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Study of Structural Parameters Effect Caused by Soft Storey in Multi-Storey Building

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***Abstract:** In the present work study is carried out for the behavior of G + 10 storied RC buildings with Rectangular shaped plan of soft storey at different levels. Floor height provided as 3.4m and also properties are defined for the irregular R.C building modelled in STAAD. Pro V8i software. Here twelve models are created in which soft storey is provided at ground, fifth and eleventh storey in all four seismic zones. From result it is found that Location of Soft storey effects seismic behavior of building in every zone from low to high seismicity. As the location of soft storey goes upper it gives more stable structure compared to soft storey at ground level. Soft storey at top level of structure is more stable than soft storey at middle part of structure, soft storey at top level gives Lower values of displacement in all seismic zones.*
***Keywords:** STAAD pro., seismic zones, base shear, overturning moment, displacement, soft storey*

I. INTRODUCTION

If the P-A impact is considered to be the primary purpose for the dynamic fall apart of building structures throughout earthquakes, as it should be determined lateral displacements calculated inside the elastic design process can also offer very critical information approximately the structural behavior of the device codes outline smooth storey irregularity by stiffness contrast of adjoining floors, displacement primarily based criteria for such irregularity determination is greater green, distribution concepts optimum solution where size, cost, effectiveness every aspect counts In the multi storey building the soft storey can be formed at any level to serve various purposes and to fulfil required function necessity, due to various needs a soft storey is also unavoidable and thus it becomes very important to study the performance of a soft storey building and study its effect. Generally, in a structure the weak or soft storey is provided at the ground storey level but open storey can be provided at any other floor level.

II. LITERATURE REVIEW

Poncet, L. - 2004 In this work three height locations of mass discontinuity and two ratios of seismic weight were considered. A regular structure was also studied for comparison. Both the equivalent static load method and the response spectrum analysis method were used in design. Mass irregularity was found to have limited impact on collapse prevention when static analysis was used. For irregular structures exhibiting lower performance than the regular frame, the response was improved by adopting dynamic analysis but not to the level achieved with the regular structure. From results it is found that all structures were found to be adequate for immediate occupancy after frequent but low amplitude earthquakes, but the irregular structures designed with static analysis generally experienced the storey drift limit at lower ground motion amplitudes than the reference regular structure. The use of dynamic analysis in design improved the response of all irregular structures. Except for buildings with mass discontinuity at mid-height, irregular structures designed with the dynamic method behaved similarly to or better than the regular structure.

Mr. Pathan Irfan Khan - 2016 This paper highlights the effect of mass irregularity on different floor in RCC buildings with as Response Spectrum analysis using STAAD-Pro V8i software. In this project work seismic analysis of RCC buildings with mass irregularity at different floor level are carried out. The Model Considered was of G+10 having swimming pool on 3rd, 6th and 9th Floor. Maximum Base Shear along X and Z directions is also calculated. Lateral Displacements and Storey Drift is also evaluated for X and Z directions. Axial Forces, Torsion and Bending Moment are calculated for six different columns. It was found that According to RSA results, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.

Shridhar Chandrakant Dubule - 2018 The study is concerned with the effects of various vertical irregularities on the seismic response of a structure. The objective of the project is to carry out Response spectrum analysis (RSA) of vertically irregular RC building frames and to carry out the ductility based design using IS 13920 corresponding to Response spectrum analysis (RSA). Comparison of the results of analysis of irregular structures with regular structure is done. Three types of irregularities namely mass irregularity, stiffness irregularity and stiffness &mass irregularity were considered.

According to our observation, the storey shear force was found to be maximum for the first storey and it decreases to minimum in the top storey in all cases. The mass irregular structures were observed to experience larger base shear than similar regular structures. The stiffness irregular structure experienced lesser base shear and has larger interstorey drifts. From results it is observed that, the storey shear force is maximum for the first storey and it decreases to minimum in the top storey. The stiffness irregular structure experiences lesser base shear than similar regular structures. The mass irregular structures experiences larger base shear than similar regular structures.

Abul Hasnat - 2013 In this paper, response of a 15-storeyed frame to lateral loads is studied for stiffness and vertical irregularities. The proportional distribution of lateral forces evolved through seismic action and wind load also in each storey level due to changes in stiffness of frame on irregular frame is analysed. Analysis output are focused on mainly two basic points storey drift and displacement under the action of load combination prescribed in Bangladesh National Building Code (BNBC)-1993. In BNBC, different kinds of irregularities are defined. In this paper, definitions according to BNBC are followed and analysis was carried out using CSI-ETABS 9 software. On the basis of analysis, some outlines are mentioned regarding safety and safe construction of irregular structure thus to reduce earthquake hazard. From results it is concluded that the analysis proves that irregularities are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution around the building. Therefore, regular and symmetrical structures exhibit more favourable and predictable seismic response characteristics than irregular structures.

P. Narasimha Rao - 2017 In this project work seismic analysis of multistoried building with mass irregularity at different floor level are carried out. Here a G+12 stories building with mass irregularity has been modelled for seismic analysis. In this thesis design of structure for this building is carried out by using ETABS software and computer-aided analysis. One regular building and three irregular buildings are compared. They have same plan size but mass irregularity is considered at 6th floor, 8th floor and 10th floor of the building. The stability checking such as storey drift, overturning moment and sliding are also checked in the building with static analysis and also with dynamic analysis (time history analysis). And then, after the models with and without change of mass and inter-storied height are being analysed, structural response (storey drift, storey shear and storey moment) and member forces are compared. The conclusion can be drawn that the buildings with vertical structural irregularity have lower performance than the regular building. It is observed that if change of inter-storey height and load mass are at the middle of the building, the building can affect more seismic effects and can have more damage than that of change of mass in another storey level.

Mohamed Riyas N.K - 2016 In this paper the seismic vulnerability of building is shown with an Example of G+24 building with soft storey at intermediate floor using linear static analysis. Analysis and design would be carried out on a RCC moment resisting framed tall building without Infill wall on different floors with the help of Software ETABS 2015. From the result it is concluded that, the deflection of and displacement of storey are always maximum at soft storey level. There is a drop in the storey stiffness at soft storey level in all Models. From this more care is need design the columns in the soft storey. The infill walls increase the stability of the building.

Vishal N - 2020 In this paper the structural behavior of a 20-storey building with vertical setback irregularity has been modelled and analysed by response spectrum method considering with and without Construction Sequence Analysis (CSA) using different structural systems in CSI ETABS V16 as per BIS 1893:2016 (Part 1). Finally, results such as axial force, shear force, bending moment are drawn for the structural members and response such as storey displacement, storey shear and storey drift are plotted and compared for each structural system. From results is found that for response spectrum in X-direction, maximum displacement at top storey is decreased by 49% for dual system and by 30% for braced system similarly for response spectrum in Y-direction, maximum displacement at top storey is decreased by 55% for dual system and by 24% for braced system when compared with moment frame system.

