results are made. Thesis is concluded.*

Key Words: Diagrid, Diagrid angles, Storey heights, Number of modules, Storey Displacement, Storey Drift, Base Shear.

1. INTRODUCTION

Diagrids are the structural configuration located on the perimeter of a building which consists of a narrow network of intersecting parallel members which perform resistance of gravity loadings and lateral loadings. The technology of implementation of structural steel sections diagonally to achieve maximum productivity in the aspects of strength and stiffness is not a recent discovery, however the importance on diagrid structure has renewed a lot with reference to tall structures specially those which consists of 1) complex geometries 2) curved shapes and 3) completely free forms. The structures implemented with diagrid systems are basically quite advanced forms of braced tube structures, due to the arrangement on perimeter holds to conserving the highest bending opposition and also rigidity similar to the latter, structural members in the diagonal direction are stretched throughout the facade that leads to the creation of congestion in elements and allows avoiding vertical columns completely.

1.1 OBJECTIVES

The main aim of this study is to understand the structural behavior of the diagrid structure for varied diagrid angles, varied number of modules against different storey heights.

1. Studying the response of the diagrids to different storey heights
2. To study the effect of different diagrid angles
3. To study the effect of different number of modules
4. To study the effect of above mentioned parameters on storey displacement, storey drift and base shear of the structure under linear static analysis

2. METHODOLOGY

In the present study G+20 and G+30 buildings having diagrid structural system is modelled and analysed using ETABS 2017 software. Evaluation of response of storeys such as displacement at the top storey, drift in the storeys and shear in the storeys is taken up. And same procedure is carried out for designing different parameters and diagrid angles. Typical floor height of 3.6 m is taken and ground floor tallness of 3.5m is taken. Linear static analysis is taken up under zone 3 for varied heights and varied diagrid angles.

Table-1 Material Properties

Young's modulus of(M30) concrete	$30*10^6$ kN/m^2
Density of reinforced concrete	30 kN/m^3
Young's modulus of steel	$2*10^5$ kN/m^2
Density of steel	Fe 500
Density of Masonry	20 kN/m^3
Poisson's ratio	0.2

Table-2 Details of the building

Model	Diagrid angle	No.of module
MODEL 1	$67^0$22'	2
MODEL 1A	$78^0$13'	4
MODEL 2	$67^0$22'	2
MODEL 2A	$74^0$28'	3
Plan area dimension	18m*18m	
No. of floors in the first model M1	G+20	
No. of floors in the first model M2	G+30	
Type of building	Commercial building	

Storey height at ground floor	3.6m
Typical floor height	3.5m
Height of the model M1	75.5m
Height of the model M2	111.5m

Table-3 Sectional data

Member	Member no.	G+20 building	G+30 building	Property
Slab		120mm thick	120mm thick	Concrete
Beam	B	ISMB 500	ISMB 500	Steel
Column	C1	450*450mm	600*600mm	Concrete
	C2	700*700mm	700*700mm	Concrete
Diagrid	D1	350mm pipe with 12mm thickness	350mm pipe with 12mm thickness	Steel

Table-4 Loads considered

1	Live load at intermediate floors(IS 875 part 2)	4 kN /m^2
2	Live load at the top storey(IS 875 part 2)	1.5 kN /m^2
3	Floor finish at each storey(IS 875 part 1)	2.5 kN /m^2

Table-5 Seismic forces(IS:1893 (part 1)-2016)

Importance factor	1
Type of structure	SMRF
Response reduction factor	5
Zone of seismic force	III
Zonal seismic factor	0.16
Soil condition	Medium

Table-6 Wind load(IS:875 (part 3)-1987)

Basic wind speed	39 m/s
Wind location	Mangalore
Risk co-efficient	1
Category of terrain	III
Structure class	C
Topography factor	1
Design wind pressure for G+20	1025.397 N/m^2
Design wind pressure for G+30	1124.414N/m^2

