Seismic Analysis of Multistoried Building on Sloping Ground with Ground, Middle and Top Soft Storey

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Abstract: ***Buildings that rest on sloping ground are different from those that rest on level ground. Buildings located on sloping ground are much more prone to earthquakes because they are, in general, irregular, asymmetrical and tensional. Therefore, the movement of the ground affects them much more. Therefore, there is increased insertion of the shear wall to resist side loading. In this work, the multi-storey building G + 20 is analyzed on slopes of 0o and 24o. For the improvement and analysis of full-filled shear walls, GMT, type L and type C soft soil is used. The structure is analyzed by the response spectrum method and responses such as displacement, ground deviation, period and base slices are evaluated and compared using E-TAB software.***

Keywords: E-TAB, brick masonry, shear wall, response spectrum method, displacement, ground displacement, time period and base shear.

I. INTRODUCTION

The main objective of this work is to improve the structure which is on a sloping ground. The structure is analyzed using the Response Spectrum method using the E-TAB software (2018).

A. Shear Wall: Shear walls are vertical RCC members that resist lateral loads. The shear wall reduces the displacement of floors that meet the earthquake.

• In this work 200 mm thick L-type and C-type cut walls are used.

B. Brick Masonry: Brick masonry is very durable in construction. It is built by placing brick and mortar. In this analysis, brick masonry is very helpful in reducing displacement.

• Currently 230mm thick paper brick masonry is used for analysis.

C. Soft Storey: These are multiple floors in which one or more floors have openings for windows, large doors and vehicle parking. The rigidity of this floor is less than that of the normal floor.

• In this article, the Ground, Middle, and Top floors are made smooth for analysis.

II. OBJECTIVES OF THE PROJECT

A. Study the effect of infill on the frame when subjected to seismic loads on sloping terrain.

B. Study the effect of soft floors in multi-story buildings when subjected to seismic loads on sloping terrain.

C. Study how shear walls can improve the performance of soft story RC buildings on sloping terrain.

D. To find displacement, floor drift, base shear, time period using the equivalent static method and the response spectrum method of RCC construction under sloping terrain.

III. METHODOLOGY

This paper attempts to investigate the seismic effect on the RCC multistory building model G + 20 with masonry infill, GMT with resilient floor, L-type and C-type shear wall. The 21-story RCC building models are created and analyzed by ETAB software (2018). After successfully completing the models, the best position of the different sloping terrains is found by changing the different degree to minimize the seismic effect. Different models have been created and the results are compared to additional models. The height of each storey is maintained at 3.5 m. The seismic zone considered is V and the ground is average. In this document the structure includes live load, seismic load and dead load and these are respectively in accordance with IS 875 part 1, IS 1893-2016, IS 875 part I. The structure is analyzed using the static method linear and linear dynamic method. Responses such as displacement, floor deviation, period, and base cut are calculated. After analyzing the structure, the obtained values are used to form a table, graphs and finally the conclusion.

A. Linear static method

This method is employed to seek out the crosswise (horizontal) signals. This method is straightforward and required less computational energy which is calculated in keeping with the IS code of practice. In this method firstly the design of Base shear is calculated for the full building then they obtained results of Base shear is circulated right along the peak of the building. The crosswise signal of every floor is circulated to every horizontal resisting section.

B. Linear dynamic method

IS 1893 (part 1): 2002 recommended the tactics of dynamic building analysis just in the case of (i) ordinary buildings - those over 40 m tall in zones IV and V, and people over 90 m high in zones II and III (ii) Irregular buildings - all frame buildings higher than 12 m in height zones IV and V and people over 40 m in height zones II and III. The main purpose of the dynamic analysis is to find the design seismic signals, which are distributed to various points along the height of the building and to the different transverse load resistance sections of the structure and the analysis is somewhat similar to the linear static method. In the case of a

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dynamic analysis, the entire masses are assumed to be grouped at the level of the floor and at each floor, only the sway displacement is allowed.
Analysis of the dynamic method, it is assumed that the irregular building type is based on the 3D modeling of this building which will have adequate rigidity and mass circulation along the height of the building so that its responses can be predicted easily and with more precision.

IV. STRUCTURAL MODEL

The plan area of the structure is 32mx25m and height of the structure is 72m. Building which are resting on sloping ground are different from those building which are resting on flat ground. Hence, they are much more prone to Earthquake because they become irregular, unsymmetrical and torsional. So, adopting Full Brick Masonry, Shear wall maintaining Ground, Middle and top soft storey to resist the lateral load of the structure.

