Dynamic Response Analysis of Skybridge Connected Reinforced Concrete Buildings

Mr. Dhananjay Gopinath Gund [1*] Prof. A. A. Sengupta [2]
[1*]*PG Student, Dept. of Civil Engineering, Dr. Vithalrao Vikhe Patil College of Engineering, Ahmednagar*
[2*] *Professor, Dept. of Civil Engineering, Dr. Vithalrao Vikhe Patil College of Engineering, Ahmednagar*

Abstract: ***It is well known that high-rise buildings act as very important roles in modern cities. First of all, tall buildings can be effectively used to meet the requirements of modern society and solve the problem of limitation of construction site resources. On the other hand, they are the signals of economic properties and civilization. Nowadays high-rise buildings rise higher and higher, with more and more complex and individual plan and elevation, such as multi-tower buildings. "Sky Bridge", "skywalks" or "elevated walkway" bring up images of a narrow, glass walkway connecting two towers usually commercial the only purpose of which, is to let people go from one meeting to the next without having to travel up and down or through fresh air. Dynamic actions are caused on buildings by both wind and earthquakes. But, design for wind forces and for earthquake effects are distinctly different. In this research analyze twin tower structure of G+ 25 with having steel sky walker bridge at 20th floor , the structure analyze for seismic forces, and design steel sky walk bridge for the same by using Staad-Pro***

1. INTRODUCTION

The architectural design of high-rise buildings has become increasingly novel and spectacular in recent decades, leading to the diversity of their exterior and dynamic behavior. In addition, more and more high-rise buildings are being built in relatively adjacent, due to insufficient land availability in populated areas, particularly in major cities. Consequently, there is an increasing tendency to build high-rise buildings in relatively adjacent as a linked building system. That is a system composed of a number of structures coupled by structural links like sky-gardens and sky-bridges. Hence, there are various kinds of connecting, such as fixed, semi-fixed and hinged. There are two great symbols that demonstrate this tendency, the Petronas Twin Towers in Malaysia and Marina Bay Sands Hotel in Singapore. These linked building systems are generally extremely high to attain a great manifestation. Intrinsically, the seismic response is the main concern in the practice of structural design as the response of structure essentially depends on many parameters, such as earthquake characteristic, type of soil and structure properties. FEM is a numerical technique which could be utilized to analyze various types of engineering issues in static, dynamic, linear or nonlinear conditions.

The most delicate and feasible tool among finite element method tools used for industrial and university research. It provides efficient analysis for dynamics like wave water and earthquake loadings on structures. Comprehensive investigations on the seismic responses for individual high-rise building were reported by various researchers. In addition, there are several studies have been published focusing on responses of wind-induced for coupled building system connected via structural links. These attempts have presented an excellent comprehension of the dynamic response for such buildings. Several great matters regarding the design of these wind-resistant structures have been specified. For example, issues related to vibration mode and natural frequency for generic coupled structures, inter-building coupled structures effects on those properties and structures wind-induced responses. Despite that, only a few studies on seismic responses for the linked building system could be found in open literature, owing to the considerable complication of this issue.

A. Skywalk

One possible method of improving the safety of tall buildings is by introducing horizontal evacuation at height through use of a sky bridge linking towers. The concept of being able to evacuate occupants at a level other than ground, should the building be at risk, seems sensible, especially if any emergency in a tall building effectively cuts off vertical evacuation routes and thus the connection to the

ground plane. Implications of incorporating sky bridges in high rise buildings in Hong Kong was proposed recently as a strategy for the improved fire safety of cities with dense high-rise buildings. From the point of view of a developer, to lose two whole floors in a 75 storey building to what is in effect dead space might be a massive loss to the let table revenue. That depends on how the "plot area ratio" is interrupted.

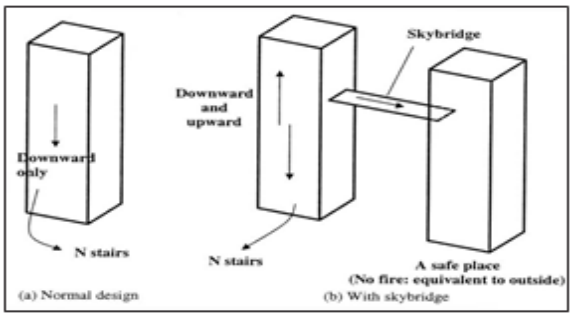


Fig 1 Evacuation in high-rise building.

