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A Study on Effect of Shear Walls and Bracing System in a Multi-Storey Building Having Soft Storey at Various Levels

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ABSTRACT

Many urban cities witnessing construction of high rise building day by day. Structural Engineers are challenged to give effective and economic design of structures considering effect of lateral loads. Due to the demand of land and aesthetic views architects have subjected to go semi residential projects like a building with both residential units and commercial units in the same structure due to this structure are built with vertical irregularities and stiffness irregularities. This paper investigates the behavior of tall structures with soft stories at various levels in the structure. These soft stories are induced due to variation of stiffness along the vertical height of stories, this intern is cause due to change in story heights. A comparative study is carried out to provide an insight for the guiding response parameters such as story shear, story displacement, storey drift, stiffness variation and time period have been carried out using dynamic analysis to investigate the influence of these parameters on the behavior of shear walls and bracing system in a multi-storey building having storey at some various levels.

Keywords: Multi-storey; Soft storey; Shear wall; Bracing system.

I. INTRODUCTION

The lateral loads in the structure are effectively countered by various structural elements such as bracing, diagrids, shear walls, dampers, etc. Due to the demand of land and aesthetic views architects have subjected to go semi residential projects like a building with both residential units and commercial units in the same structure due to these structures are built with vertical irregularities and stiffness irregularities. In the currently study a sincere attempt is made to study behaviour of tall structures with soft stories at different level and also effect of position and orientation of shear walls and bracing in the structure. Soft storey are one or two stories in a multi-storey building whose lateral stiffness is less than stiffness of above stories. These soft stories are created due to providing more windows, wide doors, more commercial spaces and increasing height stories compared to other stories

These soft stories may possibly to collapse during earthquake effects this phenomenon we called as soft story collapse. These building act as an inverted pendulum during the seismic and produced high stress in the structural elements. To overcome these problem we need to make improvement to structure. Providing shear walls or bracing system to building is one of best method to overcome problems from seismic effects, while providing shear walls the position of shear walls and Orientation shear walls plays important role and also while providing bracing system to structural building the type of bracing system, dimension of bracing system plays a important role. And due to providing shear walls and bracing system to structural building it improves strength and stiffness of structural buildings.

To safe design for the multi-storey with soft storey and to avoid damage, collapse of the structure code gives two alternative design approaches:

- During dynamic analysis of the structure it is compulsory to consider the strength and stiffness of infill walls and also include inelastic deformations under the design seismic force disregarding the reduction factor (R).

- During design of columns and beams at soft storey in a structure it is required to consider 2.5 time of storey shear and the moments. And if shear walls are provided in structural building with soft storey then while designing it is required to consider 1.5 time of the calculated storey shear forces.

In this present study am doing comparative study on effect of shear walls and bracing system in a multi-storey building having storey at some various levels.

II. METHODOLOGY

- Create the RC frame soft storey structure with and without shear wall and bracing using software E-TABS 2016.
- Analyse the structure for DL, LL and EQ as primary load cases. Load combination as prescribed in IS codes are considered for designs.
- Analysis includes dynamic response spectrum analysis.
- Analysis of selected models and comparative study of on the result obtained from analysis.
- Compare analysis results of soft storey structure with and without shear wall and bracing system.
- In this study 9 types of model are chosen.
- The plan, slab thickness, column size, beam size, shear wall thickness, live load, wall load, super dead load, earth quake load, remains same for all the models but height of the building changes.
- Analysis is carried out by considering a fixed support at the base of the building.

