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Comparative Analysis of RCC and Steel Building Using STAAD Pro

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Abstract: During occurrence of earthquake various types of structural failure occurs in structure due to some weak points and this weak points arises due to creation configuration of structures such as discontinuity bin mass, geometry and stiffness of structure and this discontinuities are termed as Irregularities. In the Present project work an attempt will be made to study the effect of vertical Irregularity for RCC and steel framing for low medium and high rise construction. Comparative analysis will be done between this two framing material systems. After analyzing and studying various structural parameters of RCC and Steel building it is found that for same earthquake zone and same geometric configuration steel structures gives less magnitude of axial force and base shear as compared to RCC structures. While comparing displacement ad time period RCC structure shows lower values than steel structures. So from the analysis it is clear that if steel structures are used in vertically irregular zone special displacement control provisions are to be done.
Keywords: Structural Parameters, Irregularities, Axial force, Displacement, Base shear.

I. INTRODUCTION

During earthquake, structural failure starts off-evolved at factors of weak spot this weak spots arises due to structural discontinuity in mass, stiffness and structural geometry. Buildings which have any one or all of this discontinuities are termed as Irregular structures contribute large number of building constructions. most of building failure are found to be due to some kind of irregularity in building. Changes in structural mass variation or geometric variation affects the behavior of building during earthquake. Mean while framing material also affect the seismic behavior of vertically irregular building.

To study the effect of structural irregularity during earthquake in rcc and steel framing the building model is prepared as per IS 1893:2002 (part1)

II. AIM

The aim of present work is to analyze various models with varying framing material and height of building for most stable and Economical framing system.

III. OBJECTIVE

The main objectives of our work are as follows :-

A. To evaluate the seismic behavior of RC building having different types of irregularities, mainly vertical geometric irregularity.
B. To design and compare RCC and steel structure for various heights and irregularities.
C. To obtain and compare results based on parameters i.e. displacement, Base shear Time Period, and Axial Forces

IV. TYPES OF IRREGULARITY

A. Plan Irregularities

1) *Torsion Irregularity* **-** To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure
2) *Re-entrant Corners* **-** Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction

3) *Diaphragm Discontinuity*- Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next
4) *Out-of-Plane Offsets* - Discontinuities in a lateral force resistance path, such as out-of-plane offsets of vertical elements
5) *Non-parallel Systems* - The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements

B. Vertical Irregularities

1) Stiffness Irregularity —Soft Storey- A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above
2) Stiffness Irregularity —Extreme Soft Storey-A extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above. For example, buildings on STILTS will fall under this category,
3) Mass Irregularity - Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. The irregularity need not
4) Vertical Geometric Irregularity be considered in case of roofs Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey
5) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force A in-plane offset of the lateral force resisting elements greater than the length of those elements
6) Discontinuity in Capacity — Weak Storey, A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above, The storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.

V. STRUCTURAL PARAMETERS

Table 1 Detail Structural Parameters

Parameter	Value
Live load	3 kN/m2
Density of concrete	25 kN/m3
Thickness of slab	130 mm
Depth of beam	300 mm
Width of beam	230 mm
Dimension of column	230 x 300 mm (Model M1) 230 x 380 mm (Model M3) 300 x 450 mm (Model M5)
Thickness of outside wall	230 mm
Thickness of inner side wall	150 mm
Height of floor	3.05 m
Earthquake zone	II
Damping ratio	5%
Type of soil	II
Type of structure	Special moment resisting frame
Response reduction factor	5
Importance factor	1
Roof treatment	1 kN/m2
Floor finishing	1 kN/m2

In case of Steel structure suitable ISMB section will be selected and will be reduced by using OPTIMIZE command of staad pro.

