International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 12, December-2018

# Analysis and Design of Conventional Structural System and Its Comparison with Diagrid Structural System.

Miss Sushmita.G.Agasabal[1], Prof. S.A.Warad[2]

[1] *Student, M.Tech Structural Engineering, Dept of Civil, B.L.D.E.A`s V.P. Dr. P.G. Halakatti College of Engineering and Technology, Vijayapur-586103,sushmitaagasabal76@gmail.com*

[2] *Assistant Professor, Dept of Civil, B.L.D.E.A`s V.P. Dr. P.G.Halakatti College of Engineering and Technology, Vijayapur-586103*

***Abstract:** Now a day's construction of high rise building is rapidly increasing throughout the world. Therefore the diagrid structural system is most widely used for high rise buildings because of its structural efficiency and aesthetic look. The diagride structure is a type of structure in which the diagonal members are used in the periphery of the structure. In present work concrete diagride structural system with corner column and without corner column is analyzed and compared with conventional structural system. Due to inclined columns in the periphery, lateral loads are resisted by axial action of the diagonal in diagrid structure compared to bending of vertical columns in conventional structure. A regular G+18 storey RCC building with plan size 20mX20m located in seismic zone III is considered for analysis. STAAD.Pro software is used for modelling and analysis of structural members. All the structural members are designed as per IS 456:2000 and load combinations of seismic forces are taken as per IS 1893(part 1):2000. Comparison of results on terms of axial force, bending moment, shear force and displacement is presented. Thus it can be concluded that behaviour of diagrid structural system with corner column is more efficient than diagride without corner column and conventional structural system.***

***Keywords:** STAAD.Pro, diagride structural system, conventional system, axial force, bending moment, displacement.*

## 1. INTRODUCTION

Due to the rapid increase in the population and land values in all aspects, mainly in the urban areas it is a pressure on a structural engineer to come up with a better performing structural system. The evolution of urban population and subsequent weight on constrained space has significantly affected the private development of the city. A major challenge for multi utilize tall structures is to rollout them versatile to occupy at various flood levels reacting to the requests of real estate market.

Now a day the diagrid frame works are generally used for the steel structure because of its structural efficiency and aesthetic look, geometric configuration. The diagride structure is a type of structure in which the diagonal members are used in the periphery of the structure. The major difference between diagonal structural system and conventional framed structure is there are no vertical columns present in the periphery and are used to support the floor edge. Diagride is a specific type of space truss. It comprises of edge grid comprised of a progression of triangulated truss frame work. Diagrids are framed by intersecting of diagonals and horizontal parts. The diagrid has great appearance and it is effectively recognized. The diagrid buildings carry lateral loads more efficiently as compared to conventional framed buildings due to the presence of diagonal member's axial action. Diagrid structural system is becoming more famous during these days. Due to the presence of the diagonal members in the periphery of the structure, it is not necessary to provide vertical columns. The design and productivity of structural component required on the facade of the structures. Diagrid structures gives incredible basic proficiency without vertical segment likewise opened new tasteful potential for all building engineers. The individual diagrid frame conveys gravity loads and in addition lateral loads due to their triangulated design. The diagrid frame work can be planar, crystalline or goes up against numerous shapes but commonly used are crystalline structures or curve and flow to expand their stiffness. Border diagrids regularly convey the lateral and gravity loads of building and are used to compare the flood edges.

### *1.1 The objectives of the present research work are:*

- Determination of optimum configuration for conventional framed buildings and diagrid building with same plan area using STAAD.Pro software.
- Comparing the results of conventional framed structural system with diagrid structural system with corner columns and without corner columns in terms of following parameters.
  - ❖ Axial force
  - ❖ Bending moment
  - ❖ Shear force
  - ❖ Displacement

## 2. LITERATURE REVIEW

1) Raghunath. D. Deshpande [2015] -The structural design of high raised building is mainly governed by lateral forces due to wind and earthquake. Exterior structural system or interior structural system resists this lateral force. Generally braced frame, shear wall core and their combinations with frames are interior system, where lateral load is resisted by centrally located elements. The new system called diagrid structural system is adopted as an inclined column on the facade of the building. The inclined columns in diagrid structures resists lateral loads by axial action of diagonals when in bending of vertical columns in framed tube structure. Since lateral shear can be carried by the diagonals on the periphery carried by the diagonals on the periphery diagrid structures generally do not require core. In this study, 60 storey building is considered for the analysis and designing. A square plan of 24*24 m is considered. For modelling and analysis of structural member ETABS software is used. Structural members are designed as per IS800:2007 considering all load combinations. For analysis and design of the structure, structure along wind and across the wind is considered. Both the conventional and diagrid structural systems are compared. They concluded that diagrid structures perform better against the deflection and it show reduction in the structural weight to great extent.

