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Analysis of Diagrid structure by using pushover analysis method

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***Abstract*: Construction of multi-storey building is rapidly increasing throughout the world. Recently the diagrid structural system has been widely used for tall buildings due to the structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. These days the latest trend of technology in diagrid structures is evolving. These are more efficient in achieving stiffness against lateral loads and are considered better options in designing tall buildings. The purpose of a pushover analysis is to determine the capacity of a structure beyond its limit state up to its ultimate state. It helps in understanding the deformation and cracking of a structure in case of earthquake.In the present study, steel diagrid structure model with brace angle 55° with x type of bracings is compared with structure without bracing by pushover analysis method. Design is done using STAAD Pro.V8i(Select series 6software.**

Keywords: Diagrid structure, pushover analysis, high rise building, displacement.

I. INTRODUCTION

The diagrid (diagonal grid) is a framework of diagonally intersecting metal, concrete or wooden beams that is used in the construction of buildings and roofs. It requires less structural steel than a conventional steel Frame. The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential. Development of city. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve important agricultural production have all contributed to drive residential buildings upward. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are: rigid frame, shear wall, wall-frame, braced tube system, outrigger system and tubular system. Recently, the diagrid – Diagonal Grid – structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. The need for structurally efficient system to resist lateral forces is gaining importance. Lateral forces induced from earthquake is the major hazard causing damage to the buildings. Pushover analysis is a static nonlinear analysis in which the structure is subjected to incremental lateral loads till a target displacement is achieved. As the magnitude of lateral loads on the structure increases, members in the linear state change into the inelastic state, which is indicated by formation of hinges. After the structure is subjected to lateral loads, the resulting internal forces and deformations in the structural members are determined. Base shear and roof displacements are obtained at each incremental step and pushover or capacity curves are plotted.

1.1 Necessity of Pushover Analysis

1. Pushover analysis allows tracing the sequence of yielding and failure on member and structural level as well as

the progress of overall capacity curve of the structure

2. Pushover provide information on many response characteristics that cannot be obtained from an elastic static or elastic dynamic analysis.
3. Estimates of inter-story drifts and its distribution along the height.
4. Determination of force demands on brittle members, such as axial force demands on columns, moment demands on beam-column connections.
5. Determination of deformation demands for ductile members.
6. Identification of location of weak points in the structure (or potential failure modes).
7. Consequences of strength deterioration of individual members on the behaviour of structural system.
8. Identification of strength discontinuities in plan or elevation that will lead to changes in dynamic characteristics in the inelastic range.
9. Verification of the completeness and adequacy of load path.
10. Pushover analysis also exposes design weaknesses that may remain hidden in an Elastic analysis. These are story mechanisms, excessive deformation demands, strength irregularities and overloads on potentially brittle members.

II. LITERATURE REVIEW

- Ravi K Revankar, R.G.Talasadar International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 3September 2014.

In this paper study of diagrid system which is modelled with 12 storey diagrid building is analysed using SAP 2000 by considering Dead, Live and Seismic Loads (IS 1893-Part-1, 2002) and designed using IS-800. Afterwards the FEMA 356 hinges are assigned to the same building and conducted Nonlinear Static (Pushover) to find out the performance points that is Immediate Occupancy, Life Safety, and Collapse Prevention of diagrid elements. At the same time Base Shear and Displacements are studied and Spectral Displacement Demand & Spectral Displacement Capacity is compared to know the adequacy of design. And it is evident that the designed 12 storey diagrid building doesn't require redesign. (1)

- Kiran Kamath 1 , Sachin Hirannaiah 2 ,Jose Camilo Karl Barbosa Noronha 3International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 5, Special Issue 9, May 2016

This paper focuses on the study of performance characteristics of diagrid structures square in plan using pushover analysis. The models studied are square in plan with aspect ratio H/B, (where H is the total height and B is the base width of structure) varying from 2.67 to 4.26. Three different exterior brace angles are considered. Seismic response of structure in terms of base shear and roof displacement corresponding to performance point were evaluated and compared. The base shear at performance does not show a specific trend with increase in the aspect ratio and brace angle considered in the study(2)

- SushantLamichhane, Hemanth H MInternational Journal of Advanced Research Trends in Engineering and Technology (IJARTET) Vol. 5, Special Issue 14, April 2018.

