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Literature Review on Analysis and Design of High-Rise Buildings in Seismic Zones

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ABSTRACT: This research focuses on seismic behavior of high-rise buildings. Building under study is Fortune One Tower located at Jinnah Avenue Sector F9 Islamabad (Seismic zone 2B) having 22 Stories with 04 basements. The project aims at finding the economical sizes of structural members and provide safety, stability and serviceability in the proposed building. The building was modelled in ETABS 2016 (Extended Three-Dimensional Analysis of Building System Version 2016). Linear Static and Linear Dynamic Analysis were performed on the selected building. Equivalent Lateral Force method was used as static analysis while Response Spectrum Analysis was used as Dynamic Analysis. Building Code of Pakistan (BCP), Universal Building Code (UBC-97) and American Concrete Institute (ACI 318-14) codes were followed for the design of the building. The outcome of this research is the economical sizes of structural members. Results established the superiority of Response Spectrum Analysis over the Equivalent Lateral Force Method.

KEYWORDS: Static Analysis, Dynamic Analysis, Equivalent Lateral Force & Response Spectrum Analysis.

I. INTRODUCTION

Earthquake is a natural cataclysm responsible for millions of deaths around the world since ancient times. The trembling of the earth due to an underground movement of tectonic plates along a fault plane or from volcanic activity is what we called an earthquake. Pakistan is situated in a region of high seismicity, which is evident from the catastrophic seismic event of October 8, 2005(Naseer et al., 2010). An earthquake of 7.6 Magnitude shook Kashmir and Northern parts of Pakistan resulting 73000 deaths, more than 70000 injured or disabled, 2.8 million people become homeless, 2.3 million people are left with inadequate food and a total loss of 5.2 billion dollars to the economy of Pakistan (Durrani et al., 2005). The possibility of repetition of such devastating earthquakes even greater than Magnitude of 8 are expected in the region(Avouac et al., 2006).

The population of world is increasing, so is the case with urbanization, as a result vertical construction is necessary to accommodate the increased population and to avert the diminishing agricultural lands (Ibrahim, 2007) but earthquakes have greater potential to damage high-rise buildings. Since forces developed under earthquakes are unpredictable and random in nature, the engineering tools need to be sharpened for analyzing such structures. Loads acting on a building may be static like load of people, furniture, snow, dead load of the building itself etc., or dynamic like earthquake forces, wind etc. Dynamic forces can be distinguish from static forces by their ability to produce acceleration with respect to the natural frequency of the structure (Kakpure and Mundhada, 2017). Designers usually perform only the conservative static analysis (Kumar, Kushwaha and Sinha, 2018) due to its simplicity while it is clearly mentioned in UBC-97 when the height of an irregular building exceeds 65 ft, dynamic analysis must be performed. Hopefully, by this research we can make them understand the significance of using dynamic analysis because it gives lesser values of all critical parameters associated with seismic event (Kakpure and Mundhada, 2017).

In the present work, a high-rise building comprising of 22 storeys with 04 basements located at sector F9 Islamabad (Seismic zone 2B) is analyzed both by Equivalent Static Analysis and Response Spectrum Analysis method using Structural Analysis Software ETABS 2016.

II. LITERATURE REVIEW

Chandurkar and Pajgade (2013) focused on evaluating the response of a 10-storey building with a seismic shear wall, utilizing ETAB v 9.5 software. Their primary objective was to assess how changing the location of the shear wall within the multi-storey building affected its response. They analyzed four models: one featuring a bare frame structural system, and the remaining three employing a dual-type structural system.

The findings indicated that placing shear walls in short spans at corners yielded excellent results. However, larger dimensions of shear walls were deemed ineffective for buildings with 10 stories or fewer. This suggests that while shear walls are advantageous for high-rise structures, their efficacy diminishes for shorter buildings.

The study highlighted the importance of proper positioning of shear walls, as shifting their locations was observed to influence the distribution of forces. Notably, shear walls positioned strategically at significant locations were effective in reducing displacements caused by earthquakes.

Furthermore, the research revealed that larger dimensions of shear walls tend to attract a substantial portion of horizontal forces. This underscores the critical role played by shear walls in mitigating seismic loads, particularly when appropriately sized and positioned.

