International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 11 | Nov -2016 www.irjet.net p-ISSN: 2395-0072

SEISMIC EVALUATION OF RC FRAME BUILDING WITH BRACINGS RESTING ON VARYING GROUND PROFILE

RESHMA H K[1], DR.B SHIVAKUMARA SWAMY [2]

[1]*Post graduate, Department of civil engineering, DR.AIT*
[2] Professor *and Head of Department of civil engineering, DR.AIT*

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Abstract - *In north and north-eastern part of India it is observed that its geographical area is mostly covered by mountains and hilly areas which are more susceptible to damage during earthquake. Though it is a undesirable condition to construct buildings on hilly areas due to the severity of seismic damages it is difficult to construct buildings only on plain terrains in these regions due to rapid urbanization. Therefore the need of building constructions has drastically increased to a large extent which leads to scarcity of plain terrain for the construction of buildings. Due to the scarcity of the plain terrain in this region there is an obligation of the construction of the buildings on the varying slopes of the strata. Hence, this study is done to understand the behavior of the buildings constructed on varying ground profile. In order to achieve the aforementioned we have considered a seven and ten storied RC frame on different ground profile that includes flat, irregular and 30 degree slope with and without bracings. The building is located in seismic zone V on a medium soil site. The modeling and analysis of the RC frame buildings has been done by using structure analysis tool ETAB and results found is validated by performing linear static analysis, response spectrum analyses as per IS:1893 (part 1): 2002 and time history analysis is done considering time history function as 2001 Bhuj earthquake. Comparison between the structures with and without bracings is done and after examination it is understood that the structures with lateral force resisting systems are more safe and suitable.*

***Key Words*: Seismic evaluation, sloping ground, Bracings ,response spectrum ,time history(Bhuj).**

1. INTRODUCTION

Earthquake is the most disastrous and unpredictable phenomenon of nature. Mass destruction of the low and high rise buildings in the recent earthquakes leads to the need of investigation especially in a developing country like India. Structure subjected to seismic forces are always vulnerable to damage and if it occurs on a sloped building as on hills which is at some inclination to the ground the chances of damage increases much more due to increased lateral forces on short columns on uphill side. Structures on slopes differ from those on plains because they are irregular horizontally as well as vertically.

When a building is constructed on sloping ground the possibilities of the presence of short column at the base of the structure is evident. Some columns in the RC frames will be considerably shorter in height than other columns in the same story. From the past earthquakes we can say that RC frame buildings that have columns of different heights within one story suffered more damage in the shorter columns than in the taller columns located in the same story.

Short columns are stiffer as the effective height over which a short column can freely bend is small and require a larger force to deform by the same amount than taller columns that are more flexible. Thus short columns attract larger seismic forces as compared to regular columns. This increased force generally incurs extensive damage on the short column. The damage in these short columns is often in the form of X-shaped cracks, which is characteristic for shear failure. Stiffness of a column means resistance to deformation – the larger is the stiffness, larger is the force required to deform it. If a short column is not adequately designed for such a large force, it can suffer significant damage during an earthquake

2. OBJECTIVES

The present study is aimed at evaluating reinforced concrete structure resting on flat, irregular slope and slope 30 comprising of seven and ten storeys with the subsequent objectives:

- To evaluate the response of multi-storeyed RC framed structure resting on flat, 30 degree and irregular slope subjected to sinusoidal ground movement and earthquake excitation stimulated to Bhuj earthquake.
- Finding out storey displacements, storey drift and storey shear at each storey using equivalent static analysis, response spectrum analysis and time history analysis method.
- To investigate the seismic performance of multi-storeyed RC framed structure resting on flat, 30 degree and irregular slope provided with X bracing at corners using equivalent static analysis ,response spectrum analysis and time history analysis procedure.

3. ANALYSIS METHODS

The analysis methods adopted in this study are as follows:

Equivalent static load method: This method is the simplest procedure used to examine structures subjected to earthquake and attain reasonable results. It is suggested and widely used in most of the code for earthquake analysis especially for structures meeting certain regularity conditions. For the latter to be true the structure must be low to medium rise and should not twist significantly when subjected to ground motion.

Response spectrum method : This methodology allows the numerous methods of responses of a building to be taken into account (in the recurrence space). This is regularly required in a few construction regulations for all separated from horribly simple or appallingly confused structures. The response of a structure can be characterized as a blend of numerous unique shapes (modes). Blend strategies incorporate the accompanying:

- Absolute - top qualities are included
- Square base of the sum of the squares (SRSS)
- Complete quadratic mix (CQC) - a system that is a change on SRSS for firmly divided modes.