The present study ETABS software is used for modelling and analysis of diagrid structural system and conventional structural system for 10 storey building is considered. A floor plan of 9*9m is considered for both the structures. Pushover analysis will be conducted to find out the performance point that is Immediate Occupancy, Life Safety, and Collapse prevention of Diagrid elements and for the conventional buildings as well. At the same time Base shear and Displacement are studied and is compared to know the adequacy of structure.(3)

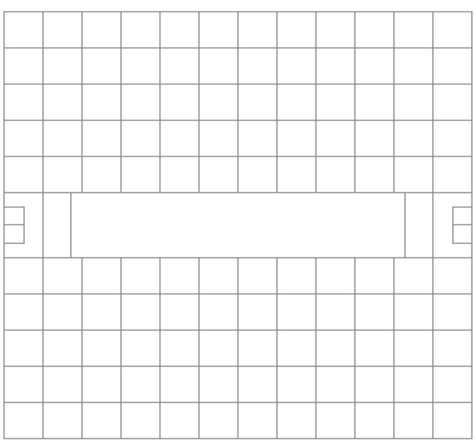
- Ms.Pallavi B. Gadge1 , Mr.Gajanan D. Dhawale2 , Miss. Rutuja K. Kakpure3International Advanced Research Journal in Science, Engineering and Technology ISO 3297:2007 Certified Vol. 5, Issue 5, May 2018.

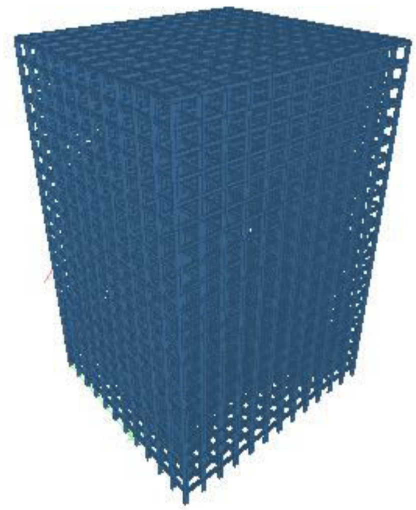
The seismic performance of a multi-story steel frame building is designed according to the provisions of the current Indian code (IS 800 -2007). The shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as D, K, and V type eccentric bracings. A typical eight-story steel frame building is designed for various types of eccentric bracings as per the IS 800- 2007. D, K, and V are the different types of eccentric bracings considered for the present study. Performance of each frame is studied through nonlinear static analysis.(4)

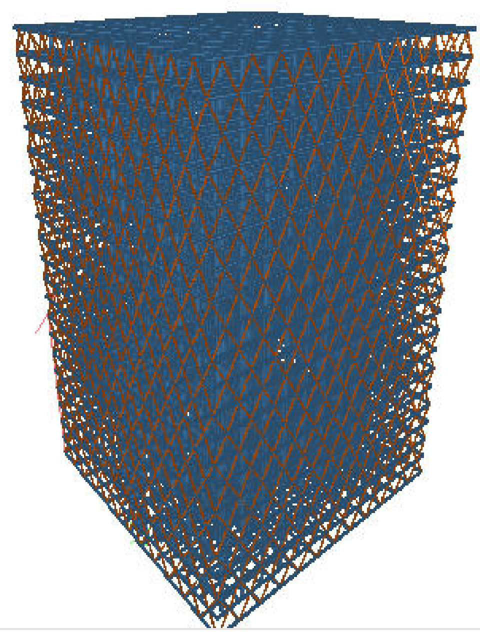
III. METHODOLOGY

The design methodology is applied to a structures G+20 storey tall building. Primary data required for the project is taken from "Nita Reality,Pune.

The diagrid structure of each storey height is 4m.The building's plan dimensions are 60x 59 meters.







Data-

Soil bearing capacity-32 tonne.

Zonal factor Z=0.16

Importance Factor=1.2

Response Reduction Factor=5.0

Time period both in x and y direction=0.075xH.0.75

=0.075x84 0.75

=2.08

Material properties:-

Steel: Fe500

Density: 7850 Kg/m3

Modulus of Elasticity: 2.1 X 105 N/mm2

Poisson's ratio: 0.3

Section Properties:-

Beam-: ISHB450

Column-ISWB600

Bracings-ISA120x120x12

IV. ANALYSIS

For Pushover analysis

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 18-June-20

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 5 0 0;…..

