EFFECT OF BRACINGS ON SEISMIC BEHAVIOR OF MULTI-STORIED RC FRAMED STRUCTURE RESTING ON SLOPED GROUND USING ETABS

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Abstract - *At present, India is the country with the largest population in the world. It is increasingly becoming difficult to locate areas to live as there is congestion of space in big cities. This study investigates the G+12 storied structure resting on 10-degree sloped ground surface. The analysis is performed for seismic zone V as per Indian Standards codes by using Response Spectrum Method of Analysis. We have used steel bracings like X, K, V and diagonal for the study. The comparison is made between response parameters like Base Shear, Storey Displacement, Storey Drift and Storey Shear for sloped buildings to conclude about the considered structures in ETABS software through Response Spectrum Method of Analysis. This study helps to understand the performance and behavior of structures on sloped ground using different types of bracings.*

Key Words: **RCC Structure, Bracing Systems, Response Spectrum Analysis, ETABS Software**.

1. INTRODUCTION

Earthquakes are historically and extensively caused due to structural damage in seismic behavior of structure. Bracing systems are provide essential support in earthquake-prone areas and helping to multi-storied buildings remain strong on both level and sloped ground. The various types of bracings such as X, K, V, Inverted chevron and diagonal. To enhance the durability and strength of structure with their effectiveness depends on placement and arrangement. They are mostly used in buildings to improve resistance against horizontal loads. In recent times, fast growth in large cities are caused lack of level land. Due to this it creates a major challenge to engineers for construction of buildings on sloped ground surface. This shows the preparation of complex geometric design and structural irregularities.

1.1 Framed Structures

Structures are most widely adopted frame systems in modern construction. Allowed loads can be efficiently transferred to the foundation to ensure the safety and stability. Such structures are highly effective in resisting vertical loads like, dead & live loads and lateral forces causes by wind or earthquakes. The structures are built to using reinforced concrete and structural steel components for using both combinations depended on to resist loads. These systems are classified as rigid frames, braced frames or moment resisting frames. Today, framed structures are widely provision in multi-storey buildings, industrial facilities and bridges.

1.2 Bracing Systems

Bracing system are structural arrangements to provided in framed buildings are resist lateral loads induced by wind and earthquakes. They consist of inclined members placed between axial load member and flexure member to form a triangulated frame work, which effectively transfers lateral forces to the foundation. In high-rise buildings, bracing systems are essential for increasing structural stiffness and stability. They also help to reduce storey drift during earthquakes, to enhancing overall safety.

1.3 Earthquake Resistant Structures

A Seismic resistant structure is created to seismic forces by assure safety and strength, for minimum damage during a seismic excitation. These structures are completely not in earthquake-proof, they are designed to absorb & it dissipates seismic energy effectively.

1.4 Response Spectrum Analysis

A Response spectrum analysis the method useful for evaluate how the structures respond to earthquakes. To examine structural outcome. It assesses the buildings response to earthquakes and varying seismic intensities. Graphical presentation to of buildings to maximum response and its occurrence helps to design and assessment. It is generally used for dynamic analysis technique in seismic engineering to assess the tremor response of buildings. Each building responds specify to seismic activity based on its natural frequency, damping ratio and mode shapes, which should be considered in design and analysis.

2. OBJECTIVES

The aim of the study is to investigate the seismic behavior of multi-storied RC building on flat ground and sloped ground at an inclination of 10 degrees, its interactive behaviors when added with different types of bracings at different locations.

- To create and analyze a G+12 RC building resting on flat and sloped ground using response spectrum method of analysis.
- Insert X, K, V and diagonal bracings at different locations of the building.
- To compare the results w.r.t seismic behavior i.e., Base Shear, Storey Shear, Storey Displacement and Storey Drift of all the models using tabular columns and graphical figures and conclude with what type for bracing is suitable for a better, safer and economic section.