VI. MATERIAL PROPERTIES:

Table 2 material properties

Material	Concrete	Steel
Grade	M 25	Fe 415
Mass Density	2549.3	7849
Unit Weight	25	76.97
Modulus of Elasticity	25,000,000	20,000,000
Poisson's Ratio	0.15	0.3

VII. MODEL NOMENCLATURE

Each model according to its specific floor and material condition are labeled as follows :-

Table 3 Model Description

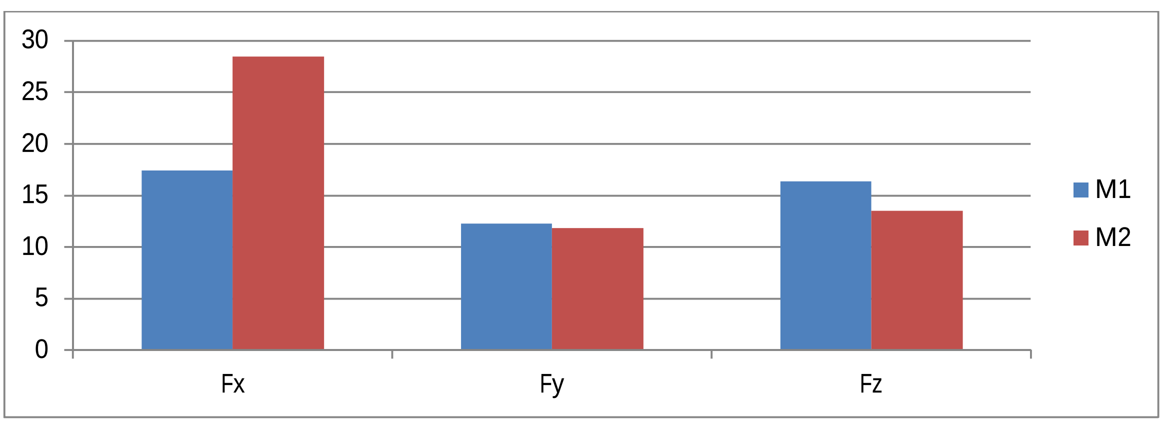
Model Description	Label
G+4 RCC Frame Building	M1
G+4 Steel Frame Building	M2
G+6 RCC Frame Building	M3
G+6 Steel Frame Building	M4
G+10 RCC Frame Building	M5
G+10 Steel Frame Building	M6

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

A. *Axial Forces*

Table 4 Axial Force comparison for model M1 & M2

Sr No	Parameter	M1	M2
01	Fx	17.398	28.445
02	Fy	1229.253	1187.267
03	Fz	16.362	13.543



As the intensity of Fy is large it is take as ($1229.25 = 12.29 \times 10^3$)

From the above graph it can be observed that model 2 shows higher values in X direction while in all other side i,e Z and Y it has values on lower side which will result in low requirement of structural steel.

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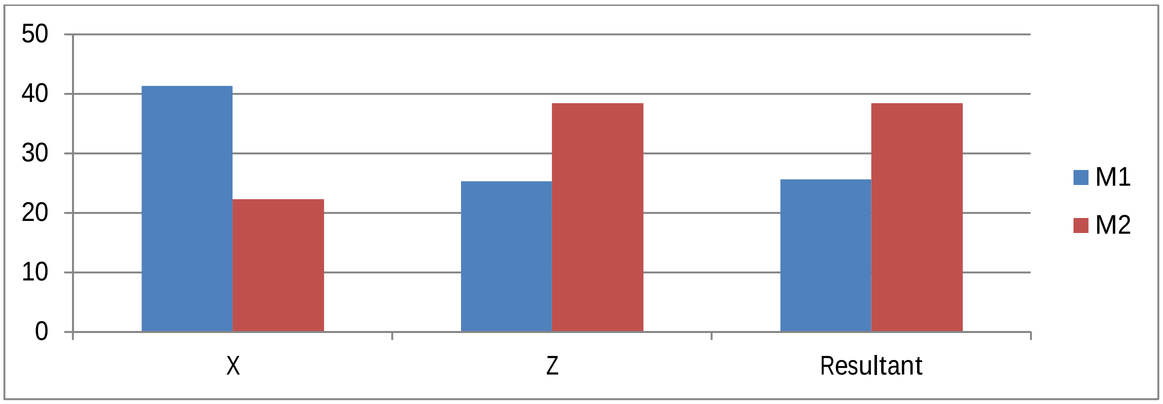
B. Displacement