Lovneesh Sharma - 2019 The present study was conducted. For this, different types of irregularities were chosen for 12 storeys building i.e. H-shape, L-shape and O-shape. The introduction of V-type bracing has its own significance in the present study. Heavy mass was placed at 6th floor and 9thfloor but not simultaneously. Dynamic seismic analysis in seismic zone V was adopted and it was carried out in Staad. Pro software. The evaluation of the irregular building along with the effectiveness of bracing was found out as it was the ultimate objective of the present study. It concluded that the lateral sway of the column shows very little variation when the heavy mass was transferred from 6thfloor to 9th floor as the value of displacement is almost same. But L-Shaped 12 storey building shows poor performance while resisting the lateral forces as it entails maximum value of displacement i.e.,82.405 mm. With the introduction of heavy masses on floor, bending moment and shear force has increased 1.46 and 1.50 times respectively.

Sanjay GK - 2018 In this study tried to determine the performance of a building with soft storey (G+15) at various level and also, we tried to check the results of the same structure along with "shear wall".

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Static analysis and linear response spectrum analysis are done using the software SAP2000 and the results obtained from the structure like storey displacement, storey shear, Storey drift and time period were compared with the structure with and without shear wall for seismic zone III & V. from results it is found that Building having soft storey at GF,5,10 floor level without shear wall has highest value of displacement in both X & Y direction in zone III The displacement value is considerably reduced in the buildings with shear wall up to the soft storey level in both X & Y direction.

Silpa Rani MV - 2013 This paper deals with the study of seismic response of a building with soft storey at different level. The study consists the modelling of a G+6 storied irregular RC building. The modelling of the whole building is carried out using the computer program STAAD.Pro V8i software. Parametric studies on displacement, inter storey drift and base shear have been carried out using equivalent static analysis to investigate the influence of these parameter on the seismic behavior of buildings with soft storey. The selected building is analysed through five models and the comparison of result is carried out. From the result it is found that soft storey at ground level is a typical feature in the modern multistorey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas this has been verified in numerous experiences of strong shaking during the past earthquakes. Though multistoreyed buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load.

III. METHODOLOGY

For easy work flow during progress of work, whole work is divided into various parts which are in detail as discussed below

General introduction focuses on the background of this dissertation. It shows that detailed investigation and study has to be done for soft storey behavior and soft storey design. Literature review deals with the summary of the technical papers published till date and the data regarding the dissertation in the same. It also focuses on the extensive research significances carried out up till now regarding the dissertation as well as the scope for further studies.

A. Modelling of Building

Here the study is carried out for the behavior of G+10 storied R.C buildings with Rectangular shaped plan of soft storeys at different levels. Floor height provided as 3.4m and also properties are defined for the irregular R.C building modelled in STAAD. Pro V8i software, Here twelve models are created in which soft storey is provided at ground, fifth and eleventh storey in all four seismic zones.

B. Building Plan and Dimension Details

The following are the specification of G+ 10 storied irregular RC building located in seismic zone III. Here the rectangular shaped building is selected. For modelling in STAAD Pro.V8i software the first step is to specify nodal co-ordinate. Then beams, columns and plate elements to be modeled and assign the properties for beams, columns and the plates. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poison's ratio, weight density, thermal coefficient, damping ratio and shear modulus.

C. Load Formulation

As it is well known that while analyzing it is advised to go for various load combinations as they are more severe while studying the behaviors of building under earthquake. In the present work Static gravity loads were taken from IS 875 part 1 and part 2 and their combinations were as per 18 456:2000 while earthquake loads and their combinations were taken as per IS 1893 (part 1) 2002

D. Analysis

The twelve-dimensional reinforced concrete structures with G+10 storied building with soft storeys at different level are analysed using STAAD Pro software. The main code for the analysis is IS 1893 (Part 1) 2002 and provide the outline for calculating seismic design force. The method of analysis used is Equivalent static analysis to calculate displacement, base shear and storey drift. Among the different types of analysis, seismic analysis comes forward because of its optimal accuracy, efficiency and ease of use. Seismic analysis is done to evaluate the maximum shear force, bending moment and the dynamic results in the form of storey drift and lateral displacements. Equivalent Static Analysis defines a series of forces acting on a building to represent the effect of earthquake ground motion.

IV. CASE CONSIDERATION AND MODELLING

The various building parameters and material constants along with the detailed description about case considered as per tables given below

A. *Material Constants*

Table 4.1 Material Constants

Material	Concrete	Steel
Grade	M 40	Fe 500
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

B. *Building Parameters*

Table 4.2 Building Parameters

Parameter	Value
Live load	3 KN/m2
Live load at upper soft storey's	5.KN/m2
Density of concrete	25 KN/m3
Thickness of slab	125 mm
Depth of beam	380 mm
Width of beam	230 mm
Dimension of column	300 x 450 mm
Thickness of outside wall	230 mm
Thickness of Parapet wall (1m)	100 mm
Height of floor	3.40 m
Damping ratio	5%
Earthquake zone	II/III/IV/V
Type of soil	II
Type of structure	Special moment resisting frame
Response reduction factor	5
Importance factor	1.5
Roof treatment	I KN/m2
Floor finishing	I KN/m2
Number of Storey's	11 (G+10)
Depth of Foundation	1.50 m

C. Model nomenclature

Table 4.3 Model Nomenclature

Model Description	Label
Soft Storey at ground floor in Zone-II	S1
Soft Storey at fifth floor in Zone-II	S2
Soft Storey at eleventh floor in Zone-II	S3
Soft Storey at ground floor in Zone-III	S4
Soft Storey at fifth floor in Zone-III	S5
Soft Storey at eleventh floor in Zone-III	S6