3. METHODOLOGY

- To create a G+12 RC building model in ETABS.
- To apply different types of loads (Dead load, Live Load and Earthquake Load) and different load combinations as per IS 1893:2016 (Part-1).
- To apply all the parameters of earthquake and perform the analysis using RSM of analysis.
- For the same models, insert the various types of bracings at different locations and perform the analysis.
- To extract the analytical results, tabulate it and represent it in a graphical method for better comparison between each models.
- To compare the final results of seismic performance by seismic parameters like Base Shear, Storey Displacement, Storey Drift and Storey Shear for each models.

Table -3.1: Parameters considered for generation of RC buildings

SL.NO	PARAMETERS	SPECIFICATIONS
1	Type of structure	Commercial
2	No of stories	G+12
3	Total Height of building	45.5 meters
4	Storey height	3.5 m
5	Plan size	35 m x 30 m
6	Column Size	400 x 800 mm
7	Beam Size	300 x 450 mm (X-direction) 300 x 600 mm (Y-direction)
8	Bracing Size	200 x 150 x 10 mm
9	Slab Thickness	150 mm
10	Grade of Concrete	30 N/mm²
11	Grade of Steel	Fe 550 N/mm²
12	Density of Concrete	25 KN/m³
13	Density of Brick	20 KN/m³
14	Bays Width in X-Direction	5 m
15	Bays Width in Y-Direction	6 m
16	Earthquake Load	As per IS 1893-2016
17	Moment Resisting Frame	SMRF
18	Type of Soil	II
19	Zone Factor	0.36
20	Importance Factor	1.5
21	Response Reduction Factor	5
22	Earthquake zone	V

Table -3.2: Various models are considered for RSA

Sl. No	Model	Bracings Type
1.	M-1	Without Bracing
2.	M-2	X-Bracing
3.	M-3	K-Bracing
4.	M-4	V-Bracing
5.	M-5	Diagonal Bracing