A. Properties of members

Young's modulus of concrete	35355.33MPa
Poisson's ratio	0.2
Density	25 KN /m^3
Thermal coefficient	0.0000055/^{o}C
Grade of concrete	M_{40}
Yield strength of steel	Fe_{500}

B. Seismic Parameter

Zone value	0.36
Response reduction factor(R)	5 (S.M.R.F)
Importance factor	1.5
Damping ratio	0.05
Soil Type	Medium

C. Size of Members

Column size	1100mm x 1100mm, 900mm x 900mm, 700mm x 700mm
Beam size	230mm x 525mm
Slab thickness	150mm
Shear	200mm
Brick Masonry	230mm

VI. PLAN, ELEVATION, AND 3D VIEW OF DIFFERENT MODELS.

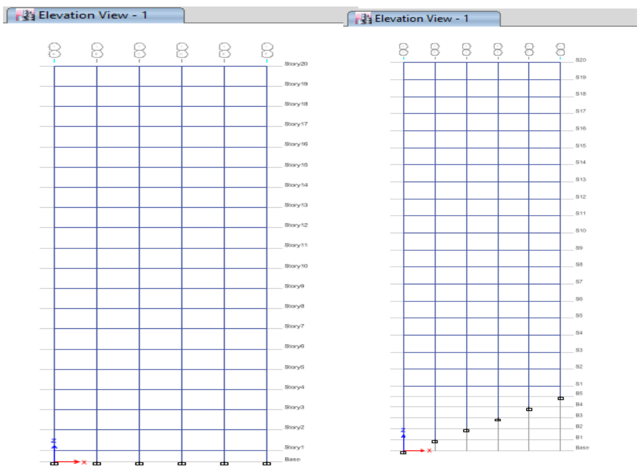


Fig 2- elevation of 0^0 and 24^0

D. Load Intensity

Live load on each floor	3 KN/m^2
Live load	1.5 KN/m^2
Floor finish	1 KN/m^2
Wall load	12.305 KN/m^2

E. Load Combinations

The load combination is itself calculated by the E-TAB software and the models are analyzed as the calculated load combination.

V. ABOUT E-TAB

The new creative and dynamic ETABS is a complete programming package designed for the complicit examination and structure plan. Combining 40 years of persevering creative work, this latest ETABS offers unparalleled direction-based 3D rendering and rendering tools, incredibly smart non-linear and fast-paced illustration power, mind-boggling limits, and an intensive game plan when this is a large version. Clever and sensible materials and introductions reports and schematic drawings that connect with clients to quickly and easily unravel and understand the review and setup. Figure 1 shows the reference axis in the E-TAB software (2018). The X and Y coordinates indicate the horizontal direction parameter and the Z coordinates are called the vertical direction parameter

