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# Seismic Performance of RC Set Back Building on Sloping Ground

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***Abstract*: *From various studied it was found that buildings with any type of irregularity gets more damage than a regular building. Indian code provides various provisions to compensate the seismic design of irregular building. It is generally believed that the buildings with regular shapes have a dominant fundamental mode participation during seismic response and as the irregularity increases the contribution of higher mode increases. Accordingly, Various previous studies have proposed methodologies to quantify vertical irregularity of the buildings in terms of their fundamental mode properties. In the present work various models with unique type of vertical irregularities were analyzed with the help of Staad Pro. And an comparatively stable model amongst all were find out.***
***Keywords: Slope, Axial force, Displacement, Base shear.***

## I. INTRODUCTION

The economic growth and rapid urbanization in a hilly region has accelerated development of infrastructure and construction activities. Because of which, population density in the hilly region has increased. Therefore, there is popular and pressing demand for construction of multi-story building in hilly region. Hill buildings are different from those in plains; they are very irregular in horizontal and vertical plains. Hence, they are susceptible to severe damage when affected by earthquake ground motion. In this study the 3D analytical model of G+25 storey building is to be generated of step setback building for zone iv and zone v case with varying slopes. Building models are analyzed by STAAD. Pro software

## II. AIM

To Analyze and Design multi-storey building in with set back on sloping ground

## III. OBJECTIVE

The main objectives of our work are as follows :-

*A.* Compare various parameters such as base shear, displacement, axial force, bending moment for various models.
*B.* To study the building resting on sloping ground.
*C.* To create the models of building resting on various slopes ($0^0$, $5^0$,$10^0$ , $20^0$, $30^0$)
*D.* To carry out equivalent static analysis for buildings on sloping ground.
*E.* To carry out dynamic analysis by using Response spectrum method for building on sloping ground.

## IV. GENERAL STUDY

### *A. Seismic Behaviour Of Buildings On Slopes In India*

North and north-eastern parts of India have large scales of hilly region, which are categorized under seismic zone IV and V. In this region the construction of multi-storey RC framed buildings on hill slopes has a popular and pressing demand, due to its economic growth and rapid urbanization.

This growth in construction activity is adding increase in population density. While construction, it must be noted that Hill buildings are different from those in plains i.e., they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Since there is scarcity of plain ground in hilly areas, it obligates the construction of buildings on slopes. During past earthquakes, reinforced concrete (RC) frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey.

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*B. Response Spectrum Method*

According to the IS 1893 (part I)-2012, high rise and irregular building must be analyzed by response spectrum method using design spectra shown. There is significant computational advantage using response spectrum method of seismic analysis for prediction of displacement and member forces in structure. It is analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of essentially elastic structure. It provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelop spectra such that a smooth curve represents the peak response for each realization of structural period.

## V. STRUCTURAL PARAMETERS

Table 1 Detail Structural Parameters

| Parameter | Value |
|---|---|
| Type of Building: | RCC Framed Structure |
| Number of storey | 10 (Ground + 8) |
| Plan Size | 25 m X 30 m |
| Floor to floor height | 3 m. |
| Height of plinth | 1.5 m above G.L. |
| Depth of foundation | 3.0 m. below G.L. |
| External walls | 150 mm thick |
| Internal walls | 150 mm thick |
| Height of parapet | 1.0 m |
| Materials | Reinforced concrete for the columns and beams |
| Concrete | M25 |
| Steel | Fe500 |
| Slab Thickness | 125 mm |
| Elastic Modulus of concrete | $5000\sqrt{fck}$ |
| Size of Beams | 230 mm X 430 mm |
| Size of Columns | 230 mm X 460 mm |
| Density of Concrete | 25 kN/m$^3$ |
| Density of brick masonry | 20 kN/m$^3$ |
| Type of frame | SMRF |
| Seismic zone | II |
| Response reduction factor | 5 |
| Importance Factor | 1 |

## VI. CASE COMBINATION

Table 2 case combination

| DESCRIPTION | ABBRIVATION |
|---|---|
| Regular Concrete Structure | S1 |
| Sloping structure at $5^0$ | S2 |
| Sloping structure at $10^0$ | S3 |
| Sloping structure at $20^0$ | S4 |
| Sloping structure at $30^0$ | S5 |

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## VII. GEOMERTY OF MODELS

1) Plan of Model

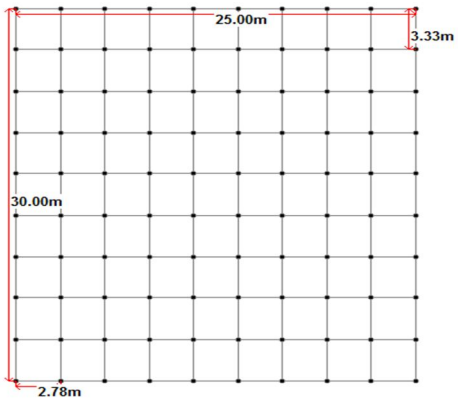
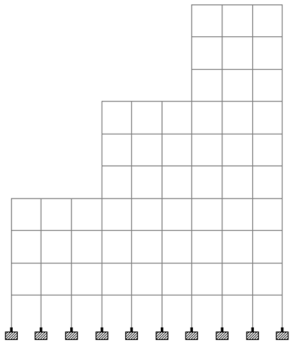
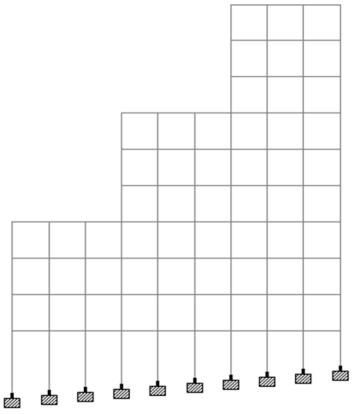