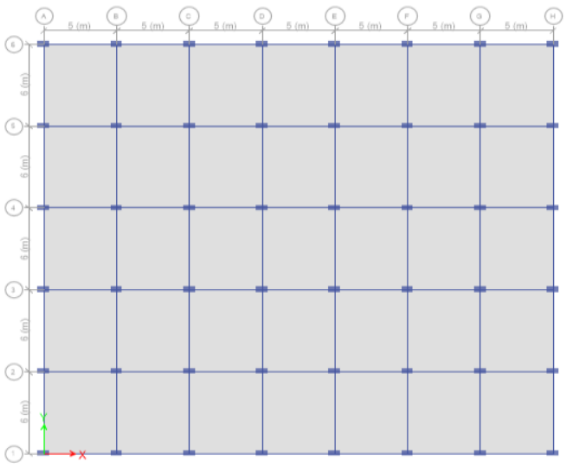

Fig-1: Plan view

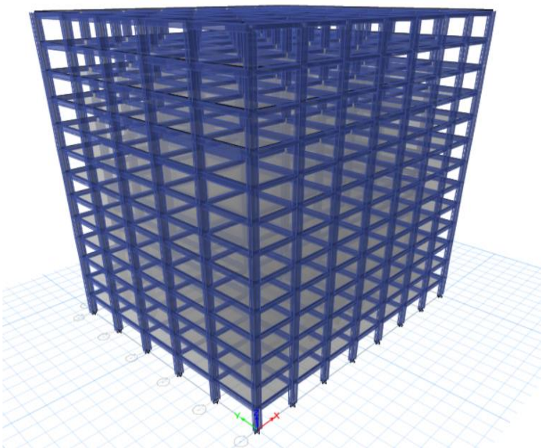

Fig-2: 3D view of RC frame M-1 on FGS

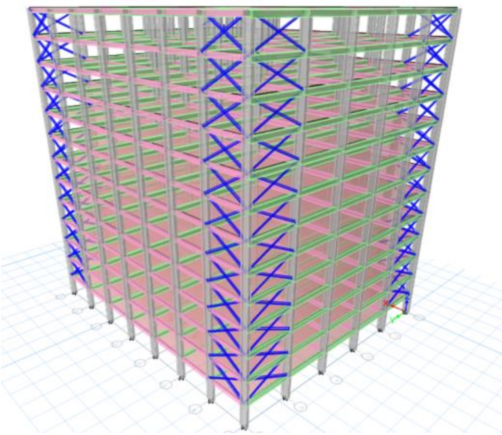

Fig-3: 3D view of RC frame M-2 on FGS

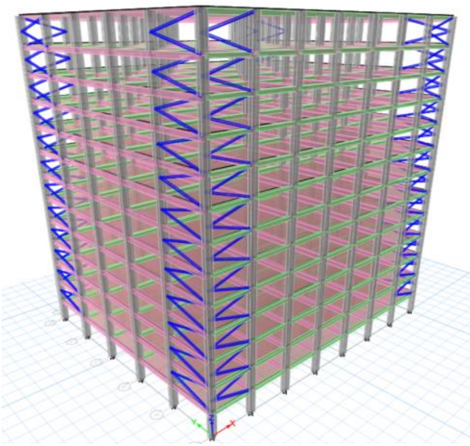

Fig-4: 3D view of RC frame M-3 on FGS

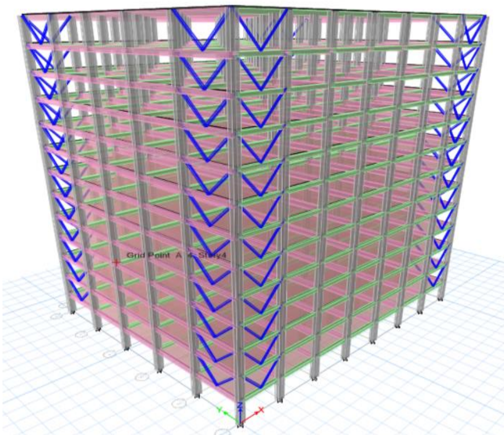

Fig-5: 3D view of RC frame M-4 on FGS

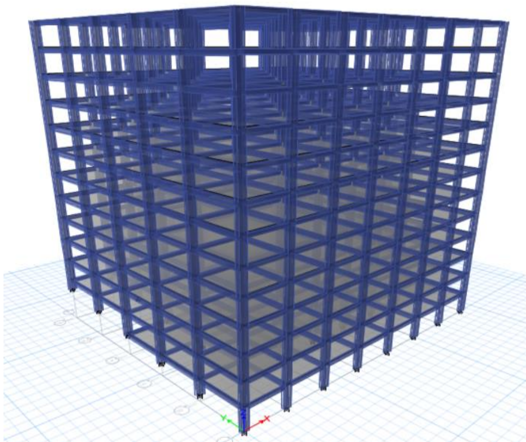

Fig-6: 3D view of RC frame M-1 on SGS

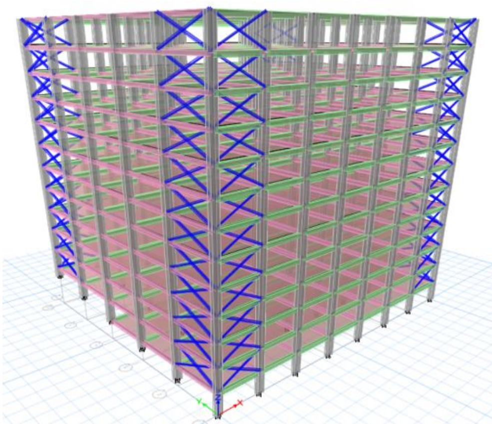

Fig-7: 3D view of RC frame M-2 on SGS

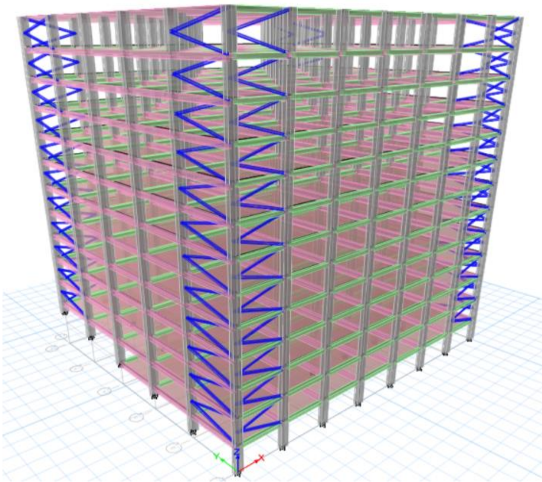

Fig-8: 3D view of RC frame M-3 on SGS

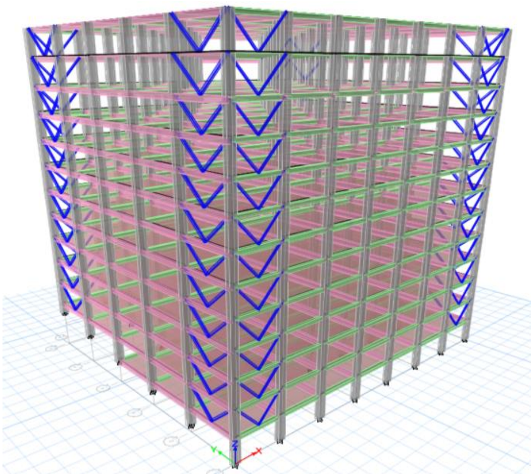

Fig-9: 3D view of RC frame M-4 on SGS

4. RESULTS AND DISCUSSIONS

4.1 Base Shear

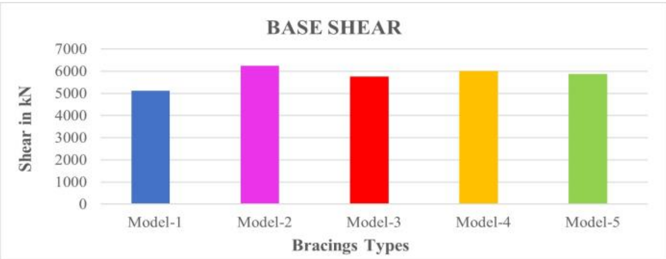

Chart -1: Base Shear variation in X-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that base shear on flat ground surface of Model-2 shows the maximum