International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | Jun 2023 www.irjet.net p-ISSN: 2395-0072

"A PARAMETRIC EVALUATION OF TWIN TOWER STRUCTURE HAVING HORIZONTAL AND VERTICAL CONNECTION VARIATIONS"

Thakor Vishalkumar Sureshbhai[1], Aakash R. Suthar[2]

[1]*Student Civil Engineering Department, L.J.I.E.T. Ahmedabad, Gujrat, India*
[2]*Assistant Professor Structural Engineering Department, L.J.I.E.T. Ahmedabad, Gujrat, India*

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Abstract - Modern structures have extremely integrated and multi-functional architectural designs. A multi-tower is a group of two tall buildings that are linked to each other. Due to the numerous high-rise construction projects that have been completed, structural development in the metropolis has rapidly increased. The fundamental process in designing a high-rise building with the same height and geometry is structural analysis. It is preferable to choose high structures if the horizontal dimension of the construction field is decreasing. At high vertical dimensions, there is always an issue because of the cantilever action, wind loads, and seismic loads. To make the structure resistant to all these kinds of forces while making it more rigid and stable for the wind and seismic loads, the idea of the "MULTI-TOWER WITH LINK" was developed. Structure without connected beams and structure with connected beam. In this work, the analysis of G+28 (85.98m) and G+24 (75 m) high rise and medium rise twin towers connected at various heights and spans is studied. The goal of this study is to ensure that connecting beams in twin tower structures that are subject to lateral loads are used effectively and are positioned perfectly. The model will be examined for static and dynamic conditions in this building, which is in Ahmedabad Zone III. The parameters like Storey Displacement, Drift and Base Shear to be studied in ETABS software. The economy and the maximum durability were determined at connections, which are provided at 0.8 H + 5% distance (where H represents the height of the building). If the structures are parallel and close to each other, the reduction in displacement and drift is typically more significant, ranging from 30% to 40%. On the other hand, if the structure are some distance apart but still parallel to each other, the reduction in displacement and drift is generally lower, around 5% to 10%.

***Key Words*: Twin tower, Connecting beams, Response Spectrum Analysis, Base shear, Storey displacement, Storey drift, ETABS.**

1. INTRODUCTION

1.1 General

To satisfy the needs of the urban population, developing nations are gradually converting to tall structure development. High-rise buildings now have a variety of exteriors and show dynamic behavior due to the architectural design, which has recently grown more unique and outstanding [5]. Two single towers serve as the main structure of a double tower connected building, which is a complex architectural form connected by links like passageways [3]. The connecting body is offered at a specific height and creates unique structural system for a building. . High-rise connected structures have simple and developed static performance. The location of the link will affect the dynamic properties of tall structures and may change how they react to loads such as earthquakes, wind, and other forces [3]. The type of connection chosen for the corridor affects both the behavior of the structure and the members of the passageway.

Serviceability requirements such story displacement, story drift, and base shear in static and dynamic analysis are the main criteria that the structures should be satisfy. Among the alternatives for satisfying the serviceability criteria in elevated constructions is to provide Connecting Beams (CB). The idea of connecting beams is kind of similar to that of sky bridges. In this study, the separate towers are to be connected by a link, or connecting beam, at specific floor levels depending on the requirements. It makes it easier for people and things to move about, typically between or with other buildings. Due to the rise in buildings, their attractive aesthetics, and the rising need for additional emergency exits, these structures, particularly those connecting buildings, are currently enjoying rapid growth in popularity [4].

Horizon Decks are a category of overhead walkway that often connects two or more buildings in an urban areas. They often connect train stations or other transportation with its own footbridges and span many km in various Asian nations. Skyways often link the first few stories above ground level, but sometimes they are considerably higher, like in the Malaysian Petronas Towers. Since retail businesses frequently occupy places in the structures connected by walk ways, the area along the skyway may serve as a mall. Sky bridges connecting buildings are frequently seen in non-commercial regions with closely related structures, such as university campuses (Wikipedia, 2017) [6].

1.2 Definitions

- **Storey Displacement:** Displacement is the change in an object position relative to a reference frame. Maximum displacement is h/500. Where h is total height of building.
- **Storey Drift:** It is the relative displacement between the floors above or below the storey under consideration.
- **Base Shear (V_B):** It is the horizontal lateral force in the considered direction of earthquake shaking that the structure shall be designed for.

2. LITRTURE REVIEW

2.1 Paper No. 1

Name of Journal:: Journal of the Institution of Engineers (India)

Name of publisher: Springer, Oct 2020

Title of Paper: A Study on effect of Connecting Beams in a Twin Tower Structure

Author: Krishnam Raju Penumatcha, Ravindra Vipparthy, Ambika Yadav

Content:

The aim of this study is to ensure sure that connecting beams in twin tower structures that are subject to lateral forces are used effectively and are positioned perfectly. In order to achieve this, a three-dimensional study of the twin buildings was conducted without inserting connecting beams between them and, in contrast, with connecting beams included at various floor levels. As a result, eight options were looked into, including the one without connecting beams that was subject to earthquake and wind. Both static and dynamic situation of the wind study, which included P-Δ effect with a basic wind speed of 50 m/sec and earthquake analysis in Zone II were done. The structure has 3 basements and a G+14-story building with a 20m x 40m plan dimension. The length and width of the link are 3m and 3.4 m respectively and the height of the structure is 54m.

Conclusion:

Earthquake analysis: - under static analysis is within the permissible limit in all the eight alternatives but in dynamic analysis Alt-5, 6, 7, 8 and Alt-1, 2, 3, 4 is within permissible limits and exceeded permissible limits respectively. Wind analysis: - Alt-8 reduced 21% lateral sway within the permissible limit in static analysis and exceed by 18% compared to its permissible limit in dynamic analysis.