D. Plan of model

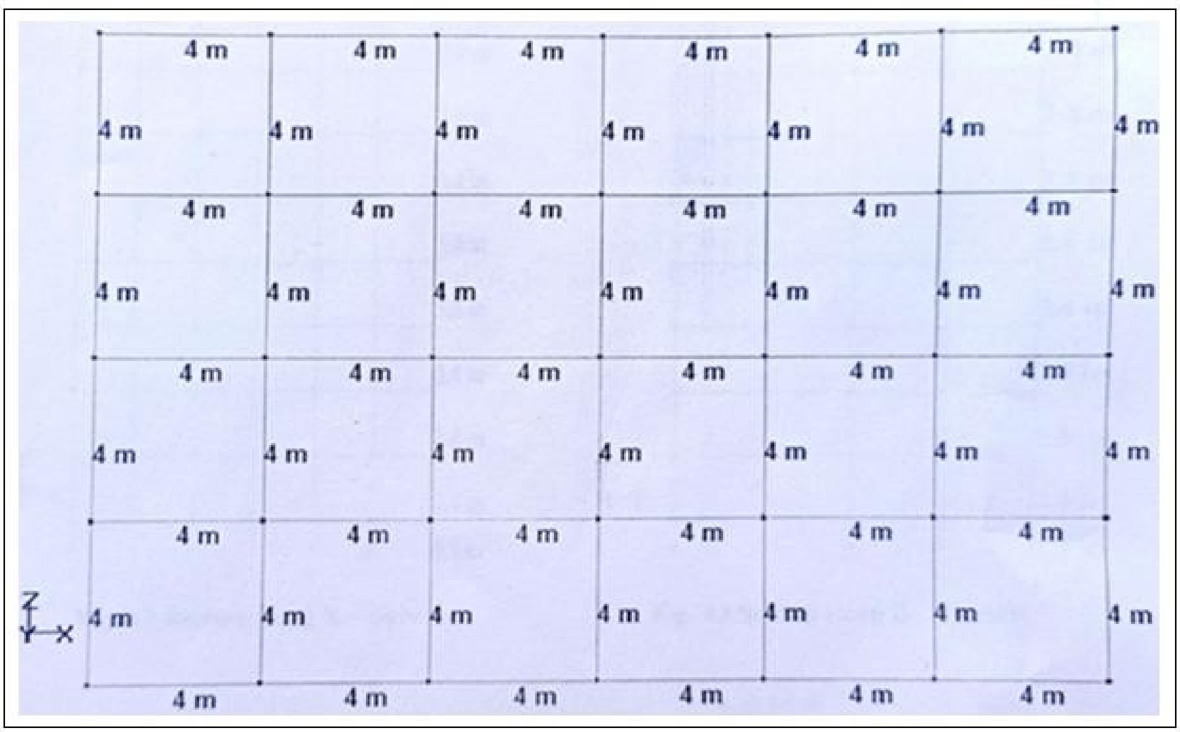

Fig. 4.1 Plan of model

E. Cross section along X and Z – axis

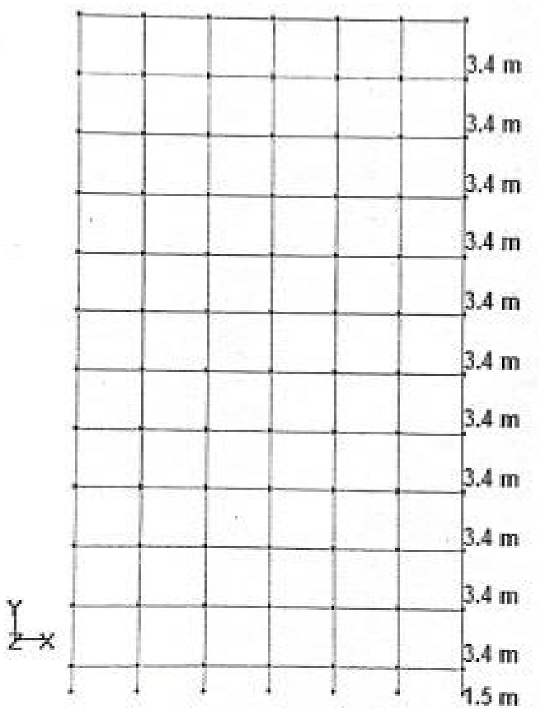

Fig. 4.2 Section along X - direction

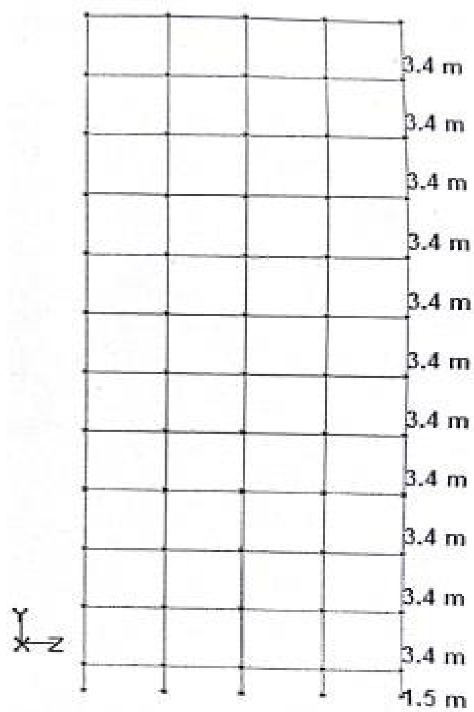

Fig. 4.3 Section along Z - direction

F. Support Condition for model

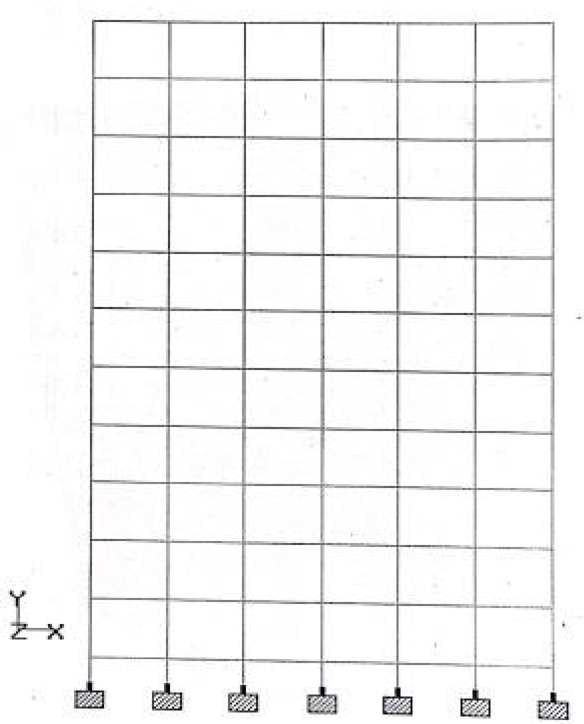

Fig. 4.4 Fixed Support at base

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G. 3D view of model

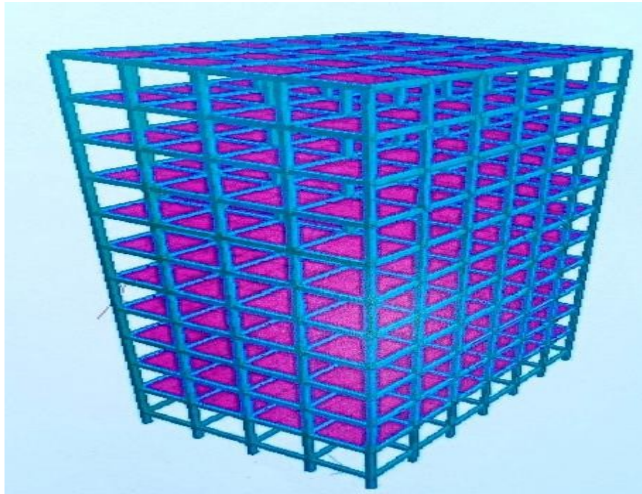


Fig 4.5 3D view with slab

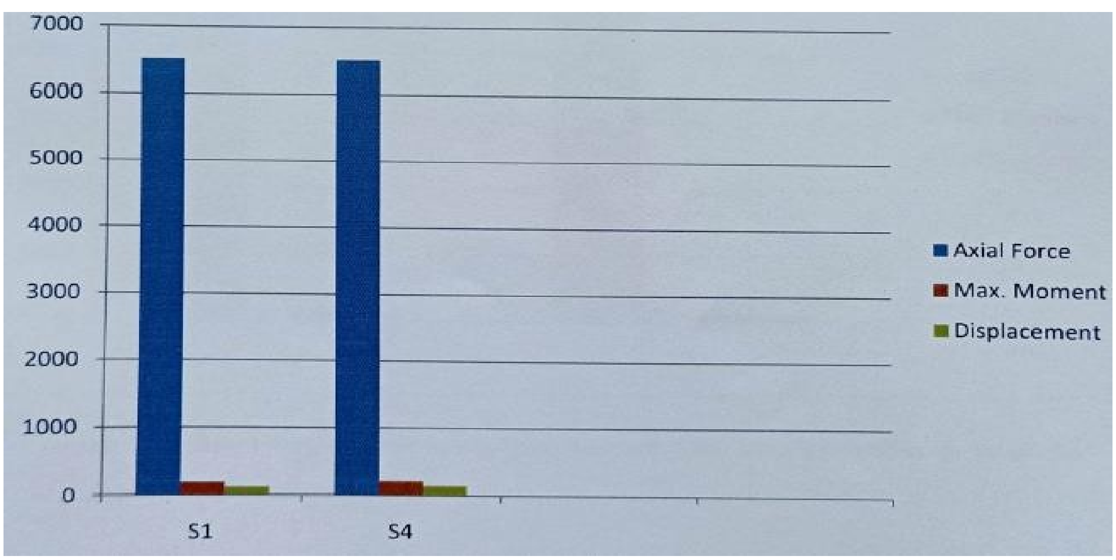
V. RESULTS AND DISCUSSION

A. Result Comparison for Similar level Soft Storey in all seismic zones

