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"SEISMIC ANALYSIS OF MULTISTOREY BUILDING WITH DIFFERENT SLAB TYPES ON PLAIN AND SLOPING GROUND"

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Abstract: *The buildings present on sloping ground are very different from those on plain ground, on sloping ground the buildings are very irregular and unsymmetrical in horizontal and vertical planes. The buildings on sloping ground causes more damage during earthquake, because on sloping ground the structure is constructed with different column heights.*

Flat slab is most widely used systems in reinforced concrete construction in offices, residential and industrial buildings in many parts of the world. Grid floor system consisting of beam spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large room such as, auditoriums, theaters halls, show room of shops.

The object of the present work is to compare the behaviour of multi-storey buildings having flat slab, grid slab, with that of conventional slab on plain ground and sloping ground. In this study 3D analytical model with the slope chosen in between 0 to 30 degree. The response spectrum analysis is performed for all the models as per IS 1893-2002 using ETABS 2015 software. From the response spectrum analysis the properties of the building such as displacement, storey drift and storey shear have been studied for all the models.

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Key Words: *Conventional slab, Grid slab and Flat slab, Plain and Sloping ground, Response Spectrum Analysis.*

1. INTRODUCTION

1.1General:

Earthquake is the major reason for the issue of safety for the construction of multi storey buildings. The buildings which are present now are designed and constructed as per older code provisions.

Buildings which are present on hilly areas are very different from those on plain ground. On hilly areas they are very irregular and unsymmetrical. Hence, they tend to severe damage to the structure when affected by earthquake. Because on hilly areas the structure is constructed with different column heights.

1.2 Flat Slab

Commonly the reinforced concrete slab is supported directly by beams and beams are supported by columns this system is known as slab-beam construction. In slab-beam construction, beam decreases the available net clear floor height, hence in structures like offices, warehouses and public halls sometimes due to aesthetic view beams are not provided thus slabs are directly placed on columns. So these type of construction of slabs directly supported by columns are known as Flat slab as shown in figure below.

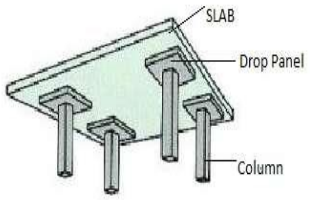

Fig.1 Flat Slab

1.3 Grid Slab: Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is required. The sizes of the beams running in perpendicular directions are generally kept the same.

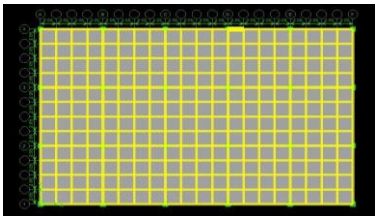

Fig.2 Grid Slab

2. OBJECTIVES OF THE STUDY

1. To compare the performance of RC frame on Plain Ground & Sloping Ground with Flat Slab, grid slab and conventional slab Structure. In sloping ground the angles are 0 to 30 degrees along the horizontal length of the building (10°, 20° & 30°).

2. Response spectrum analysis is carried out for critical zone (i.e., zone V) as per IS 1893 (Part 1):2002 for medium soil type.
3. To study the effect of storey shear, displacement and storey drift.

3. DESCRIPTION OF MODELS:

3.1 CONVENTIONAL SLAB BUILDING MODELS:

MODEL-1 (M1): Conventional slab model on plain ground
MODEL-2 (M2): Conventional slab model on 10 degree sloping ground
MODEL-3 (M3): Conventional slab model on 20 degree sloping ground
MODEL-4 (M4): Conventional slab model on 30 degree sloping ground

3.2 GRID SLAB BUILDING MODELS:

MODEL-5 (M5): Grid slab model on plain ground
MODEL-6 (M6): Grid slab model on 10 degree sloping ground
MODEL-7 (M7): Grid slab model on 20 degree sloping ground
MODEL-8 (M8): Grid slab model on 30 degree sloping ground

3.3 FLAT SLAB BUILDING MODELS:

MODEL-9 (M9): Flat slab model on plain ground
MODEL-10 (M10): Flat slab model on 10 degree sloping ground
MODEL-11 (M11): Flat slab model on 20 degree sloping ground
MODEL-12 (M12): Flat slab model on 30 degree sloping ground

3.4 BUILDING INFORMATION

Building: Multi-story building , No's of floors: 10, Each floor height: 3.0 , Soil type: Medium soil (type II) Zone: V

MATERIALS

M25-concrete: Beams and Slab , M30-concrete: Columns
Fe-500 steel

MEMBER DIMENSIONS

Column: 450mm x450mm , Slab thickness: 150 mm
Beam: 230mm x 450mm , Wall thickness: 230 mm
For grid slab models: overall depth 425mm, Slab thickness 125mm, Stem width at top 125mm, Stem width at bottom 125mm, Spacing of ribs that are parallel to slab 1-axis and 2-axis is 900mm, For flat slab models, Drop 200mm