2.2 Paper No. 2

Name of Journal: International Journal of Civil Engineering and Technology (IJCIET)

Name of publisher: Scopus Index, Nov 2018

Title of Paper: Seismic Response analysis of linked twin tall buildings with structural coupling

Author: Imad Shakir Abbood, Mahir Mahmod, Ammar N. Hanoon, Mohd Saleh Jaafar and Mohamed H. Mussa

Content:

This study used finite element modelling to examine the impact of structural linkages on seismic responses for a connected building system. Twin 40-story reinforced concrete frame-wall constructions that are connected horizontally by structural linkages serve as the study representation of the linked building system. Analyze the 40 story twin building with connected beam at different location. Two floors are connected in each connection. Connection of building is 15 m span and 18 m wide at different height. The structure has G+39-story building with a 75m x 30m plan dimension. The length and width of the link are 15m and 18m respectively and the height of the structure is 160m.

Conclusion:

The study demonstrated that the link was more effectual in strengthening the system and reducing the responses when installed at the last top two floors (Case 4). The link is most effective in the structures when installed at approximately 0.8 of the building height.

2.3 Paper No. 3

Name of Journal: Journal of Emerging Technologies and Innovative Research

Name of publisher: JETIR, June 2020

Title of Paper: Dynamic Analysis of Regular Twin Tall RCC Structure with Various Sizes of Links at Most Effective Location

Author: Vinesh N. Bhinde, Pratik A. Parekh, Narendra R. Pokar

Content:

A multi-tower is a group of two tall buildings that are linked to one another. It is preferable to use tall structures if there is a reduction in the horizontal dimension of the building site. In structures with great vertical dimensions, there is constantly a difficulty because of cantilever action, wind loads, and seismic loads. To make the structure resistant to all of these kinds of forces while making it more stiff and stable for the wind and seismic loads, the idea of the "MULTI-

TOWER WITH LINK" was developed. Analyze the 40 story and 50 story twin structure. The connection of beam Links at 0.4H+0.8H, 0.6H+0.8H and 1.0H+0.8H Height. Link length is 6m and width is 6m, 18m, 30m. Analysis done with Zone IV and V, Time history method and wind load analysis. The structure has G+39 and G+49 story building with a 66m x 30m plan dimension. The length and width of the link are 6m and 6m, 18m, 30m respectively and the height of the structure is 140m and 175m.

Conclusion:

Best location of Link is 0.6H+0.8H and the optimum width is 1.0B according to study for 40 story structure. In 50 Storey values of shear and displacement are higher in Time History Analysis.

2.4 Paper No. 4

Name of Journal: International Journal of Engineering Research & Science (IJOER)

Name of publisher: Academia, Nov 2017

Title of Paper: Parametric Analysis on Buildings with Connecting Corridors

Author: Afiya V N

Content:

The term "irregular building frame system" refers to high-rise constructions that are connected and consist of primary towers and a passageway between them at a specific height. The structure was modelled using ETABS software. The models were examined using linear static and linear dynamic analysis. Storey displacements, storey drifts, base shear in the passageway beams are analyzed for seismic loading. Analysis of G+10 story twin structure in static and dynamic analysis. Building is connected at 2^{nd}, 5^{th} and 10^{th} floor with 3m wide passage. Length of the beam or distance between two structures is 4m, 6m and 8m.The structure has G+9 story building with a 24m x 24m single plan dimension. The length and width of the link are 4m, 6m, 8m and 3m respectively and the height of the structure is 30m.

Conclusion:

When compared to regular structures, linked buildings have more complicated characteristics that vary depending on where the connection is made. These tall, flexible structures move considerably in response to lateral stresses like wind and earthquakes. The results indicate that the horizontal displacement and drift under seismic loading in Y direction is larger than the displacements and drifts in X direction. The effort to maximum base shear is larger in X direction than Y direction.

2.5 Paper No. 5

Name of Journal: International Advanced Research Journal in Science, Engineering and Technology

Name of publisher: IARJSET, May 2020

Title of Paper: Dynamic Analysis of the Twin-Tower High-Rise Structure with Basement

Author: Jadav Bhavesh Bhanajibhai, N. B. Umravia

Content:

Due to the multiple high-rise building projects that have been completed, structural growth in the metropolitan area has grown rapidly. In order to construct a high-rise building with the same height and geometry, structural analysis is an essential element. It is a good option for housing, but there are some difficult issues, such parking for cars and other requirements like common areas. Since this type of construction is frequently found in residential and business complexes, many of them offer shared parking on one, many, or underground floors. Behaviors of structure G+20, G+25, and G+ 30 stories symmetrical twin tower without an underground basement, with 2 and 4 number of Basement. The analysis results obtained from all models were performed by using various linear dynamic structure analysis approaches such as Equivalent Static Force Method (ESFM), Response Spectrum Method (RSM), and Time History Analysis (Bhuj).

Conclusion:

Twin tower connected with the basement it has been observed that when analysis Structure with incremental 5 number of stories (16 m height) in both tower and 2 number (8 m depth) of common basement simultaneously. Its effect on the base shear has been increasing average 12-14% and 18-20% respectively. The maximum base shear value is directly impacted by the basement depth. Because the twin tower height construction supports the basement.

3. RESEARCH GAP AND OBJECTIVES

3.1 Research Gap

- In papers, the structurally optimized location of link connection is quite unclear.
- The width of the connection is bit ambiguous in the papers referred.
- Determine the greatest distance between buildings that is safe with one link.
- Determine the building spacing required to support two connections.
- Establish the specific height for the connection.

3.2 Objectives

- Application of Load combinations according to IS code specifications.
- To analyze models in terms of Base shear, Storey displacement and Storey drift.
- Height and Length of the required connection.
- Numbers of connections that are required.
- The distance between two or more connections.

