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SEISMIC ANALYSIS OF MULTISTORIED BUILDING ON SLOPING GROUND WITH GROUND, MIDDLE & TOP SOFT STOREY

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Abstract— The present study deals with evaluation of R.C building. R.C building are generally designed as framed structures without regard to structural action of masonary walls . The open story known as soft story perform poorly during earthquakes further Due to the diverse configurations of buildings in hilly areas, these buildings become highly irregular and asymmetric, due to variation in mass and stiffness distributions on different vertical axis at each floor. Further, due to site conditions, buildings on hill slope are characterized by unequal column heights within a story, which results in drastic variation in stiffness of columns of the same storey.

Keywords— Sloping ground , Bare frame , Full infill , GMT soft story ,GMT ss & L type shear wall ,GMT ss & C type shear wall , EQX , EQY , RSX , RSY

I. INTRODUCTION

In many part of world , hilly area are more liable to seismic action . In this hilly region, old fashioned material like brunt brick, stone masonry bamboo, etc., which is locally available, is used for the construction of houses. Buildings constructed on slopes are different from those in plains , they are susceptible to severe damage when affected by earthquake ground motion . A soft story building consists of large opening , such as a parking garage or series of retail business with huge window . Shear wall is a structural member used to lateral forces parallel to the plane of wall the presence of shear wall can inprove the performance of building .

II. OBJECTIVES

1. To carry out lateral load analysis for building models as per code .
2. To make out the effect of soft storey in multi-storey buildings when subjected to seismic loading.
3. To make out how shear wall reduces the effect of soft storey and how it can enhance the performance of R.C buildings.

III. METHODOLOGY

The plan layout for all the building models will be same i.e., 30x36 m. Study have to be carried out for different models of a seventeen storey building . Following data is used in the analysis of the RC frame building models. Thickness of masonary wall (tw) = 0.23m, thickness of slab (ts) = 0.15m Density of Reinforced Concrete 25kN/m³ , Density of brick masonry 20kN/m³, Poisson's Ratio of concrete 0.2, Floor finishes 1.0kN/m², Imposed loads 3.5KN/ m², Roof live 1.5 KN/ m² , Thickness of shear wall 0.20m, Zone –V, Zone factor (Table2 of IS 1893-2002) – 0.36, Importance factor, I (Table 6 of IS 1893-2002) – 1.0, Response reduction factor, R (Table 7 of IS 1893-2002) – 5.00, Soil type (figure 2 of IS 1893-2002) – Type II (Medium soil) .

Models to be considered for Analysis

Model 1 - Bare frame model however masses of walls are included .

Model 2 – Building has full brick masonry infill of 230 mm thick in all the stories .

Model 3 – Building has no brick masonry infill Ground middle & top story .

Model 4 – Building model is same as model 3 further L type shear wall is provided in both X & Y direction at corners .

Model 5 - Building model is same as model 3 further Ctype shear wall is provided in both X & Y direction at corners .