LIVE LOAD

LL: 4. kN/m^2 (IS: 875 (Part 2) -1987, Table 1) FL: 1.5 kN/m^2

DATA

As per IS: 1893-2002 the following values are taken Damping ratio: 5% , Zone factor (Z): 0.36 Importance factor (I):1.0

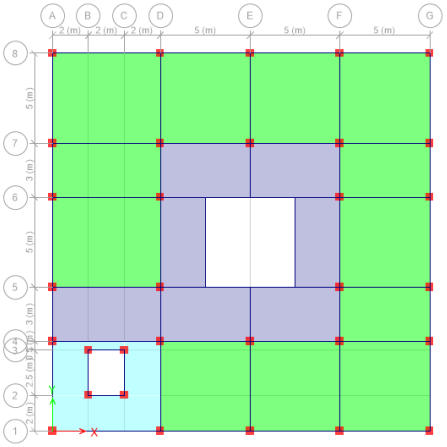

Fig.3 Plan of the model

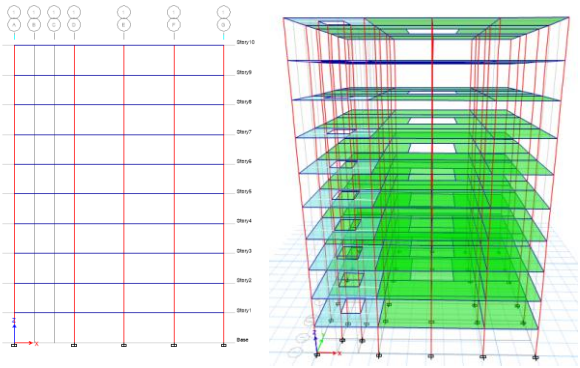

Fig.4 Showing elevation and 3D view of conventional slab building model (M1)

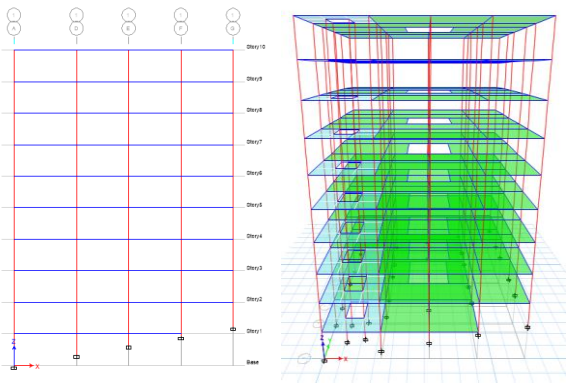

Fig.5 Showing elevation and 3D view of conventional slab building model on 10 degree sloping ground (M2)

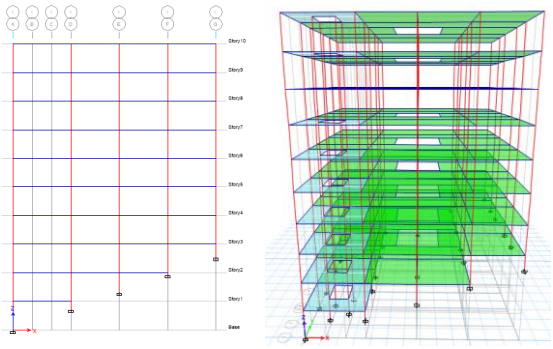

Fig.6 Showing elevation and 3D view of conventional slab building model on 20 degree sloping ground (M3)

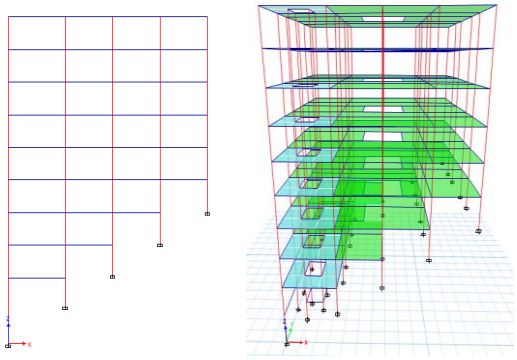

Fig.7 Showing elevation and 3D view of conventional slab building model on 30 degree sloping ground (M4)

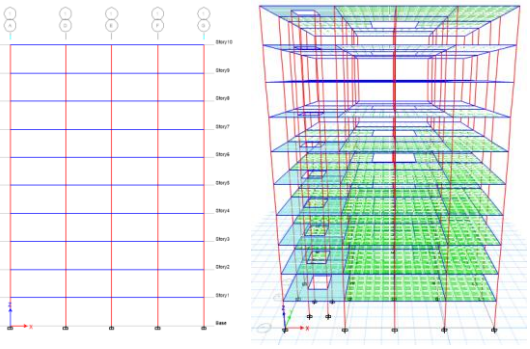

Fig.8 Showing elevation and 3D view of grid slab building model (M5)

