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Comparative Analysis of Conventional and Diagrid Structural Buildings with Plan Irregularity

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Abstract: Earthquakes plays an important part in the analysis and designing of structure. It takes long time to analyse and design structure manually under different loading conditions but with the help of software the analysis and construction of any structure can be done easily so with the help of STAAD PRO software we Compare the performance of Diagrid Structural Building and conventional structural buildings with plan irregularities to analyze the stability of structure in seismic zone .Buildings with large height are more vulnerable to collapse due to high wind and earthquake load. The risk of failure in such a multistory building can be minimized by adopting lateral load resisting systems. In this study, modeling is done on irregular plan. For irregular plan, C-shape of plan and L-Shape of plan are considered. In this thesis, four models are analyzed, two diagrid frames, and two conventional frame models for C-Plan and L-Plan separately. The building consists twelve storey frame structure having total height 36m and storey height is kept 3 m for each floor. In this project the First Comparison done between diagrid structural system, and conventional frame structural system for C-Type and L-Plan separately and after that second overall comparison is between C-Plan and L-plan. Comparison has been done for different types of models for earthquake load case by considering various parameters like, displacement, base shear, bending moment.
STADD PRO stands for structural analysis and design software.M40 grade of concrete and Fe-500 steel as per IS 800:2007 were used. Load combinations are taken as per IS 1893:2002 code and method of analysis used is Linear response method and live load are taken according to IS-875. Earthquake zone 4 has been adopted for analysis. When diagrid are connected to the floor the fluctuations of results occurred between the floor. The value of Base shear in diagrid structure is smaller than the bare frames. The result of work showed that diagrid system resist lateral load more efficiently than conventional frame as it yields the least value for displacement, bending moment and shear force

Key Words: Diagrid, Lateral loads, Displacement, Base Shear, Moment, plan irregularity

1. Introduction

In today's trend, the rate of growth of population is increased day by day. Due to these increasing population rate the space required for land is insufficient. So, civil engineer construct a building in sufficient space and in sufficient plan. Due to sufficient space, height of building is kept to be maximum for accommodation. In old days these tall buildings only use for commercial purpose but now it is for commercial as well as residential purpose. There aremany cases of damage of building from past earthquake all over the world. Due to their structural simplicity, buildings are particularly vulnerable to damage and can collapse when subjected to earthquake motion. In simple or conventional building, when height of building increases the lateral load resisting system (includes earthquake load and wind loads) becomesmore important than the structural system that resists gravitational load. The simple buildingsas its height increases due to intensity earthquake it experiences or it starts deforming its shapein the form buckling. And it causes the collapse of building

There fore the response of structures to seismic activity has attracted the attention of engineers due to consequences that accompany the earthquakes. The introduction and improvement of computer technology gave lots of scope for researches and practicing engineers to study the use of earthquake resisting frame technology to reduce the damage caused to these structures.

1.1.1 General Approach to Control Seismic Damage to Building Using Lateral Load Resisting System

Buildings are subjected to two types of loads i.e. lateral load due to wind and earthquake and vertical load due to gravity. The structural system of the building cater for both the types of loads. The structural system of building may also be consisting of two components systems such as Horizontal framing system consisting of slab and beams which is primarily responsiblefor transfer of vertical load to the vertical framing system and Vertical frame system of structureconsisting of beams and columns, which is primarily responsible for transfer of lateral load to beam to column, column to foundation. However, the two components work in conjunction with each other. So, for increasing the stability of interior and exterior structural system the civil engineer construct a building with lateral load resisting frame system. Lateral load resistingsystems are

1. Interior Structure

- Rigid Frames
- Braced Hinged Frames
- Shear Wall / Hinged Frames Shear Wall (or Shear Truss) - Frame InteractionSystem
- Outrigger and belt truss Structure

2. Exterior Structure

- Framed Tube / Braced Tube /Bundled Tube /Tube in Tube Structure
- Diagrid Structure
- Space Truss Structures
- Super frames
- Exo-skeleton Structure

Each complex form category, tall buildings are designed with various structural systems, suchas braced tube, dia-grid and braced systems. In this chapter, we studied lateral load resisting frame system i.e. diagrid frame system.