B. Howe Truss

A Howe truss bridge is made up of flanges, purlins, and diagonals, with the vertical elements in tension and the diagonal ones in compression

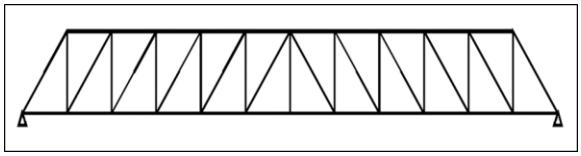


Fig 2 Howe Truss

C. Pratt Truss

This truss features diagonal members that slope down toward the centre, which distinguishes it from the Howe truss.

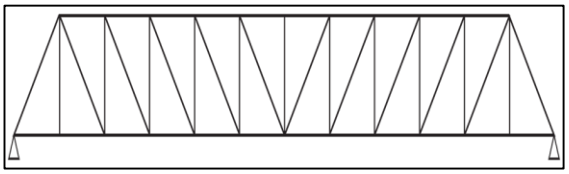


Fig 3 Pratt truss

2. STATE OF DEVELOPMENT

V. R. Shinde et. al. (2021) A bridge must be designed to safely resist all loads and forces that may reasonably occur during its life. These loads include not only the weight of the structure and passing vehicles, but also load from natural causes, such as wind and snow. The loads may act individually but more commonly occur as a combination of two or more loads applied simultaneously. The project discussed analysis and design of steel truss bridge, the bridge is 70m long and 7.5m width and 6 m high, the spaces between the trusses in the roof are various, from the beginning we leave space that equal 0.5 m. The analysis was done by staad pro program. The project studied maximum axial forces, shear forces, torsional values & moment.

Nandar Lwin et. al. (2014) But it is difficult to standardize the seismic analysis and evaluation procedure for truss bridge due to their complexity of size, shape and form. Therefore, the aim of the present paper is to carry out seismic evaluation case study for an existing steel truss bridge with Time History Analysis (THA) to determine as a part of seismic performance categories. The analysis is used by the guidelines of AASHTO-LRFD 2007. Type of plastic hinge for seismic design is reviewed by California Department of Transportation (CALTRANS) approved consensus group. Earthquake loads are based on International Building Code (IBC 2006). SAP 2000 software is used as a tool for structural analysing. A hypothetical bridge model is 1050 ft long, 48 ft wide and 58 ft high. This includes three lanes, two of which are applied for vehicles and one for train, and sidewalk at each. HS 20-44 is considered as truck loading and 1929 Meter Gauge Standard Heavy Mineral is used for train loading. Load combinations of bridge are considered for strength limit state-III, extreme event limit state-I and service limit state-I according to AASHTO specifications. Maximum displacements, rotations and accelerations occurred at different points varying with different times and different damping ratios are discussed in this study. Self-mass of this bridge model is 667 kip-sec2/ft and its self-weight is 21451 kips. The fundamental mode is occurred at 0.576705seconds. Type of modes is used as Ritz vectors acceleration type.

Surendra Chaurasiya et. al. (2019) The figurative tower which compliance all the structural state of affairs are in trend. These structures are not only constructed to deliver the present need but also to show the domination among all over the world which is also used as benchmark in the world. A number of structures were build till date and all of those are symbolic marvels like Petronas Tower in Kuala Lumpur, Huaguoyuan towers in China, Imperial Tower in India, Palm Tower in Doha and the list is myriad. Also a lot of twin towers are under construction not only across the world but also in India too. Such structures are made possible by bridging the gap between these two towers by

various means like making the bridge or by RCC frame, steel connections, etc. In this paper various papers are studied to comprehend the concept and optimize the need. The study on various research papers along with existing towers help in deciding the objectives of the study and so the optimizing parameters.