Fig no. 1: Plan of the Building

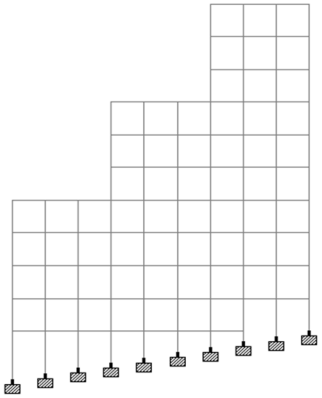
2) Side Views of all models



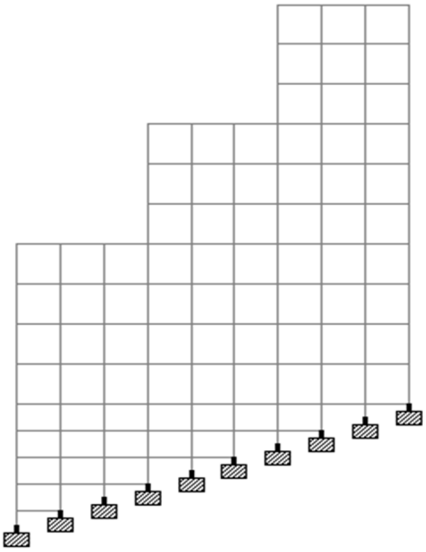
Model 1: $0^0$ (S1)



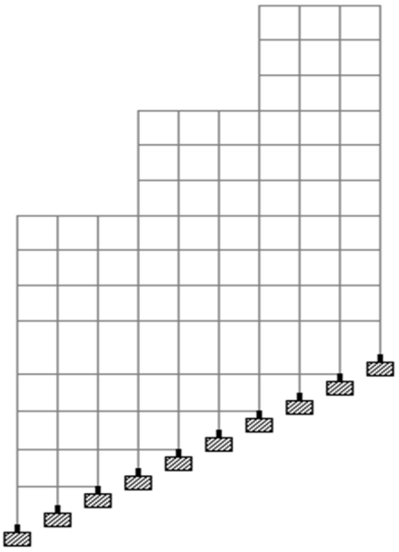
Model 2: $5^0$ (S2)



Model 3: $10^0$ (S3)



Model 4: $20^0$ (S4)



Model 5: $30^0$ (S5)

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## VIII. RESULTS FOR LOW RISE MODELS (G+4)

### *A. Zone IV*

#### *1) Step Setback Building*

Table 3: Base shear results for zone iv step setback building

| Angle | Base Shear (kN) | |
|---|---|---|
| | X-Direction | Z-Direction |
| $0^0$ | 4042.27 | 4030.72 |
| $5^0$ | 4071.76 | 4065.8 |
| $10^0$ | 4146.5 | 4136.02 |
| $20^0$ | 4154.93 | 4154.74 |
| $30^0$ | 4210.66 | 4267.51 |

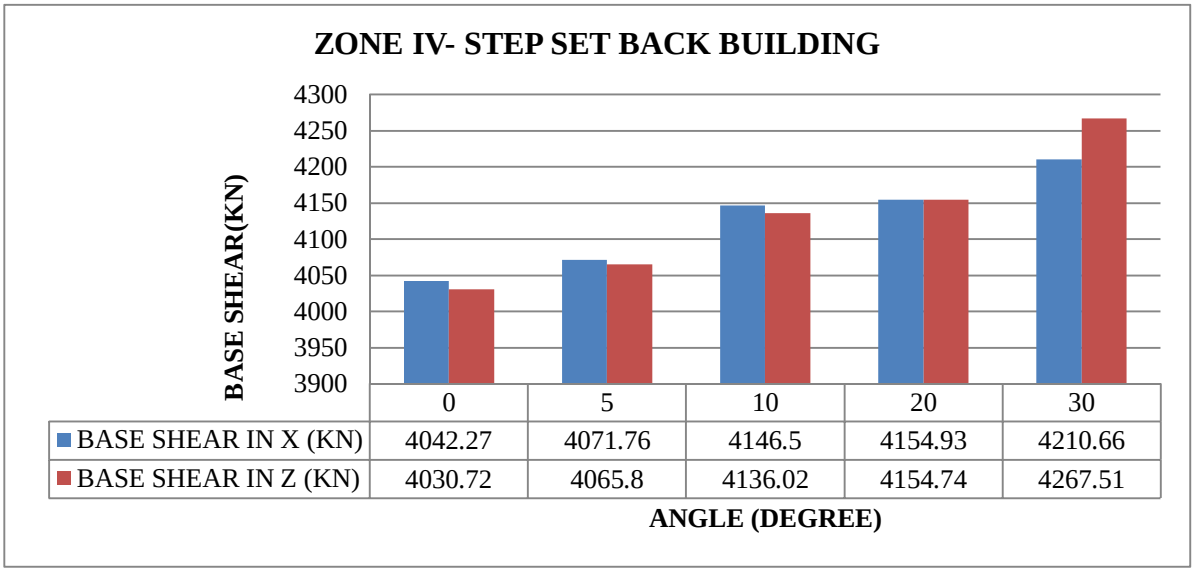



Fig 2 Base shear comparison in Zone-IV

In zone IV, it is observed that both the values of base shear in x and z directions are quite similar in case of step setback building. Base shear is low at flat ground i.e. on $0^0$ and then it is rising gradually up to $5^0$ slopes, after that again rises for $10^0$ and $20^0$ but has high value for $30^0$ Slope.

### *B. Zone V*

#### *1) Step Setback Building*

Table 4 : Base shear results for zone v step setback building

| Angle | Base Shear (kN) | |
|---|---|---|
| | X-Direction | Z-Direction |
| $0^0$ | 6066.73 | 6061.48 |
| $5^0$ | 6108.3 | 6102.53 |
| $10^0$ | 6219.74 | 6207.89 |
| $20^0$ | 6070.47 | 6066.91 |
| $30^0$ | 6318.97 | 6401.26 |