Table 5 Displacement comparison for model M1 & M2

Sr No	Displacement	M1	M2
01	X	41.318	22.335
02	Y	0.165	0.14
03	Z	25.345	38.393
04	Resultant	25.624	38.438

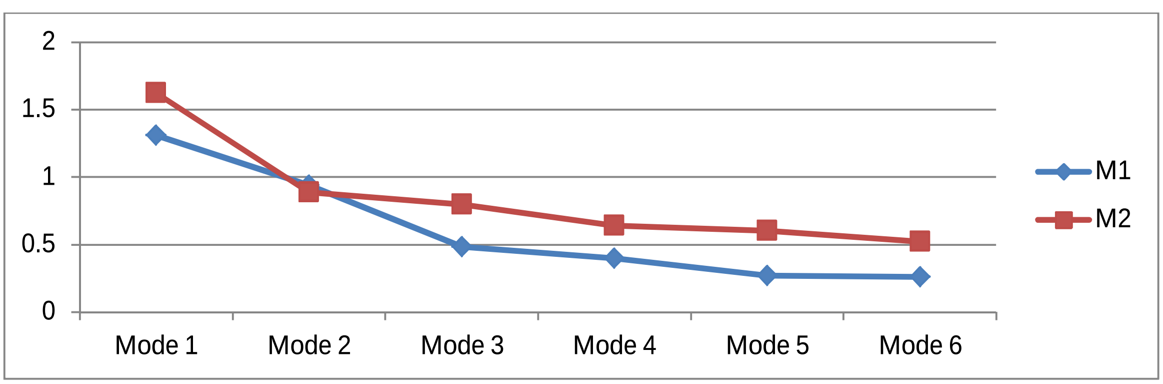


From the graph of Displacement it can be observed that Steel structure shows less displacement values compared to RCC structures in Z direction. While In X direction its value is almost half of RCC structure.

C. Time Period

Table 6 Time Period comparison for model M1 & M2

Sr No	Mode	M1	M2
01	1	1.309	1.622
02	2	0.94	0.89
03	3	0.482	0.8
04	4	0.397	0.642
05	5	0.272	0.604
06	6	0.259	0.521



The comparative graph of time period shows that RCC structure shows less period of oscillation compared to steel structures which requires high time period this is may be due ductile behavior of structural steel

D. Base Shear

Table 7 Base Shear comparison for model M1 & M2

Sr No	Parameter	M1	M2
01	Base Shear	129.743	124.58

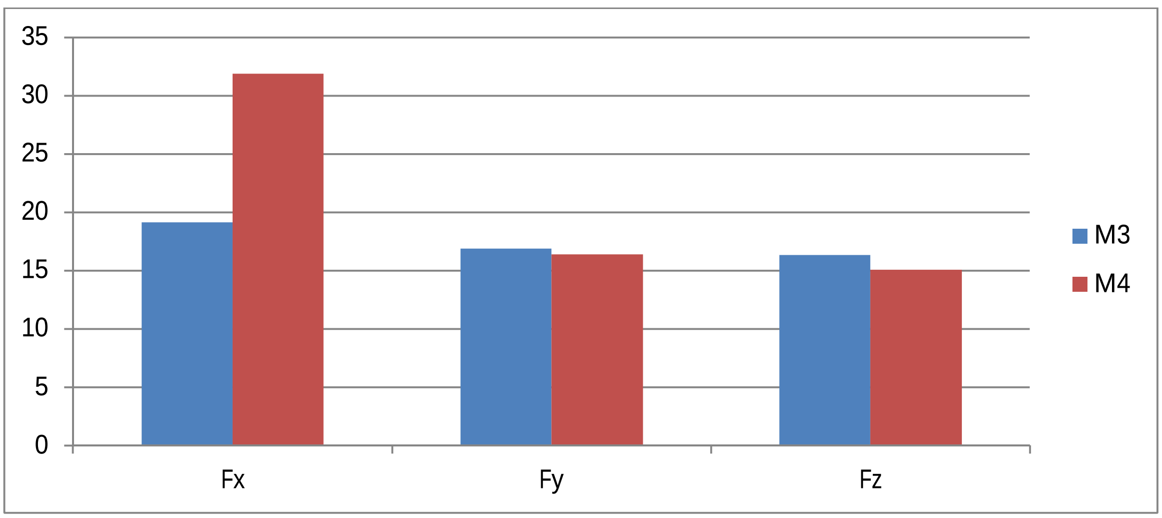
Above base shear comparison represents that steel structures shows lower values than rcc structure. There is nearly 4.14 % reduction in base shear for steel structures.