value is 6238.32 kN and Model-1 shows the minimum value is 5116.03 kN in X-direction. When (Model-2) is compared with (Model-1), then value of base shear decreased by 18%.

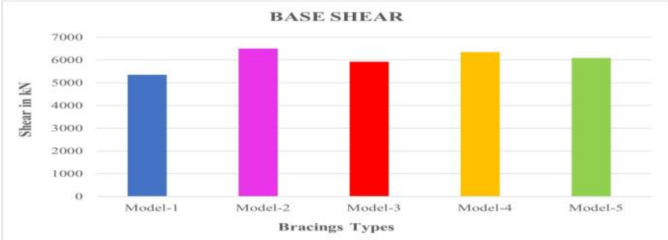

Chart -2: Base Shear variation in Y-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that the base shear on flat ground surface of Model-2 shows the maximum value is 6505.1059 kN and Model-1 shows the minimum value is 5348.0516 kN in Y-direction. When (Model-2) is compared with (Model-1), then value of base shear decreased by 18%.

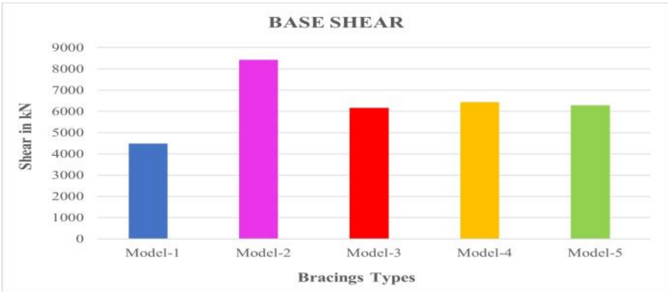

Chart -3: Base Shear variation in X-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly observed that the base shear on sloped ground surface of Model-2 shows the maximum value is 8430.6835 kN and Model-1 shows the minimum value is 4482.0827 kN in X-direction. When (Model-2) is compared with (Model-1), then value of base shear decreased by 47%.

