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Seismic Analysis of Diagrid Structure on Sloping Ground Using Response Spectrum Method

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ABSTARCT: Uncontrolled growth in urban population in India has resulted in scarcity of land in developed and developing cities. One solution to this problem is building tall structures to meet the increasing demand for working and living spaces. Several of these developing cities and towns have hilly terrain and thus building tall structures along slopes is a need but a challenge. In recent years, several such structures have failed mainly due to the lack of lateral stability. To make these structures stable against earthquake forces, while also keeping economy in mind, diagrid structures are a solution. These diagrid structures give better results compared to conventional buildings.

In this study, a 12 stories diagrid structure on type 2 and type 3 soil of diagrid angle 58.13° is considered and the building is constructed on a sloping ground of slope 20° . Seismic analysis is carried out under seismic zone 4. In this project, two types of irregularities are considered, i.e., plan irregularity and vertical irregularity. Further, under plan irregularity, C- type of dimension $24 \times 40\text{m}$ and T- type of dimension $24 \times 24\text{m}$ are analyzed. In vertical irregularity, stiffness irregularity of dimension $20 \times 20\text{m}$ and mass irregularity $20 \times 20\text{m}$ are considered.

The analysis are planned to be done by response spectrum method using E-Tabs-2019 software. The result obtained in various parameter storey displacement, stiffness and storey drift are analysed. The comparison of results between two type of soil and also in between with and without diagrid structure of all types of irregularities will also be presented.

KEYWORDS: Diagrid, Response Spectrum Method, Irregularity, Sloping Ground, E-Tabs.

I. INTRODUCTION

A Diagrid is an exterior structural system that uses solely slanted columns on the building's façade instead of any perimeter vertical columns. In contrast to the bending of vertical columns in framed tube structures, these diagonals' axial action resists shear and overturning moments. The development of braced tube structures led to the diagrid systems. The main distinction between a diagrid building and a braced tube building is that diagrid buildings lack vertical columns around their perimeter. Due to their triangulated design, the diagonal members of diagrid constructions serve as both inclined columns and bracing elements, and they experience primarily internal axial forces. Placement of diagonals is the oldest and most natural solution in steel structures, and has widespread applications, receiving great popularity among engineers and architects.

The load path can be divided into two main parts, vertical load and horizontal shear as shown in fig. vertical load will be transferred in the form of an axial load from the diagrid members above the node to the gusset plate and stiffness, then to diagrid members below the nodes as shown. The horizontal shear will be in the form of an axial load in the diagrid members above the nodes with one in compression and one in tension to the gusset plate and stiffness. The force will be then transferred as shear force in the gusset plate and then to the other pair of tensile and compressive forces on the diagrid member below the node Diagrid System.



II. RELATED WORK

From literature survey diagrid structural systems offer several advantages over conventional systems in terms of material efficiency, aesthetics, and potential sustainability benefits. However, they also come with unique challenges, including engineering complexity and potential construction difficulties. The choice between these systems should be based on the specific project's goals, budget, and architectural vision. The design and analysis of a diagrid structural system for a high-rise steel building require a multidisciplinary approach, with collaboration between structural engineers, architects, and construction professionals. It is essential to prioritize both structural performance and architectural aesthetics to achieve a successful and safe design. Their combination of structural efficiency, architectural versatility, and lateral stability makes them well-suited for iconic and innovative designs in urban environments. However, their design and construction require careful planning, engineering expertise, and attention to detail to ensure both safety and aesthetic success. Overall, the seismic performance of buildings on sloping ground depends on a combination of factors related to the site, foundation, structural design, and local seismic conditions.

III. METHODOLOGY

The following steps are followed to meet the objectives of the project

- Detailed literature work is carried out regarding the seismic response of diagrid building resting on sloping ground.
- With and without diagrid steel Frame building models are considered on Type-2 and Type-3 soil of G+12 stories considering different irregularities i.e plan irregularity (C-type and T-type), vertical irregularity (stiffness and mass irregularity) on sloping ground of 20° slope and 58.13° diagrid angle is considered.
- Linear dynamic analysis Response Spectrum method is carried out.
- Results are analyzed considering the Parameters such as storey displacement, storey drift and storey stiffness.
- Comparison is done between with and without diagrid structure of both types of soil by considering all the types of irregularities and conclusions are drawn.

