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COMPARATIVE ANALYSIS OF STEEL BUILDING ON SLOPING GROUND FOR DIFFERENT ANGLE

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Abstract – *The unpredictable natural disasters like earthquakes leads to the importance of seismic studies. In this research paper we study steel structure on sloping ground where structure is step-back. The structure is totally commercial building. The structure is examined for seismic zone III and soil condition is hard consider. The structure is compared the sloping ground and plain ground and also with and with-out bracing system. The total 24 model is done on ETABS 2019 software. The 12 model is analysis on plain ground and sloping ground with-out Bracing system and 12 model is analysis on plain ground and sloping ground with-Bracing System. The slope is 10-degree, 20-degree and 30-degree. The bracing is applying X-Bracing at outer peripherals and Diamond-Bracing at Center of core. The Models are analysis for various aspect like Story Displacement, Natural period of Oscillation, Base Shear, etc. In this research P-delta is not Consider.*

Key Words: Steel Structure, Step back, Sloping Ground, Bracing, RSM, *Natural period of Oscillation, Base Shear*

1. Introduction

Generally, all buildings are constructed on horizontal plain level ground. In the hilly region having sloping ground it is hard to build the multistory structures. The constructions of the building now days are progress on sloping ground due to lack of horizontal plain level ground. These hill regions are the most hazardous view shows sometimes due to some natural calamities like land sides and seismic activity. The earthquake is the one of the major factors is consider on the sloping and mountainous areas. Thus, due to growing level of heavy population the biggest reason of construction done on mountainous areas.

1.1 Steel Structure

Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity. Structural Steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications. Common shapes include the I-beam, Channels, Angles and Plate. In modern construction, steel structures are used for almost every type of structure including heavy industrial building, high-rise building, equipment support system, infrastructure, bridge, tower, airport terminal, heavy industrial plant, pipe rack, etc

1.2 Scope of the Project

- The structure is (G+10), (G+20), and (G+30) floor for commercial used where floor to floor height 3.5m.
- The building rest on sloping in one side ground where slope is 10, 20, 30 and plain ground under the seismic and wind load.
- The building frame is step back. The structure should be analysis with and without Bracing system.
- The result of this analysis will include base shear, Displacement, natural period of oscillation.
- The conclusion will be finding out and compared with different configuration. At the end, a suitable configuration of building to be used in hilly region is suggested.

1.3 Methodology of Project

- In this research paper I will study the Steel frame With and With-Out Bracing System In plain ground and sloping ground in different angle.
- Modal of structure is done on CSI ETABS
- Analysis of Steel Structure as per IS800:2007.
- Seismic analysis carried out by Response Spectrum Method as per IS 1893:2016 and Wind analysis as per IS875 (part 3):2015.
- Modal is to be run on CSI ETABS software.
- The result should be obtained from ETABS.
- Observed and compare the result like base shear, Natural period of oscillation and displacement, etc.
- Conclusion

2. Model Configuration

There are following model is done on CSI ETABS by Response Spectrum Method and Wind analysis, these are as below.

1. STEEL Frame (G+10) building on plain ground.
2. STEEL Frame (G+20) building on plain ground.
3. STEEL Frame (G+30) building on plain ground.
4. STEEL Frame (G+10) step back building on sloping 10 degree.
5. STEEL Frame (G+20) step back building on sloping 10 degree.
6. STEEL Frame (G+30) step back building on sloping 10 degree.
7. STEEL Frame (G+10) step back building on sloping 20 degree.
8. STEEL Frame (G+20) step back building on sloping 20 degree.
9. STEEL Frame (G+30) step back building on sloping 20 degree.
10. STEEL Frame (G+10) step back building on sloping 30 degree.
11. STEEL Frame (G+20) step back building on sloping 30 degree.
12. STEEL Frame (G+30) step back building on sloping 30 degree.
13. STEEL Frame with Bracing (G+10) building on plain ground.
14. STEEL Frame with Bracing (G+20) building on plain ground.
15. STEEL Frame with Bracing (G+30) building on plain ground.
16. STEEL Frame with Bracing (G+10) step back building on sloping 10 degree.
17. STEEL Frame with Bracing (G+20) step back building on sloping 10 degree.
18. STEEL Frame with Bracing (G+30) step back building on sloping 10 degree.
19. STEEL Frame with Bracing (G+10) step back building on sloping 20 degree.
20. STEEL Frame with Bracing (G+20) step back building on sloping 20 degree.
21. STEEL Frame with Bracing (G+30) step back building on sloping 20 degree.
22. STEEL Frame with Bracing (G+10) step back building on sloping 30 degree.
23. STEEL Frame with Bracing (G+20) step back building on sloping 30 degree.
24. STEEL Frame with Bracing (G+30) step back building on sloping 30 degree.

