Response of Multistory Building Located on 20^0 and 30^0 Sloping Ground under Seismic Loading

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Abstract – *Construction space on plain ground is main criteria now days since there is the scarcity of land and it has been observed that the construction site shifted on hill. Since the main thing is how to maintain the structure that would not to be collapse under seismic activities and under sloping ground. Construction on steep slope is very hard since the structural weight is transferring on slope. The objective of the present study is to perform the analysis and comparison of building situated on plane ground and on sloping ground. For sloping ground, step back structures and step back set back structures were taken and total 5 building cases B1 to B5 analyzed by software approach. To determine how the structural design parameters evolve by taking 20 degree and 30 degree slope. Basic parameters such as shear forces, bending moments, torsional moments in both beams and columns are taken into account. Staad pro software with response spectrum method is used in this work. Building with Step Back Set Back configuration (30 degree inclination) suited the best of all the structural cases.*

Key Words**: Hill slope angle, Multi-story building, Response spectrum analysis, Seismic forces, Sloping Ground, Step back frame, Step back set back frame.**

1. INTRODUCTION

Indian seismic zones define the shaking properties of the ground, since it is highly recommend designing the structure seismic proof. All the structures should be analyzed before the construction since there are many possibilities of failure. But what if the structure supposed to be constructed on hill like in northern and north eastern states of India. Since the slope varies there are many possibilities that during an earthquake, structure would collapse down from a hill. To make the structure which maintain its own stability under steep slope under earthquake.

Step Back Structures:- The structure maintaining its horizontal plane same as under plain ground but the lower part maintain its sloping position.

Step Back Set Back Structures:- The structure not maintaining its horizontal plane but arrange just like steps and the lower part maintain its sloping position.

2. AIM OF THE PRESENT STUDY

In seismic prone regions, there are many possibilities of hazard or destruction to a structure. To make the structure seismic proof it is essential to analyze the multistory building on 20 degree and 30 degree sloping ground under earthquake effects to determine its design parameters. The various purposes of this work are as follows:

1. To explore the possibilities of overall structural resistance of Step back and Step back set back structure at 20^0 and 30^0 on hill slope.
2. To take different cases and comparing them among each other by using Response Spectrum Method of dynamic analysis using Staad pro software.
3. To determine maximum Axial Forces in columns at ground level for various cases.
4. To find and examine maximum Shear Forces in columns for various cases.
5. To show the variation of maximum Bending Moments in columns for various cases.
6. To investigate maximum Shear Forces in beams parallel to X and Z direction for various cases.
7. To study and compare maximum Bending Moments in beams along X and Z direction for various cases.
8. To evaluate maximum Torsional Moments in beams along X and Z directions.

3. MODELING OF VARIOUS STRUCTURAL CASES

For this study, a standard residential G+ 8 storied building is taken having story height of each floor is 3.66 m and overall building height is taken as 36.60 m. The size of beams is taken as 500 mm x 300 mm, interior and exterior columns are 450 mm x 450 mm and thickness of slab is 125 mm respectively. The built up area of the structure is taken as 288 sq. m. A total of 5 building cases have taken for analysis after analyzing various research papers. These cases are numbered as CASE B1 to B5 mentioned below consist of building on plain ground, step back configuration with 20 degree and 30 degree inclination and Step back set back configuration with 20 degree and 30 degree inclination such that these modeled structures are situated on sloping ground.. Dead load as per IS 875 part I is taken as 12 KN/m2 on intermediate floors, 10 KN/m2 on roof, Live load as per IS 875 part II is taken as 2 KN/m2. Zone factor is taken as 0.36, Importance factor taken as 1, response reduction factor taken as 5.

The fundamental natural period (Ta) for moment resisting frame building with brick infill panels are taken for both X and Z direction by using formula:-

$$T_a = \frac{0.09h}{\sqrt{d}}$$

All the cases are assumed to be placed over medium soil condition and situated at earthquake zone V as per Indian Standard. Modeling and analyzing are performed in Staad Pro software.