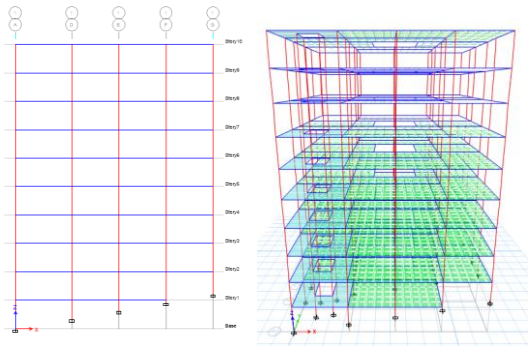

Fig.9 Showing elevation and 3D view of grid slab building model on 10 degree sloping ground (M6)

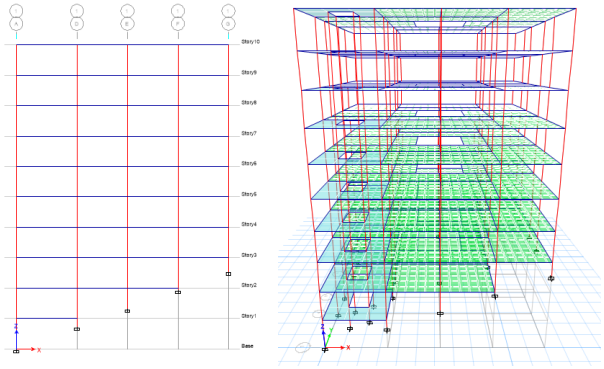

Fig.10 Showing elevation and 3D view of grid slab building model on 20 degree sloping ground (M7)

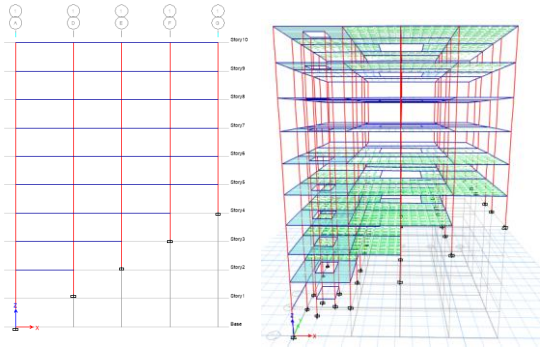

Fig.11 Showing elevation and 3D view of grid slab building model on 30 degree sloping ground (M8)

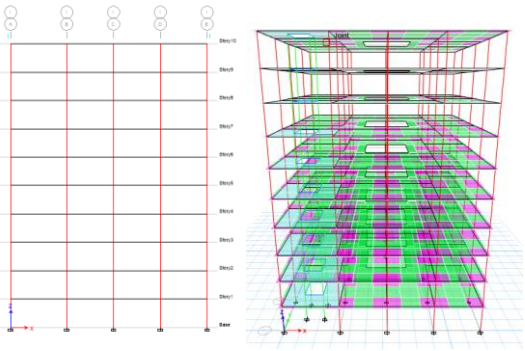

Fig.12 Showing elevation and 3D view of flat slab building model (M9)

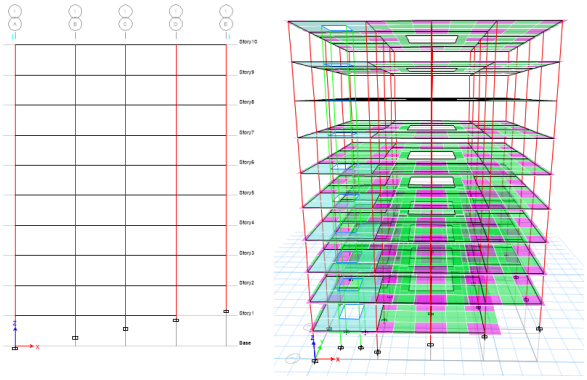

Fig.13 Showing elevation and 3D view of flat slab building model on 10 degree sloping ground (M10)

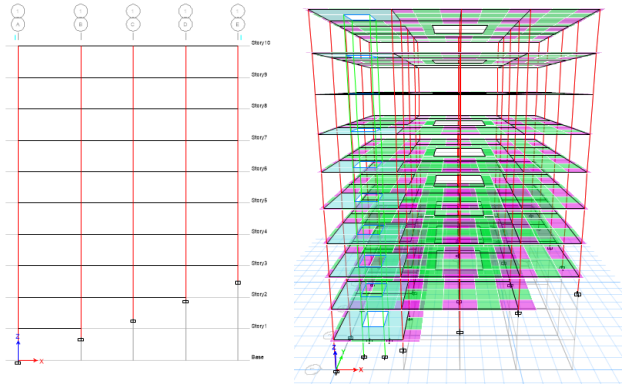

Fig.14 Showing elevation and 3D view of flat slab building model on 20 degree sloping ground (M11)