2.1 Input Data for Models

Table -1: Preliminary Data

Sr. No.	Description	Value
1	Length in X and Y direction	17.5 m
2	Story height	3.5 m
3	Number of Story	(G+10), (G+20) and (G+30)
4	No. of Slope in Degree with respect to horizontal	0, 10, 20, 30 Degree
5	Type of support at base	Fixed
6	Bracing System	Cross-Bracing System at periptery
		Diamond-Bracing System at Center of Core
7	Bracing System Position Show in Fig. 4. to Fig. 7.	This System is use for G+10, G+20 and G+30 at 0 Degree, 10 Degree, 20 Degree, 30 Degree Slope
8	Soil Type	I
9	Seismic Zone (Z)	0.16
10	Importance Factor (I)	1.2
11	Response Reduction Factor for Without Bracing (R)	5
12	Response Reduction Factor for With Bracing (R)	4.5
13	Wind Speed	44m/s
14	Risk Factor (K1)	1
15	Terrain Roughness (K2)	1
16	Topography Factor (K3)	it's Depends on Slope of Ground it is show in Table No. 3.25. and 3.26.
17	Importance Factor (K4)	1
18	Dead Load on Slab	1.5kN/m2
19	Live Load on Slab	3.5 kN/m2
20	Dead Load on Beam	5 kN/m2

