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Comparative Study of Regular and Irregular High-Rise Building with Transfer Floor using Dampers

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Abstract: ***The Techniques used in the field of Construction works are improving day by day. The construction of High-rise buildings in Metro cities nowadays have much importance, in-order to fulfill all the necessary needs to be achieved during a Construction process within the limited space available. One of the main draw-back is the formation of Vertical irregularity in buildings. This can be minimized by the installation of Transfer floors in the structures. The transfer floor is the floor system which supports vertical as well as lateral loads and transfer it to different underneath systems whose above portion can be used for residential as well as office purpose while below portion can be used for malls, parking etc... The high-rise buildings are analyzed by Response spectrum analysis using the structural software for building analysis ETABS 2016 software. The analyzed models have transfer slab system at different floor levels i.e. at the odd floor levels of the building.***
Keywords: Transfer floor, Response spectrum, Displacement, Shear, Moment, Seismic zones, FVD, Vertical irregularity

I. INTRODUCTION

The Technology is developing day by day that tends to cause new trends in the construction field where the new innovative architectural techniques are used in high rise buildings, mega tall structures with the advanced and powerful structural analysis. High-rise buildings are now a days very popular in places where land availability is an issue mostly in densely populated areas as it requires less space and accommodates large number of People. The Multi-storied buildings had become an indispensable form for the construction of new housing in urban areas. For such conditions, we require structures that satisfy both the residential and commercial needs in one building which is a common solution. As a result of development, the demand for high-rise buildings with columns has also been raised. In-order to have different arrangement system between floor levels of the buildings stable structures are to be designed. Here comes the importance of Transfer floor. A Multi-storied building with a transfer floor system consisting of a structure located below the transfer floor, which serves as functional areas of an atrium while the structure above the transfer slab act as a residential unit.

A high rise building with transfer floor system the space below the structure can be used as transfer system such as shopping mall, parking, commercial markets, multi-purpose halls, etc. while the structure above can be used as office, residential units etc. making more economical and shorter span design. It's been a common solution to use transfer slab as a medium to transfer load between upper and lower part of building. Most of the buildings are constructed with these vertical irregularities, i.e. the structural walls and columns with transferring mechanism between different column arrangements at floor level. A transfer floor supports a system that is resistant to vertical and lateral loads.



Fig.1 Building with Transfer Slab [P.S. Lande *et.al* (2018)]

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1) *Transfer Floors:* A transfer floor is the floor system which supports a vertical as well as lateral load resisting system and transfer its loading to different underneath system. Transfer floor distribute the load from closely spaced columns to the columns with long span. A transfer floor is the floor system which supports vertical as well as lateral load resisting system. A transfer floor had different floor systems such as slab and girder. Depending upon the transfer loads above the transfer structure, the type of transfer floor system is chosen.

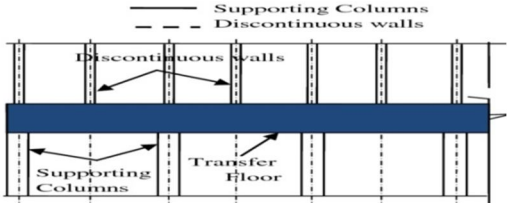


Fig.2 Transfer floor along with column sections [P.S. Lande et.al (2018)]

II. NEED FOR THE STUDY

The New and Innovative techniques are used in Construction field by the proper utilization of available land. By the addition of Transfer floor in buildings, the buildings can be effectively utilised. The portion below the transfer floor can be used for parking purposes and the portion above transfer floor for residential or office buildings. Hence the analysis is to be made in-order to determine the ability of building to withstand Lateral loads especially Seismic loads. The ability of the building to withstand Storey displacement subjected to seismic loads is to be determined.

III. SCOPE AND OBJECTIVES

The scope of the study is to perform Response spectrum analysis of Regular building with Transfer floors using Dampers subjected to Seismic loads using ETABs.