4. MODELING

4.1 Building Configurations

For the present study, 40 types of models have been selected to determine the effect of distance and height on the connections. High rise and medium rise buildings are Model I & III and Model II & IV are taken, respectively. The total height of structural models I, II, III and IV are 85.98m, 49.98m, 75.5m and 49.5m, respectively. Models I and II are real plans, while Models III and IV are hypothetical plans. For a realistic plan, members with shear walls with thicknesses of 230mm, 250mm, 300mm, 350mm, 380mm, 410mm, 460 mm, and 510mm are selected. Column sizes are 300x550mm, 300x690mm, 300x900mm, 410x1120mm, and 510x610mm; the width of the beams is according to the column and shear wall width; the slab thickness in the 2nd basement, 1st basement, and typical floor is 250mm, 180mm, and 150mm, respectively. For a hypothetical plan Column size is 380x900mm, beams are 300x600mm and 380x600mm, slab thickness is 125mm, and shear walls are 300mm thick.

4.2 List of Models with Various Connections

4.2.1 Model 1 Realistic plan with actual connection

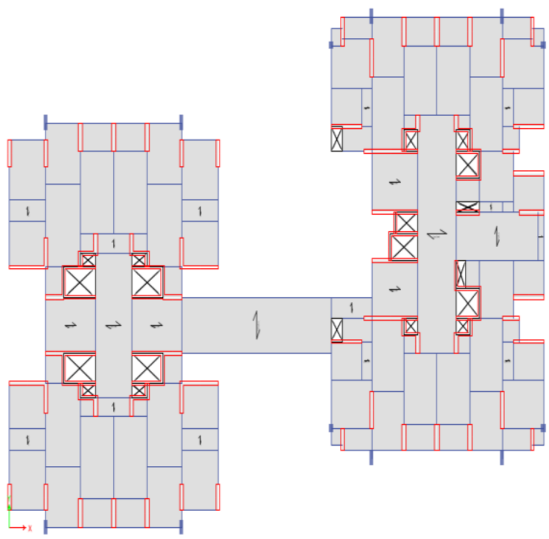

Fig. 1 Model 1 Realistic plan with actual connection

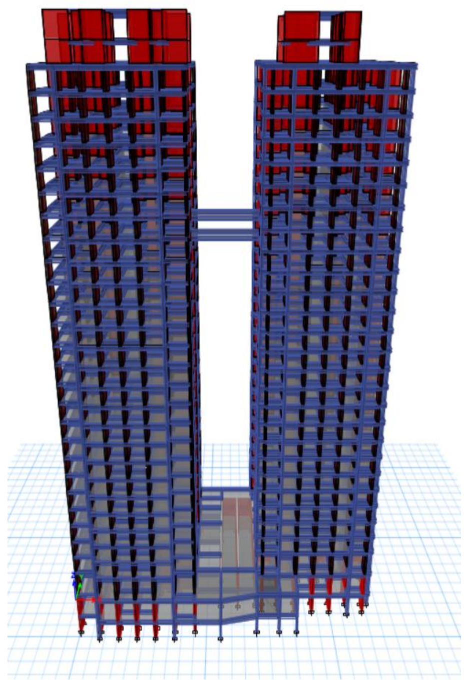

Fig. 2 Model 1 Realistic plan with actual connection 3-D view

4.2.2 Model 2 Realistic plan with 40% height + 5% distance connection of building

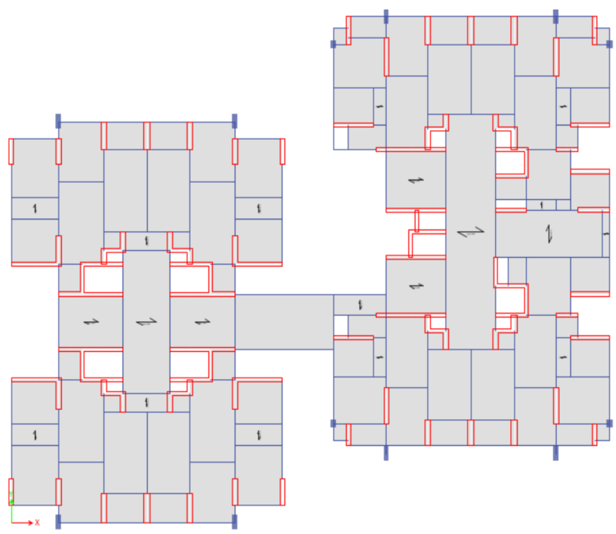

Fig. 3 Model 2 Realistic plan with 40% height + 5% distance connection of building

4.2.3 Model 3 Realistic plan with 60% height + 10% distance connection of building

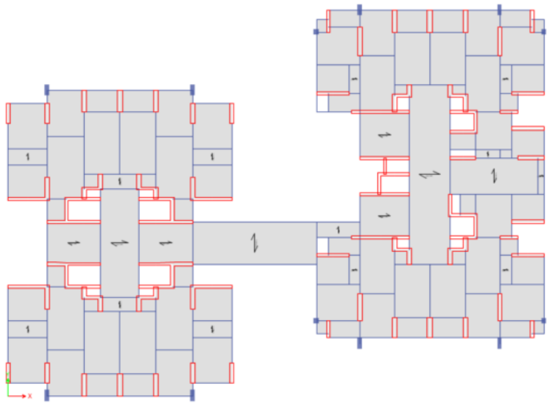

Fig. 4 Model 3 Realistic plan with 60% height + 10% distance connection of building

4.2.4 Model 4 Realistic plan with 80% height + 15% distance connection of building

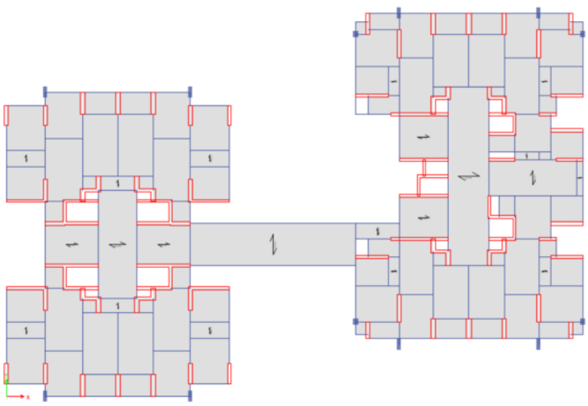

Fig. 5 Model 4 Realistic plan with 40% height + 5% distance connection of building