1) Comparison for Max. Axial Force, Moment and Displacement

Table 5.1 Axial Force, Moment and Displacement Comparison for model S1, S4

Sr. No.	Model No.	Max. Axial Force (KN)	Max. Moment (KN.m)	Max. Displacement (mm)
01	S1	6502.86	195.72	129.64
02	S4	6502.86	212.03	144.93

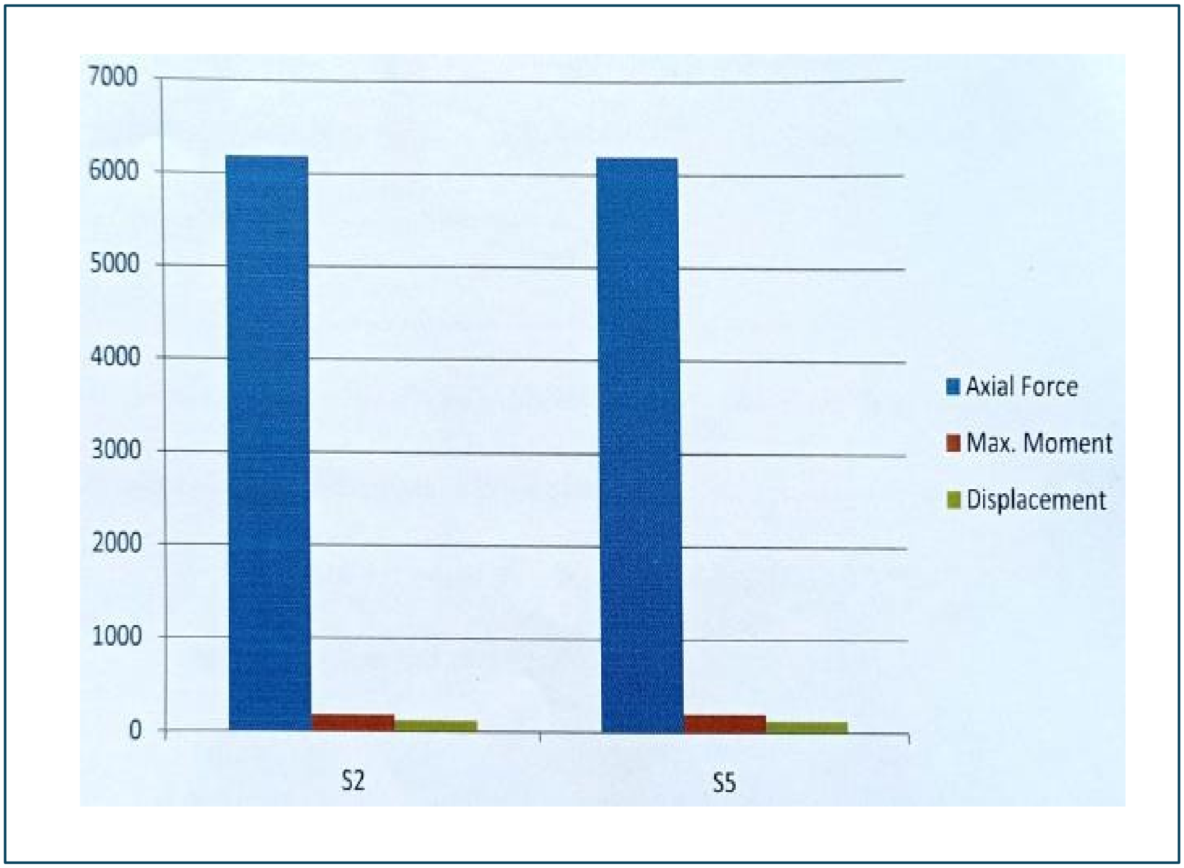


Graph 5.1 Comparison Axial Force, Moment and Displacement for model S1, S4

2) Comparison for Max. Axial Force, Moment and Displacement

Table 5.2 Axial Force, Moment and Displacement Comparison for model S2, S5

Sr. No.	Model No.	Max. Axial Force (KN)	Max. Moment (KN.m)	Max. Displacement (mm)
01	S2	6194.90	178.39	125.74
02	S5	6194.90	196.53	134.72