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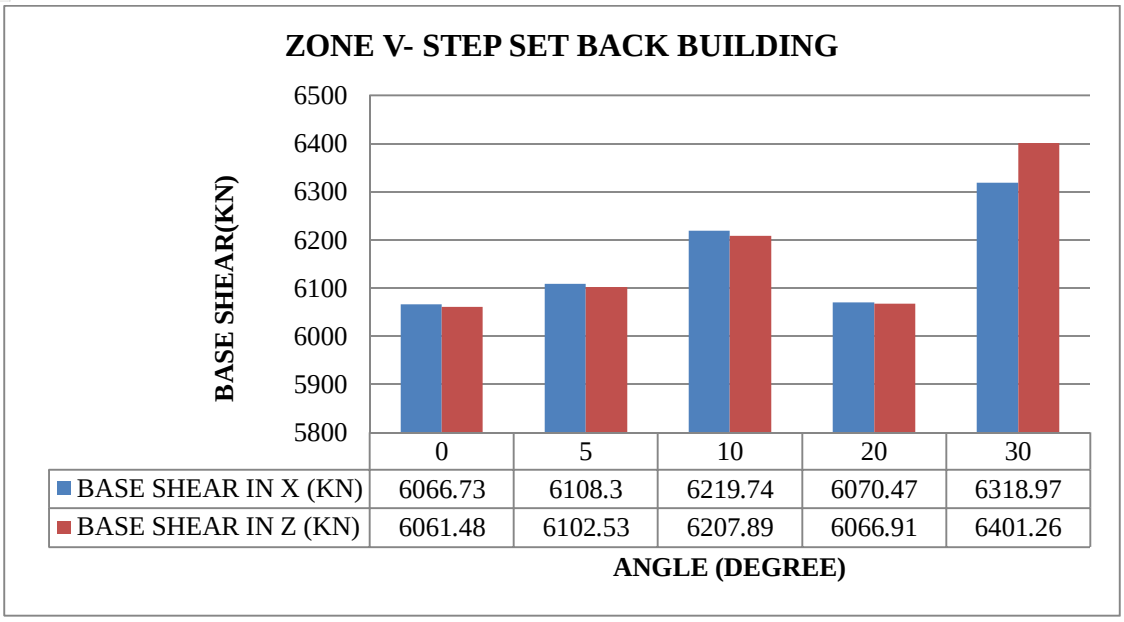



Fig 3 Base shear comparison in Zone-V

2) *Displacement (storey drift):* Story drift is difference in a lateral deflection between two adjacent stories. It is the drift of one level of a multistory building relative to the level below. Following are the maximum values of displacement from different load cases. The results are carried out for step setback building in each zone and graphs are plotted.

Table 5 Storey displacement In Zone-IV

| Angle | Max Displacement(mm) |
|---|---|
| | Step Set Back |
| $0^0$ | 28.062 |
| $5^0$ | 32.664 |
| $10^0$ | 26.667 |
| $20^0$ | 30.974 |
| $30^0$ | 76.415 |

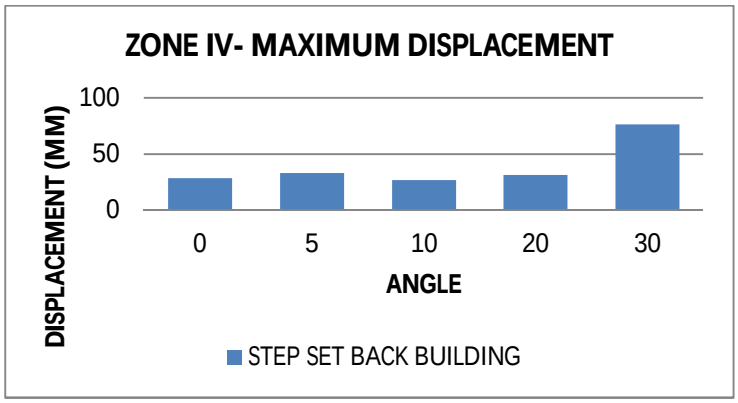



Fig 4 graph of storey displacement in Zone-IV

From the above graph in zone IV it is observed the magnitude of displacement on $30^0$ slope is greatest as compared to other slopes. Whereas for $10^0$ Slope the value of displacement is lea than all other slopes.

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*C. Zone V*

Table 6 Displacement results for zone v

| Angle | Max Displacement(mm) |
|---|---|
| | Step Set Back |
| $0^0$ | 42.036 |
| $5^0$ | 48.986 |
| $10^0$ | 39.94 |
| $20^0$ | 40.693 |
| $30^0$ | 114.622 |

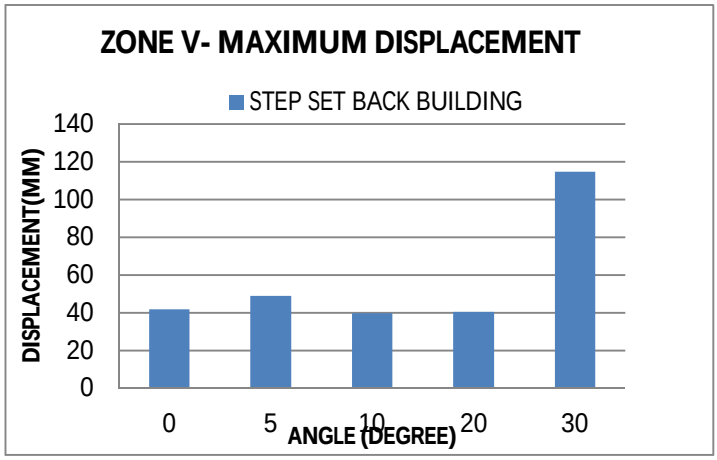



Fig 5 graph of storey displacement in Zone-V

And From the above graph in zone V it is observed that the magnitude of displacement on $30^0$ slope is greatest as compared to other slopes. So at or beyond $30^0$ slope the structure is not safe in displacement.

*D. Time Period*

It is the time needed for one complete cycle of vibration to pass a given point. It is a time taken to complete one vibration. Following are the results in each zone.

