In the name of God

Shahid Chamran University of Ahvaz, Iran

Faculty of Engineering, Higher Education Office

MSc Thesis Proposal Submission

Title in English

Evaluating the effect of using the Outrigger Braced Systems in improving the performance of the diagrid structure

Title in Persian

Supervisor(s)

Type of Research

• Theoretical	○ Experimental	○ Applied-Experimental	○ Applied-Theoretical

Starting Date	Estimated ending date

1-Problem definition, objectives, and assumptions

1.1-Problem definition:

The word diagrid derives from combining the words diagonal and grid according to the commonly seen physical structure. It is a structural innovation that emerged in Russia more than 100 years ago. The origin of the Diagrid Structure in architecture dates back to the work of engineers. It was pioneered by Russian architect Vladimir Shukhov (1853-1939), along with the mathematical principles involved in this structure being the revolutionary Hyperboloids of Revolution.

The long diagonal network first appeared in tall structures around 1960. Saint Petersburg's 13-story IBM building is one of the earliest examples of this technique in use [1]. Today, Consequently, diagrids are employed in longer than males and towering structures, particularly when the framework has complex curvature and mathematics [2]. Given the inherent stability of triangles and the fact that the structure of a diagrid is made up a triangulated network pieces stacked on top of one another, this network would also be stable [3,4]. Diagrid fibres' structural performance has been the subject of numerous studies in recent years. A 33-story diagrid's actions skyscraper in various geometries during Earthquakes in the distance was researched by Lee et al. (2018) [5].

In a steel diagrid construction, A. S. A. D. (2018)looked at seismic activity and harm assessment [6]. By using a performance-based design (PBD) method, Li et al. (2018) examined a 12-story diagrid structure's behavior and investigated how the diagrid brace angle affected this building's behavior [7]. A 30-story diagrid structure's seismic performance characteristics were examined by Heshmati et al. (2019) using FEMA-P695 data [8]. A 30-story diagrid structure that was built using the Performance-Based Plastic Design (PBPD) method and documented in FEMA-P695 records underwent a collapse evaluation by Li et al. (2019) [9]. The findings of these research demonstrated that diagrid systems susceptible to earthquakes performed well and favorably.

Fig1: Examples of diagrid buildings in the world

1.2-Objectives:

Engineering structures are subjected to enormous cyclical forces during earthquakes. Many structural failures of buildings during severe seismic vibrations indicate that stable strength and the ability to dissipate energy stably are highly desirable in order to keep shear forces and overall structural displacement at acceptable levels. Is showing. Seismic activity, therefore, raises more concerns in the design of building structures in earthquake-prone areas. Based on studies by other investigators, the floor layout and overall view of a large digrid structure octagonal in shape design are presented in this article. There are 16 inner columns and eight outside ones in the building. The reinforced concrete comprised of an octagonal diagrid section for bearing lateral loads and a rectangular core for supporting gravity loads that is joined to the net-like segment by girders. The building has 50 floors with an average height of 3.3 meters. The storeys' concentric braces are distributed equally throughout the plan and each one. It is important to note that the structure is built to withstand an earthquake, but the interior frames are only intended for gravity loads [10].

As one of the best structural systems for resisting loadings is one that has an outrigger that is braced. A horizontal outrigger truss or deep girders link the central core to the perimeter columns of an outrigger braced system, which has a central core made of braced frames or shear walls. The efficiency of a structural structure is determined by its capacity to tolerate increased lateral loads, which rise with the building's height. On creating high-rise structures, and their resistance to earthquakes. The higher the building, the greater the risk of its collapse due to earthquakes, Therefore, this research aims to evaluate the effect of using the Outrigger Braced Systems in improving the performance of the diagrid structure.

1.3-Assumptions & hypotheses:

1.3.1 design the floor layout and overall view of a large digrid structure octagonal in shape design are presented that is article. There are 16 inner columns and eight outside ones in the building. The reinforced concrete comprised of an octagonal diagrid section for bearing lateral loads and a rectangular core for supporting gravity loads that is joined to the net-like segment by girders. The building has 50 floors with an average height of 3.3 meters. The storeys' concentric braces are distributed equally throughout the plan and each one. It is important to note that the structure is built to withstand an earthquake, but the interior frames are only intended for gravity loads [10].

1.3.2 Outrigger frame design and configuration, to investigate. In this building model, the center frame is designed as a frame supported by a total of four strut frames.

