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Seismic Analysis of G+20 Story Inclined Sky Bridge Building and Conventional Building

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Abstract: ***Seismic analysis of adjacent buildings linked through Inclined sky bridges using ETABS 2021.This project aims to carry out the Seismic analysis of adjacent buildings connected at different levels with Inclined sky bridges. The study assesses selected alternatives by changing the position of Inclined sky bridges at three sections in height, mid-height (1/2), three quarter-height (3/4), and the top of the buildings. Both static and dynamic earthquake loading cases are imposed, based on the seismic codes, to evaluate inter-story drift, base shear and joint displacements. Buildings with and without sky bridges are compared to measure the effect of Inclined sky bridges. The study reveals the effectiveness of Inclined sky bridges on improving the seismic behaviour by judiciously locating Inclined sky bridges as Lateral displacement and storey drift are typically reduced when Inclined sky bridges are included.***

Keywords: Sky Bridges, High-Rise Buildings, Lateral Loads, Seismic Analysis, Base Shear, story drift, Story Displacement, ETABS.

I. INTRODUCTION

The fast pace of worldly population both contributed with the urban migration has raised the requirement for all the more living and working spaces. Urban areas, which are already suffering from a scarcity of land and a hike in land prices, encounter great difficulty in meeting this increasing demand. Therefore, high-rise has become the alternative to the second line of development. These high-rises are not just a way to efficiently use the land, but a combination of structural engineering, cutting-edge architecture and urban planning. The skyscrapers of today are more than just tall buildings. They represent a more modern and advancing urban life and respond to the increasing demand for sustainable living.

Consistent with such a trend, connecting two or more tall buildings by a sky bridge have been featured as had been implemented in many modern high-rise architectures. Sky bridges offer a whole range of benefits, such as better building connections, safety advantages, increased usability, and aesthetic allure. These high-level connections are particularly convenient in facilitating pedestrian movement between high-rise towers, which diminish dependence on elevators, and provide other evacuations routes in the event of emergency. And they also helps cities thermodynamically by reducing ground level congestion, noise, pollution and traffic problems. In terms of their structure, sky bridges can be built with struts, reinforced concrete, or steel frames, depending on the function and constructional vocabulary of the connected buildings. An outstanding example is the Petronas Twin Towers, where the sky bridge is an important aesthetic feature, as well as an integral part of the fire safety strategy. the Sands Sky Park, which is a gateway-joined sky bridge on the 57th storey, forming a cantilever segment, accomplished as a truss structure, spanning the total three hotel towers within 340 meters with the roof extended to cover and straddle the tops of each integrated tower. The Sky Park-an exceptional “boat-shaped” platform 200 meters above ground The Shanghai World Financial Center, situated in Shanghai, China The sky bridge of SWFC is a crucial connection between either tower and plays a critical role in its structural integrity and iconic image. The 94th-floor sky bridge links several parts of the tower and makes the structure more functional.

II. NUMERICAL STUDY

The study involves the seismic analysis of two structures joined by a Inclined sky bridge located in various locations. Modelling two identically tall, 20-story buildings joined by a sky bridge made of RCC material, with a similar-height of 61.5 m, using ETABS21 software. This building, which is located in seismic zone IV, had its seismic analysis done using the Response Spectrum approach. A comparative analysis is conducted between variables such maximum storey drift, maximum base shear, maximum top storey lateral displacement, and maximum storey displacement.

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A. Details of Building Model

Table 1 Building details

ETAB21	
Floor Height	3m
Stories	20
Tower Height	61.5m
Plan Dimensions	25m*25m
Space B/W Tower	15m
Slab Thickness	120mm
Shear wall Thickness	250mm
Column Size	750mm*750mm
Beam Size In Tower	300mm*500mm
Beam Size In Sky Bridge	300mm*750mm
Bracing	ISMB 250
Length Of Inclined Sky Bridge	17.5m
Width Of Bridge	5m
Inclined Sky Bridge Angle	34.38
Steel Grade	Fe500
Concrete Grade	M30
Density Of Brick Masonry	20 kN/M3

Table 2 Load Specifications

Dead Load	As per IS 875 (p-1)
Live Load	
Roof	1.5 kN /m^2
Other Floor	2.5 kN /m^2
Sky Bridge	4 kN /m^2
Floor Finish	0.5 kN /m^2
Wall Load	
Roof Wall	1.5 kN /m
Outer Wall	13.8 kN /m
Code	IS 1893:2016
Seismic Zone	IV
Importance Factor	1
Soil Conditions	Medium
Damping	5%
Response Reduction Factor (Smrf)	5
Model Combination Method	CQC
Directional Computation Type	SRSS