The main objectives are:

A. To conduct Response spectrum Analysis on Regular and Irregular buildings.
B. To determine the Efficiency of Transfer floors in buildings by placing them on each floor level along with Shear wall.
C. To determine the effect of using Dampers in buildings subjected to Seismic loads.
D. To analyse the Storey Displacement
E. To Compare the results of Regular Buildings at 2 Seismic Zones

IV. METHODOLOGY

At first, the Modelling of the Regular building with transfer floor at different levels i.e. Odd floor levels is done along with Dampers (FVD) using ETABS 2016 software. After Modelling, different load cases are applied including Dead load, Live load, Seismic load etc. Then the Analysis is carried out and results are compared at both the zones for Storey Displacement.

Table 1 Details of the building parameters used for the Analysis

Description	Details
Plan dimension	30 m X 60 m
Building height	55.5 m
No. of Stories	14
Floor Height	4 m
Wall dimension above Transfer floor (m)	0.2 X 6 m
Wall dimension below Transfer floor (m)	0.6 X 4 m
Slab thickness above/below Transfer floor	0.2 / 0.4 m
Live load below Transfer floor	6 kN/m^2
Live load at and above Transfer floor	2.5 kN/m^2
Super dead load at and above Transfer floor	4 kN/m^2
Super dead load below Transfer floor level	5.5 kN/m^2

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The loads assigned in the Analysis will include Dead load in the form of Super Dead load (IS 875 part I-1987), Live load (IS 875 part II – 1987) and Seismic loads (IS 1893 – 2002). Response spectrum method is used for the Analysis of the Structures. The Analysis is performed in ETABS 2016 Software. The Transfer floor is assigned in 4 floor levels with Shear wall and Dampers and each case has been Analysed in Regular and Irregular buildings.