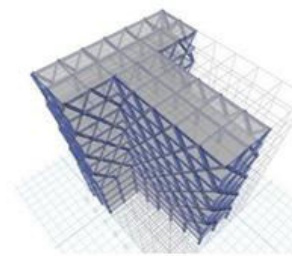
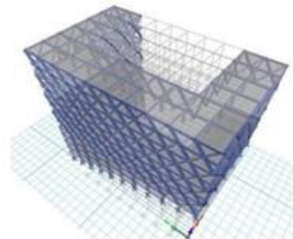
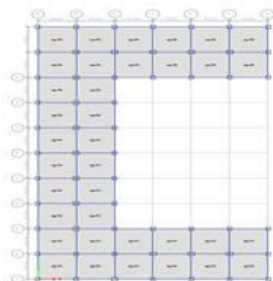
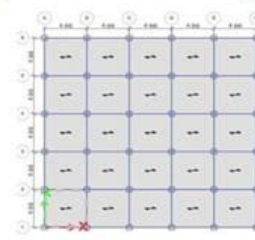
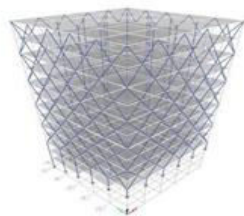
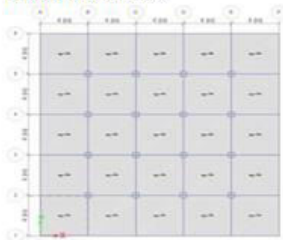
IV. RESULTS

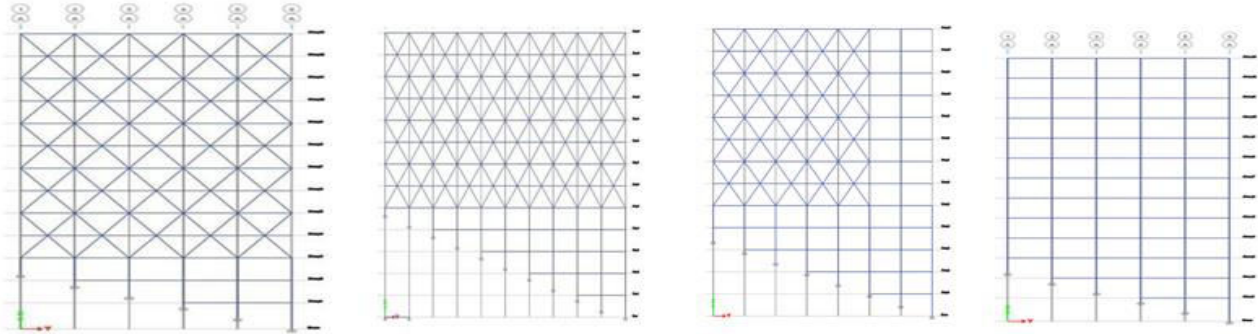
1. BUILDING CONFIGURATION

Super dead load-1.2 kN/m²
Column-Steel Tube
500mmx500x50mm
Beam-ISMB500

Diagrid-SteelAngle-
450mmx450x50mm
Mild steel grade-Fe 250
C-Type-24mx40m

C-Type-24mx40m
T-Type-24mx24m
Stiffness Irregularity-20mx20m
Mass Irregularity-20mx20m

