Seismic Time History Analysis Of Building On Sloping Ground Cosidering Near/Far field Earthquake

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***Abstract*— The scarcity of plain ground in hilly areas compels construction activity on sloping ground resulting in various buildings such as residential building, hospitals, colleges, hotels and offices resting on hilly slopes. The behavior of buildings during earthquake depends upon the distribution of mass and stiffness in both horizontal and vertical planes of the buildings. The buildings constructed in hilly area are subjected to severe earthquake. In India most of the hilly area is laying in severe earthquake zone, so in this work the time history of chamoli and uttarkashi earthquake considering near field and far field is applied on the building on plain ground and sloping ground and the response of building is studied.**

***Keywords*— sloping ground, time history, earthquake, response of building**

I. INTRODUCTION

The various types of buildings are constructed in the hilly area from the reinforced cement concrete. The I.S.-1893-2002 gives various methods such as static and dynamic methods for the analysis of the buildings. The buildings constructed in the hill area are highly asymmetric in plan as well as elevation, so dynamic method must be used for seismic analysis of the buildings. These methods are response spectrum method and time history method. In the response spectrum method the data such as zone factor, type of soil etc. are applied from I.S.-1893. In time history method the actual record of accelelogram is applied on the building and analysis of the building is carried out in software.

Time history method gives more realistic result compared to the response spectrum method because in time history the actual acceleration data of earthquakes are applied and response of building is studied. If the epicentre of the earthquake is very near to building it is known as near field earthquake and if epicentre is at far distance from building it is known as far field earthquake. So in this work the data of 2indian earthquakes namely chamoli earthquake and utaarkashi earthquake from near field and far field are collected and it is applied on the building on plain as well as sloping ground and the response of the building on sloping ground with respect to plain ground is compared.

Due to site conditions, buildings on hill-slops have unequal column heights which results in variation of column stiffness. In buildings with unequal vertical members (i.e., column and/or walls) also the floors twist about a vertical axis and displace horizontally and suffered more damage in the shorter columns as compared to taller columns in the same storey. This particular effect is known as short column effect and the short columns are subjected to severe damage during strong ground shaking.

II. MODELING AND ANALYSIS

In the present work the building on plain ground with 5 storey and 10 storey is modelled in SAP 2000 software. The size of the beams is 230 mmX500 mm and the size of the column is 300mmX500mm. The slabs are considered as 130 mm thickness. The slabs are modelled using shell element in the SAP software, necessary meshing is given to slab to transfer the slab load properly to adjacent beams. All the beams are loaded with 230 mm thick wall and wall load is applied uniformly on the beams. The slabs are loaded with floor finish of $1KN/M^2$. The live load applied on all the slab is $3\ KN/M^2$. The static analysis of the building has been carried out for the dead loads and live loads.

The necessary mass of the buildings are considered in the modal analysis of the buildings. The total number of modes is considered in such a way that modal participation factor is more than 90 percentages, and modal analysis considering 12 modes has been carried out.

The same 5 storey and 10 storey building is modelled on the sloping ground considering 23 degree and 27 degree slope. The necessary size of column, beam and slabs are assumed in all the buildings are same. The diaphragm constraint is given to joints in SAP 2000 software to take effect of rigid diaphragm in seismic analysis. According to above discussion following models are prepared in SAP software.

1) 5 storey Building on plain ground and on angle of slope: 23 degree ,
2) 5 storey Building on plain ground and on angle of slope: 27 degree
3) 10 storey Building on plain ground and on angle of slope: 23 degree
4) 10 storey Building on plain ground and on angle of slope: 27 degree
5) Height of each storey: 3.5m
6) Live load: $3\ KN/M^2$ for all typical floor

