

Seismic Evaluation of Diagrid Structure With Performance Based Design

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Abstract- This paper contrives some fundamental principles of Performance Based Design (PBD) and its significance in today's age. In this advanced world of era the construction techniques and designing facets are approaching at the frontline as the conventional method of designing have failed to give an appropriate required result. The main reason for introducing PBD concept is to address the control damage of structure in minor & average earthquake, life safety, efficient & economic structure & to prevent structure from collapse in crucial stage of earthquake. PBD gives an output of standardized approach for structural design and in progress of counterfeit tools and performance test method required in design and judgement process. Diagrid structure is an upcoming and most trending structural concept in Civil/Structural world which deals with architectural aesthetic appearance, structural stability & economic deliberation. Diagrid structure is one of the best upcoming structural systems for the high-rise buildings which deals with the lateral loads like Wind loads, Seismic loads. The structure which resists the lateral load is provided by internal structural system or external structural system. Mostly braced frame or shear core walls and their combination with RCC frames in Internal system, where resistance to lateral loads is given. Diagrid structure is similar to the framed tubular structure, braced tube structural system to resist the lateral loads by elements which are provided at the periphery of the structure. Selection of location of all the structural elements and structural system is very much important which give a stability, durability, etc. to the structure for an effective structural designed system. Now a days, diagrid structural system is used for tall buildings for a good flexibility and efficiency in planning. Diagrid consist of closely spaced vertical columns which are in inclined positioned at the periphery 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 structure do not require core walls at the periphery of the structure because lateral shear is carried by the tubular framing which is provided at the peripheral location of the building.

Keywords- Principle, Performance Based Design (PBD), Structural stability, Diagrid structure, Seismic loads, Life safety, Collapse, Tubular structural

I. INTRODUCTION

The perspective view of recent development in the theory concept and technology of structural design industry [1], Performance-based design supports for a tremendous change in structural analysis, design theories and ideas. Now, to enhance the earthquake resisting structure designing concept are changing from “Strength” to “Performance” [2]. In this process, Non-Linear analysis plays an important role in determining and understand the inelastic behavioural and damage pattern of any particular building/structure for lateral loads. Static Pushover analysis in Non-linear and Response Spectrum in Dynamic analysis takes an important role for determining the performance of the structure and static pushover analysis is a process where the earthquake is applied gradually to the structural model in software up to the plastic collapse mechanism is formed [3]. There are some problems with applying a conventional design procedure to get an accurate result of performance of the building in structural engineering industry. Hence, experts are coming up with new techniques and concept for more accuracy in the results of buildings and PBD is one of the outcomes for greater accuracy in the results of structure. One of the small objectives of new concepts for earthquake resisting structures are to achieve a proper structural response which satisfies both global and local level i.e., at system level and element level & this can be happen by trial & error method approach.

A difference between conventional design and performance-based design is in the objectives of both concepts. In conventional design requires to achieve D/C Ratio i.e., Demand-to-capacity ratio and in PBD it requires to achieve the desired stage of performance, which may be measured in several ways. Each n every method requires various iteration until it achieves the D/C ratio in conventional as well as the particular structural performance in PBD. The conventional method relates to demands and capacity where as in PBD it goes for risk, hazards, consequences, etc. In conventional method, seismic level and acceptance of damage in structure and in PBD both these are considered with predicted repercussion & unreliability's in analysis and design of structure.

he design of tall building should be achieved with life safety, structural stability, etc. but this are the technical terms which are not visible to eyes and these are the functionality of the structure, but the main thing which is visible to our eyes and which affects more to us is great architectural aesthetic view. Diagrid structures are the most trending concept for stable and architectural view. The shaping, rigidity, stability, etc to the gravitational and lateral forces proper analysis and design with various terms & conditions & various technical concepts are to be considered. As the height of the building increases importance lateral forces also increases that high-rise building must have sufficient strength to transfer all the loads with the stability good capacity of the structure. Diagrid is a form of Space Truss. It consists of tubular structure with triangulated truss at the defined angle. Diagrid has good appearance and easy to recognize. Due to the diagrids structural system, it also reduces the number of columns and core walls at the periphery of the structure. It consists of diagonal members which helps to resist the lateral loads acting on structure & it is very effective structural type for overall withstanding of structure

II. AIM OF STUDY

To enhance the structure ability from strength level to performance level with stability, life safety, immediate occupancy, collapse prevention & Prescriptive Designing

III. PROBLEM STATEMENT

In recent years, all around the world it has been validated that structure gives poor performance under the seismic conditions. About 60% of Indian land is under seismic zone III, IV & V. Major 38 cities of India are under seismic prone areas which has been classified by the National Disaster Management Authority and Bureau of Indian Standards & cities like Delhi, Mumbai, Dehradun, Patna, Chennai, Pune, Amritsar, Kolkata, Kochi, Trivandrum and also these cities are densely populated. A very compelling parameter for the high-rise buildings is wind loading and also has to come up with lateral drifts. For many years, various research and studies are conducted for seismic performance of the structures which concluded that it is a biggest threat for the high rise building under seismic conditions. In earlier stage, Structural Engineers & Designer tackled many problems while designing the high-rise structure for lateral movement.