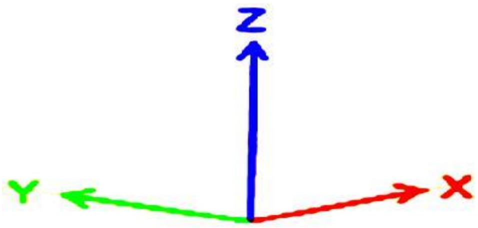


Fig 1: Generalized Coordinates in ETABS 2018

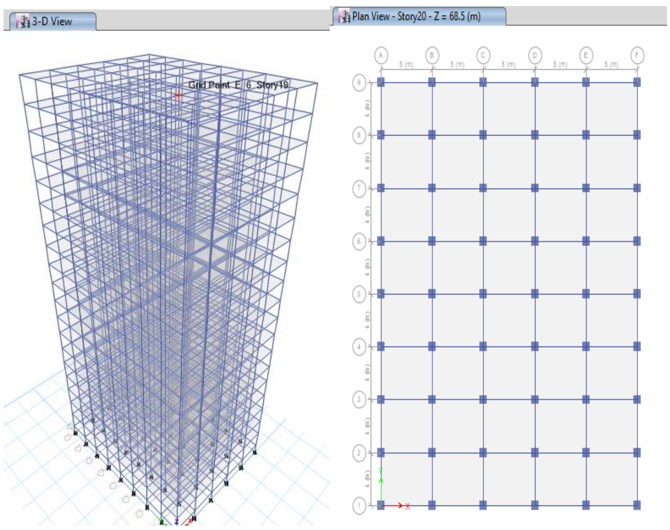


Fig 3- Bare Frame

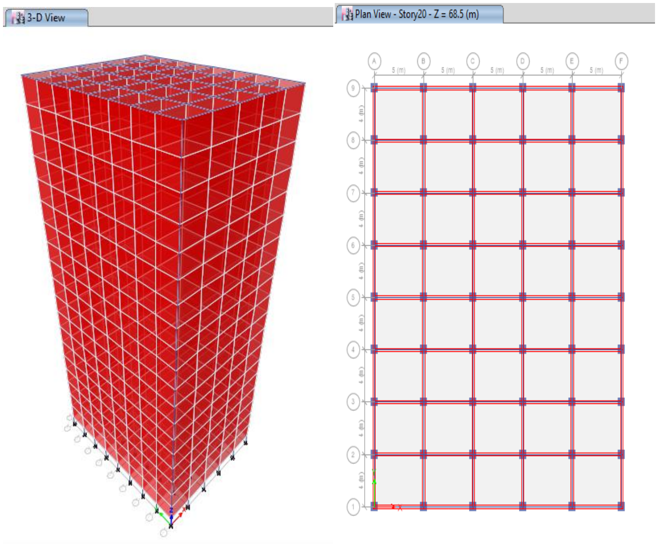


Fig 4- Masonry Brick Infill

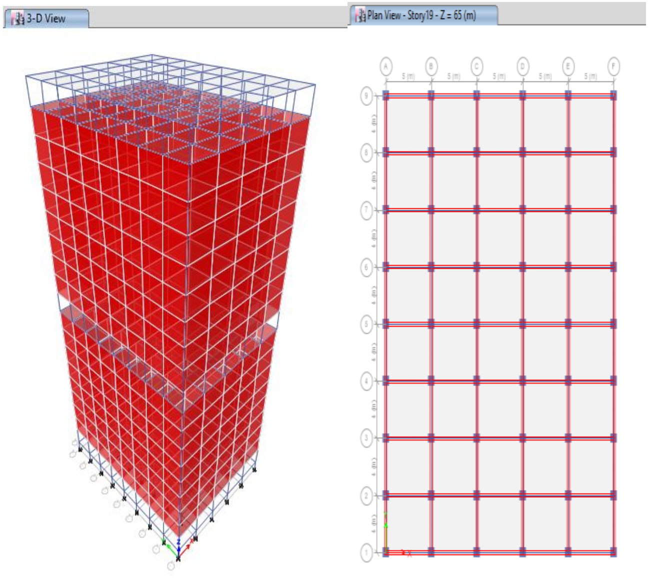


Fig 5- GMT with Soft Storey

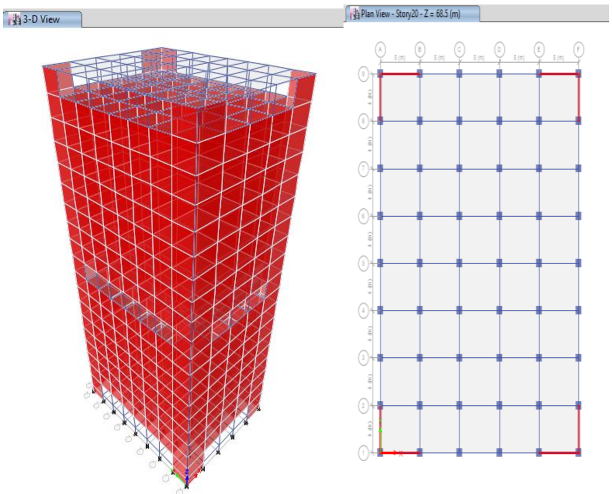


Fig 6- GMT with L type Shear wall

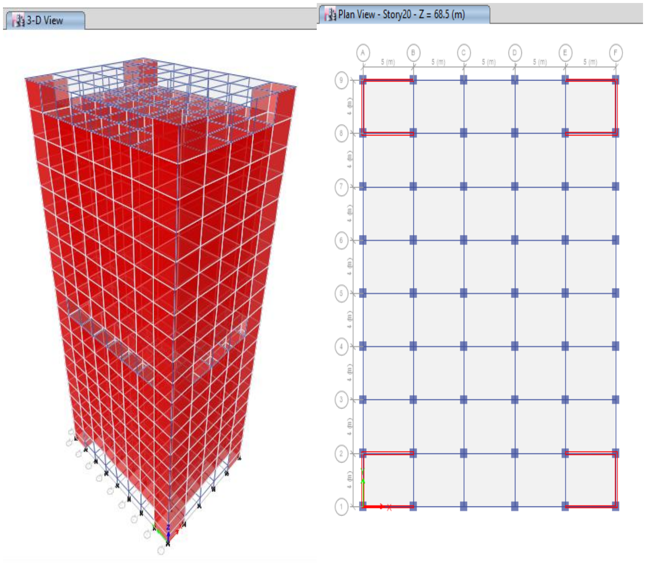


Fig 7- GMT with C type Shear wall

VII. RESULTS AND DISCUSSION

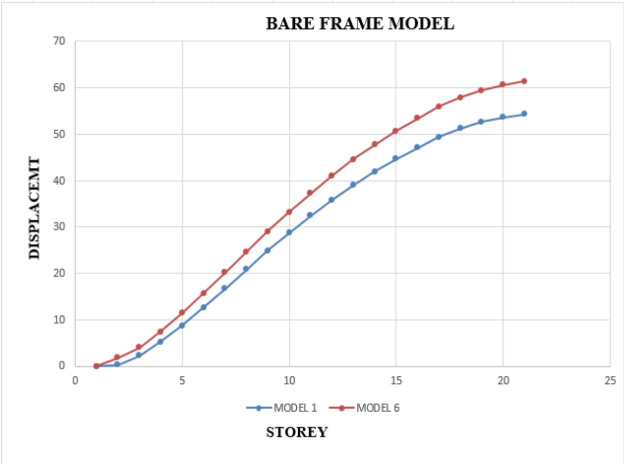
The results of Normal building and sloping ground building is compared by considering Masonry Brick Infill, GMT soft storey, GMT with L type shear wall and GMT with C type Shear wall. The lateral responses like displacement, storey drift, time period and base shear is evaluated and compared.

Table I. Displacement due to Response Spectrum Method

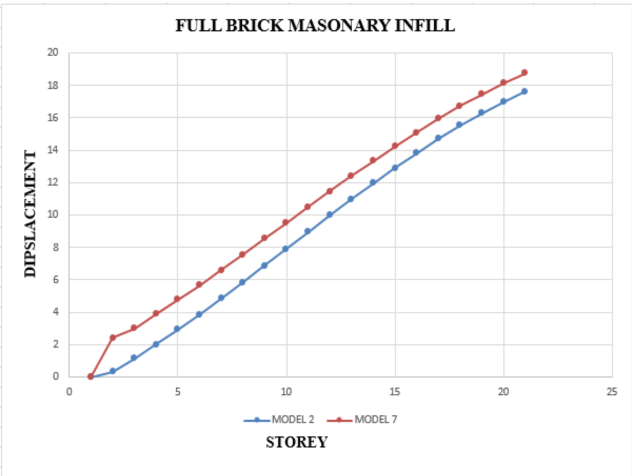
	DISPLACEMENT ALONG X-DIRECTION									
storey	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8	MODEL 9	MODEL 10
	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR
Story20	54.325	17.61	17.753	16.67	16.29	61.377	18.766	19.467	17.9	17.478
Story19	53.646	16.98	17.011	15.997	15.609	60.599	18.14	18.767	17.226	16.785