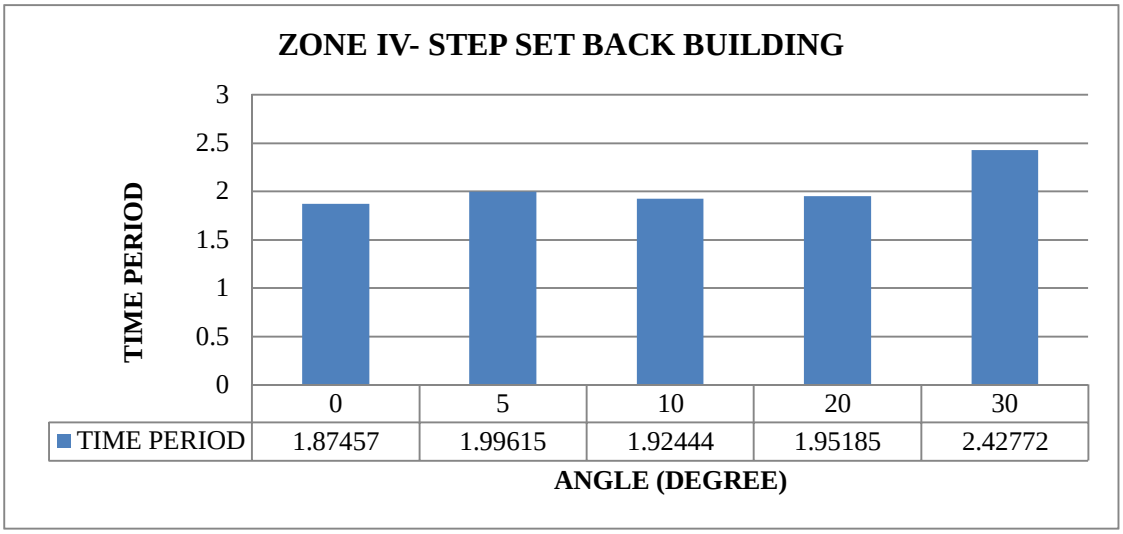



Fig 5 graph of time period in Zone-IV

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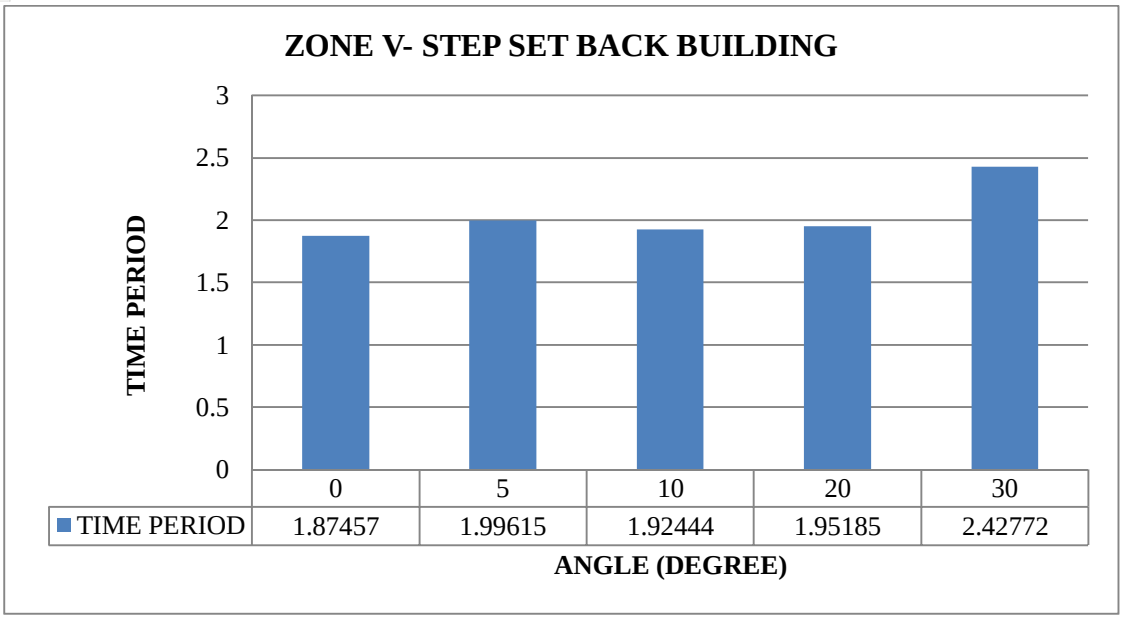



Fig 7 graph of storey displacement in Zone-V

It is observed that in both zones buildings on plane ground has less time period than building on sloping ground. Whereas in sloping condition buildings with $0^0$ have less time period amongst all others.

*E. Column Axial Forces*

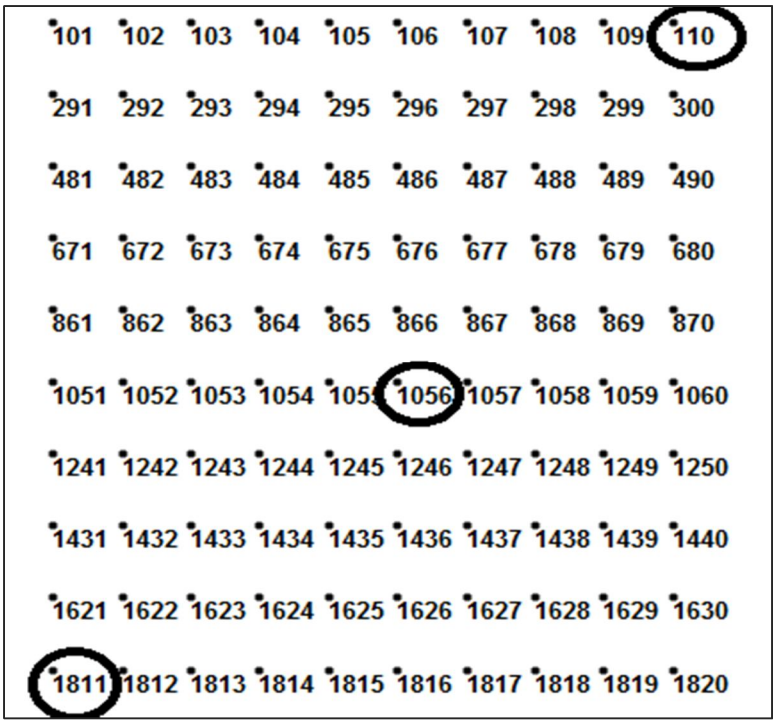
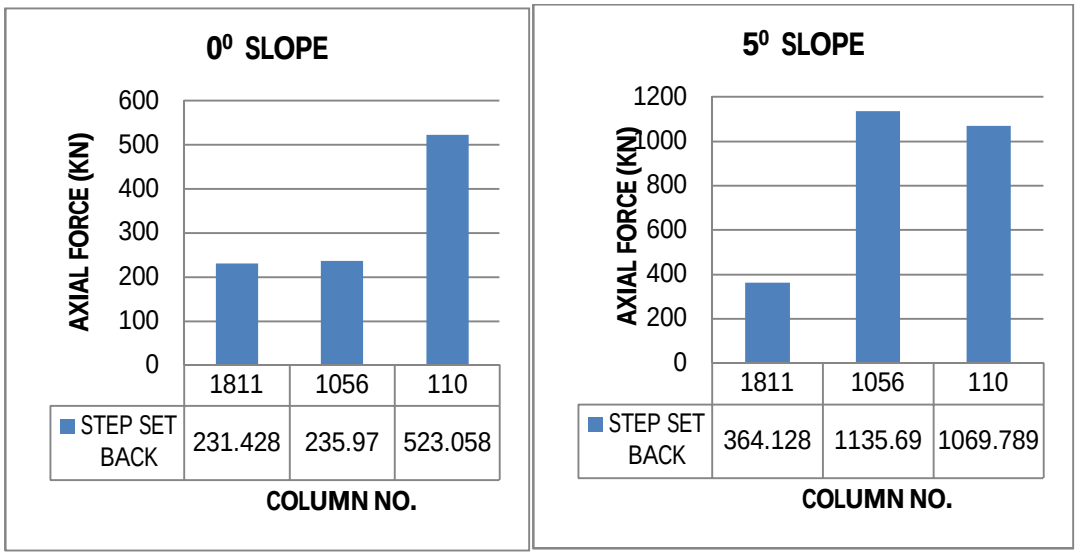