Now days, Diagrid Structure is most desirable option for high rise buildings. So, it becomes necessary to analyze the performance level of Diagrid Structural System attuned with Indian Standard Code Practise. There are linear static methods namely code compliance method and nonlinear static methods which are also called as pushover methods namely capacity

spectrum method and displacement coefficient method are available. Lives are not safe in buildings while earthquake occurs. Hence, to make each and every life's safe it is necessary to study the performance level of Diagrid Structures by Performance Based Design and preventing structure from collapse, failures of members, immediate occupancy, etc

IV. PERFORMANCE BASED DESIGN

What is Performance based design?

Performance based design is process in a detailed manner that how a building is likely to perform, which gives an ability to stand the structure in hazardous conditions which are mostly experienced, considering the uncertainties the building should come up with an actual building response. Performance – based design starts with selecting design criteria which relates to the one or more performance objectives. Performance of the structure should be up to that stage which considers the risk factor and resisting the structure with good performance and stand structure from collapse as much as possible at certain limits. In performance – based design, identifying and rectifying the problems in the structure & how the structure is performing and how it is giving a best output which every structural engineer is required and this complete should be satisfied under all rules, limitations, and also under IS Code analysis and design analysis process.

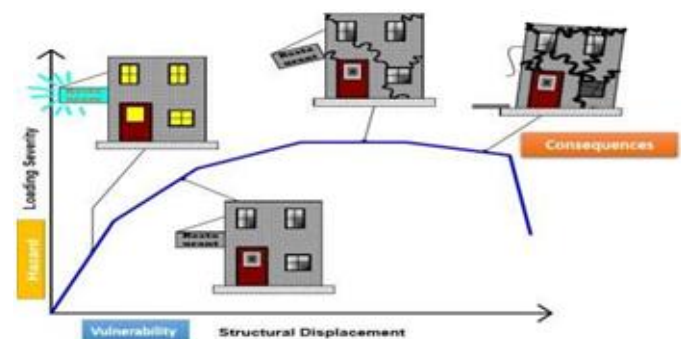


Fig 1. Performance Level Graph of Structure

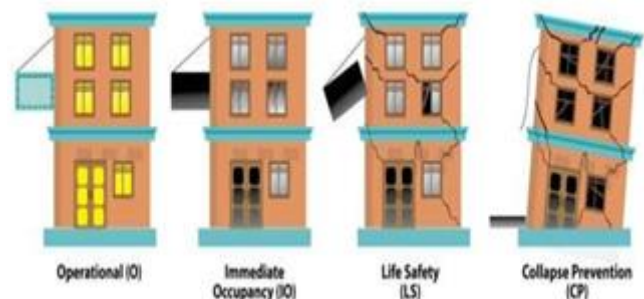


Fig 2. Performance Level of Structure

V. MODELLING

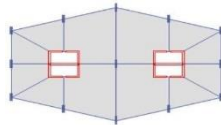


Fig 3. Etabs Plan

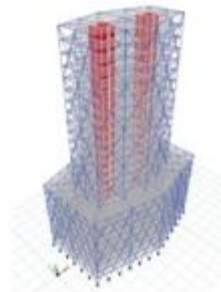


Fig 4. 3D Etabs Mode

VI. ANALYSIS REPORT

Table 1. Static Earthquake Results

Static Earthquake Analysis		
Direction	X – Direction	Y – Direction
Max Displacement	37.04 mm	78.14 mm

Table 2. Wind Analysis Results

Wind Analysis		
Direction	X – Direction	Y – Direction
Max Displacement	9.78 mm	35.48 mm