Table.4.1 Description of Model

Modal no	No of storey	Model description	Height of building (m)
1	10	It is a standard model with all storey height 3m and no vertical irregularity.	31.5
2	10	Soft storey at first floor due to increasing first storey height by 5m.	33.5
3	10	Soft storey at fifth floor due to increasing fifth storey height by 5m.	33.5
4	10	Soft storey at ninth floor due to increasing ninth storey height by 5m.	33.5
5	10	Soft storey at first floor due to increasing first storey height by 5m and providing shear wall at core of the structure.	33.5
6	10	Soft storey at first floor due to increasing first storey height by 5m and providing shear wall at corners of the structure.	33.5
7	10	Soft storey at first floor due to increasing first storey height by 5m and providing shear wall at half position of both opposite side corners of the structure.	33.5
8	10	Soft storey at first floor due to increasing first storey height by 5m and providing diagonal (X) bracing at soft storey.	33.5
9	10	Soft storey at first floor due to increasing first storey height by 5m and providing V bracing at soft storey.	33.5

The details of the model geometry are given as follows

Number of stories = 10.
Number of grid lines in X direction =6.
Number of grid lines in Y direction =6.
Spacing of grids in X direction = 5 m.
Spacing of grids in Y direction = 5 m.
Type of soil-type = II (medium soil)

The details of the materials properties are given as follows

Concrete M40 grade
Steel HYSD500

Sectional properties are defined as follows

Column 600*600 mm

Beam	200*600 mm
Slab thickness	150 mm
Shear wall thickness	200 mm
Bracing	200*450 mm

Loads

Floor	3kN/m2
Roof	1.5kN/m2

Seismic Loads (IS 1893:2016)

Zone	III
Zone factor	0.16
Soil type	II
Importance factor	1.5
Response reduction	3