2.1 ETABS SOFTWARE:

- ONE WINDOW, MULTIPLE USES: It offers the simultaneous performance of a) Modelling b) Analysis c) Design d) Reporting in a single user interface.
- HARDWARE SUPPORTED GRAPHCS : The graphics supported by the hardware allows steering of the models with fast rotations, fly-throughs.
- TEMPLATES: This software has a wide range of templates for starting a new model in quicker pace. The user is given the ability of grid defining spacing of the grid, number of storeis, structural system of the sections by default, slab and panel secions and dead and live uniform loads.
- MODEL VIEWS: The software manipulates the models with high precision and the elevation, plans and the 3D view can be generated simultaneously. The customviews along with cutting planes is what enables to manipulate and view the geometries which are complex easily.
- GRID SYSTEMS: a) Cartesian, b) cylindrical c) general free-formed grid systems are the various grid systems that can be defined in ETABS. Numerous grids can be defined in a model and also can be placed at any origin within the model and can be rotated with respect to any direction.
- DRAWING TOOLS: Many drafting and drawing utilities are built in the software to enhance the experience of the engineer and user can check out the shortcuts to the common industry standard and controls.
- PLANS AND ELEVATIONS: The view of plan and elevation are developed at every grid line to enable quick navigation of model. Custom elevation sections can be defined by the users by using the feature of Developed Elevation.
- INTERACTIVE TABLE DATA EDITING: Dock tables can be checked and the data can be edited using it. The defining of model from spread sheets and viewing the analysed results is much easier.
- MESHING TOOLS: This software enables the engineers to have wide variety of options under meshing and all that one need to do is to select the object area, select the rules for the automatically generative mesh.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 11 | Nov 2020 www.irjet.net p-ISSN: 2395-0072

