

Comparative Study of Different shapes of Diagrid Structure System with Conventional System using Response Spectrum Analysis

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Abstract - Construction of the multi-storey building is quickly increasing throughout the globe. Advances in construction technology, materials, structural systems, analysis and design software package expedited the expansion of those buildings. Diagrid buildings square measure rising as structurally economical furthermore as architecturally important assemblies for tall buildings. Safety and minimum harm level of a structure may well be the prime demand of high-rise buildings. To meet these requirements, the structure should have adequate lateral enough ductility. In this thesis Analysis and design of 16 storey diagrid building with plan of 18 m × 18 m size is considered. Staad professional software system is employed for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 considering all load combinations. Seismic load as Dynamic load as per IS1893-2002 and Wind load as IS 875-part 3 considered for analysis and design of the structure. Load distribution in diagrid system is also studied for 16 storey building. Similarly, analysis and design of diagrid building in different plan shapes i.e Circular and Triangular are carried out and compare with conventional building. analysis values are compared in terms of Moment, Shear force, Axial force, Displacement, Drift and the economical aspect is compared for the seismic zone III. The main objective of this thesis is to investigate the Dynamic behaviour of buildings, i.e., diagrid and conventional frame under the seismic zone III. For comparison of this buildings under the same seismic zone, the parameters in both type of the buildings is taken same. The work is to be carried are out by conducting (a) Modelling of both the building frames. (b) Analysis of building frames considering seismic parameters(c) Study of results in terms of moments, stresses & Moment in Slab, forces, drift, deflection, and the economy. Response spectrum analysis results provides a more realistic behaviour of structure response and diagrid structure is more effective in lateral load resistance Seismic and wind analysis of conventional building with different shapes of diagrid building with equivalent plan area at seismic zone III is carried out and the following conclusions are drawn. In this study, its miles discovered that due to diagonal columns in outer edge of the structures, the diagrid structure is more effective in lateral load resistance. Due to this asset of diagrid shape, interior column is used of smaller size for gravity load resistance and best small quantity of lateral load is considered for it. While in case of conventional body building, each gravity and lateral load is resisted with the aid of exterior similarly to interior column.

Key Words: Diagrid Structure, Response Spectrum Method, Peak Factor method, Storey Shear, Node Displacement. Stresses in Slab and beam.

1. INTRODUCTION

The diagrid structural system may be outlined as a diagonal member shaped as a framework created by the intersection of various materials like metals, concrete or wood beams that are used in the construction of buildings and roofs. Diagrid structures of the steel members are efficient in providing a solution both in term of strength and stiffness. But these days a widespread application of diagrid is employed within the giant span and high-rise buildings, significantly after they area unit complicated geometries and arced shapes. Diagrid structure consists of inclined columns on the exterior surface of the building. Due to inclined columns, lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure. Diagrid structures typically, don't need core because of lateral shear may be carried by the diagonals on the outer boundary of a building.

1.1 Types of Diagrid Structural System and Materials of Construction

A. Steel Diagrid Structural System

The most normally and popularly used material within the construction of diagrids is steel. The sections commonly used are rectangular, rounded and wide flanges. The weight and size of the sections are made to resist the high bending loads. They can be quickly erected and the cost of labour for the installation is low.

B. Concrete Diagrid Structural System

The most commonly used diagrid material is concrete. The concrete diagrids are used in both types, precast and cast in-situ. As the formed concrete sections are versatile, it allows them to fit perfectly in the structure geometry. It also protects from fire damages. But the formed concrete constitutes a lot of to the loading of the structure.

C. Timber Diagrid Structural System

The least used material within the construction of diagrids is timber. This material has more disadvantages. The only

advantage of this material that the section of timber is easily available in any shape and size. The installation cost is low. The major disadvantages are that timber has lesser material strength. Durability and weathering of timber are the major issues that make for the disadvantages of timber as a diagrid construction material.

1.2 Advantages of Diagrids

- I. The advantages of the diagrid in the construction of the structure majorly improves the aesthetic view of the building.
- II. The use of diagrid reduces the steel up to 20% compared to brace frame structure. It doesn't want technical labor because the construction technology is easy.
- III. The diagrid makes the maximum use if the structural material is used. When glass material is employed with the diagrid, it permits generous quantity of sunshine within the structure
- IV. These structures have majorly column free exterior and interior, free and clear, unique floor plans can be implemented.
- V. Increased the stability due to triangulation.
- VI. Combination of the gravity and lateral load-bearing systems, potentially providing more efficiency.
- VII. Provision of alternate load paths (redundancy) in the event of a structural failure (which lacks in case of conventional framed building).
- VIII. Reduced weight of the superstructure can translate into a reduced load on the foundations.