Fig 8 Selected columns for axial force and bending moment

As shown in above fig 8 selected columns for analysis of axial force and bending moment. By using graph comparative study between set back and step set back building located on slope of specific angles is carried out. This gives following results along with magnitude of the axial forces and bending moment.

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*1) Zone IV*




It is observed that in zone IV magnitude of the column at the middle is high at 50 as compare to other two. Axial force at $0^0$ is very low.

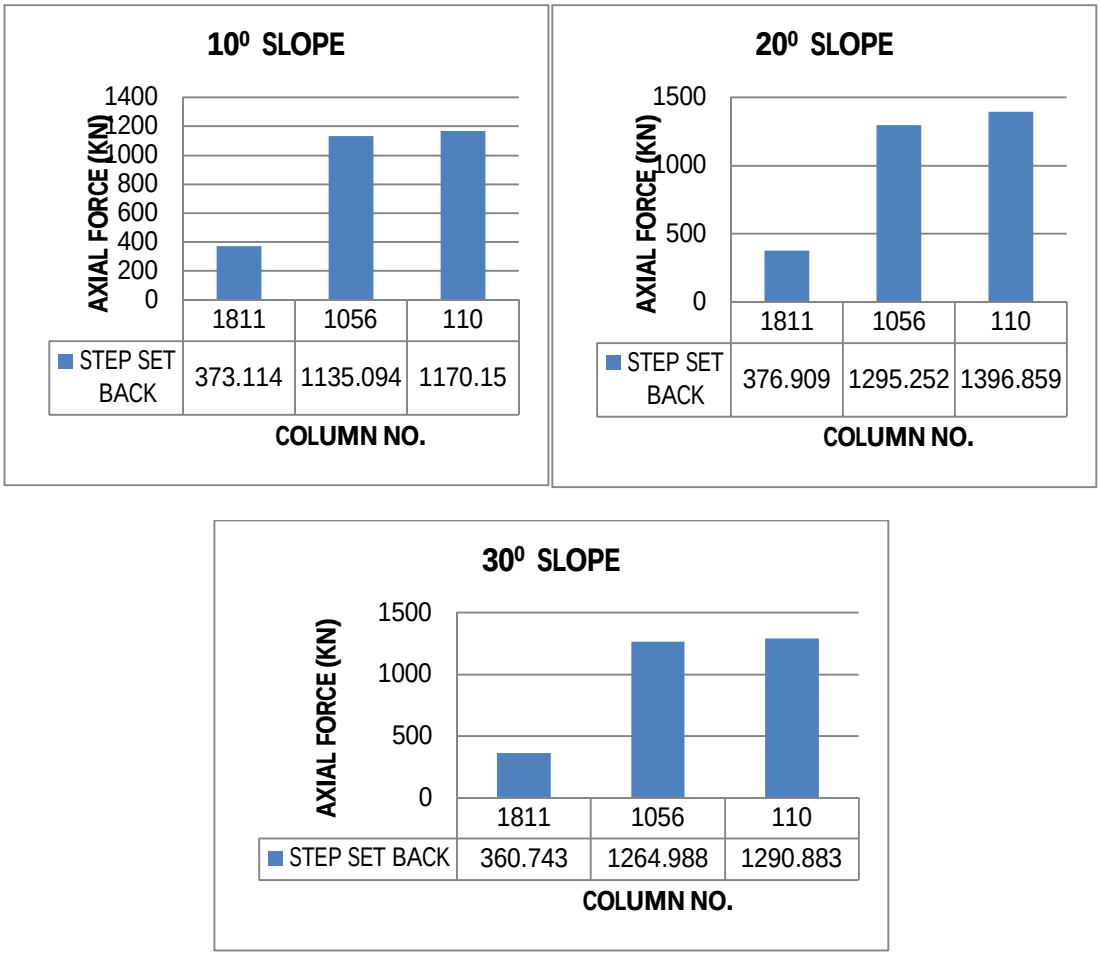
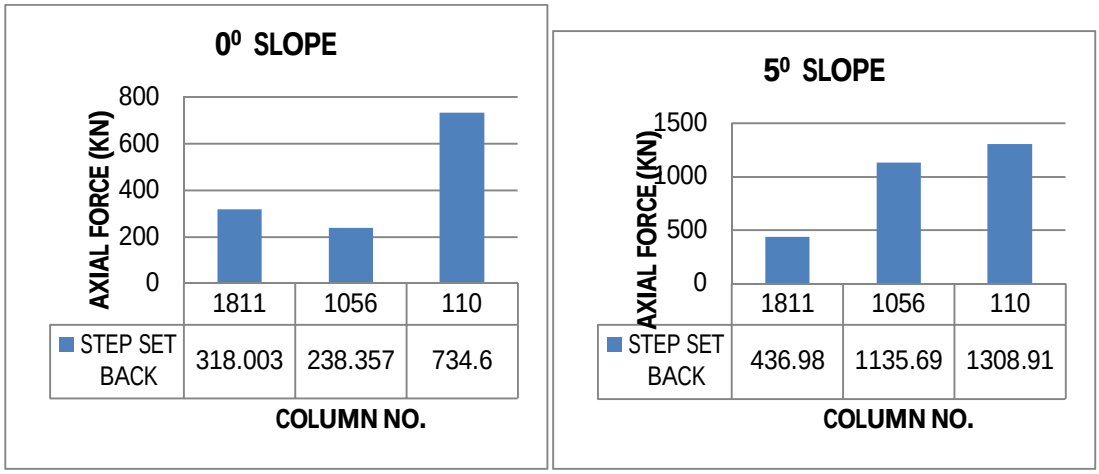



Fig no. 9: Graphs showing comparison for axial forces in column in zone IV

The value of axial forces for $0^0$ slope are lowest and have highest values for buildings on $20^0$ and $30^0$.