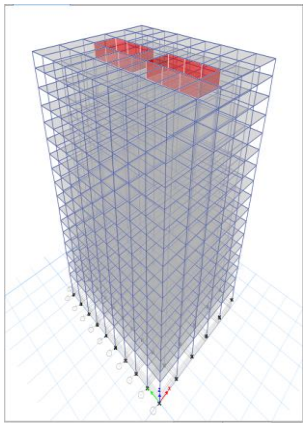

Figure 1: Bare frame

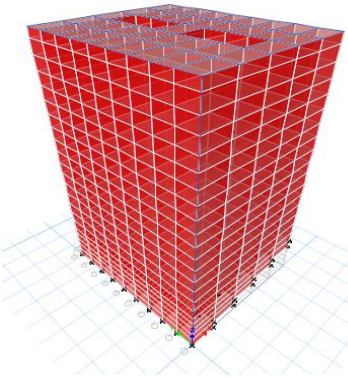

Figure 2:Full infill

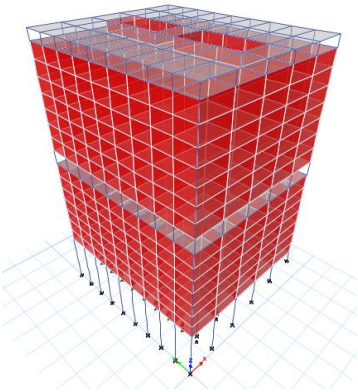

Figure 3: GMT soft story

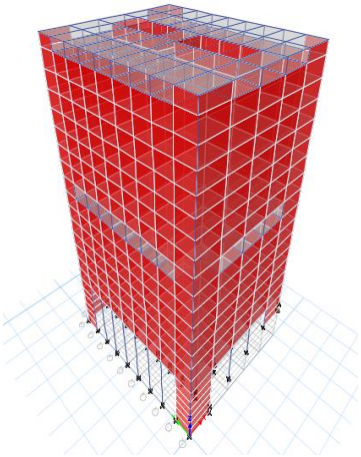

Figure 4:GMT SS & L type shear wall

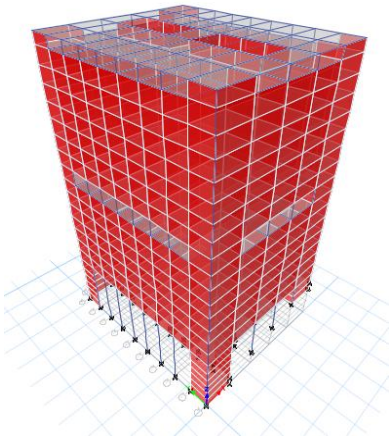

Figure 5: GMT SS & L type shear wall

IV. ANALYSIS

The analysis of building is carried out using ETABS , equivalent static method and response spectrum method were used .

In equivalent static method estimate the first mode response period of the building from the design response spectra. Use the specific design response spectra to determine that the lateral base shear of the complete building

Response spectrum analysis this approach permits the multiple modes of response of a building to be taken into account.. Computer analysis can be used to determine these modes for a structure. Following are the types of combination methods in response spectrum method

- absolute - peak values are added together .
- square root of the sum of the squares (SRSS) .
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes .

V. RESULTS & DISCUSSION

1.TIME PERIOD

All objects have a natural period or the time it takes to swing back and forth . if you pushed the flag pole it would sway at its natural period . As seismic wave move through the ground , the ground also moves at its natural period .

Table 1:Model Vs Time period for different degree

Models	0 degree	6 degree	12 degree	18 degree
bare frame	2.115	2.16	2.18	2.19
full infill	0.57	0.587	0.608718	0.631718
gmt soft story	0.614	0.655	0.706	0.758
gmt ss & L type sw	0.564	0.591	0.615	0.636
gmt ss & C type sw	0.54	0.563	0.5845	0.6051

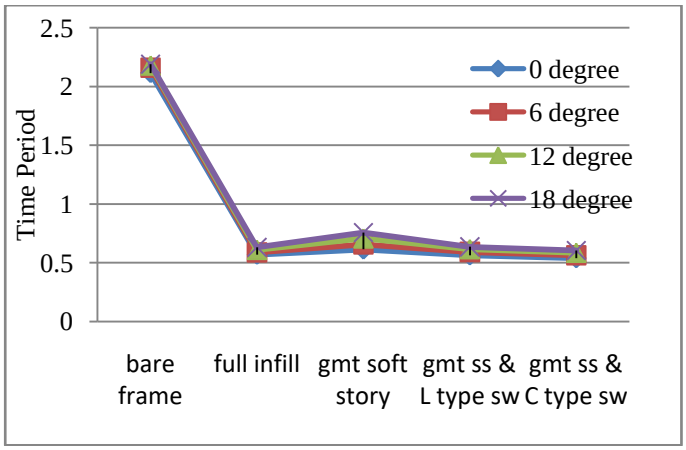

Figure 6:Model Vs Time Period

As the angle of slope is increased the time period also increased . The percentage increase of time period was ,

For bare frame 2.127 % (6°) , 3.073 % (12°) , 3.546 % (18°) with respect to 0 degree .

For full infill 2.98 % (6°) , 6.79 % (12°) , 10.8 % (18°) with respect to 0 degree .

For gmt soft story 6.67 % (6°) , 14.98 (12°) , 23.45 (18°) with respect to 0 degree

For gmt soft story along with L type shear wall 4.78 % (6°) , 9.04 % (12°) , 12.76 %(18°) with respect to 0 degree .