4. VARIOUS CASES WITH RESPECT TO DIFFERENT BUILDING CONFIGURATIONS

- CASE B1 - General building on plane ground (0 degree inclination)
- CASE B2 – Building with Step Back configuration (20 degree inclination)
- CASE B3 - Building with Step Back configuration (30 degree inclination)
- CASE B4 - Building with Step Back Set Back configuration (20 degree inclination)
- CASE B5 - Building with Step Back Set Back configuration (30 degree inclination)

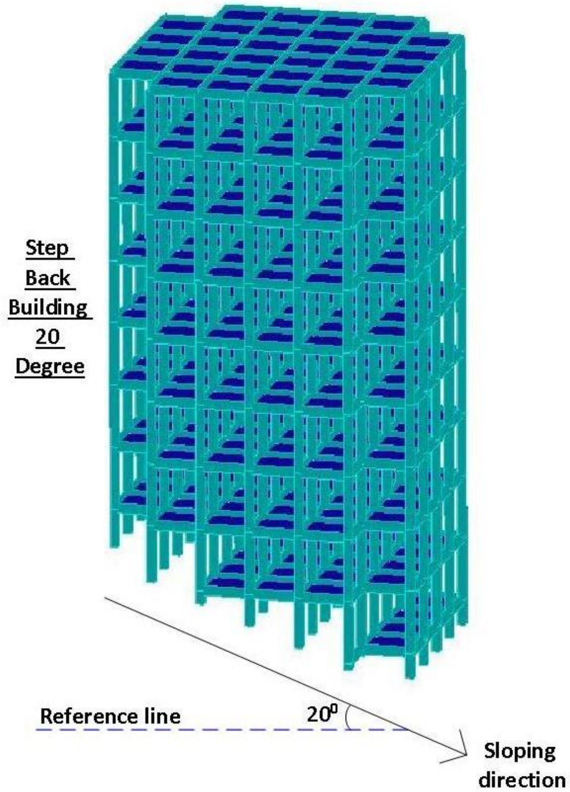


Fig -2: Step Back Building 20 Degree

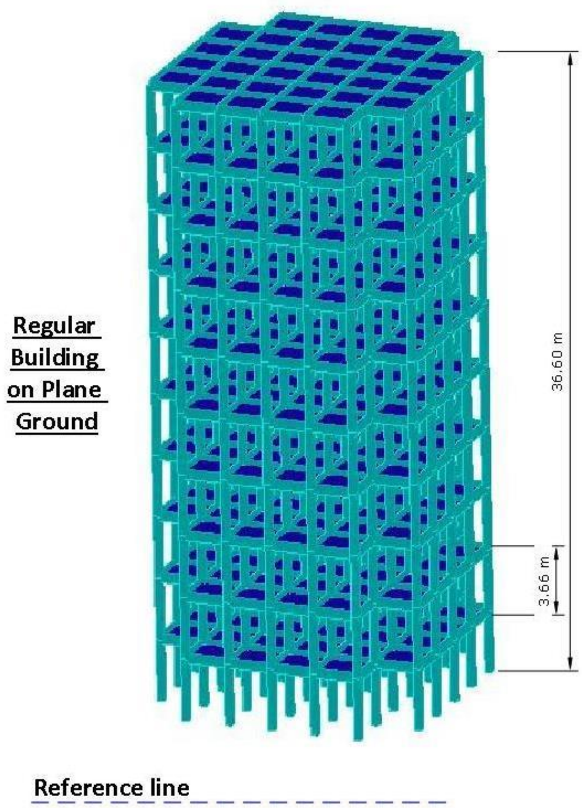