2.2 Plan View of Building

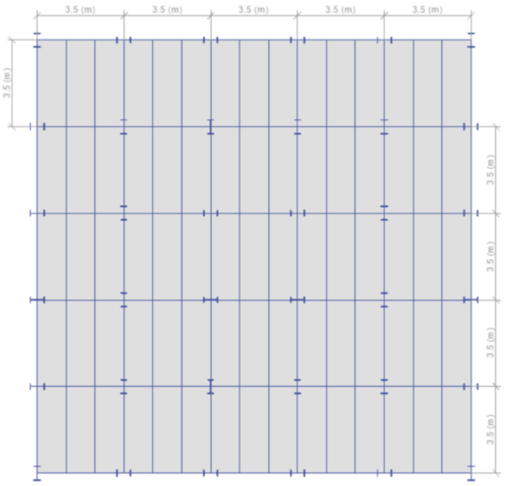


Figure 1: Plan View of Building

2.3 Building Elevation View

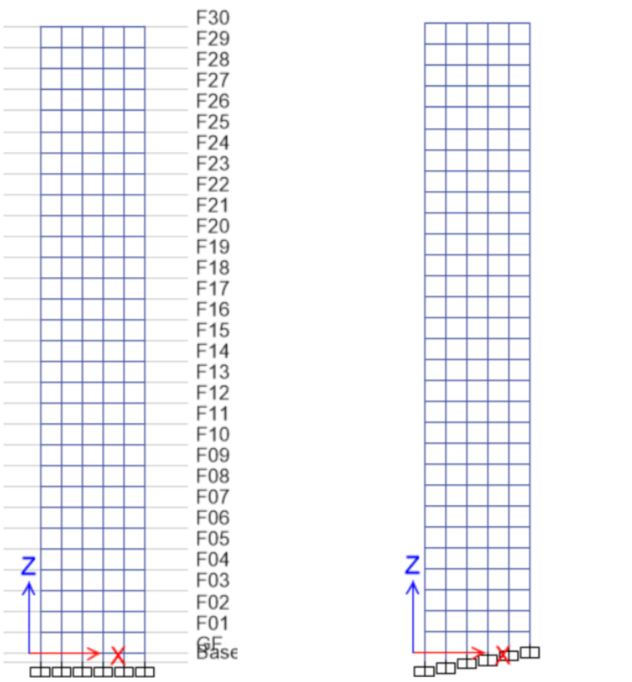


Figure 2: With-out Bracing Steel frame on Plain Ground and 10-Degree Slope

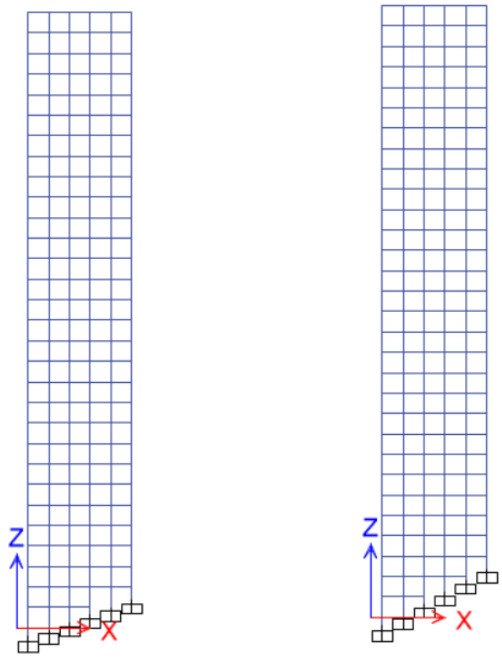


Figure 3: With-out Bracing Steel frame on 20-degree Ground and 30-Degree Slope

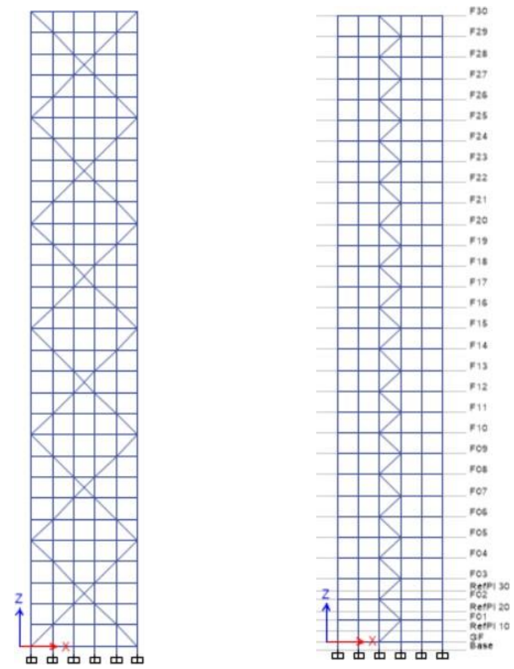


Figure 4: With Bracing Steel frame on Plain Ground

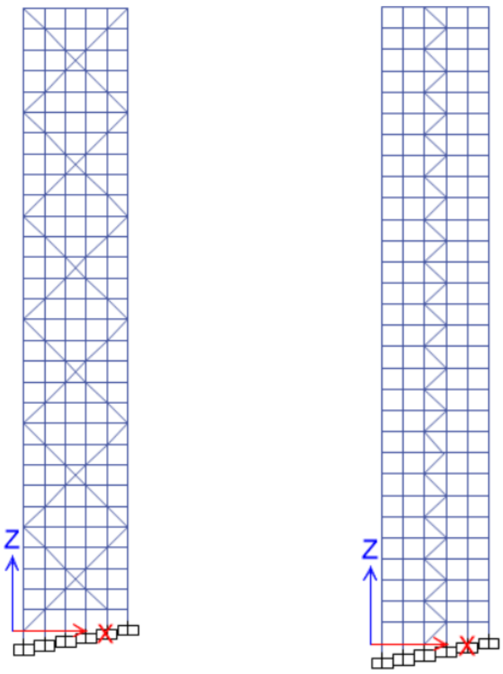


Figure 5: With Bracing Steel frame on 10-degree Slope

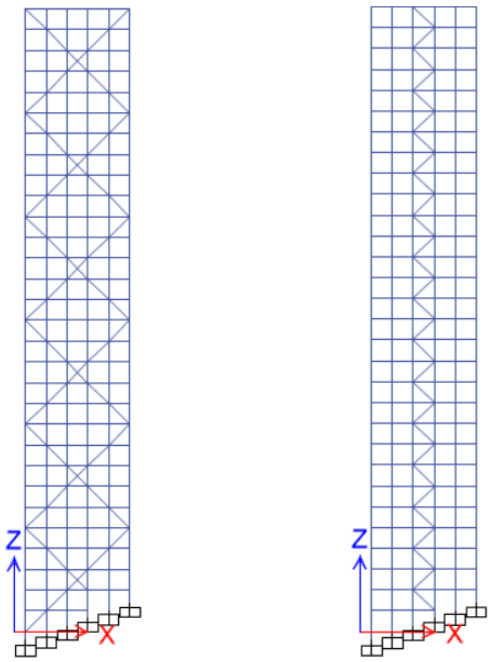


Figure 6: With Bracing Steel frame on 20-degree Slope