2) Khushbu Jani [2012] -When the height of building is increased its structural design is mainly governed by lateral forces, it may be earthquake or wind loads. Exterior structural system or interior structural system resists this lateral force. Recently diagrid structural system is adopted for high rise buildings due to structural efficiency and flexibility in architectural planning.

In this journal, analysis and design is done for 36 storey diagrid steel building. A regular floor plan of 36*36m size is considered. ETABS software is used for analysis and modelling of structural members. For designing and for load combinations IS 800:2007 code book is used. The pattern of load distribution in diagrid system is also studied for 36 storey building. And analysis and design is done for 50, 60, 70 and 80 storey diagrid structures. Comparison of analysis results in terms of period, top storey displacement and inter storey drift is presented in this paper. From this analysis diagrid structures shows less drift, displacement, so it is concluded that lateral forces in the diagrid structures are resisted by the diagrid columns on the periphery. The lateral forces are resisted by both internal columns and peripheral diagonal columns.

3) Shubhangi.V. Pawar [2017] - In this paper earthquake and wind analysis of steel diagrid structures with square, rectangular and circular shapes are presented. The Indian standard code of practice IS 1893(part1:2002), IS 875:1987(part 3), IS 800:2007 guidelines and methodology are used to analysis and design of the building. Modelling and analysis is done by the software ETABS. Zone III is considered for earthquake and wind analysis. Equal plan area of 1296 m^2 is used for square, rectangular and circular plans. Linear static analysis is done for analysis. The behaviour of the building components was studied and compared displacements, storey drift and base shear.

4) Pallavi Bale [2016] - In this paper, concrete diagrid structure is analysed and compared with conventional framed structure. The components of tall structures are governed by lateral loads because of earthquake and wing. Its resistance is provided by interior or exterior structural work. A new technique called diagrid systems are now a day’s used to resist these lateral and gravity forces.

In this paper a standard 5 storey RCC working plan of 15*15m was situated in seismic zone V is considered for study. For modelling and analysis, STAAD.Pro software is used. IS 1893(part 1):2002 code book was used for seismic design and for load combinations. The storey drift, displacement, bending moments, shear forces, area of reinforcement and economic aspects are discussed. In this study, it is observed that due to diagonal columns in the periphery of the structure, diagrid is effective against lateral load resistances. From this study it is concluded that, diagrid structure indicates less lateral displacement and drift compared to regular building. Diagrid indicates more effective regarding steel usage. And diagrid buildings are more aesthetic in look and it becomes important for high rise buildings.

5) Saket Yadav [2015] - Here, the study of conventional building and diagrid is done to know the structural response and then to evaluate the structural benefits of diagrid system. For the study a plan of 18*18m and G+15 storey steel building is considered. Zone v is taken for the analysis. STAAD.Pro software is used for modelling and analysis. All structural members are designed as per IS 800:2007 and IS 1893(part 1):2002. From the analysis of results they concluded that, the major portion of the load in diagrid structures are taken by the external diagonal members. So, the maximum shear force, bending moment in internal and perimeter beams and internal columns are significantly reduced. An overall economy nearly 12% is achieved in diagrid buildings when compared to conventional buildings.

## 3. MODELLING AND ANALYSIS

*3.1 Modelling*

In this project a symmetrical building of G+18 Storey is considered for study. The plan area 400 m² is considered for all types of model. For the analysis STAAD.Pro Software is used. Details of the building are given below.

TABLE 3.1
Sectional Properties of the Building

| MEMBER | DIAGRID BUILDING | CONVENTIONL BUILDING |
|---|---|---|
| **Beam**<br>First 5 storeys<br>Next 15 storeys | <br>500*380mm<br>450*300mm | <br>500*380mm<br>450*300mm |
| **Column**<br>First 5 storeys<br>Next 15 storeys | <br>600*450mm<br>500*380mm | <br>600*450mm<br>500*380mm |
| **Diagrid** | 300*300mm | - |

*3.2 Description of model*

*A. Building Data*

a. Number of Storey -G+18
b. Typical Storey Height- 3m
c. Building Height – 57 m
d. Grade of Concrete – M25
e. Grade of Steel- Fe 415
f. Slab Thickness- 200mm
g. Area of the Plan- 400m²
h. Angle of Diagrid - 45°
i. Structure Type – concrete structure
j. Number of Bays along X and Y direction- 5
k. Length of each Bay- 4m
l. Thickness of wall- 230 mm

