

ANALYSIS AND DESIGN OF G+20 MULTI-STOREY BUILDING WITH SKY WALK BY USING STAADPRO

Prafull B. Dhule¹, Satish S. Manal²

¹ P.G. Student, Civil Engineering Department, CSMSS College, Chhatrapati Sambhajnagar (Aurangabad)

² Assistant Prof, Civil Engineering Department, CSMSS College, Chhatrapati Sambhajnagar (Aurangabad)

Abstract - The rapid global trend of urbanization has necessitated the construction of multi-story and high-rise buildings to optimize limited urban land space. Structural design in such tall buildings is critically focused on ensuring safety, serviceability, and economic viability, particularly when subjected to severe lateral forces like wind and seismic ground motion. This project report presents the structural analysis and design of a G+20 (Ground + 20 stories) twin-tower high-rise building complex featuring an integrated skywalk system, performed using the finite element analysis software, STAAD.Pro V8i. The structural model consists of twin towers of a circular cross-sectional geometry (30 meters in diameter, 45 meters center-to-center spacing) with a height of 63 meters. The towers are connected by four separate skywalks, strategically located at the 4th, 9th, 14th, and 19th floor levels, which function as critical safety escapes and pedestrian connectors. The design utilized M40 grade concrete and Fe500 grade steel. The key findings confirmed the robust structural integrity and excellent serviceability of the design. The Story Drift Analysis Report indicated that all calculated story drift ratios successfully "PASS" the prescribed code limits. The maximum observed story drift was 0.5747 cm (at the 8th story), which is well within the allowable drift limit (L/40). The seismic analysis showed a fundamental time period of 1.61687 seconds. In conclusion, the structural analysis and design process, leveraged by the advanced capabilities of STAAD.Pro, resulted in a safe, cost-efficient, and compliant design for a complex high-rise structure with connecting skywalks.

Key Words: G+20, High Rise, Skywalk, STAAD Pro, Drift Analysis.

1. INTRODUCTION

Now a days tall or multi-story buildings has gain importance very much, because in tier-1 cities there is a rapid increase in population with limited space for building. All people require good accommodation, aesthetics, comfort and safety. That is the reason for increase in construction of multi-story buildings. Structural design of multi-story buildings is basically worried with safety during ground motion, serviceability what's more, and potential for monetary misfortune. Design of structures using Limit State method Design The members are designed for the limiting bending moment and serviceability limits, hence the structures are left with minimum reserve energy. Earthquakes will cause more severe effect on tall buildings compared to small buildings.

1.1 High-Rise Building:

A high-rise building is a tall, multi-story structure generally defined as being significantly taller than surrounding buildings and requiring mechanical vertical transportation, like elevators, to access its upper levels. They are primarily built to maximize usable space on expensive or limited urban land, serving as residences, offices, or mixed-use facilities. This strategy is known as vertical urban expansion. It is a structure consisting of many structures connected by connecting structures such as sky gardens and sky bridges. Therefore, there are many types of connections: fixed, semi-fixed, articulated, etc. There are two big symbols that show this trend: Petronas Towers in Malaysia and Marina Bay Sands in Singapore. These home connections are often too developed to be effective. More importantly, seismic response is an important consideration in structural design, as the response of the main structure depends on many parameters such as seismic properties, soil type and materials. FEM is a mathematical technique that can be used to analyze many engineering problems under static, dynamic, linear or nonlinear conditions.

1.2 Building Shapes (Cross-Sectional Types):

The shape of a high-rise building's cross-section is a critical design choice, dictated by a combination of structural integrity (especially lateral load resistance), aerodynamics, functionality, and aesthetics.

(i) Rectangular/Square:

Rectangular and square high-rise buildings are common due to their structural simplicity, which makes them easier and more efficient to design and construct. Their straightforward geometry allows for simplified calculations for self-weight, wind loads, and seismic loads, and provides regular, easy-to-divide floor plans.

(ii) Circular/Cylindrical:

Circular and cylindrical high-rise buildings are impressive architectural structures, with famous examples including the Guangzhou Circle in China, which is the world's tallest circular building, the Aldar HQ in Abu Dhabi, and the Westin Bonaventure Hotel in Los Angeles. These designs offer unique benefits such as reduced wind resistance and aesthetic appeal and are sometimes inspired by cultural symbolism.