Diagrid Frame System

The wordy meaning of diagrid is dia means many and grids regard those intersecting triangularmembers or beams. Diagrid frame system is a particular form of space truss. Diagrid system consists of perimeter grid made up of a series of triangulated truss system. Diagrid frame of thebuilding is formed by intersecting the diagonal and horizontal components it has good appearance and it is easily recognized. The configuration and efficiency of a diagrid structuralsystem reduce the number of structural element required on the façade of the building frames, therefore less obstruction to the outside view. The structural efficiency of diagrid frame systemalso helps in removing interior and corner columns, therefore allowing significant flexibility with the floor plan. The diagonal members in diagrid frame structural systems can carry gravityloads and lateral forces due to their triangulated configuration. Diagrid structural frame system æ more effective in minimizing shear deformation because they carry lateral shear by axial action of diagonal members. Diagrid structures generally do not need require high rigidity because lateral shear force can be carried by the diagonal members located on the periphery.

Advantages derived from Diagrid Structural System

- Taller and safe Structure, Go for Super-tall Structures.
- No periphery Columns
- Freedom of Architectural Complex Geometries
- Resistant to lateral loadings efficiently
- Efficient use of structural strength
- Enhanced Stiffness and Strength
- Less amount of Material Required

Limitations of Diagrid structure:

Despite of many advantages of diagrid frame structural system, still there is more need to explore new tricks and configurations in the structure. The limits of diagrid structure given as follows.

- The complex design of the diagrid frame system can present challenges in the computation,analyses and construction process.
- Because of the design variables like the diagonal angle and the bending to shear flexibility ratio, it is not predicated the response in advance, which approach will govern, either global stiffness demand or member strength demand.
- There is a limitation of height of structure. For diagrid constructed of steel 100 storey is maximum height and 60 stories for diagrid constructed of concrete.

- Concrete diagrid system is very complex in design. Thus, diagrid structure requires a large amount of form work, which eventually leads to higher construction cost.
- Similarly, steel members of structure are pre-fabricated due to their complexity. This also increases the construction cost of structure.
- Interior diagrid may result to strange interior height.
- The diagrid is a very strong design statement overall. This can sometimes be overpowering.

2. Objectives

- To study the C-Type and L-Type irregular structure.
- To study the conventional frame and diagrid frame action in high rise building for C Type and L-Type irregular structure
- To compare the performance of the building with diagrid structural system, and conventional frame system under seismic loading for C- Type and L-Type plan separately using STAAD Software.
- To obtain the response in terms of parameter such as storey displacement, storey drift shear.
- To determine the best and the appropriate structural system for the different type of highrise buildings.

3. Methodology

The main contributions of this thesis for the high-rise buildings can be summarized as follows:

Diagrid system has high stiffness and strength to resist lateral load due to earthquake in high rise building. Diagrid system was the most efficient lateral load resisting system in earthquake load case based on displacement, storey drift, moment and axial force criteria. The forces are more in central column has been investigated. There is estimating earthquake forces on conventional frame model and different types of diagrid model and investigate the performance of the structures against earthquake.

- Consideration of C-type and L-type of plan.
- Consideration of conventional frame and diagrid frame.
- Evaluation of the response of different models of building using STAAD Software.
- Comparison of the response obtained by different parameter for C-Type and L-type of plan separately.

4. Scope Of Project

From earlier research work till now, various researches have carried out work on diagrid structure and from this project we can study C-Type and L-Type irregular structure and also analyses digrid structure with and without plan irregularity in high buildings for C-Type and L-Type of structure.

The comparison of the buildings with digrid structural system and conventional frame system under seismic loading for C-Type and L-Type plan using STAAD PRO software can be carried out to obtain the response in terms of parameters such as storey drift, displacement, basec shear and moment.

5. Modelling

In this study four models are considered, C-Conventional, C-Diagrid, L- Diagrid, L-conventional plan irregularity. All the plans have same area of 192 m^2. The 12 storey building is consider and total height of building is 36 m keeping each storey height 3 m a.thickness of slab is 100 mm, column section 450*300 mm and beam section is 230*300 mm. seismic zone IV for that zone factor is o.24, Response reduction factor 5 (SMRF), Soil type is hard soil, Importance factor is 1, damping ratio consider is 5%.The structure are modeled in STAAD PRO software.