III. MODELLING

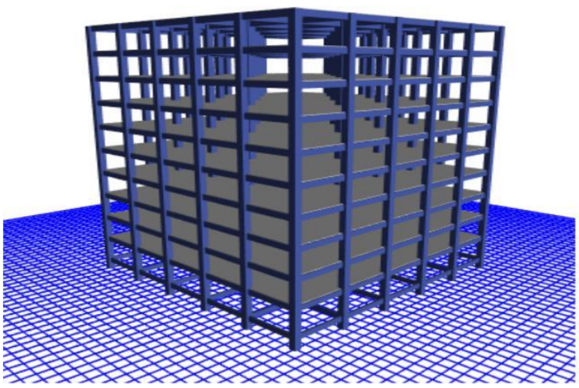

Fig1: Standard Model without Soft Storey

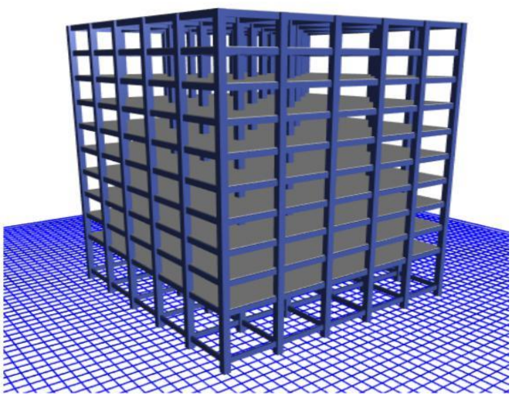

Fig 2: Building with Soft Storey at First Storey

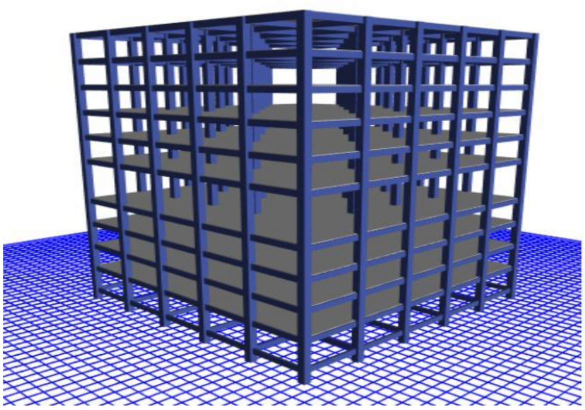

Fig3: Building with Soft Storey at Fifth Storey

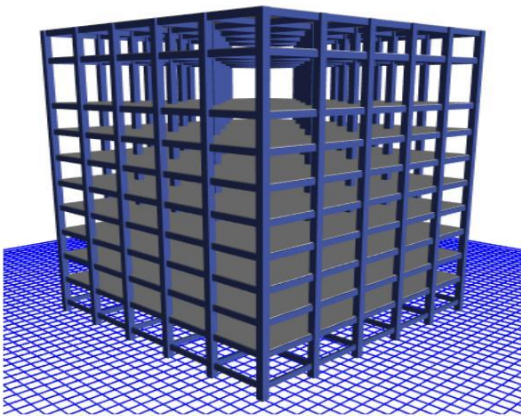

Fig4: Building with Soft Storey at Ninth Storey

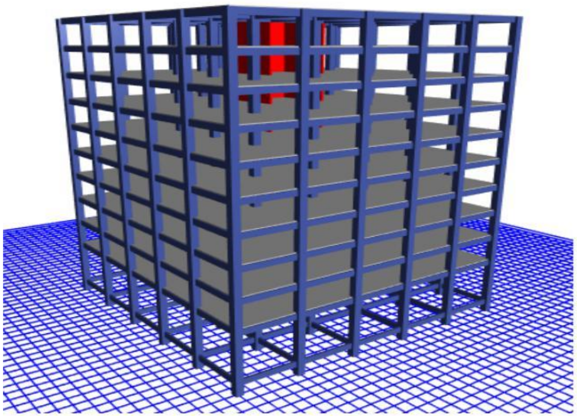

Fig5: Soft Storey at First Storey with Shear Walls at Core

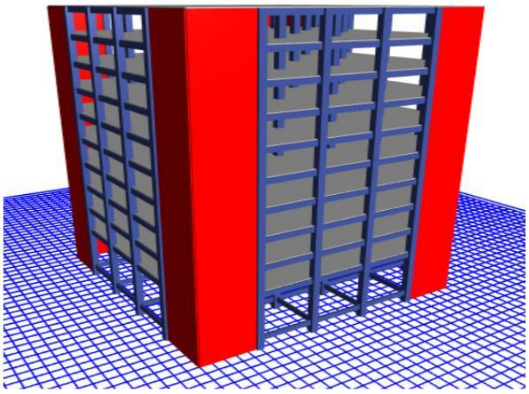

Fig6: Soft Storey at First Storey with Shear Walls at Corners

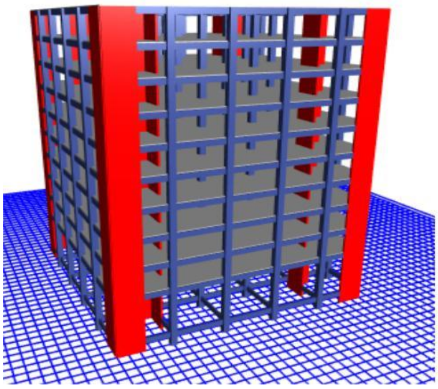

Fig7: Soft Storey At First Storey With First Storey

Shear Walls at Half Position of Both opposite Side Corners

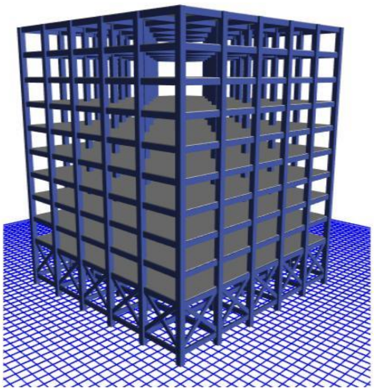

Fig8: Soft Storey at First Storey with

X Bracing System

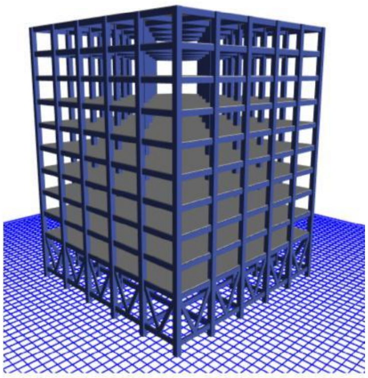

Fig9: Soft Storey at

with V Bracing System

IV. RESULTS

1. In this study is about objective 1 it states the comparative study of multi-storey building having soft storey at various level are model 1 multi-storey building without soft storey, model 2 soft storey at first storey, model 3 soft storey at fifth storey and model 4 soft storey at ninth storey.

