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Dynamic Analysis of Irregular Steel Building with or Without Diagrid Structure

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ABSTRACT- In this paper, our work presents the comparison of irregular steel structures with or without diagrids according to earthquake conditions proposed in IS 1893:2016. An irregular 2B + G+18 story steel building with plan size (15 m x15 m), located in zone IV having medium soil conditions is considered for analysis. The modelling and analysis are carried out using ETABS 2019 software. All structural members are designed as per IS456:2000. Analysis and study of both steel buildings, taking into account the dynamic analysis along the wind and the lateral effects of the wind and all load combinations confirming the I.S code. Building models are analyzed by ETABS 2019 software to study the effect of maximum storey displacement, maximum storey drift, base reactions, storey stiffness and storey forces etc.

KEYWORDS- Steel Building, Irregular steel structures Diagrid Structure, Dynamic analysis

I. INTRODUCTION

The origin of 'diagonal' structures is surely the Russian genius Vladimir Shukhov. He pioneered new analytical methods in many different fields, and I have been fortunate to visit some of his constructed projects more than once. Shukhov left a lasting legacy to early Soviet Russia constructivism, and as the leading engineer and mathematician during the late 19th and early 20th century he created hyperboloid, thin shell and tensile structures of extraordinary refinement and elegance. The structural efficiency of the diagrid system makes the number of interior columns decrease, so permitting abundant flexibility on the plan design.

Diagrid structural system has emerged as an improved solution for lateral load resisting system in terms of lateral displacement. Diagrid give additional resistance within the building that makes the structural system simpler. Diagrid Structure has higher stiffness than different models. Diagrid Structure is lighter than different models and so additional economical.

Diagrid structural system has emerged as a much better solution for lateral load resisting system in terms of lateral displacements, steel weight and stiffness. it's stiff enough to resist wind forces up to higher heights. The diagrid gives maximum interior space to the structure and provides an honest aesthetic perspective. because of a smaller number of columns, effective and efficient planning of the facade of the building is feasible. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, therefore allowing significant flexibility with floor plan.

II. OBJECTIVE OF THE STUDY

- To calculate the lateral design forces on irregular steel buildings comprises of high-rise building with or without diagrids using dynamic analysis analysisand compare the different structures' results.
- To compare the analysis results of shear force, bending moment, storey drift, storey stiffness and base reaction values of both the buildings.
- Only high-rise (2B+G+17) steel buildings are considered.
- Dynamic analysis was done on the structures using ETABS software.
- Column was modeled as fixed to the base.

III. LITERATURE REVIEW

A. M Satya Sai Kiran Chowdary, Himath Kumar Y and Lingeshwaran N [1]

In this study seismic performance of 20-story concrete and steel diagrid structures are considered using response spectrum method. Time history method is used only for concrete diagrid structure. This paper presents the study of response and time period with acceleration of high rise building with concrete and steel diagrid structural system. This paper study the response of two different diagrid structures of G+20 storey to obtain optimized position of diagrid. All structural members of diagrid model are designed as per IS456:2000 and for seismic analysis for concrete and steel diagrid structure IS1893:2002 and ASCE7-10 are considered. Parameters like storey shear, storey drift, storey displacement, Time period and Structural weight is done to determine the cost-effective and effective structure.

B. H M Meghana, Sabyath P Shetty [2]

They presents a state-of-art review of the effects of bracing angle in the diagrid steel structures, effects of aspect ratio, then comparison between different shapes of diagrid structures and analysis of wind load and seismic load using E-Tabs software. Design, study and analysis of 36-storey steel buildings diagonally, taking into account the dynamic analysis along the wind and the lateral effects of the wind and all load combinations according to IS 800: 2007 standard for the buildings.

C. Vahid Mohsenian, Saman Padashpour, Iman Hajirasouliha [3]

They presents the work to assess the seismic reliability of diagrid structural systems. For 16, 24 and 32 storey buildings with diagrid structural systems using 65° diagrid angle, supply and demand response modification factors are calculated for the structures. This work demonstrates the reliability of steel diagrid systems and acceptable seismic performance. To satisfy different performance targets under any seismic hazard level, multi-level response modification factors concluded in this work can be used in performance-based design of diagrid structures.