In summary, Chandurkar and Pajgade's study underscores the effectiveness and economy of shear walls in high-rise structures. It emphasizes the necessity of careful consideration in selecting the placement and dimensions of shear walls to optimize their performance in resisting seismic forces and reducing displacements during earthquakes.

Viswanath K.G (2010) conducted a study on the seismic performance of reinforced concrete buildings utilizing concentric steel bracing. The analysis encompassed buildings of varying heights, ranging from four to sixteen stories, situated in seismic zone IV. Staad Pro software was employed for the analysis, adhering to IS 1893: 2002 (Part-I) standards.

In this investigation, steel bracing was strategically placed around the peripheral columns of the buildings. The research aimed to assess how the distribution of steel bracing along the building's height influenced its seismic performance.

The findings revealed several benefits of employing X-type bracings. Firstly, buildings equipped with these bracings experienced reduced lateral displacements, indicating improved stability during seismic events. Additionally, the use of steel bracings effectively decreased both flexural and shear demands on the beams and columns. This reduction in demands was attributed to the bracings' ability to transfer lateral loads via axial load mechanisms.

Of particular note, buildings outfitted with X-type bracing exhibited minimal bending compared to structures utilizing other types of bracing systems. This suggests that X-type bracing may offer superior performance in resisting seismic forces and minimizing structural deformation.

Moreover, the study highlighted the advantages of steel bracing systems for seismic retrofitting. Notably, the addition of steel bracings did not significantly increase the total weight of the buildings, making them a viable and efficient retrofitting solution.

In summary, Viswanath K.G's research underscores the effectiveness of concentric steel bracing in enhancing the seismic performance of reinforced concrete buildings. It emphasizes the importance of thoughtful distribution and selection of bracing types, with X-type bracing demonstrating superior performance in mitigating lateral displacements and reducing structural demands. Additionally, the study highlights the potential of steel bracing systems as a lightweight and practical solution for seismic retrofitting projects.

Chavan and Jadhav (2014) delved into the seismic analysis of reinforced concrete structures employing various bracing arrangements. They utilized the equivalent static method within Staad Pro software to conduct their study. The bracing configurations investigated included diagonal, V-type, inverted V-type, and X-type arrangements.

Their findings revealed significant reductions in lateral displacement when X-type bracing was implemented, with reductions ranging between 50% to 60% compared to other bracing types. Additionally, the maximum displacement experienced by the structures was notably diminished with the use of X-type bracing.

Furthermore, the study observed an increase in the base shear of the building when X-type bracing was employed. This increase in base shear indicated a corresponding enhancement in stiffness compared to the bare frame configuration.

In summary, Chavan and Jadhav's research underscores the efficacy of X-type bracing in reducing lateral displacement and enhancing stiffness in reinforced concrete structures subjected to seismic loads. These findings suggest that X-type bracing arrangements may offer superior seismic performance compared to other bracing configurations.

Esmaili et al. (2008) conducted a comprehensive study on the structural aspects of a 56-story high-rise tower situated in a high seismic zone in Tehran. The seismic evaluation of the building was carried out using non-linear dynamic analysis methods.

The existing building was characterized by main walls and side walls serving as shear walls, interconnected to the main wall through the coupling of beams. Following their analysis, the researchers arrived at several key conclusions regarding the structural design and seismic resilience of the building:

1. Time-dependency of concrete: The study emphasized the importance of considering the time-dependency of concrete in structural analysis, particularly in regions prone to seismic activity. This factor becomes crucial for accurately assessing the behavior of the building under seismic loading conditions.
2. Steel bracing system for energy absorption: Esmaili et al. recommended the incorporation of a steel bracing system to facilitate energy absorption and enhance ductility. However, they cautioned that axial loads experienced by steel braces could potentially compromise their performance, suggesting a need for careful design considerations.
3. Separation of functions for shear walls: The study highlighted the necessity to avoid utilizing shear walls for both gravity and bracing systems. Such an approach was deemed both conceptually and economically unsound due to potential performance drawbacks and inefficiencies.
4. Confinement of concrete in shear walls: Esmaili et al. proposed the confinement of concrete within shear walls as a viable strategy for enhancing ductility and structural stability. This approach can significantly improve the building's ability to withstand seismic forces and mitigate damage during earthquakes.