2. Objective of Study

Safety and minimum harm level of a structure may well be the prime demand of high-rise buildings. To meet these requirements, the structure should have adequate lateral enough ductility. In this thesis Analysis and design of 16 storey diagrid building with plan of 18 m × 18 m size is considered. Staad professional software system is employed for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 considering all load combinations. Seismic load as Dynamic load as per IS1893-2002 and Wind load as IS 875-part 3 considered for analysis and design of the structure. Load distribution in diagrid system is also studied for 16 storey building. Similarly, analysis and design of diagrid building in different plan shapes i.e Circular and Triangular are carried out and compare with conventional building. analysis values are compared in terms of Moment, Shear force, Axial force, Displacement, Drift and the economical aspect is compared for the seismic zone III. The main objective of this thesis is to

investigate the Dynamic behaviour of buildings, i.e., diagrid and conventional frame under the seismic zone III. For comparison of this building under the same seismic zone, the parameter in both type of the buildings is taken same

3. Methodology

Response Spectrum analysis consider for seismic analysis as per IS 1893-2002/05 and Static wind analysis peak factor method consider for Wind analysis as per IS 875-III

Different Model of building considered is given below:

Model-1 Conventional Building Denoted as CB

Model-2: Square Diagrid Building denoted as SDB

Model-3: Circular Diagrid Building denoted as CDB

Model-4: Triangular Diagrid Building denoted as TDB

The plan area for the proposed work is **18 x 18** m in which size of panels is **3x3** m for conventional and square diagrid building and similar area consider for circular and triangular buildings the preliminary sections of columns and beams were fixed based on deflection criteria [i.e. span to depth ratio].