Time history analysis: It is an analysis of the dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion time history.

3. Building configurations

Building configurations considered are a seven and ten storied RC frame on different ground profile that includes flat, irregular and 30 degree slope with and without bracings. The building is located in seismic zone V on a medium soil site. The modeling and analysis of the RC frame buildings has been done by using structure analysis tool ETAB.
According to above discussion following models are prepared in ETAB software.

1) seven storey Building on plain ground and on angle of slope: 30degree .

2) Seven storey Building on plain ground and on irregular slope.

3)Ten storey Building on plain ground and on angle of slope: 30degree .

4) 10 storey Building on plain ground and on irregular slope.

5) Height of ground storey: 4m

6) Height of upper storeys: 3m

MATERIAL PROPERTIES	
Grade of concrete (fck)	M25
Grade of Reinforcing steel (fy)	Fe-415
Unit weight of concrete	25kN/m3
SECTIONAL PROPERTIES	
Column size	300 X300 mm
Beam size	300 X 600 mm
Bracing size	150 mm
Slab thickness	150 mm
BUILDIING PLAN	
Number of bays in X-direction	5
Number of bays in Y-direction	3
Width of bay in X-direction	5m
Width of bay in Y-direction	5m
LOAD ASSIGNMENT	
Live load on floor slab	3kN/m2
Floor finishing	2 kN/m2
SEISMIC DATA	
Seismic zone	V
Importance factor (I)	1
Response reduction factor	3
Soil type	medium soil
Response spectrum function	IS 1892:2002 Spectrum
Function damping ratio	0.05
Time History function	BHUJ

Table -1: Details of material properties , sectional properties ,building plan and Seismic data

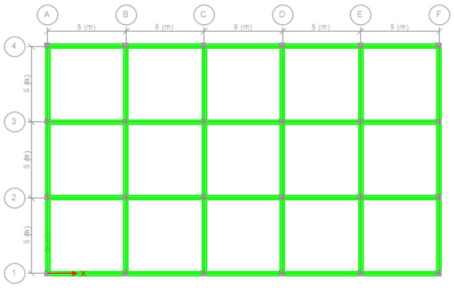
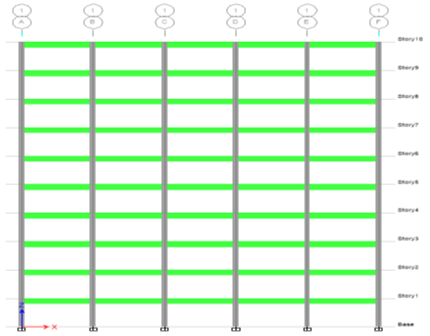
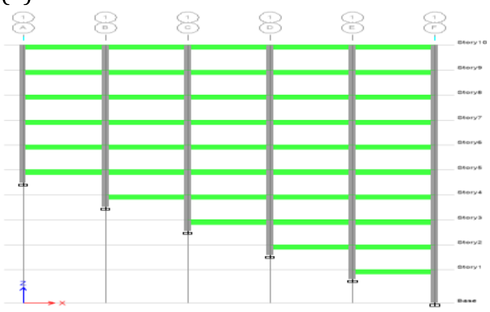


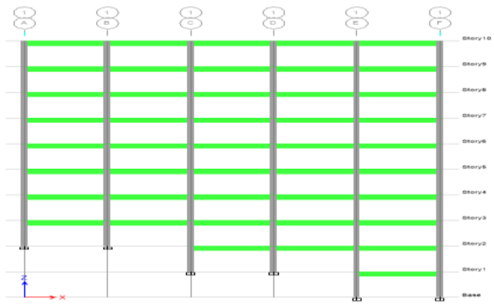
Fig -1: Plan of RC frame building
Plan dimension: 25 x15 m.



(a) Flat

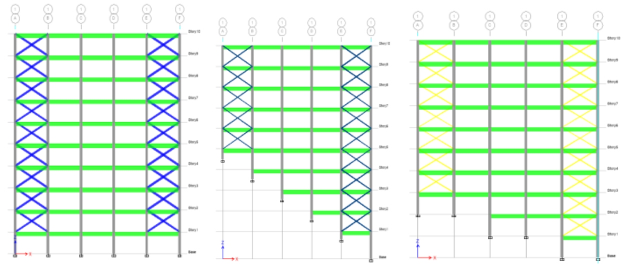


(b) 30 deg slope



(c) irregular slope

Fig -2: RC frame building models resting on flat, 30deg slope and irregular slope.



