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Integrated Design And Analysis Of A Multi-Storey (G+20) Structure Incorporating A Sky Walk.

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Abstract: This project addresses the critical need for advanced structural analysis and design of high-rise buildings, focusing specifically on a G+20 multi-story twin tower structure integrated with connecting skywalks. The inclusion of a skywalk connecting the towers at multiple levels (4th, 9th, 14th, and 19th floors) adds considerable complexity to the structural behavior, particularly concerning load transfer and lateral stability under various loading conditions, including dead loads, live loads, wind loads, and seismic forces, in compliance with Indian Standard (IS) codes, notably IS 456:2000, IS 875, and IS 1893. The structural analysis and design were performed using software STAAD.Pro. The model incorporated twin circular towers subjected to detailed seismic and dynamic wind analysis. The analysis results demonstrated high structural integrity and confirmed the stability of the design. The seismic evaluation confirmed a highly symmetrical and regular distribution of mass and stiffness, evidenced by an identical Base Shear (Vb) of 23024.88 kN in both the X and Z directions. The maximum vertical displacement of Skywalk in (Y-Translation) is -7.624 cm (76.25mm) at Node 8 and maximum Horizontal displacement (X-Translation) is -2.86445cm ie 28.6mm Node 33. In conclusion, the design is validated as safe and durable, demonstrating that the structural system, including the integrated skywalk, can efficiently withstand extreme environmental and gravitational loads.

Index Terms **- High Rise, G+20, STAAD Pro, Skywalk.**

Introduction

The rise of multi-story and tall buildings has become increasingly important, especially in tier-1 cities where rapid population growth has limited the available space for new construction. There is a continuous demand for comfortable, safe, and aesthetically pleasing accommodation. Consequently, the construction of high-rise structures is constantly increasing. The structural design of these buildings primarily focuses on safety during ground motion, maintaining serviceability, and minimizing potential economic loss. When structures are designed using the Limit State method, members are configured for limiting bending moment and serviceability requirements, resulting in minimal reserve energy.

Tall buildings are typically more susceptible to severe earthquake effects than smaller ones, and asymmetrical buildings are more prone to damage than symmetrical ones. High-rise structures are particularly sensitive to horizontal loads, which can cause high lateral displacements—a condition that is undesirable for both the structure's integrity and the occupants' comfort. Due to the massive influx of people from rural to urban areas and the limited availability of land, the construction of multi-story buildings on small urban plots has become commonplace. The functional design of a building is crucial, and its specific requirements must be tailored to its purpose. Therefore, every Civil Engineer must understand the intended use of a building by consulting with stakeholders, while also applying the fundamental principles of Reinforced Cement Concrete (R.C.C.) structural design.

1.2 HIGH RISE BUILDING

A high-rise building is a multi-story tower that is notably taller than neighbouring structures and relies on mechanical systems, such as elevators, for vertical access. These buildings are typically constructed to maximize the utilization of limited or high-value urban land, often functioning as residential, office, or mixed-use developments, a concept referred to as vertical urban expansion. There is therefore an increasing trend towards the construction of high-rise buildings in adjacent areas as a form of connected housing. It is a structure consisting of many structures connected by structures like sky gardens and sky bridges. Numerous researchers have published studies investigating the seismic response of single high rise towers.

1.3 SKYWALK

A skywalk, or sky bridge, is an elevated passageway connecting two or more tall buildings above ground level. These structures allow people to move safely and directly between towers without needing to descend to the ground floor. Typically constructed from steel, concrete, and glass, skywalks are engineered to withstand environmental stresses common at high elevations, such as intense wind loads, vibrations, and shifts in temperature. They are commonly incorporated into modern skyscrapers, commercial complexes, hotels, and hospitals. Incorporating sky bridges is a key strategy for enhancing safety in tall structures. They provide essential elevated, horizontal escape routes. In the event of an emergency, such as a fire, the ability for occupants on upper floors to horizontally evacuate across a bridge to an adjacent tower is a vital and practical safety measure.

1.4 TYPES OF TRUSSES USED AS SKYWALK:

(i) Pratt Truss

This Pratt truss is defined by its web members, where the vertical elements are under compression, while the diagonal members are subjected to tension under standard loads. The Pratt Truss is often selected for its efficiency and cost effectiveness when dealing with typical vertical forces, such as the weight of the structure itself and the pedestrian load.