Design parameters used for Study-

Model: G+16

Seismic Zones: III

Floor height :3.6 m

The configuration of both the models: Square, Circular and triangular

Angle of diagrid- 67.4°

Plan size 18X18

Size of columns: 500mmX500mm

Size of beams :300mmX500mm

Thickness of slab:120mm

Size of Diagonals: 300X500

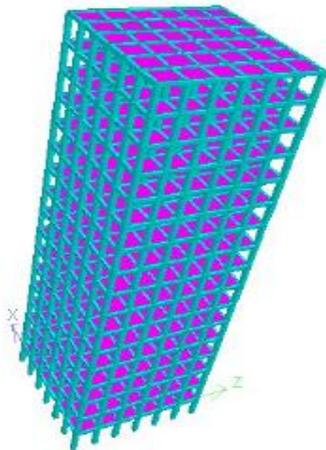


Fig -1: Conventional Building

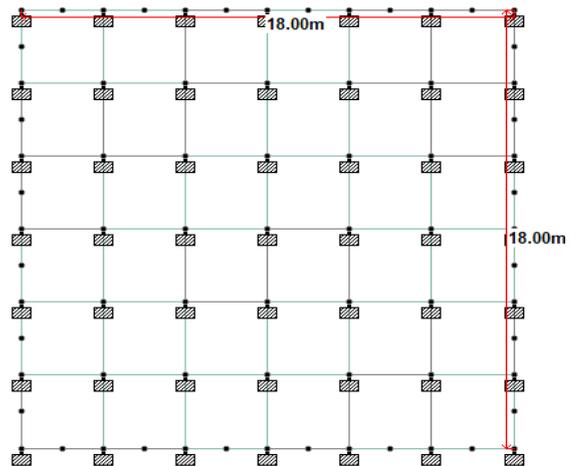


Fig -4: Square diagrid Building Plan

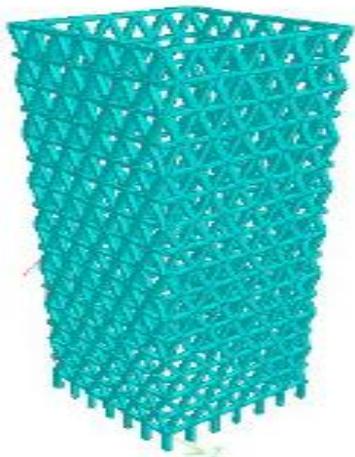


Fig -2: Square diagrid Building

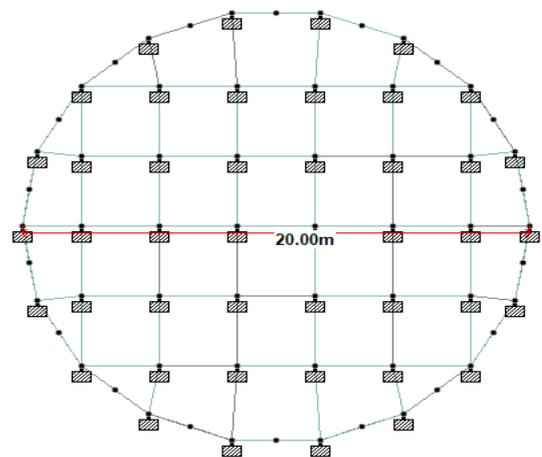


Fig -5: Circular diagrid Building Plan

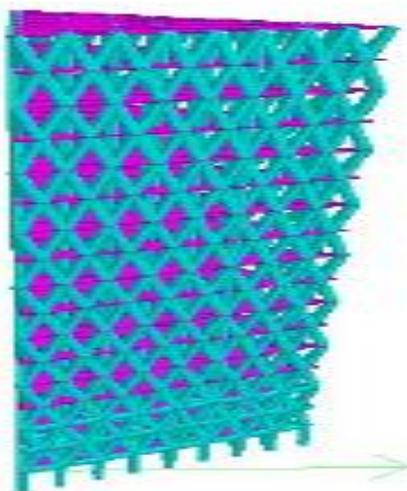


Fig -3: Triangular diagrid Building

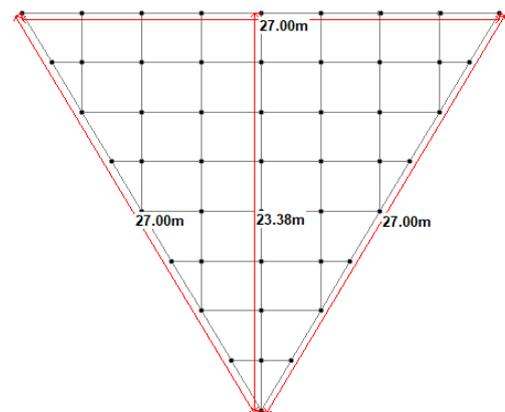
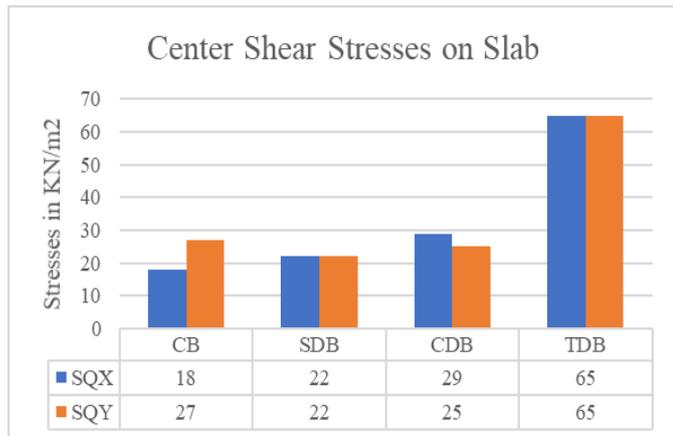
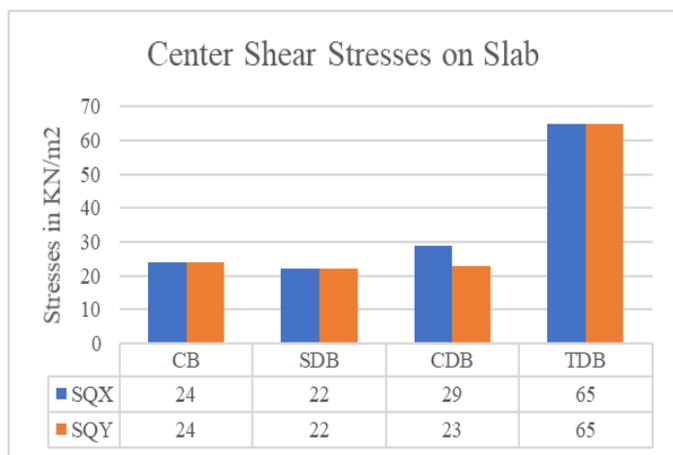