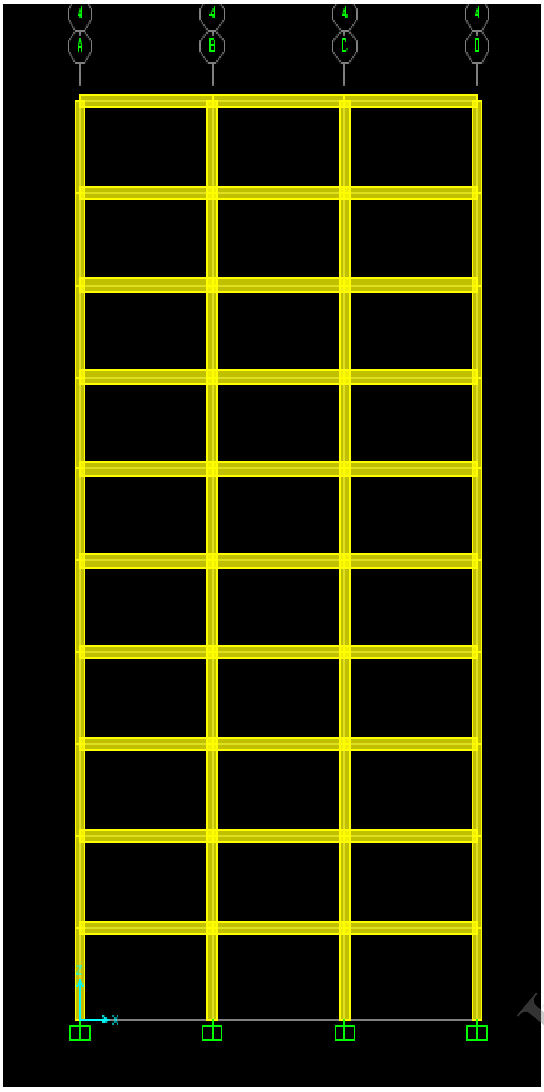

Fig. 1. model of building on plain ground

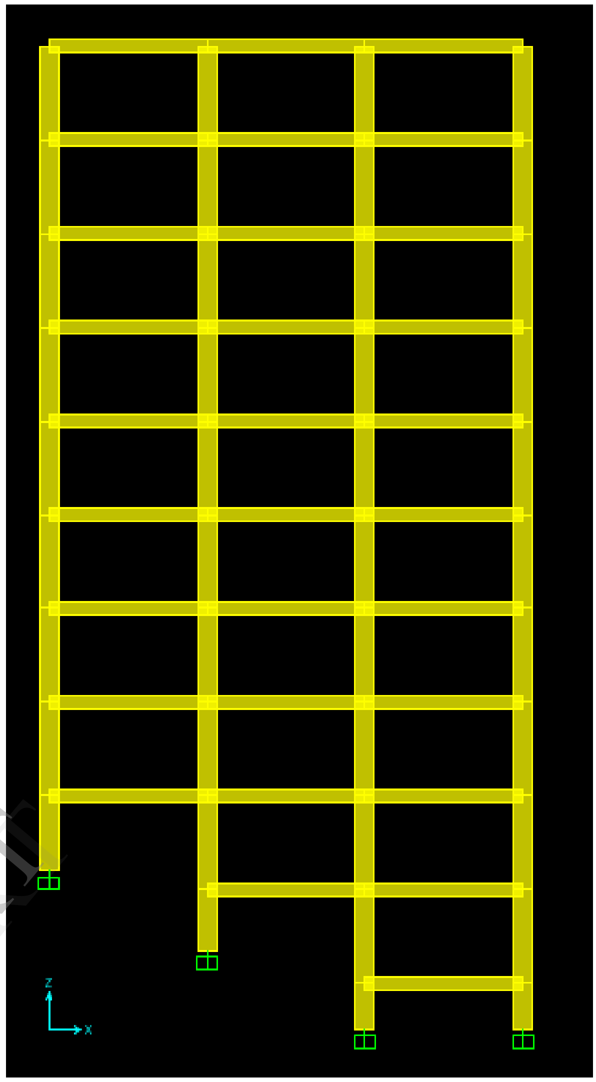

Fig. 2. model of building on plain ground

The response spectrum function as per the following details according to I.S.-1893-2002 are also applied in the SAP software

(a) Zone : Zone - V
(b) Type of soil : Type –II medium soil
(c) Importance factor : 1
(d) Response Reduction factor : 5

In addition to response spectrum analysis of all the buildings time history of chamoli and uttarkashi earthquake considering near field and far field earthquake is also applied. The linear time history analysis of the buildings on plain and sloping ground has been carried out. The details of time history of chamoli and uttarkashi earthquake are as under. Fig.3 shows the acceleration time history of chamoli earthquake, and fig.4 shows acceleration time history of uttarkashi earthquake. The details are as under.

