Performance Based Evaluation of Diagrid Structures By Time History

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Abstract- *The advancement of tall buildings based on recent structural ideas with recently approved high strength materials and construction methods have been towards "stiffness" and "lightness". Lateral loads rule structure design of high-rise buildings. This research paper consists of earthquake analysis of Steel structure, tube structure and diagrid Structure with different angle of inclination. As per Indian standard code of practice IS- 1893 (Part I: 2002), IS-875:1987(Part III), IS-800-2007 procedure used to analyse and design building. Etab2015 structural analysis software is used to analyse buildings under the effect of earthquake. The response of building examined and compared on the bases of displacement, story drift, and base shear.*

Keywords- Diagrid Structural System, ETABS 2015 High-Rise Building, time history analysis, Storey Drift and Storey Displacement.

I. INTRODUCTION

Tall structures risen in the late nineteenth century in the U.S.A. They constituted a so-called "American Building Type," implying that most essential tall structures were worked in the U.S.A. Today, they are an overall structural wonder. Numerous tall structures are fabricated around the world, particularly in Asian nations, for example, China, Korea, Japan, and Malaysia. In view of information accessible and distributed in the 1980s, around 49% of the world's tall structures were situated in North America. The basic effectiveness of diagrid framework additionally helps in staying away from inside and corner sections, and in this manner permitting critical adaptability with the floor arrange. "Diagrid" framework around edge spares roughly 20 percent of the basic steel weight when contrasted with a regular moment-frame structure. The askew individuals in diagrid basic frameworks convey gravity stacks and additionally sidelong powers due to their triangulated setup. Diagrid can spare upto 20% to 30% the measure of auxiliary steel in a high-rise building. The expression "diagrid" is a mix of the words "inclining" and "lattice" and alludes to a basic framework that is single-thickness in nature and increases its auxiliary trustworthiness using triangulation. Diagrid frameworks can be planar, crystalline or go up against different arches, they frequently utilize crystalline structures or ebb and flow to expand their solidness. Border diagrids regularly convey the sidelong and gravity heaps of the building and are utilized to bolster the floor edges. "DIAGRID (a portmanteau of slanting matrix) is a plan for developing tall structures with steel that makes triangular structures with corner to corner bolster shafts." It is triangulated pillar framework which might be bended or straight, and flat bars that make basic framework for elevated structure. The distinction in outside supported customary casing auxiliary example and the diagrid basic example is that these structures don't utilize traditional vertical sections.

A. MERITS OF DIAGRID STRUCTURAL SYSTEM

1) Increased solidness because of triangulation
2) Combination of the gravity and sidelong load-bearing frameworks, possibly giving more proficiency.
3) Reduced weight of the superstructure can convert into a diminished load on the establishments.
4) By embracing this framework we can set aside to around 20% of auxiliary steel in elevated structures contrasted with confined structures
5) The utilization of diagrid decreases the steel up to 20% contrasted with prop outline structure. It needn't bother with specialized work as the development innovation is basic.
6) The diagrid makes the greatest utilize if the basic material is utilized.
7) When glass material is utilized with the diagrid, it permits liberal measure of light inside the structure.
8) These structures have significantly section free outside and inside, liberated, interesting floor arrangements can be executed.

The inclining individual from the diagrid conveys both shear and minute. So the ideal point of putting of the diagonals is needy of building stature. The ideal edge of the segments for most extreme twisting inflexibility in the typical building is 90 degree and for the diagonals for shear unbending nature is 35 degree. It is expected that the ideal edge of the diagrid falls in the middle of the both. Generally embraced range is 60 - 70 degree. As the tallness of the building expands the ideal edge likewise increments.

II. PROPOSED METHODOLOGY

1. To carryout extensive literature review and executed the objectives of the study.
2. Lateral loads are applied in the form of earthquake forces and structures are analyzed for equivalent static and dynamic time historey inputs.
3. ETABS software is used for the different modeling and analysis of different building configurations.
4. Key results are extracted and presented in the form of tables and graphs.