Fig -6: Triangular diagrid Building Plan

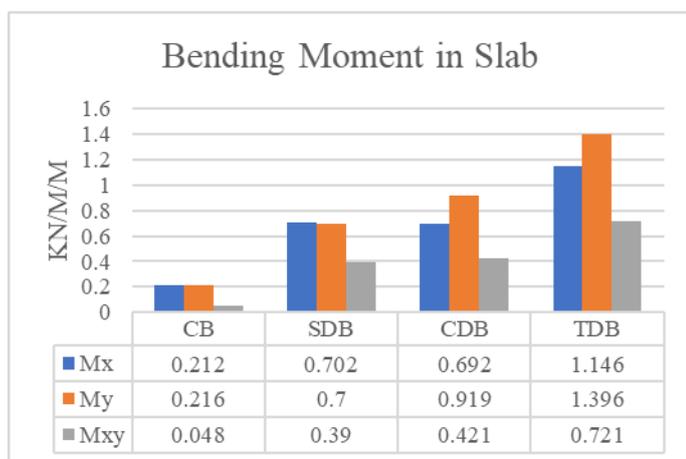
3. Results



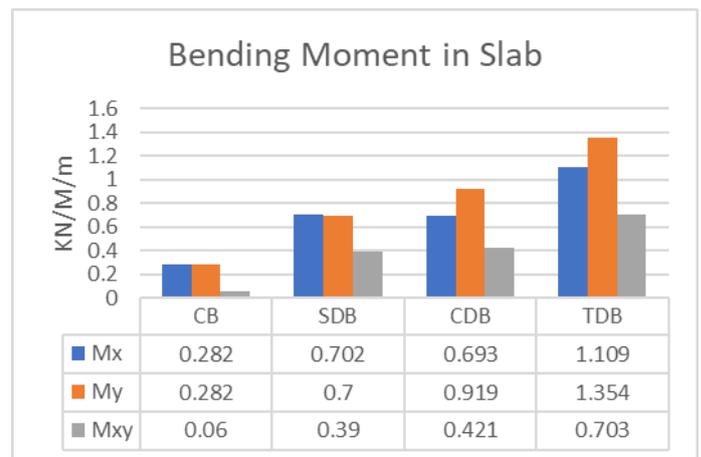
Graph 1 Center Shear Stresses Vs Different types of building for Seismic Analysis



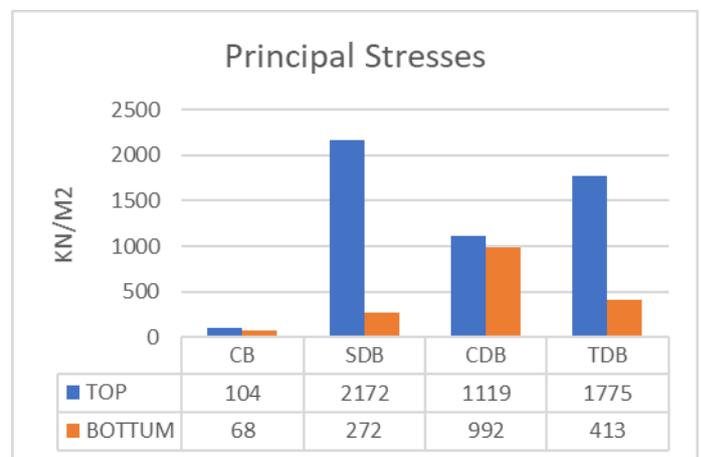
Graph 2 Center Shear Stresses Vs Different types of building for Wind Analysis



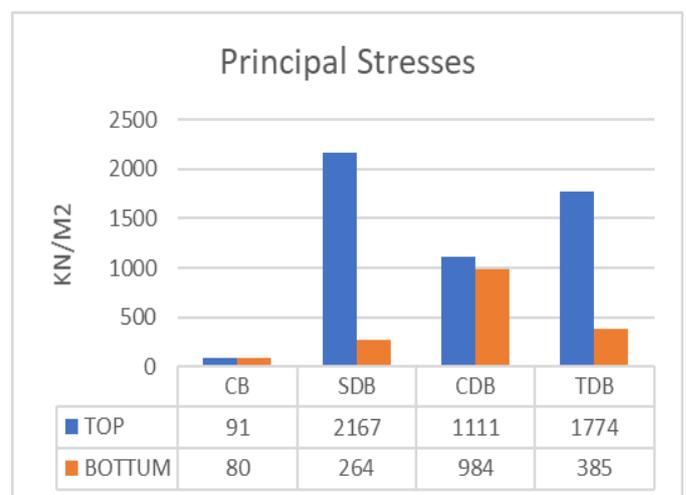
Graph 3 Bending Moment in Slab Vs Different type of building for Seismic Analysis