IX. RESULTS FOR MEDIUM RISE MODELS (G+6)

A. Axial Forces

Table 8 Axial Force comparison for model M3 & M4

Sr No	Parameter	M3	M4
01	Fx	19.135	31.876
02	Fy	1691.311	1640.971
03	Fz	16.331	15.081
04	Mx	26.81	22.291
05	My	0.501	0.003
06	Mz	22.069	131.056

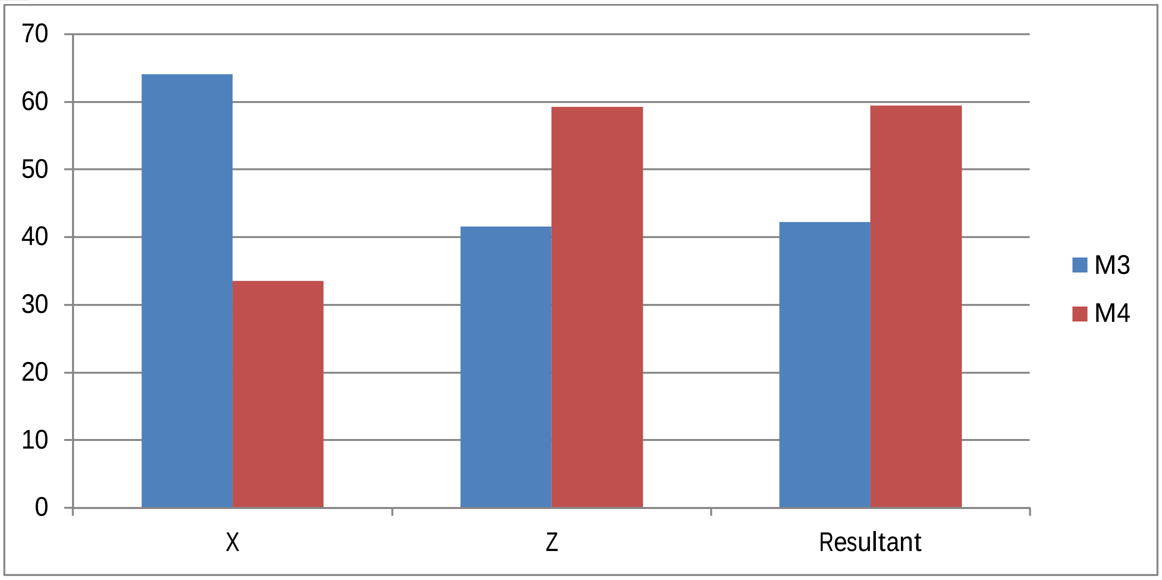


Graph of axial forces shows that there is no considerable difference in magnitude of forces in Z direction and Y direction but has significant change in X direction. Model M3 has high horizontal values but have lower values on in Y direction.