Story18	52.621	16.282	16.442	15.39	14.973	59.462	17.456	18.221	16.615	16.136
Story17	51.197	15.518	15.83	14.741	14.299	57.905	16.717	17.642	15.966	15.451
Story16	49.374	14.695	15.163	14.039	13.575	55.916	15.927	17.017	15.271	14.722
Story15	47.122	13.814	14.444	13.283	12.797	53.454	15.089	16.349	14.527	13.944
Story14	44.665	12.911	13.7	12.492	11.982	50.735	14.23	15.659	13.752	13.13
Story13	41.979	11.964	12.912	11.651	11.118	47.77	13.334	14.932	12.932	12.272
Story12	39.044	10.982	12.096	10.769	10.209	44.534	12.407	14.181	12.074	11.373
Story11	35.856	9.973	11.085	9.779	9.221	41.026	11.458	13.261	11.118	10.398
Story10	32.424	8.947	9.226	8.376	7.96	37.255	10.493	11.619	9.789	9.171
Story9	28.763	7.911	8.213	7.369	6.953	33.244	9.518	10.693	8.815	8.175
Story8	24.9	6.874	7.365	6.441	6	29.024	8.541	9.907	7.91	7.227
Story7	20.872	5.844	6.515	5.527	5.067	24.641	7.568	9.116	7.013	6.293
Story6	16.743	4.833	5.676	4.634	4.164	20.16	6.608	8.33	6.129	5.379
Story5	12.63	3.84	4.846	3.765	3.296	15.691	5.659	7.549	5.257	4.486
Story4	8.762	2.914	4.065	2.954	2.494	11.438	4.762	6.804	4.425	3.64
Story3	5.203	2.008	3.28	2.174	1.742	7.461	3.875	6.045	3.604	2.824
Story2	2.249	1.139	2.269	1.362	1.023	4.017	2.997	4.982	2.712	2.009
Story1	0.352	0.333	0.514	0.368	0.27	1.785	2.416	3.516	1.876	1.35
Base	0	0	0	0	0	0	0	0	0	0