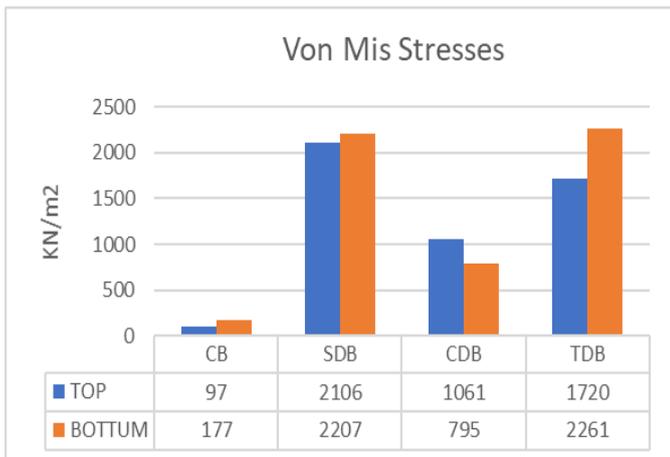
Graph 4 Bending Moment in slab Vs Different type of building for Wind Analysis



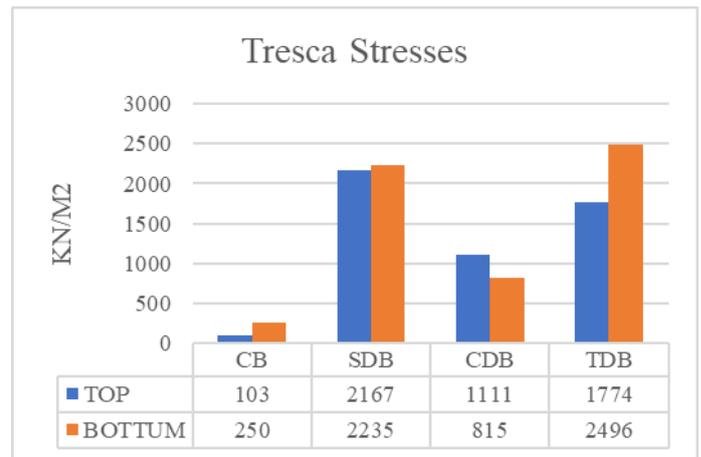
Graph 5 Principal Stresses Vs Different types of Building for Seismic Analysis



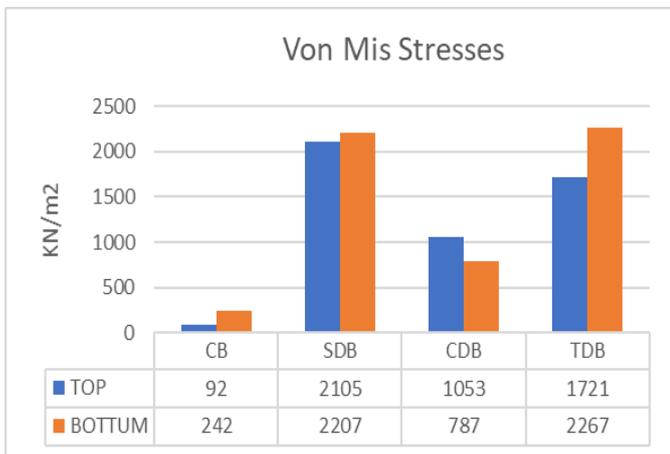
Graph 6 Principal Stresses in Different types of Building for Wind Analysis



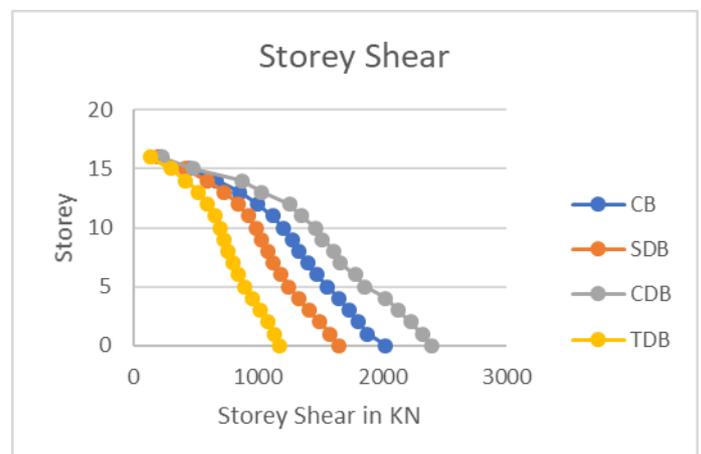
Graph 7 Von mis stresses Vs Different types of Building for Seismic Analysis