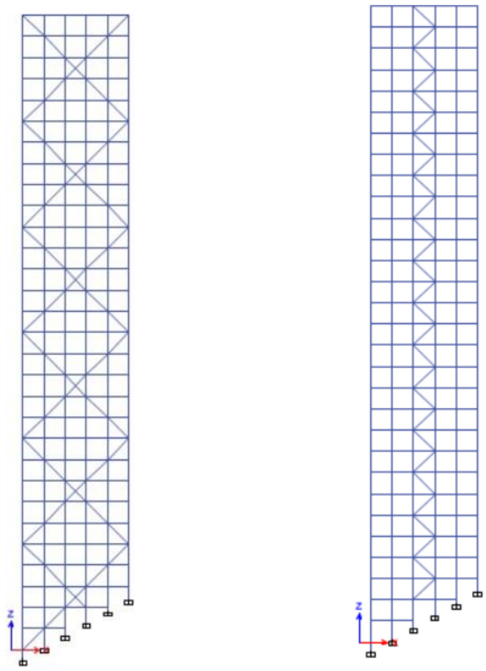


Figure 7: With Bracing Steel frame on 30-degree Slope

3. Result

3.1 Base Shear

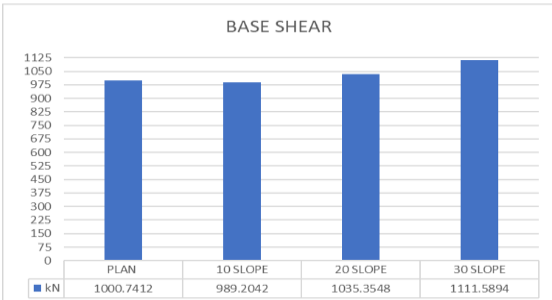


Chart No.1. Base Shear With-Out Bracing System Frame(G+10) Structure

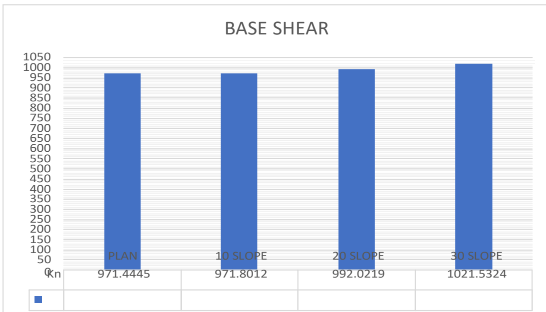


Chart No.2. Base Shear With-Out Bracing System Frame(G+20) Structure

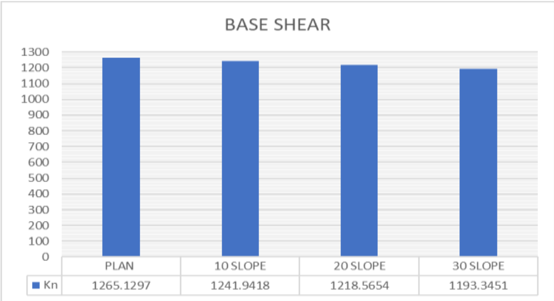


Chart No.3. Base Shear With-Out Bracing System Frame(G+30) Structure

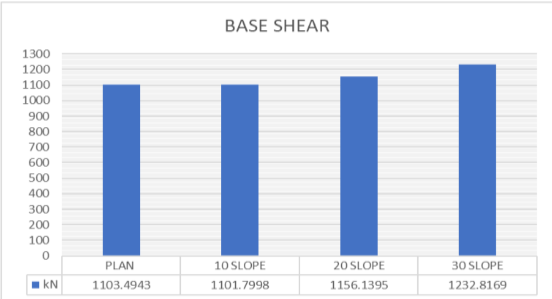


Chart No.4. Base Shear with Bracing Frame System(G+10) Structure

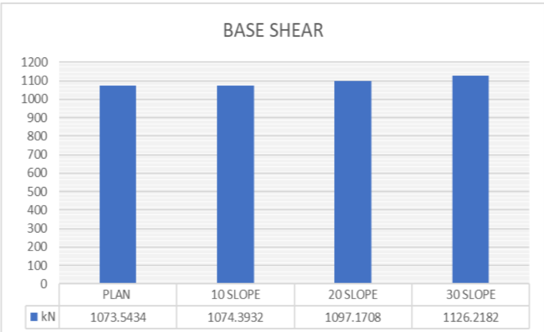


Chart No.5. Base Shear Frame with Bracing (G+20) Structure