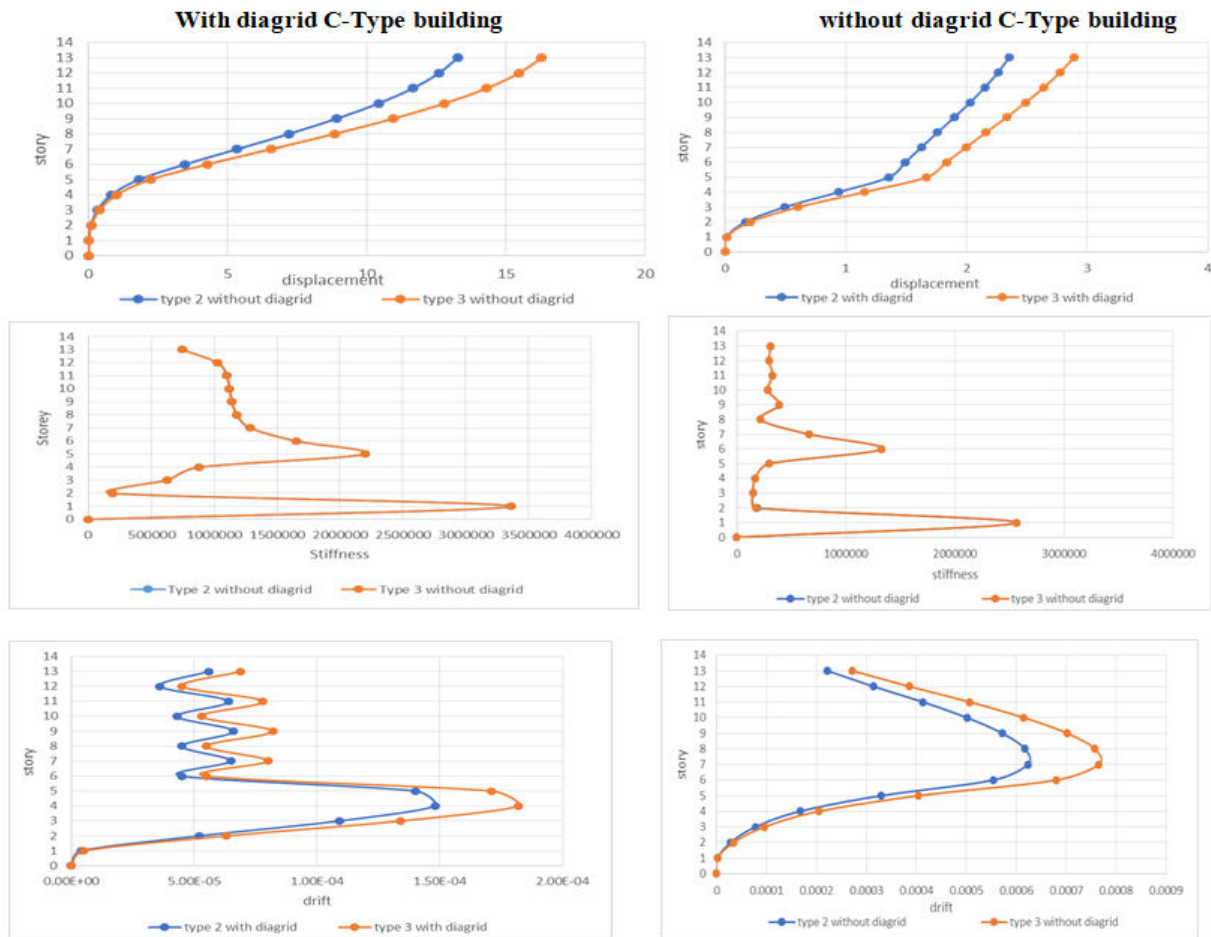




Elevations of mass, stiffness, C-Type, T-Type, without diagrid model

V. EXPERIMENTAL RESULTS

A. Storey V/S Displacement, Stiffness and storey drift of C-Type building in EQX direction

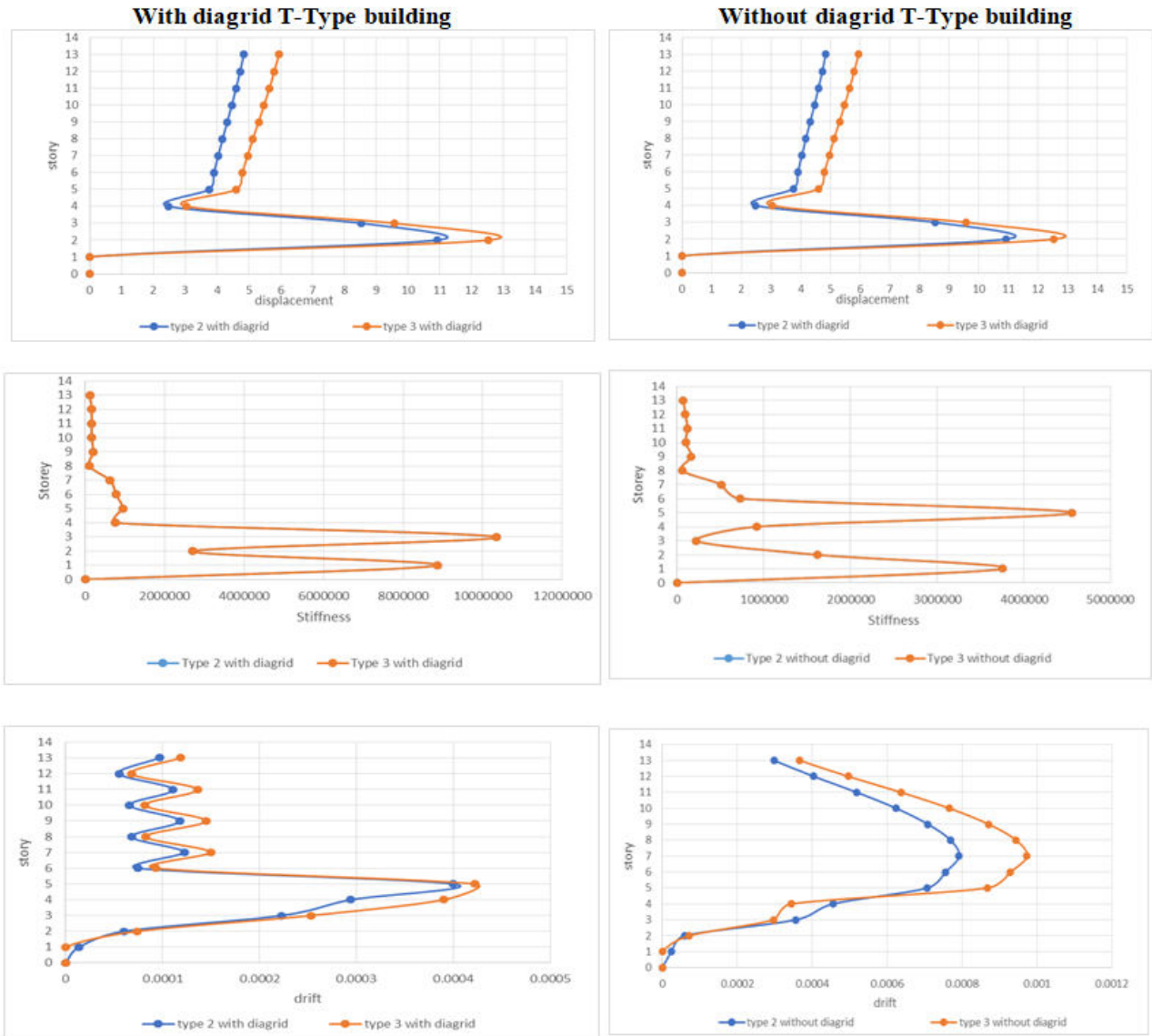




The above fig shows that effect of with and without diagrid structure of C-Type on Type-2 and Type-3 soil by considering the parameter displacement, Stiffness and drift.

- In C-Type building the displacement is increases slightly in type 3 soil when compared to type 2 soil.
- In between with and without diagrid structure with diagrid structure and Type-2 soil has high stiffness. The stiffness is high in story 1 and storey 5 because from storey 5 diagrid is provided.
- The drift variation is slightly less in with diagrid and Type-2 soil. Drift is maximum at storey 4 and storey 5 because variation starts from story 5 i.e diagrid provide at this storey 5 and drift variation is in zigzag manner in diagrid building because due to the ground slope.