For gmt soft story along with C type shear wall 4.26 % (6°) , 8.24 % (12°) , 12.05 %(18°) with respect to 0 degree

2.Maximum story displacements

The maximum storey displacements with respect to ground level are presented in tables.

Table 2:Model Vs Maximum displacement for diff degree

EQX				
Model	0 degree eqx	6 degree eqx	12 degree eqx	18 degree eqx
bare frame	53.717	54.098	53.563	52.974
full infill	12.977	13.857	14.717	14.414
gmt soft story	14.293	14.617	15.766	14.794
gmt ss & L type sw	12.214	13.023	14.665	13.52
gmt ss & C type sw	12.036	12.842	13.498	13.446

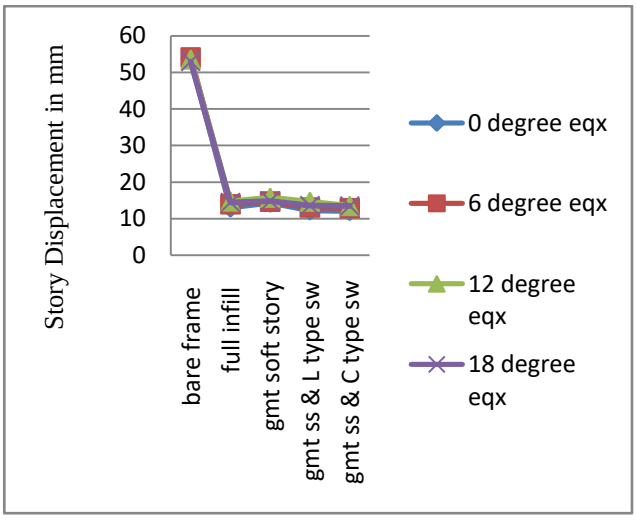

Figure 7 Model Vs Maximum story displacement

Table 3:Model Vs Maximum displacement for diff degree

EQY				
Model	**0 degree eqy**	**6 degree eqy**	**12 degree eqy**	**18 degree eqy**
bare frame	46.472	47.306	47.367	47.306
full infill	14.463	15.157	16.72	15.763
gmt soft story	15.274	16.114	17.121	17.248
gmt ss & L type sw	14.204	14.774	16.376	15.373
gmt ss & C type sw	13.679	14.318	15.105	14.86

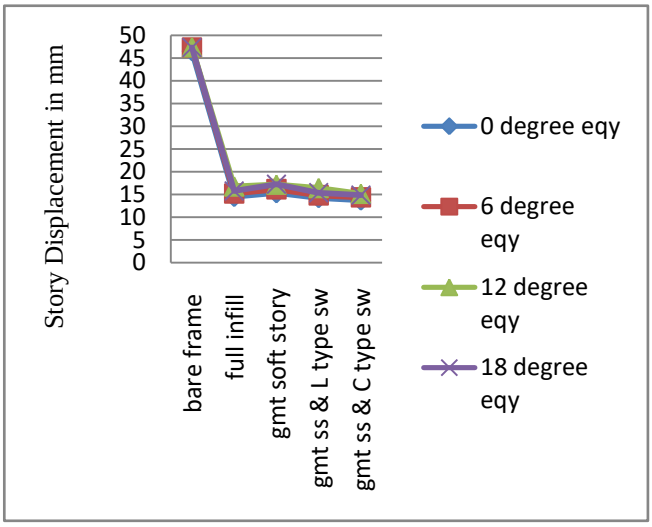

Figure 7 Model Vs Maximum story displacement

Table 4:Model Vs Maximum displacement for diff degree

RSX				
Model	**0 degree rsx**	**6 degree rsx**	**12 degree rsx**	**18 degree rsx**
bare frame	41.787	42.422	42.827	43.197
full infill	11.215	12.157	13.281	13.078
gmt soft story	12.272	12.63	14.046	13.139
gmt ss & L type sw	10.542	11.365	12.878	12.18
gmt ss & C type sw	10.385	11.203	11.961	12.113