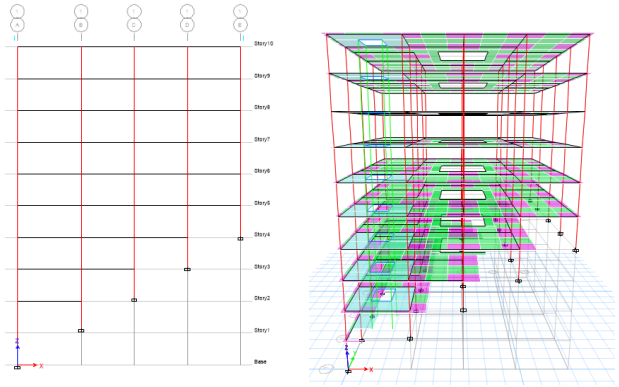

Fig.15 Showing elevation and 3D view of flat slab building model on 30 degree sloping ground (M12)

4. RESULTS AND DISCUSSION

The results of all 12 models are presented and discussed in detail. The results of conventional slab models, grid slab models and flat slab models on plain and sloping ground are compared using response spectrum analysis.

CONVENTIONAL SLAB:

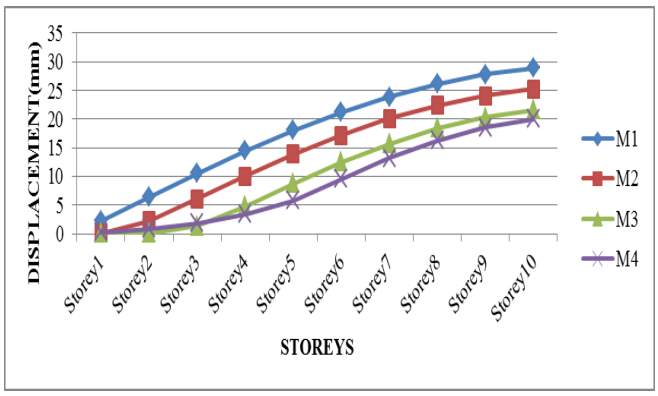

Fig-16 Showing Displacement in X-direction For Model-1 to Model-4 by Response Spectrum Analysis in mm.

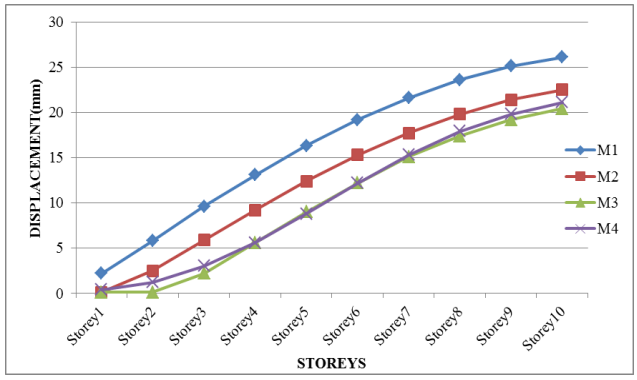

Fig-17 Showing Displacement in Y-direction For Model-1 to Model- 4 by Response Spectrum Analysis in mm.

Discussions on displacement results:

1) The displacement in X direction is found to be maximum in model M1 and it is equal to 28.9mm at storey 10.

2) The displacement in Y direction is found to be maximum in model M1 and it is equal to 26.1mm at storey 10.

3) When all the models are compared ,the maximum displacement is found in model M1 along X direction and is equal to 28.9mm at storey 10.

4) It is seen that, for models along longitudinal direction by response spectrum analysis, the displacements are decresed by 12.45%,25.25%,30.79% for model M2,M3,M4 respectively compared to model M1.

5) It is seen that, for models along transverse direction by response spectrum analysis, the displacements are decresed by 13.79%,21.83%,19.15%, for model M2,M3,M4 respectively compared to model M1.

6) The values of displacement are within the permissible limit as per IS 1893-2002.

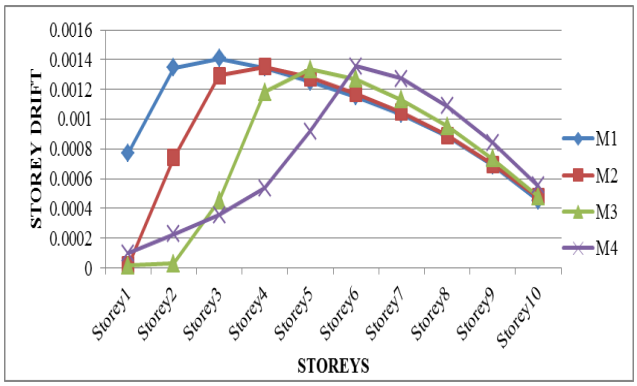

Fig-18 Showing Story Drift In X-direction For Model-1 To Model-4 By Response Spectrum Analysis