B. Storey V/S Displacement, Stiffness and storey drift of T-Type building in EQX direction.

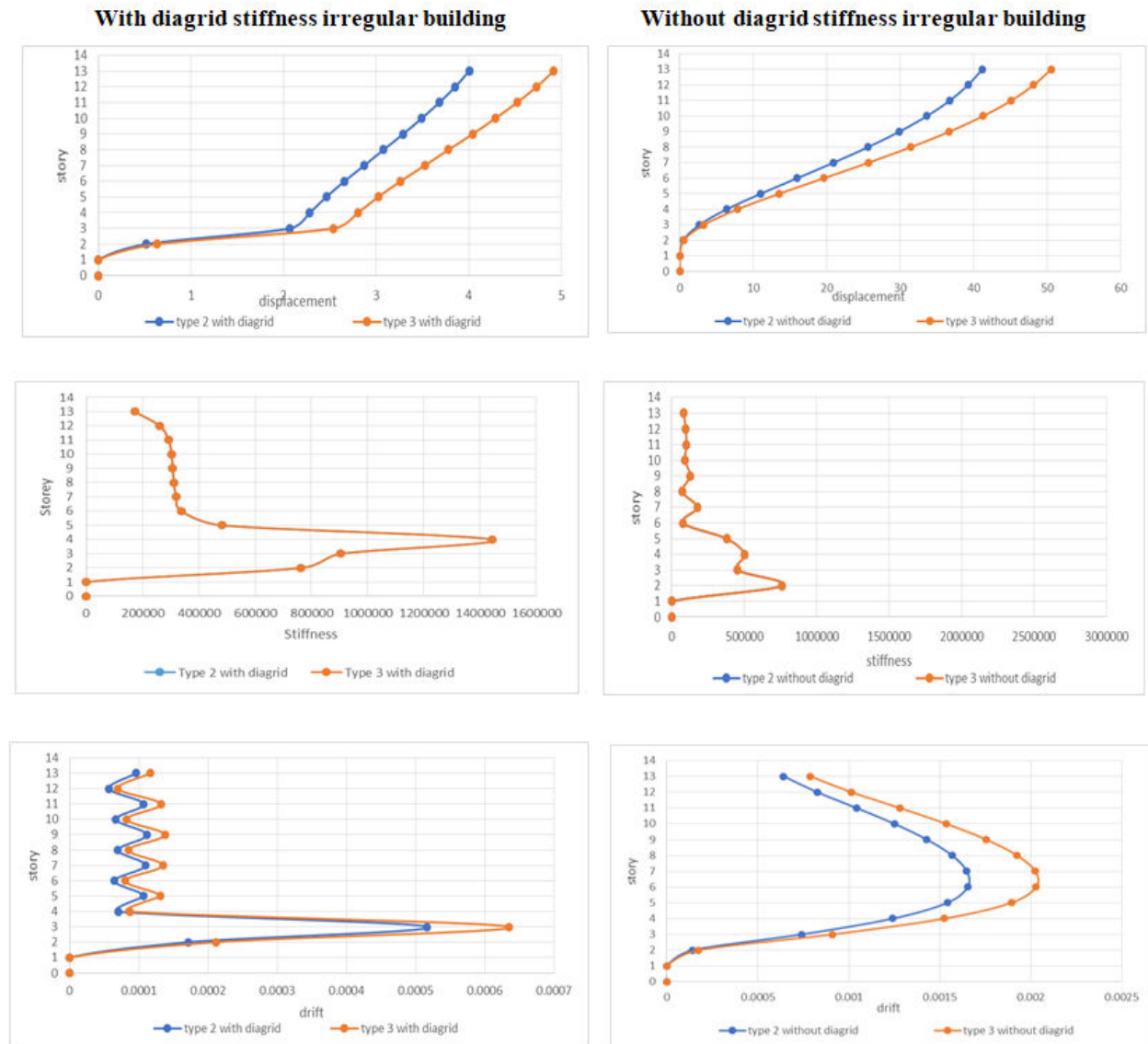




From above figure shows that effect of with and without diaphragm structure of T-Type on Type-2 and Type-3 soil by considering the parameter displacement, Stiffness and drift.