Nisarg Patoliya et. al. (2023) The study utilizes ETABS19 software to model and analyse the building. This paper focused primarily on the earthquake forces that act on buildings. In this research, two buildings of similar heights i.e., 20, 24 and 28 stories are connected with one, two, or three sky bridges at different floor levels. The objective is to determine the most effective location and number of sky bridges to achieve optimal solutions. The study aims to compare the structural parameters of RCC sky bridges such as storey displacement, storey drift and base shear. This research provides valuable insights into the use of RCC material for constructing sky bridges and can serve as a basis for future studies on the topic

Vanni Nicoletti et. al. (2023) This paper concerns the experimental and numerical dynamic characterization of a newly built steel and wooden cable-stayed footbridge. The footbridge was dynamically tested in situ under ambient vibration, and the results allowed the real dynamic behavior of the footbridge to be captured. The dynamic response under pedestrian dynamic loads was also investigated and compared with the limitations provided by the main international codes and guidelines for footbridge serviceability assessment. A numerical model of the footbridge was also developed and updated based on the experimental outcomes. Then, the calibrated model was used to numerically assess the footbridge's serviceability following the guideline prescriptions for pedestrian load simulation, and the design accuracy was also validated. This paper aims to increase the state-of-the-art knowledge about footbridge dynamic testing so as to support the design of new and futuristic structures as well as prove the effectiveness of using the requirements of codes and guidelines for footbridge serviceability assessment by adopting a calibrated numerical model.

Wensheng LU et. al. (2018) This paper summarizes tests of several scaled multi-tower high-rise building models on the shaking table. The assumption of rigid floor is obviously unsuitable for the analysis of multi tower buildings. A new analytic model considering the effect of flexible transfer floor is put forward. The theoretical dynamic behavior is compared with the test results. The conjunction floors between towers at higher levels, and the stiffness of foundation contribution to structural dynamic behavior is also discussed in this paper. Several suggestions and conceptual guidelines are concluded. It is well known that high-rise buildings act as very important roles in modern cities. First of all, tall buildings can be effectively used to meet the requirements of modern society and solve the problem of limitation of construction site resources. On the other hand, they are the signals of economic properties and civilization. Nowadays high-rise buildings rise higher and higher, with more and more complex and individual plan and elevation, such as multi-tower buildings.

A. Wood et. al. (2005) This is a good choice when vertical (usually downward) evacuation routes out of the tall building cuts off in a fire. A skybridge can increase the evacuation efficiency without increasing the number of fire stairs. This is well demonstrated in the Petronas Towers in Kuala Lumpur, Malaysia. There are many big cities in the Far East having so many highrise buildings (in highrise cities) built closely together. The possibility of linking currently empty refuge floors with skybridges is worthwhile to consider, especially for building clusters owned by the same developer. Skybridges retrospectively into an existing tall building cluster in the central business district of Hong Kong is taken as an example. Possible improvement on the evacuation efficiency is suggested. This can be extended to be a strategy toward the possible inclusion of skybridges in high-rise design as an improved fire safety provision of tall buildings all over the world.

Hitesh A. Patel et. al. (2015). In the present work study of pedestrian planning is taken up, to improve the pedestrian facility at these intersections. To check the adequacy of pedestrian facilities, pedestrian surveys i.e. pedestrian volume count, and pedestrian interview survey also traffic survey and also check the Levels of service of the exiting pedestrian facilities are evaluated for the existing condition as per the guidelines of HCM (2000) and guidelines of pedestrian facility IRC 103: 2012.