A. EQUIVALENT STATIC METHOD

Seismic examination of most structures is as yet done on the doubt that the sidelong (level) drive is indistinguishable to the genuine (dynamic) stacking. This system requires less effort because, beside the real time span, the periods and conditions of higher typical techniques for vibration are not required. The base shear, which is the total level drive on the structure, is registered on the start of the structures mass, its urgent time of vibration, and relating shape. The base shear is scattered along the height of the structure similar to sidelong drive as demonstrated by codal formula. Planar models appropriate for each of the two orthogonal parallel heading are dismembered autonomously, the eventual outcomes of the two examinations and the distinctive effects, including those in view of torsional developments of the structure, are combined. The equivalent gooey damps the estimated qualities for the even weights to near the yield point. Arrange tremor demands for the LSP are addressed by static parallel powers whose aggregate is proportionate to the pseudo sidelong load. When it is associated with the straightly adaptable model of the building it will achieve arrange movement amplitudes approximating most outrageous evacuations that are ordinary in the midst of the layout seismic tremor. To arrange the earth shake weights to process the inward powers will be sensible vague of foreseen that in the midst of would setup earth shiver.

B. TIME HISTORY ANALYSIS:

Time history examination techniques incorporate the stepwise plan in the time space of the multi-level of-chance states of development, which address the veritable response of a building. It is the most complex examination system available to an essential master. Its answer is a prompt limit of the seismic tremor ground development picked as a data parameter for a specific building. This examination methodology is by and large confined to checking the propriety of suppositions made in the midst of the arrangement of fundamental structures rather than a strategy for doling out sidelong propels themselves.

III. MODELLING

The modelling procedure includes model the various other configurations, to study the seismic behaviour of different structural configuration of steel structure.

- Model Type 1- Steel moment resisting frame
- Model Type 2- Tube Structural system.
- Model Type 3-Diagrid Angle 45 degree w r t horizontal.
- Model Type 4- Diagrid Angle 60 degree w r t horizontal.
- Model Type 5- Diagrid Angle 75 degree w r t horizontal.

A. MATERIAL PROPERTIES

- The material considered for analysis RC is M-25 grade concrete and Fe-415 structural steel:
- Young’s Modulus - steel, Es = 2, 10,000 MPa
- Young’s Modulus - concrete, Ec =25,000 MPa
- Characteristic strength of concrete, fck = 25 MPa
- Yield stress for steel, fy = 250 MPa

B. MODEL GEOMETRY

The Building is a 50-storied, 8 bays along X-direction and 8 bays along Y- direction, Steel frame with properties as specified below. The floors are modeled as rigid deck section. The details of the model are given as follows:

1) Steel moment resisting frame of 50 stories resting is considered in the present study.
2) Three different structural systems i.e., moment resisting frame, tube structure and diagrid structural systems of varied angles are considered for the present study.
3) Base dimension of the building is considered as 40 m x 40 m along X and Y direction respectively, having total height of 150 m.

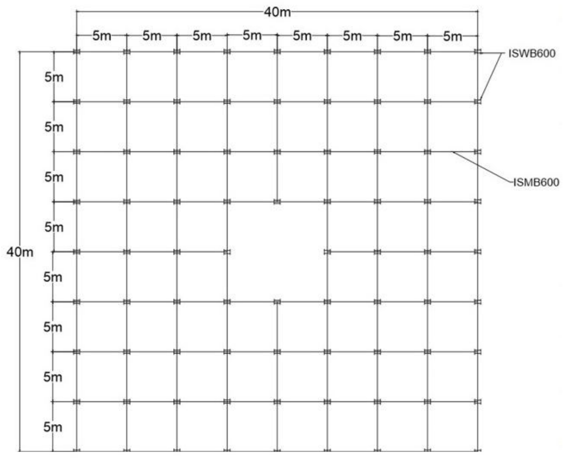

Fig 1: plan view of steel frame structure

Storey height = 3.0 meters between floors including ground floor. Bay width along X Dir. = 5 m, Y Dir. = 5 m.