4.2.5 Model 5 Hypothetic plan without any connections

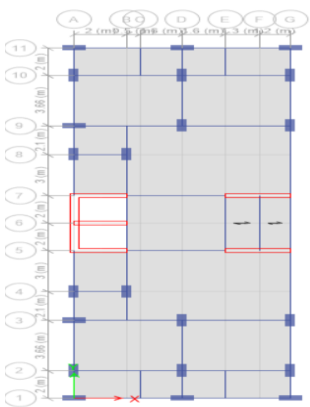

Fig. 6 Model 5 Hypothetical plan without any connections

4.2.6 Model 6 Hypothetical plan with 40% height + 5% distance connection of building

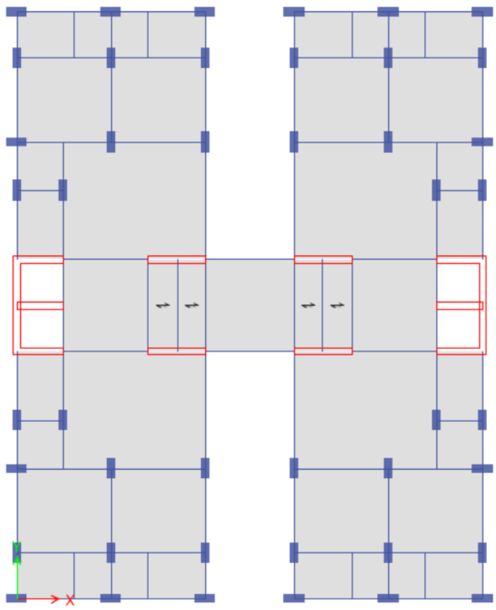

Fig. 7 Model 6 Hypothetical plan with 40% height + 5% distance connection of building

4.2.7 Model 7 Hypothetical plan with 60% height + 10% distance connection of building

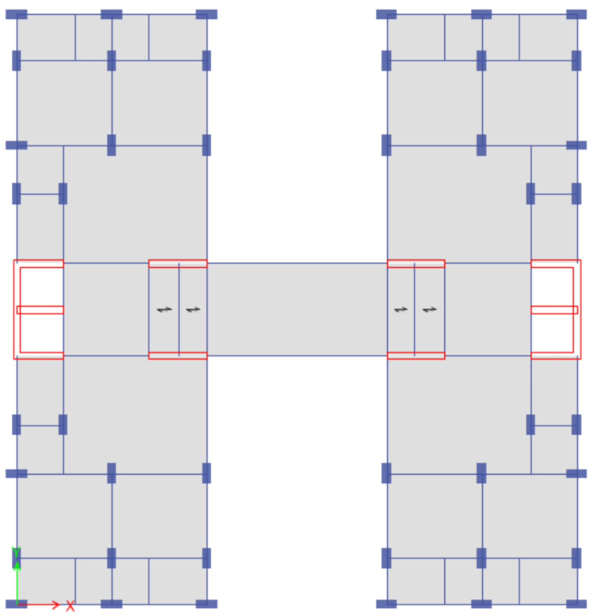

Fig. 8 Model 7 Hypothetical plan with 60% height + 10% distance connection of building

4.2.8 Model 8 Hypothetical plan with 80% height + 15% distance connection of building

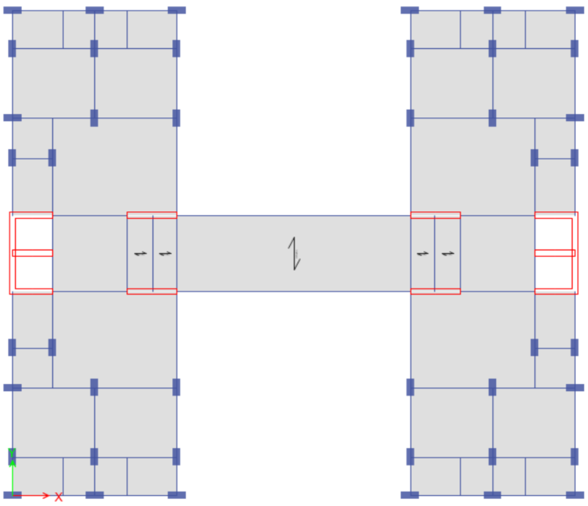

Fig. 9 Model 8 Hypothetical plan with 60% height + 15% distance connection of building

4.3 Data for Analysis of the Building

Table-1 Loading Data for Analysis

Deal load	1.5 kn/m^2 typical floor 2.3 kn/m^2 terrace floor
Live load	2 kn/m^2 typical floor 1.5 kn/m^2 terrace floor
Location	Ahmedabad
Seismic zone	3
Response reduction factor R	5
Earthquake load	IS-1893 2016 (part I)
Type of soil	Type 2 Medium soil
Allowable bearing pressure	200 kn/m^2
Storey height	2nd basement 3.25 m 1st basement 4.35 m All typical floor 3 m
Height of building	High rise building 85.98 m and 77.5 m Medium rise building 49.98 m and 49.5 m
Foundation depth	Realistic plan 3 m Hypothetical plan 2.5 m
Wall thickness	All periphery 230mm thick Inner wall 115mm thick
Parapet wall height	1.2 m
Main beam size	Realistic plan 380*600mm Hypothetical plan 300*600mm
Slab thickness	125, 150, 180, 250 mm
Column size	Realistic plan 380*900mm, 410*900mm Hypothetical plan 380*900mm
Shear wall	300mm, 350mm 410mm, 460mm, 510mm thick
Base support	Fixed

4.4 Material Property

- **Concrete:** For all column M40 and M50 grade and for beams M35 and M40.
- **Steel:** HYSD reinforcement of grade Fe500 confirming to IS: 1786 (2008) is used.