C-Type conventional and Diagrid structure

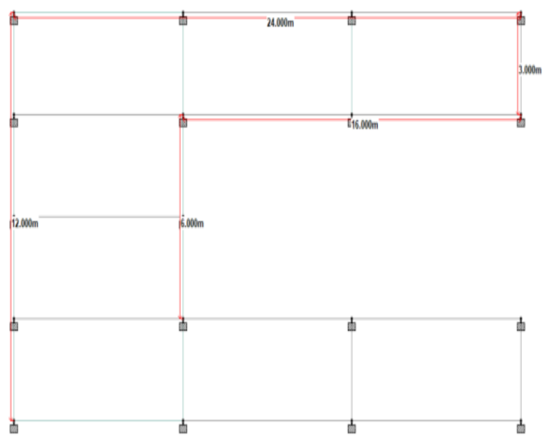

Fig 5.1 Base plan of C- Structure

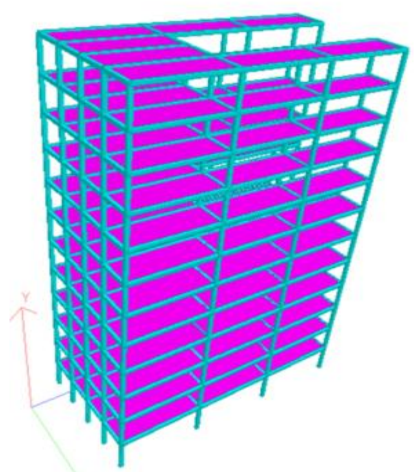

Fig 5.2 3D view of C-conventional Structure

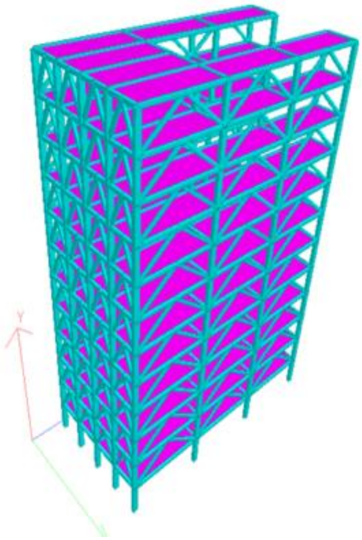

Fig 5.3 3D view of C-Diagrid Structure

For C-TYPE the rendering view of models is shown above. The 3d view of conventional model and diagrid model shown. These 3d view of model obtained from STAAD-Pro Software

L-Type conventional and Diagrid structure

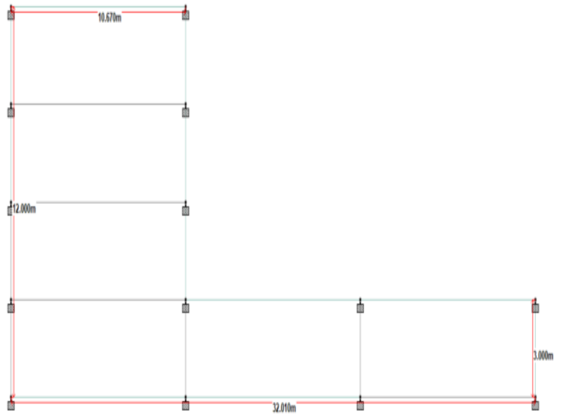

Fig 5.4 Base plan of L- Structure

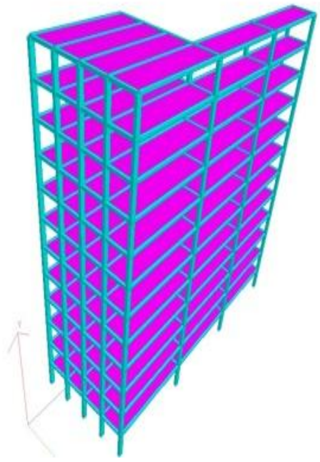

Fig 5.5 3D view of L-conventional Structure

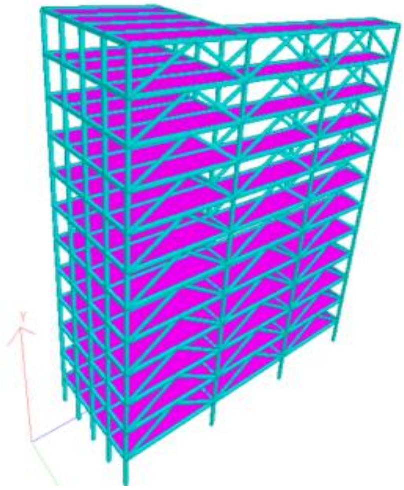

Fig 5.6 3D view of L-Diagrid Structure

For L-TYPE the rendering view of models is shown above. The 3d view of conventional model and diagrid model shown. These 3d view of model obtained from STAAD Software.