B. Displacement

Table 9 Displacment comparison for model M3 & M4

Sr No	Displacement	M3	M4
01	X	64.06	33.57
02	Y	0.326	0.252
03	Z	41.556	59.21
04	Resultant	42.267	59.416

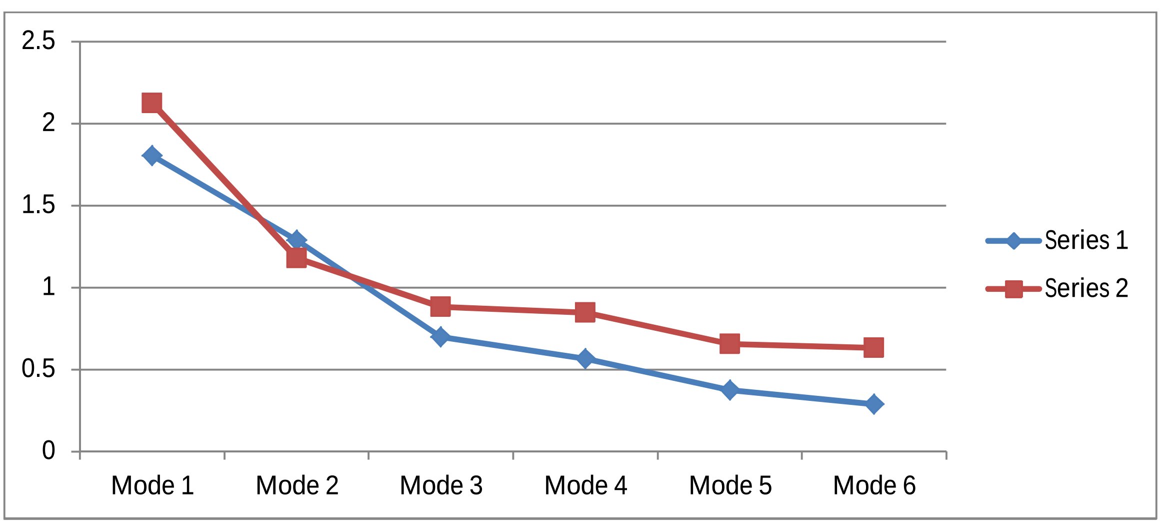


From the above graph of displacement it can be clearly seen that model M4 have high displacement values than model M3. So, from this comparison it can be conclude that steel structures should not be used for irregular type structure for medium rise building.

C. Time Period

Table 10 Time Period comparison for model M3 & M4

Sr No	Mode	M3	M4
01	1	1.804	2.123
02	2	1.288	1.178
03	3	0.7	0.882
04	4	0.564	0.848
05	5	0.374	0.654
06	6	0.288	0.632



Above time period comparison shows that in medium rise structures rcc structures shows low time period while for same zone and same structural geometry steel structure requires more time. From this it can be concluded that steel should not be used in this case from the view point of time period.