Table II. Storey Drift due to Response Spectrum Method

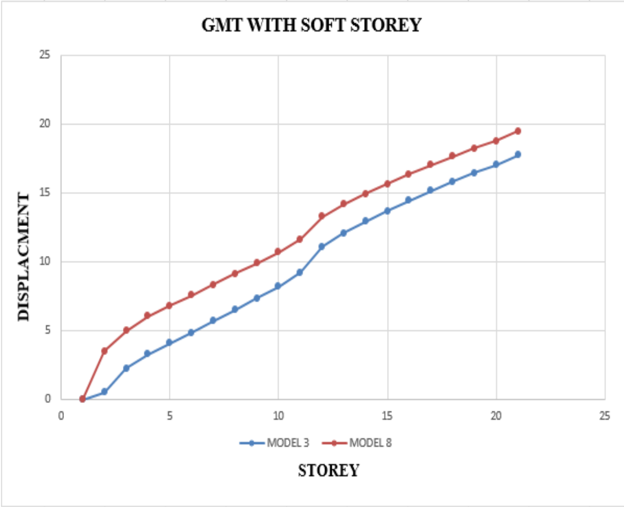
	STOREY DRIFT ALONG X-DIRECTION									
storey	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8	MODEL 9	MODEL 10
	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR	X-DIR
Story20	0.00028	0.00018	0.00022	0.0002	0.0002	0.00034	0.00018	0.00021	0.0002	0.000202
Story19	0.00044	0.0002	0.00017	0.00018	0.00019	0.00051	0.0002	0.00016	0.00018	0.000189
Story18	0.0006	0.00022	0.00018	0.00019	0.0002	0.00068	0.00022	0.00017	0.00019	0.0002
Story17	0.00073	0.00024	0.0002	0.00021	0.00021	0.00081	0.00023	0.00019	0.0002	0.000214
Story16	0.00083	0.00026	0.00021	0.00022	0.00023	0.00092	0.00025	0.0002	0.00022	0.000228
Story15	0.00086	0.00027	0.00022	0.00023	0.00024	0.00095	0.00026	0.00021	0.00023	0.000238
Story14	0.00091	0.00028	0.00023	0.00025	0.00025	0.00101	0.00027	0.00022	0.00024	0.000251
Story13	0.00097	0.00029	0.00024	0.00026	0.00026	0.00107	0.00028	0.00022	0.00025	0.000263
Story12	0.00102	0.0003	0.0003	0.00029	0.00029	0.00113	0.00028	0.00027	0.00028	0.000285
Story11	0.00108	0.0003	0.00055	0.00041	0.00037	0.00119	0.00029	0.00049	0.00039	0.000359
Story10	0.00113	0.0003	0.0003	0.00029	0.00029	0.00124	0.00029	0.00028	0.00029	0.00029
Story9	0.00117	0.0003	0.00025	0.00027	0.00028	0.00129	0.00029	0.00023	0.00027	0.000276
Story8	0.0012	0.0003	0.00025	0.00027	0.00027	0.00132	0.00028	0.00023	0.00026	0.000271
Story7	0.00121	0.00029	0.00024	0.00026	0.00026	0.00132	0.00028	0.00023	0.00026	0.000264
Story6	0.00119	0.00029	0.00024	0.00025	0.00025	0.0013	0.00028	0.00023	0.00025	0.000257
Story5	0.00111	0.00027	0.00023	0.00023	0.00023	0.00122	0.00026	0.00022	0.00024	0.000243
Story4	0.00102	0.00026	0.00023	0.00022	0.00022	0.00114	0.00026	0.00022	0.00024	0.000234
Story3	0.00084	0.00025	0.00029	0.00023	0.00021	0.00099	0.00025	0.0003	0.00026	0.000233
Story2	0.00054	0.00024	0.0005	0.00031	0.00023	0.0009	0.00057	0.00103	0.00057	0.000425
Story1	0.00018	0.00017	0.00026	0.00018	0.00014	0.00046	0.00051	0.00073	0.00046	0.000333
Base	0	0	0	0	0	0	0	0	0	0