*B. Seismic Data (As per 1893, Part 1:1983)*

a. Zone factor - 0.16(III)
b. Response Reduction Factor, R- 5 (SMRF)
c. Importance factor, I - 1
d. Types of soil -II (Medium Soil)

*C. Loading Data*

a. Live loads for Floors - 4 k N /m² as per IS 875 (part 2):1987
b. For Roofs -1 k N/m²
c. Floor finish - 0.75 k N/ m²
d. Wall loads- 13.8 k N/m² as per IS 875(part 1):1987

*3.3 Plan and 3D View of all the Structures*

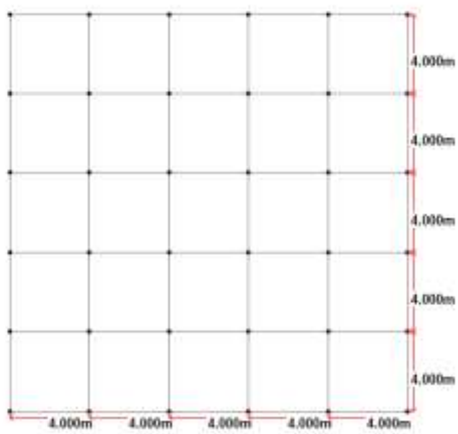


Fig.1 Plan of structure

Fig.2 3D View of conventional framed structure

Fig.3 3D View of diagrid structure with corner column

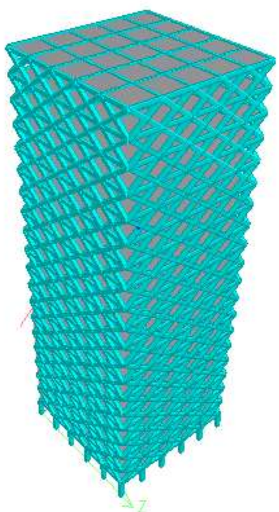

Fig.4 3D View of diagrid structure with corner column

## 4. RESULTS AND DISCUSSIONS

The parameters such as axial force, bending moment, shear forces, displacements and reinforcement requirement etc are calculated for all three types of buildings by using software. The comparison between conventional building , diagrid with corner column and diagrid without corner column building is made in terms of the parameters which have mentioned above. Abbrivations of the models are as follows,

M1 : Conventional framed structure
M2 : Diagrid structure with corner column
M3 : Diagrid structure without corner column

*4.1 Axial Force*

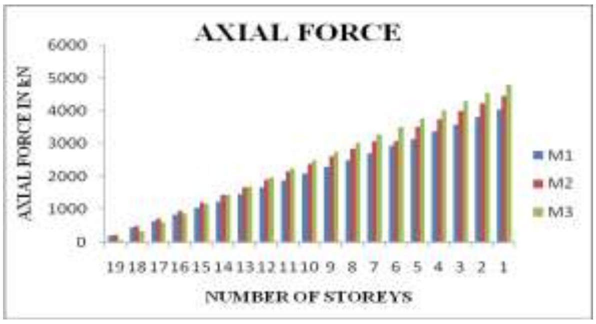


Fig.5 Axial Force in kN

From the fig 5, the axial force is initially high in diagrid building with corner column (M2), diagrid building without corner column (M3) and goes on decreases as the number of storey's increase as compared to conventional framed structure (M1). The axial force of conventional framed structure is half of the diagrid structure

*4.2 Bending moment along z-axis*

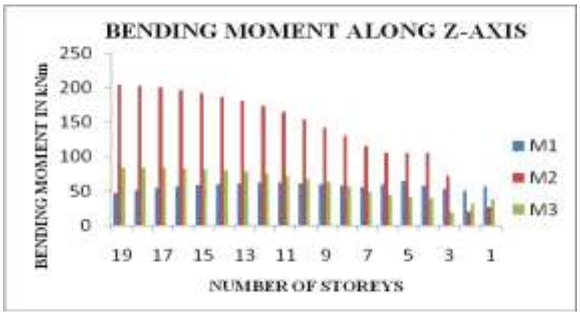


Fig.6 Bending moment along Z-axis in kNm

From the fig.6, initially the bending moment is very low in all the three buildings and goes on increases as the number of storeys increases. Here the diagrid building with corner column(M2) posses higher bending moment as compared to conventional building(M1) and diagrid building without corner column(M3).The bending moment of conventional framed structure(M1) is nearly 47% less as compared to diagrid structure with corner column(M1) and without corner column(M2).