Fig -1: Regular Building on Plane Ground

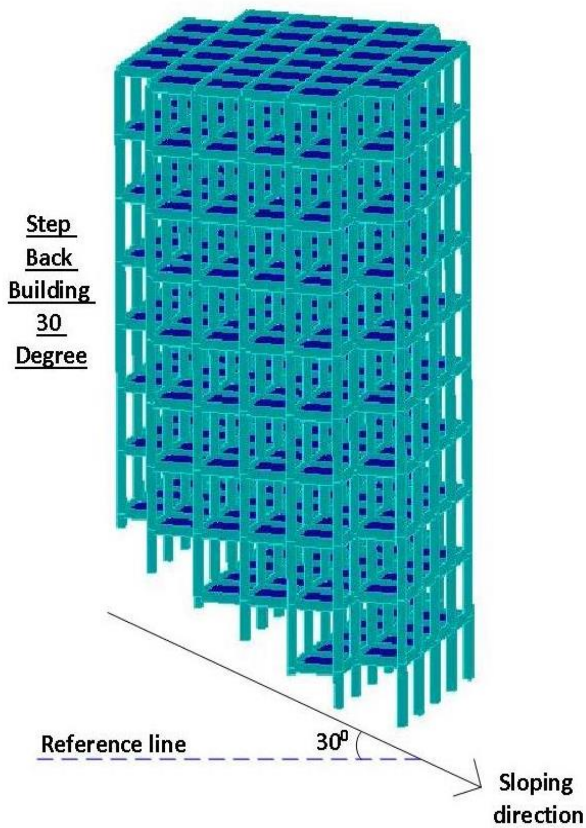


Fig -3: Step Back Building 30 Degree

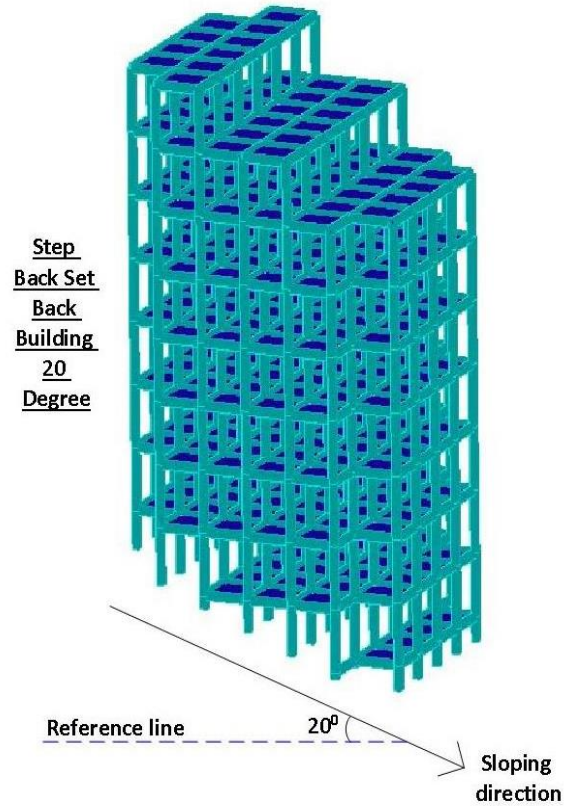


Fig -4: Step Back Set Back Building 20 Degree

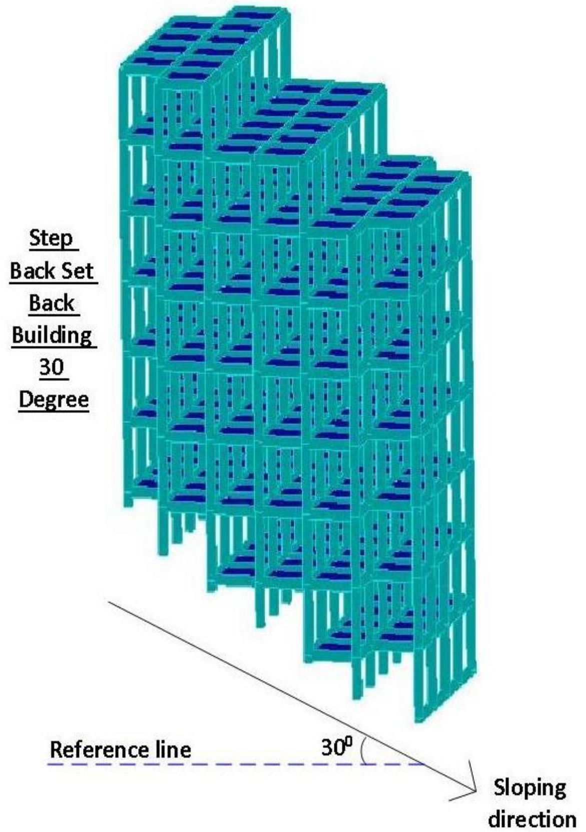


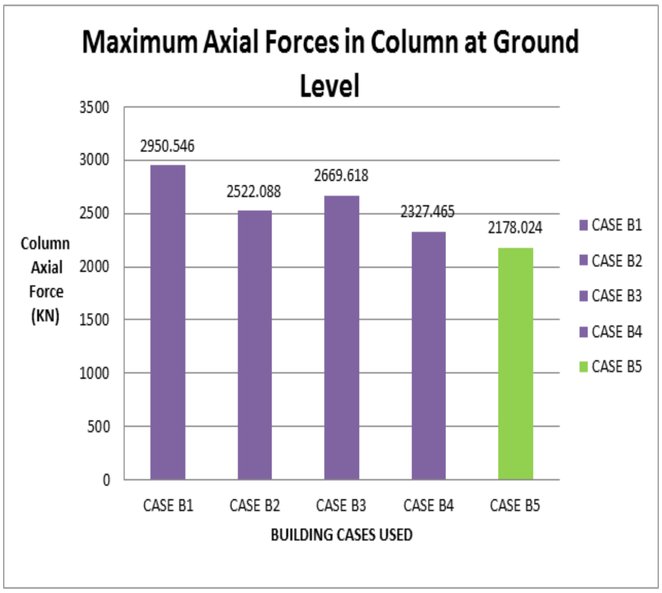
Fig -5: Step Back Set Back Building 30 Degree

5. COMPARATIVE ANALYSIS OF OBTAINED RESULTS

By using response spectrum method, all the five building modeled cases are modeled and analyzed systematically by taking earthquake effects in both the