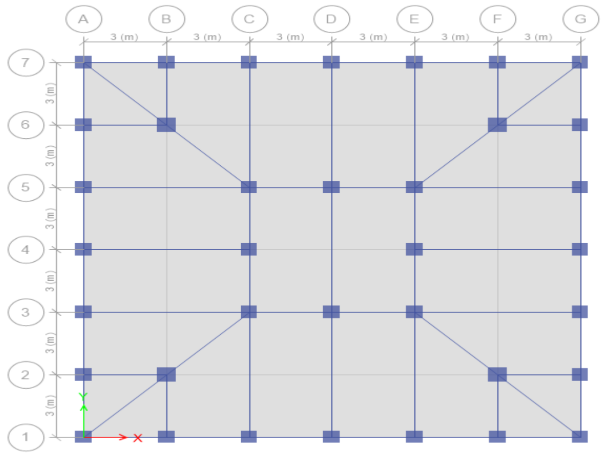

Fig. 1 Plan at the ground level

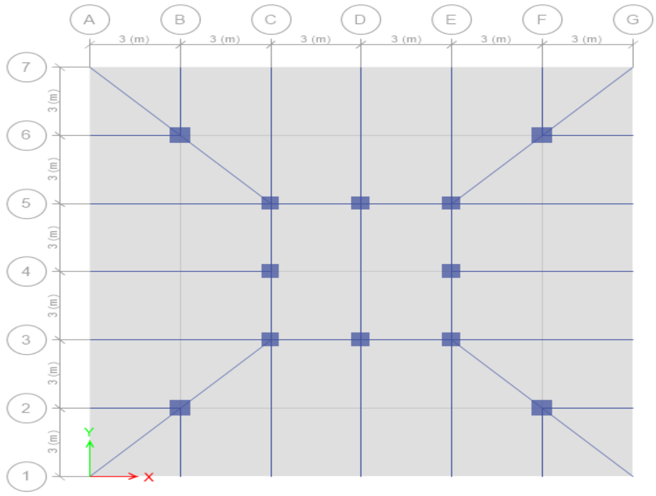

Fig 2. Plan at intermediate levels

3. RESULTS AND DISCUSSION

3.1Top storey displacement

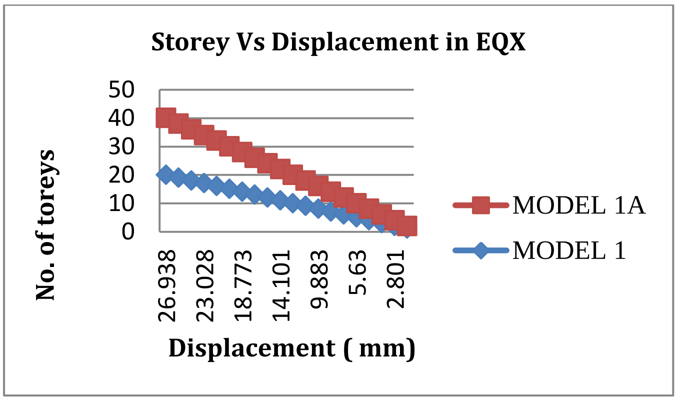

Chart 1 Displacement values of Model 1 and Model 1A in EQX direction

It was observed that the maximum values of displacement for Model 1 was found to be 26.938mm corresponding to the 20th storey which was lesser that the value of displacement 31.448 for Model 1A corresponding to 20th storey.

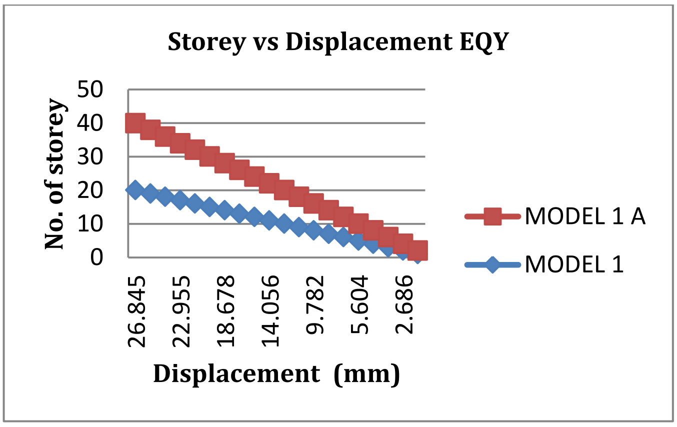

Chart 2 The displacement values of the Model 1 and Model 1A in EQY direction

It is seen that in both load cases EQX and EQY the displacement values are lesser for Model 1 than Model 1A. according to IS 456:2000 in clause 20.5 and page no.33, the highest displacement in the top storey should not be more than the value obtained by H/500 in which H=total height of the building. The analysis results obtained are within permissible limits and displacement of the structure decreases as the structure becomes stiff.

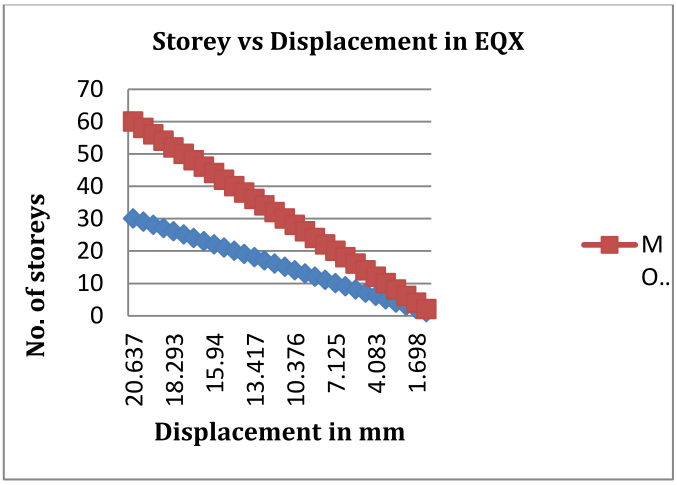

Chart 3 Displacement values in the Model 2 along with Model 2A in EQX direction

It was observed that the maximum values of displacement for Model 2 was found to be 20.637 corresponding to the 30th storey which was lesser that the value of displacement 21.282 for Model 2A corresponding to 20th storey.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 11 | Nov 2020 www.irjet.net p-ISSN: 2395-0072