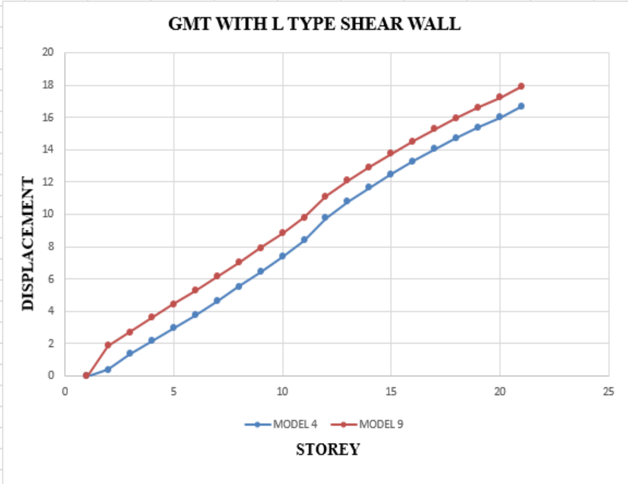
Graph 1: Bare Frame Building



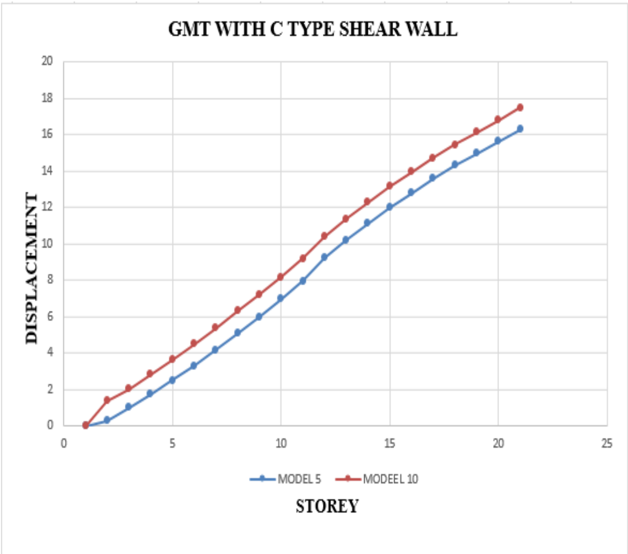
Graph 2: Full Brick Masonry Infill



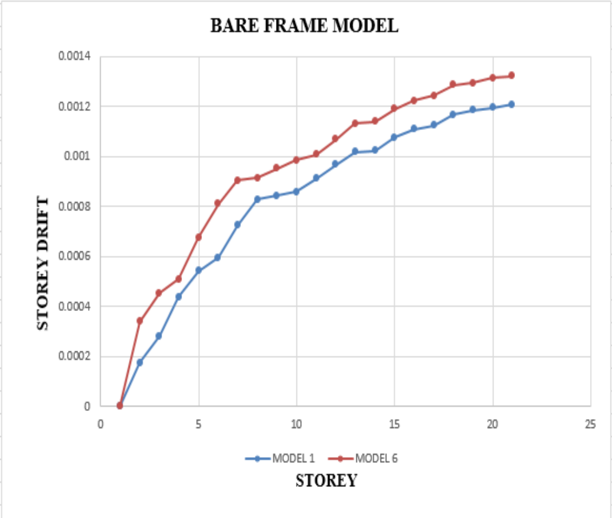
Graph 3: GMT Soft Storey



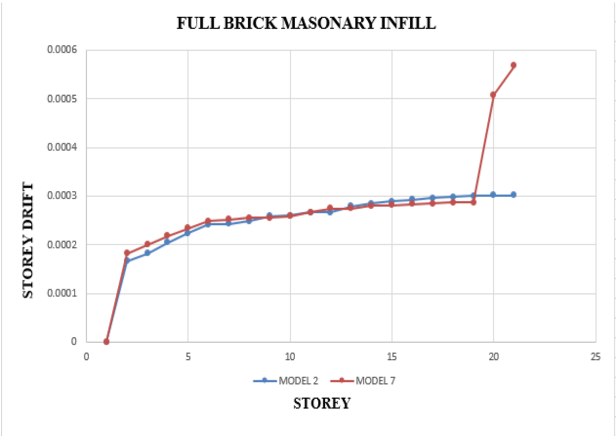
Graph 4: GMT with L type shear wall



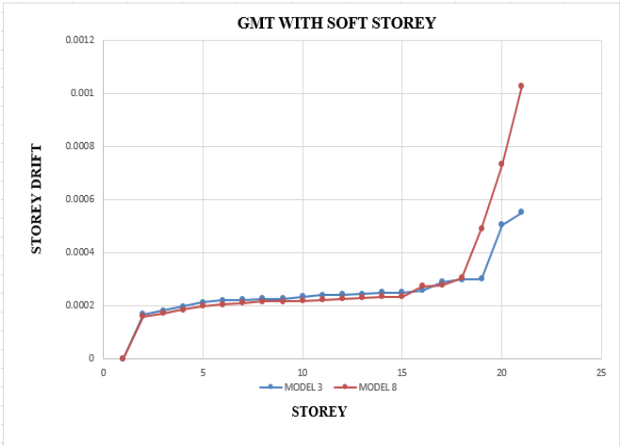
Graph 5: GMT with C type shear wall



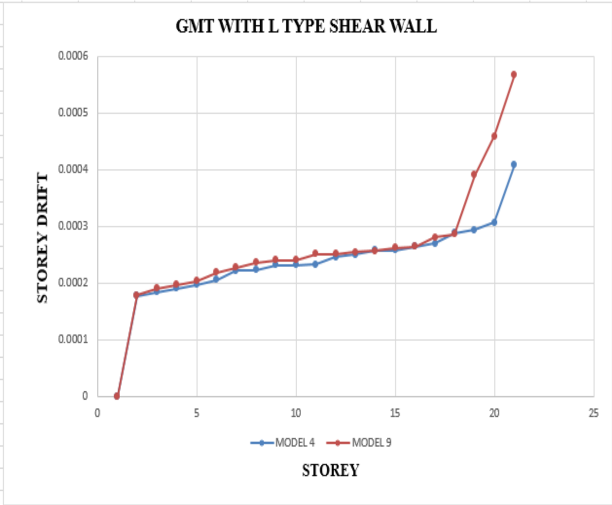
Graph 6: Bare Frame Building



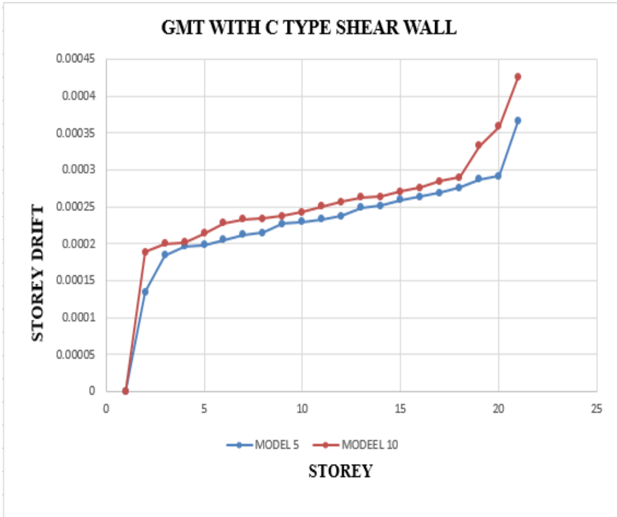
Graph 7: Full Brick Masonry Infill



Graph 8: GMT with soft storey



Graph 9: GMT with L type shear wall



Graph 10: GMT with C type shear wall

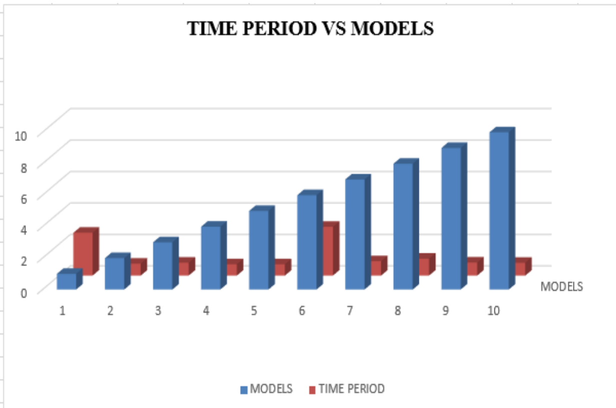


Fig8: Time period vs. models

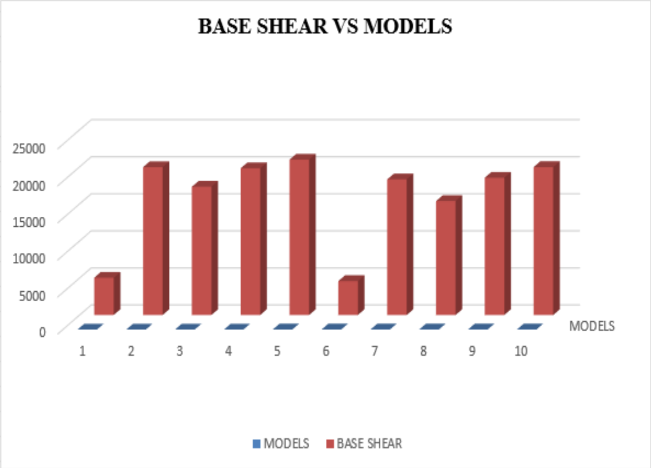


Fig 9: Base shear vs. models

VIII. DISCUSION

1. The Displacement, Storey drift, Time Period and Base Shear of regular building and sloping ground(24^0) building models are compared. The variation is less in these models because of the same stiffness and corresponding loads.
2. 0^0 and 24^0 models are considered with masonry brick infill, GMT soft storey, GMT soft storey with L type and C type shear wall. The model with masonry brick infill has less displacement because of large stiffness.
3. C type shear wall plays an important role in reducing the lateral load and among all the models, the model with C type shear wall is more effective.
4. Graph 1 shows the displacement of bare frame building. The model with 24^0 sloping shows the higher displacement because of irregularity in stiffness and instability.