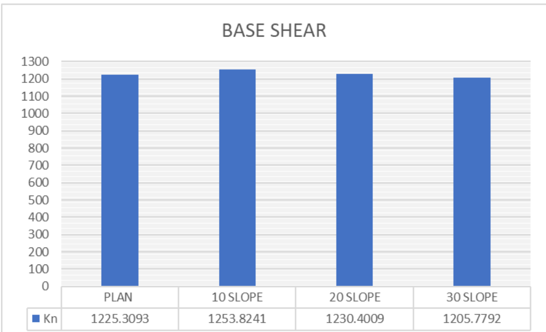


Chart No.6. Base Shear Frame with Bracing (G+30) Structure

3.2 Natural Period of Oscillation

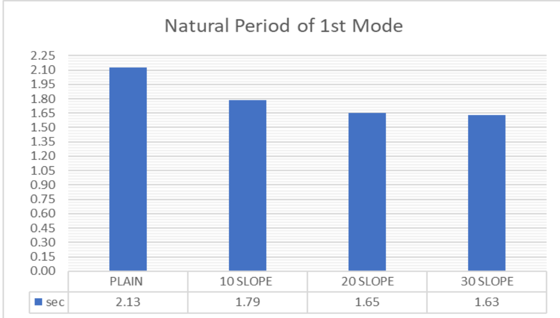


Chart No.7 Fundamental Natural Period With-Out Bracing System Frame(G+10) Structure

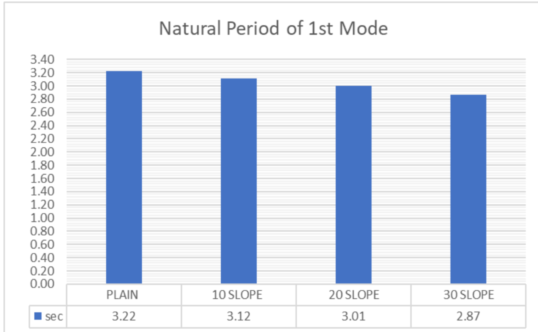


Chart No.8 Natural Period of Mode oscillation With-Out Bracing System Frame(G+20) Structure

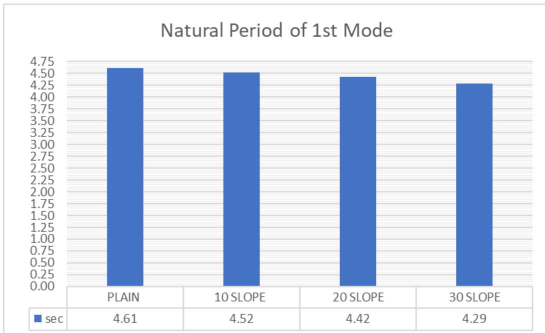


Chart No.9 Natural Period of Mode oscillation With-Out Bracing System Frame(G+30) Structure

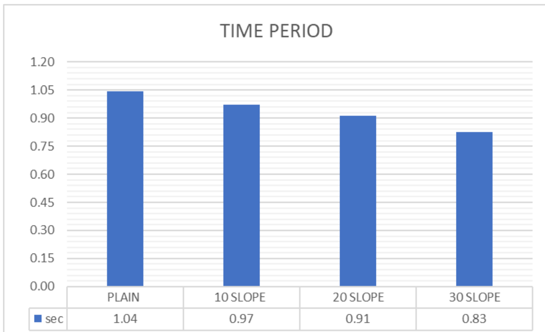


Chart No.10 Natural Period of Mode oscillation With Bracing Frame System(G+10) Structure