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Table 3 Legend Clarification

Symbol	Meaning
SCB	Skybridge Configuration
W/O, I10, I15, I20	Inclined skybridge connecting at storey without,10^{th} , 15^{th} , 20^{th} story
EQx/EQy	Static earthquake loading in X/Y direction
RSx/RSy	Dynamic response spectrum in X/Y direction

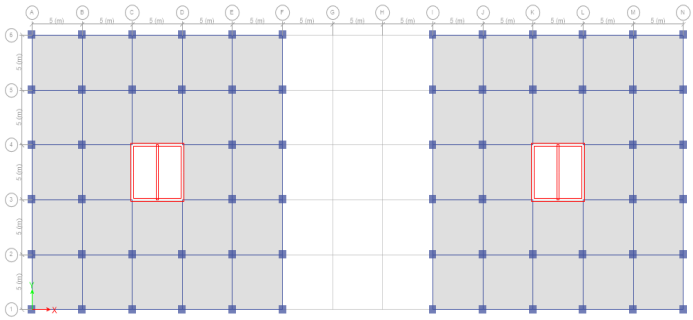


Fig. 1 Building Plan

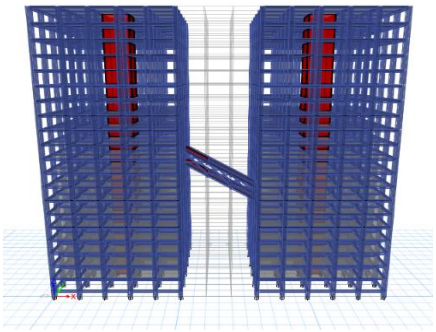


Fig. 2 Building 3D view

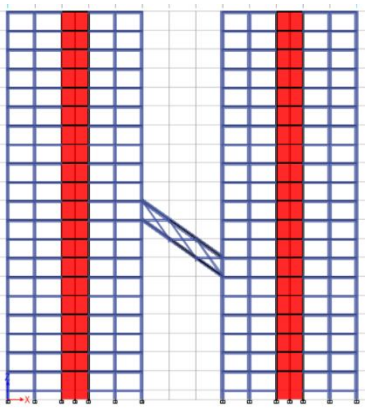


Fig. 3 SCB I10

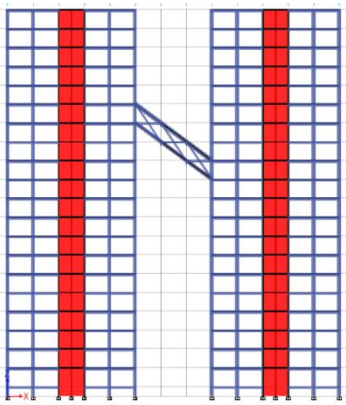


Fig. 4 SCB I15

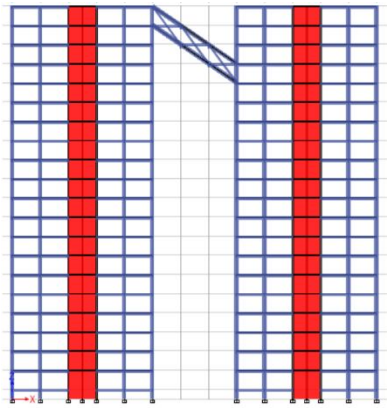


Fig. 5 SCB I20

III. RESULT

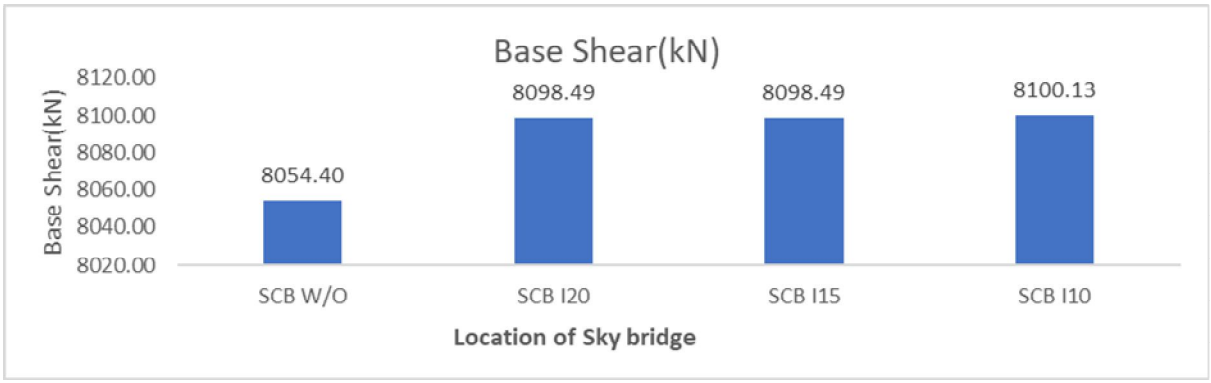


Fig. 6 Building Base Shear

- In 20 floor building connecting by one sky bridge Inclined at 10th ,15th and 20th floor base shear of building is increasing 0.55% to 0.57%