(iii) Triangular/Three-Lobed (Y-Shape):

High-rise buildings with a triangular, three-lobed (Y-shape) design are a significant architectural and engineering solution, primarily used to enhance structural stability against wind forces and maximize space efficiency and views. Three wings or lobes branching from a central core. Often seen in supertalls like the Burj Khalifa (three-lobed plan).

(iv) Tapered/Setback:

Buildings that reduce their cross-sectional area as they rise in height. Tapered/setback high-rise buildings are designed to be wider at the base and gradually narrower towards the top, which improves structural stability and reduces wind loads by minimizing aerodynamic forces and vortex shedding. This design approach also leads to structural efficiency, as less material is needed at the top, which can lower construction costs, and the design can also create iconic architectural landmarks.

1.3 Skywalk:

A skywalk in high-rise buildings is an elevated bridge or passageway that connects two or more tall buildings above ground level. It allows safe and direct movement of people between towers without needing to go to the ground floor. These structures are often made of steel, concrete, and glass, and are designed to withstand wind loads, vibrations, and temperature changes at high altitudes. They are commonly found in modern skyscrapers, commercial complexes, hotels, and hospitals

1.4 Types of Skywalks in High-Rise Buildings

(i) Enclosed Skywalk

An enclosed skywalk is a fully covered elevated passage that connects two or more high-rise buildings. It is built using glass panels, aluminum cladding, or steel framing, providing a climate-controlled and secure environment for pedestrians. These are often found in commercial complexes, hospitals, airports, and office towers where comfort and safety are priorities.

(ii) Open Skywalk:

An open skywalk is an elevated pedestrian bridge without full enclosure. It typically has guardrails or partial side protection, allowing free airflow and visibility. It is suitable for areas with mild climates and lower pedestrian volume, often used for maintenance or low-traffic connections.

(iii) Glass Skywalk:

A glass skywalk is a transparent pedestrian bridge made mostly of tempered or laminated glass panels. It allows users to view the surroundings or the ground below, giving a sense of openness and excitement. Common in tourist attractions, observation towers, and luxury buildings, it combines structural engineering with aesthetics

(iv) Suspended (Cable-Supported) Skywalk:

A suspended or cable-supported skywalk uses tension cables, hangers, or suspension systems to support the walkway between buildings. It provides flexibility and reduces the structural load on the main towers. This design is preferred when connecting towers that may move slightly due to wind or seismic activity.

(v) Structural Steel Skywalk:

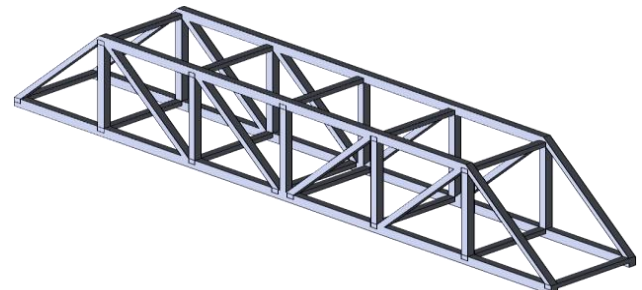
A structural steel skywalk is a robust bridge made of steel beams, trusses, and decks, designed to carry heavy pedestrian or service loads. It is strong, durable, and can be either open or enclosed depending on design needs.

1.5 Truss for Skywalk:

Truss structures are very common and effective for skywalks (elevated pedestrian bridges) because they are efficient for spanning long distances while being relatively lightweight and providing good structural stability.

(i) Pratt Truss:

Features vertical members in compression and diagonal members in tension. It's often considered cost-effective and efficient for common vertical load scenarios (like the weight of the structure and pedestrians).



(ii) Warren Truss:

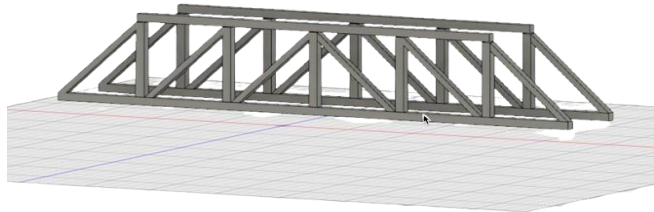
Characterized by a series of equilateral triangles, with diagonal members that alternate between tension and compression. It's often the most cost-effective due to its simplicity and reduced number of members, making it ideal for moderate.



(iii) Howe Truss:

Essentially the opposite of the Pratt truss, with vertical members in tension and diagonal members in compression. Why it's used: While less common than the

Pratt truss for steel, timber Howe trusses are sometimes used in environments like nature trails to blend in.