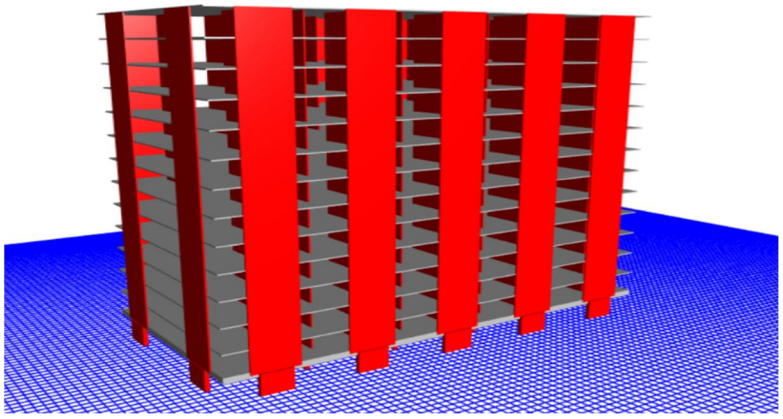


Fig.3 3D View of Transfer Floor at floor I

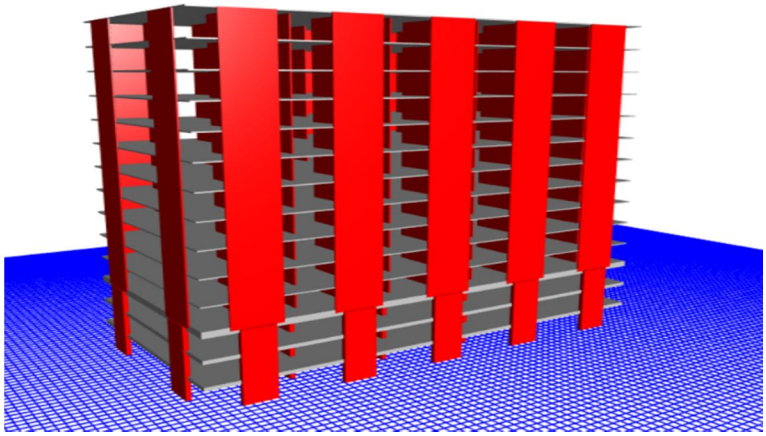


Fig.4 3D View of Transfer Floor at floor III

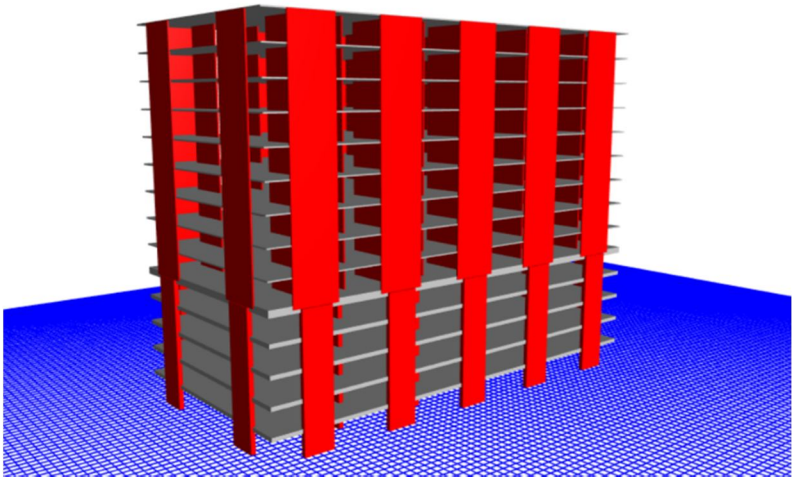


Fig.5 3D View of Transfer Floor at floor V

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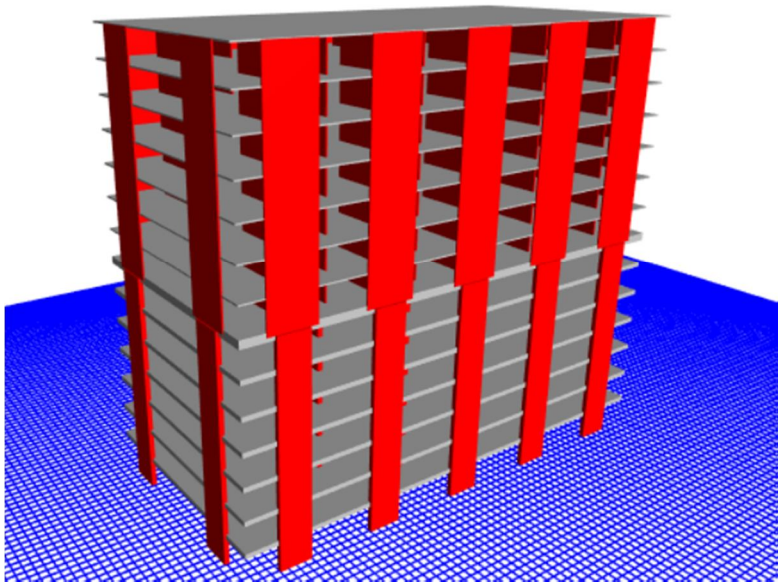