In summary, Esmaili et al.'s research offers valuable insights into the structural design and seismic retrofitting considerations for high-rise buildings in earthquake-prone regions. Their recommendations underscore the importance of careful material selection, system integration, and design principles aimed at enhancing the seismic resilience of tall structures.

Akbari et al. (2015) conducted a thorough assessment of the seismic vulnerability of steel X-braced and chevron-braced reinforced concrete (RC) structures by developing analytical fragility curves. Their study involved investigating various parameters including the height of the frame, the p-delta effect, and the fraction of base shear allocated to the bracing system.

Key findings from their research include:

1. Effectiveness of steel-braced RC dual systems: The study demonstrated that steel-braced RC dual systems exhibit lower damage probability and greater capacity compared to unbraced systems, given a specific designed base shear.
2. Impact of bracing and frame strength combination: Combining a stronger bracing system with a weaker frame was found to reduce the overall damage probability of the system. This highlights the importance of optimizing the interaction between the bracing and frame components in seismic-resistant design.

3. Comparison of X-type and chevron bracing: Chevron braces were found to be more effective than X-type bracing systems, irrespective of the height of the frame. This suggests that chevron bracing may offer superior seismic performance in RC structures.

4. Base shear distribution: For X-type bracing systems, evenly distributing the base shear between the braces and the RC frame was deemed appropriate. In contrast, for chevron-braced systems, allocating a higher share of base shear to the braces was recommended for optimal performance.

5. Impact of p-delta effect: The inclusion of the p-delta effect was found to significantly increase the damage probability, especially for taller dual systems. The effect was more pronounced for smaller Peak Ground Acceleration (PGA) values, indicating its greater influence under lower seismic intensities.

In summary, Akbari et al.'s study provides valuable insights into the seismic behavior and performance of steel-braced RC dual systems. Their findings underscore the importance of considering various design parameters and system configurations to optimize the seismic resilience of RC structures in high-risk seismic zones.

Kappos and Manafpour (2000) introduced a novel methodology for the seismic design of reinforced concrete (RC) buildings, leveraging a feasible partial inelastic model of the structure and establishing performance criteria for two distinct limit states. Their approach was designed to be compatible with incorporation into design codes such as Eurocode 8.

The methodology involved employing both time-history (non-linear dynamic) analysis and pushover analysis (non-linear static analysis) to assess the seismic response of RC buildings. By adopting this method, the researchers aimed to achieve improved seismic performance compared to standard code procedures, particularly for regular RC frame buildings.

Key findings from their study include:

1. Enhanced seismic performance: The methodology demonstrated better seismic performance compared to conventional code procedures, especially for regular RC frame buildings. This suggests that the incorporation of feasible partial inelastic models and performance criteria contributes to improved seismic resilience.

2. Control of behavior under different seismic scenarios: The study highlighted that controlling the behavior under "life-safety" conditions was easier than under serviceability earthquakes. This was attributed to the adoption of performance criteria that included ductility requirements for members specifically tailored to "life-safety" earthquakes. Ductility is crucial for dissipating seismic energy and preventing structural collapse during earthquakes.

3. Compatibility with design codes: One of the significant advantages of the proposed methodology is its compatibility with existing design codes such as Eurocode 8. This facilitates its potential adoption and implementation by practicing engineers and designers within the framework of established design standards.

In summary, Kappos and Manafpour's methodology offers a promising approach to seismic design for RC buildings, integrating feasible partial inelastic models and performance criteria tailored to different seismic limit states. Their findings suggest that this methodology could lead to improved seismic performance, particularly for regular RC frame buildings, and offers a framework that aligns with established design codes.

Yamada et al. conducted a comprehensive study on the deformation and fracture characteristics of lateral load-resisting systems, specifically focusing on shear walls for reinforced concrete (RC) frames and steel bracing for steel multi-storey frames under earthquake conditions. Their investigation encompassed experimental and analytical approaches, considering models with three different spans and varying numbers of storeys (3, 6, and 9). Key aspects of their study include:

1. Experimental and analytical analysis: The research involved both experimental testing and analytical modeling to assess the behavior of lateral load-resisting systems under earthquake-induced forces. This comprehensive approach allowed for a thorough understanding of the performance of shear walls in RC frames and steel bracing in multi-storey steel frames.