Storey Shear (kN):

Table1: Storey Shears along X-Direction

Storey level	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Roof	467	367	450	513
9th	1135	927	1088	1297
8th	1640	1380	1560	1659
7th	2034	1741	1906	2027
6th	2351	2031	2167	2347
5th	2623	2274	2408	2635
4th	2882	2498	2557	2907
3th	3125	2716	2789	3153
2nd	3341	2926	3035	3368
1st	3483	3112	3200	3511
Plinth	3490	3119	3216	3526

Fig10: Storey Shear Graph

Storey Displacement:

Table2: Storey Displacement along X-Direction

Storey level	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Roof	28.83	30.86	31.39	31.55
9th	28.06	30.20	30.68	30.54
8th	26.73	29.08	29.46	27.22
7th	24.81	27.44	27.68	25.07
6th	22.33	25.33	25.33	22.53
5th	19.35	22.77	22.23	19.53
4th	15.93	19.81	14.84	16.07
3th	12.11	16.46	11.07	12.21
2nd	8.00	12.71	7.30	8.07
1st	3.88	8.47	3.55	3.91
Plinth	0.58	0.65	0.53	0.58
Base	0	0	0	0

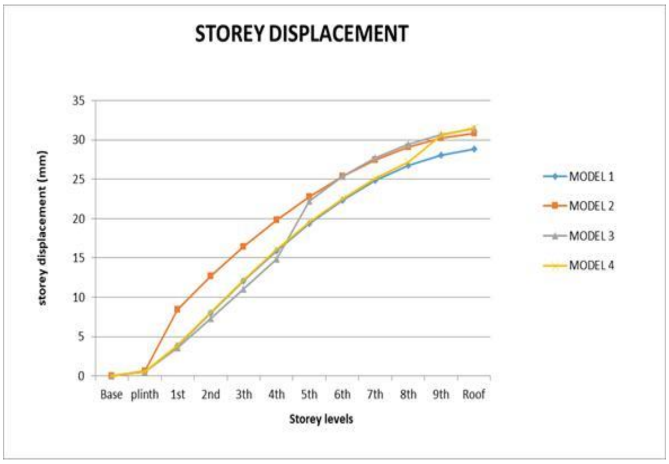

Fig11: Storey Displacement

Stiffness Variation

Table3: Stiffness Variation

STOREY LEVEL	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Roof	495365.052	462687.936	493271.493	412473.266
9th	713606.824	689306.333	711062.807	312268.795
8th	736013.216	722559.199	728351.144	653148.05
7th	736185.314	727093.702	707921.536	713918.771
6th	734010.118	726567.602	643670.083	727553.986
5th	733634.03	725091.721	307260.284	731920.765
4th	738919.29	723206.143	651682.329	738844.549
3th	755083.374	716192.252	731818.405	754880.621
2nd	809397.208	687380.21	807248.782	809001.777
1st	1055544.473	397968.384	1059946.02	1055187.31
plinth	6022270.887	4801772.24	6047008.89	6029215.62