Amitabh Kumar et. al. (2011) Generic panel slab formwork with drop heads is used for flexibility to adopt different geometry, early stripping and crane independent faster construction. Guided climbing formwork is used for few peripheral walls. MEVA-ALUFIX panels are used for columns and other

walls. Equipment has been planned after studying the towers' geometry and site logistics. Eight hoists are being installed in phases. Four high performance pumps are used for the initial 150m height and above 150m four high pressure pumps are planned along with standby. Seven self-climbing concrete placer booms are being erected in phases. Design changes influenced the selection and placement of equipment's. Variable storey height was a challenge to optimize and synchronize climbing sequence of ACS, Tower Cranes and Placer booms. Erection of equipment's was challenging due to space constraints, the fast track construction schedule and the densely populated area. High performance concrete and temperature control concrete is made available through in-house plants and other grades (M40, Lean concrete) are sourced from outside. Design mix keeps on changing during construction due to the variability in raw materials

3. SUMMARY OF LITERATURE

From literature survey it is found that which work was done on twin building type of bridge and which works are limited or not done. Previous research studied the skywalk structure with the vibration and wind analysis only with having specific truss patterns. The study aims to compare the structural parameters of RCC sky bridges such as storey displacement, storey drift and base shear. This research provides valuable insights into the use of RCC material for constructing sky bridges and can serve as a basis for future studies on the topic.

4. GAP IDENTIFICATION

From the previous studies to comprehend the concept and optimize the need for the structures. The use of STEEL for constructing sky bridges has several advantages, including increased durability and reduced maintenance requirements. In the further Study need to perform vibration analysis of different type truss patterns for Sky Walk Bridge with seismic load by Finite Element Method using Staad Pro, And design economic structure of Skywalk for the Twin Tower Building with using Stadd Pro Software analysis As per IS800 for wind and vibration loads.

5. PROBLEM STATEMENT AND ANALYSIS

The Sky walk bridge analyses with effective span 25m with different type truss patterns. Design economic structure of Skywalk for the Twin Tower Building with using Stadd Pro Software analysis As per IS800 for wind and vibration loads

Truss Types Used

1) Pratt Truss
2) Howe Truss

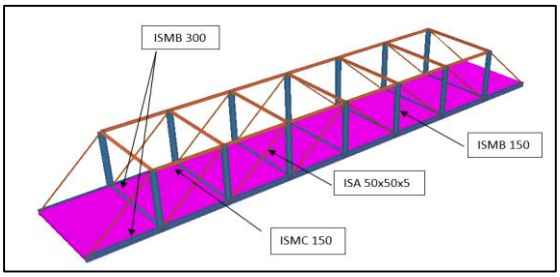


Fig 4 Truss Model

A. Truss Modelling and Analysis

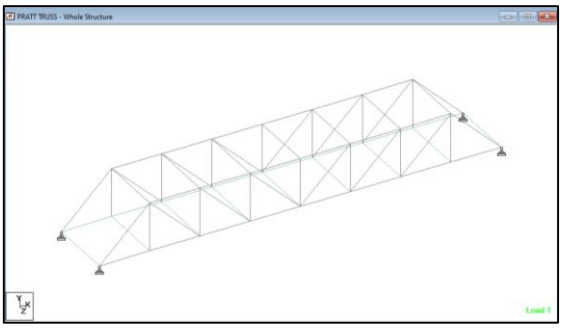


Fig 4 Pratt Truss

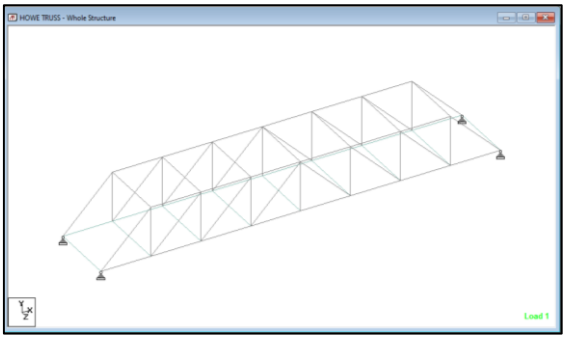
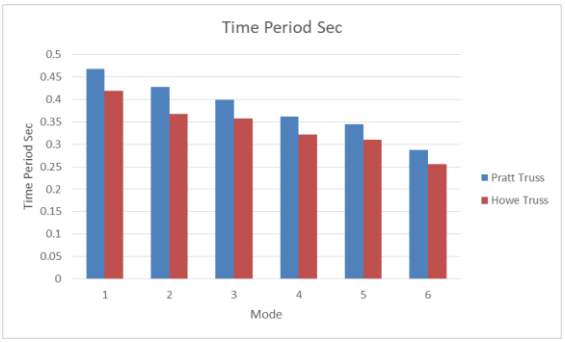