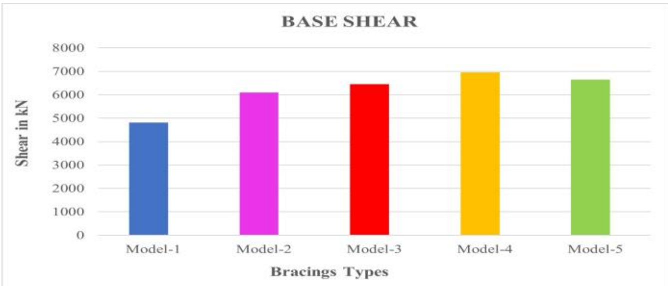

Chart -4: Base Shear variation in Y-dir. for various types of bracings on SGS

4.2 Storey Displacement

Chart -5: Storey displacement variation in X-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that maximum storey displacement on flat ground surface of Model-1 shows the maximum value is 77.486 mm and Model-2 shows the minimum value is 65.679 mm in X-direction. When (Model-1) is compared with (Model-2), then value of displacement decreased by 16%.

Chart -6: Storey displacement variation in Y-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly determined that maximum storey displacement on flat ground surface of Model-1 shows the maximum value is 72.604 mm and Model-2 shows the minimum value is 61.374 mm in Y-direction, when (Model-1) is compared with (Model-2), then value of displacement decreased by 16%.

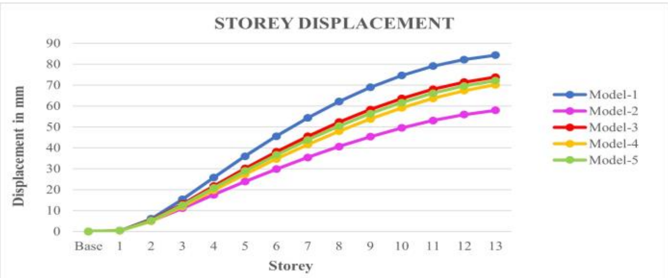

Chart -7: Storey displacement variation in X-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly determined that maximum storey displacement on sloped ground surface of Model-1 shows the maximum value is 84.254 mm and Model-2 shows the minimum value is 57.923 mm in X-direction. When (Model-1) is compared with (Model-2), then value of displacement decreased by 32%.

Chart -8: Storey displacement variation in Y-dir. for various types of bracings on SGS

4.3 Storey Drift

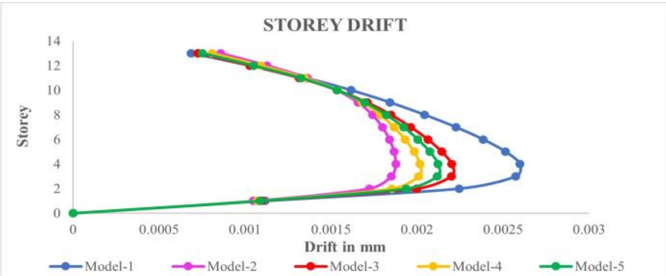

Chart -9: Storey drift variation in X-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that 12-storey structure on flat ground with precise materials and section properties, storey drift of the seismic data in the X-direction of higher value for the Model-1 is 0.002597. When compared with remaining Model values 2, 3, 4 and 5 are lesser respectively.