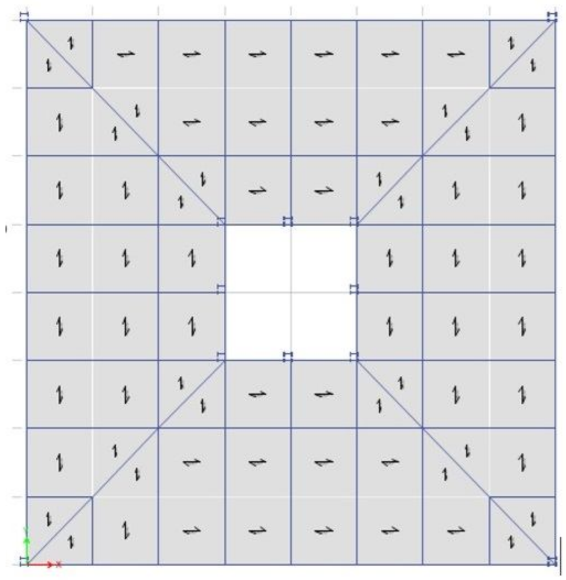

Fig 2: plan view of Diagrid structure

IV. RESULTS

A. EARTH QUAKE ANALYSIS RESULTS: Dynamic Time Historey

Dynamic time historey analysis results are presented here in the form of tables and time historey response plots. And all the results are summarized as per the discussions below.

1. PEAK DISPLACEMENTS SUMMARY (mm)

Table 1 Peak acceleration summary

Peak Displacement (mm)				
Steel MRF	Tube Structure	Diagrid - 45 deg.	Diagrid - 60 deg.	Diagrid - 75 deg.
172	155	150	192	140

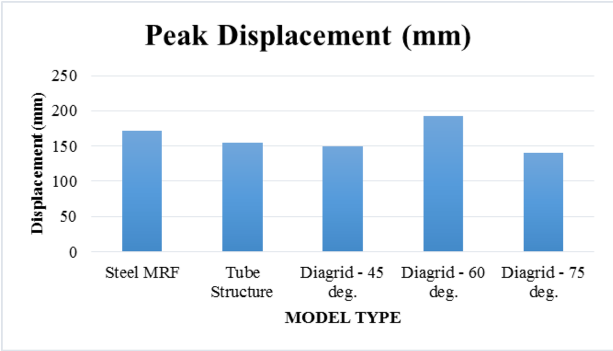

Fig.3 : Storey vs. Displacements

From the about result it can be seen that diagrid structure of 45 and 75 degree having less peak displacement.

2. PEAK ACCELERATION SUMMARY (m/s^2)

Table 2 Peak acceleration summary

Peak Acceleration (m/sec^2)				
Steel MRF	Tube Structure	Diagrid - 45 deg.	Diagrid - 60 deg.	Diagrid - 75 deg.
2.72	3.14	4.02	4.3	3.76

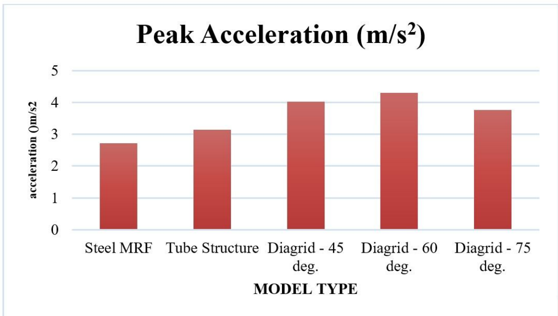

Fig. 4 Peak acceleration summary

From the about result it can be seen that diagrid structural system of 60 degree is having high peak acceleration of 4.3 m/sec2.