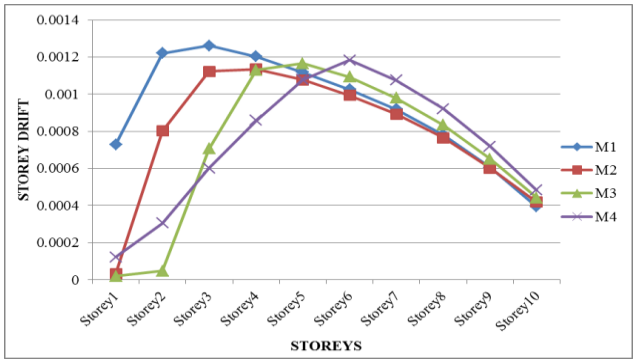

Fig-19 Showing Story Drift In Y-Direction For Model-1 To Model 4 By Response Spectrum Analysis

Discussions on Storey drift results:

1) The story drift in X direction is found to be maximum in model M1 and is equal to 0.001409 at storey 3
2) The story drift in Y direction is found to be maximum in model M1 and is equal to 0.001262 at storey 3
3) When all the models are compared ,the maximum displacement is found in model M1 along X direction and is equal to 0.001409 at storey 3
4) The storey drift values are within the permissible limit as per IS 1893-2002.

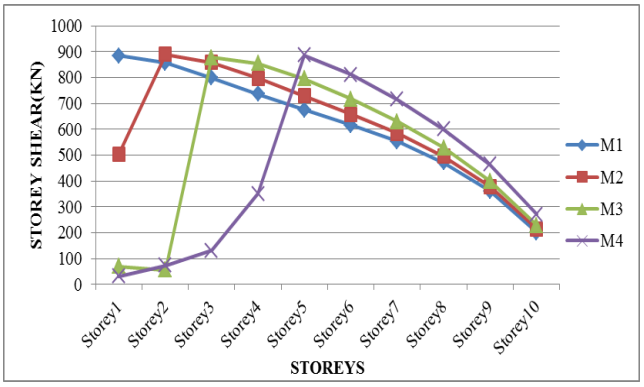

Fig-20 Showing Story Shear In X-Direction For Model-1 To Model 4 By Response Spectrum Analysis

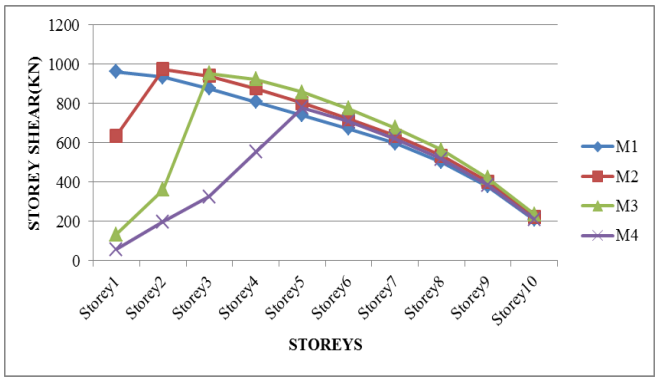

Fig-21 Showing Story Shear In Y-Direction For Model-1 To Model 4 By Response Spectrum Analysis

Discussions on Storey shear results:

1) The story shear in X direction is found to be maximum in model M2 and is equal to 889.9925 KN at storey 2.
2) The story shear in Y direction is found to be maximum in model M2 and is equal to 974.6785 KN at storey 2.
3) When all the models are compared ,the maximum Storey shear is found in model M2 along Y direction and is equal to 974.6785 KN at storey 2.

GRID SLAB:

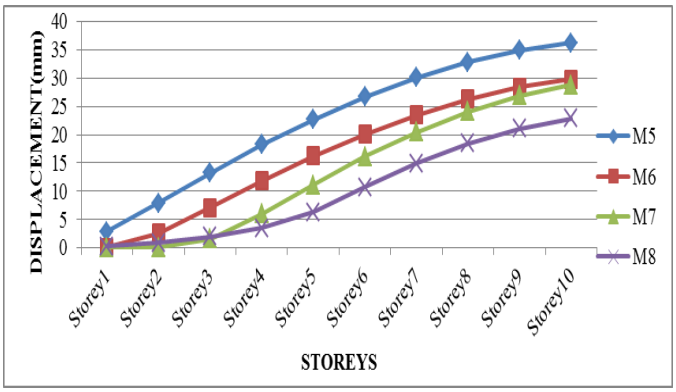

Fig-22 Showing Displacement In X-Direction For Model-5 To Model-8 By Response Spectrum Analysis in mm