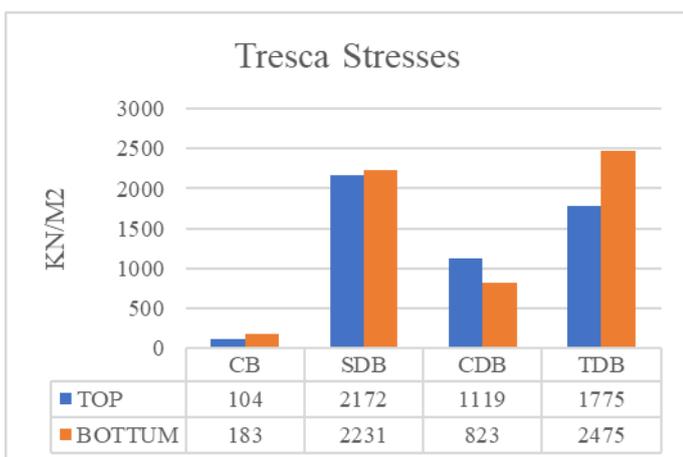
Graph 10 Tresca Stresses Vs Different types of building for Wind Analysis



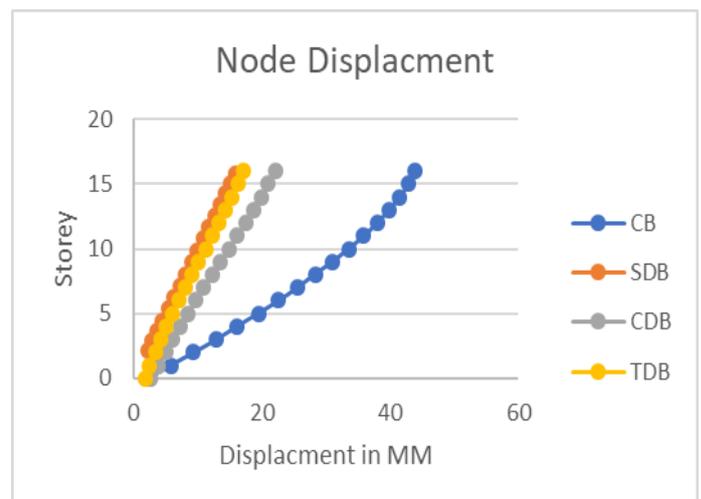
Graph 8 Von Mis stresses Vs Different types of building for Wind Analysis