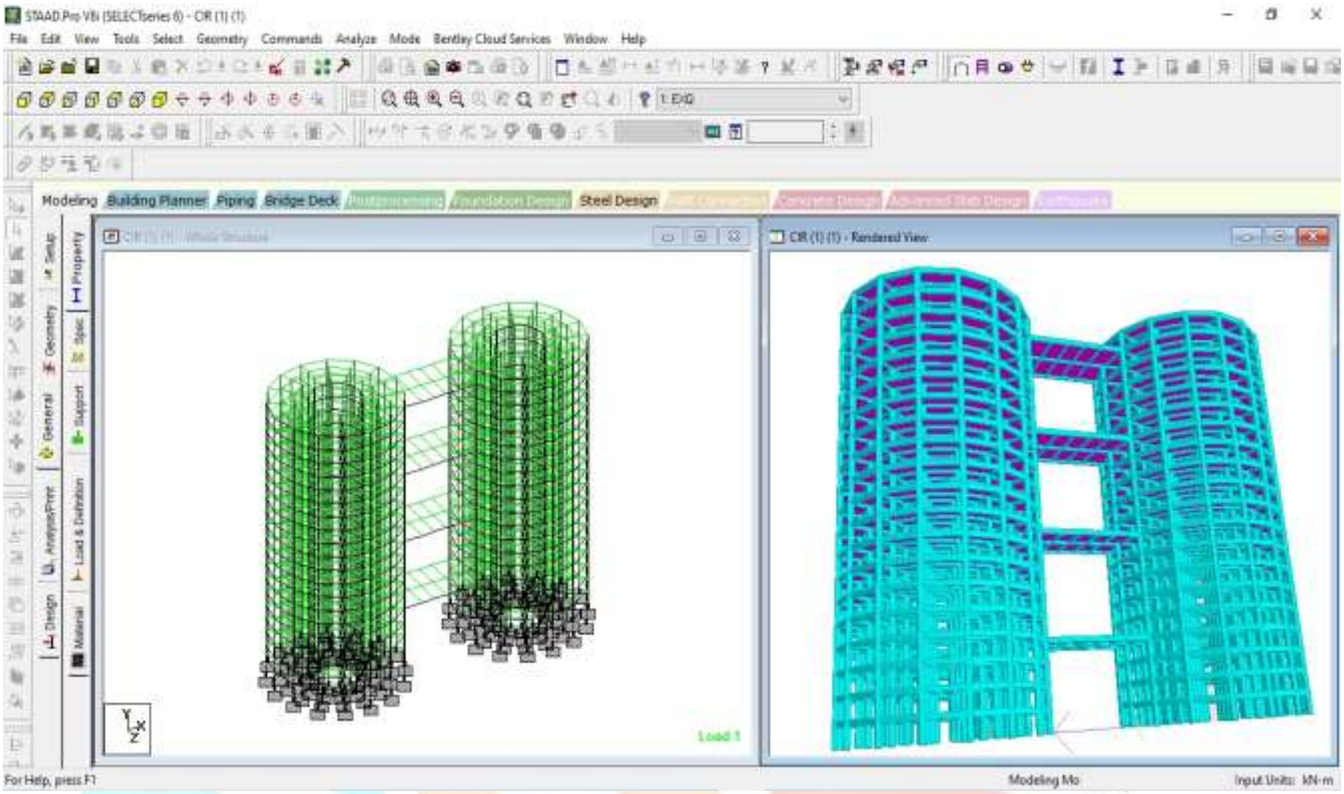
(ii) Howe Truss

The Howe truss features a distinctive pattern where its vertical members are in tension and its diagonal members are in compression. This is structurally the inverse of the Pratt truss.

II. OBJECTIVES

1. To design and analyze a G+20 multi-story building with an integrated skywalk using STAAD.Pro for structural stability and efficiency.
2. To evaluate load-bearing capacity by considering dead loads, live loads, wind loads & seismic loads as per building codes.
3. To conduct seismic and wind analysis to ensure structural safety against earthquakes and high wind forces.
4. To analyze the behavior of the skywalk under pedestrian loads and environmental forces for safe integration with the main structure.
5. To validate the design outputs from STAAD.Pro by comparing them with relevant IS codes and industry standards.
7. To assess the sustainability and environmental impact of the structure, promoting energy efficient and eco-friendly solutions.