6. Results

The results obtained are shown below in the form of table and Graphical representation.

Table 6.1: Shear force and bending moment for C-type conventional Model

DIRECTION	LOAD	SHEAR FORCE IN Z DIRECTION (KN)	BENDING MOMENT IN Y DIRECTION(KN-M)
Max Fx	RSA	550.791	745.256
Max Fy	RSA	10.846	20.568
Max Fz	RSA	625.978	943.4

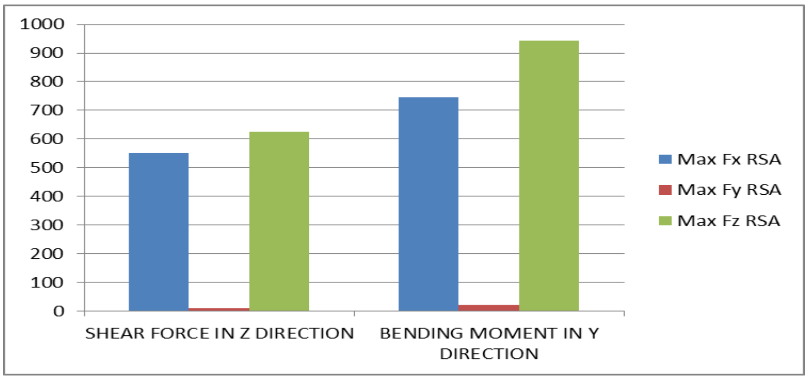

Fig 6.1 Graph of Shear force and bending moment in kN for C-type conventionl Model

Table 6.2: Shear force and bending moment for L-type Diagrid Model

DIRECTION	LOAD	SHEAR FORCE IN Z DIRECTION (KN)	BENDING MOMENT IN Y DIRECTION (KN-M)
Max Fx	RSA	294.59	295.395
Max Fy	RSA	0.605	0.841
Max Fz	RSA	399.068	615.688

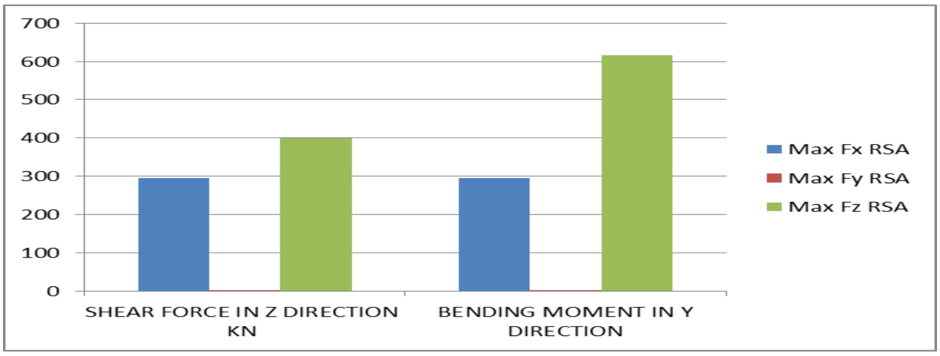

Fig 6.2 Graph of Shear force and bending moment in kN for C-type Diagrid Mode

The comparison of Shear Force in between diagrid building and conventional building for C-type plan are shown in table and graph The maximum Shear Force is found to be 625.978kN in z direction and the minimum is found 10.846 kN in y direction for conventional c-type structure. The maximum Shear Force is found to be 399.068 kN in z direction and the minimum is found 0.605 kN in y direction for diagrid c-type structure.in comparison of conventional building and diagrid building the maximum Shear Force is foundto in conventional c-type structure. Hence in c plan structure for shear force diagrid frame system is 46.51% less than conventional c structure.

The comparison of Bending Moment in between diagrid building and conventional building for C-type plan are shown in table and graph The maximum Bending Moment is found to be 943.34 KN in z direction and the minimum is found 20.568 kN in y direction for conventional c-type structure .The maximum Bending Moment is found to be 615.688 kN in z direction and the minimum is found 0.841 kN in y direction for diagrid c-type structure. in comparison of conventional building and diagrid building the maximum Bending Moment is foundto in conventional c-type structure. Hence in c plan structure for Bending Moment diagrid frame system is 60.36% less than conventional c structure.