D. Chetan S.Pattar1, Prof. Smt. Varsha Gokak [4]

This paper presents the work on a 16-story square plan structure along with C-Type and L-Type structure which have plan irregularity in them is considered for the analysis. The dynamic linear method that is response spectrum method of the structures are analysed. Comparative analysis of results is carried out for various parameters like base shear, top story shear, top story displacement, time period, storey drift. The regular structure is compared with the Plan irregular structure.

E. Vinay.A.C1, Manjunath.N.[5]

This paper presents the study on analysis of 50 storey steel building of regular floor plan 40mx40m and diagrids with various angles (30°, 45°,55°, 65°) compared with conventional steel structure to find out the desired angle of inclination of diagrids for structural efficiency. Analysis and modeling are carried out in ETABS software. IS 800-2007 is considered for the load combinations in all the structural members. For earthquake analysis IS 1893-2002 is considered. Comparative analysis of results for the various parameters like time period, base reactions, story drift and story displacement are carried out.

F. Samsul A Rahman Sidik Hasibuan, Faqih Ma'arif, Baskoro Abdi Praja[6]

They present the various structural factors that contribute to damage during an earthquake are vertical irregularities, irregularities in strength and stiffness, mass irregularities, torsional irregularities, and so on. Over the past decade, performance-based design (PBD) procedures have become one of the most critical areas in earthquake engineering.

G. Harish Varsani, Narendra Pokar & Dipesh Gandhi [7]

This paper presents the analysis of conventional structural system and diagrid structural system for 24 storey building. For conventional and diagrid structures, a regular floor plan of 36 m × 36 m size is considered. Analysis and modelling are carried out on ETABS software. IS 800:2007 is considered for all load combinations in all structural members. Dynamic analysis along wind and across wind are considered for analysis of the structure. Similarly, analysis of 36, 48 and 60 storey diagrid structures are carried out. Results are compared in terms of time period, storey displacement, storey shear and storey drift with conventional building.

IV. THEORY AND FORMULATION

In this study, Irregular High-Rise Steel Building (2B+ G+18) with or without Diagrids in Zone 4 is considered. In Irregular 2B+ G+18 story high-rise steel building without diagrid at a height equal to 3m for each level. The grade of steel use is fe 350. In Irregular 2B+ G+18-story high-rise steel building with diagrids at a height equal to 3m for each level. Irregular 2B+ G+18 story high-rise steel building without diagrid at a height equal to 3m for each level. The grade of steel used is fe 350.

For the present work, modelling has been done for irregular high-steel buildings by taking IS code into account. 2B+G+17 storey steel building with a storey height of 3 meters for all and with a plan size of 24m, is considered. Live load on all the structures is taken as 4 KN/M2 on floor levels and 1.5 KN/M2 on the roof level and slab thickness as 150mm. All three models are modeled in ETABS 2019 software taking all the codal provisions into account.

Table 1: Plan Properties

PLAN PROPERTIES	SPECIFICATIONS
Details of Building	High-Rise 2B+G+18 Story Steel Building
Plan configuration	24m
Floor to Floor Height	3m
Building Height	60m

Table 1 defines the plan properties like details of building, building height of the modeling.

Table 2: Material Properties

MATERIAL PROPERTIES	SPECIFICATIONS
Grade of steel	FE350
Size of Column	VARIES
Size of Beam	VARIES
Size of Slab	100MM
IS-Code referred	IS 800:2007

Table 2 defines the material properties like size of beam, slab and column of the building.

Table 3: Load Properties

LOAD PROPERTIES	SPECIFICATIONS
Live Load	3KN/M2
Live Load on Roof	2KN/M2
IS-Code referred	1.IS-875 Part-1 for Dead Load 2.IS-875 Part-2 For Live Load

In the above table 3 defines the load properties like live load, live load on roof of the building.