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*2) Zone V*




It is observed that in zone V the magnitude of the column at the middle is high as compare to other two. Axial force at $0^0$ is very low in case of step setback building.

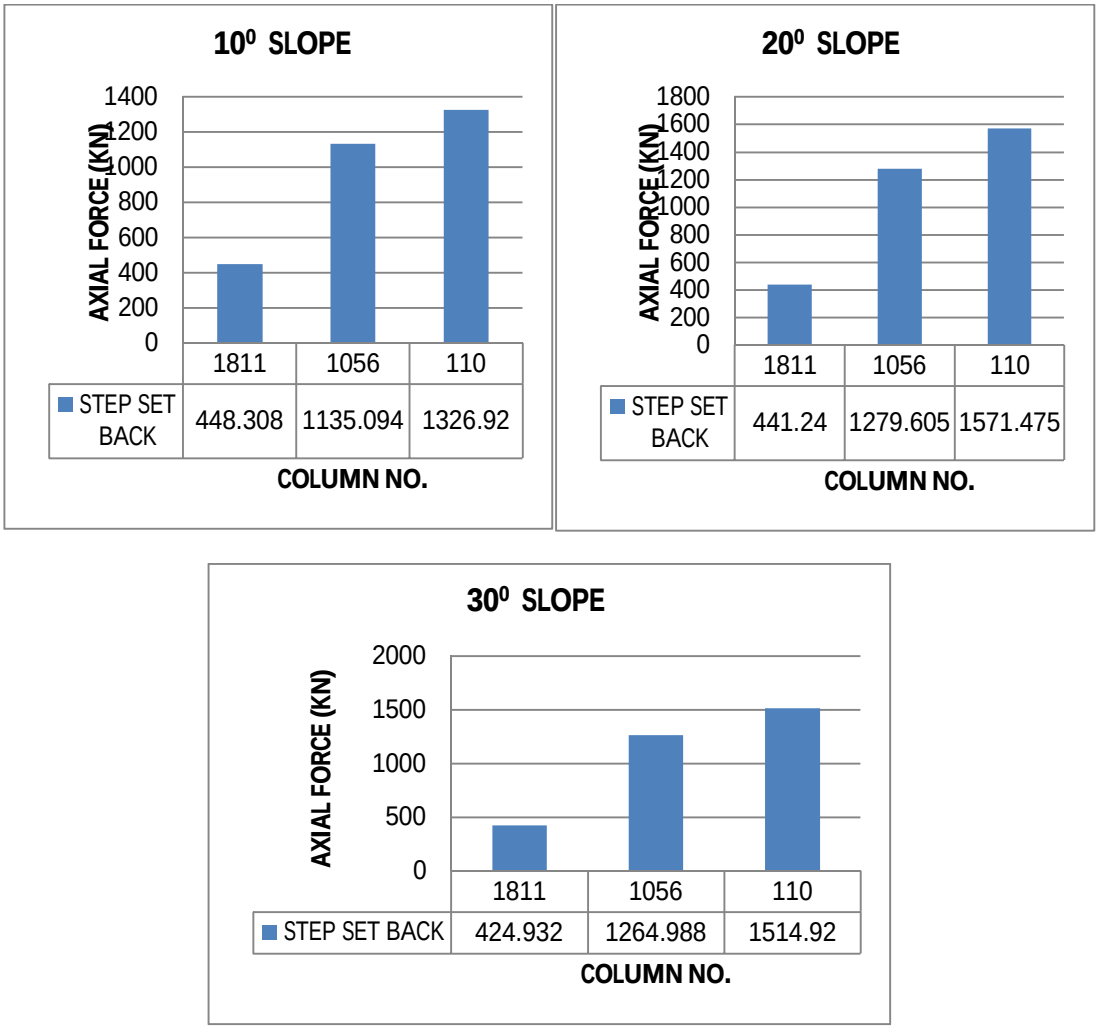



Fig no.10 : Graphs showing comparison for axial forces in column in zone V

The value of axial forces at various slopes respectively are quite similar, there is not so difference in it same as there in zone IV.