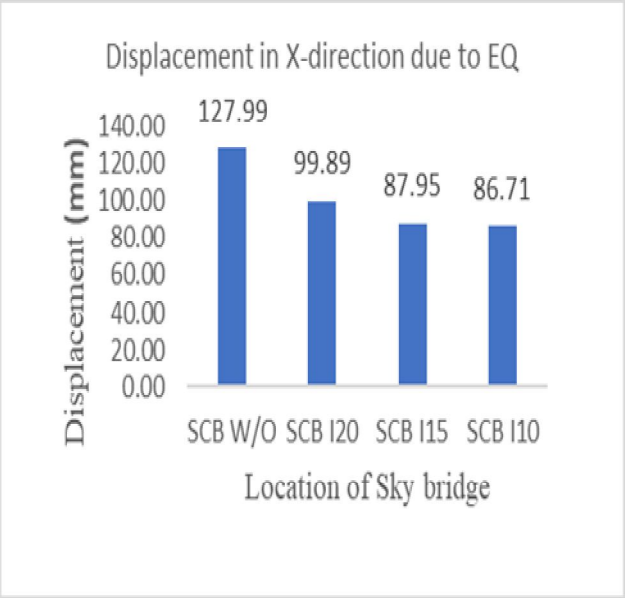


Fig. 7 Displacement in X-direction due to EQ

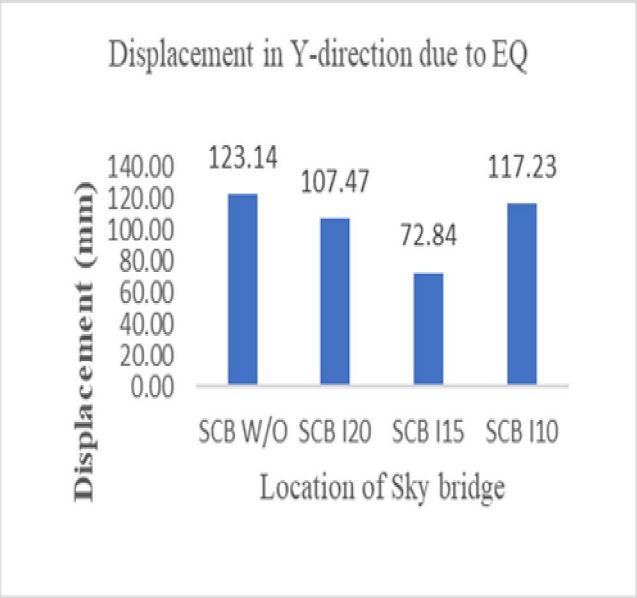


Fig. 8 Displacement in Y-direction due to EQ

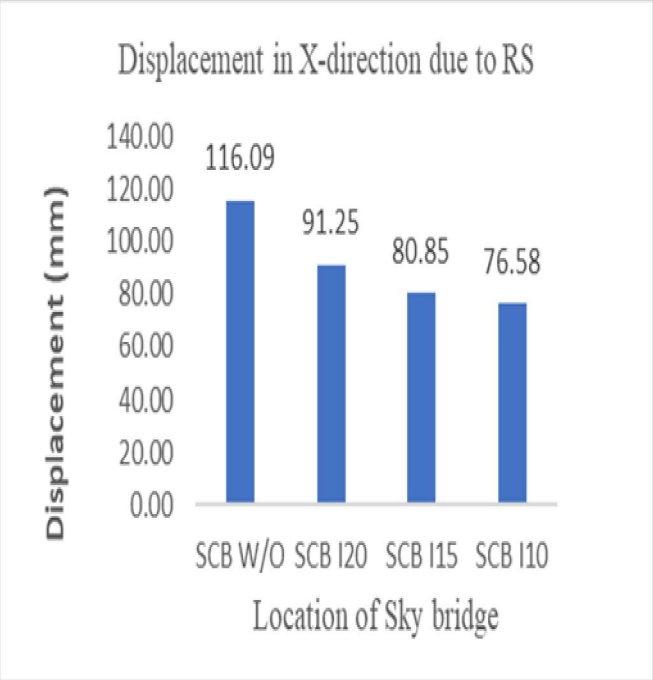


Fig. 9 Displacement in X-direction due to RS

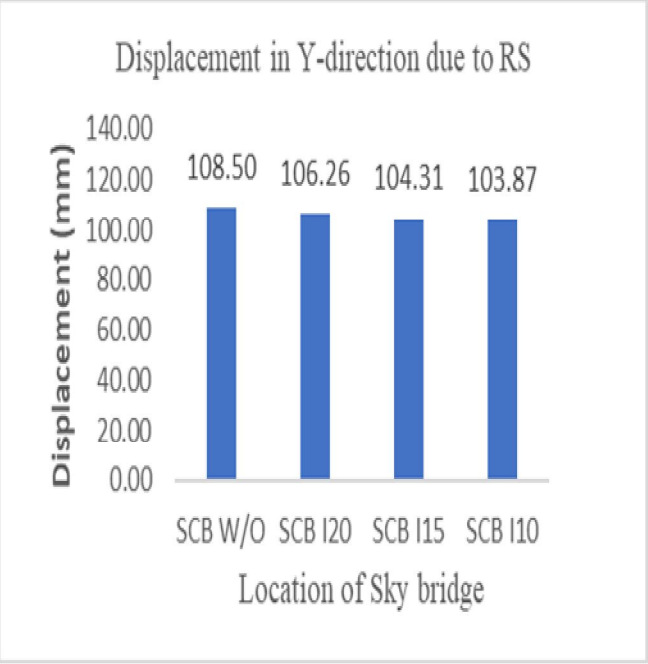


Fig. 10 Displacement in y-direction due to RS

Figure 1 Story Displacement

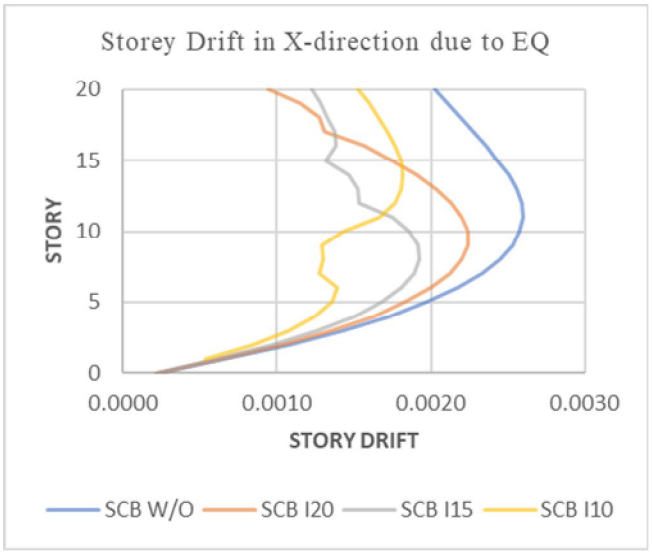


Fig. 11 Storey Drift in X-direction due to EQ

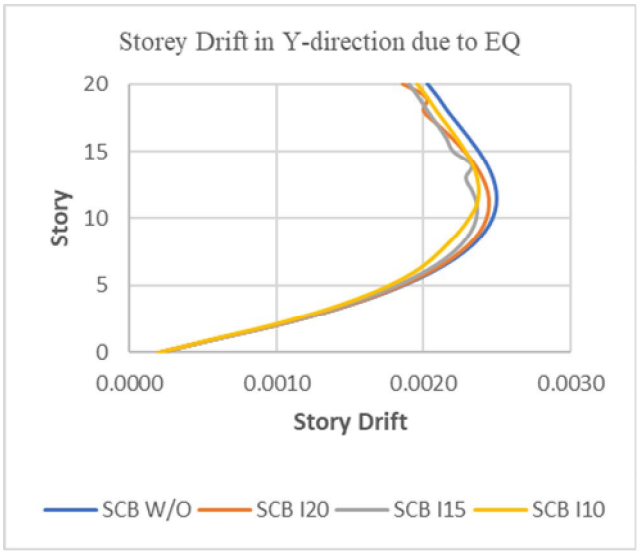


Fig. 12 Storey Drift in Y-direction due to EQ

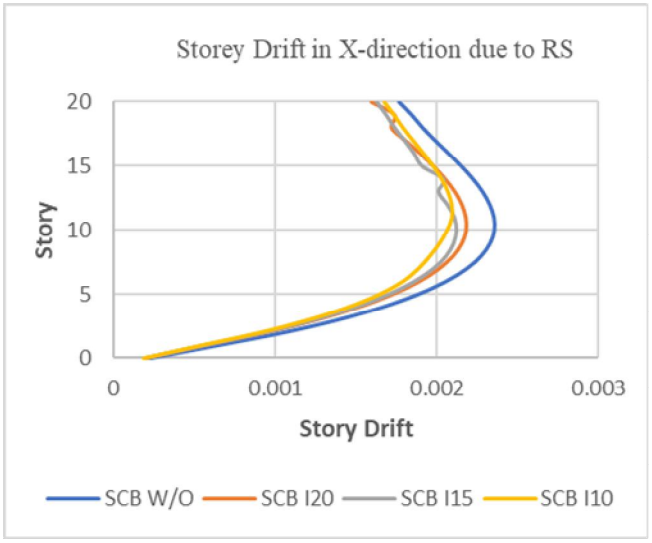


Fig. 13 Storey Drift in X-direction due to RS

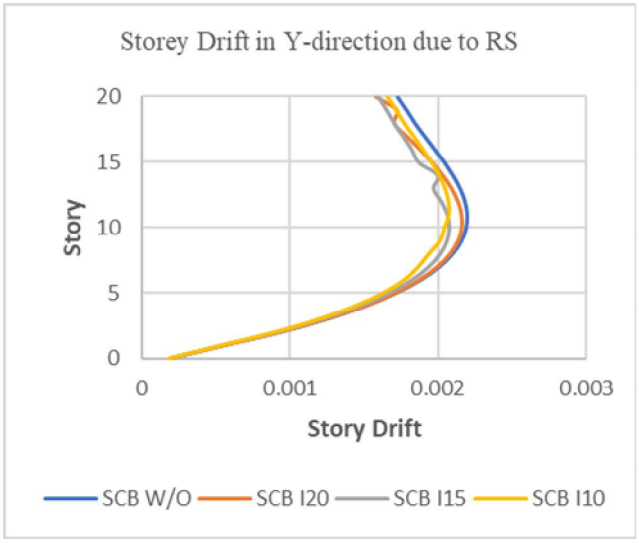


Fig. 14 Storey Drift in Y-direction due to RS

Figure 2 story drift

- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor max story displacement of building is decreasing 22% to 32% in the direction of the bridge.
- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor max story displacement is increasing 4% to 40% along the across side.
- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor max story displacement of building is decreasing 21% to 34% in the direction of the bridge.
- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor max story displacement is decreasing 2% to 4% along the across side.
- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor story drift of building is decreasing 53.5% in the direction of the bridge.
- In 20 floor building connecting by one sky bridge Inclined at 10^{th} ,15^{th} and 20^{th} floor story drift is decreasing 8% along the across side.

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IV. CONCLUSSION

From results of the seismic analysis of two buildings connected by a skybridge, utilizing both the Static Equivalent Method and the Response Spectrum Method in ETABS software. The analysis focused on comparing the seismic performance of buildings with and without a skybridge connection, as well as evaluating the effectiveness of inclined skybridges.

A. Impact on Base Shear

- The addition of inclined skybridges generally increases the base shear of the connected buildings compared to standalone structures.

B. Effect on Maximum Story Displacement

- Inclined Skybridges are generally effective in reducing the maximum story displacement
- A single inclined skybridge (SCB I15-12) shows a significant reduction of 31.28% in EQx and 40.85% in EQy, and 30.35% in RSx.