directions. Comparison of the selected cases are done keeping in mind the step back and step back set back frame of 20 degree and 30 degree over a hilly slope Results evaluated by software approach are shown both in tabular form as well as graphical form.

Table -1: Maximum Axial Forces in column at ground level

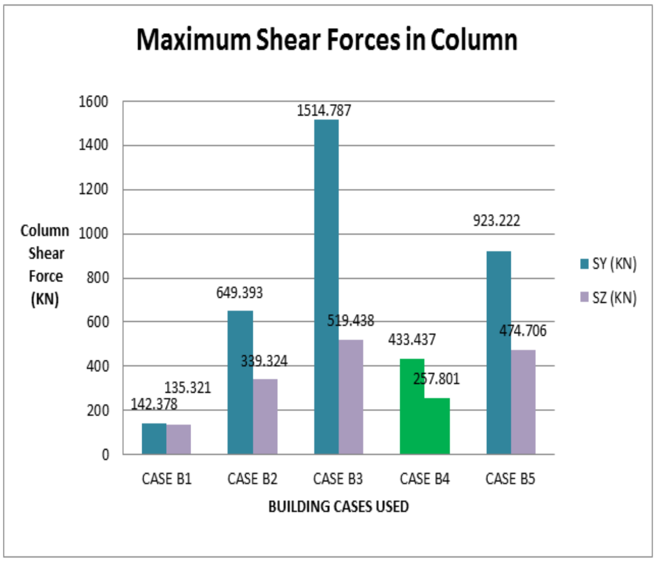
CASES	Column Axial Force (KN)	Case that creates least axial force
CASE B1	2950.546	CASE B5 (comparing the worst case in sloping ground)
CASE B2	2522.088	
CASE B3	2669.618	
CASE B4	2327.465	
CASE B5	2178.024	