Table 4: Seismic Properties

`	SPECIFICATIONS
Soil Type	**MEDIUM SOIL**
Zone considered	Zone 4
Zone Factor	0.16
Importance Factor	1.2
Response Reduction Factor	3
Damping	0.05
Rock & Soil Site Factor	II
IS-Code referred	IS-1893 Part-1 (2016)

Table 4 defines the seismic properties like zone factor, soil type, zone considered and importance factor of the building.

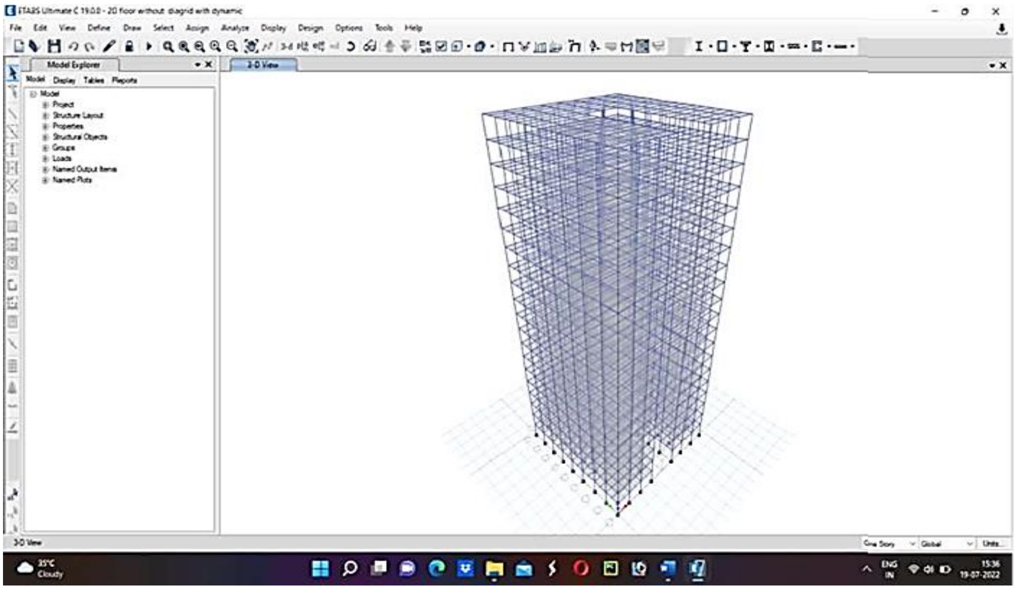

Figure 1: 3D View of High-Rise (2b+ G+18) Story Steel Building without Diagrids

Figure 1 shows the 3d view of high-rise storey building without diagrids.

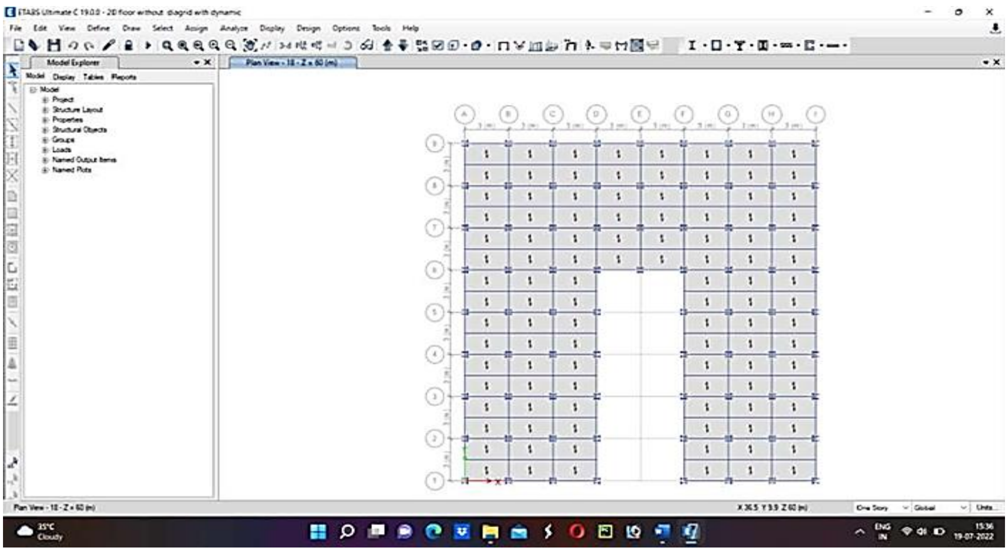

Figure 2: Plan View of High-Rise (2B+ G+18) Story Steel Building Without Diagrids

In the above figure 2 shows the Plan view of high-rise (2B+18) storey steel building without diagrids and figure 3 shows the 3D view of high-rise (2B+18) storey steel building with diagrids.