2-Research methodology, main features and steps of the research

2.1-Methodology and Main features:

A three-dimensional simulation program is used on the structure of the building by exposing the building to ten earthquakes, each tremor to a different degree from the other, navigating the resulting displacement, analyzing the shear strength obtained on the building structure and its resistance to those earthquakes, and comparing the results with the other results that are obtained after Reinforcing the building with the internal axes and exposing it to ten other earthquakes, as well as noting the size of the deformation in the form of the building's structure and weaknesses and know the extent the effect of using the Outrigger Braced Systems in improving the performance of the diagrid structure.

2.2-Steps of the research:

This study collects initial information and library research on the diagrid structure and Outrigger Braced Systems. After gathering information and preparing the research background, he uses the Abaqus finite element software, followed by numerical validation models, to begin designing experiments.

3- Literature review

As the structure's height increases, it gets more susceptible to lateral loads, and careful planning is needed. The structural systems should be selected based on the needs of the facility in order to design the building to standards that safely transmit lateral and vertical loads to the foundation. There are several lateral load resisting systems, one of which is the bracing system, which can be used as retrofitting for firming up the building or as a lateral load resisting system. Diagrid is yet another structural system that is a freshly designed mechanism for lateral load resistance. Outrigger structural solutions can improve the lateral strength and stiffness of a structure.

1- Both Keshav K. Single and Dhanaraj M. Patil (Seismic Behaviour of Outrigger Braced Systems in High Rise 2-D Steel Buildings)

In this study analyzes the seismic behavior of outrigger-braced structures in order to determine the ideal outrigger placement in high-rise 2-D steel structures. To understand the seismic response, a non-linear static pushover study was performed for this purpose on various outrigger braced high-rise steel structures of 20, 25, 30, and 35 floors. In this research, the position of the outriggers varies depending on the storey height, from the bottom of the building to the top. Notably, the position of the outriggers, the distribution of the lateral loads, and the height of the structure have a significant impact on the seismic performance of the high-rise building. Outrigger placement in high-rise structures has a major impact on seismic performance by improving base shear-measured strength and stiffness.storey displacement, inter-storey drift ratio, and performance point. Similarly, nonlinear static pushover analysis by using different lateral load patterns points out that the optimum location of outrigger could be varied with different load patterns.

2- Structure Engineering, Iranian University of Technology in Babol, Majid Moradi & Moein Abdolmohammadi Earthquake Engineering, Department of Civil Engineering, University of Zanjan, Zanjan, Iran.

The Diagrid structural systems were found to be the core of this investigation. It has attracted a lot of attention from designers and engineers just because it’s outstanding structural performance and creativity. In this work, the in order to better understand the seismic behavior of diagrid structural systems under near-field and far-field earthquakes and the advantages of the energy technique, this seismic behavior is examined. For this, a finite element model of a 50-story building is generated, and the behavior of the structure is studied through incremental dynamic analysis (IDA). Engineering demand elements such as plastic strain energy and final story drifts are explored (EDP). Comparing the fragility curves of final narrative drifts to plastic strain energy, a structural fragility analysis method is also illustrated. This study shows how the energy approach may be used to assess the possibility that the structure will outperform its four performance levels: flexible, LS, CP, and rigid and global instability. In both the greatest story drift and energy techniques, the results demonstrate that the superstructure is more fragile in far-field quakes than in near-field quakes. Furthermore, the fragility

curves produced by the energy technique at the LS and Instability levels show a reasonable similarity to the curves produced by the method of greatest narrative drift. The energy strategy, on the other side, produces more cautious results at the CP grade. It has been proven that the.

3- Paresh V. Patel, Khushbu Jania the 3rd Nirma University International Conference will have tracks for chemical, civil, and mechanical engineering. (Design and Analysis of a High-Rise Steel Structures Using the Diagrid Structural System)

The advancement of building High-rise constructions were made possible by technology, materials, structural systems, and design and analytical techniques. Greater buildings' structural designs are constrained by lateral stresses generated by wind or earthquakes. The internal or external structural systems of the structure offer lateral load resistance. Generally, Central sections of an interior system with shear wall cores, braced frames, and their combinations with frames withstand lateral stress. By virtue of characteristics provided on the structure's edge, the framed tube, braced tube structural system, in contrast, inhibits lateral loads. The developed structural system must be set up so that structural components are used efficiently and in accordance with design standards. Because of its structural efficiency and flexibility in architectural planning, towering buildings have recently embraced a diagrid structural system. The diagrid structure, which is comparable is made up of inclined columns on a building's facade that are closely spaced vertical columns in a framed tube. The diagonal's axial motion resists lateral stresses, owing to angled columns, likened to the Vertical column bending in a tube frame structures Diagrid constructions don't usually demand a core since the diagonals may withstand lateral shear on the building's border. The design and analysis of a 36-story diagrid steel building are shown. A typical (36 m ,36 m)floor layout is studied. The ETABS program is used for structural component planning and analyzing. According to IS 800:2007, all structural elements are made, accounting for all stresses. variations. Dynamic across the wind and along the wind are used to examine the structure. A 36-story building's load distribution in a diagrid system is also examined. The construction and analysis of (50, 60, 70, and 80) story diagrid buildings is similar. In this study, study findings in the forms of time, top storey displacement, and inter-storey drift are compared.