Table 6.3: Shear force and bending moment in kN for L-type conventional Model

DIRECTION	LOAD	SHEAR FORCE IN Z DIRECTION	BENDING MOMENT IN Y DIRECTION (KN)
Max Fx	RSA	312.41	329.65
Max Fy	RSA	377.34	585.145
Max Fz	RSA	377.34	585.145

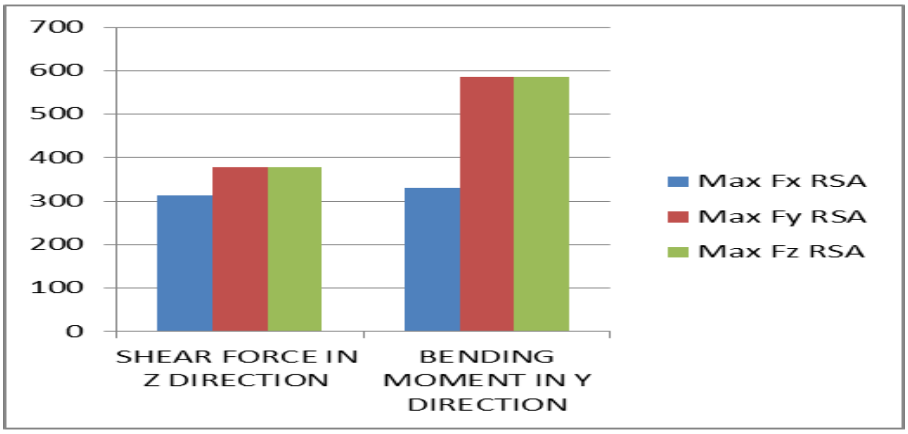

Fig 6.3 Graph of Shear force and bending moment for L-type conventional Model

Table 6.4: Shear force and bending moment in kN for L-type Diagrid Model

DIRECTION	LOAD	SHEAR FORCE IN Z DIRECTION (KN)	BENDING MOMENT IN Y DIRECTION (KN-M)
Max Fx	RSA	239.214	310.094
Max Fy	RSA	239.214	310.094
Max Fz	RSA	275.955	382.775

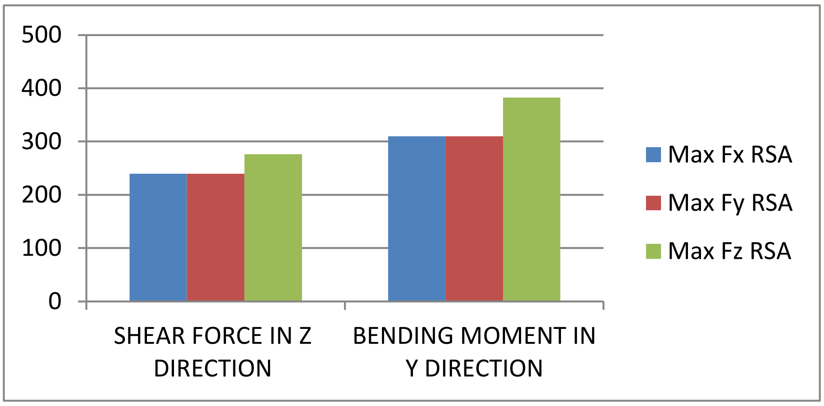

Fig 6.4 Graph of Shear force and bending moment for L-type Diagrid Model

The maximum Shear Force is found to be 377.34 kN in z direction and the minimum is found 312.41 kN in x direction for conventional L-type structure and The maximum Shear Force is found to be 275.955 kN in z direction and the minimum is found 239.214 kN in x direction for diagrid L-type structure,. in comparision of conventional building and diagrid building the maximum Shear Force is foundto in conventional L-type structure.hence in L plan structure for shear force diagrid frame system is 23.43% less than conventional L structure.

The maximum Bending Moment is found to be 585.145 kN in z direction and the minimum is found 329.65 kN in x direction for conventional L-type structure and The maximum Bending Moment is found to be 382.775 kN in z direction and the minimum is found 310.94 kN in x direction for diagrid L-type structure,. in comparision of conventional building and diagrid building the maximum Bending Moment is foundto in conventional L-type structure. Hence in L plan structure for Bending Moment diagrid frame system is 5.93% less than conventional L structure.