Fig.6 3D View of Transfer floor at floor VII

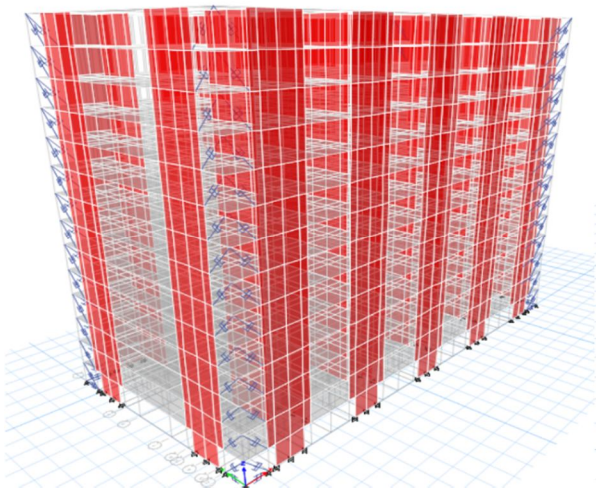


Fig.7 Regular building with Dampers

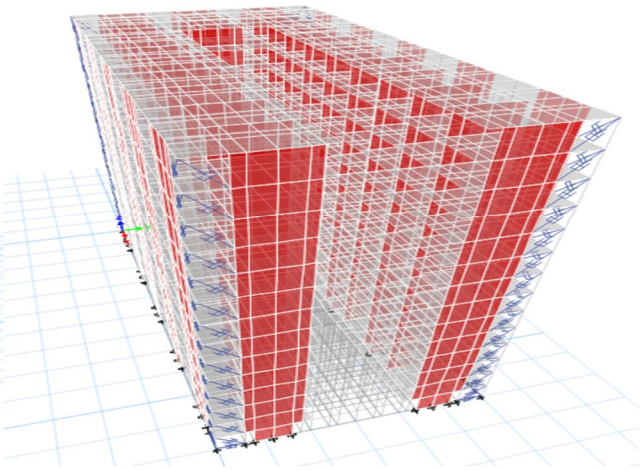


Fig.8 Irregular building with Dampers

V. RESULT AND DISCUSSION

A. Storey Shear

The Storey Shear values are compared for both Regular and Irregular building at Zone III and Zone V. The comparison of results is prepared in such a way that the two extreme conditions that is the Transfer floor provided at 1st floor and 7th floor are taken for the study. The results were then compared for both the buildings. The Storey Shear value of the Regular as well as the Irregular building goes on decreasing from the higher stories to the base of the building, as the height of the building increases on both X and Y directions. at Seismic Zone V the Storey Shear goes on increasing as the Storey height decreases and the Irregular building has higher values than that of Regular building. Since a severe zone, Seismic Zone V showed higher values than that of Zone III Storey Shear values. The value of shear at base is zero as it is fixed base structure. The maximum shear is obtained at the bottom storey and minimum at the top storey level of the buildings. For an Irregular building, as the distribution of load is uneven there are high chances of vertical irregularity. Dampers can withstand this uneven load to a specific limit.

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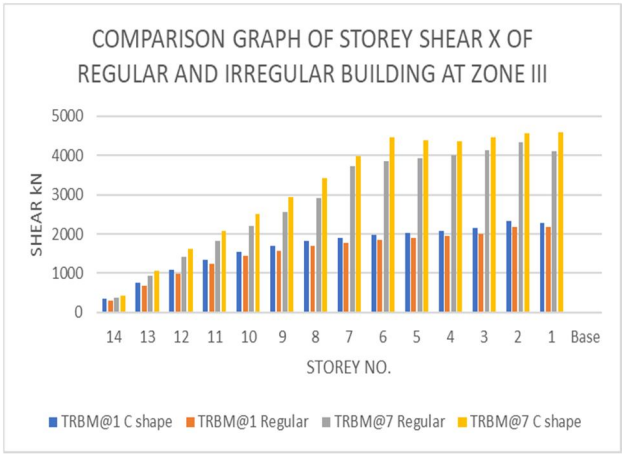


Fig.9 Comparison graph of Storey Shear along X Direction of Regular and Irregular building at Seismic Zone III

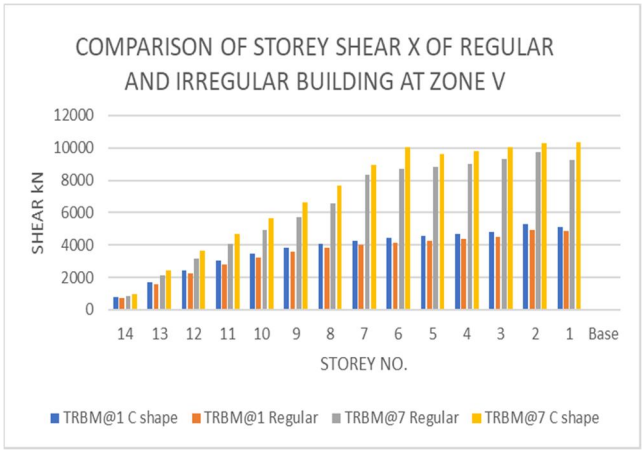


Fig.10 Comparison graph of Storey Shear along X Direction of Regular and Irregular building at Seismic Zone V

B. Overturning Moment

The Overturning Moment values are compared for both Regular and Irregular building at Zone III and Zone V. The comparison of results is prepared in such a way that the two extreme conditions that is the Transfer floor provided at 1st floor and 7th floor are taken for the study. The results were then compared for both the buildings.