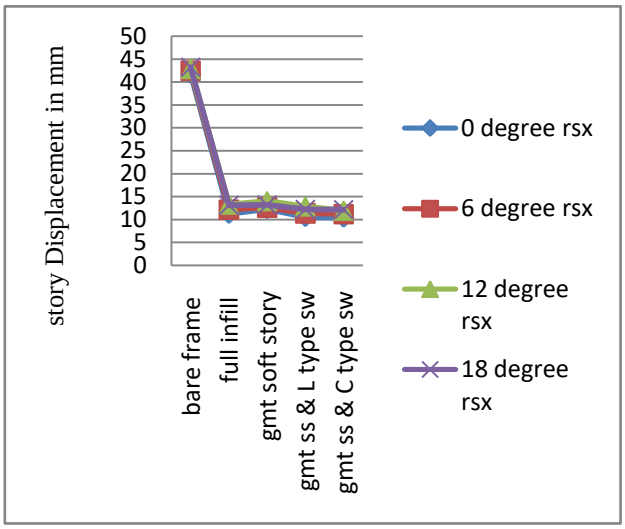

Figure 8 Model Vs Maximum story displacement

Table 5:Model Vs Maximum displacement for diff degree

RSY				
Model	**0 degree rsy**	**6 degree rsy**	**12 degree rsy**	**18 degree rsy**
bare frame	36.849	41.066	41.255	40.589
full infill	12.496	13.681	16.117	15.346
gmt soft story	13.131	15.556	17.75	19.277
gmt ss & L type sw	12.283	13.318	15.6	15.018
gmt ss & C type sw	11.882	13.029	14.207	14.707

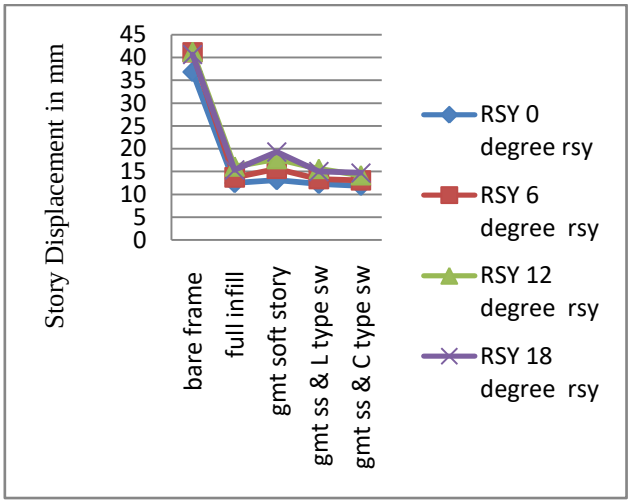

Figure 9 Model Vs Maximum story displacement

The maximum displacement was found to be for bare frame the percentage increase or decrease of with respect to modelon plain ground are shown in table .

Table 6:Model Vs % ↑ for 6 degree wrt 0 degree degree

6 degree % ↑ wrt 0 degree				
Model	Eqx	eqy	Rsx	rsy
bare frame	0.709273	1.794629	1.519611	11.444
full infill	6.781228	4.798451	8.399465	9.483035
gmt soft story	2.266844	5.499542	2.91721	18.46775
gmt ss & L type sw	6.623547	4.012954	7.806868	8.42628
gmt ss & C type sw	6.696577	4.671394	7.876745	9.653257

Table 7:Model Vs % ↑ or ↓ for 12 degree wrt 0

12 degree % ↑ or ↓ wrt 0 degree				
Model	eqx	eqy	Rsx	Rsy
bare frame	-0.28669	1.925891	2.488812	11.95691
full infill	13.40834	15.60534	18.42176	28.97727
gmt soft story	10.30574	12.09244	14.45567	35.1763
gmt ss & L type sw	20.06714	15.29147	22.15898	27.0048
gmt ss & C type sw	12.14689	10.42474	15.17573	19.56741

Table 8:Model Vs % ↑ or ↓ for 18 degree wrt 0 degree

18 degree % ↑ or ↓ wrt 0 degree				
Model	Eqx	eqy	Rsx	rsy
bare frame	0.003153	-0.00248	0.021502	-0.19303
full infill	-0.27606	-0.8932	-0.28158	-1.38621
gmt soft story	-0.63537	0.089699	-0.93345	3.026153
gmt ss & L type sw	-1.56678	-0.93657	-1.20104	-1.00749
gmt ss & C type sw	-0.04679	-0.16909	0.192853	0.688654

3. STORY DRIFT

The storey drift is limited to 0.004 times the storey height so , that least amount of damage would take place during earthquake and pose less psychological fear in the minds of people .The maximum story drift of different models along X and Y are shown in tables.