D. Base Shear

Table 11 Base Shear comparison for model M3 & M4

Sr No	Parameter	M3	M4
01	Base Shear	139.85	139.32

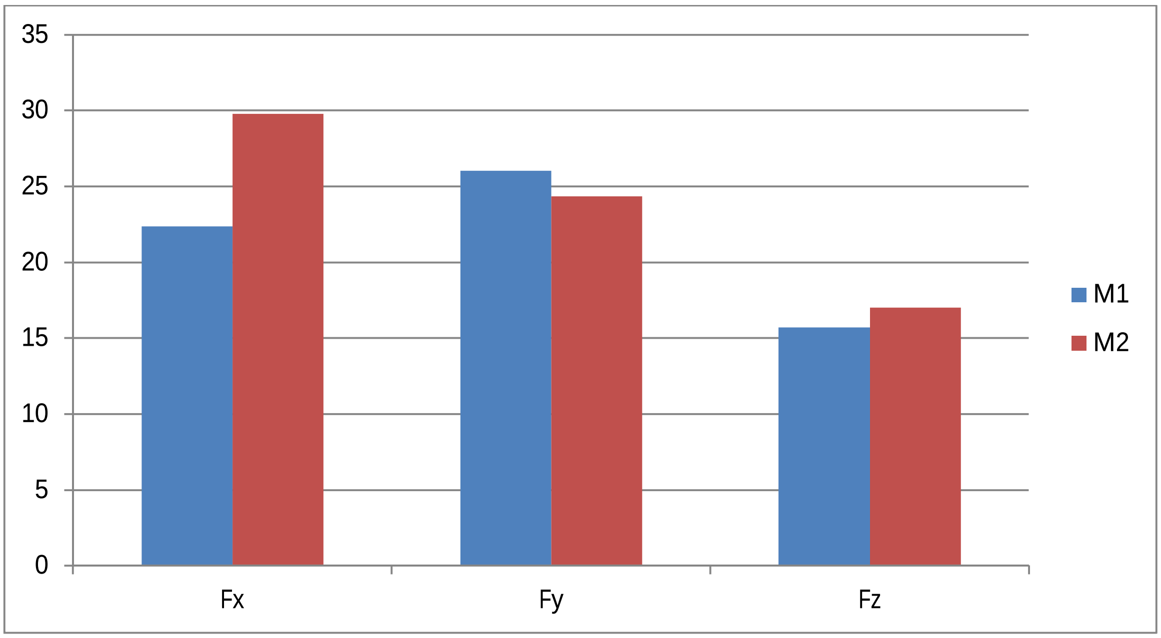
Above table of base shear values show nearly same magnitude for both type of structural framing material. But steel structures has a slight lower values than rcc structures.

X. RESULTS FOR HIGH RISE MODELS (G+10)

A. Axial Forces

Table 12 Axial Force comparison for model M5 & M6

Sr No	Parameter	M5	M6
01	Fx	22.353	29.78
02	Fy	2602.216	2435.561
03	Fz	15.713	17.029

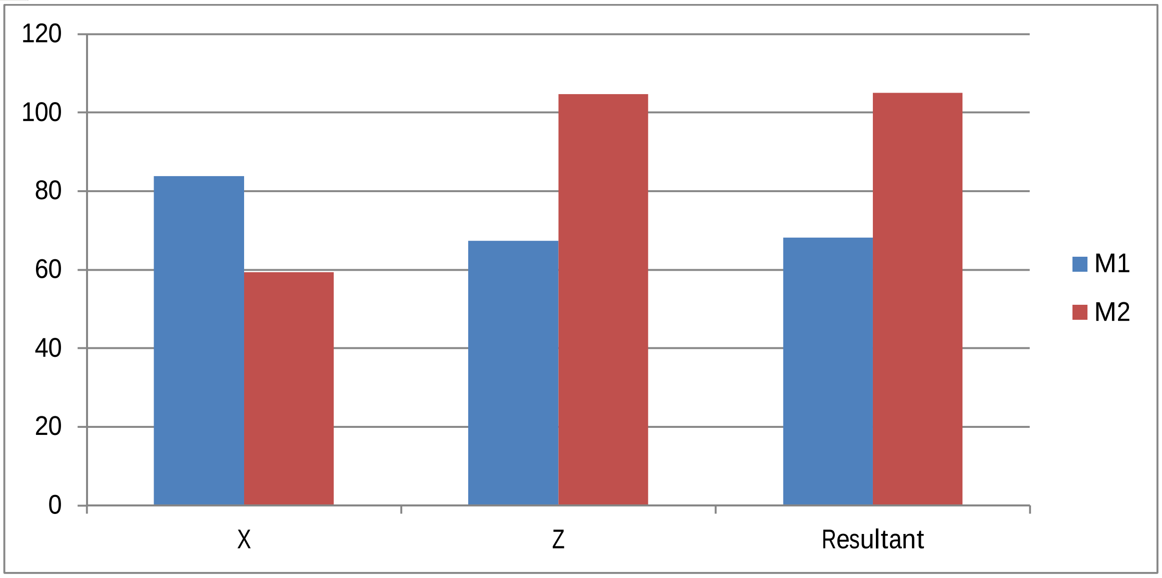


From the above graph t can be clearly seen that there is reduction of 6.84 % in steel structures when compared to rcc structure. While in horizontal force magnitude rcc structures has lower values. From this it can be concluded that steel structures can be used in high rise construction as compared to rcc structure for same geometric configuration.