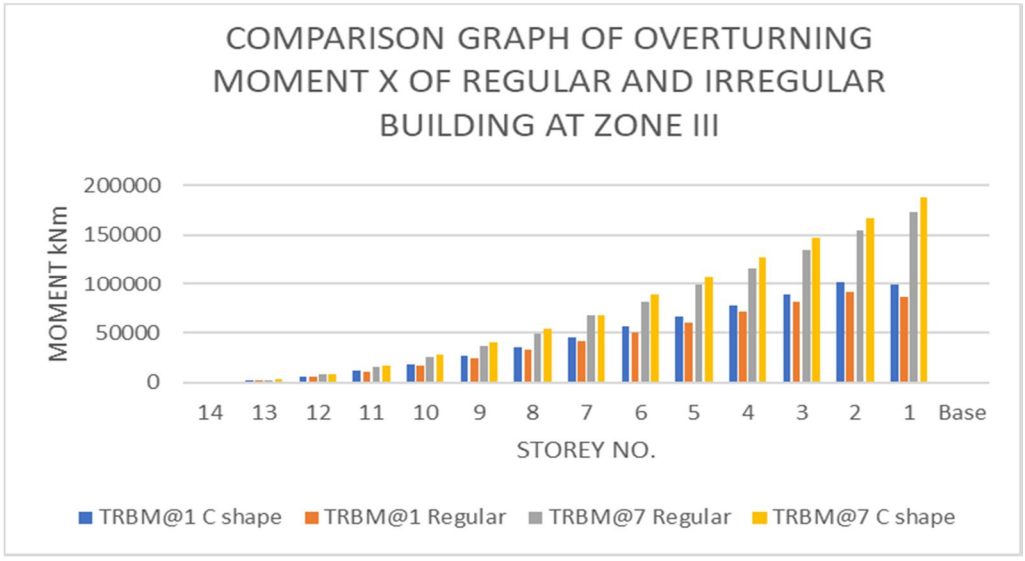


Fig.11 Comparison graph of Storey moment along X Direction of Regular and Irregular building at Zone III

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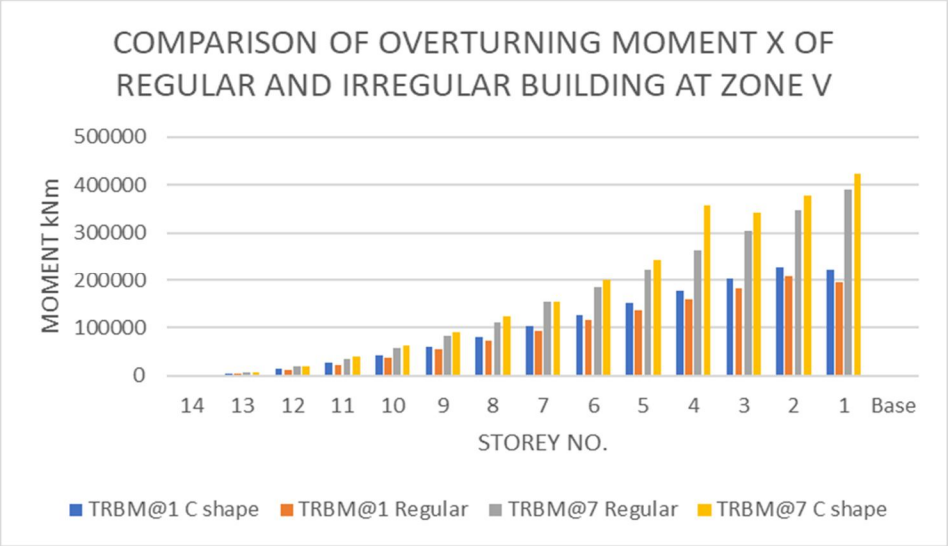


Fig.12 Comparison graph of Storey moment along X Direction of Regular and Irregular building at Zone V

The Overturning Moment values are obtained zero at the base of the building. The Regular Rectangular building and Irregular C shaped buildings were Analysed for both the Seismic Zones III and V. The Moment values along X direction and along Y directions were obtained from the results. For the comparison purpose we consider only Moment along X direction. The Overturning Moment is maximum at the bottom storey of the Regular and Irregular structure. The value of Moment at the First floor of the building is higher than that of top storey levels of the building. The Moment value goes on decreasing as the height of the building increases. This shows that the Overturning Moment is inversely proportional to the height of the structure in Zone III and Zone V.