Table 9:Model Vs Maximum story drft for diff degree

EQX				
Model	**0 degree drift eqx**	**6 degree drift eqx**	**12 degree drift eqx**	**18 degree drift eqx**
bare frame	0.00153	0.00151	0.00149	0.00147
full infill	0.0003	0.00032	0.00067	0.00031
gmt soft story	0.00075	0.00071	0.00035	0.00065
gmt ss & L type sw	0.00046	0.00047	0.00051	0.00045
gmt ss & C type sw	0.00045	0.00045	0.00047	0.00044

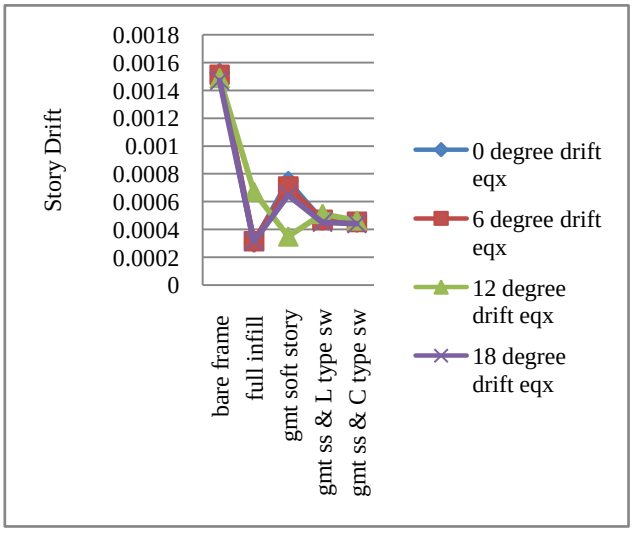

Figure 10 Model Vs Max Story drif

Table 10:Model Vs Maximum story drft for diff degree

EQY				
Model	**0 degree drift eqy**	**6 degree drift eqy**	**12 degree drift eqy**	**18 degree drift eqy**
bare frame	0.00134	0.00129	0.00123	0.0012
full infill	0.00035	0.00035	0.00071	0.00034
gmt soft story	0.00083	0.00078	0.00038	0.00066
gmt ss & L type sw	0.00058	0.00056	0.00052	0.00052
gmt ss & C type sw	0.0005	0.00048	0.00054	0.00045

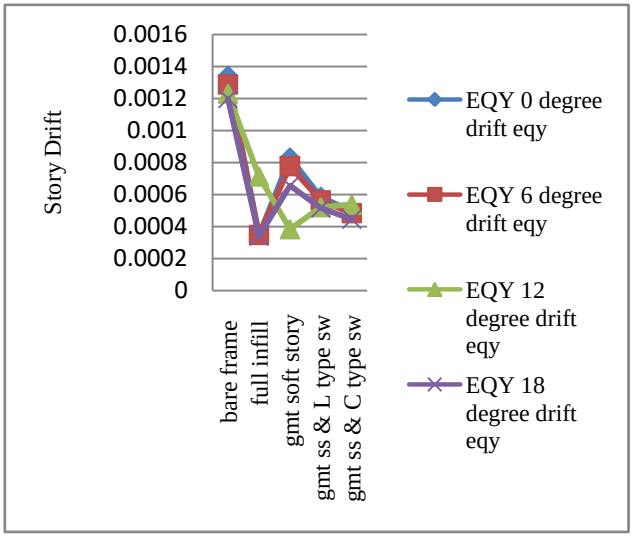

Figure 11 Model Vs Max Story drift

Table 11:Model Vs Maximum story drft for diff degree

RSX				
Model	**0 degree drift rsx**	**6 degree drift rsx**	**12 degree drift rsx**	**18 degree drift rsx**
bare frame	0.00123	0.00121	0.00121	0.00122
full infill	0.00027	0.00028	0.00044	0.00029
gmt soft story	0.00063	0.00059	0.00032	0.00055
gmt ss & L type sw	0.00039	0.0004	0.00057	0.0004
gmt ss & C type sw	0.00038	0.00039	0.0004	0.00039