2. SYSTEM DEVELOPMENT

2.1 Design and Analysis of G+20 Multi-storey Building with Sky walk by using STAAD Pro:

Designing and analyzing a G+20 (Ground + 20 floors) multistorey building with a skywalk using STAAD Pro involves several key steps, ranging from the modeling of the building to the analysis of structural loads and the final design of components.

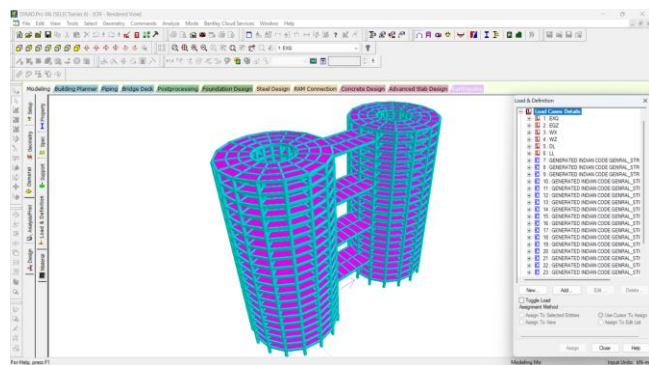


Fig. 1. G+20 Multi-Storey Building with Skywalk

BUILDING DETAILS:

Detail	Description
Structure Type	High-rise twin towers of circular geometry.
Software Used	STAAD Pro V8i
Key Feature	Four Skywalks connecting the two towers.
Height/Stories	20-story building.
Skywalk Locations	Floors: 4th, 9th, 14th, and 19th.
Tower Diameter	30 meters for each circular tower.
Floor Height	3m
Stories	20
Tower Height	63m

Plan Dia	30m
Space B/W Towers Centre to Centre	45m
Slab Thickness	0.18m
Column Size	0.7 X 0.7m
Beam Size in Tower	0.7 X 0.4m
Steel Grade	Fe500
Concrete Grade	M40
Load Codes	IS 875 (Dead, Live Load and Wind Load) and IS 1893 (Seismic Design).
Live Load	up to 5 kN/m ²
Seismic Zone:	Zone 3
Response reduction factor (R)	5 Special Moment Resisting Frame (SMRF)
Seismic zone factor	0.16 (Zone 3)
Soil Type	2 Medium Soil
Damping Ratio	0.05 (5% is the standard value used for the majority of Reinforced Concrete (RC)
Fundamental Natural Period (T)	0.09 seconds (Very stiff structure)
Importance factor (I)	1.2 (e.g., commercial buildings with an occupancy of more than 200 people).
Wind Zone	Zone 3

2.2 Skywalk Design Consideration:

(i) Connection with Main Building:

Model the skywalk's connection to the building carefully, ensuring proper load transfer.

(ii) Structural System:

Skywalks often involve a mix of beams and cables or a more rigid frame, depending on the architectural design.

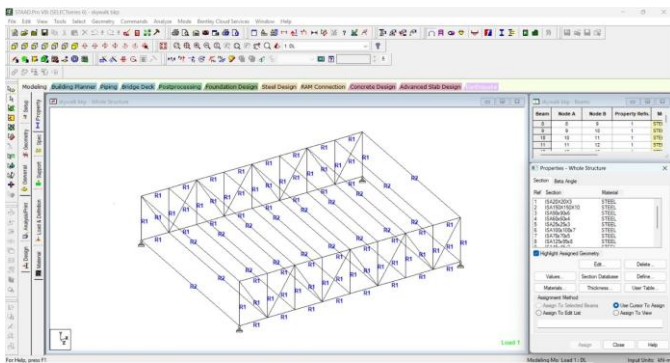


Fig. 2. Skywalk Model

SKYWALK DETAILS:

Detail	Description
Truss Type	Howe
Length Of Skywalk Bridge	15m
Width Of Skywalk Bridge	11.48m
Height Of Skywalk Bridge	3m
Structure Location	General Metropolitan Area
Seismic Zone (Z factor)	Zone III
Basic Wind Speed (Vb)	Vb = 44 m/s
Truss Material	Steel (Fe 410 / E250)

3. RESULTS:

1. Story Drift Analysis:

The maximum drift occurs at: **Story: 8**
Height: 21.00 meters **Direction: Z-direction**
 The story drift value of 0.5747 cm is the inter-story drift for the 8th story, meaning it is the difference in lateral displacement between the 8th and 7th floors. This value is checked against the allowable drift ratio, which is indicated as L/40 (L being the story height, which is typically 3.00m in this report since the height increment is 3.00m per story).