(d)Flat slope With brace (e) 30 deg slope With brace (f) irregular With brace

Fig -3: RC frame building with bracings resting on flat, 30deg slope and irregular slope.

5. RESULT AND DISCUSSION

The dynamic analysis has been carried out and the time period for first 12 modes are plotted and shown in the chart-1 and chart-2. The base shear for plain building and sloping building considering equivalent static method (ESA),response spectrum method(RSA) and time history method (THA) are shown in the chart-3 to chart-8.

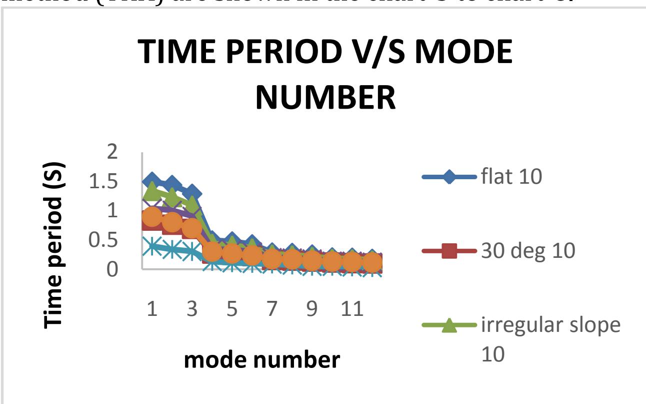


Chart-1: Comparison of time period for ten and seven storey buildings.

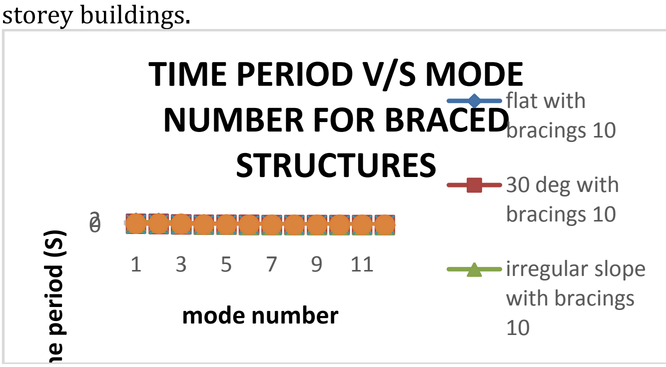


Chart-2: Comparison of frequency for ten and seven storey building with bracings.

- The highest time period is observed for the first mode of a 10 storey structure .Time period 30 degree slope is less than the time period of irregular slope structure for first 6 modes, hence we can say that 30 degree slope building is more rigid than irregular slope building.

- As observed from the graph the time period of first 6 modes is different for all the structures considered and after the 6th mode it is approximately equal.
- The rigidity of 30 degree slope structure is maximum since it exhibits the lowest time period and hence it absorbs more earthquake forces.
- The time period value increased for bare frame compared to RC frames with bracings.