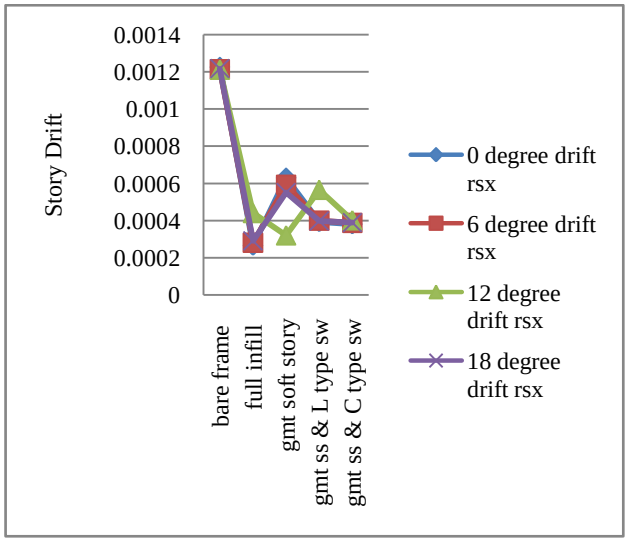

Figure 12 Model Vs Max Story drift

Table 12:Model Vs Maximum story drft for diff degree

RSY				
Model	**0 degree drift rsy**	**6 degree drift rsy**	**12 degree drift rsy**	**18 degree drift rsy**
bare frame	0.00108	0.00119	0.00115	0.00116
full infill	0.00032	0.00034	0.00039	0.00036
gmt soft story	0.0007	0.00072	0.00071	0.00067
gmt ss & L type sw	0.0005	0.00049	0.00048	0.00047
gmt ss & C type sw	0.00042	0.00043	0.00048	0.00042

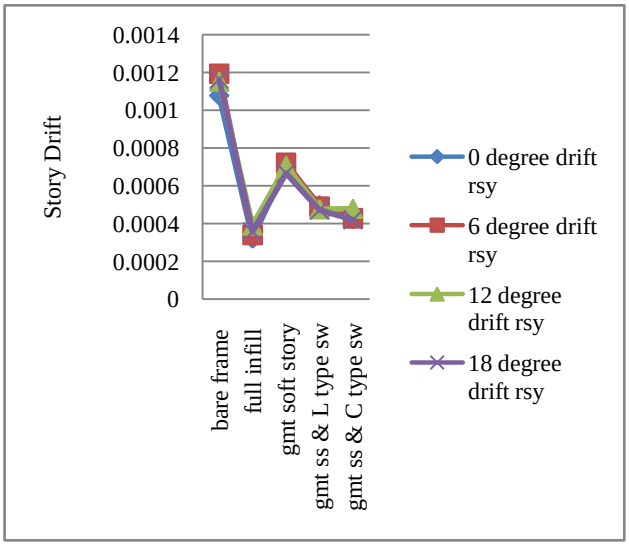

Figure 13 Model Vs Max Story drift

4. BASE SHEAR

It is an estimate of maximum expected lateral force that will occur due to seismic ground motion at the base of a structure .

Table 13:Model Vs Base Shear for diff degree

EQX				
Model	**0 degree base shear eqx**	**6 degree base shear eqx**	**12 degree base shear eqx**	**18 degree base shear eqx**
bare frame	6643.91	6663.19	6680.66	6728.48
full infill	28232.6	29605.7	33701.5	30162.3
gmt soft story	25816.2	24985.2	24266.2	23830.8
gmt ss & L type sw	26974.1	27670.7	28003.9	27638.8
gmt ss & C type sw	27050.5	27771.1	32054.6	27996.3