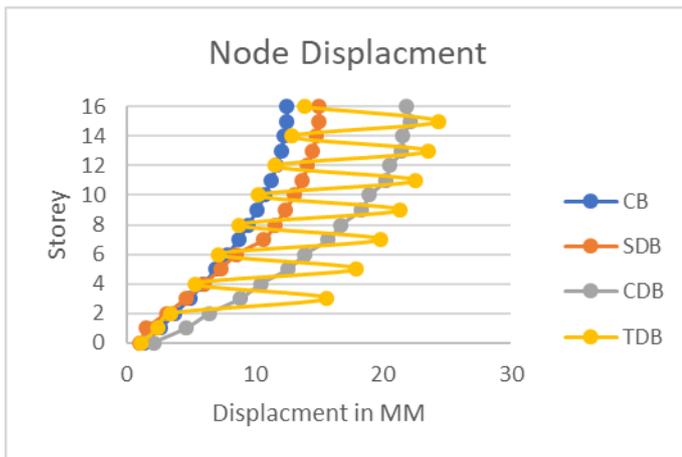
Graph 11 Storey vs peak storey shear



Graph 9 Tresca Stresses Vs Different types of building for Seismic Analysis



Graph 12 Storey vs Displacement for Seismic Analysis



Graph 13 Storey Vs displacement for Wind Analysis

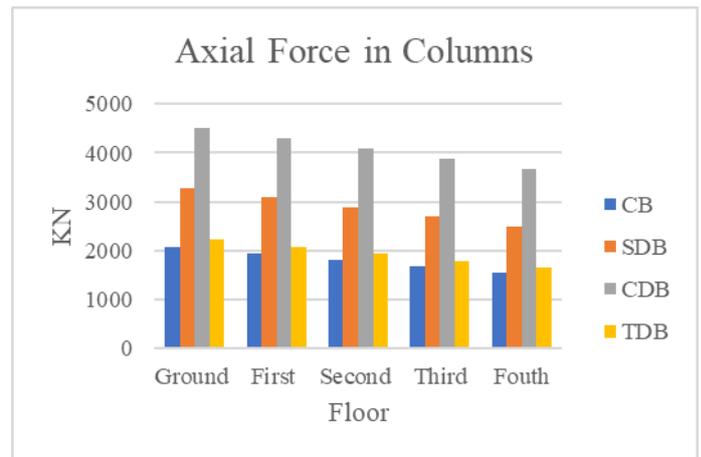
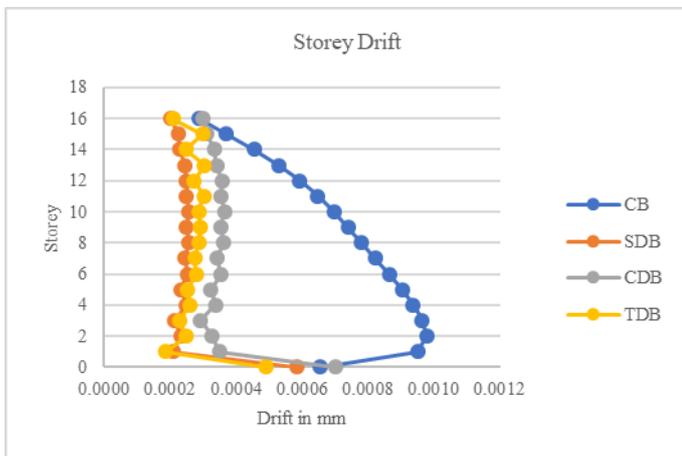
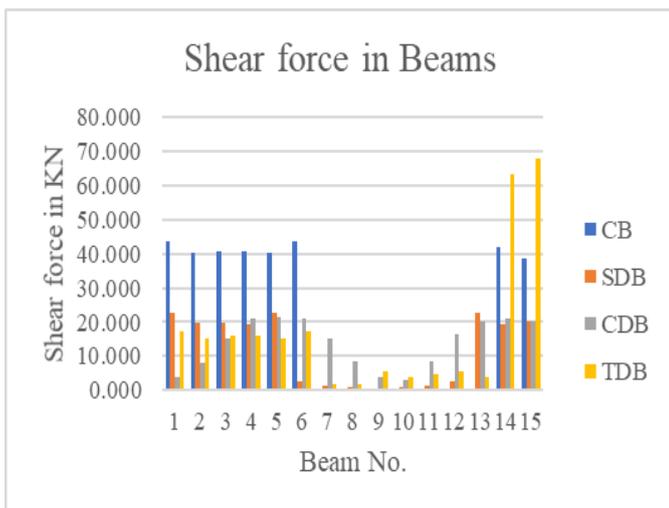


Figure 16 Axial force in Column



Graph 14 Storey Drift for Seismic Analysis



Graph 15 Beam Vs Shear force for Seismic Analysis

4. Conclusions

Response spectrum analysis results provides a more realistic behaviour of structure response and diagrid structure is more effective in lateral load resistance Seismic and wind analysis of conventional building with different shapes of diagrid building with equivalent plan area at seismic zone III is carried out and the following conclusions are drawn from the study:

- 1 Centre shear stresses in slab SQX and SQY are increase in diagrid buildings as compare to conventional building however in terms of shape of building these stresses shows higher value in triangular form diagrid building as compare to square and Circular.
- 2 Maximum bending moment at the middle of the slab i.e. MX, MY & MXY more growth in rectangular and triangular shapes of diagrid constructing as examine to standard constructing but barely will increase in round shape diagrid building in plan.
- 3 Similarly, Principal, Max Von Mis and Fresca stresses at top and bottom of the slab more increase in square and triangular shapes (in plan) of diagrid building as compare to conventional building but slightly increases in circular shape diagrid building in plan.
- 4 Total base shear increases in the circular form of diagrid constructing and decreases in square and triangular form of diagrid constructing while comparing with traditional constructing for seismic analysis.
- 5 It concludes that the node displacement is decreases in all shapes of diagrid buildings whilst examine with conational kind of building.
- 6 In this study, its miles discovered that due to diagonal columns in outer edge of the structures, the diagrid

structure is more effective in lateral load resistance. Due to this asset of diagrid shape, interior column is used of smaller size for gravity load resistance and best small quantity of lateral load is considered for it. While in case of conventional body building, each gravity and lateral load is resisted with the aid of exterior similarly to interior column.