5. Graph 2 dhows the displacement of full brick masonry infill building. The model with 24^0 sloping has the higher displacement value because of sloping ground.
6. The graph 3 shows the displacement of GMT soft storey. The model without sloping ground has lesser displacement value as compared to sloping ground.
7. The graph 4 shows the displacement of GMT soft storey with L type shear wall. The model of 24^0 has the highest displacement value because of unsymmetry.in building.
8. The graph 5 shows the displacement of GMT soft storey with C type shear wall. The model of 24^0 shows the higher displacement as compared to 0^0 model.
9. The graph 6 shows the storey drift of bare frame structure. The model with sloping ground has the highest storey drift as compared to 0^0 model.
10. Graph 7 shows the storey drift of brick masonry infill. In brick masonry infill as the storey height increases, the storey drift also increases gradually.
11. The graph 8 shows the storey drift of GMT soft storey. At beginning as the storey height increases the storey drift also increases gradually up to certain limit, then further it suddenly increases with much difference in storey drift.
12. Graph 9 indicates the storey drift of GMT soft storey with L type shear wall. In this model, at beginning there is a much more difference in storey drift then further it gradually increases as the storey height increases.
13. The graph 10 shows the storey drift of GMT soft storey with C type shear wall. The model with 24^0 has the highest storey drift as compared to 0^0 model.
14. Among all the models, the model with bare frame has the highest time period because of increase in displacement.