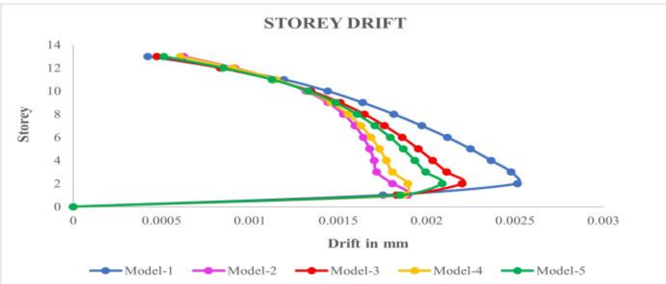

Chart -10: Storey drift variation in Y-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that 12-storey structure on flat ground with precise materials and section properties, storey drift of the seismic data in the Y-direction of higher value for the Model-1 is 0.002478. When compared with remaining Model values 2, 3, 4 and 5 are lesser respectively.

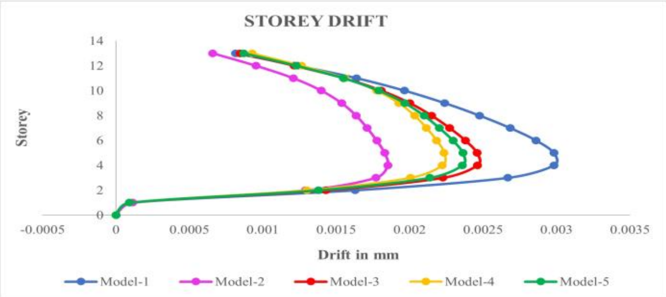

Chart -11: Storey drift variation in X-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly observed that 12-storey structure on sloped ground with precise materials and section properties, storey drift of the seismic data in the X-direction of higher value for the Model-1 is 0.002983. When compared with remaining Model values 2, 3, 4 and 5 are lesser respectively.

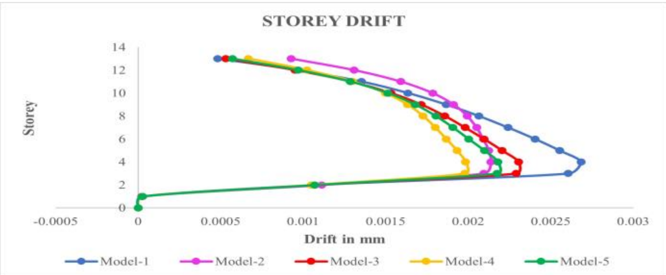

Chart -12: Storey drift variation in Y-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly observed that 12-storey structure on sloped ground with precise materials and section properties, storey drift of the seismic data in the Y-direction of higher value for the Model-1 is 0.002684. When compared with remaining Model values 2, 3, 4 and 5 are lesser respectively.

4.4 Storey Shear

Chart -13: Storey Shear variation in X-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that storey shear on flat ground surface of Model-2 shows the maximum value is 6238.32 kN and Model-1 shows the minimum value is 5116.03 kN in X-direction. When (Model-2) is compared with (Model-1), then value of storey shear decreased by 18%.

Chart -14: Storey Shear variation in Y-dir. for various types of bracings on FGS

From the above graph and tables, it is clearly observed that storey shear on flat ground surface of Model-2 shows the maximum value is 6505.1059 kN and Model-1 shows the minimum value is 5348.0516 kN in Y-direction. When (Model-2) is compared with (Model-1), then value of storey shear decreased by 18%.

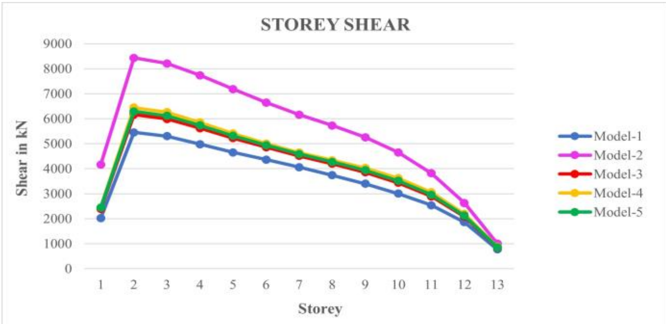

Chart -15: Storey Shear variation in X-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly observed that base shear on sloped ground surface of Model-2 shows the maximum value is 4160.361 kN and Model-1 shows the minimum value is 2019.6807 kN in X-direction. When (Model-2) is compared with (Model-1), then value of storey shear decreased by 52%.