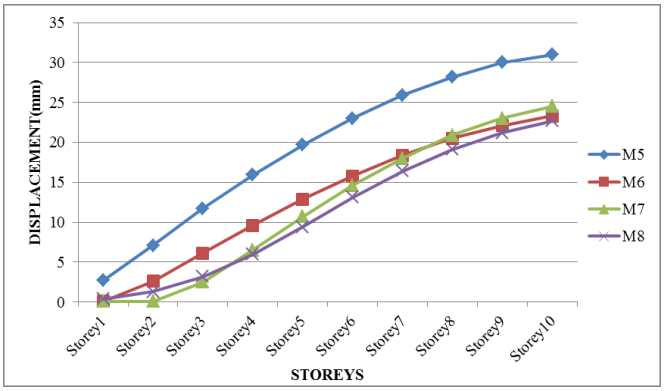

Fig-23 Showing Displacement In Y-Direction For Model-5 To Model 8 By Response Spectrum Analysis in mm

Discussions on Displacement results:

1) The displacement in X direction is found to be maximum in model M5 and it is equal to 36.2mm at storey 10.
2) The displacement in Ydirection is found to be maximum in model M5 and it is equal to 31mm at storey 10.
3) When all the models are compared ,the maximum displacement is found in model M5 along X direction and is equal to 36.2mm at storey 10.

4) It is seen that, for models along longitudinal direction by response spectrum analysis, the displacements are decresed by 17.67%,20.44%,36.74% for model M6,M7,M8 respectively compared to model M5.
5) It is seen that, for models along transverse direction by response spectrum analysis, the displacements are decresed by 24.83%,20.96%,26.77%, for model M6,M7,M8 respectively compared to model M5.
6) The values of displacement are within the permissible limit as per IS 1893-2002.

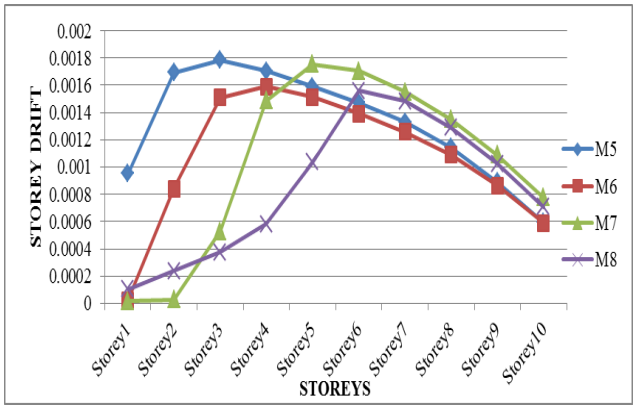

Fig-24 Showing Story Drift In X-direction For Model-5 To Model-8 By Response Spectrum Analysis

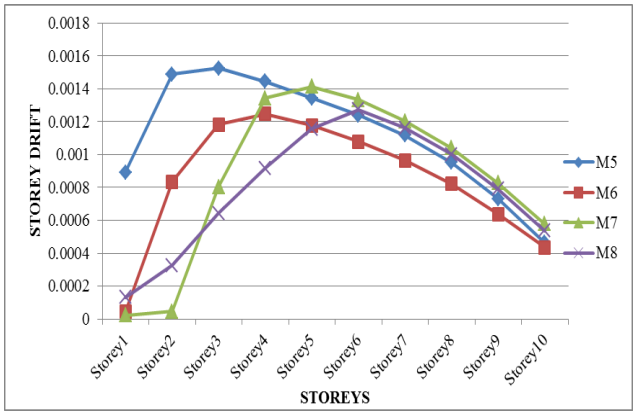

Fig.25 Showing Story Drift In Y-Direction For Model-5 To Model 8 By Response Spectrum Analysis

Discussions on Storey drift results:

1) The story drift in X direction is found to be maximum in model M5 and is equal to 0.001783 at storey 3 .
2) The story drift in Y direction is found to be maximum in model M5 and is equal to 0.001527 at storey 3.
3) When all the models are compared ,the maximum drift is found in model M5 along X direction and is equal to 0.001783 at storey 3.
4) The storey drift values are within the permissible limit as per IS 1893-2002.

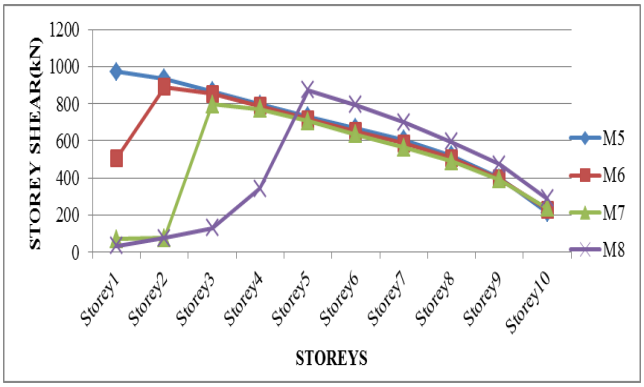

Fig.26 Showing Story Shear In X-Direction For Model-5 To Model 8 By Response Spectrum Analysis