a) Name of time history : chamoli
b) Magnitude : 6.6
c) Duration of earthquake: 25.42 second
d) Peak ground acceleration : 1.9507 m/sec2
e) Time for PGA : 4.8 second
f) Duration: short
g) Total no of acceleration records : 1270
h) Time step:0.02 second

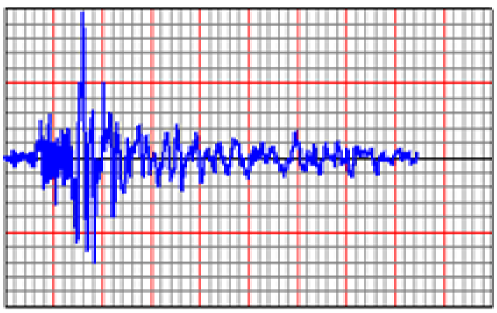

Fig. 3. Chamoli time history

a) name of time history : uttarkashi
b) Magnitude : 7.0
c) Duration of earthquake: 21.32 second
d) Peak ground acceleration : 2.48 m/sec2
e) Time for PGA : 4.26 second
f) Duration: short
g) Total no of acceleration records : 1808
h) Time step :0.02 second

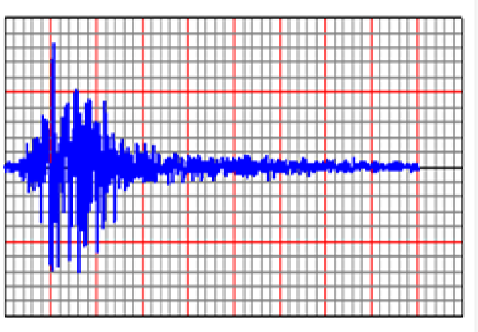

Fig. 4. Uttar kashi time history

A. Dynamic Analysis

First modal analysis of the structures are carried out for first 12 modes and the dynamic characteristics of plain building and building on sloping ground has been studied. After performing dynamic analysis the response spectrum analysis has been done the numbers of modes considered are 12 so that modal participation factor is more than 90 percentages as per the I.S.-1893-2002. The base shear and other parameters are studied in the response spectrum analysis of the building. After performing the response spectrum analysis the time history analysis for chamoli earthquake considering near field and far field has been carried out. The seismic time history analysis for uttarkashi earthquake is also carried out considering near field and far field.

III. RESULT AND DISCUSSION

The dynamic analysis has been carried out and the time period for first 12 modes are plotted and shown in the fig5.
The base shear for plain building and sloping building considering response spectrum method and time history method are shown in the fig. 6 to fig.10.