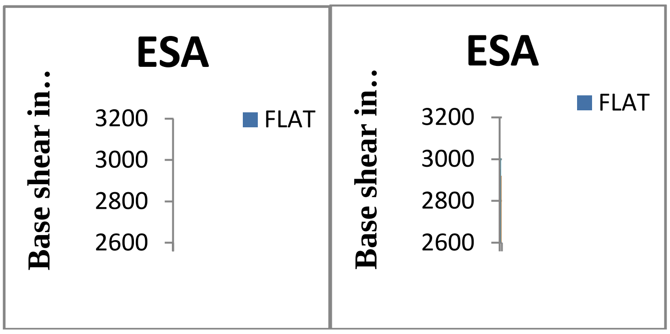


Chart-3: Base shear for 7 storey building along X and Y dir by ESA method

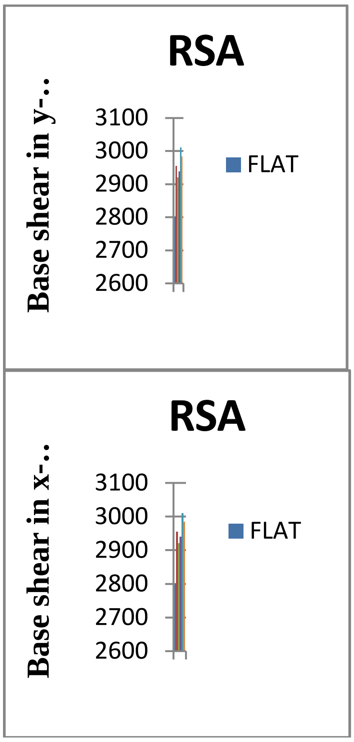


Chart-4: .Base shear for 7 storey building along X and Y dir by RSA method

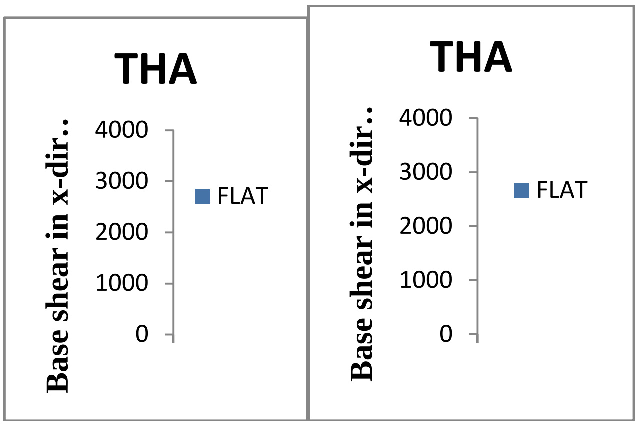


Chart -5:Base shear for 7 storey building along X and Y dir by THA method

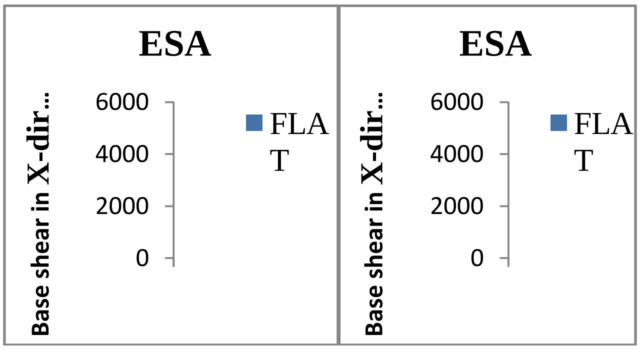


Chart -6: Base shear for 10 storey building along X and Y dir by ESA method

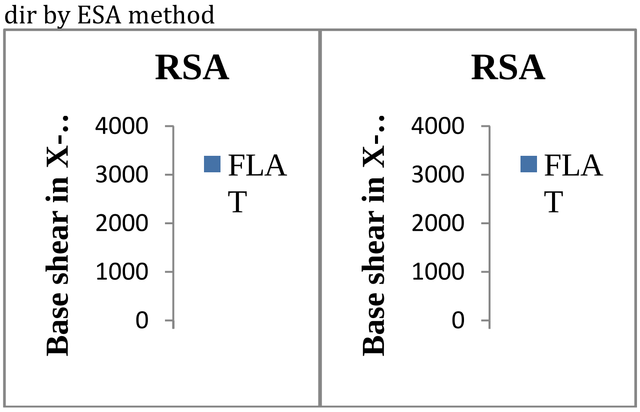


Chart -7: Base shear for 10 storey building along X and Y dir by RSA method

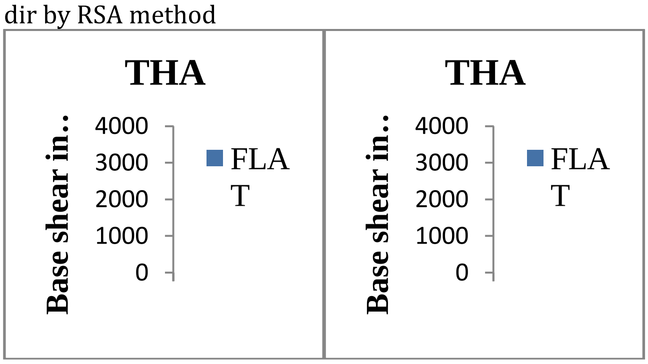


Chart -8: Base shear for 10 storey building along X and Y dir by THA method

Base shear of structure on slope strata is more than that of structure on flat ground. in ESA method and in RSA method the base shear nearly same for both but in THA it is observed that base shear is less for structure on slope. This is because time history analysis method is more accurate it shows base shear of structure on slope strata is less compared to regular structures as in structures on slope the mass is varying on each floor this change is not accounted in ESA and RSA method.