5 ANALYSIS AND RESULTS

5.1 General

The results from the E-tab model are discussed in this chapter. Analysis of the building base shear, storey drift in x and y directions, and storey displacement in x and y directions were done.

5.1.1 Model Descriptions

Each model has been named in the following way: The model number is written in format of model - followed by roman number and alphabet.eg model IA .The Number I Indicate type of (High rise or Medium rise) building and the Alphabet an Indicate height and distance of the connections.

Table 2 Model Indicating the Height and Distance of the connections

Model	Height of connection	Distance of the connection
A	In Realistic plan (55.48m) In Hypothetical plan only single building	In Realistic plan (16.27m) In Hypothetical plan (0.0m)
B	40% of total height of building	5% of total height of building
C	60% of total height of building	10% of total height of building
D	80% of total height of building	15% of total height of building
E	40% of total height of building	5% of total height of building
F	60% of total height of building	10% of total height of building
G	80% of total height of building	15% of total height of building
H	40% of total height of building	5% of total height of building
I	60% of total height of building	10% of total height of building
J	80% of total height of building	15% of total height of building

Table 3 Model Indicating Type of Structure

Model	Type of Building
I	High rise realistic building
II	Medium rise realistic building
III	High rise hypothetical building
IV	Medium rise hypothetical building

Table 4 List of Model

Model	Vertical connection (M)	Horizontal connection (M)
Model I A	55.48	16.27
Model I B	34.48	4.3
Model I C	34.48	8.6
Model I D	34.48	12.9
Model I E	52.48	4.3
Model I F	52.48	8.6
Model I G	52.48	12.9
Model I H	67.48	4.3
Model I I	67.48	8.6
Model I J	67.48	12.9

Model II A	0	0
Model II B	19.48	2.5
Model II C	19.48	5
Model II D	19.48	7.5
Model II E	28.48	2.5
Model II F	28.48	5
Model II G	28.48	7.5
Model II H	40.48	2.5
Model II I	40.48	5
Model II J	40.48	7.5
Model III A	0	0
Model III B	29.5	3.88
Model III C	29.5	7.75
Model III D	29.5	11.6
Model III E	44.5	3.88
Model III F	44.5	7.75
Model III G	44.5	11.6
Model III H	62.5	3.88
Model III I	62.5	7.75
Model III J	62.5	11.6
Model IV A	0	0
Model IV B	20.5	2.47
Model IV C	20.5	4.95
Model IV D	20.5	7.42
Model IV E	29.5	2.47
Model IV F	29.5	4.95
Model IV G	29.5	7.42
Model IV H	38.5	2.47
Model IV I	38.5	4.95
Model IV J	38.5	7.42