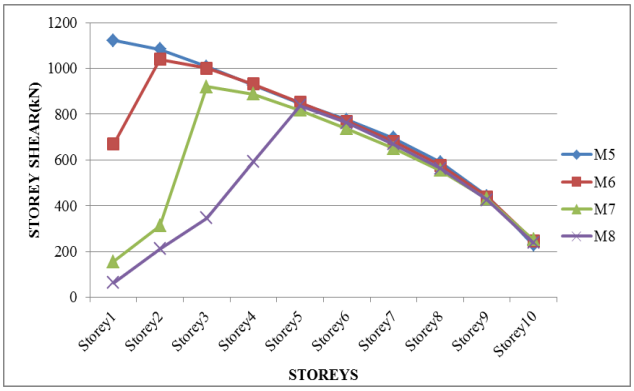

Fig.27 Showing Story Shear In Y-Direction For Model-5 To Model 8 By Response Spectrum Analysis

Discussions on Storey shear results:

1) The story shear in X direction is found to be maximum in model M5 and is equal to 973.0442kN at storey 1.
2) The story shear in Y direction is found to be maximum in model M5 and is equal to 1122.313kN at storey 2.
3) When all the models are compared ,the maximum Storey shear is found in model M5 along Y direction and is equal to 1122.313kN at storey 2.

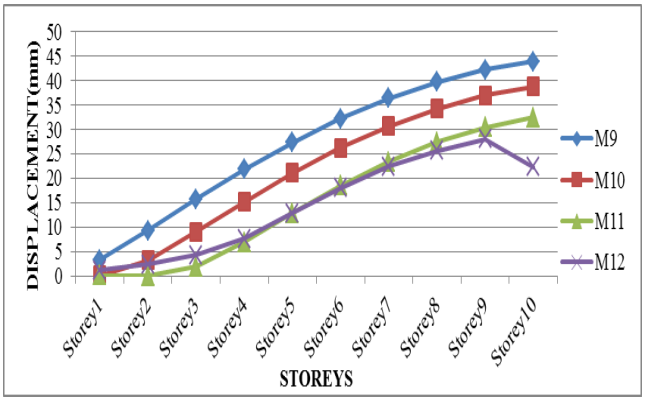

Fig.28 Showing Displacement In X-Direction For Model-9 To Model 12 By Response Spectrum Analysis In mm.

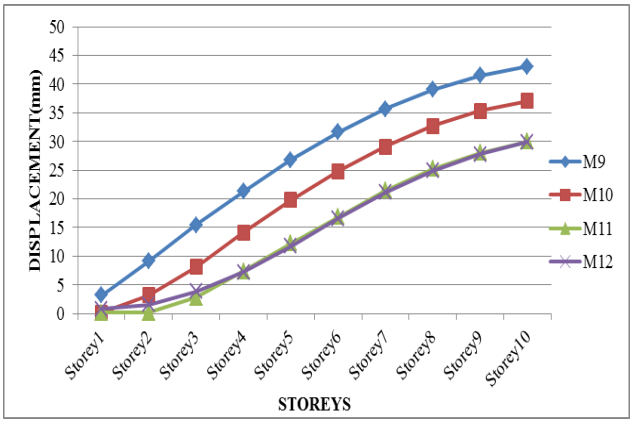

Fig.29 Showing Displacement In Y-Direction For Model-9 To Model 12 By Response Spectrum Analysis In mm.

Discussions on Displacement results:

1) The displacement in X direction is found to be maximum in model M9 and it is equal to 44 mm at storey 10.
2) The displacement in Ydirection is found to be maximum in model M9 and it is equal to 43.1 mm at storey 10.
3) When all the models are compared ,the maximum displacement is found in model M9 along X direction and is equal to 44mm at storey 10.
4) It is seen that, for models along longitudinal direction by response spectrum analysis, the displacements are decresed by 11.81%,11.5%,49.31% for model M10,M11,M12 respectively compared to model M9.
5) It is seen that, for models along transverse direction by response spectrum analysis, the displacements are decresed by 13.92%,30.39%,30.62%, for model M10,M11,M12 respectively compared to model M9.
6) The values of displacement are within the permissible limit as per IS 1893-2002.