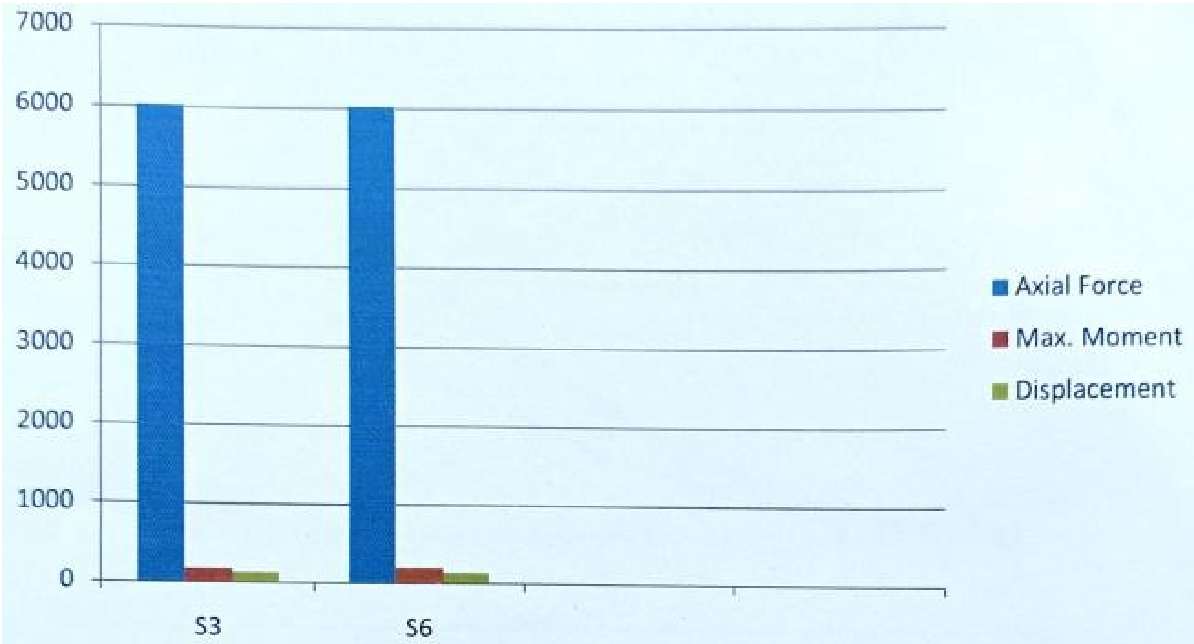


Graph 5.2 Comparison Axial Force, Moment and Displacement for model S2, S5

3) Comparison for Max. Axial Force, Moment and Displacement

Table 5.3 Axial Force, Moment and Displacement Comparison for model S3, S6

Sr. No.	Model No.	Max. Axial Force (KN)	Max. Moment (KN.m)	Max. Displacement (mm)
01	S3	6024.46	177.22	123.92
02	S6	6024.46	196.72	132.31



Graph 5.3 Comparison Axial Force, Moment and Displacement for model S2, S5

4) Comparison for Base Shear Distribution

Table 5.4 Storey Shear Distribution Comparison for S1, S4

Sr. No.	Height	Storey Level	Model	
			S1	S4
1	37.40	11	109.80	175.69
2	34.00	10	117.15	187.44
3	30.60	9	095.79	153.26
4	27.20	8	076.57	122.51
5	23.80	7	059.50	95.20
6	20.40	6	044.58	71.34
7	17.00	5	031.80	50.91
8	13.60	4	021.20	33.91
9	10.20	3	012.73	20.36
10	6.80	2	006.40	10.25
11	3.40	1	002.23	3.57
12	0.00	0	000.07	0.11

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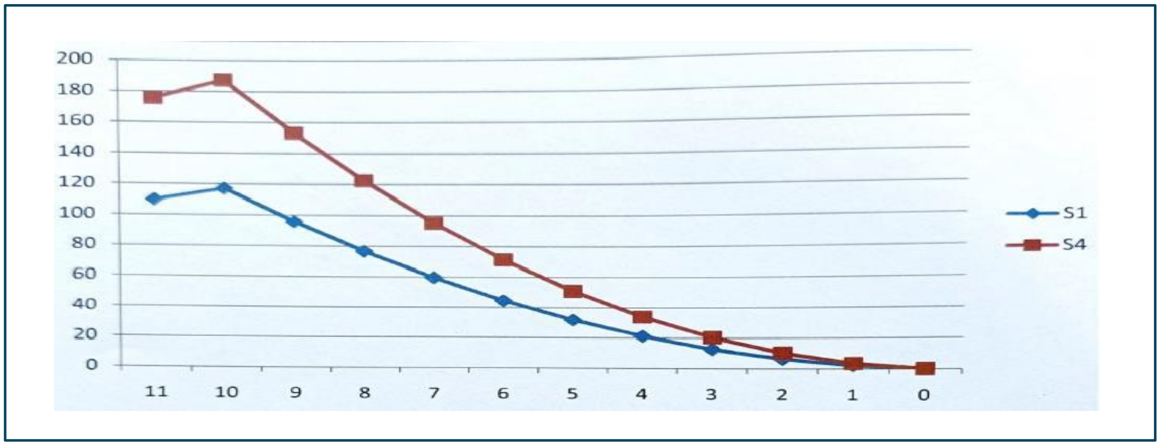
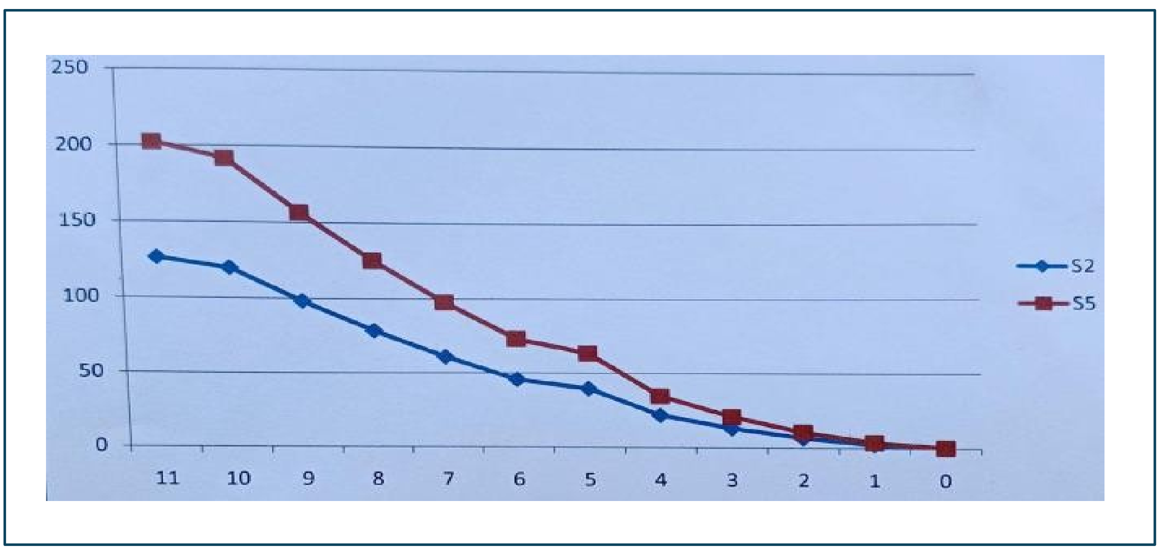


Graph 5.4 Comparison of Storey shear distribution for model S1, S4

5) Comparison for Base Shear Distribution

Table 5.5 Storey Shear Distribution Comparison for S2, S5

Sr. No.	Height	Storey Level	Model	
			S2	S5
1	37.40	11	126.45	202.33
2	34.00	10	119.83	191.72
3	30.60	9	97.97	156.75
4	27.20	8	78.32	125.31
5	23.80	7	60.86	97.38
6	20.40	6	45.60	72.96
7	17.00	5	39.54	63.26
8	13.60	4	21.68	34.69
9	10.20	3	13.02	20.83
10	6.80	2	6.55	10.48
11	3.40	1	2.28	3.65
12	0.00	0	0.076	0.12