C. Storey Displacement

For the Analysis, we consider the two main cases i.e. Transfer floor at 1st and 7th floor levels respectively.

Table 2 The values of Displacement for Regular and Irregular building at Zone III

STOREY NO.	Regular Trbm @ 1st Floor mm	Irregular Trbm @ 1st Floor mm	Regular Trbm @ 7th Floor mm	Irregular Trbm @ 7th Floor mm
14	21.942	22.648	17.805	18.04
13	20.059	20.661	16.283	16.212
12	18.117	18.614	14.713	14.331
11	16.131	16.53	13.122	12.429
10	14.108	14.418	11.537	10.552
9	12.07	12.304	10.028	8.78
8	10.048	10.219	8.659	7.22
7	8.079	8.201	7.54	5.992
6	6.204	6.291	6.461	5.002
5	4.47	4.535	5.121	3.873
4	2.93	2.991	3.705	2.741
3	1.649	1.707	2.341	1.723
2	0.712	0.749	1.161	0.857
1	0.15	0.162	0.313	0.242
Base	0	0	0	0

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Table 3 The values of Displacement for Regular and Irregular building at Zone V

STOREY NO.	Regular Trbm @ 1st Floor mm	Irregular Trbm @ 1st Floor mm	Regular Trbm @ 7th Floor mm	Irregular Trbm @ 7th Floor mm
14	49.37	50.959	40.061	40.59
13	45.132	46.486	36.637	36.478
12	40.764	41.882	33.105	32.245
11	36.294	37.191	29.525	27.966
10	31.743	32.44	25.959	23.742
9	27.158	27.683	22.562	19.755
8	22.609	22.993	19.482	16.245
7	18.179	18.452	16.964	13.482
6	13.959	14.154	14.537	11.255
5	10.059	10.204	11.522	8.715
4	6.593	6.729	8.336	6.166
3	3.711	3.841	5.268	3.877
2	1.602	1.686	2.612	1.929
1	0.338	0.364	0.705	0.545
Base	0	0	0	0

On comparing the storey displacement, the Irregular building shows the higher displacement values than that of the Regular building. The displacement value goes on increasing from the bottom storey of the building to the top storey of the building. Thus, we could say that the Storey Displacement shows a Direct relationship with the Storey height. As the height of the building increases the displacement value also increases at Seismic Zone III. Similarly, at Seismic Zone V the Storey displacement goes on increasing as the Storey height increases and the Irregular building has Higher values than that of Regular building. Since a severe zone, Seismic Zone V showed higher values than that of Zone III Displacement values.