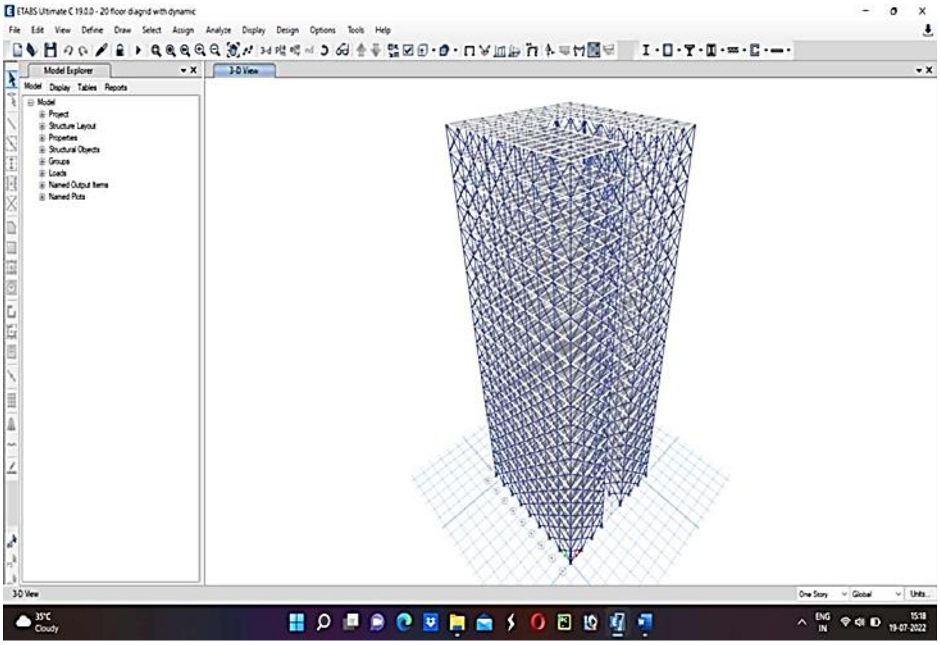

Figure 3: 3D View of High-Rise (2B+ G+18) Story Steel Building with Diagrids

Figure 3 shows the 3D view of high-rise steel building with diagrids.