Graph -1: Graphical representation of Maximum Axial Forces in column at ground level

Table -2: Maximum Shear Forces in columns

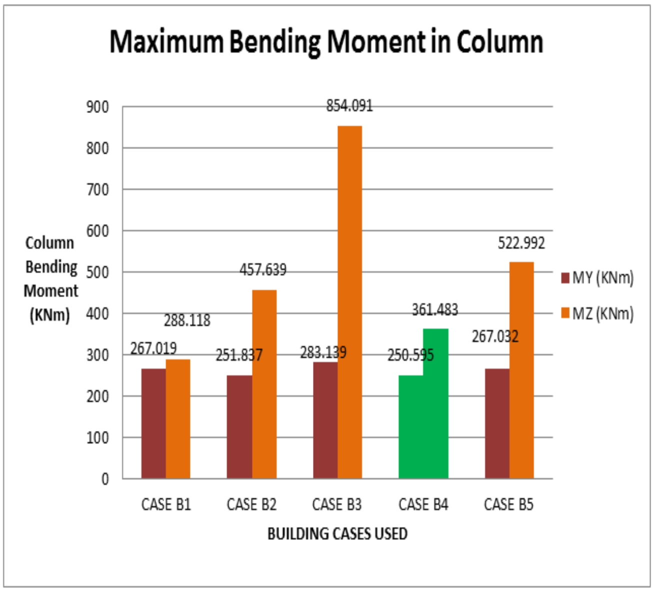
CASES	Column Shear Force (KN)		Case that creates least shear force
	Shear along Y	Shear along Z	
CASE B1	142.378	135.321	CASE B4 (comparing the worst case in sloping ground)
CASE B2	649.393	339.324	
CASE B3	1514.787	519.438	
CASE B4	433.437	257.801	
CASE B5	923.222	474.706	



Graph -2: Graphical representation of Maximum Shear Forces in columns

Table -3: Maximum Bending Moment in columns

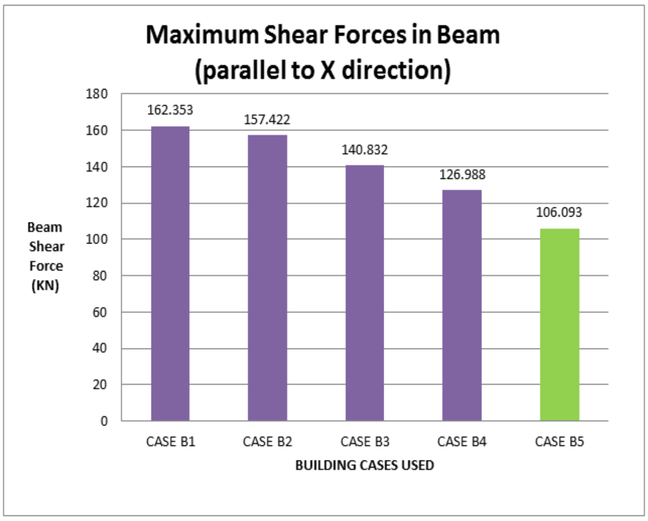
CASES	Column Bending Moment (KNm)		Case that creates least bending moment
	Moment along Y	Moment along Z	
CASE B1	267.019	288.118	CASE B4 (comparing the worst case in sloping ground)
CASE B2	251.837	457.639	
CASE B3	283.139	854.091	
CASE B4	250.595	361.483	
CASE B5	267.032	522.992	