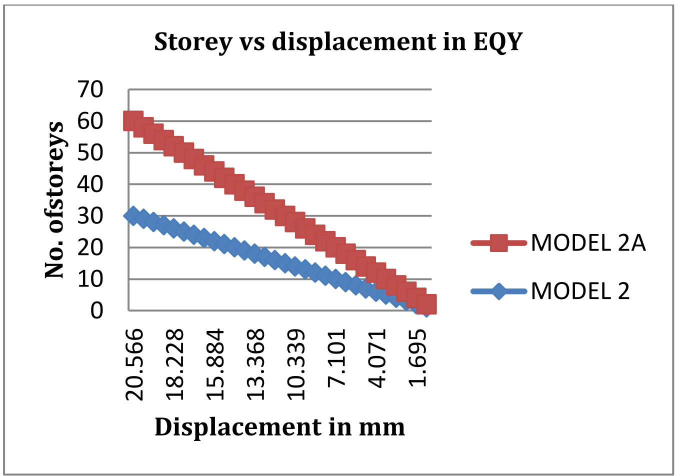

Chart 4 Displacement values for Model 2 and Model 2A in EQY direction.

- It is seen that in both load cases EQX and EQY the displacement values are lesser for Model 2 than Model 2A
- The analysis results obtained are within permissible limits and displacement of the structure decreases as the structure becomes stiff.

Storey Drift: The lateral displacement of a level correlation with the higher or below levels and is also distinct. In earthquake engineering it is an important condition used. It is incremental of lateral height and of limiting measure of drift.

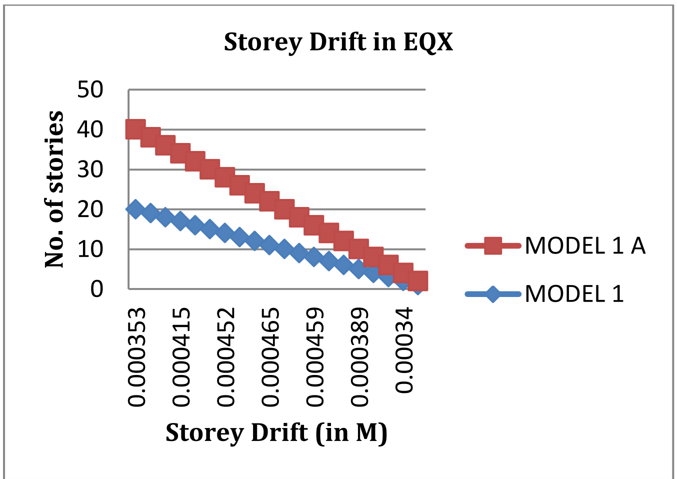

Chart 5 Storey drift values in the Model 1 and Model 1A in EQX direction

It is observed that value of the storey drift for the Model 1 was found to be maximum for the 12th storey having 0.000454m .It is lesser than that of the Model 1 A at where maximum of the value was found to be 0.000498 m corresponding to 13th storey.

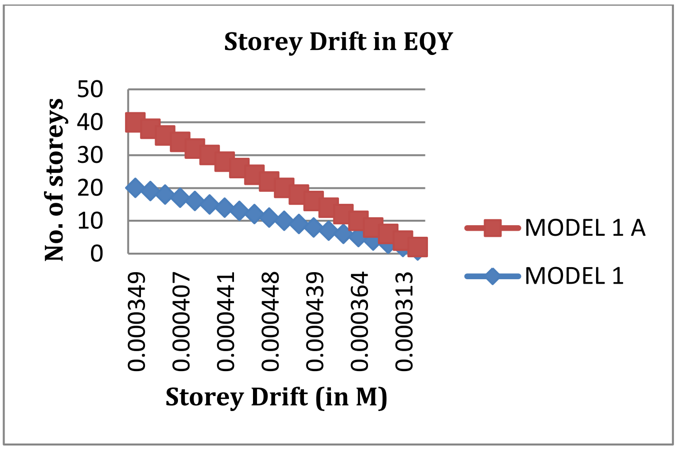

Chart 6 Storey drift values of the Model 1 and Model 1A in EQY direction

Inner storey drift is how the storey drift is generally defined. According to IS 1893:2002 referring the clause 7.11.1 in page no. 27, maximum drift value of storey shall not exceed o.oo4 also H/250 times the storey height (H= height of the storey in m) with a partial load factor of 1. Values are within permissible limits.