- In T-Type building the displacement is increases slightly in type 3 soil when compared to type 2 soil.
- We know that stiffness is decreasing as we move towards the upper floors. Due to the high displacement in without diaphragm structures the stiffness is less. In EQX direction the stiffness is maximum at story 5 because from this storey we provided the diaphragm.
- The drift is maximum but storey 4 and storey 5 because the variation is observed in in this storey due to presence of diaphragm.

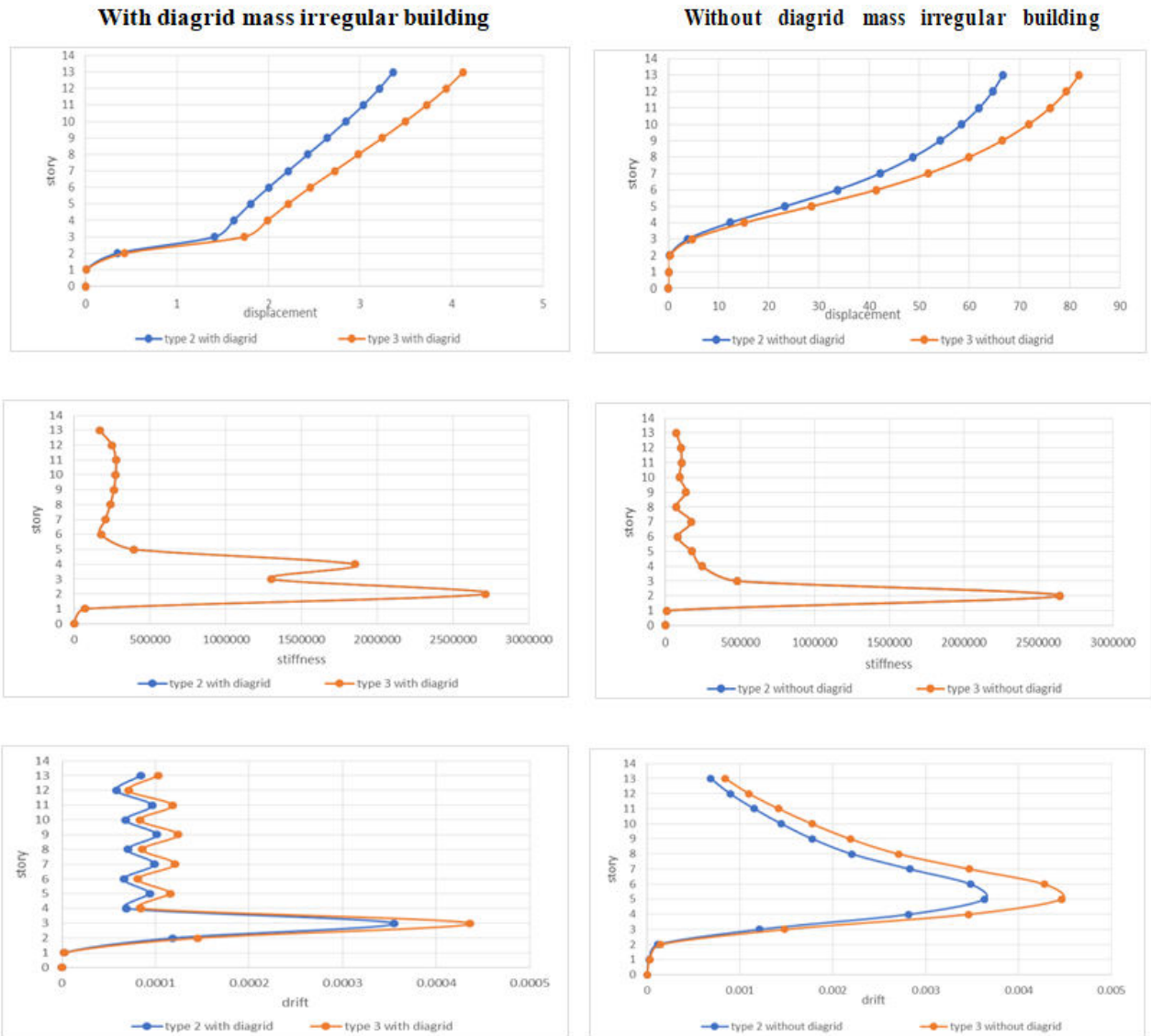
C. Storey V/S Displacement, Stiffness and storey drift of stiffness irregular building in EQX direction.