3. BASE FORCE SUMMARY (kN)

Table 3 Base force summary

Base Force (kN)				
Steel MRF	Tube Structure	Diagrid - 45 deg.	Diagrid - 60 deg.	Diagrid - 75 deg.
11589	14563	32449	20992	18482

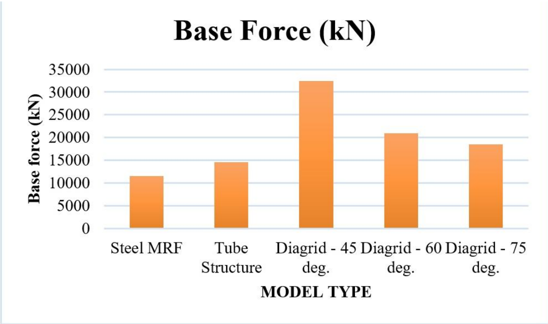

Fig. 5 Base force variation

V. CONCLUSIONS

Following conclusions are made from modal, equivalent static and dynamic time history analysis of steel moment resisting frame with setback resting on sloping ground with different types of bracings systems.

- In dynamic time history analysis compared to steel moment resisting frame, diagrid structural systems of 45 and 75 degrees are having less peak displacements and can reduce the peak displacements up to 19%.
- Due to high stiffness, diagrid structural system of 60 degree is having high peak acceleration of 4.3 m/sec2.
- From the results and discussions it can be concluded that, diagrid structural system with angle 75 degree can be suggested for high rise steel moment resisting frame in comparison with conventional tube structure and steel moment resisting frames.

REFERENCE

[1] K. Moon Design and Construction of Steel Diagrid Structures, , NSCC2009 , School of Architecture, Yale University, New Haven, USA.

[2] Kim J., Jun Y. and Lee Y.H., “Seismic Performance Evaluation of Diagrid System Buildings", 2nd Specialty Conference on Disaster Mitigation, Manitoba, June 2010.

[3] JaniKhushbu, “Analysis and Design of Diagrid Structural System for High Rise Steel Buildings”, M. Tech. Dissertation, Nirma University, Ahmadabad, 2012.

[4] Moon, K., Connor, J. J. & Fernandez, J. E. (2007). Diagrid Structural Systems for Tall Buildings: Character-istics and Methodology for Preliminary Design, The Structural Design of Tall and Special Buildings, Vol. 16.2, pp. 205-230.

[5] Jaani K, Patel PV. Analysis and design of high rise steel buildings. Nirma University International Conference on Engineering; 2012.

[6] Carpintery A, Lacidogna G. Structural analysis of high rise buildings under horizontal loads: A study on the Intesasanpalo tower in Turin. Engineering Structures. 2013; 56:1362–71.

[7] Gu M, Quan Y. Across wind loads of typical tall buildings. Journal of Wind Engineering. 2004; 92(13):1147–65..

[8] Lin N, Letchford C, Tamura Y, Liang B, Nakamura O. Characters of windforces acting on tall buildings. Journal of wind engineering and industrial aerodynamics. 2005; 93(3):217–42.

[9] Sunmoona K. Diagrid structures for complex shaped tall buildings. 12th East Asia Pacific Conference on Structural Engineering and Construction; 2011. p. 1343–50

[10] Varnitchai P, Munir A. Identification of reasons for high inelastic seismic demands in high rise RC core wall buildings. 12th East Asia Pacific Conference on Structural Engineering and Construction; 2011. p. 1359–66.

[11] Maniatakis CA, Pshiaris LN, Spyrakos CC. Effect of higher modes on the seismic response and design of moment resisting RC frame structures. Conference at National Technical University of Greece; 2012.

[12] Mandal A, Ghosh S, Reddy GR. Performance based evaluation of the response reduction factor for ductile frames. National Conference Mumbai; 2013.

[13] Salama MI. Estimation of period of vibration for concrete moment-resisting frame buildings. HBRC Journal. 2013; 11(1):16–21.