Graph 5.5 Comparison of Storey shear distribution for model S2, S5

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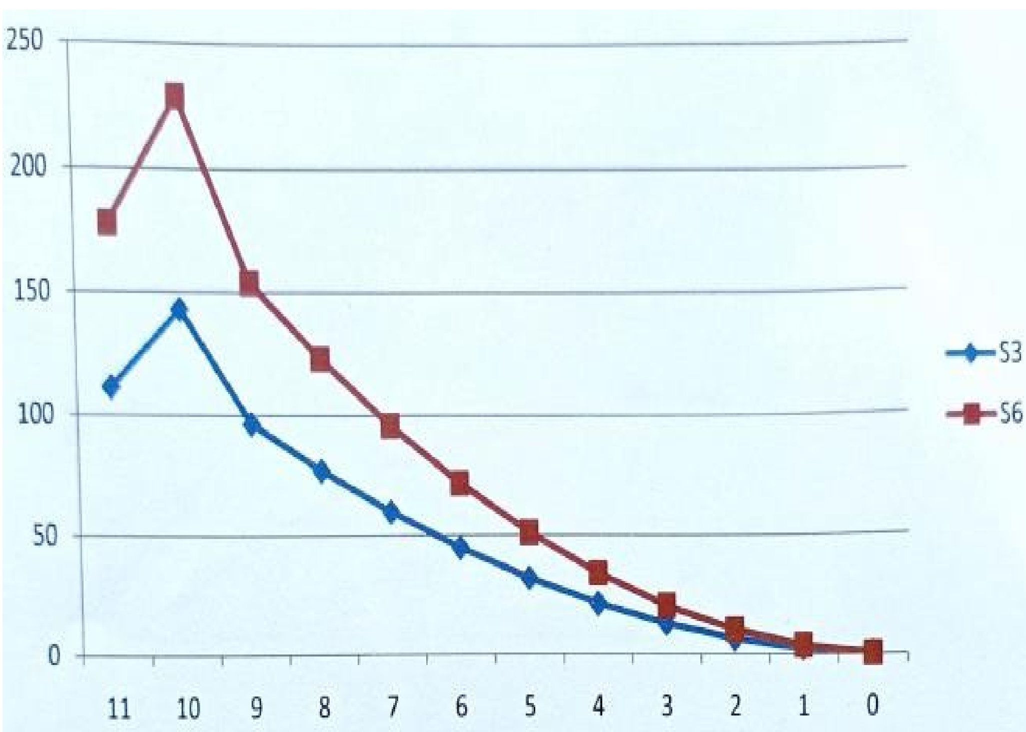
6) Comparison for Base Shear Distribution

Table 5.6 Storey Shear Distribution Comparison for S3, S6

Sr. No.	Height	Storey Level	Model	
			S3	S6
1	37.40	11	111.29	178.06
2	34.00	10	143.13	229.01
3	30.60	9	96.32	154.11
4	27.20	8	77.00	123.19
5	23.80	7	59.83	95.74
6	20.40	6	44.83	71.73
7	17.00	5	31.99	51.19
8	13.60	4	21.31	34.10
9	10.20	3	12.80	20.47
10	6.80	2	6.44	10.30
11	3.40	1	2.24	3.59
12	0.00	0	0.75	0.12

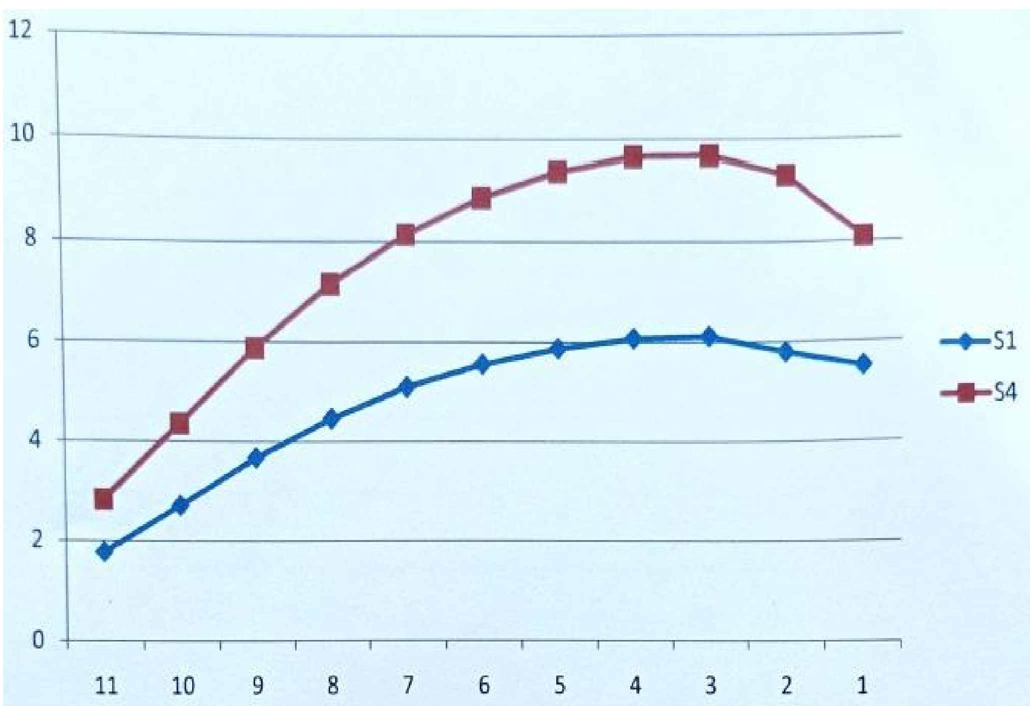


Graph 5.6 Comparison of Storey shear distribution for model S3, S3

7) Comparison for Storey Drift

Table 5.7 Storey displacement Comparison for model S1, S4

Sr. No.	Height	Node No.	Model	
			S1	S4
1	37.40	427	1.77	2.83
2	34.00	392	2.71	4.36
3	30.60	357	3.68	5.88
4	27.20	322	4.47	7.15
5	23.80	287	5.10	8.14
6	20.40	252	5.56	8.87
7	17.00	217	5.88	9.37
8	13.60	182	6.08	9.66
9	10.20	147	6.12	9.68
10	6.80	112	5.80	9.31
11	3.40	77	5.51	8.08



