RESEARCH ARTICLE OPEN ACCESS

A Review on Seismic Analysis of Connected and High Rise Buildings

Manoj Kumar Sharma [1], Hemant Kumar Sain [2]

[1] M.Tech Student, Department of Civil Engineering, Arya College of Engineering & Research Centre, Jaipur, Rajasthan, India
[2] Assistant Professor, Department of Civil Engineering, Arya College of Engineering, Jaipur, Rajasthan, India

ABSTRACT

This comprehensive review delves into two significant aspects: the seismic analysis of connected and high-rise buildings, and an exploration of the historical evolution of high-rise structures. Understanding the seismic behavior and vulnerabilities of interconnected and tall buildings is crucial for ensuring their structural integrity and the safety of occupants, particularly in regions prone to seismic activity. The introduction section of this review provides an overview of the seismic analysis of connected and high-rise buildings, emphasizing the challenges and complexities involved in analyzing the dynamic interactions between these structures during seismic events. Additionally, the review delves into the historical development of high-rise buildings, spanning ancient civilizations to the modern era. This historical overview highlights key milestones, technological advancements, and architectural innovations that have shaped the evolution of high-rise structures. By examining seismic analysis methodologies and historical insights, this review aims to offer valuable perspectives for enhancing structural resilience, informing future design strategies, and advancing seismic analysis techniques for interconnected and tall buildings in seismic-prone regions.

Keywords — Building, Multi Story, High Rise Building, Connected Buildings, Seismic Analysis.

I. INTRODUCTION

The structural integrity and safety of buildings are of paramount importance in densely populated urban areas, especially in regions prone to seismic activity. The interconnectedness of buildings within close proximity introduces a unique challenge in seismic analysis and design. Understanding the dynamic behavior and potential risks associated with connected buildings during earthquakes is crucial for ensuring public safety, minimizing damage, and guiding effective urban planning and structural design strategies.

Seismic analysis of connected buildings involves the comprehensive assessment of the response of interconnected structures to seismic forces. This analysis considers various factors, including the proximity of buildings, their structural interdependencies, and the dynamic interactions that occur during seismic events. Unlike isolated structures, connected buildings influence each other's response to ground motion, amplifying or mitigating the impact of seismic forces.

Skyscrapers stand tall in contrast to low-rise structures, offering various functions such as residential living, office spaces, hotels, retail establishments, or a blend of multiple purposes. Multi-unit buildings (MDUs) is the preferred term for multi-story residential structures, whereas skyscrapers specifically denote towering structures. The construction of high-rise buildings has become more feasible and cost-effective due to advancements in building materials and elevator technologies like the innovative DJF elevator design.

Steel and durable materials play a crucial role in erecting skyscrapers. While steel is commonly used in their construction, concrete remains a prevalent choice for the majority of these structures. The classification of a tall building as a skyscraper is not strictly defined by a particular floor count, but generally, a building is considered a skyscraper if it exceeds 40 floors. However, the distinction between tall buildings and skyscrapers isn't rigid.

There exist similarities between tall buildings and skyscrapers, yet skyscrapers are typically characterized by having at least 40 floors and soaring heights surpassing 150 meters (490 feet). The essential features and defining aspects between these towering structures lie in their exceptional height, often serving as iconic landmarks in cityscapes.

II. HIGH-RISE BODIES

Various According to varying definitions across different sources, a skyscraper is characterized by specific criteria. Emporis defines a skyscraper as a multi-storey building ranging between 35 to 100 meters in height or a building with 12 to 39 floors, where the height is not specified. In the Companies Act of Hyderabad, India, a skyscraper is delineated as a structure with four or more stories or one that reaches a height of 15 to 18 meters or higher.

The New Short Oxford English Dictionary intriguingly identifies a skyscraper as a mall, offering an alternative perspective. Meanwhile, the International Conference on Fire Safety in Buildings defines a tower as a structure whose height may impede egress during emergencies.

In the United States, a skyscraper is typically understood as a structure exceeding 23 meters in height, nearly equivalent to seven stories. Additionally, within the domains of civil engineering, surveying, architecture, and related fields, a tower is commonly defined as being at least 75 feet tall by a majority of experts.

High-rise structures pose distinctive challenges for geotechnical and civil engineers, especially in seismic or hazardous terrains. Geotechnical methods such as high compression or mud present specific challenges in such contexts. Moreover, these tall structures often create obstacles for firefighters during emergencies. Both traditional and contemporary home designs frequently encounter significant issues with various building systems, including attic systems, HVAC (heating, ventilation, and air conditioning), sprinklers, heating systems, stairways, and elevators.