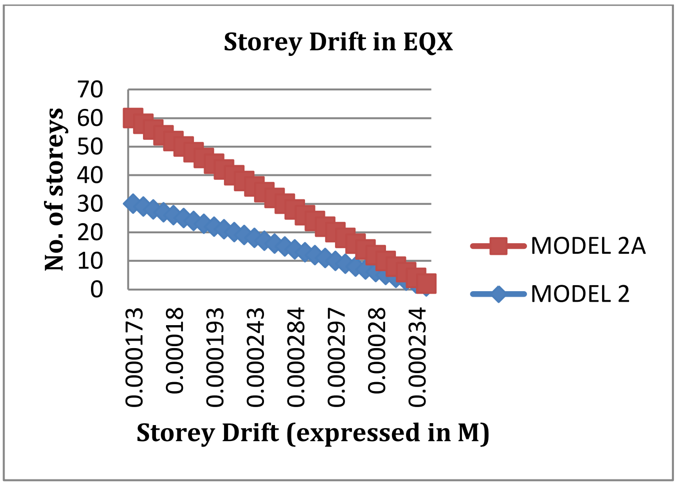

Chart 7 The storey drift values for Model 2 along with Model 2A in EQX direction

It is detected that values of the storey drift for the Model 2 was found to be maximum for the 10 th storey having 0.000297m .It is lesser than that of the Model 2 A at where maximum of the value was found to be 0.000317 m corresponding to 9th storey.

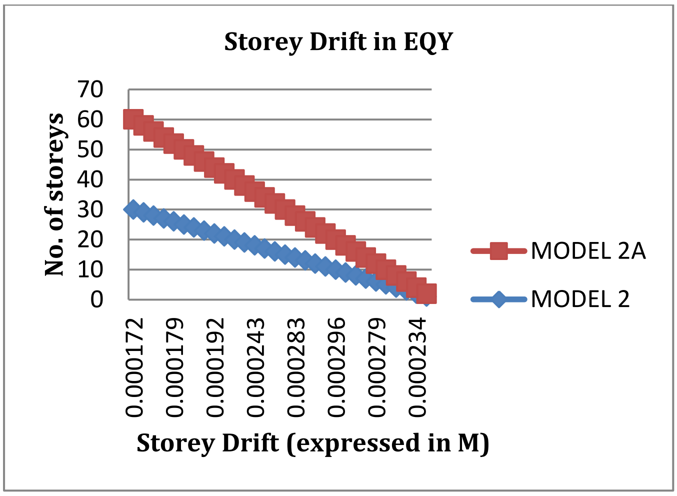

Chart 8 The storey drift values for Model 2 together with Model 2A in EQY direction

It is observed that value of the storey drift for the Model 2 was found to be maximum for the 10 th storey having 0.000296m .It is lesser than that of the Model 2 A at where maximum of the value was found to be 0.000316 m corresponding to 9th storey.

Base shear :

It is an approximate estimate of expected maximum force from lateral side that occurs because of seismic ground motion detected in base of the building. It depends on numerous factors like

1. Site soil situations.
2. Presence of geological faults ot sources of seismic activity.
3. Probability of ground motion due to seismic action.