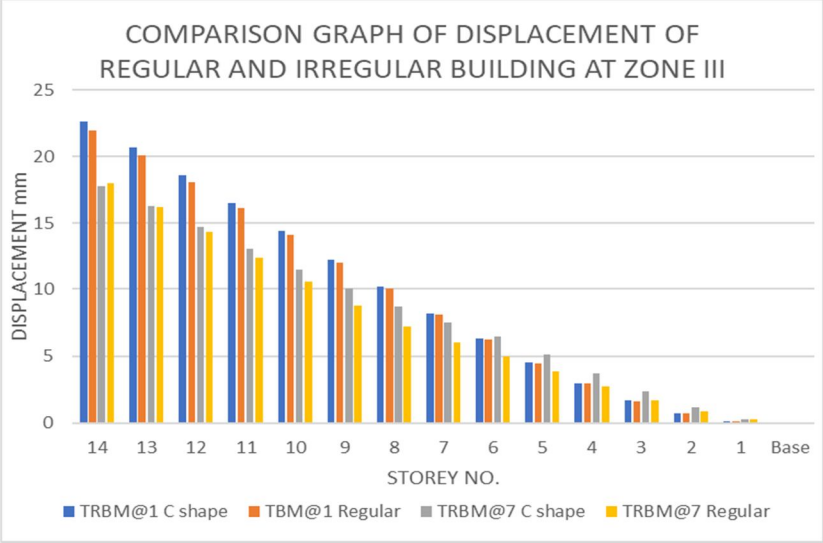


Fig.13 Comparison graph of Storey Displacement of Regular and Irregular building at Zone III

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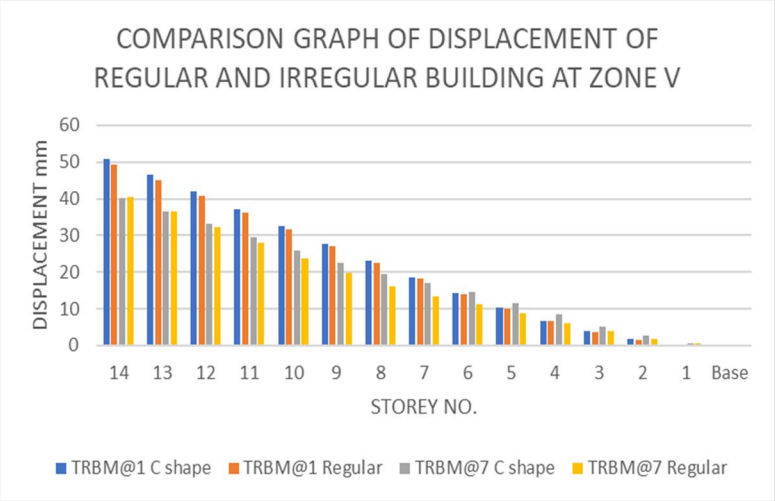


Fig.14 Comparison graph of Storey Displacement of Regular and Irregular building at Zone V

VI. CONCLUSIONS

The Transfer floor is placed on various floor levels of the building to determine the stable position. In the Analysis Four main positions are odd floor levels that is on the Ist, IIIrd, Vth and VIIth floor levels respectively and the results are compared. Dampers are also provided on the four corners of the building. The two Seismic zones that are taken are Zone III and Zone V in-order to study the characteristics of building at moderate and Severe conditions. The results are compared to get the following factors to be determined:

A. The value of Storey shear increases in X and Y direction. Storey shear value since having lower values at the bottom storey levels, it will be having best performance when the Transfer floor is located at 10-20% of the total height of building i.e. when the Transfer floor is placed at the first or second floor level. For the easy to construct and to meet the necessities it is more preferable in the first floor of the Building.

B. Shear value decreases above the transfer floor location, this is because as the dimensions of Slabs present below and above the Transfer floor are different which causes a sudden deduction in the mass.

C. Storey Moment is more for Transfer slab provided at lower level. The Transfer slab provided at first floor are having highest value than Moment values at higher floors as the more vibrations are caused towards the base stories of the building. The Moment value goes on decreasing when the Transfer slab is located on to the higher floor levels as the height of the building increases.

D. Displacement value increases as the height of the building increases. The value goes on increasing above the Transfer floor as the loads are acting more on the upper floors which leads to increased deflection values.

E. The values of Storey Shear, Displacement and Overturning Moment are more for Zone III than that of comparing with Zone V values. But still Zone V being a very severe Seismic zone, Zone V must not be taken for construction with Transfer floor as it shows vigorous values even in the presence of Seismic Dampers. Dampers are quite efficient to withstand the seismic loads more significantly also in the case of Irregular building.

F. The Irregular building with Dampers shows higher values for Storey Displacement, Storey Shear and Overturning Moment than Regular building. Thus, it is suggested to consider the Regular plan building configuration.

G. The values for Storey Displacement, Storey Shear and Overturning Moment shows that the Transfer floor provided at First floor seems to be more stable than at higher floor levels.