Graph 5.7 Storey displacement Comparison for model S1, S4

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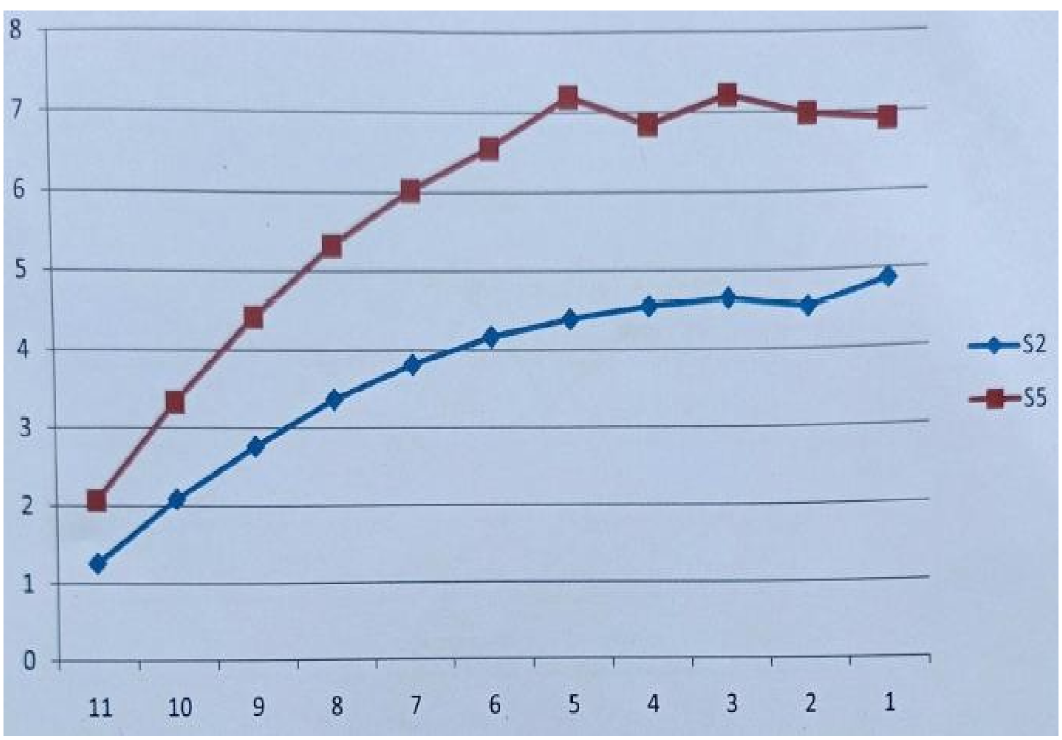
8) Comparison for Storey Drift

Table 5.8 Storey displacement Comparison for model S2, S5

Sr. No.	Height	Node No.	Model	
			S2	S5
1	37.40	427	1.26	2.07
2	34.00	392	2.09	3.33
3	30.60	357	2.77	4.42
4	27.20	322	3.37	5.32
5	23.80	287	3.81	6.02
6	20.40	252	4.17	6.55
7	17.00	217	4.39	7.19
8	13.60	182	4.55	6.84
9	10.20	147	4.65	7.21
10	6.80	112	4.54	6.98
11	3.40	77	4.87	6.90



Graph 5.8 Storey displacement Comparison for model S2, S5

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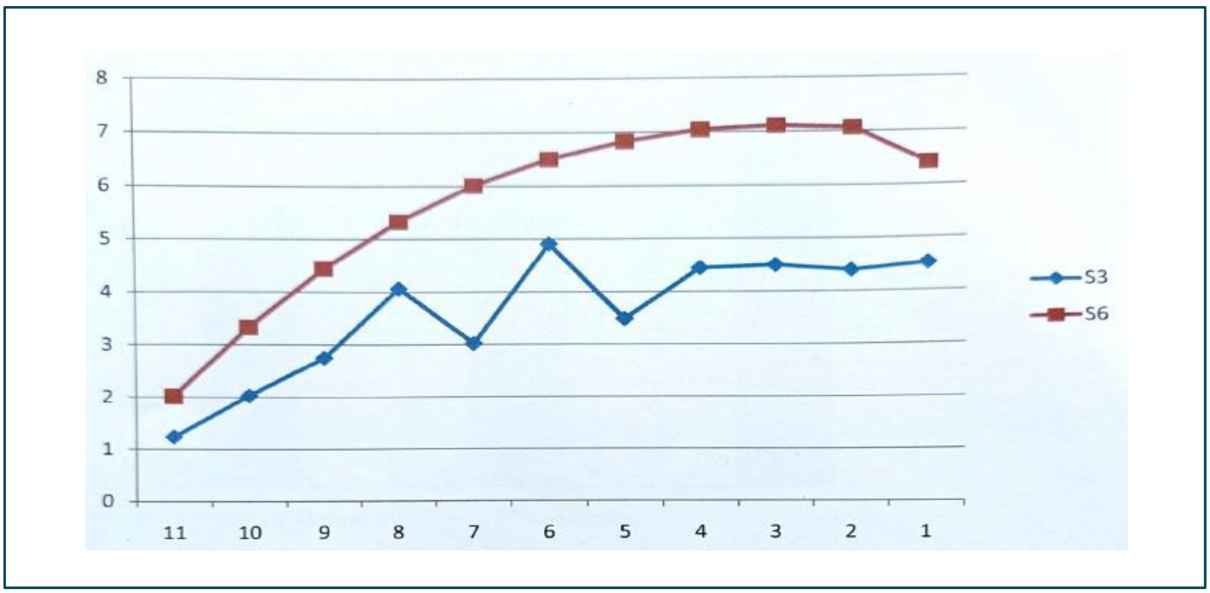
9) Comparison for Storey Drift

Table 5.9 Storey displacement Comparison for model S3, S6

Sr. No.	Height	Node No.	Model	
			S3	S6
1	37.40	427	1.24	2.02
2	34.00	392	2.03	3.33
3	30.60	357	2.75	4.44
4	27.20	322	4.07	5.33
5	23.80	287	3.02	6.01
6	20.40	252	4.91	6.50
7	17.00	217	3.49	6.83
8	13.60	182	4.45	7.04
9	10.20	147	4.5	7.11
10	6.80	112	4.40	7.07
11	3.40	77	4.52	6.41