Graph -3: Graphical representation of Maximum Bending Moment in columns

Table -4: Maximum Shear Forces in beams parallel to X direction

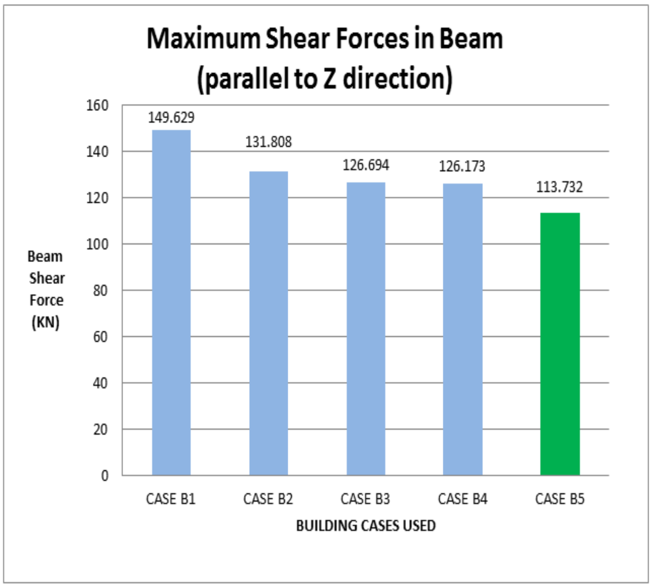
CASES	Beam Shear Force (parallel to X direction) (KN)	Case that creates least shear forces in beams
CASE B1	162.353	CASE B5 (comparing the worst case in sloping ground)
CASE B2	157.422	
CASE B3	140.832	
CASE B4	126.988	
CASE B5	106.093	



Graph -4: Graphical representation of Maximum Shear Forces in beams parallel to X direction

Table -5: Maximum Shear Forces in beams parallel to Z direction

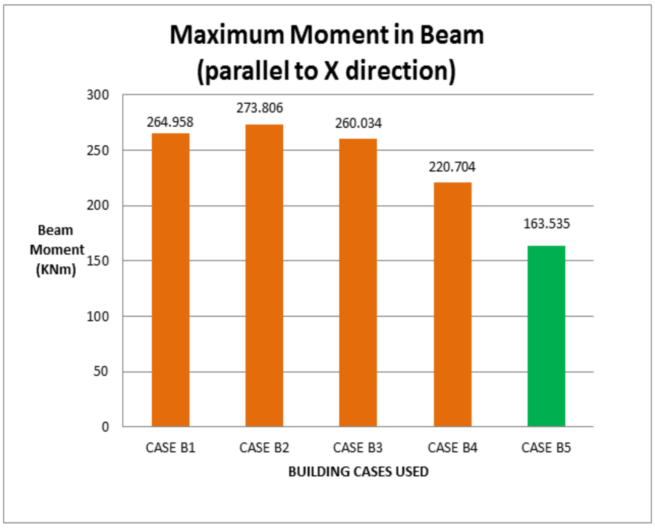
CASES	Beam Shear Force (parallel to Z direction) (KN)	Case that creates least shear forces in beams
CASE B1	149.629	CASE B5 (comparing the worst case in sloping ground)
CASE B2	131.808	
CASE B3	126.694	
CASE B4	126.173	
CASE B5	113.732	



Graph -5: Graphical representation of Maximum Shear Forces in beams parallel to Z direction

Table -6: Maximum Bending Moment in beams along X direction

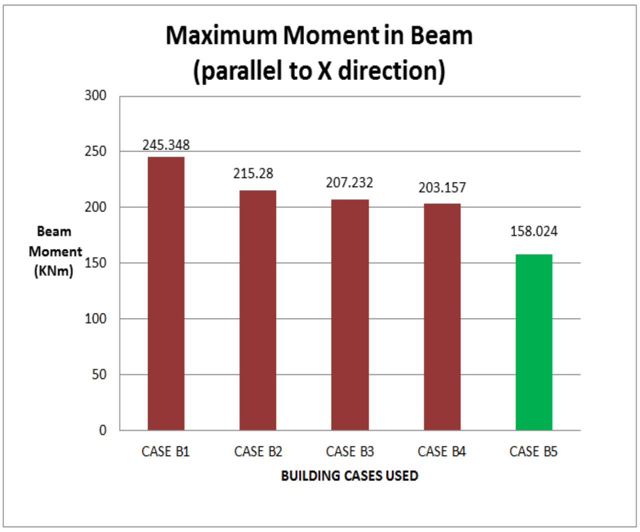
CASES	Beam Bending Moment (along X direction) (KNm)	Case that creates least bending moment in beams
CASE B1	264.958	CASE B5 (comparing the worst case in sloping ground)
CASE B2	273.806	
CASE B3	260.034	
CASE B4	220.704	
CASE B5	163.535	