Table 6.5: Displacement in mm for C-type conventional Model

DIRECTION	LOAD	DISPLACEMENT (MM)
MAX X	RSA	801.932
MAX Y	RSA	1900.725
MAX Z	RSA	801.935

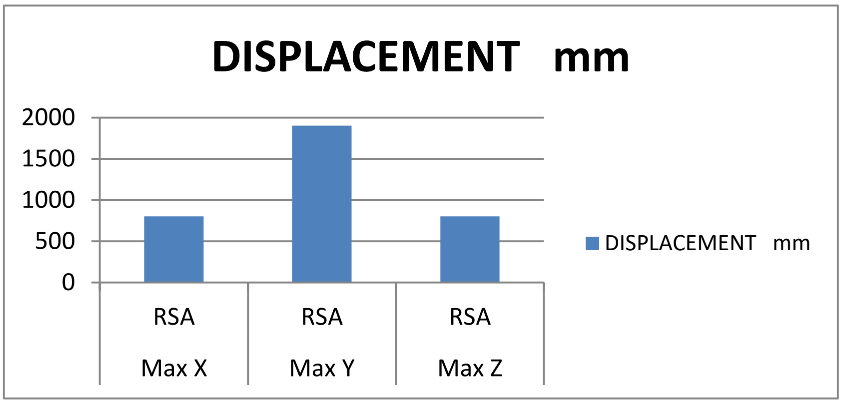

Fig 6.5: Graph of Displacement in mm for C-type conventional Model

Table 6.6: Displacement in mm for C-type Diagrid Model

DIRECTION	LOAD	DISPLACEMENT (MM)
MAX X	RSA	779.64
MAX Y	RSA	225.94
MAX Z	RSA	778.64

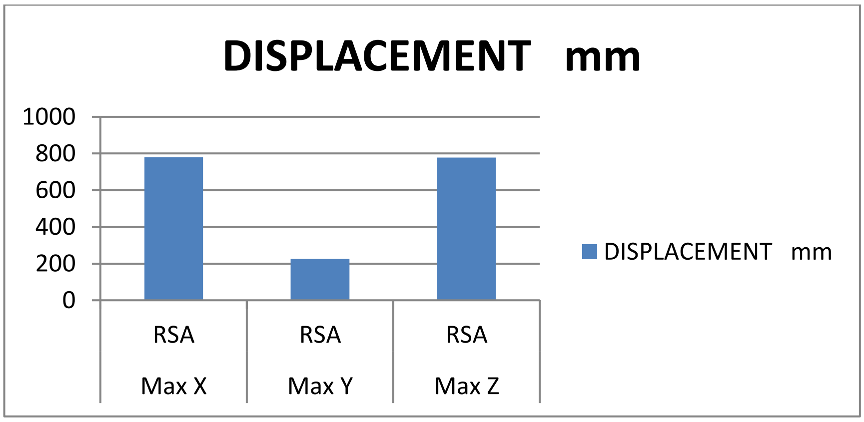

Fig 6.6: Graph of Displacement in mm for C-type Diagrid Model

The comparison of Displacement in between diagrid building and conventional building for C- type plan and L-type plan are shown in table.The maximum Displacement is found to be 1900.725 mm in y direction and the minimum is found 801.932 mm in x direction for conventional c-type structure .The maximum Displacement is found to be 779.64 mm in x direction and the minimum is found 225.94 mm in y direction for diagrid c-type structure. in comparision of conventional building and diagrid building the maximum Displacement is foundto in conventional c-type structure. hence in c plan structure for Displacement diagrid frame system is 2.77% less than conventional c structure.