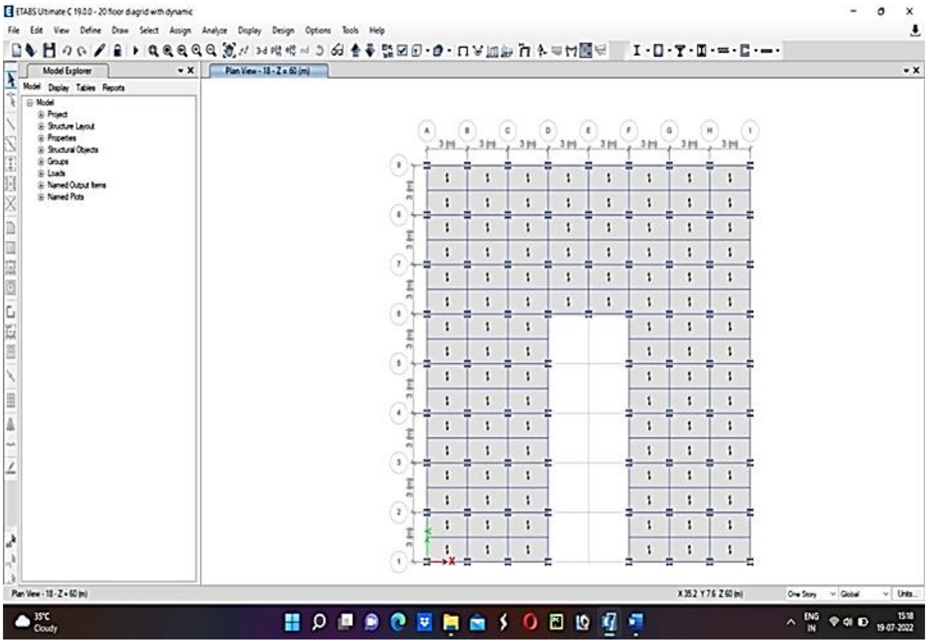

Figure 4: Plan View of High-Rise (2B+ G+18) Story Steel Building with Diagrids

In figure 4 shows the Plan view of high-rise (2B+18) storey steel building with diagrids,

V. RESULTS AND DISCUSSION

After the analysis from E-TABS, the results of both the structures are noted. Results like maximum storey displacement, maximum storey drift, shear force, bending moments and storey stiffness are noted and compared among the 6 structures. The results obtained are discussed below:

Table 5: Comparison of Maximum Storey Displacement Values

Storey Number	2B +G+18 without Diagrids		2B + G+18 with Diagrids	
	EQX	EQY	EQX	EQY
18	27.033	26.308	13.493	10.106
17	26.127	25.874	12.961	9.771
16	25.094	25.247	12.395	9.421
15	23.931	24.453	11.796	9.056
14	22.662	23.523	11.165	8.678
13	21.313	22.485	10.506	8.288
12	19.907	21.355	9.823	7.888
11	18.463	20.146	9.121	7.48
10	16.993	18.867	8.404	7.068
9	15.504	17.523	7.677	6.653
8	14.001	16.119	6.945	6.238
7	12.491	14.659	6.212	5.827
6	10.978	13.147	5.483	5.422
5	9.464	11.586	4.765	5.026
4	7.953	9.86	4.063	4.643
3	6.444	8.329	3.385	4.277
2	4.941	6.636	2.738	3.931
1	3.454	4.901	2.133	3.61
Basement 1	2.016	3.129	1.589	3.319
Basement 2	0.728	1.357	1.056	3.036

Table 5 shows the comparative values of maximum story displacement in 2B+G+18 story steel building with or without diagrids.

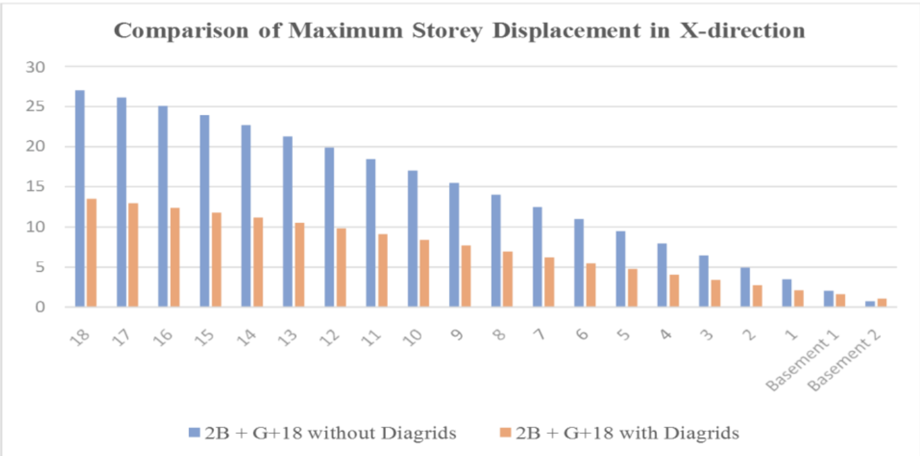

Figure 5: Graphical Representation of Maximum Storey Displacement in X-direction

- From figure 5, it is concluded that a diagrid building displaces less as compared to without diagrid building.