MEMBER INCIDENCES

1 4 5; 2 5 6; 3 7 8; 4 8 9;…

DEFINE MATERIAL START

ISOTROPIC STEEL

E 2.05e+008

POISSON 0.3

DENSITY 76.8195

ALPHA 1.2e-005

DAMP 0.03

TYPE STEEL

STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2

END DEFINE MATERIAL

MEMBER PROPERTY INDIAN

DEFINE PUSHOVER DATA

FRAME 2

GNONL 0

VDB 1

LDSTEP 500

HINGE FEMA MEMB

SPECTRUM PARAMETERS

DAMPING 5.0000

SC 5

SS 0.25

S1 0.1

DISP Z 0.5 JOINT 13

END PUSHOVER DATA

LOAD 1 LOADTYPE Gravity TITLE LOAD CASE 1

SELFWEIGHT Y -1 LIST ALL

PERFORM PUSHOVER ANALYSIS

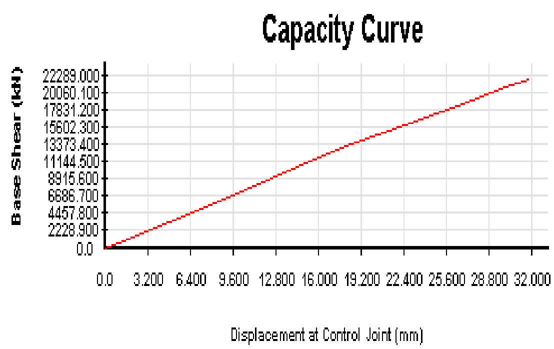
FINISH

V. RESULTS

For Pushover analysis without bracing

Load Step	Displacement mm	Base Shear kN
1	0	0
2	1.032	763.174
3	8.67	6409.63
4	14.472	10685.413
5	16.505	12177.014
6	18.522	13666.901
7	20.895	15151.815
8	22.931	16476.824
9	26.5	18801.332
10	30.07	21126.243
11	31.855	22288.699

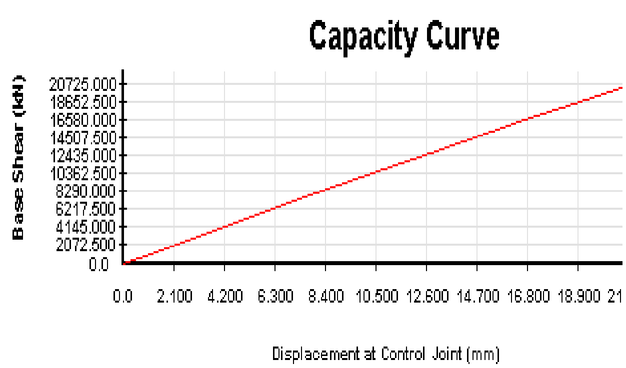
Table shows as the displacement increases base shear found increasing.



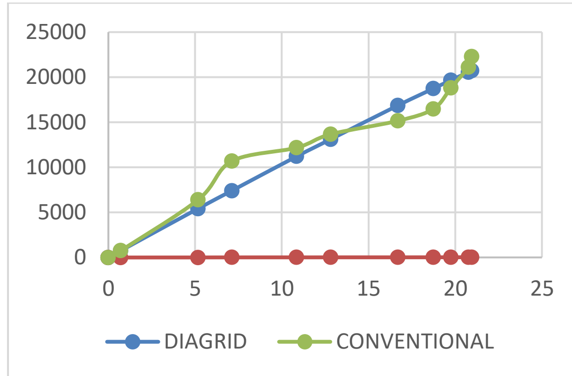
For Pushover analysis with bracing

Load Step	Displacement mm	Base Shear kN
1	0	0
2	0.714	747.683
3	5.182	5431.06
4	7.125	7409.644
5	10.855	11207.752
6	12.817	13106.821
7	16.692	16857.845
8	18.737	18733.296
9	19.75	19652.926
10	20.763	20556.561
11	20.955	20724.875

Table shows as the displacement increases base shear found increasing.

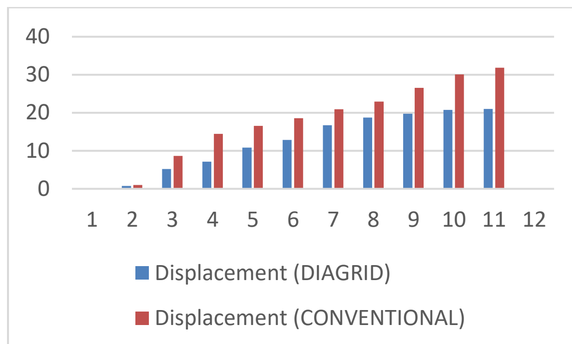


Base Shear



The graph shows base shear of Diagrid structure gives more linear curve while conventional structure gives fluctuating type of curve.

Displacement



Bar chart shows Displacement of Diagrid structure is less than that of the conventional structure.

VI. CONCLUSION

1. Maximum % difference is base shear found is 44.20% i,e base shear of conventional structure is higher than that of diagrid structure.
2. Maximum % difference is displacement found is 50.76% i,e displacement of conventional structure is higher than that of diagrid structure.
3. From above two conclusions the performance point study of diagrid and conventional indicated that the diagridstructures have performance points at less vulnerable damage states than conventional structure.

4. Comparing the results of structures with diagrid and conventional, base shear vs. displacement curve indicates that the diagrid structures are far better than conventional structure. It also indicates that the capacity curve become more linear for diagrid structures.
5. Conventional buildings are found to have more displacement as compared to the diagrid structures.
6. Seismic capacity of the Diagrid structure is more than conventional structure.
7. Diagrid structure is more efficient than the conventional structure.
8. Since the diagrid structure avoids the use of vertical column and usesdiagonal grids as a column it resists more load. Here also it is found that diagrid resisted more lateral loads than the conventional which resisted gravity loads only.

VII. FUTURE WORK

1. Composite material can be used for Pushover analysis.
2. Can be studied for higher structures.

VIII. REFERENCES

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