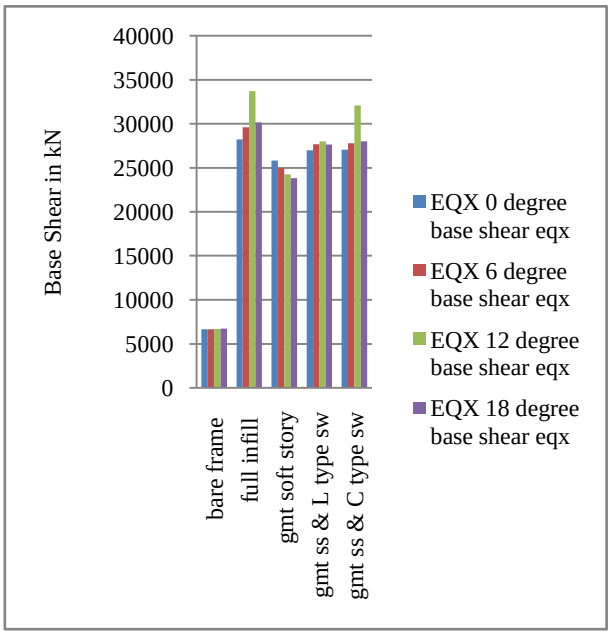

Figure 14 Model Vs Base Shear in kN

Table 14:Model Vs Base Shear for diff degree

EQY				
Model	**0 degree base shear eqy**	**6 degree base shear eqy**	**12 degree base shear eqy**	**18 degree base shear eqy**
bare frame	7700.08	7607.59	7500.28	7457.94
full infill	26945.5	27456.4	30649.2	27344.9
gmt soft story	23724	22763.8	21363.8	20111.8
gmt ss & L type sw	25996.1	25454.9	24753.8	24233.8
gmt ss & C type sw	27050.5	26819.5	25577.1	24988.2

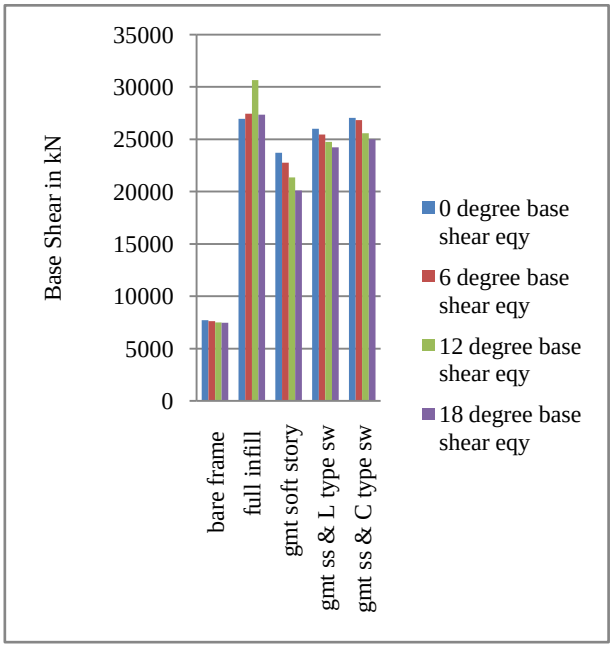

Figure 15 Model Vs Base Shear in kN

Table 15:Model Vs Base Shear for diff degree

RSX				
Model	**0 degree base shear rsx**	**6 degree base shear rsx**	**12 degree base shear rsx**	**18 degree base shear rsx**
bare frame	6744.35	6791.99	6809.56	6858.76
full infill	28781	30178	34353.3	30744.9
gmt soft story	26315.2	25469	24735.6	24292.1
gmt ss & L type sw	27496.2	28205.2	28544.3	28172.4
gmt ss & C type sw	27575	28308.4	32674.7	28537.5

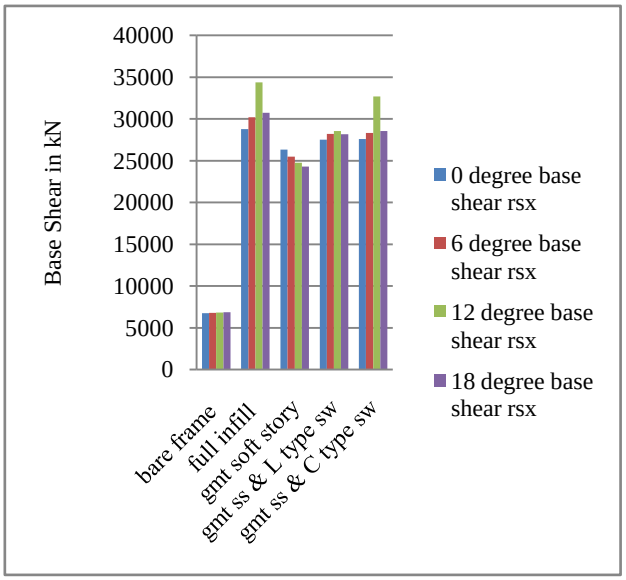

Figure 16 Model Vs Base Shear in kN

Table 16:Model Vs Base Shear for diff degree

RSY				
Model	**0 degree base shear rsy**	**6 degree base shear rsy**	**12 degree base shear rsy**	**18 degree base shear rsy**
bare frame	7899.7	7751.6	7645.27	7602.09
full infill	27470.9	27987.1	31241.1	27872.7
gmt soft story	24182.9	23204.1	21776.7	20499.8
gmt ss & L type sw	26499	25946.5	25232.8	24702.9
gmt ss & C type sw	27574.3	27337.5	26336.9	26083.2