REFERENCES

- [1] Irfan Saleem., Dr. Sunil Kumar Tengli (2018). "Parametric Study Parametric Study on Asymmetric Diagrid Structure." International Journal of Applied Engineering Researching 0973-4562 Volume 13, Number 7 (2018) pp. 61-66
- [2] Chetan S.Pattar, Prof. Smt. Varsha Gokak (2018). "Analysis Of Diagrid Structures With Plan Irregularity." International Research Journal of Engineering and Technology, Volume: 05 Issue: 08. e-ISSN: 2395-0056, (435-438)
- [3] Akshat., Gurpreet Singh, (2018). "Dynamic Analysis of Diagrid Structural System In High Rise Steel Buildings." International Journal of Civil Engineering and Technology, Volume 9, Issue 8, August 2018, pp. 71-79, Article ID: IJCIET_09_08_009.
- [4] Trupti A. Kinjawadekar. Amit C. Kinjawadekar., (2015). "Comparative Study Of Seismic Characteristics Of Diagrid Structural Systems In High Rise Construction International Journal of Civil Engineering and Technology, Volume 9, Issue 6, june 2018, pp. 315-323, Article ID: IJCIET_09_08_036.
- [5] Avnish Kumar Rai & Rashmi Sakalle (2017). "Comparative Analysis of A High Rise Building Frame With And Without Diagrid Effects Under Seismic Zones Iii & V." International Journal Of Engineering Sciences & Research Technology, DOI: 10.5281/zenodo.886723
- [6] Ravi Sorathiya ,Asst. Prof. Pradeep Pandey (2017). "Study on Diagrid Structure Of Multistorey Building." International Journal of Advance Engineering and Research Development Volume 4, Issue 4, April -2017. Pp-512-524
- [7] Deep Bajoria, Gaurav Banwat, Avishekh Jaiswal, Saurabh Agarwal.,(2017). "Dia-Grid Structures." International Research Journal of Engineering and Technology. Volume: 04 Issue: 09 | Sep -2017,pp-1341-1345.
- [8] N. Snehal S. Mali., Roshni John., D. M. Joshi (2017) "Response of High Rise Building with Different Diagrid Structural System" International Journal of Science Technology & Engineering,4(5), 1030-1040.
- [9] Shubhangi V. Pawar¹, M. S. Kakamare (2017) "Earthquake and Wind Analysis of Diagrid Structure International Journal for Research in Applied Science & Engineering Technology. Volume 5 Issue VII, July 2017, pp-1729-1739.
- [10] Ravish Khan, Sangeeta Shinde (2016) "Analysis of Diagrids Using Symmetric and Asymmetric Plan Geometry" International Journal of Recent Advances in Engineering & Technology (IJRAET). 4(3), 2347 - 2812.
- [11] Kiran Kamath, Sachin H, Jose Camilo Karl Barbosa Noronha (2016) "An Analytical Study on Performance of a Diagrid Structure Using Nonlinear static Pushover Analysis" Perspectives in Science (2016), <http://dx.doi.org/10.1016/j.pisc.2016.04.004>
- [12] Manthan I. Shah, Snehal V. Mevada, Vishal B. Patel (2016) "Comparative Study of Diagrid Structures with Conventional Frame Structures" Int. Journal of Engineering Research and Applications. Vol. 6, Issue 5, (Part - 2) May 2016, pp. 22-29
- [13] Arpitha L M, Sahana T S, Siddu Karthik C S (2016) "Comparative Study of Diagrid Structures over Braced tube Structures International Journal of Innovative Research in Science, Engineering and Technology, 5(7) 13652-13660.
- [14] R. Bharath Reddy, S. Sai Gopi Nihal, A. S. Taneja and J. S. Kalyana Rama (2015) "Comparative Study on the Lateral Load Resistance of Multi-Storied Structure with Bracing Systems" Indian Journal of Science and Technology, 8(36) 2-9.
- [15] Prashant T G, Shrithi S Badami, Avinash Gornale (2015) "comparison of symmetric and asymmetric steel diagrid structures by non-linear static analysis" International Journal of Research in Engineering and Technology 4(5) 486-492.
- [16] Deepa Varkey and Manju George (2015). "Dynamic Analysis Of Diagrid System With Complex Shape" International Journal of Innovative Science, Engineering & Technology, 3(8) 484-487.
- [17] Andre R. Barbosa, and Garlan Ramadhan.(2014) "Seismic Performance of a Tall Diagrid Steel Building with Tuned Mass Dampers" International Journal of Innovations in Materials Science and Engineering. 1(2) 244-252.
- [18] Rohit Kumar Singh, Dr. Vivek Garg, Dr. Abhay Sharma (2014) "Analysis and design of concrete diagrid building and its comparison with conventional frame building." international journal of science, engineering and technology, 2(6) 1331-1337.
- [19] Ravi K Revankar, R.G.Talasadar (2014) "Pushover Analysis of Diagrid Structure" International Journal of Engineering and Innovative Technology." 4(3), 168-173.

[20] Khushbu Jani , Paresh V. Patel (2013).“ Analysis and Design of Diagrid Structural System for High Rise Steel Buildings” Elsevier, Procedia Engineering 51 (2013) 92 – 100, doi: 10.1016/j.proeng.2013.01.015