III. SYSTEM DEVELOPMENT

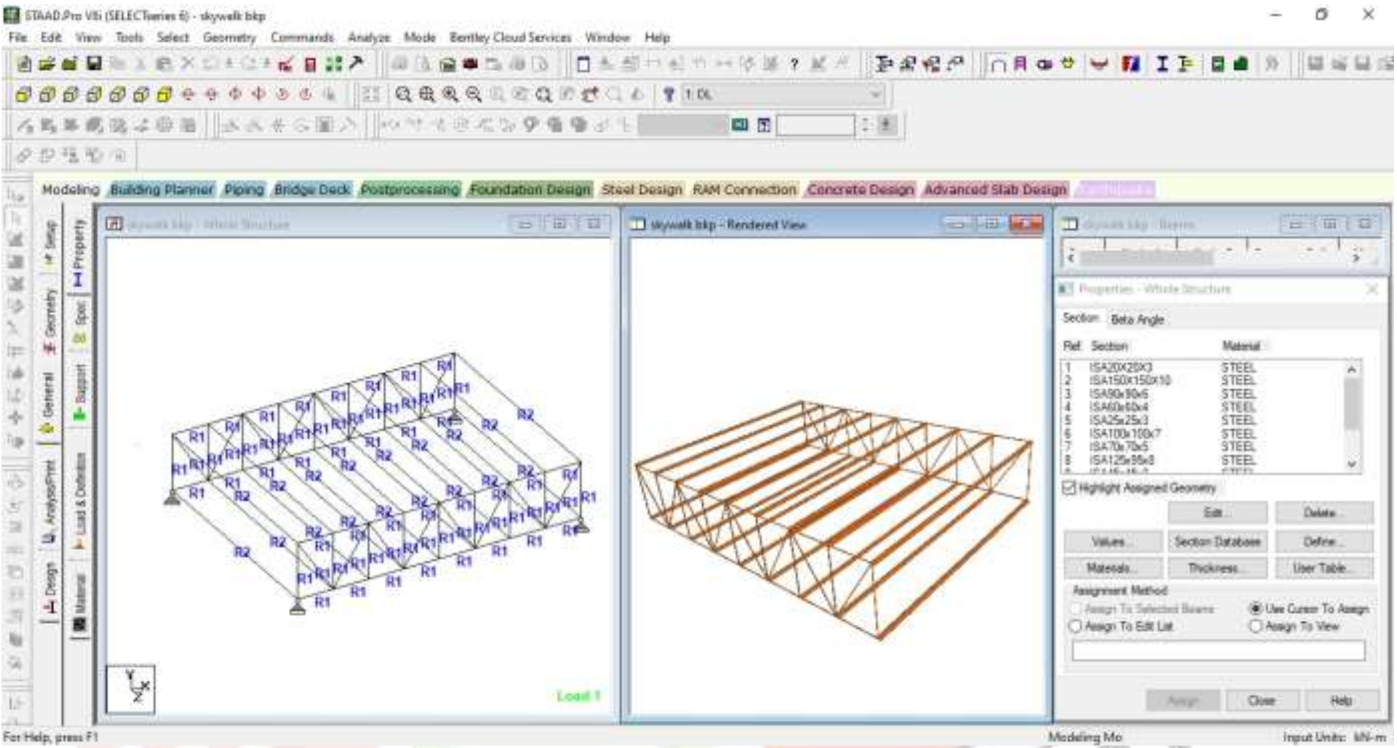


Designing and analyzing a Ground + 20-floor (G+20) multistorey building that includes a skywalk using the software STAAD.Pro requires a systematic approach, covering modeling, load application, analysis, and final component design.

Detail	Description
Structure Type	High Rise twin towers of circular geometry.
Software Used	STAAD Pro V8i (Modeling/Analysis/Design)
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	45m (Centre to Centre)
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	Upto 5kN/m²
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 (commercial buildings with an occupancy of more than 200 people).
Wind Zone	Zone 3

SKYWALK DETAILS:



Detail	Description
Truss Type	Howe
Length Of Skywalk Bridge	15m
Width Of Skywalk Bridge	11.48m
Height Of Skywalk Bridge	3m
Seismic Zone (Z factor)	Zone III
Basic Wind Speed (Vb)	Vb = 44m/s

IV. RESULTS

SEISMIC RESULTS:

The seismic results show the overall calculated forces and periods for the structure based on the IS – 1893

PARAMETER	X DIRECTION	Z DIRECTION
Time Period	1.61687	1.61687
Sa/G (Spectral Acceleration Coefficient)	0.841	0.841
Base Shear (VB)	23024.88	23024.88

DISPLACEMENTS REPORT OF SKYWALK:

PARAMETER	VALUE (MM)	LOCATION
Maximum Vertical Displacement (Y-Translation)	7.625cm (76.25mm)	At Node 8
Maximum Horizontal Displacement (X-Translation)	2.86cm (28.6mm)	At Node 33

V. CONCLUSION

Conclusion of Structural Analysis
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.

1) **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. A value of Sa/G = 0.841 is relatively high, indicating a strong seismic demand for the calculated period of 1.61687 seconds.

2) **Base Shear (VB):** The Base Shear is the total horizontal force that the structure's foundation must be designed to resist under the seismic load. It is calculated as the total seismic weight multiplied by a seismic coefficient. The total weight is 760380.19 KN, and the total base shear in both X and Z directions is 23024.88 KN. The coefficient of 0.0303 is VB/Weight, which is used to calculate the design lateral force required by the code. The identical results for the X and Z directions suggest a symmetrical structural model or an equal distribution of **seismic** forces in the two principal horizontal directions.

3) **Max Displacements of Skywalk:** The maximum vertical displacement (Y-Translation) is -7.624 cm (76.25mm) at Node 8 The maximum Horizontal displacement (X-Translation) is -2.86445cm ie 28.6mm at Node 33

Overall Conclusion: The results for the time period, spectral acceleration coefficient, base shear and displacement in both the x and z directions confirm that the structure has a highly symmetrical and regular geometry, stiffness, and mass distribution, resulting in balanced seismic behavior.

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