Graph -6: Graphical representation of Maximum Bending Moment in beams along X direction

Table -7: Maximum Bending Moment in beams along Z direction

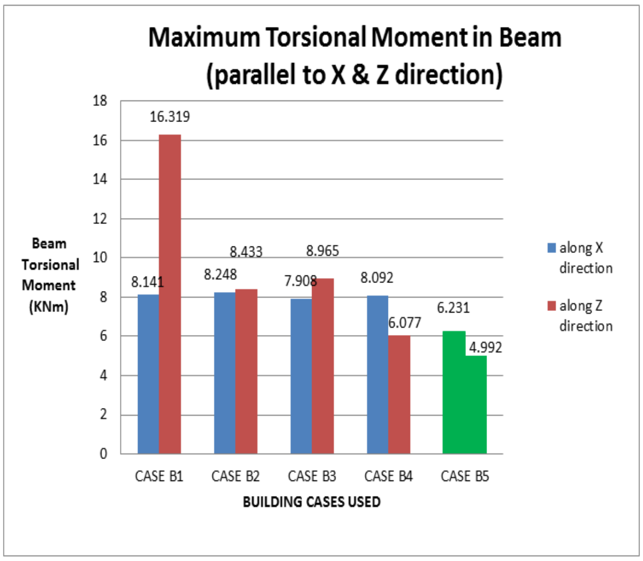
CASES	Beam Bending Moment (along Z direction) (KNm)	Case that creates least bending moment in beams
CASE B1	245.348	CASE B5 (comparing the worst case in sloping ground)
CASE B2	215.280	
CASE B3	207.232	
CASE B4	203.157	
CASE B5	158.024	



Graph -7: Graphical representation of Maximum Bending Moment in beams along Z direction

Table -8: Maximum Torsional Moment in beams along X and Z direction

CASES	Beam Torsional Moment (along X direction) (KNm)	Beam Torsional Moment (along Z direction) (KNm)	Case that creates least torsional moment in beams
CASE B1	8.141	16.319	CASE B5 (comparing the worst case in sloping ground)
CASE B2	8.248	8.433	
CASE B3	7.908	8.965	
CASE B4	8.092	6.077	
CASE B5	6.231	4.992	



Graph -8: Graphical representation of Maximum Torsional Moment in beams along X and Z direction

6. CONCLUSION AND RECOMMENDATIONS

The following conclusion has been investigated by different model configurations are as follows:-

1. Total 5 different cases used in this work. The main focus in this work is to show how the values differ from each other under 20 degree and 30 degree.
2. Maximum Axial forces in column at ground level seem to be low in case of Case B5, since the load distributed on sloping ground.
3. In case of shear forces in column, other than structure on plain ground, building with step back set back 20 degree inclination shows least values.
4. Again Case B4 with 20 degree inclination shows least values in maximum Bending Moment in columns.
5. Beam in Both X and Z direction shows least values of shear forces in Case B5.
6. Step back set back 30 degree configuration suited the least values of Maximum Bending Moment in beam parallel to both X and Z direction respectively.
7. Torsion in beam again shows least values in Case B5.
8. It is found that when there will be incremental degree of sloping ground, building on greater slope transfer larger loads as compared to plain ground. Step back set back frame perform better than frame as per result.

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