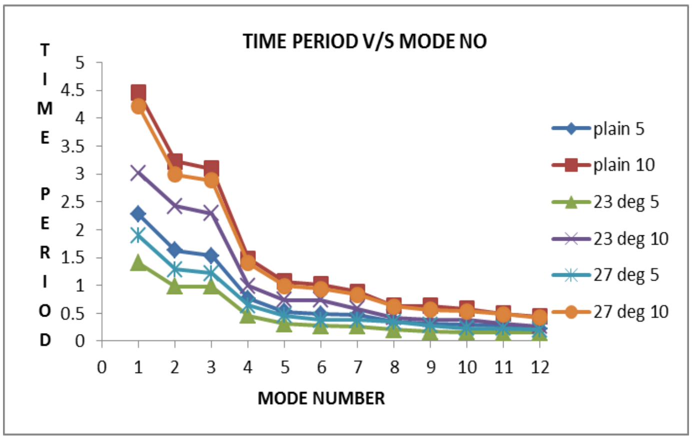

Fig.5 Time period v/s mode number

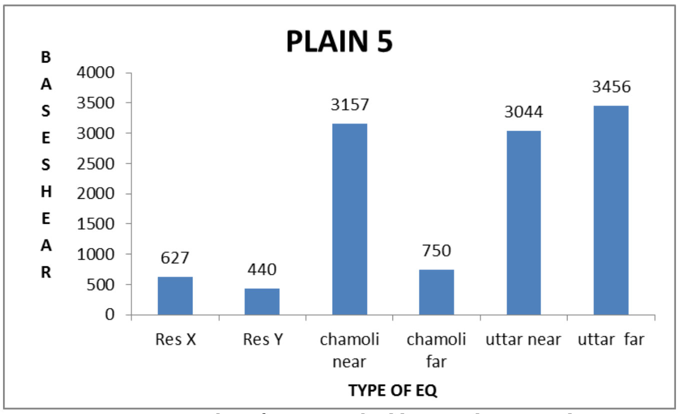

Fig 5 .Base shear for 5 storey building on plain ground

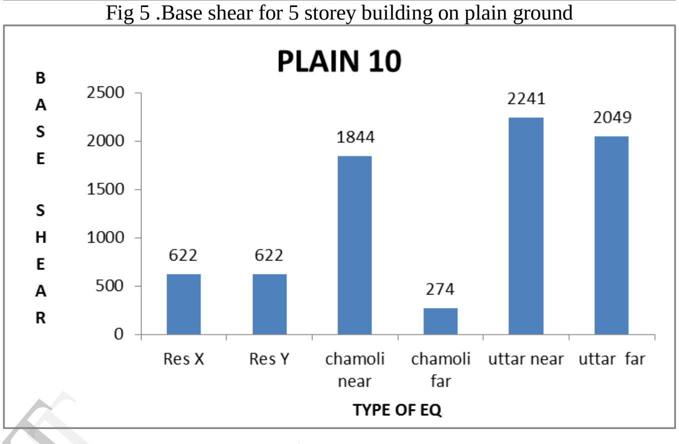

Fig. 6. Base shear for 10 storey building on plain ground

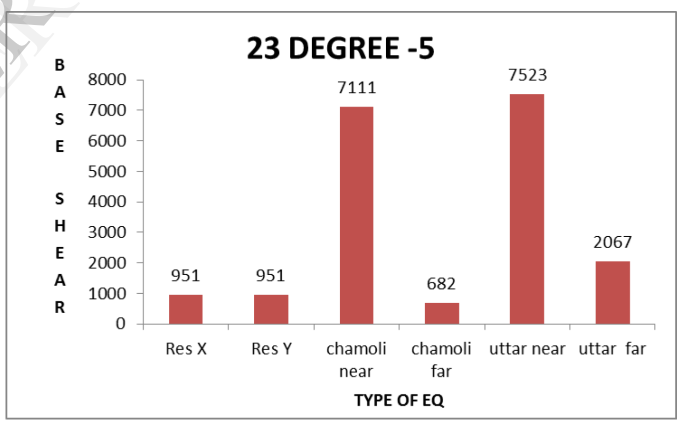

Fig. 7. Base shear for 5 storey building on 23 degree slope

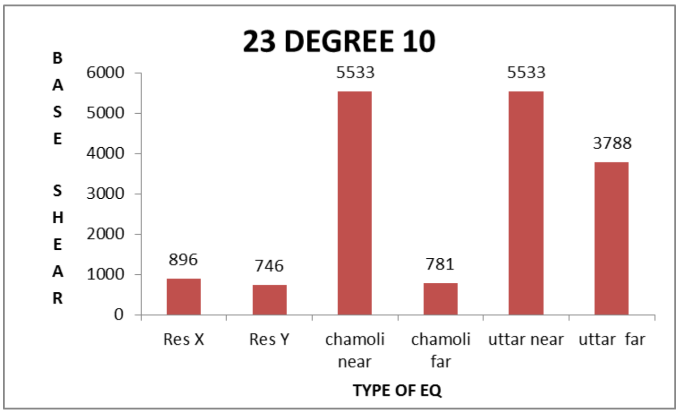

Fig. 8. Base shear for 10 storey building on 23 degree slope

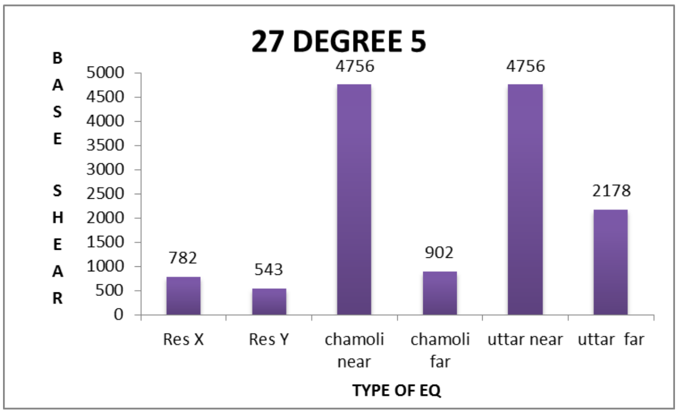

Fig. 9. Base shear for 5 storey building on 27 degree slope

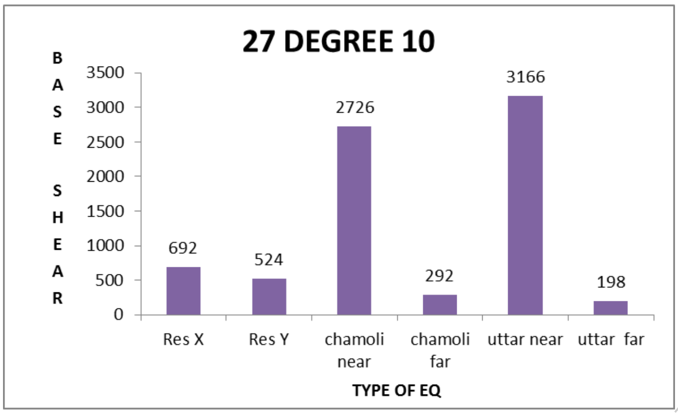

Fig. 10. Base shear for 10 storey building on 27 degree slope

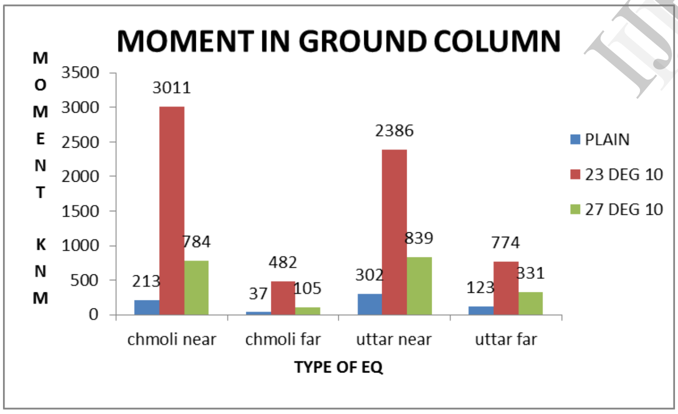

Fig. 11. Moment in column at ground floor

IV. Conclusion

The following conclusions were drawn from the study.

(1) The time period in first mode is higher for 10 storey building compared to 5 storey building and the time period in first mode is only 1.4 second for 23 degree slope, so buildings on 23 degree slope are more rigid compared to plain and 27 degree slope.

(2) From the graph of time period we can observe that time period is different for first 5 modes in all the buildings and after 5th mode the time period is almost same.

(3) The building on 23 degree slope has lowest time period so it is more rigid building and gives higher earthquake forces

(4) The base shear by response spectrum method is higher for buildings on sloping ground compared to building on plain ground.

(5) In case of chamoli near field earthquake base shear in 5 storey building is 125 percent higher in 23 degree slope and 147 percent higher in 27 degree slope compared to plain ground

(6) In case of chamoli far field earthquake base shear in 5 storey building is almost same in building on 23 degree slope, 27 degree slope and plain ground.

(7) In case of uttarkashi near field earthquake base shear in 5 storey building is 147 percent higher in 23 degree slope and 57 percent higher in 27 degree slope compared to plain building

(8) In case of uttarkashi far field earthquake base shear in 5 storey building is less on 23 degree and 27 degree slope compared to plain building.