5.2 Chart for Result Interpretations

5.2.1 Comparison of Storey Displacement in Model I

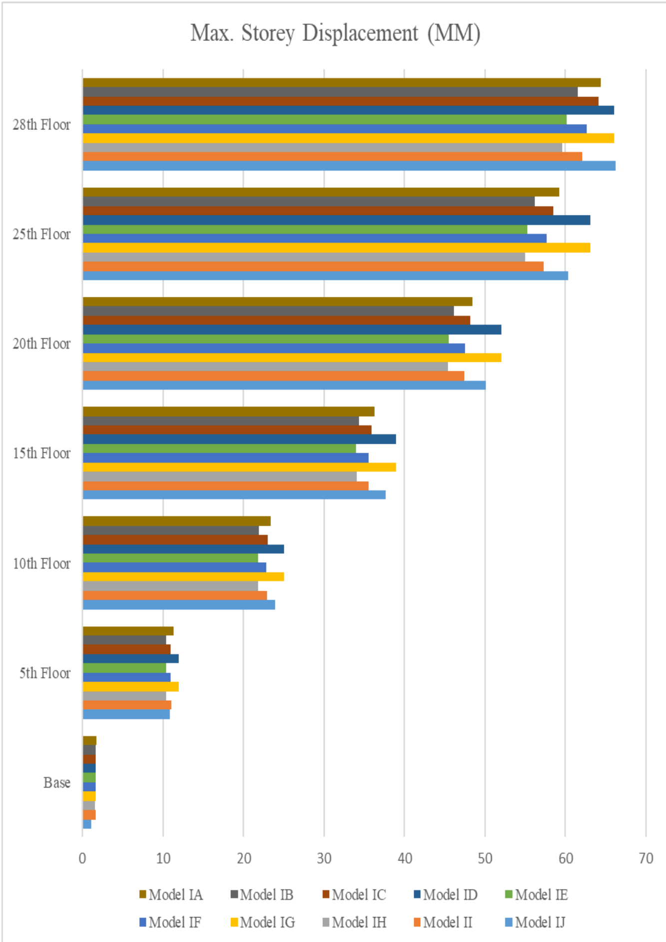

Chart-1 Storey Displacement in Model I

5.2.2 Comparison of Storey Displacement in Model II

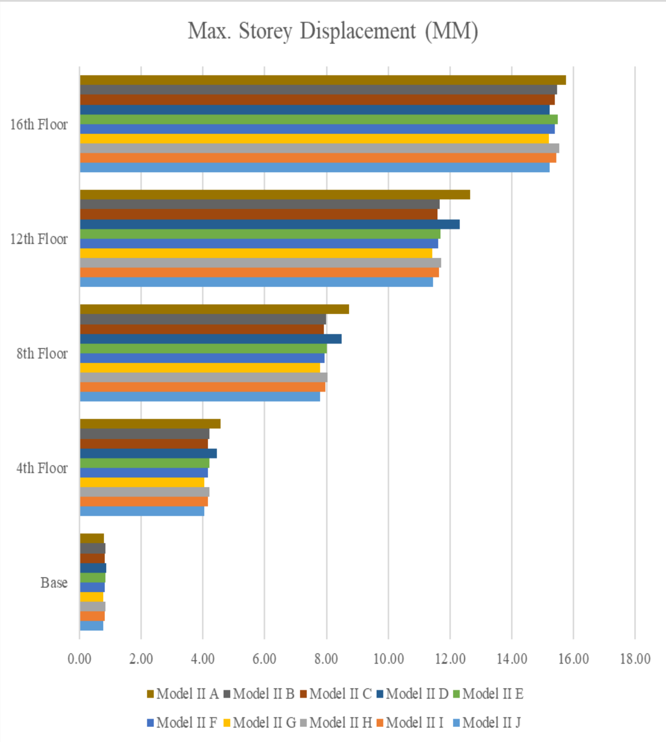

Chart-2 Storey Displacement in Model II

5.2.3 Comparison of Storey Displacement in Model III

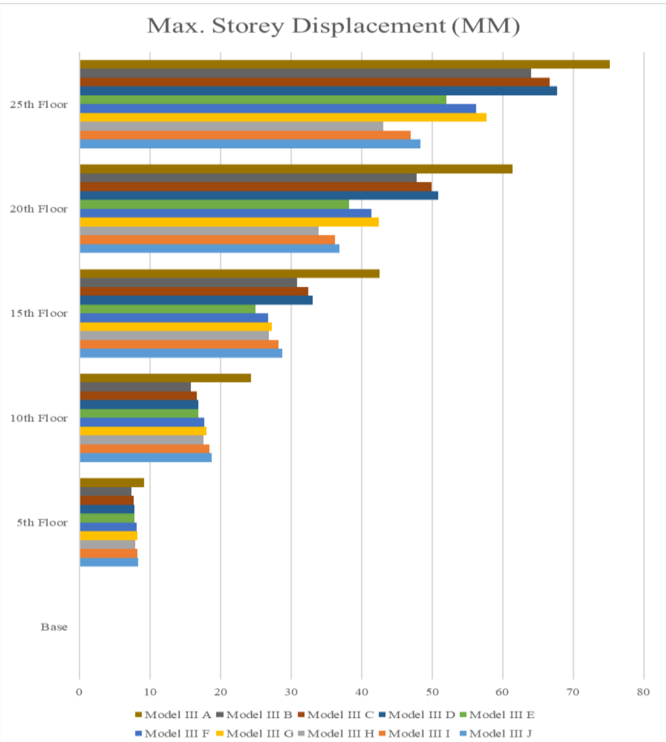

Chart-3 Storey Displacement in Model III

5.2.4 Comparison of Storey Displacement in Model IV

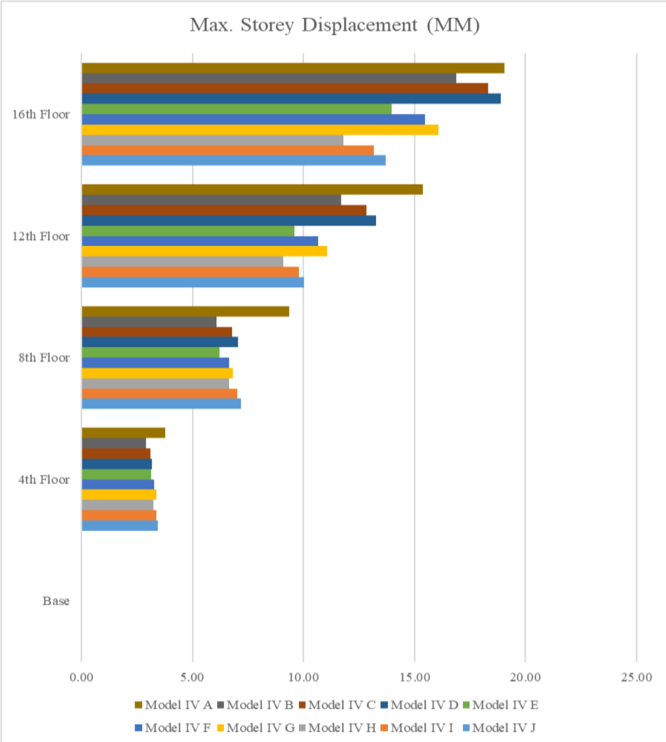

Chart-4 Storey Displacement in Model IV

5.2.5 Comparison of Storey Drift in Model I

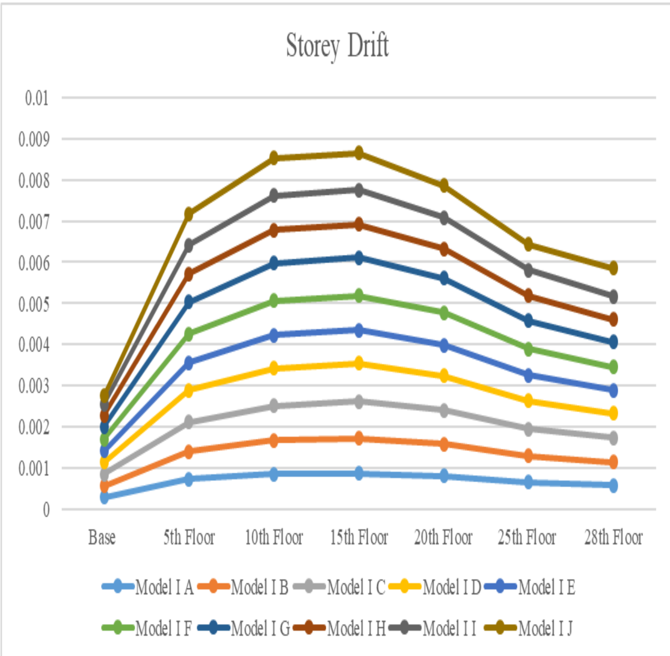

Chart-5 Storey Drift in Model I

5.2.6 Comparison of Storey Drift in Model II

Chart-6 Storey Drift in Model II

5.2.7 Comparison of Storey Drift in Model III

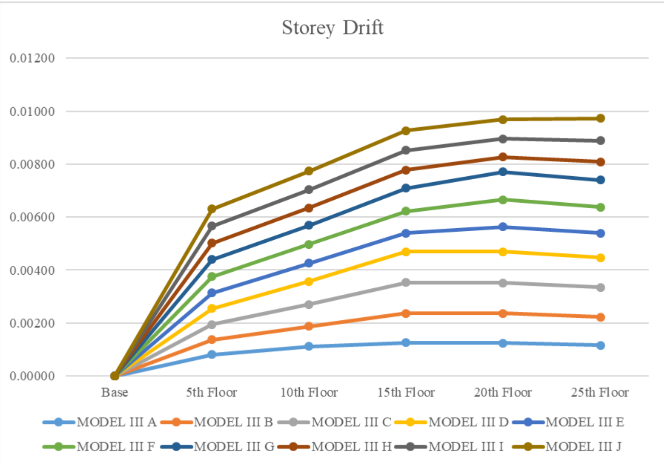

Chart-7 Storey Drift in Model III

5.2.8 Comparison of Storey Drift in Model IV

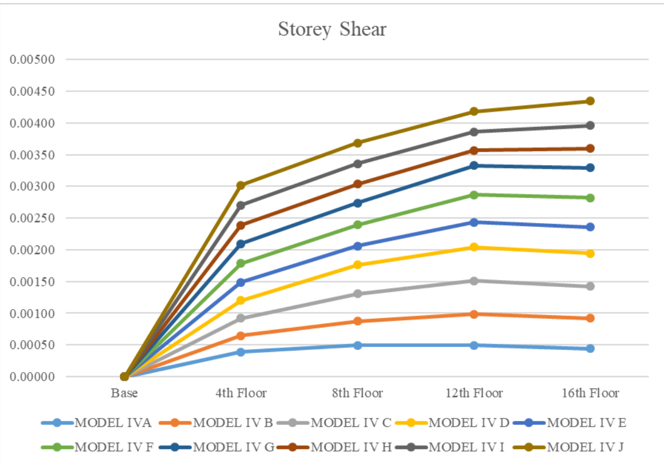

Chart-8 Storey Drift in Model IV

5.2.9 Comparison of Base (Storey) Shear in Model I

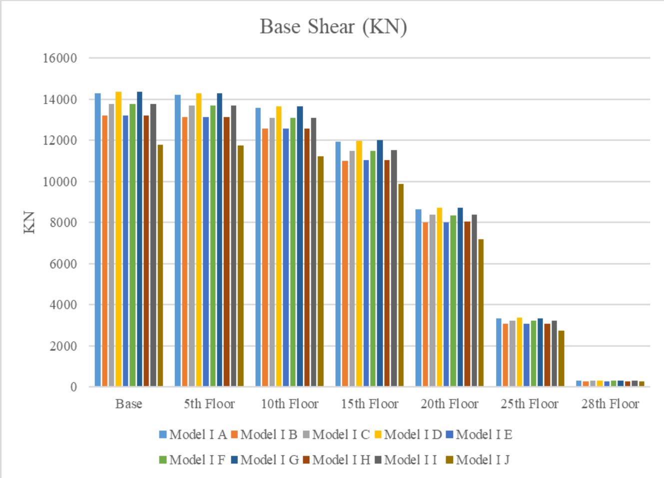

Chart-9 Base Shear in Model I

5.2.10 Comparison of Base (Storey) Shear in Model II

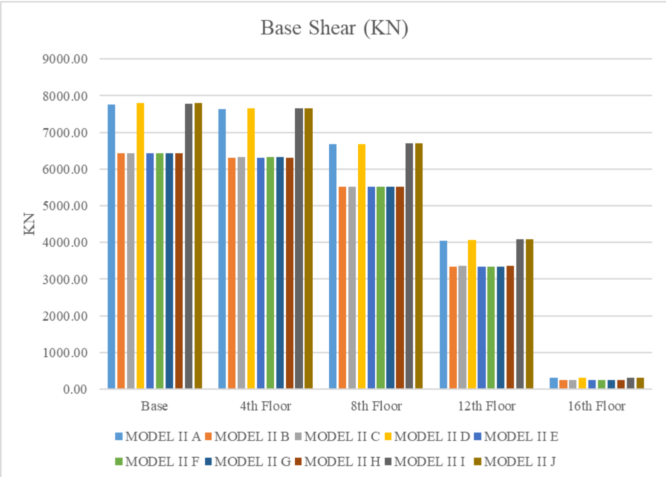

Chart-10 Base Shear in Model II

5.2.11 Comparison of Base (Storey) Shear in Model III

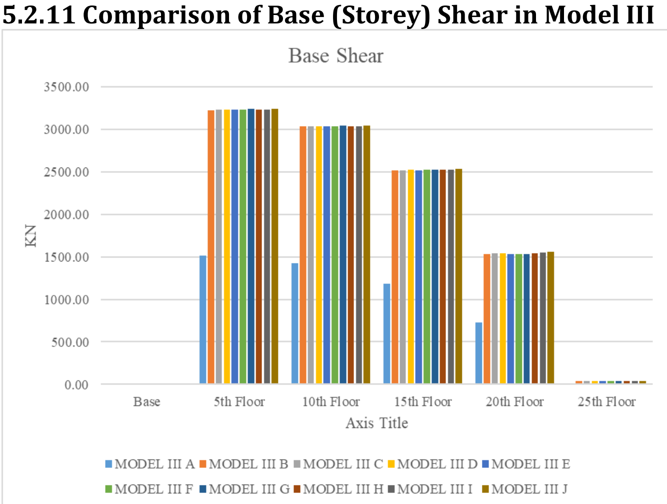

Chart-11 Base Shear in Model III

5.2.12 Comparison of Base (Storey) Shear in Model IV

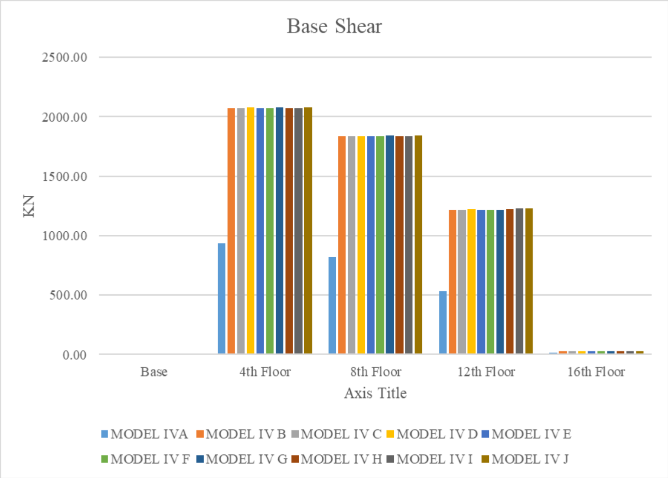

Chart-12 Base Shear in Model IV

6 CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

- Results for high-rise and medium-rise structures with twin towers are reported in this research. The building is built according to with IS code specifications, and the findings above results in the following conclusion:
  - The maximum displacement for the type I A was 64.385 mm, whereas the maximum displacement for the models I J and I H was 66.281 mm and 59.633 mm, respectively.
  - According to the above outcomes, high-rise structures might have displacement increases of 2.95% and reduction of 7.38% respectively, if connections are given at 0.8H + 15% and 0.8H + 5% respectively.