From the graphs shown above it is observed that base shear increases when the structural systems are provided with bracings.

The base shear in braced frame are increased because when the bracings are provided to the structure the stiffness of the structure increases ,hence attracting higher force, due to its stiffness and mass also. This is clearly visible in the above graphs .

It can be observed that for bare frame the displacement reduces even though the base shear increases due to the lateral resistance provided in the form of bracings.

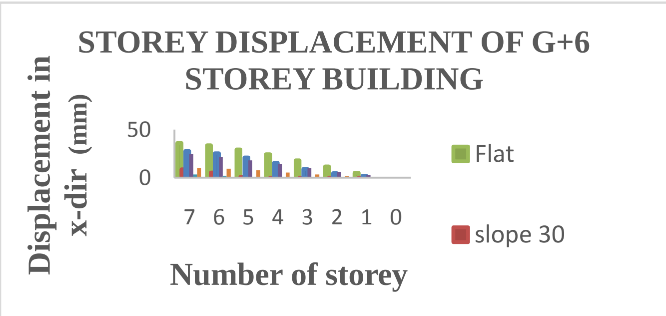


Chart-9: Storey displacement for 7 storey building

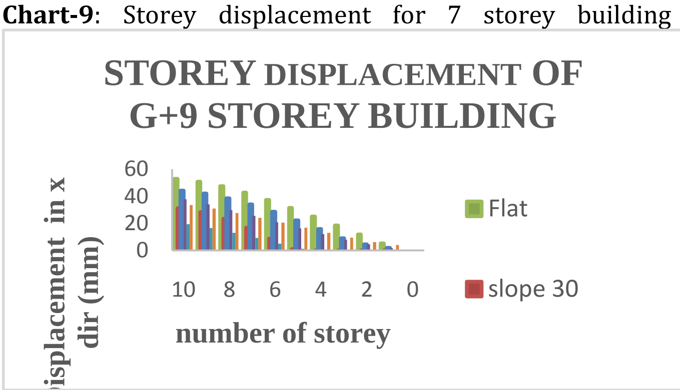


Chart -10: Storey displacement for 10 storey building

- From the above graphs it is observed that the displacements of ten storey RC frame buildings is more than seven storey RC frame buildings and hence we can say that as the storey height increases the displacement also increases.
- The displacement values in all braced frame structural models used for the study are reduced due to increase in stiffness of frames when bracing is provided.

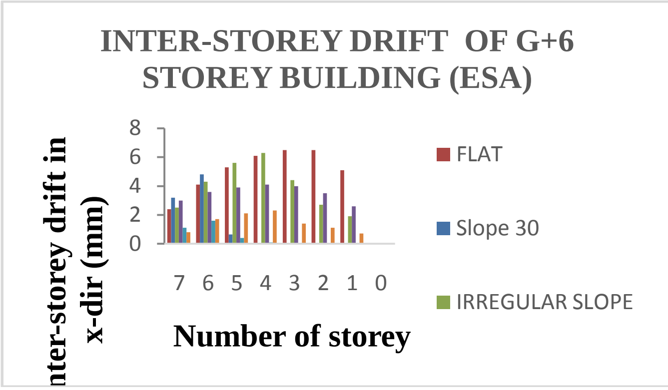


Fig **Chart -11**: Inter-storey drift for 7 storey building by ESA method

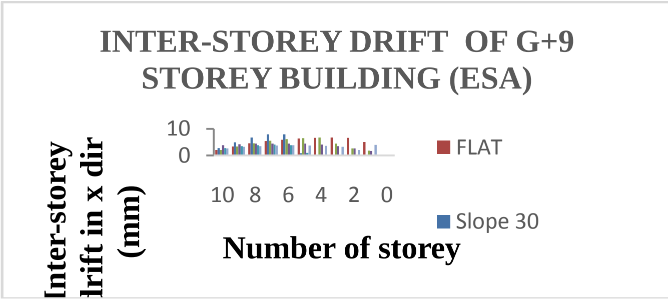


Chart -12: Inter-storey drift for 10 storey building ESA method

Since stiffness is disproportional for structures on slope compared to flat the inter storey drift is found to be more. Hence, the floor displacement is more in stiffness irregular structure than regular structure