- The displacement increases slightly in type 3 soil when compared to Type 2 in both EQX direction.
- From the figure it is clear that in vertical stiffness irregularity the stiffness is almost same in both type of soil. In EQX direction the stiffness is maximum at storey 4 because till storey 3 the sloping round ends from storey 4 for acts like a normal ground.
- The drift results it is observed that due to the variation at storey 3 the drift is maximum in this storey due to presence of diagrid.

D. Storey V/S Displacement, Stiffness and storey drift of mass irregular building in EQX direction.

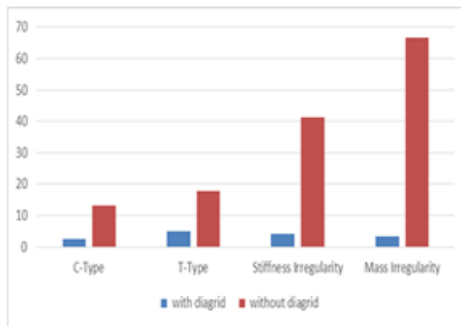


- Compared to Type-2 and Type-3 soil in Type-3 soil the displacement is higher.
- In with diagrid building the Stiffness is high in storey 2 and storey 4 in EQX direction, but in withoutdiagrid building stiffness is high only at storey 2,because at storey 4 mass irregularity occurs.
- Hence from the above statement it is clear that if the mass is high then stiffness is less. So that by providingthe diagrid we can increase the stiffness of the building.



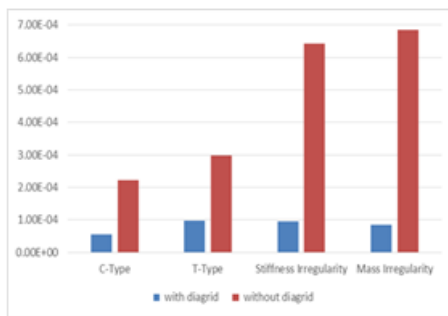
- The drift is increased in without diagrid structures and Type 3 soil compared to with diagrid structures and Type 2 soil.
- From the drift results graph it is clear that drift is maximum at storey 4 due to the mass irregularity.

E. For All Irregularities Top Storey Displacement



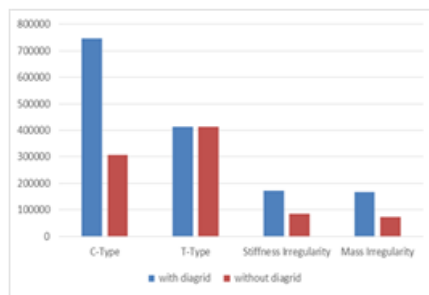
- From the storey displacement results in the above table it is clear that the diagrid structural system will have greater resistance than that of ordinary steel building.
- From the figure it is clear that displacement is drastically reduced in with diagrid structures in both the directions.
- By comparing all types of irregularities the displacement is higher in mass irregular building by providing diagrid we reduce the displacement upto 90%.

F. For All Irregularities Top Storey Drift



- Storey drift of all the structures are within safe permissible limit i.e. 0.004h as per IS 1893-2016.
- The storey drift is less for with diagrid structures when compared to without diagrid structure.
- The building with mass irregularity have high storey drift when compared to other types and it is reduced in with diagrid structure.