4- Johan Leonard received a B.S. in civil engineering from the Massachusetts Institute of Technology and the Illinois Institute of Technology in 2004. (Analysis of Shear Lag Effect in High-rise structures with Diagrid System).

In this study show the most efficient high-rise building system has been the framed tube system. However, impacts of shear lag produce axial stresses are distributed nonlinearly along the face of the framed tube structure. The public's attention has been drawn to a particular structural system known as a diagrid system. The diagrid system predates written history. Since 1960, the idea has been widely accepted, although few structures have been erected using the diagrid method. However, the deployment of such towering buildings on a bigger scale was not feasible due to the high cost associated accompanied by the faulty node connections. Technology has only recently made it possible to link diagrid nodes more cheaply. There aren't many technical literatures on diagrid building systems, despite the fact that they are the newest trend in high-rise structures. In order to determine the ideal angle for the diagrid, Moon (2005) investigated the various angles. He has also reviewed the issues with diagrid construction design. This thesis seeks to further Moon's investigation on the diagrid building shear deformation effect. SAP2000 is used to model and evaluate the structural performance of digrid structures with various configurations for shear lag effect.

5-Hrdya Menon ,Paul Jose. September 2016 (Performance Assessment of High-Rise Building using Diagrid)

In this study, the construction development has been significantly increasing for the sake of tall building structures. Lately, tall buildings have adopted Due to its structural effectiveness and flexibility in architectural planning, several structural systems, including braced tube structures, space trusses, diagrid structural systems, and etc. A specific kind of space truss is called a diagrid. A perimeter grid made up of several triangulated truss systems makes up the structure. Diagrid is made by intersecting the diagonal and horizontal parts. In diagrid structures, as contrast to the bending of vertical columns in typical structures owing to lateral loads, axial motion of the diagonal counters lateral loads. to inclined columns. Steel is commonly utilized for tall building diagrid structures. The design and analysis of a 30 RC building using steel is shown. A standard 36 x 36 m floor layout is now being studied. The ETABS software is used to simulate structural components.

According to IS 456:2000 and IS 800:2007, all structural components were created taking into account all possible load combinations. It is later determined what angle is best for a 30 story RC structure with a steel diagrid.

6-Hamid Reza Tavakolia, Majid Moradib, Mohammad Javad Goodarzi and Hossein NajafidaAssociate professor, Babol Noshirvani University of Technology, Email: tavakoli@nit.ac.ir PhD in Earthquake Engineering, Babol NoshirvaniUniversity of Technology, Email: majid_moradi68@yahoo.com.published in 15/01/2022 (An Effect of Outrigger Seismic Collapse Probability of Braced System on Tall Building).

In this study show the placement of bracing in outrigger braced systems can influence earthquake response and energy balance. It is attempted to investigate the influence location of an outrigger braced system optimization on the seismic reaction of a 50-story skyscraper. The seismic responses are investigated using IDA curves. Both SA and Standard deviation are Parameters for intensity measurement (IM). As engineering demand variables, maximum story drift and inelastic strain energy are considered (EDP).First, IDA curves are calculated on the basis on the structures' maximum storyline drift. After determining the performance level, the fragility curves are determined and compared. The energy balance in the structures is then investigated, as well as the strain energy parameter chosen as the EDP, in accordance with which the damage Level is defined The plastic strain energy is used to examine the results of visualizing fragility curves The findings show that optimizing the installation of an outrigger braced system enhances all structural aspects while lowering the risk of collapse. Furthermore, the fragility curves generated by plastic strain energy as EDP are quite similar to the fragility curves generated by story drift as EDB.

4- References

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5- Project Timetable (based on section 2.2)

	Project Period of Performance by Month																		
Activities (example)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Literature Review																			
Fundamental & Governing Eqs.																			
Experiment																			
Analysis of Results																			
Conclusion & Writing up																			

6- Advisor(s)

Name:	Academic Rank:
Field:	University:
Department:	Faculty:
Email:	Mobile Number:
Address:	