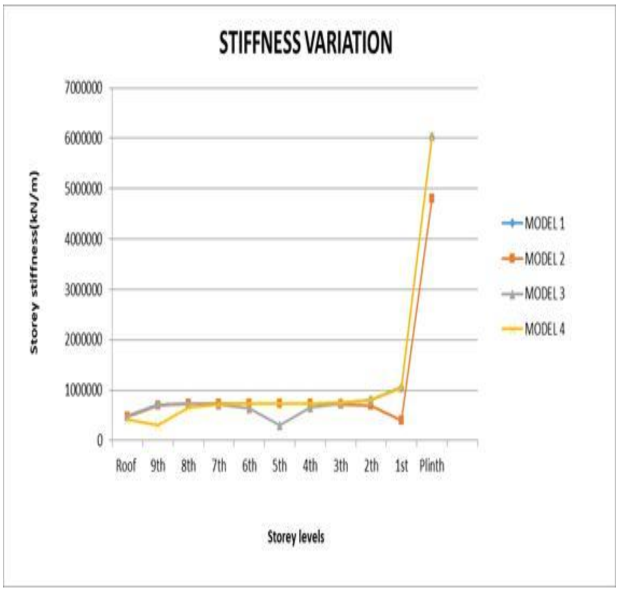

Fig12: Stiffness Variation

2. In the study is about objective 2 it states the comparative study of multi-storey building having soft storey with and without shear walls are shear walls are provided at different locations like core position, corner position etc. and comparative study between the model 2 multi-storey building soft storey at first storey, model 5 multi-storey building soft storey at first storey with shear walls at core, , model 6 multi-storey building soft storey at first storey with shear walls at corners, and , model 7 multi-storey building soft storey at first storey with shear walls at half position of both opposite side corners of the structure.

Storey Shear (kN):

Table4: Storey Shears along X-Direction

Storey Level	MODEL 2	MODEL 5	MODEL 6	MODEL 7
Roof	367	640	810	649
9th	927	1556	1995	1560
8th	1380	2267	2924	2277
7th	1741	2819	3663	2859
6th	2031	3266	4272	3348
5th	2274	3655	4795	3773
4th	2498	4012	5252	4153
3th	2716	4340	5649	4487
2nd	2926	4630	5974	4764
1st	3112	4868	6219	4971
Plinth	3119	4878	6229	4979

Fig13: Storey Shear Graph

Storey Displacement: Table5: Storey Displacement along X-Direction

Storey level	MODEL 2	MODEL 5	MODEL 6	MODEL 7
Roof	30.868	35.147	20.159	22.754
9th	30.209	33.038	18.342	21.289
8th	29.085	30.374	16.316	19.601
7th	27.449	27.358	14.194	17.667
6th	25.332	24.063	12.014	15.499
5th	22.776	20.548	9.815	13.133
4th	19.814	16.887	7.652	10.622
3th	16.464	13.169	5.585	8.041
2nd	12.718	9.506	3.691	5.488
1st	8.475	5.961	2.074	3.121
Plinth	0.658	0.511	0.229	0.305

Stiffness Variation; Table6: Stiffness Variation

STOREY LEVEL	MODEL 2	MODEL 5	MODEL 6	MODEL 7
Roof	462687.9	367425.8	434206.	433360.
9th	689306.3	692098.2	973097.	891807.
8th	722559.1	871179.0	1365044	1141333
7th	727093.7	984893.3	1664357	1285477
6th	726567.6	1068911.8	1928958	1387656
5th	725091.7	1147579.3	2206241	1483188
4th	723206.1	1250301.1	2536927	1595448
3th	716192.2	1382140.8	2988330	1749431
2nd	687380.2	1549012.9	3705241	1992703
1st	397968.3	1112366.4	3350285	1754314
plinth	4801772.	13171397.4	3402686	1938475