G. For All Irregularities Top Storey Stiffness



- The top Storey stiffness for different types of irregular building are tabulated and shown in the bar graph.
- The story stiffness is high for a structure having diagrid when compared to without diagrid structures.
- For C-Type building has high stiffness compared to all other irregularities and the stiffness is less in mass irregularity.

V. CONCLUSION

- From the above results we can conclude that with diagrid structures gives better results in all the views compared to without diagrid structures.
- By considering all the parameters in between Type 2 and Type 3 soil there is slight variation is observed. In Type-2 soil we get good results in all the parameter.
- From above results by providing the diagrid to the structures we can reduce the displacement and drift of the structures and increase the stiffness of the structure.
- From the graph it is clear that the displacement and drift is maximum in mass irregularity and less in C-Type building. By providing diagrid to the structure we can reduce the displacement.



- From the above results we get to know in C-Type (plan irregularity) building the stiffness is higher and lesser in mass irregularity.

REFERENCES

1. Ajay K. S., Pradeep K. R. (2013), "Earthquake behaviour of reinforced concrete framed buildings on hill slopes", International Symposium on New Technologies for Urban Safety of Mega Cities in Asia, Report No: IIIT/TR/2013/-1.
2. Birajdar B. G., "Seismic analysis of buildings resting on sloping ground", 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, Paper No. 1472, 2004.
3. D. Lee and S. Shin, "Advanced high strength steel tube diagrid using TRIZ and non-linear pushover analysis", Journal of Constructional Steel Research, 96 (2014) 151–158.
4. Engineering and Technology (IRJET), June 2015, Vol. 2, Issue 3, PP 2295–2300.
5. IS: 456-2000: Code of practice for plain and reinforced concrete, Bureau of Indian standards, New Delhi.
6. IS: 875(part I) –1987: Code of practice for design loads (other than earthquake) for buildings and structures (Dead loads).
7. IS: 875(part II) – 1987: Indian Standard code of practice for design loads (other than earthquake) for buildings and structures (Imposed loads).
8. IS: 875(part III) – 1987: Indian Standard code of practice for design loads (other than earthquake) for buildings and structures (Wind loads).
9. IS: 1893(part I) – 2002: Indian Standard Criteria for earthquake resistant Design of structures Part 1 general provisions and buildings.
10. Khadiranaikar and Arif M., "Seismic performance of buildings resting on sloping ground", IOSR J Mech Civ Eng (IOSR-JMCE) 11(3):12–19.
11. K. Jani, P. V. Patel, "Analysis and Design of Diagrid Structural System for High Rise Steel Buildings", Procedia Engineering, 51 (2013) 92–100.
12. K. Kamath, S. Hirannaiah, J. C. K. B. Noronha, "An analytical study on performance of a diagrid structure using non-linear static pushover analysis", Perspectives in Science, (2016) 8, 90–92.
13. K. S. Moon, "Diagrid Structures for Complex-Shaped Tall Buildings", Procedia Engineering, 14 (2011) 1343–1350.
14. Nagarjuna and Shivakumar B Patil (2015), "Lateral Stability of Multistorey building on Sloping Ground", International Research Journal of Engineering and Technology, volume-2, issue-4, pp. 1662-1669.
15. R. D. Deshpande, S. M. Patil, S. Ratan, "Analysis and comparison of diagrid and conventional structural system", International Research Journal of
16. Satish Kumar and D.K. Paul., "Hill buildings configuration from seismic consideration", Journal of structural Engg., vol. 26, No.3, October 1999, pp. 179-185.
17. S. S. Nalawade., "Seismic Analysis of Buildings on Sloping Ground", M.E. Dissertation, University of Pune, Pune Dec-2003.
18. S. K. Deshmukh, and F. I. Chavan, "Seismic Analysis of R.C.C. Building Resting on Sloping Ground", International Journal of Pure and Applied Research in Engineering and Technology, Vol. 3, pp.119-133, 2015.
19. S. M. Nagargoje and K. S. Sable, "Seismic performance of multi-storeyed building on sloping ground", Elixir International Journal, 7 December 2012



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