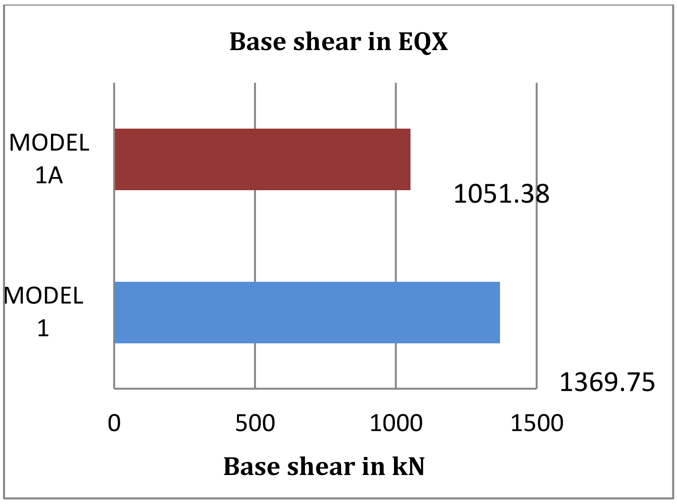

Chart 9 Graph of Base shear values of the Model 1 and Model 1A in EQX direction

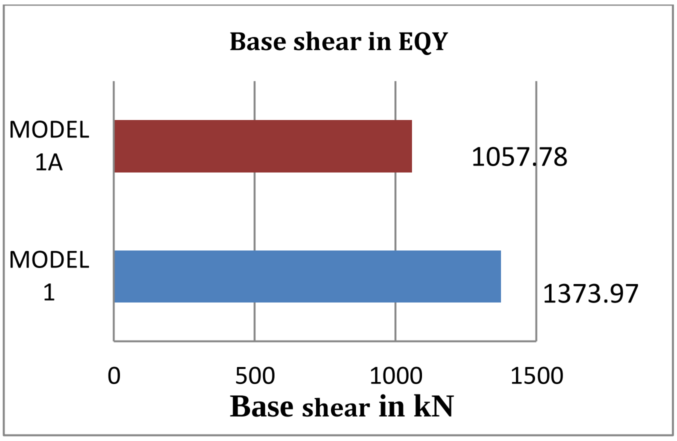

Chart 10 Graph of Base shear values of the Model 1 and Model 1A in EQY direction

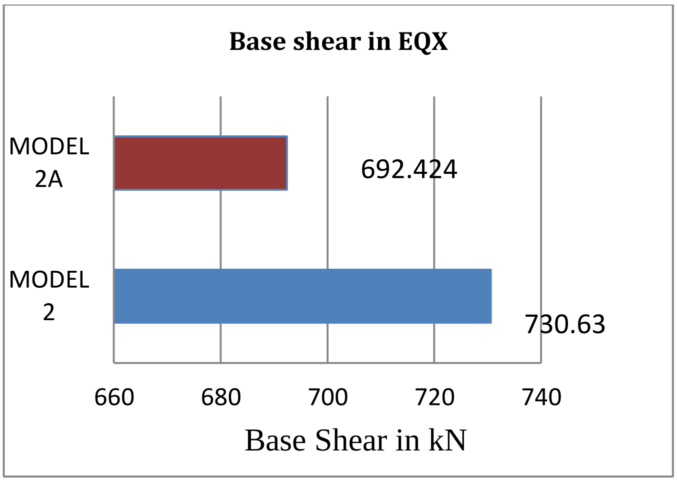

Chart 11 Graph of Base shear values for Model 2 and Model 2A in EQX direction

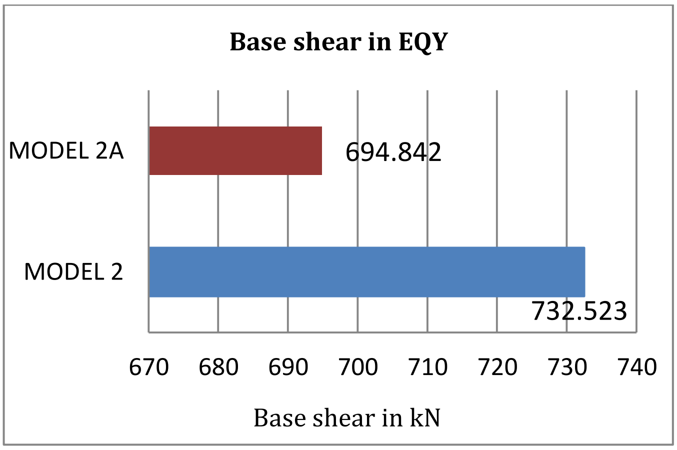

Chart 12 Graph of Base shear values of the Model 2 and Model 2A in EQY

- For Model 1 the base shear value was observed to be 1373.97 kN and for Model 1A it was 1057.78kN.

- For Model 2 the base shear value was 732.523 kN and that for Model 2A it was observed to be 694.842 kN.
- For Model 1 and Model 2 the angle differs by about half. Base shear values minimises as the height of the structure is increases.