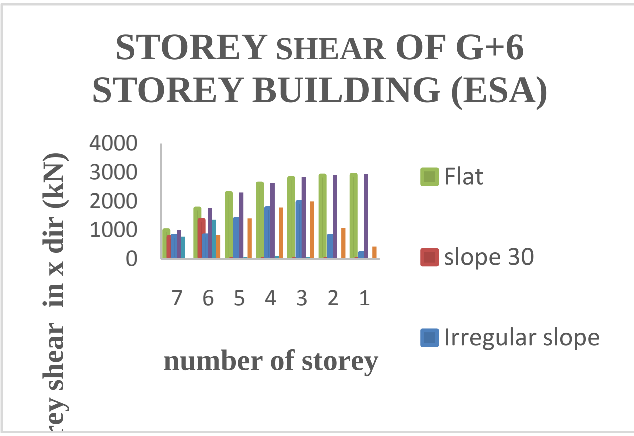


Chart -13: .storey shear for 7 storey building by ESA method

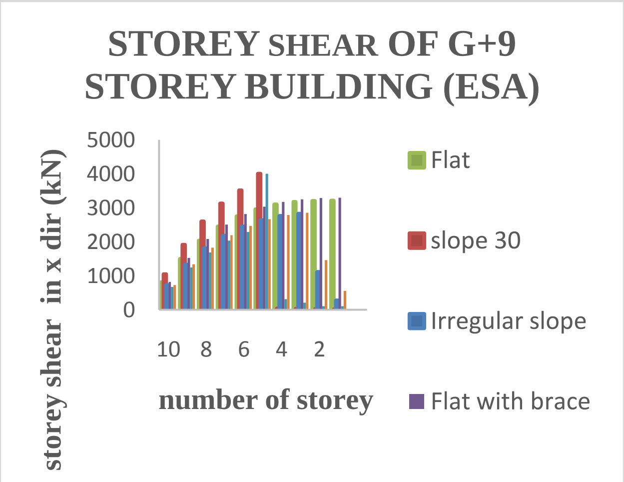


Chart -14: storey shear for 10 storey building by ESA method

From the above graphs we can observe that increase in storey shear is proportional to the increase in mass, therefore the effect of storey shear can be said as mass depended phenomenon, which is particular to the study. The braced RC frames are observed to have more shear force when compared to bare frames because stiffer system attracts higher forces due to increase stiffness and mass.

3. CONCLUSIONS

From the above figures the following conclusion can be obtained

- Time period of structures on 30 degree slope is less than the time period of structures on irregular slope and flat, hence we can conclude that 30 degree slope building is more rigid than structures on irregular slope and flat.
  The structures on 30 degree slope is more rigid than structures on irregular slope and flat since it exhibits the lowest time period
- and therefore it absorbs more earthquake forces on the other hand structures on flat is flexible as its time period is maximum.
- Time period increases with increase in number of storeys while frequency is observed to be decreased.
- Time period for RC frame buildings can be reduced by providing bracings, when compared with bare frames.
- From the above study it is observed that the displacements of ten storey RC frame buildings is more than seven storey RC frame buildings and hence we can conclude that as the storey height increases even displacement increases .
- Higher the position of extra mass the moment of the inertial force is more leading to larger displacement. Due to less stiff ground storey the inter storey drift is found to be more in stiffness irregular structure. Hence, the floor displacement is more in stiffness irregular structure than regular structure.
- Inter-storey drift obtained are observed to be within the permissible limits as specified in clause 7.11.1 of IS1893-2000(part1) .
- Inter-storey drift can be minimised by using bracings for structures resting on flat, irregular slope and 30 degree slope .
- Storey shear decreases with increase in storeys for structures on flat but it is not evident for structures on slopes .hence we can conclude that increase in storey shear is proportional to the increase in mass and it does not depend on storey height completely.
- The storey shear for bare frame is less when compared to braced frame structures.
- Base shear of structure on slope strata is more than that of structure on flat ground in ESA method and in RSA method the base shear nearly same for both but in THA it is observed that base shear is less for structure on slope. This is because time history analysis method is more accurate it shows base shear of structure on slope strata is less compared to regular structures as in structures on slope the mass is varying on each floor this change is not accounted in ESA and RSA method. Therefore we can Conclude that time history analysis is more precise and should be used to validate safety of the structure..
- From the study it is concluded that the presence of bracings influences the behaviour of structure by reducing storey displacement and storey drifts considerably, but may increase the base shear, hence special attention should be given in design to reduce base shear.

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