  - The maximum displacement for the type III A was 75.22 mm, while the maximum displacement for the versions III D and III H was 67.65 mm and 43.05 mm, respectively.
  - Based on the previous results, high-rise building displacement may be reduced by 10.06% if connections are supplied at a distance of 0.4H + 15% distance, and by 42.76% if connections are provided at a distance of 0.8H + 5% distance. Furthermore, it reduces by 10 to 20% the maximum displacement in medium rise structures.
  - Based on the above data, if the connection is provided at a distance of 0.8H + 5% distance, there are potential benefits in terms of decreased maximum drift.
  - The realistic plan shows a decrease in maximum drift by 5 to 10%, while the hypothetical plan exhibits a decrease of 30 to 40%.
  - In a realistic plan, it is determined that the base shear value can be increased by 1-2%.
  - The base shear is an important parameter structural design that represents the total lateral force applied to a building during seismic or wind load.
  - In the hypothetical plan is determined that the base shear value can be doubled compared to a single or no connection links.
  - This significant increase in the base shear indicates that the lateral forces on the building in the hypothetical plan are substantially higher.
  - Based on the above results, it appears if the twin towers are parallel to each other and connected at a distance of 0.8H + 5% distance, there is a reduction in maximum displacement while simultaneously increasing the base shear.

6.2 Future Scope

- Wind dynamic analysis is an essential tool for understanding the behaviour of structure, including sky bridges, subjected to wind loads.
- Modifying the shape of the structure, including the sky bridge can be optimized its response to wind loads.
- To comprehensively understand the behaviour of structure, it is beneficial to conduct studies by varying earthquake and wind characteristics. This includes different seismic zone, soil type, terrain categories and wind condition.