2. Comparison across different configurations: Yamada et al. compared the deformation and fracture results for all three cases (RC frames with shear walls and steel frames with steel bracing) across the various span lengths and numbers of storeys. This comparative analysis likely provided insights into how different structural configurations respond to seismic loading conditions.

3. Normalization of horizontal resisting ratios: To clarify differences in deformation and fracture characteristics among the studied cases, the researchers likely employed a normalization process for the proposed horizontal resisting ratios. This normalization likely involved adjusting the data to a common scale, allowing for direct comparisons and identification of trends across different configurations.

Overall, Yamada et al.'s study contributes valuable insights into the behavior of lateral load-resisting systems in RC and steel frames subjected to earthquake forces. By combining experimental testing with analytical modeling and conducting comparative analyses across different configurations, their research likely offers valuable guidance for improving the seismic performance of multi-storey buildings.

III. CONCLUSION

In Dynamic Analysis values of Storey Drifts are 18% less than Static Analysis.

- Storey displacement increases gradually along the height of the building with highest displacement on the top of the building in both X and Y directions.
- Dynamic Analysis gives 23% less values for Storey Displacement as compared to Static Analysis.
- Axial loads in Dynamic Analysis at the Corner and Peripheral columns are 4 to 7% less than Static Analysis. However axial load for interior column is not reduced significantly by Dynamic Analysis.
- Bending moments in beams are 3 to 4% less in Dynamic Analysis than Static Analysis.
- All the critical parameters like story drift, story displacement, bending moment in beams and axial load on columns shows significant low values in Dynamic Seismic Analysis as compared to Static Seismic Analysis. The precise estimation of seismic forces and structural response in dynamic analysis is accounted for reduction in all critical parameters. So, it is highly recommended to use Dynamic Analysis in high-rise buildings.
- This work focuses on Linear Static and Linear Dynamic Analysis and can be improved by performing Non-linear Static Push Over Analysis and Non-linear Dynamic Time History Analysis.

REFERENCES

- [1] Google images for Steel Bracing in RC building.
- [2] Google images for Steel Bracing in RC building.
- [3] Google images for Shear Wall.
- [4] IS 1893 (Part 1) : 2002 Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings, (Fifth Revision).
- [5] Anil K. Chopra [2003] "Dynamics of Structures, Theory and Applications to
- [6] Earthquake Engineering" (Prentice Hall of India Private Limited).
- [7] Chandurkar P. P, Dr. Pajgade P. S. (2013). "Seismic Analysis of RCC Building with and Without Shear Wall." , International Journal of Modern Engineering Research (IJMER) (2249-6645).
- [8] Chavan Krishnaraj R. ,Jadhav H.S. (2014). "Seismic Response of RC Building With Different Arrangement of Steel Bracing System.", International Journal of engineering Research and Applications (2248-9622).
- [9] Esmaili O. et al. (2008). "Study of Structural RC Shear Wall System in a 56- Storey RC Tall Building.", The 14th World Conference on Earthquake Engineering October 12-17, 2008 , Beijing, China.
- [10] Akbari R.et al. (2014). "Seismic Fragility Assessment of Steel X-Braced and Chevron- Braced RC Frames.", Asian Journal of Civil Engineering (BHRC), VOL-16 No.1 .
- [11] Kappos Andreas J., Manafpour Alireza (2000). "Seismic Design of R/C Buildings with the aid of advanced analytical techniques." Engineering Structures 23 (2001) 319-332.
- [12] Yamada M. et al. " Multistorey Bracing Systems of Reinforced Concrete and Steel –Rigid Frames Subjected To Horizontal Loads- Proposition of Total Evaluation on the Aseismic Capacity for Design."

- [13] Viswanath K.G. et al.(2010). “Seismic Analysis of Steel Braced Reinforced Concrete Frames.” International Journal of Civil & Structural Engineering (0976-4399).
- [14] International Journal of Scientific & Technology Research Volume 4, Issue 09, September 2015 Effect of
- [15] Shape And Plan Configuration On Seismic Response of structure Milind V. Mohod (Assistant Professor,
- [16] Department of Civil Engineering, PRMIT & R,Badnera)
- [17] Earthquake Analysis of Multi Storied Residential Building - A Case Study E. Pavan Kumar¹, A. Naresh², M. Nagajyothi³, M. Rajasekhar⁴
- [18] Comparison on the effect of earthquake and wind loads on the performance of reinforced concrete buildings.



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