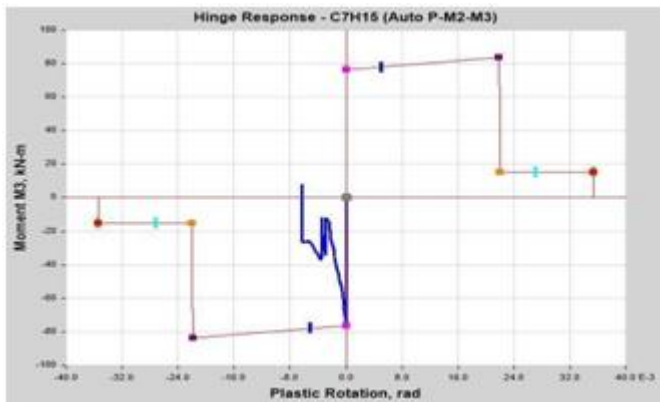


Fig 5. Hinges Graph

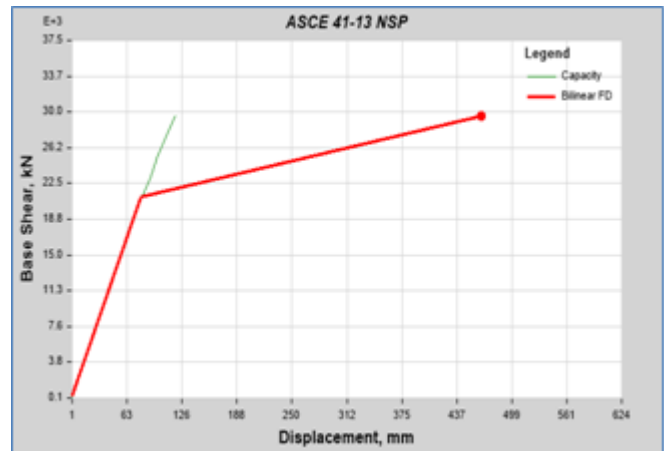


Fig 6. Static Push Over Curve

Table 3. Target Displacement

Target Displacement	464.533 mm
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Table 4. Performance Check D/C Ratio

Performance Check	Demand Set	DC Ratio For IO	DC Ratio For LS	DC Ratio For CP
Minor Crack 1	ALL	0.009	0.004	0.002
Major Crack 1	DSet1	0.009	0.004	0.002
Minor Crack 63	ALL	10.274	2.01	1.541
Major Crack 63	DSet1	10.274	2.01	1.541

VII. RESULT

1. The Performance Level of structure is on the IO.
2. The Performance point of RC Framed Structure of maximum hinges are formed is within IO.
3. The performance of the structure is increased due to diagrid structure.
4. More stiffness to the structure is provided because of diagrid structural system.
5. The strength and ductility of the structure is increased by diagrid.

VIII. CONCLUSION

1. By performing the Non – Linear Static Pushover Analysis, it has been concluded that performance evaluation of RC building can be seen.
2. Observing the Pushover curves, it can be stated that the effect of Diagrids in building has much significant effect on the capacity of the building.
3. Complete structure is within the Immediate Occupancy, it has been found that many hinges are formed within IO. Performance of structure is increased by add diagrid in

the structure. Because, core walls & columns were resisting the structure for earthquake but by adding diagrid more strength induced in structure for carrying the lateral forces.

4. Ductility of the RC frame has been increased due to diagrid structures. Push – Over Analysis is very helpful tool for Performance – Based Design in Seismic Engineering to study the behavior of the structure. It is more complex than Linear analysis, but Non – Linear Analysis consumes efforts, time, numbers of iterations to get the satisfying result.
5. Pushover analysis was performed on 25 story concrete building with steel diagrid structural system which a unique design method. Utilizing the results for the analysis, conclusion comes to that high – rise structure should be designed in diagrid structural system for good strength, good aesthetical architectural appearance with Performance – Based Design to get the best and real performance of the structure for betterment and safety of the livings which will be in such structure for any purposes.

REFERENCES

- [1] R. Oxman, “Performance – Based Design: Current Practices and Researched Issue”. International Journal of Architectural Computing, 2008. DOI: 10.1260/147807708784640090
- [2] A. Ghobrah, “Performance-based design in earthquake engineering: state of development,” *Engineering Structures* 23, 2001. DOI: 10.1016/S0141-0296(01)00036-0
- [3] A. J. kappos and G. Panagopoulos, “Performance- Based Seismic Design of 3D R/C Buildings Using ealstic Static and Dynamic Analysis Procedures,” ISET Journal of Earthquake Technology, vol. 41, 004
- [4] F. M. Azad, A Generative Design Tool for Multi-Objective Optimization of Free.
- [5] J. SZOLOMICKI and H. GOLASZ-SZOLOMICKA, “APPLICATION OF THE DIAGRID SYSTEM IN MODERN IGH-RISE,” International Journal of Advances in Science Engineering and Technology, Vols. Volume-, no. Issue-3, 2017.
- [6] Kyoung-Sun Moon, Jerome J. Connor And John E. Fernandez, "Diagrid Structural Systems For Tall Buildings:," 2007.
- [7] N. M. Kashid, “Performance-based Seismic Analysis for Buildings in India,” Earthquake Engineering, esearch papers, 2021.