*4.3 Bending moment along y-axis*

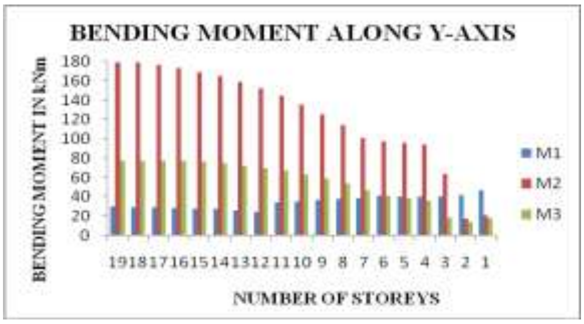


Fig.7 Bending moment along Y-axis in kNm

From the fig.7, the bending moment for diagrid structure with corner column (M2) is nearly 50% higher as compared to conventional building (M1) and nearly half of the diagrid structure without corner columns (M3). The bending moment for both diagrid building with corner column (M2) and without corner column (M3) is directly proportional to number of storeys.

*4.4 Axial force*

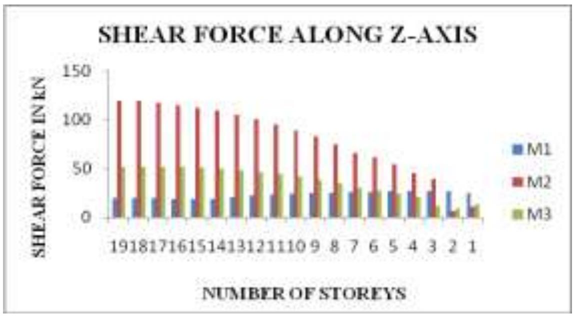


Fig.8 Shear force along Z-axis in kN

From the fig.8, the shear force for diagrid building with corner column (M2) is 33% higher than conventional building (M1) and 24% higher than diagrid building without corner column (M3). The value of shear force for conventional building (M1) is even low as compared to diagrid building without corner column (M3).

*4.4 Shear force along y-axis*

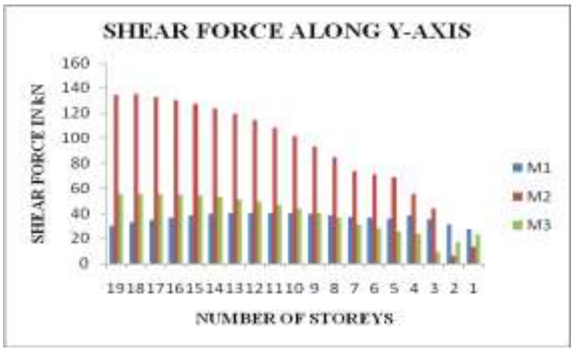


Fig.9 Shear force along Y-axis in kN

From the fig.9, initially the value of shear force for all three models (M1, M2, and M3) is less and as the number of storey's increases, the value of shear force goes on increases. The shear force for diagrid building with corner column is higher than conventional building and diagrid without corner column. The shear force for diagrid building with corner column (M2) is 31% higher than conventional framed structure (M1) and 28.6% higher than diagrid building without corner column (M).

4.5 Displacement


Fig.10 Displacement in mm

From the fig.10, initially the value of displacement is very less in all three models (M1, M2, and M3) and goes on increases as the number of storeys increase. The displacement of conventional framed structural system (M1) is nearly double the diagrid structural system with corner column (M2) and much higher than diagrid structural system without corner column (M3).

## Conclusions

The main conclusions obtained from the analysis of building frames are summarized below

1) Diagrid structural system with corner column is more efficient than conventional framed structural system and diagrid structural system without corner column due to its triangular configuration.
2) It provides better solution against lateral loads due to its structural efficiency, triangular configuration and flexibility in floor plan.
3) The axial force carried by the diagonal member get reduced due to the presence of corner column. Hence, the interior column has to take more axial force.
4) The bending moment for diagrid structure with corner column along Z-axis is nearly 50% higher as compared to conventional building and nearly half of the diagrid structure without corner columns.
5) The shear force for diagrid building with corner column is 33% higher than conventional building and 24% higher than diagrid building without corner column.
6) The shear force for diagrid building with corner column is 31% higher than conventional framed structure and 28.6% higher than diagrid building without corner column.
7) The value of displacement for diagrid structural system with corner column is less as compared to conventional structural system and diagrid without corner column.

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