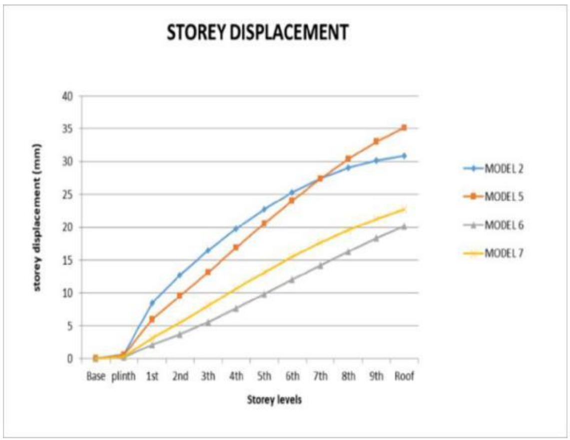

Fig14: Storey Displacement

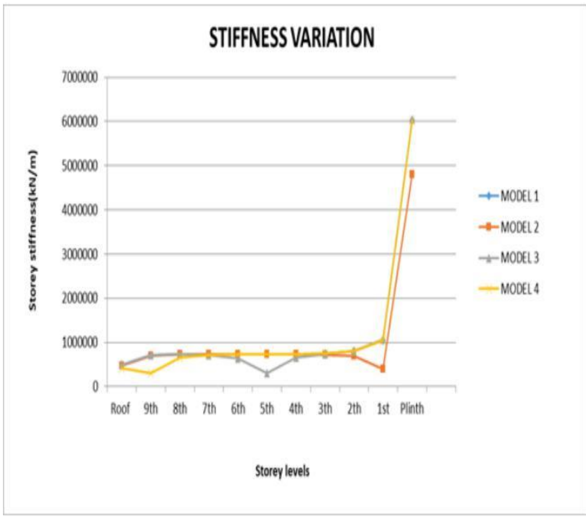

Fig15: Stiffness Variation

3. In the study is about objective 3 it means the comparative study of multi-storey building having soft storey with and without bracing system .In this case different types of bracing system are provided at soft storey in multi-storey building. Comparative study between the model 2 multi-storey building soft storey at first storey, model 8 multi-storey building soft storey at first storey with X bracing system, and model 9 multi-storey building soft storey at first storey with V bracing system.

Storey Shear (kN): Table7: Storey Shears along X-Direction

Storey level	MODEL 2	MODEL 8	MODEL 9
Roof	367	564	529
9th	927	1319	1258
8th	1380	1864	1790
7th	1741	2298	2203
6th	2031	2651	2539
5th	2274	2961	2831
4th	2498	3254	3109
3th	2716	3513	3364
2nd	2926	3721	3579
1st	3112	3850	3733
Plinth	3119	3862	3744

Fig16: Storey Shear Graph

Storey Displacement:

Table8: Storey Displacement along X-Direction

Storey level	MODEL 2	MODEL 8	MODEL 9
Roof	30.868	28.893	28.919
9th	30.209	27.985	28.048
8th	29.085	26.444	26.574
7th	27.449	24.221	24.453
6th	25.332	21.37	21.735
5th	22.776	17.961	18.485
4th	19.814	14.065	14.766
3th	16.464	9.804	10.679
2nd	12.718	5.491	6.483
1st	8.475	2.077	2.965

Plinth	0.658	0.71	0.841
Base	0	0	0

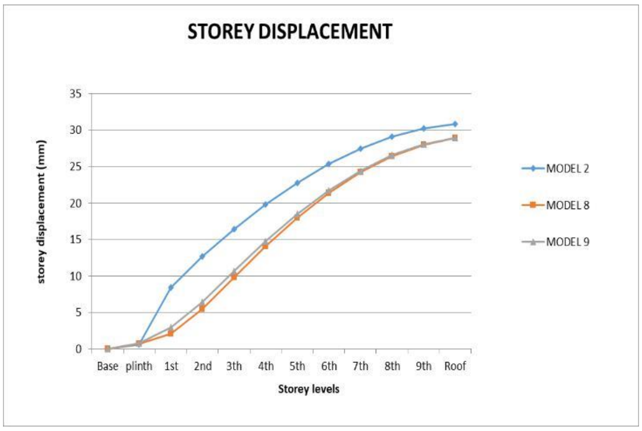

Fig17: Storey Displacement

Stiffness Variation:

Table9: Stiffness Variation

STOREY LEVEL	MODEL 2	MODEL 8	MODEL 9
Roof	462687.936	511083.626	499807.735
9th	689306.333	720712.313	715067.869
8th	722559.199	735756.309	733717.319
7th	727093.702	735427.377	733121.018
6th	726567.602	733728.474	731596.139
5th	725091.721	736407.203	733534.188
4th	723206.143	752362.02	747023.762
3th	716192.252	804957.432	791565.804
2nd	687380.21	1054077.577	987833.928
1st	397968.384	2469634.797	1540611.57
plinth	4801772.24	9957670.752	8715720.20