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*F. Beam Bending Moment*

*1) Zone IV*

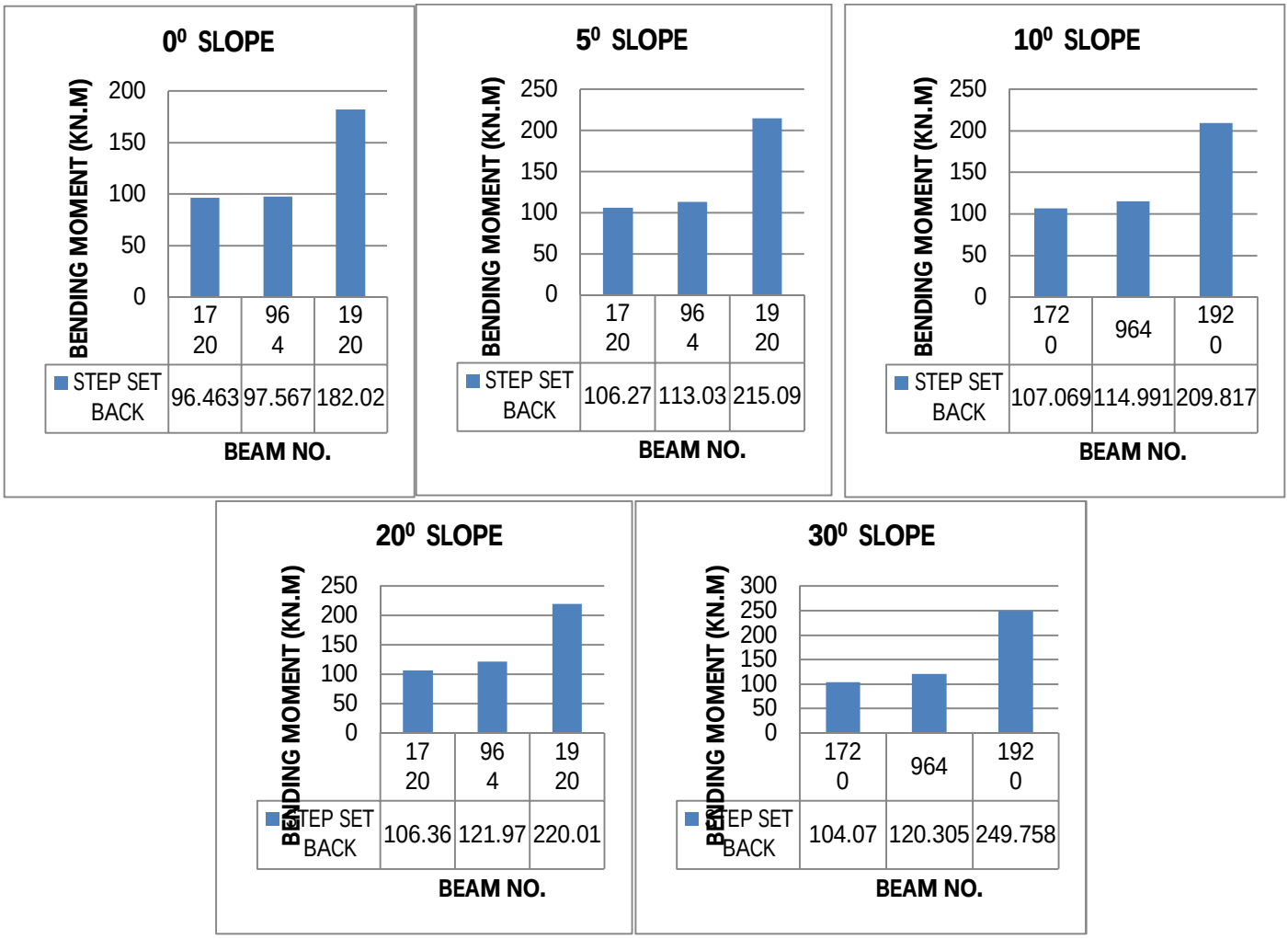
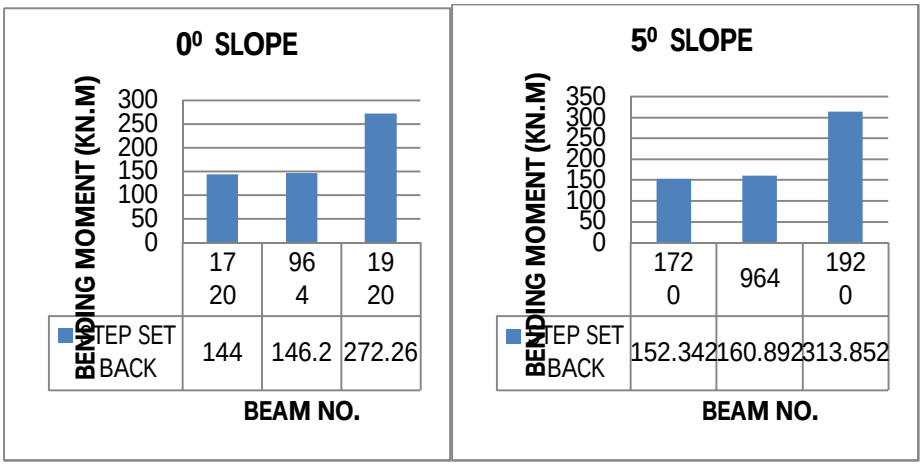



Fig no. 11 : Graphs showing comparison for bending moment in beam in zone IV

In beam analysis for bending moment in zone iv it is observed that bending moment is maximum in slope of angle 30 degree for beam no. 1920 and minimum in slope of angle 0 degree for beam no. 1720.

*2) Zone V*




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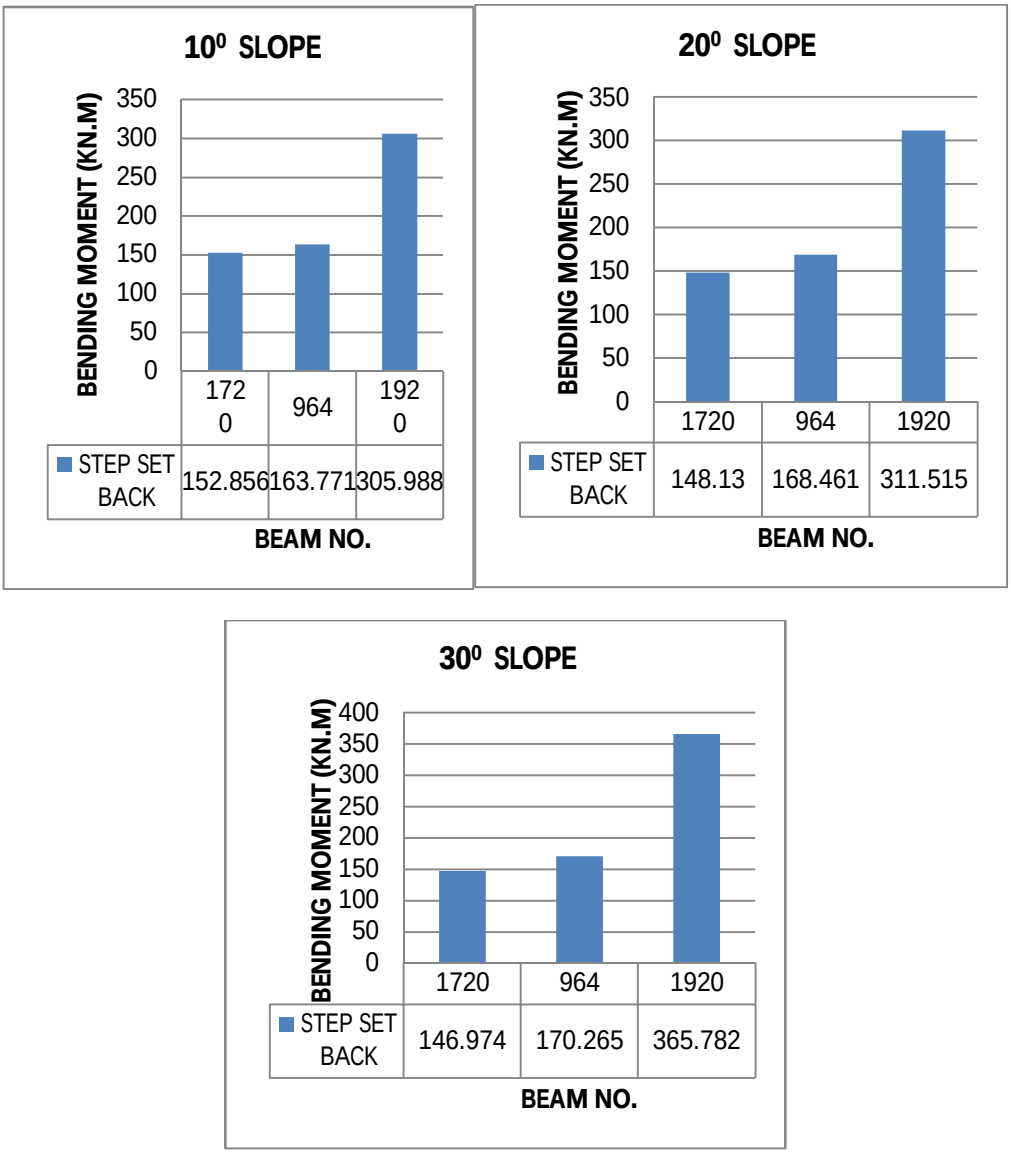