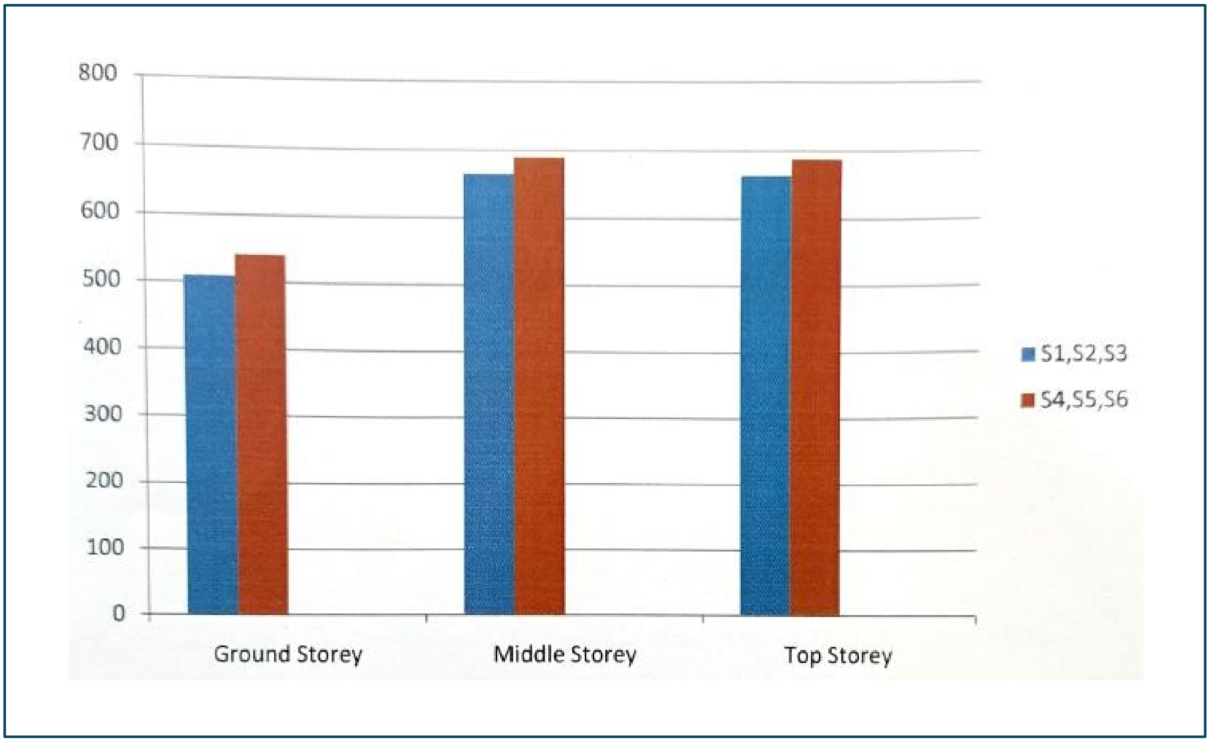
Graph 5.9 Storey displacement Comparison for model S3, S6

10) Reinforcement Comparison

Table 5.10 Reinforcement Comparison for all model

Sr. No.	Storey Level	Model	Quantity (KN)
01	Ground Storey	S1	509.93
02		S2	541.01

03	Middle Storey	S3	665.87
04		S4	689.659
05	Top Storey	S5	663.97
06		S6	688.312



Graph 5.10 Reinforcement Comparison for all model

VI. CONCULSIONS

1) Soft storey at top level gives Lower values of displacement in all seismic zones
2) soft storey at upper floor level gives gives lowest values of Axial forces and bending moment in low and moderate seismic zone, while gives a slight higher values of moments in severe and very severe seismic zones compared to soft storey located at middle floor level

VII. ACKNOWLEDGMENT

It gives me great pleasure on bringing out the report entitled.

"S*tudy of structural parameters effect caused* by *soft storey in Multi-storey building*"

No undertaking of the magnitude involved in the preparation of this project can be accomplished alone. Many have contributed till the successful acknowledge the assistance of the following individuals and would like to thank each one of them.

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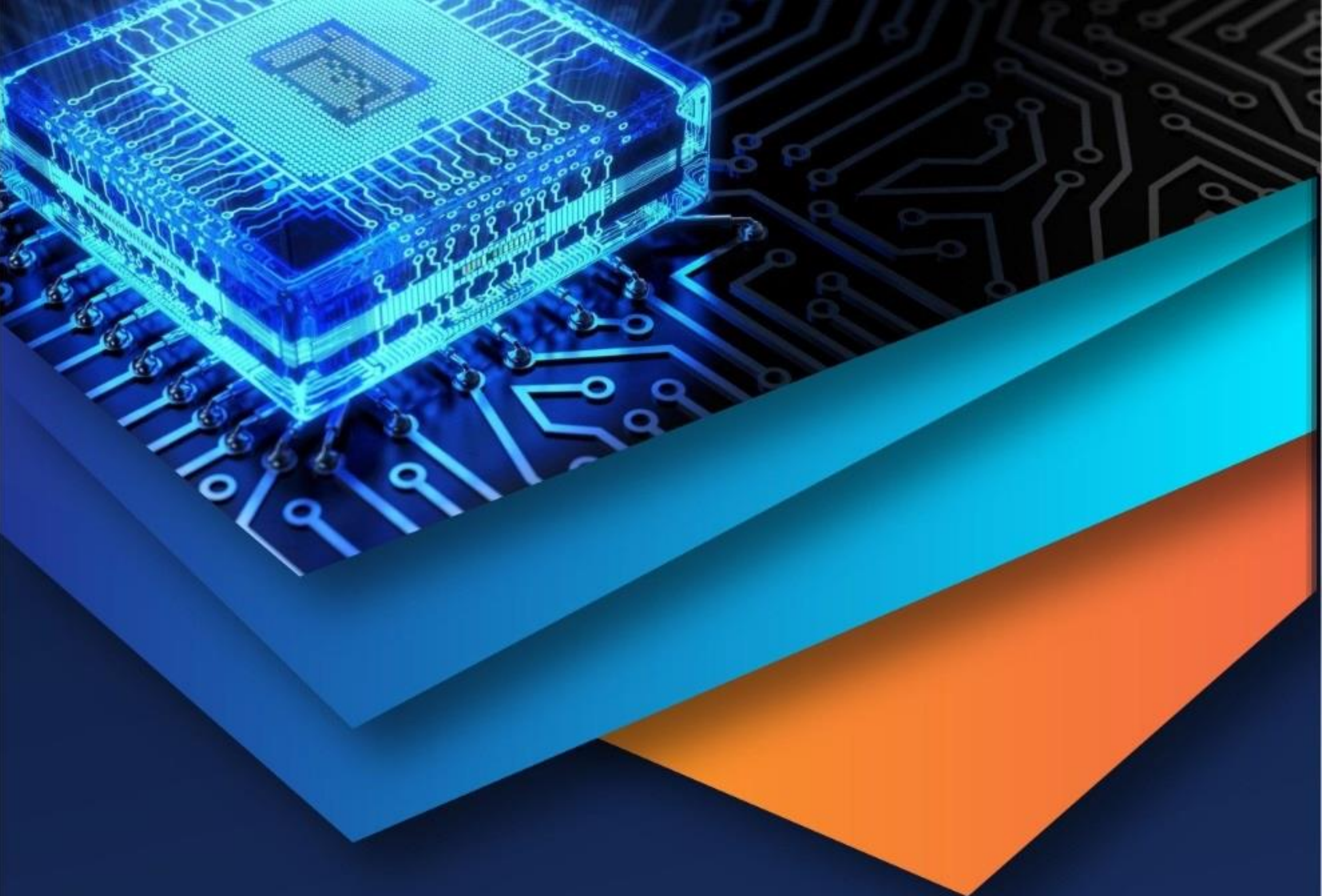

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