- Expanding research to include different types of structure, such as steel frame and shear wall with flat slab structure can be provide valuable insights.
- Each structural system responds differently to wind and seismic loads and studying various types of structures allows for a comprehensive understanding of their behaviour.

7 REFERENCE

1) Penumatcha, K. R., Vipparthy, R., & Yadav, A. (2020). A Study on effect of Connecting Beams in a Twin Tower Structure. *Journal of the Institution of Engineers (India): Series A*, *101*(4), 847-856.
2) Abbood, I. S., Mahmod, M., Hanoon, A. N., Jaafar, M. S., & Mussa, M. H. (2018). Seismic response analysis of linked twin tall buildings with structural coupling. *International Journal of Civil Engineering and Technology*, *9*(11), 208-219.
3) Bhinde, V. N., Parekh, P.A., Pokar, N.R. (2020). Dynamic Analysis of Regular Twin Tall RCC Structure with Various Sizes of Links at Most Effective Location. *Journal of Emerging Technologies and Innovative Research (JETIR).*
4) Afiya, V. N. Parametric Analysis on Buildings with Connecting Corridors. *International Journal of Engineering Research & Science (IJOER).*
5) Bhanajibhai, J. B., Umravia, N. B. (2020). Dynamic Analysis of the Twin-Tower High-Rise Structure

with Basement. *International Advanced Research Journal in Science, Engineering and Technology (IARJSET).*

6) AGARWAL, N. (2017). *A STUDY OF LATERAL DRIFT CONTROL BY CONNECTING SKY BRIDGE BETWEEN TWO BUILDINGS* (Doctoral dissertation).
7) SISODIA, R., Kiran, N. T., & Reddy, K. S. S. (2019). Analysis of a Multi-Tower Frame Structure connected at different levels using ETABS.
8) Hu, G., Tse, K. T., Song, J., & Liang, S. (2017). Performance of wind-excited linked building systems considering the link-induced structural coupling. *Engineering Structures*, *138*, 91-104.
9) IS-875-1987 (Part -3), Indian standard Code of Practice for Design loads, Bureau of Indian Standards, New Delhi.
10) IS-1893(Part 1):2016, Indian standard Criteria for Earthquake design Structure, Bureau of Indian Standards, New Delhi.
11) IS-456-2000, Plain and Reinforced concrete for code of Practice, Bureau of Indian Standards, New Delhi.