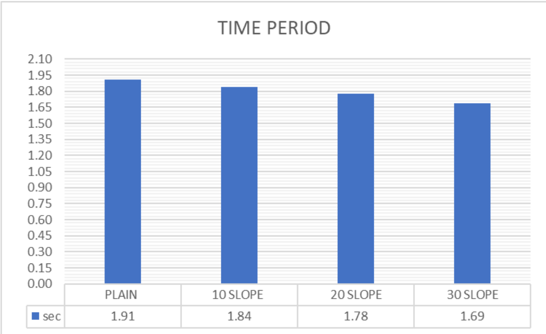
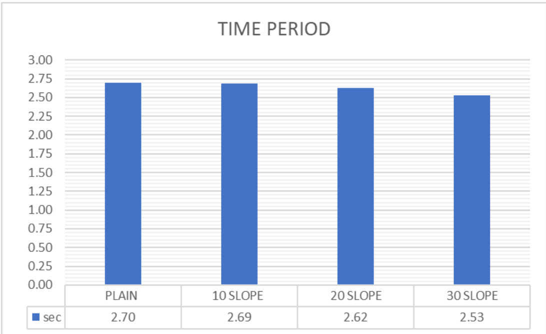


Chart No.11 Natural Period of Mode oscillation With Bracing Frame System(G+20) Structure



hart No.12 Natural Period of Mode oscillation With Bracing Frame System(G+30) Structure