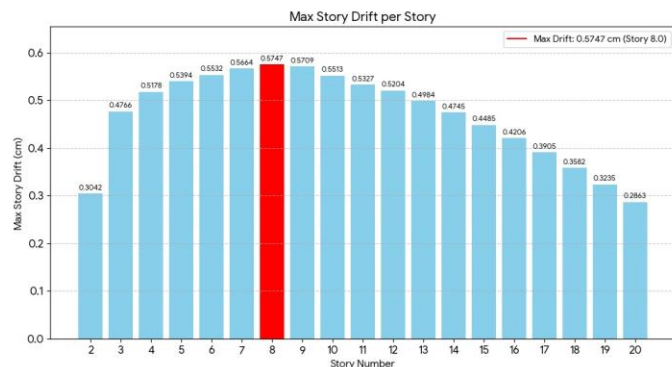


Fig. 3. Max Story Drift Per Story

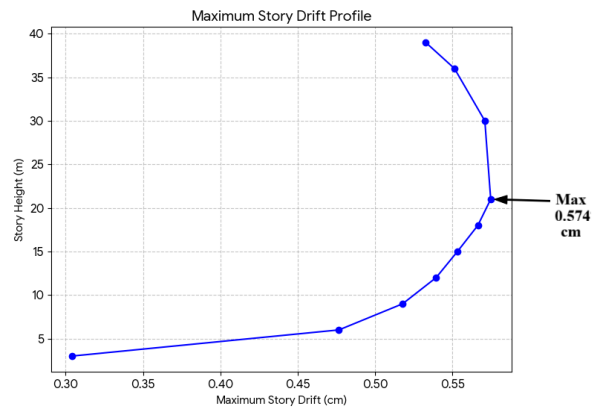


Fig. 4. Maximum Story Drift Profile

In all cases presented, the drift ratio is much higher (e.g., L/522 for this maximum drift value), indicating that the drift is well within the code limits, and the status is "PASS"

2. Time Period and Sa/G:

The Time Period is a measure of the structure's flexibility. A higher period indicates a more flexible structure. The seismic code uses this period to determine the design's Spectral Acceleration Coefficient (S/G), which represents the structure's response to earthquake ground motion. The value of Sa/G = 0.841 is relatively high, indicating a strong seismic demand for the calculated period of 1.61687 seconds

Parameter	X	Z
Time Period	1.616	1.616
Sa/G (Spectral Acceleration Coefficient)	0.841	0.841

3. CONCLUSIONS

The structural analysis and design of the G+20 multi-story building and its integrated skywalk, performed using STAAD.Pro and adhering to Indian Standard IS codes such as IS 456:2000, IS 875, and IS 1893, led to the following principal findings.

Structural Integrity:

The analysis was executed successfully, and the model was confirmed to have zero errors

Serviceability (Story Drift):

The structure demonstrated excellent performance against lateral loads (wind and seismic) in terms of story drift. The Story Drift Analysis Report indicated that for all tested loads and stories, the calculated drift ratios "PASS" the required code limits. The maximum story drift observed was 0.5747 cm (at the 8th story), which was well within the allowable limits (L/40).

Seismic Analysis:

(Time Period = 1.61687 seconds) is the time for which the structure will require swing back and forth one cycle. This value suggests a relatively flexible structure, which is typical for a tall (G+20) building.

Spectral Acceleration Coeff.

(0.841) This is the key factor from the seismic zone (response spectrum) that dictates the design force. A value of 0.841 means the ground acceleration is amplified significantly (84.1% of gravity) at this structure's natural period to determine the design seismic force

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BIOGRAPHIES**Mr. Prafull B. Dhule**

P.G. Student, Civil Engineering Department, CSMSS, Chh. Shahu College of Engineering, Kanchanwadi, Chhatrapati Sambhajnagar (Aurangabad), Maharashtra, India

**Mr. Satish S. Manal**

Assistant Professor, Department of Civil Engineering, CSMSS, Chh. Shahu College of Engineering, Kanchanwadi, Chhatrapati Sambhajnagar (Aurangabad), Maharashtra, India