Table 6.7: Displacement in mm for L-type Conventional Model

DIRECTION	LOAD	DISPLACEMENT(MM)
MAX X	RSA	1362.31
MAX Y	RSA	1071.842
MAX Z	RSA	1206.42

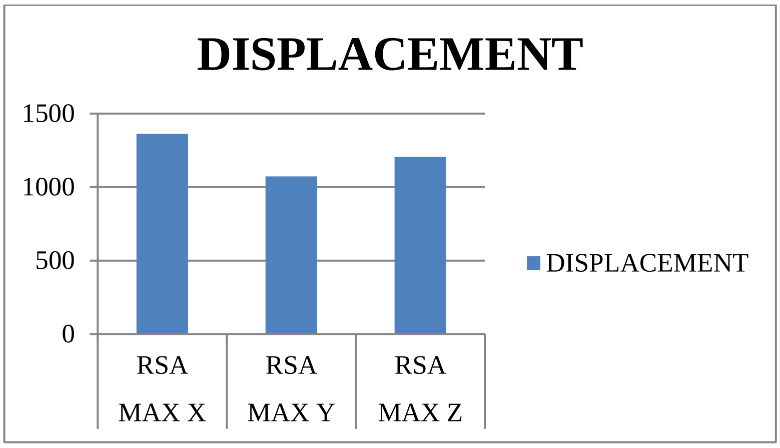

Fig 6.7: Graph of Displacement in mm for L-type conventional Model

Table 6.8: Displacement in mm for L-type Diagrid Model

DIRECTION	LOAD	DISPLACEMENT(MM)
MAX X	RSA	977.123
MAX Y	RSA	911.28
MAX Z	RSA	996.185

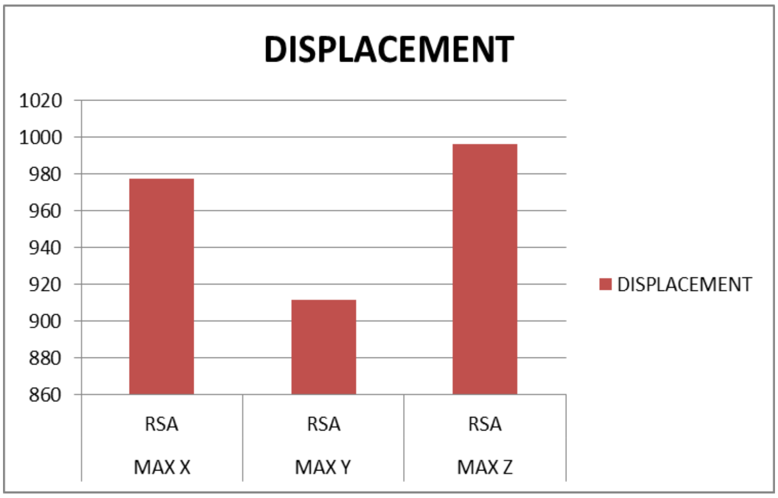

Fig 6.8: Graph of Displacement in mm for L-type Diagrid Model

The maximum Displacement is found to be 1362.31 mm in x direction and the minimum is found 1071.842 in y direction for conventional L-type structure and The maximum Displacement is found to be 996.185 mm in z direction and the minimum is found 911.28 mm in y direction for diagrid L-type structure,. in comparision of conventional building and diagrid building the maximum Displacement is foundto in conventional L-type structure.hence in L plan structure for Displacement diagrid frame system is 28.27% less than conventional L structure.

Table 6.9: Base shear in each type of structure

BASE SHEAR IN KN	
C-CONVENTIONAL STRUCTURE	1093.53
C-DIAGRID STRUCTURE	948
L-CONVENTIONAL STRUCTURE	1095.67
L-DIAGRID STRUCTURE	1088.92

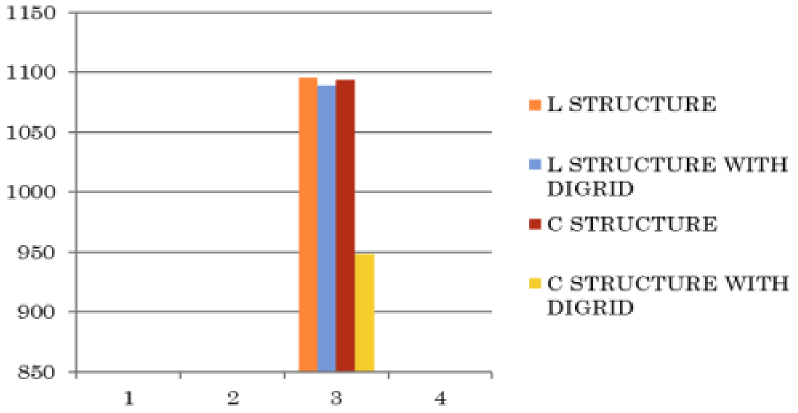

Fig 6.9: Graph of Base shear in each type of structure

1. In C plan structure, for base shear digrid frame system is 13.30% effective than conventional C structure.
2. In L plan structure , for base shear digrid frame system is 0.61% effective than conventional L structure

Summary

This chapter is discussing analysis of results and from that results graphs plotted here as per IS1893 Part-1:2002. Graph represents comparison between Diagrid system, and conventional system models in C-Type pan and L-Type plan. Also there is comparison is done here in C-Type pan and L-Type plan. Important observations were noted and conclusions are drawn.