Fig 5 Howe Truss

Table 1 Time Period Sec

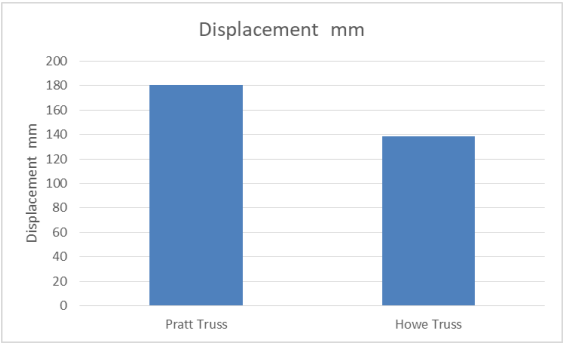
Time Period Sec		
Mode	Pratt Truss	Howe Truss
1	0.467	0.419
2	0.428	0.367
3	0.399	0.358
4	0.362	0.321
5	0.344	0.31
6	0.287	0.256



Graph 1 Time Period Sec

Table 4.3 Displacement mm

Displacement mm	
Pratt Truss	Howe Truss
180.64	138.67



Graph 2 Displacement mm

B. Results of Howe Truss 2.5 X 2.5 m Span

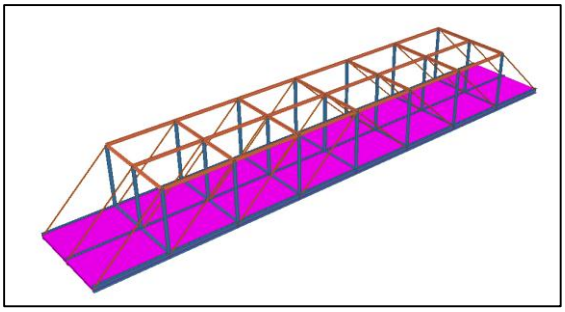
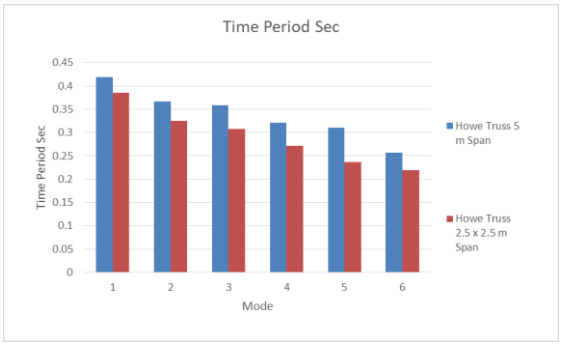


Fig 6 Howe Truss 2.5 x 2.5 m (Render View)

Table 4.4 Time Period Sec

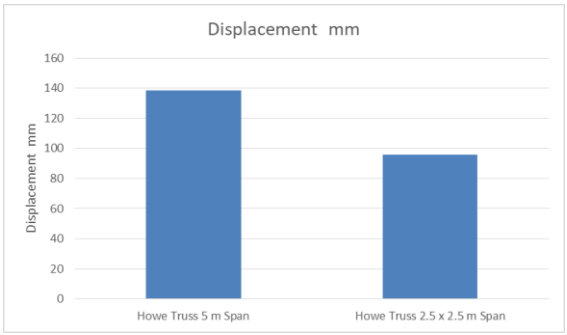
Time Period Sec		
Mode	Howe Truss 5 m Span	Howe Truss 2.5 x 2.5 m Span
1	0.419	0.386
2	0.367	0.325
3	0.358	0.307
4	0.321	0.271
5	0.31	0.237
6	0.256	0.219