3.3 Maximum story Displacement for Seismic Load

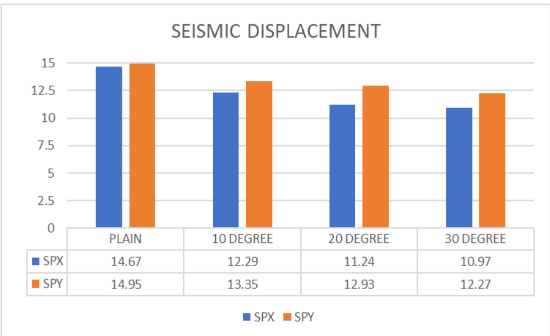


Chart No.13 Seismic Displacement With-Out Bracing frame System (G+10) Structure

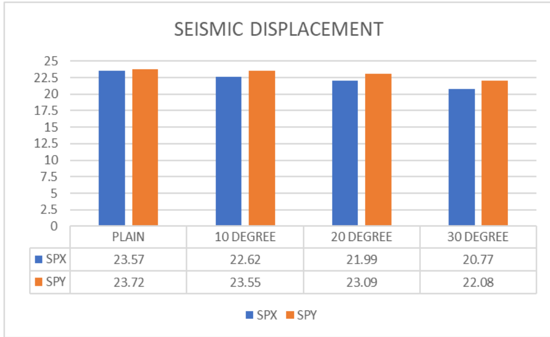


Chart No.14 Seismic Displacement With-Out Bracing frame System (G+20) Structure

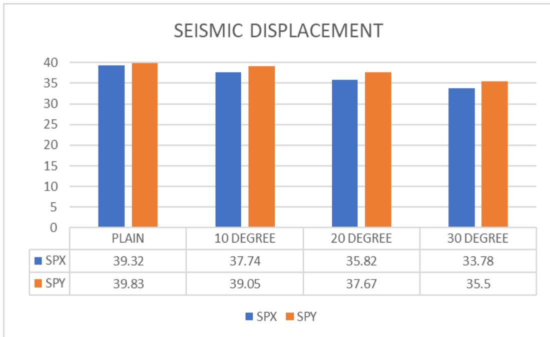


Chart No.15 Seismic Displacement With-Out Bracing frame System (G+30) Structure

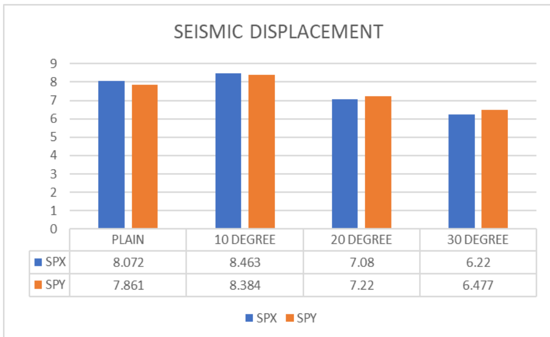


Chart No.16 Seismic Displacement With Bracing frame System (G+10) Structure

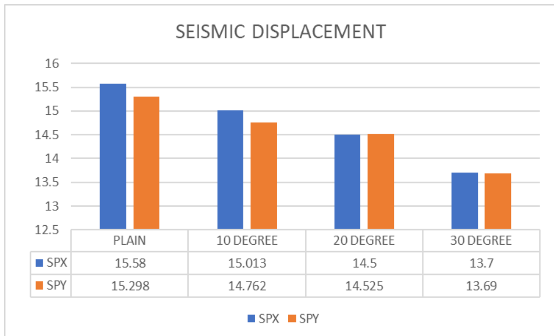


Chart No.17 Seismic Displacement With Bracing frame System (G+20) Structure

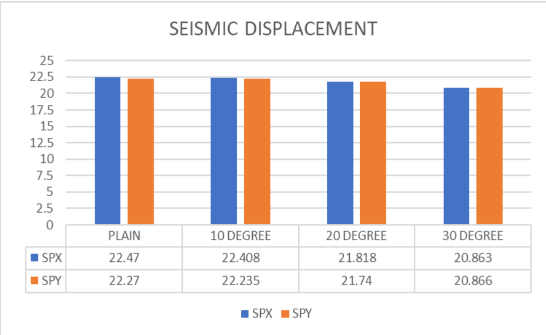


Chart No.18 Seismic Displacement With Bracing frame System (G+30) Structure

3.4 Maximum story Displacement for Wind Load

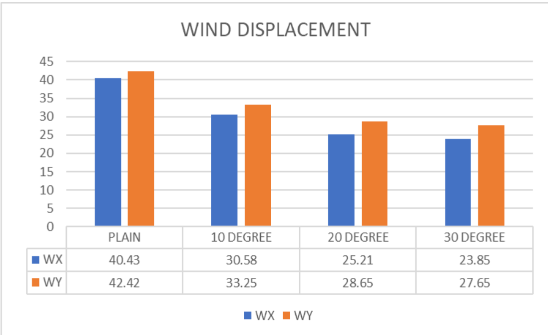


Chart No.19 Wind Displacement With-Out Bracing frame System (G+10) Structure

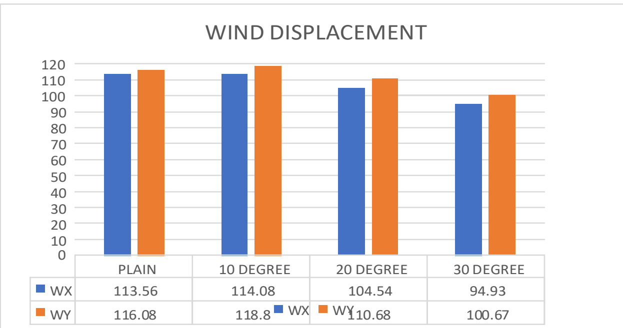


Chart No.20 Wind Displacement With-Out Bracing frame System (G+20) Structure

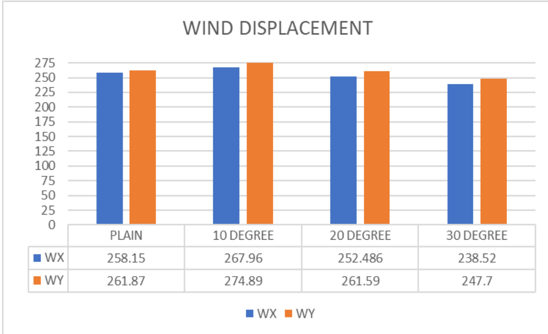


Chart No.21 Wind Displacement With-Out Bracing frame System (G+30) Structure

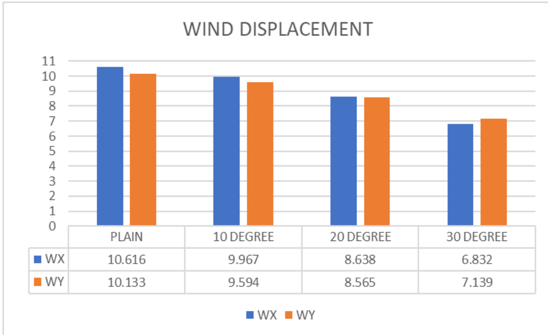


Chart No.22 Wind Displacement With Bracing frame System (G+10) Structure

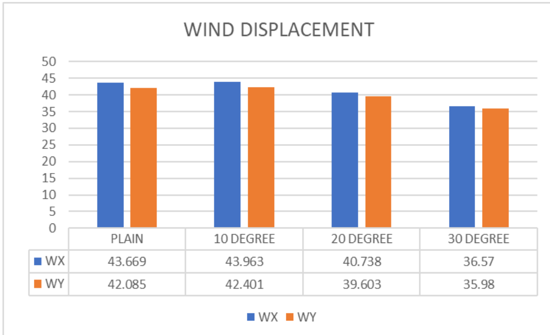


Chart No.23 Wind Displacement With Bracing frame System (G+20) Structure

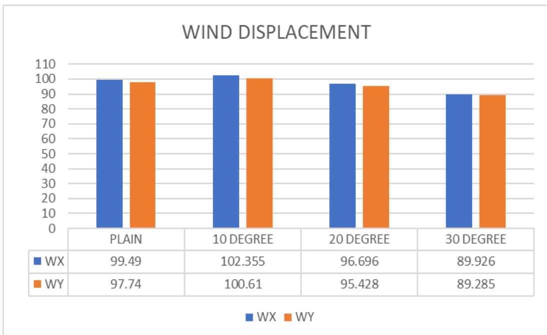


Chart No.24 Wind Displacement With Bracing frame System (G+30) Structure

4. Discussion

1. As per IS 1893, The Mass of participation is 65% in first their mode and structure is safe from torsion.
2. After analysis model, The Natural Period of mode Oscillation is Decrease, when Slope of structure is increased.
3. All structural are safe in Torsional Irregularity.
4. . In G+10 and G+20 Bracing system the Base Shear is increased, When the slope is increased.
5. In G+30 the Base Shear is observed, The Base Shear is Decreasing because of the Seismic Coefficient is less than 1.1%.
6. In G+10, G+20 with and with-out bracing structure it is observed that, The Base Shear is increased because of fundamental natural time period is decreased. And also, the weight of building is decreased when slope is increased