B. Displacement

Table 13 Displacement comparison for model M5 & M6

Sr No	Displacement	M5	M6
01	X	83.835	59.311
02	Y	0.543	0.528
03	Z	67.315	104.648
04	Resultant	68.179	105.09

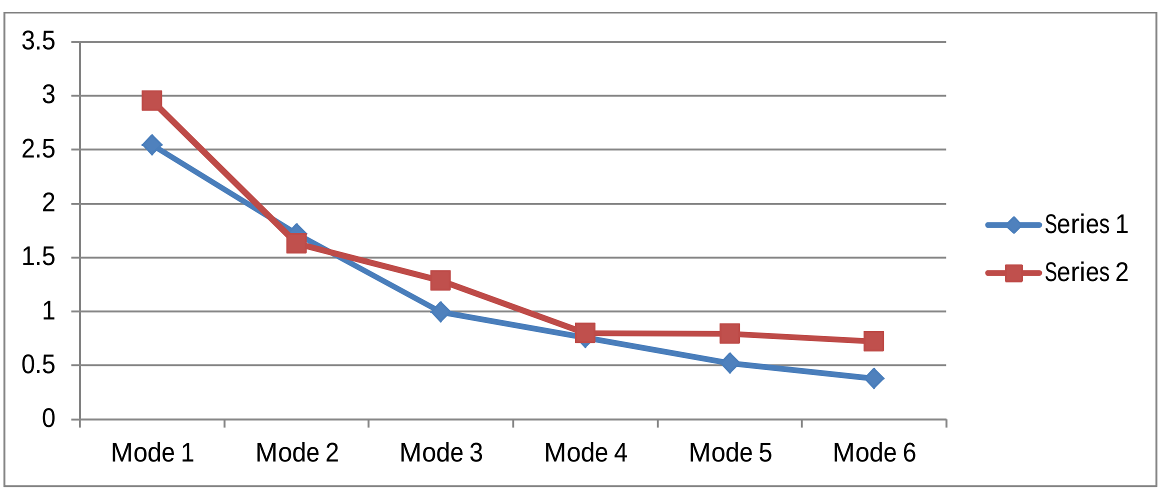


Above graph shows that resultant displacement of steel structures are significantly high than rcc structure this is because of the composite behavior of reinforcement and concrete. Also it can be concluded that form displacement point of view steel structures are not suitable in high rise construction of building and if used special displacement controls measure should be followed.

C. Time Period

Table 14 Time Period comparison for model M5 & M6

Sr No	Mode	M5	M6
01	1	2.545	2.953
02	2	1.717	1.632
03	3	0.996	1.283
04	4	0.757	0.801
05	5	0.521	0.796
06	6	0.381	0.723



Above graph shows that like in low and medium rise structures steel structures shows high values of time period in comparison with rcc structure.

D. Base Shear

Table 15 Base Shear comparison for model M5 & M6

Sr No	Parameter	M5	M6
01	Base Shear	159.78	158.07

Though there is negligible difference in magnitude of both structures steel structures has lower value than rcc which shows that steel structures reduces self-weight of structure.

XI. CONCUISONS

From all results and discussions in previous chapter following conclusions are drafted :-

A. From consideration of axial forces steel structures can be used for low, medium and high rise irregular building as it gives lower amount of axial forces than Rcc structure.
B. From Displacement consideration steel structures will not be recommended as they gives high displacement values than Rcc structures. Still if one wishes to use steel structural framing proper measures should be taken for displacement control.
C. Even in low risk Zone and varying height irregular structure under dynamic loading Steel structures oscillates for more time than Rcc structures. So steel structures should be avoid, and if used they can be properly braced to minimize time period.
D. Results shows that steel structures in all height variation gives less dead weight and helps to reduce intensity of lateral earthquake forces. So, Steel structures should be used In case of Irregular buildings in low risk zones under dynamic loading.