(9) In case of chamoli near field earthquake base shear in 10 storey building is 200 percent higher in 23 degree slope and 47 percent higher in 27 degree slope compared to plain building

(10) In case of chamoli far field earthquake base shear in 10 storey building is 185 percent higher in 23 degree slope and 7 percent higher in 27 degree slope compared to plain building

(11) In case of uttarkashi near field earthquake base shear in 10 storey building is 112 percent higher in 23 degree slope and 41 percent higher in 27 degree slope compared to plain building

(12) In case of uttarkashi far field earthquake base shear in 10 storey building is 85 percent higher in 23 degree slope reduces by 30 percent in 27 degree slope compared to plain building

(13) We are getting large increase in base shear in near field earthquake for building on 23 degree slope because that building is rigid building.

(14) As shown in fig. 12 and fig.13 the short column effect is observed on columns located near the ground floor and the bending moment in ground column increases by about 1300 percentage in near field earthquake for 23 slope and 690 percent increase in 27 degree slope compared to plain buildings.

So we can conclude that the time history analysis is exact analysis and give us idea about the actual forces developed in structure during ground shaking. The columns near ground levels are subjected to short column effect so they must be properly designed to resist the earthquake forces.

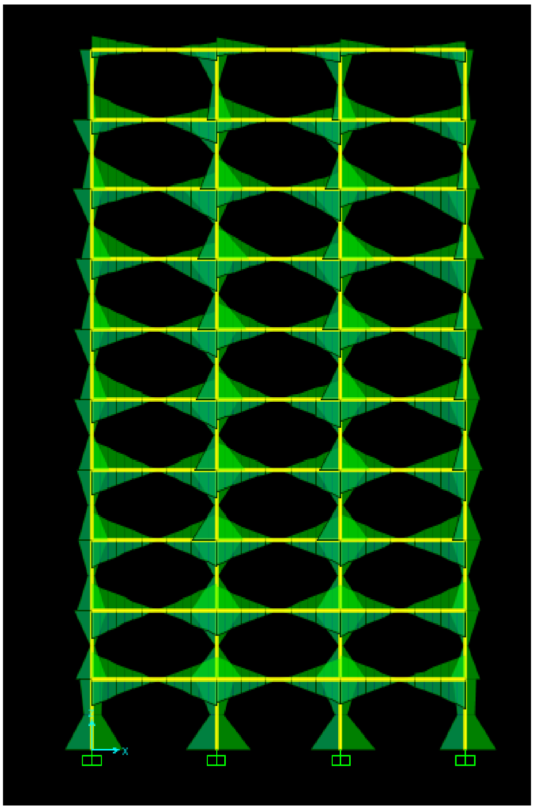

Fig. 12. Moment in column at ground floor for plain ground

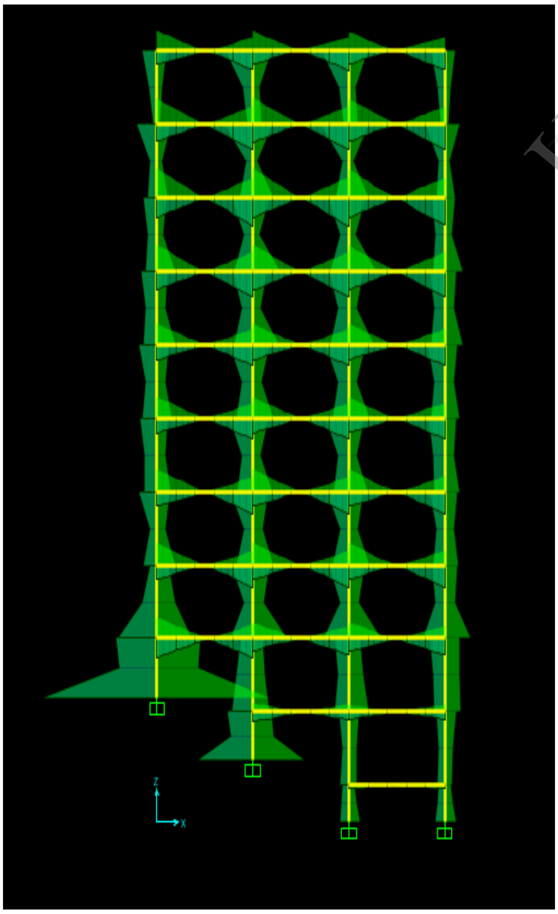

Fig. 13. Moment in column at ground floor for sloping grond

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