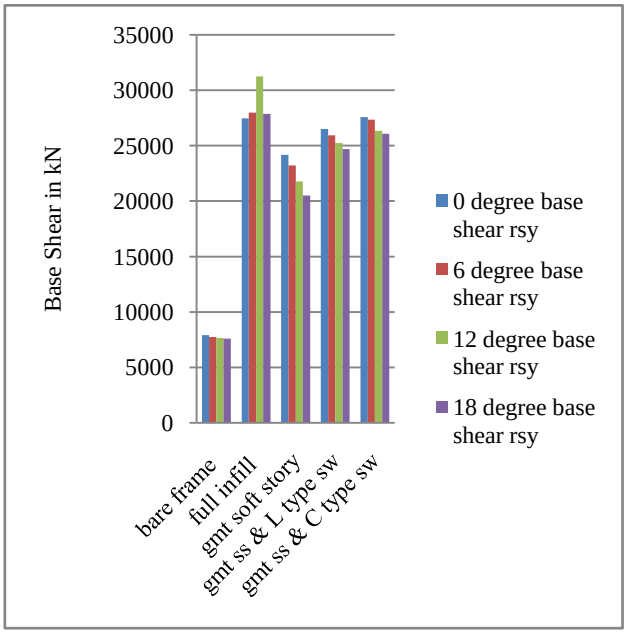

Figure 17 Model Vs Base Shear in kN

Table 17 : Model Vs % ↑ or ↓ for 6 degree wrt 0 degree

6 degree % ↑ or ↓ wrt 0 degree				
Model	Base Shear eqx	Base Shear eqy	Base Shear rsx	Base Shear rsy
bare frame	0.290191	-1.20116	0.706369	-1.87475
full infill	4.863527	1.896049	4.853897	1.879079
gmt soft story	-3.21891	-4.04738	-3.21563	-4.04749
gmt ss & L type sw	2.582477	-2.08185	2.578538	-2.08498
gmt ss & C type sw	2.663906	-0.85396	2.659655	-0.85877

Table 18 : Model Vs % ↑ or ↓ for 12 degree wrt 0 degree

12 degree % ↑ or ↓ wrt 0 degree				
Model	Base Shear eqx	Base Shear eqy	Base Shear rsx	Base Shear rsy
bare frame	0.553138	-2.59478	0.966883	-3.22076
full infill	19.37087	13.74515	19.36104	13.72434
gmt soft story	-6.00398	-9.94858	-6.00261	-9.95001
gmt ss & L type sw	3.817736	-4.77879	3.811799	-4.77829
gmt ss & C type sw	18.4991	-5.44685	18.49393	-4.48751

Table 17 : Model Vs % ↑ or ↓ for 18 degree wrt 0 degree

18 degree % ↑ or ↓ wrt 0 degree				
Model	Base Shear eqx	Base Shear eqy	Base Shear rsx	Base Shear rsy
bare frame	0.003959	0.014648	0.006986	0.018191
full infill	-2.03425	-1.48187	-2.03364	-1.47975
gmt soft story	0.107727	0.583024	0.107625	0.583429
gmt ss & L type sw	-0.04977	0.100388	-0.04966	0.100346
gmt ss & C type sw	-2.34209	0.125411	-2.34166	0.043228

VI. CONCLUSION

IS Code give empirical formulae for bare frame and fully infill frame but it does not give empirical formulae to determine the time period for soft storey building .Therefore the software like ETABS is used to determine the fundamental time period.

When effect of masonry infill is considered , the seismic base shear drastically increase as compare with that of bare frame .

The increased displacement due to soft story was reduced by using L & C type shear walls , the C type shear was found to be more effective in reducing displacements when placed at corner positions .

The maximum story displacement is found to be decreasing for higher angles .

As per the code the story drift was found to be within permissible range in X & Y direction in both the methods .

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