Chart -16: Storey Shear variation in Y-dir. for various types of bracings on SGS

From the above graph and tables, it is clearly observed that base shear on sloped ground surface of Model-4 shows the maximum value is 2088.8935 kN and Model-1 shows the minimum value is 1242.1809 kN in Y-direction. When (Model-2) is compared with (Model-1), then value of storey shear decreased by 41%.

5. CONCLUSIONS

- The analytical results of base shear on FGS of Model-1 shows the maximum value is 6238.3205 kN and Model-2 shows the minimum values is 5116.03 kN in X-direction. The base shear decreased by 18%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of base shear on FGS of Model-1 shows the maximum value is 6505.1059 kN and Model-2 shows the minimum values is 5348.0516 kN in Y-direction. The base shear decreased by 18%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of base shear on SGS of Model-1 shows the maximum value is 8430.6835 kN and Model-2 shows the minimum values is 4482.0827 kN in X-direction. The base shear decreased by 47%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of base shear on SGS of Model-1 shows the maximum value is 6951.6643 kN and Model-2 shows the minimum values is 4812.4329 kN in Y-direction. The base shear decreased by 31%, when (Model-4) is compared with (Model-1) respectively.
- The analytical results of storey displacement on FGS of Model-1 shows the maximum value of 77.486 mm and Model-2 shows the minimum values is 65.679 mm in X-direction. The displacement decreased by 16%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of storey displacement on FGS of Model-1 shows the maximum value is 72.604 mm and Model-2 shows the minimum values is 61.374 mm in Y-direction. The displacement decreased by 16%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of storey displacement on SGS of Model-1 shows the maximum value is 84.254 mm and Model-2 shows the minimum values is 57.923 mm in X-direction. The displacement decreased by 16%, when (Model-1) is compared with (Model-2) respectively.
- The analytical results of storey displacement on SGS of Model-1 shows the maximum value is 70.219 mm and Model-4 shows the minimum values is 59.677 mm in Y-direction. The displacement decreased by 15%, when (Model-1) is compared with (Model-4) respectively.
- The analytical results of storey drift on FGS in X-direction of Model-1 shows the highest value is 0.002597 mm and Model 2, 3, 4 and 5 shows the lowest values respectively.
- The analytical results of storey drift on FGS in Y-direction of Model-1 shows the highest value is 0.002478 mm and Model 2, 3, 4 and 5 shows the lowest values respectively.
- The analytical results of storey drift on SGS in X-direction of Model-1 shows the highest value is 0.002983 mm and Model 2, 3, 4 and 5 shows the lowest values respectively.
- The analytical results of storey drift on SGS in Y-direction of Model-1 shows the highest value is 0.002684 mm and Model 2, 3, 4 and 5 shows the lowest values respectively.
- The analytical results of storey shear on FGS of Model-2 shows the maximum value is 6505.1059 kN and Model-1 shows the minimum values is 5116.03 kN in X-direction. The storey shear decreased by 18%, when (Model-2) is compared with (Model-1) respectively.
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- The analytical results of storey shear on SGS of Model-2 shows the maximum value is 4160.361 kN and Model-1 shows the minimum values is 2019.6807 kN in X-direction. The storey shear decreased by 52%, when (Model-2) is compared with (Model-1) respectively.
- The analytical results of storey shear on SGS of Model-4 shows the maximum value is 2088.8935 kN and Model-1 shows the minimum values is 1242.1809 kN in Y-direction. The storey shear decreased by 41%, when (Model-4) is compared with (Model-1) respectively.

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