To mitigate wind loads and prevent passive discomfort and wind damage, many high-rise structures incorporate design features like barriers that allow sunlight to reach the ground, giving the appearance of a slender profile. This design approach aims to enhance structural stability while optimizing environmental comfort within these towering edifices.

Fig. 1: Sky bridge – Skycraper center

Fig. 2: Skyway bridges link buildings

Fig. 3: Bridge connecting two condo buildings

Fig. 4: Skywalk Rennweg

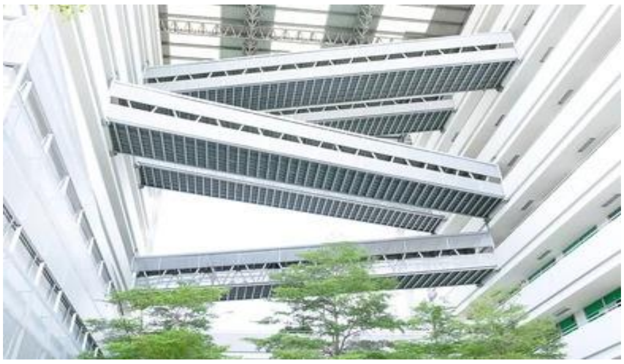

Fig. 5: More then two Bridges Between Two Buildings

III. HISTORY OF HIGH RISE BUILDINGS

The history of high-rise buildings is a testament to human innovation, evolving construction techniques, and societal needs across different civilizations and eras. Here's an overview of the historical progression:

Ancient Times: High-rise structures date back thousands of years. Ancient civilizations such as the Mesopotamians, Egyptians, and Romans constructed tall structures like ziggurats, pyramids, and Roman aqueducts. These monumental constructions displayed early attempts at building vertically and showcased advancements in engineering and construction techniques of their time.

Medieval and Renaissance Periods: Towers and cathedrals in medieval Europe, such as the famous cathedrals of Notre-Dame in Paris and the Tower of Pisa in Italy, demonstrated advancements in vertical construction. These structures were often religious or defensive in nature, utilizing thick walls and supporting structures to reach significant heights.

Industrial Revolution: The advent of the Industrial Revolution in the 18th and 19th centuries brought advancements in materials, such as cast iron and later steel, which revolutionized construction. The development of the elevator by Elisha Otis in the mid-19th century was a crucial milestone, enabling safe vertical transportation and paving the way for taller buildings.

Late 19th to Early 20th Century: The late 19th and early 20th centuries marked the emergence of modern skyscrapers. The Home Insurance Building in Chicago, completed in 1885 and designed by William Le Baron Jenney, is often considered the first skyscraper due to its pioneering use of a steel frame, which allowed for increased height and structural stability.

Skyscraper Boom and Innovations: The early 20th century witnessed a surge in skyscraper construction, notably in cities like New York City and Chicago. Architects and engineers like Louis Sullivan, Daniel Burnham, and Frank Lloyd Wright contributed to innovative designs, emphasizing functional and aesthetic aspects. The Chrysler Building and Empire State Building in New York City became iconic symbols of this era.

Post-World War II: Post-World War II, advancements in construction technology, materials, and design techniques further fueled the construction of high-rise buildings. The international style emerged, emphasizing clean lines, functional designs, and the use of steel, glass, and concrete.

Contemporary Era: The latter half of the 20th century and into the 21st century saw the rise of supertall and megatall skyscrapers reaching unprecedented heights. Buildings like the Burj Khalifa in Dubai, One World Trade Center in New York City, and the Shanghai Tower in China stand as remarkable examples of engineering prowess and architectural innovation.

Throughout history, high-rise buildings have evolved in response to technological advancements, societal demands, economic factors, and architectural trends. The pursuit of taller, safer, and more sustainable structures continues to shape the skylines of cities worldwide.

IV. CONCLUSIONS

The analysis and comprehension of seismic behavior in the context of interconnected and high-rise buildings hold paramount significance in ensuring structural integrity and safety in urban landscapes. As urbanization continues to thrive, the construction of high-rise structures and the interconnection between buildings become more prevalent, presenting unique challenges in seismic design and analysis. This review aims to delve into the complexities surrounding the seismic analysis of connected and high-rise buildings, exploring the dynamic interactions and vulnerabilities inherent in these architectural configurations. By examining past research, methodologies, and technological advancements, this review seeks to offer insights into mitigating risks, enhancing structural resilience, and advancing seismic analysis techniques for these intricate urban structures. Understanding the intricacies of seismic response in interconnected and tall buildings is fundamental for establishing robust design strategies and ensuring the safety of inhabitants and communities in earthquake-prone regions.