Graph 3 Time Period Sec

Table 4.6 Displacement Howe Truss 2.5 x 2.5 m

Displacement mm	
Howe Truss 5 m Span	Howe Truss 2.5 x 2.5 m Span
138.67	95.94



Graph 4 Displacement Howe Truss 2.5 x 2.5 m

5. CONCLUSION

The notion of employing a sky bridge to connect two or more buildings has been existent for a while The design and construction of such a structure must take into mind many aspects, such as wind load, seismic load and safety standards. In this analysis of sky Walk Bridge takes a two types of bridge Howe truss & Pratt truss The FEM has become a powerful tool for the numerical solution of a wide range of engineering problem. In this method partial differential equations are generated and solved. The response of Sky Walk Bridge under forced vibration will be determined. The results of Sky Walk Bridge are analysed for the response spectrum analysis method for Pratt and how each type of truss gives better performance than Pratt truss. After then analysing the Howe type of truss for two different types of spans, one with a 5 m span and the other with a 2.5 x 2.5 m span, according to the results, no major difference was found after changing the span.

6. REFERENCES

[1] SurendraChaurasiyaet. al. “Twin Tower High Rise Building Subjected To Seismic Loading: A Review” (IJAERS) Vol-6, Issue-4, Apr-2019

[2] Wensheng LU et. al. “Seismic Model Test And Analysis Of Multi-Tower High-Rise Buildings” WCE

[3] Wood Et. Al. “The Skybridge As An Evacuation Option For Tall Buildings For Highrise Cities In The Far East” APPLIED FIRE SCIENCE, Vol. 13, 2004-2005

[4] Hitesh A. Patel et. al. “Feasibility Study for Skywalk Proposed as in Urban Area “A Case Study” International Journal of New Technologies in Science and Engineering Vol. 2, Issue. 2, Aug 2015

[5] Amitabh Kumar et. al. “High Rise SKY Towers, Mumbai – Construction Challenges” CTBUH 2011 World Conference 2011

[6] DiagoroIsobe, Li Thi Thai Thanh and Zion Sasaki, “Numerical Simulations on the Collapse Behavior of High-Rise Towers”, Vol. 3, No. 1 , (2012)

[7] S Radhakrishnanet. al. “Collapse of Trust – Moulivakkam Twin Towers” International Journal of Research, Volume 4, Issue 1, January 2017

[8] JiDongyuet. al. “Seismic Behavior Analysis of High-rise Connected Structure” International Conference on Mechatronics, Electronic, Industrial and Control Engineering (MEIC 2014)

[9] M.R. Willfordet. al. “Performance Based Seismic And Wind Engineering For 60 Story Twin Towers In Manila” The 14thWorld Conference on Earthquake Engineering October 12-17, 2008

[10] Arthur W T Leung et. al. “Scheduling For High-Rise Building Construction Using Simulation Techniques”

[11] J. Kala et al “Footbridge Response on Single Pedestrian Induced Vibration Analysis”World Academy of Science, Engineering and Technology 26 2009

[12] StanaZivanoviý et al “Probability-Based Estimation of Vibration for Pedestrian Structures due to Walking”

[13] JianingHao et al “Natural Vibration Analysis of Long Span Suspension Bridges”5th International Conferences on Civil Engineering and Transportation (ICCET 2015)

[14] HeenaDewangan et al “A Review on Comparison of Different Types of Trusses in Vibration Analysis Using Staad Pro”IJESRT Impact Factor: 5.164 IC™ Value: 3.00 CODEN: IJESS7 July, 2018

[15] Mr. Kaushal Kumar et al “Analysis of Truss Bridge and Cost Optimization by Using Hollow Sections”May, 2019

[16] José Guilherme Santos da Silva et al “Finite Element Modeling of the Dynamic Behaviors of Tubular Footbridges”Finite Element Analysis – New Trends and Developments

[17] Prakash Kumar et al “Serviceability Analysis of a Footbridge Subjected to Pedestrian Walking”Advances in Engineering Design 2019

[18] El-SayedMashaly et al “Evaluating the vertical vibration response of footbridges using a response spectrum approach” Alexandria Engineering Journal 2013

[19] IemkeRoos et al “Human Induced Vibrations on Footbridges”Application & comparison of pedestrian load models, Delft University of Technology, Netherlands 2009

[20] Sabina Piras et al “Footbridge Design For Pedestrian Induced Vibrations” the concrete Nz Conference 2018