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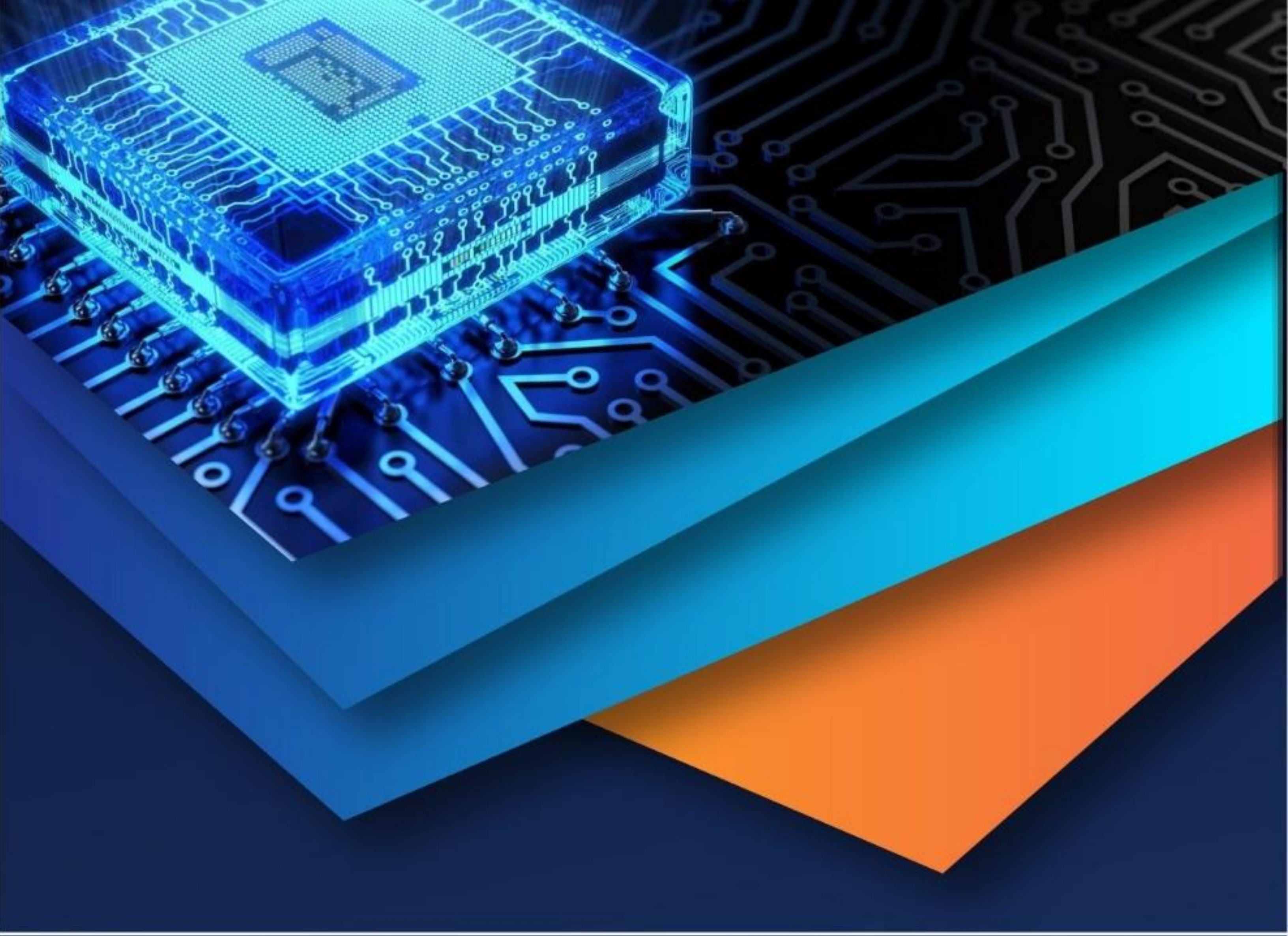

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