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7. Conclusion

In this study the seismic analysis performed on building by using STAAD Software. Initially, thecomparison between diagrid model and conventional model for C-Type and L- Type done separately by using various parameter like shear force, bending moment, displacement and Base shear. The following observations are drawn from the results obtained through analyses.

1. In C plan structure, for base shear digrid frame system is 13.30% effective than conventional C structure.
2. In C plan structure, for bending moment digrid frame system is 60.36% Less than conventional C structure.
3. In C plan structure, for shear force digrid frame system is 46.51% Less than conventional C structure.
4. In C plan structure, for Displacement digrid frame system is 2.77% Less than conventional C structure.
5. In L plan structure , for base shear digrid frame system is 0.61% effective than conventional L structure
6. In L plan structure, for bending moment digrid frame system is 5.93% Less than conventional L structure.
7. In L plan structure , for shear force digrid frame system is 23.43% Less than conventional L structure
8. In L plan structure, for Displacement digrid frame system is 28.27% Less than conventional L structure.
9. Overall performance of L-type digrid structure is more efficient than all other type of structure.
10. significant decrease of bending moment, shear force and displacement in diagrid building is found in comparison to conventional building
11. Diagrid structure shows less value than conventional structure plans.

After that, overall performance between C-plan and L-plan studied here. These two plan arecompared by various parameter like base shear, displacement, bending moment.

References

1. *K. Moon, "Optimum Grid Geometry of Diagrid Structures for Tall Buildings", Architectural Science Review, Vol. 51.3, 2008.*
2. *J. Kim, Young-Ho-Lee, "Seismic Performance Evaluation of Diagrid System Building",*
3. *M.Shah, S. Mevada, V. Patel, "Comparative Study Of Diagrid Structures With 2012. Conventional Frame Structures",ISSN:2248-9622,VOL.6, Issue 5,part-2,May 2016.*
4. *C. Pattar, Prof. Smt. V. Gokak, "Analysis Of Diagrid With Plan Irregularity", International research journal of Engineering and technology, Vol. 05, Issue 08, 2018.*
5. *C. Nayak , S. Walke, and S. Kokare(2020), "Optimal Structural Design of Diagrid Structure for Tall Structure" Springer Nature Singapore Pte Ltd. 2020.V. K. Gunjan et al. (Eds.): ICRRM 2019 – System Reliability, Quality Control,Safety, Maintenance and Management, pp. 263– 271, 2020.*
6. *Nishith B. Panchal, Dr. V. R. Patel, Dr. I. I. Pandya, "Optimum Angle of Diagrid Structural System' International Journal of Engineering and Technical Research (IJETR)ISSN: 2321-0869, Volume-2, Issue-6, June 2014.*
7. *K. Kamath H, S. Jose Camilo Karl Barbosa Noronha(2016), "An Analytical Study on Performance of a Diagrid Structure Using Nonlinear static Pushover Analysis" Perspectives in Science (2016).*
8. *Majid Moradi, Moein Abdolmohammadi(2020), "Seismic fragility evaluation of a diagrid structure based on energy method" Journal of Constructional Steel Research 174 (2020) 106311.*
9. *Tianxiang Li, T.Y. Yang, Genshu Ton (2018), "Performance-based plastic design and collapse assessment of diagrid structure fused with shear link" Struct Design Tall Spec Build. 2019;e1589.*
10. *Giovanni Maria Montuori, Elena Mele, Giuseppe Brandonisio, Antonello De Luca (2014), "Secondary bracing systems for diagrid structures in tall buildings" Engineering Structures 75 (2014) 477–488.*
11. *[Saman Sadeghi, Fayaz R. Rofooei(2018), "Quantification of the seismic performance factors for steel diagrid structures" Journal of Constructional Steel Research 146 (2018) 155–168.*