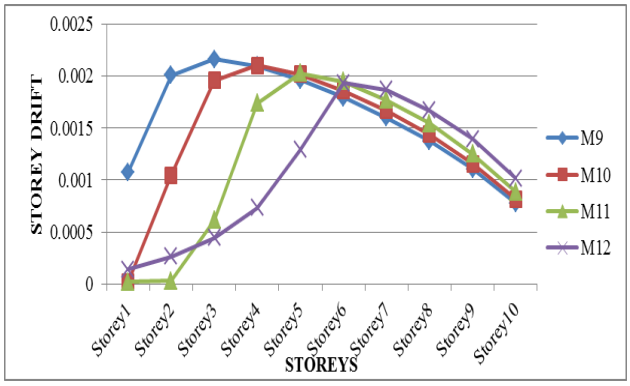

Fig.30 Showing Story Drift In X-Direction For Model-9 to Model 12 By Response Spectrum Analysis

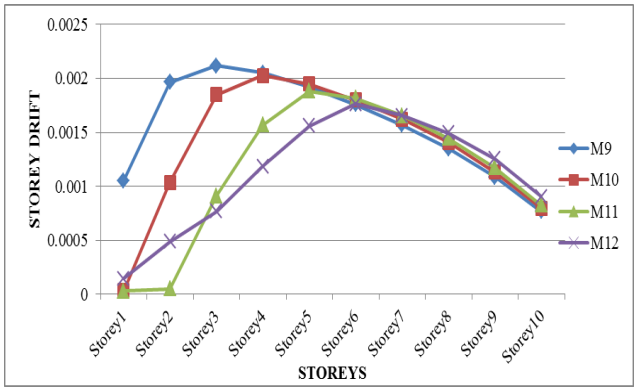

Fig.31 Showing Story Drift In Y-Direction For Model-9 To Model 12 By Response Spectrum Analysis

Discussions on Storey drift results:

1) The story drift in X direction is found to be maximum in model M9 and is equal to 0.002164 at storey 3 .
2) The story drift in Y direction is found to be maximum in model M9 and is equal to 0.002118 at storey 3.
3) When all the models are compared ,the maximum displacement is found in model M9 along X direction and is equal to 0.002164 at storey 3.
4) The storey drift values are within the permissible limit as per IS 1893-2002.

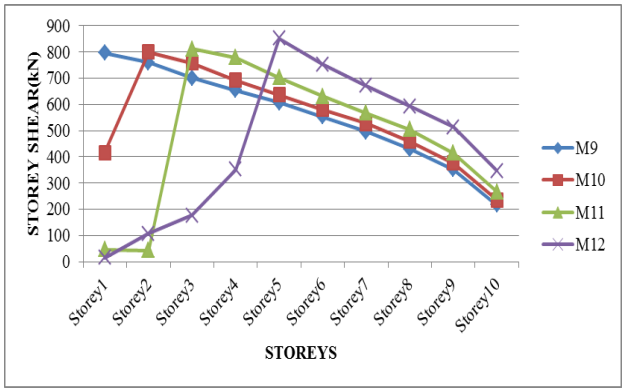

Fig.32 Showing Story Shear In X-Direction For Model-9 To Model 12 By Response Spectrum Analysis

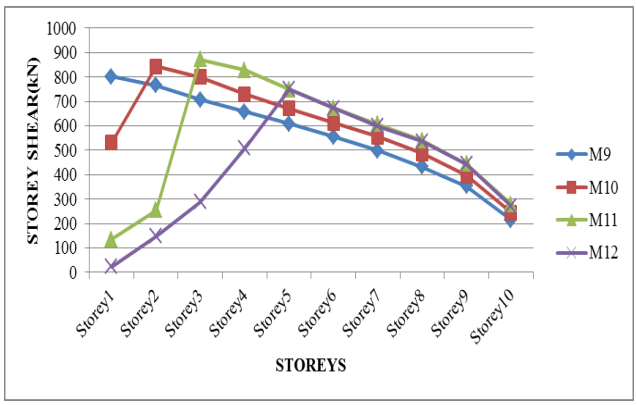

Fig.33 Showing Story Shear In Y-Direction For Model-9 To Model 12 By Response Spectrum Analysis

Discussions on Storey shear results:

1) The story shear in X direction is found to be maximum in model M12 and is equal to 852.6344kN at storey 5.

2) The story shear in Y direction is found to be maximum in model M11 and is equal to 871.8666kN at storey 3.

3) When all the models are compared ,the maximum Storey shear is found in model M11 along Y direction and is equal to 871.8666kN at storey 3.

CONCLUSION

1. The displacement for model M5 (Grid slab model) is 17.72% less and for the model M1 (Conventional slab model) is 34.31% less when compared with the model M9 (Flat slab model).

2. Storey drift is more on plain ground compared to sloping ground, this is due to increase in fixity of the structure.

3. The storey drift for model M5 (Grid slab model) is 17.60% less and for the model M1 (Conventional slab model) is 34.88% less when compared with the model M9 (Flat slab model).

4. The storey shear for model M2 (conventional slab model) is 13.15% less and for the model M11 (Flat slab model) is 22.31% less when compared with the model M5 (Grid slab model).

5. As the slope of the base increases it results in decrease in seismic weight.

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