H. The Regular building at Zone III with Transfer floor placed at First floor with Damper is safer than Irregular building is hence concluded from the Analysis.

VII. ACKNOWLEDGEMENT

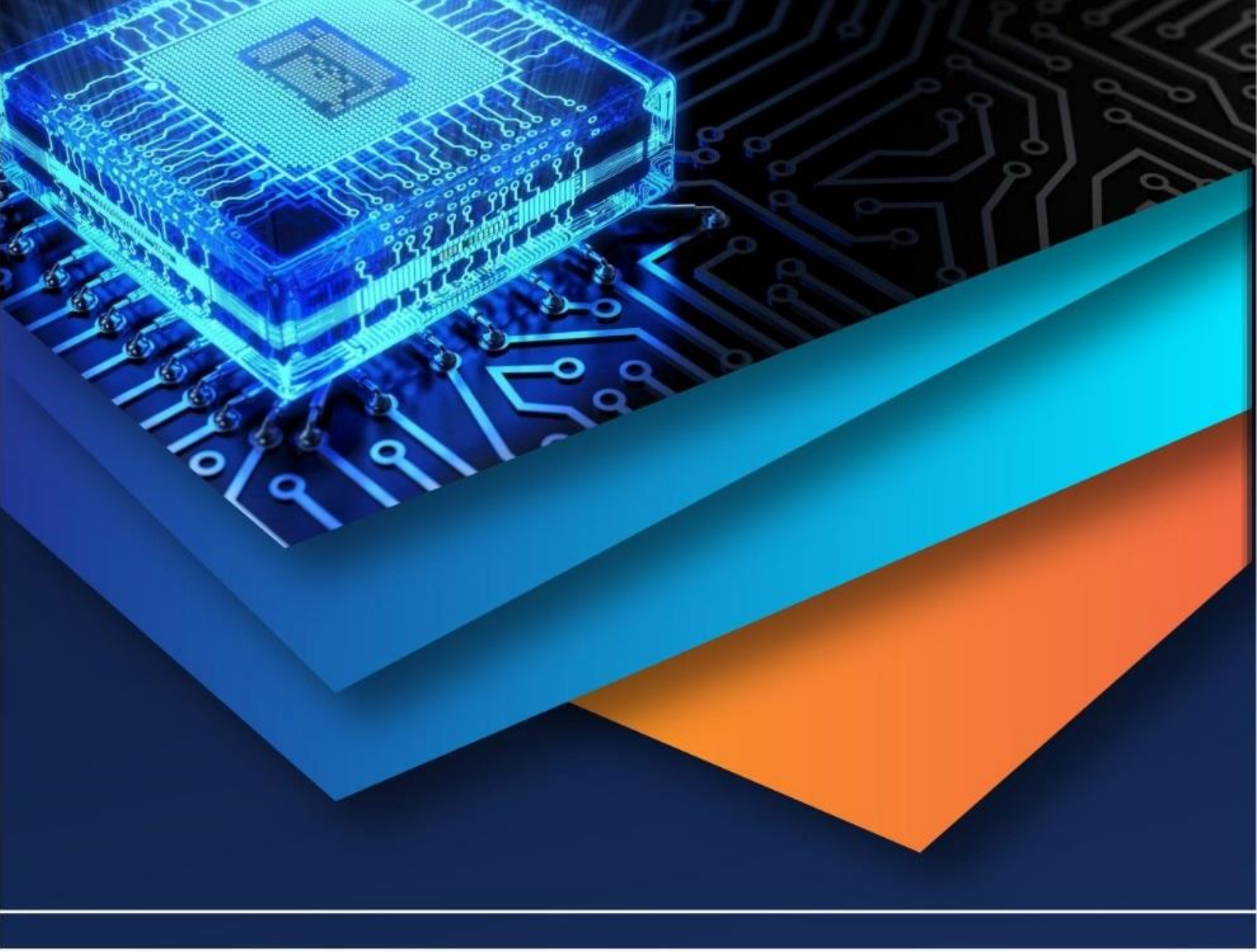
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