3. CONCLUSIONS

The conclusions arrived at are listed as below

1. The value obtained for the 20 storey buildings Model 1 and Model 1A the top storey displacement were obtained as 26.938 mm and 31.448 mm respectively showing an increment of about 30%.
2. Top storey displacement for Model 1 is 26.938 mm whereas for Model 2 with the same diagrid angle $67^0 22'$, it takes a value around 20.637mm indicating there is a variation of 26%.
3. For Model 2A the maximum value of top storey displacement was observed to be 21.282mm under diagrid angle of $74^0 28'$ which is more than that for Model 2.
4. For Model 1 the storey drift was found to be maximum for the 12th storey with the value being about 0.000467mm and for Model 1A it was 0.000498mm at the 13th storey.
5. For Model 2 the storey drift value was seen to be maximum at 10th storey of about 0.000297mm and for Model 2A it was 0.000317mm found at 9th storey of the structure.
6. For Model 1 the base shear value was observed to be 1373.97 kN and for Model 1A it was 1057.78kN.
7. For Model 2 the base shear value was 732.523 kN and that for Model 2A it was observed to be 694.842 kN.
8. For Model 1 and Model 2 the angle differs by about half.
9. When the number of modules are increased from two in Model 1 to three in Model 1A and four in Model 2 the values of i) displacement increases ii) storey drift increases and iii) base shear lowered.
10. When the number of modules are increased from two in Model 2 to four in Model 2A i) increased displacement value and storey drift ii) decrement in the bases shear value.

REFERENCES

[1] Devaraja R and Megadi M R "Analysis of curved perimeter diagrid lateral system" vol 3issue 6, 2014

[2] Dhanagopal Patil, Naveena M P"Dynamic Analysis of steel structure with bracing systems"volume 04 issue 08 2015

[3] Dr.Gopisiddappa et.al (2017) analysed tall building structures with diagrid system which are subjected to dynamic loading

[4] Femy Mariya Thomas(2015) investigated on the performance evaluation in high rise buildings

[5].J. Kim, Y.Jun and Y.-Ho Lee, "Seismic Performance Evaluation of Diagrid System Buildings", 2nd Specially Conference on Disaster Mitigation, Manitoba, 2010.

[6] Jani K and Patel V "Analysis and design and diagrid structural system for high ris buidings"Procedia Engineering,Vol 51,2013

[7]Jayesh Venkolath Rahul Krishnan "Optimal diagrid angle of high rise buildings subjected to lateral loads"

[8]. Khushbu Jani and Paresh V. Patel, "Analysis and Design of Diagrid Structural System for High Rise Steel Buildings", Published by Elesevier Ltd, Procedia Engineering 51, pp 92-100,2013.

[9]. Kyoung S. Moon, "Diagrid Structures for ComplexShaped Tall Building", Published by Elesevier Ltd, Procedia Engineering 14, pp 1343-1350,2011.

[10]. Kyoung S. Moon, Jerome J. Connor and John E. Fernandez, "Diagrid Structural Systems for Tall Building: Characteristics and Methodology for Preliminary Design", Willey Interscience Publication

[11]. Mir M. Ali and Kyoung S. Moon, "Structural Developments in Tall Buildings: Current Trends and Future Prospects", Architectural Science Review, vol. 50.3, pp 205- 223, 2007.

[12]Mohammed Maqdoom Ali ShariqNoor Mohammed FaiqDr.Krishna Niveditha "high rise diagrid structures with different module angle and base width"2395-0056,2020

[13] Nguyen B K and Atlan h "Strategies to reduce ateral forces on high rise buildings that use diagrid structural system

[14]Prashanth T G et.al (2015) compared symmetric and asymmetric structures having steel diagrid systems using non-linear static analysis

[15] Ravish Khan S.B Shinde"Analysis of braced structure in cmparison with exterior braced frame structure", Eissn:2319-1163,2015

[16]. IS: 800-2007. General Construction in Steel- Code of Practice (Third Revision), Bureau of Indian Standard, New Delhi

[17]. IS: 456-2000. Plain and Reinforced Concrete- Code of Practice (Fourth Revision), Bureau of Indian Standard, New Delhi.

[18]. IS: 1893(Part-I)-2002, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standard, New Delhi.

[19]. IS: 875(Part-I, II, III)-1987, Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Bureau of Indian Standard, New Delhi.