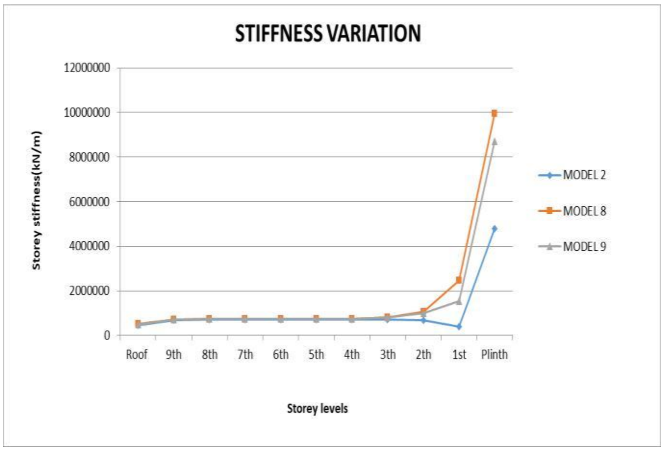

Fig18: Stiffness Variation

V. CONCLUSIONS

- From the result it can be seen that model 2 that is structure with soft storey at first stories is subjected to 89.4 %, 96.9%,and 88.45% less base shear compared to model 1, model 3 ,and model 4 respectively .So structures with less base perform poorly during earthquake effects compared with structures higher base shear.
- From the results it can be seen that structure without any soft storey have linear variation of displacement along from height of the building where as building with soft storey at various levels as seen behave non-linear variation of displacement and subjected to sudden storey displacement variation at soft storey levels.
- From the results it can be seen that structure with soft storey at various levels subjected high storey drift at soft storey levels compared to other levels.
- From the results it can be seen that structure without any soft storey the storey stiffness gradually increasing from roof to base, no stiffness reduction will come but in the case structure with soft storey at various levels subjected to stiffness reduction at soft storey levels.
- From the results it can be seen that model 2 that is structure with soft storey at first floor has 1.13, 1.03, and 1.13 times higher time period compared to model 1, model 3, and model 4 respectively. So structurewith soft storey at first floor is more flexible compared to building without soft storey and building with soft storey at various levels.
- From the results it can be seen that the building having soft storey at first storey with shear walls provided at corners has 1.99, 1.27 and 1.25 times higher base shear compare to building soft storey at first storey without shear walls, with shear walls provided at core and half position of both opposite side corners of the structure respectively. So building soft storey at first storey with shear walls provided corners has high base shear it perform better during earthquake effect compare to less base shear buildings.
- From the results it can be seen that the building having soft storey at first storey with shear walls provided at corners has 34.7%, 51.28 %,and 24.18% less storey displacement compare to building having soft storey at first storey without shear walls, with shear walls provided at core and half position of both opposite side corners of the structure respectively.
- From the results it can be seen that the building with soft storey subjected to stiffness reduction at soft storey levels .The building having soft storey at first storey with shear walls provides at corners has 77.96 %, 66.03% and 19.98% less stiffness reduction compared to building having soft storey at first storey without shear walls, with shear walls provided at core and half position of both opposite side corners of the structure respectively.
- From the results it can be seen that the building having soft storey at first storey with shear walls provided at corners has 50.62%, 45% and 19.67 % less time period compare to building having soft storey at first storey without shear walls, with shear walls provided at core and half position of both opposite side corners of the structure respectively. So building having soft storey at first storey with shear walls provided at corners has less time period it is less flexible compare to high time period buildings.
- From the results it can be seen that the building having soft storey with X bracing system provided at soft storey level is 1.23 and 1.04 times higher base shear compare to building having soft storey without bracing system and with V bracing system at soft storey level respectively. So building having soft storey with X bracing system provided at soft storey has high base shear it perform better during earthquake effect compare to less base shear buildings.
- From the results it can be seen that the building having soft storey with X bracing system provided at soft storey level is 6.4% and .09% less storey displacement compare to building having soft storey without bracing system and with V bracing system at soft storey level respectively.
- From the results it can be seen that the building having soft storey with bracing system subjected to stiffness increasing at soft storey levels. Building having soft storey with X bracing system provided at soft storey level has 1.5 times more stiffness increasing compare to building having soft storey with V bracing system at soft storey level.
- From the results it can be seen that the building having soft storey with X bracing system provided at soft storey level is 18.72% and 2.54 % less time period compare to building having soft storey without bracing system and with V bracing system at soft storey level respectively. So building with X bracing system at soft storey level has less time period it is less flexible compare to high time period buildings.

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