Table 6: Comparison of Maximum Storey Drift Values

Story Number	2B+G+18 without Diagrids		2B+G+18 with Diagrids	
	EQX	EQY	EQX	EQY
18	4.153	2.989	1.337	1.215
17	5.027	3.865	1.43	1.258
16	5.912	4.745	1.524	1.309
15	6.704	5.523	1.628	1.354
14	7.443	6.248	1.715	1.389
13	8.169	6.975	1.783	1.412
12	8.871	7.715	1.832	1.421
11	9.498	8.453	1.865	1.419
10	9.858	8.936	1.877	1.402
9	10.156	9.439	1.876	1.375
8	10.367	9.918	1.859	1.336
7	10.322	10.257	1.829	1.292
6	10.093	10.462	1.8	1.249
5	9.617	10.509	1.751	1.21
4	8.968	10.369	1.693	1.149
3	8.093	9.942	1.61	1.097
2	7.097	9.193	1.514	1.044
1	5.769	7.841	1.395	0.995
Basement 1	3.926	5.637	1.202	0.934

Table 6 shows the comparative analysis of maximum story drift values in 2B+G+18 story steel building with or without diagrids.

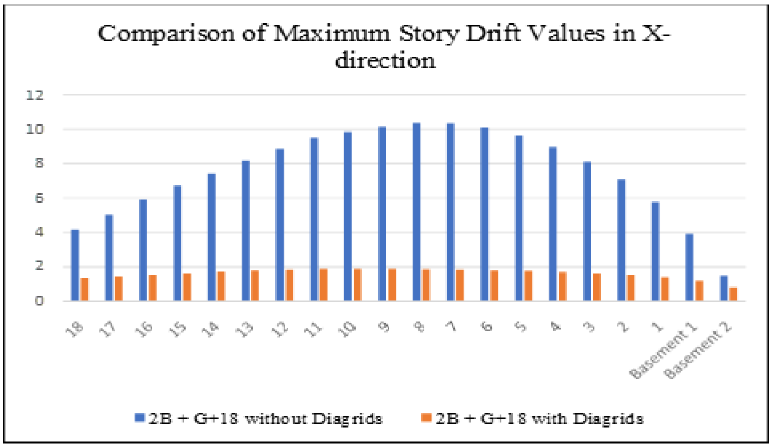

Figure 6: Graphical Representation of Story Drift values

From figure 6, it is concluded that maximum storey drift is less in diagrid buildings.

VI. CONCLUSION

From the analysis report, it is concluded that the diagrid structure resists more lateral force as displacement in the diagrid structure is less as compared to displacement without the diagrid structure. From the analysis report, it is concluded that the diagrid structure is stiffer and they displace less as compared to without diagrid structure. From the analysis report, it is concluded that story drifts in diagrid structure are lesser as compared to those without diagrid structure. From the analysis report, it is concluded that the diagrid structure performs better in resisting lateral load and is superior in performance than without the diagrid structure.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1) M Satya Sai Kiran Chowdary, Himath Kumar Y and Lingeshwaran N Sci. “Seismic analysis of tall concrete and steel diagrid structure using response spectrum and time history method in e-tabs”N Sci. Eng. 1136 012035 6th-7th March 2021, Madhya Pradesh, India
2) H M Meghana, Sabyath P Shetty “a review of the diagrid structural system for skyscraper steel structures”e-ISSN: 2582-5208 Volume:03/Issue:08/August- 2021
3) Vahid Mohsenian, Saman Padashpour, Iman Hajirasouliha Volume 29, May 2020, 101168
4) Chetan S.Pattar1, Prof. Smt. Varsha Gokak (e-ISSN: 2395-0056, pISSN: 2395-0072, Volume: 05 Issue: 08 | Aug 2018)
5) Vinay.A.C1, Manjunath.N.Hegde2 e-ISSN: 2395-0056 p-ISSN:
2395-0072 Volume: 04 Issue: 09 | Sep -2017
6) Samsul A Rahman Sidik Hasibuan , Faqih Ma’arif, Baskoro Abdi Praja. Non-Linear Behavior of Reinforced Concrete Frame Structure with Vertical Irregularities International Journal of Innovative Research in Computer Science and Technology (IJIRCST), 11(1). doi:10.55524/ijircst.2023.11.1.10.
7) Harish Varsani, Narendra Pokar & Dipesh Gandhi(ISSN(O):2393-9877, ISSN(P): 2394-2444, Volume 2,Issue 1, January- 2015)