15. Among all the models, the model with GMT soft storey with C type shear wall has the highest Base shear because of increase in stiffness.
16. The variation in displacement of 0^0 is found to be 67.58% reduction in masonry brick infill, 67.32% reduction in GMT soft storey, 69.31% reduction in GMT soft storey with L type shear wall,70.01% reduction in GMT soft storey with C type shear wall.
17. The variation in displacement of 24^0 is found to be 69.42% reduction in masonry brick infill, 68.28% reduction in GMT soft storey, 70.832% reduction in GMT soft storey with L type shear wall,71.52% reduction in GMT soft storey with C type shear wall.

IX. CONCLUSION

1. The displacement for model i.e. GMT soft storey wit C type shear wall has the highest displacement value as compared to all other models because of presence of stiffeners.
2. The model with GMT soft storey with C type shear wall proves to be more effective as compared all other models because shear wall enhances the performance of soft storey on sloping ground.
3. The model with Bare frame has the highest time period as compared to all other models ie masonry brick infill, GMT soft storey, GMT soft storey with L type shear wall and GMT soft storey with C type shear wall.
4. The model with GMT soft storey with C type shear wall has the highest Base shear value as compared to all other models because of decrease in displacement.
5. The model on sloping ground has the highest displacement values because of irregularity, asymmetry and torsional. Hence, there is a rise of insertion shear wall to reduce the lateral load.

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