C. Effect on Story Drift:

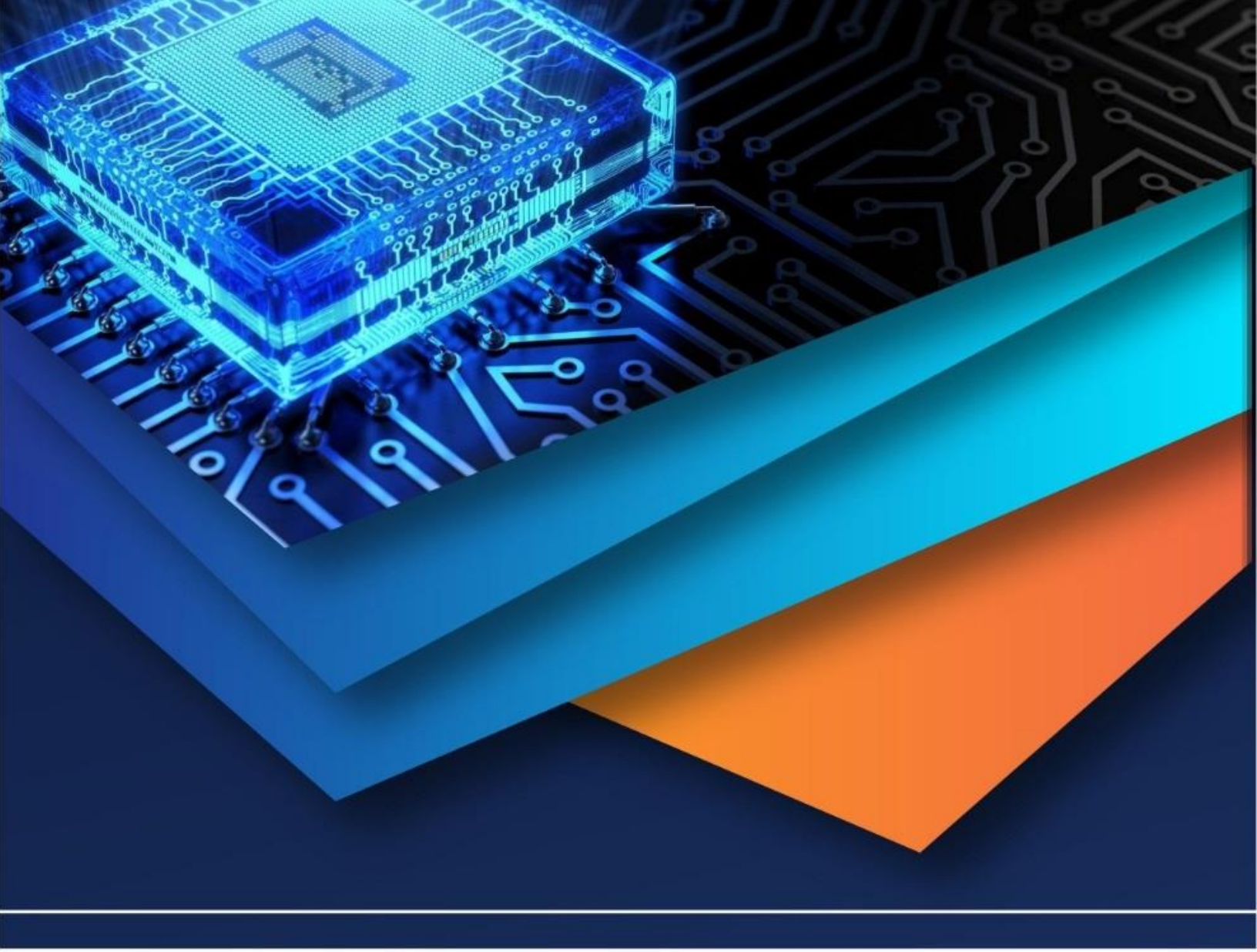
- Building is connected by inclined sky bridge drift is reduction is more in direction of sky bridge, where sightly reduction in across direction.
- SCB I20-17 consistently shows the highest percentage of drift reduction, starting from as high as 53.5%.

Among the different configurations studied, the sky bridge located at the 10th floor (SCB I10) demonstrates the minimum overall displacement, indicating superior stiffness against lateral seismic forces. Conversely, the sky bridge at the 20th floor (SCB I20) results in the maximum percentage reduction in inter-story drift, highlighting its effectiveness in controlling relative movement between stories. However, the configuration with the inclined sky bridge at the 15th floor (SCB I15) offers a well-balanced performance, achieving both significantly reduced displacement and drift.

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