Fig no. 12 : Graphs showing comparison for bending moment in beam in zone V

In beam analysis for bending moment in zone v it is observed that bending moment is maximum in slope of angle 30 degree for beam no. 1920 and minimum in slope of angle 0 degree for beam no. 1720.

## IX. CONCUISONS

*A.* Provisions of tie beams prove to be the effective for construction as it reduces the base shear, displacement and counteract the forces.

*B.* For base shear $0^0$ to $20^0$ slope are effective for construction than the other.

*C.* For displacement step setback at $10^0$ building proves most effective in zone IV and zone V.

*D.* For time period it is observed that $0^0$ Sloping ground gives less results than other slopes.

*E.* Overall for construction of building on sloping ground step setback building with slopes $5^0$ and $10^0$ proves most effective than other slopes.

## X. ACKNOWLEDGEMENT

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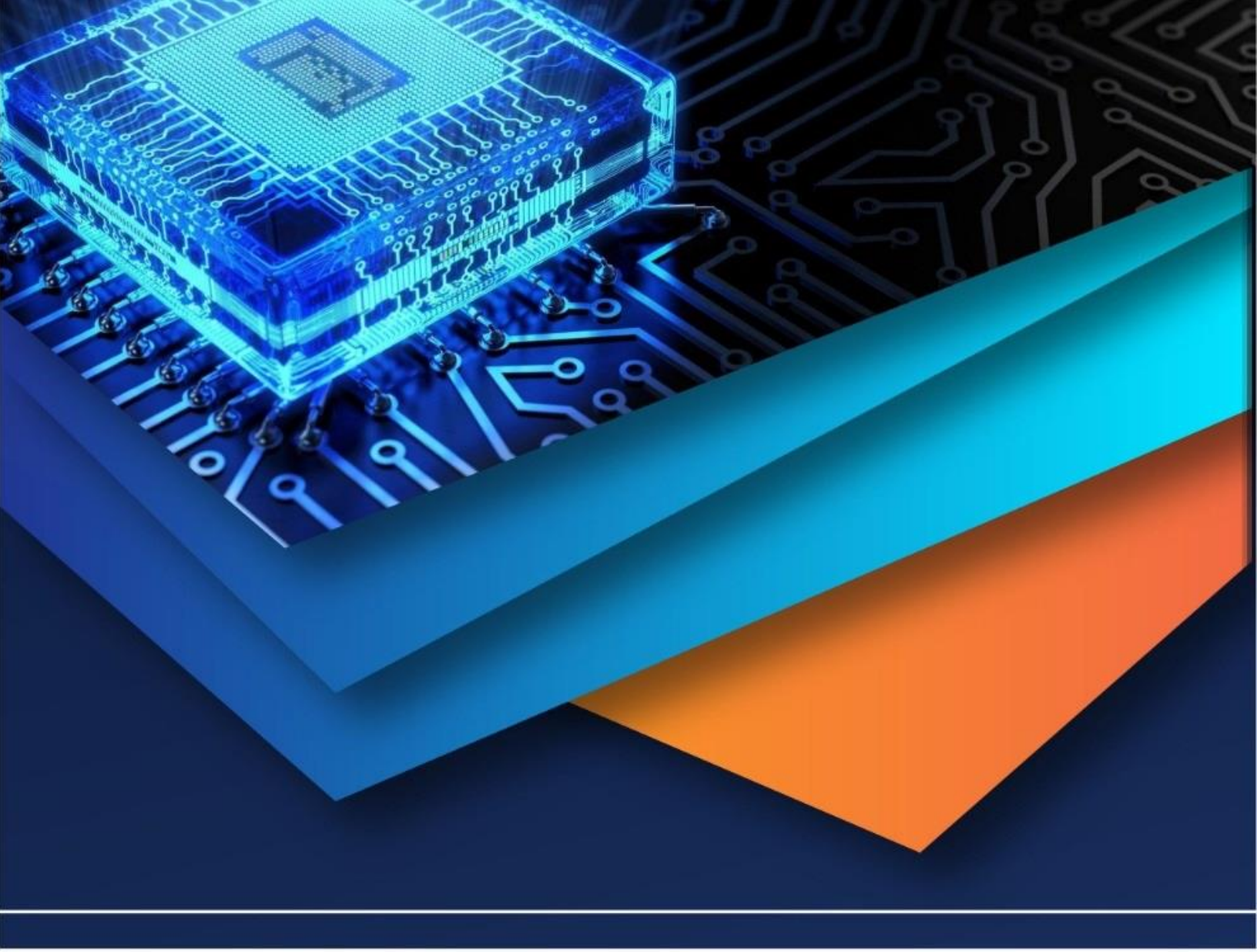
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IS codes:

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[2] IS 875: PART I, "Code of Practice for Design Loads (Other than Earthquake) Dead Loads".
[3] IS 875: PART II, "Code of Practice for Design Loads (Other than Earthquake) Imposed Loads".
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