7. . In Natural Period of oscillation get 41% difference in with-out bracing system and with bracing system. If bracing system is applying the Natural Period of oscillation is decrees 41%.
8. Compare plain ground and sloping ground. The Natural Period of Oscillation is decreased. In G+10 with-out Bracing system average 20% decreased and with Bracing system average12% decreased. Where in G+20 with-out Bracing system and with Bracing average 6% decreased. And in G+30 with-out Bracing system average 4% decreased and with Bracing system average 2% decreased.
9. The without Bracing system G+10 and G+20 structure is safe in deflection but G+30 is not safe in wind deflection it is cross the limit (H/500). The G+30 structure required Bracing system.
10. The wind load is increased when the slope is increased because as per topography factor (K3) is based on topography dimension. When the slope is increased (K3) factor is also change, at 10-degree slope the 4% force is increased and at 20-degree and 30-degree slope 3.6% force is increased.

5. Conclusions

1. After comparison it is observed that G+10 and G+20 structure can stable with-out Bracing but more than 20 story structure required Bracing System.
2. In this case G+30 story structure is better performance in Bracing System.
3. Comparison between Bracing system and with-out bracing system, if we add bracing system then stiffness of structure is increase and Because of increase stiffness, Decrease the mode of oscillation.
4. After analysis the model, the G+30 with-out Bracing system structure is unsafe.
5. After analysis the model, observed that when the slope is increased need to provided more stiffness for column up to sloping area.
6. It is observed that when the slope is increased then deflection of structure is also increased in Gravity (DLLL).

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... IS 16700:2017
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[7] Refer Books: - Steel Structures by B. C. Punmia Ashok Jain, Arun Jain
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BIOGRAPHIES

Mr. Siddhesh Bholanath Wavale has completed his BE from Mumbai University. He is currently pursing his ME structural Engineering from MGM college of Engineering and Technology, kamothe, Panvel. He has total work experience of 5 years and is currently working at CBM engineer company in high-rise multi-story project.