REFERENCES

[1] Mir M. Ali and Kheir Al-Kodmany, "Structural Systems for Tall Buildings", MDPI Journal Encyclopedia 2, pp. 1260–1286, 2022.

[2] Mir Rahman Naseri and Balwinder Lallotra, "A Review on Seismic Analysis of Hybrid Structures", International Research Journal of Engineering and Technology (IRJET), Vol. 8, Issue. 4, 2021.

[3] Gagan Makrani and Kishor Patil, "Analysis of Different Parameter of Wall Belt Support in Multistorey Building With Higher Importance Factor", International Journal of Research Publication and Reviews, Vol. 13, no. 12, pp. 1628-1637, 2022.

[4] Ankit Panjwani and Vipin Kumar Tiwari, "Comparative Analysis of Tall Buildings Subjected to Wind Loads Using Force Coefficient Method and Gust Factor Method", International Journal of Creative Research Thoughts (IJCRT), Vol. 9, Issue. 11, pp. 140-157, November 2021.

[5] Tarak Banerjee and Arya Banerjee, "A Study on Optimizing the Positioning of Shear Walls for a Plus Shaped Irregular Building", International Research Journal of Engineering and Technology (IRJET), Vol. 8, Issue. 10, pp. 1164-1168, October 2021.

[6] Nakul Khandelwal, Shruti Bhargava, Hemant Kumar Sain, "A Study on Kota Stone Powder Slurry and Ground-Granulated Blast-Furnace Slag as an Ingredient in Concrete", International Journal of Engineering Science Technology And Research (IJESTR), Vol. 7, Issue. 3, pp. 12-16, 2022.

[7] IS 1893 (Part 1), "IS 1893 (Criteria For Earthquake Resistant Design Of Structures Part 1 General Provisions And Buildings)," Bur. Indian Stand. New Delhi, 2002.

[8] Rohit Kumar Tailor, Hemant Kumar Sain, "Effect of carbon and glass fibre on compressive strength, split tensile strength and flexural strength of SCC", International Journal of Engineering Research and

Generic Science (IJERGS), Vol. 7, Issue. 5, pp. 7-12, 2021.

[9] Nikhil Goyal, Hemant Kumar Sain and Mohsin Khan Agwan, "A Study on Fıber Reınforced Concrete Usıng Dıfferent Types of Geo-Polymer Fıber in Preparatıon of Concrete Sample", Journal of Emerging Technologies and Innovative Research (JETIR), Vol. 9(9), pp. 750-753, 2022.

[10] Nitesh Kanwat, Hemant Kumar Sain, Mr. Kapil Karadia, "An Advance Study On Industrial Roof Truss With Consideration Of Irc Loading", International Research Journal of Modernization in Engineering Technology and Science, Vol. 04, Issue. 11, November 2022.

[11] Kusum Choudhary, Hemant Kumar Sain, "Seismic Behavioural Analysis of One Bay Structure With Composite Beam and RCC Columns", International Journal of Engineering Research and Generic Science (IJERGS), Vol. 7, Issue. 6, pp. 27-36, 2021.

[12] IS 1893 (Part 1), "IS 1893 (Criteria for Earthquake resistant design of structures, Part 1:General Provisions and buildings)," Bur. Indian Stand. New Delhi, no. December, pp. 1–44, 2016.

[13] Indian Standard, "IS 875-2 : 1987 Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 2: Imposed Loads," Bur. Indian Stand. New Delhi, p. 18, 1987.

[14] Nitesh Kanwat, Hemant Kumar Sain, Mr. Kapil Karadia, "A Study of Different Type of Industrial Roof Truss With Applications of Various Load Combinations", International Research Journal of Modernization in Engineering Technology and Science, Vol. 04, Issue. 11, November 2022.

[15] Hemant Kumar Sain, Basant Kumar Meena, "An experimental analysis on concrete containing GGBFS and meta kaolin with CCR", AIP Conference Proceedings 2901(1), 050008, pp. 1-13, 2023.

[16] Hemant Kumar Sain, Vishakha Sharma, Bazila Nisar, "Effect of Rock Cracks on RC Structures", AIP Conference Proceedings 2901(1), 050005, pp. 1-5, 2023.

[17] Sahar Radkia, Rohola Rahnavard, Hesham Tuwair, Farhad Abbas Gandomkar and Rebecca Napolitano, "Investigating the effects of seismic isolators on steel asymmetric structures considering soil-structure interaction", Structures, Vol. 27, pp. 1029-1040, October 2020.