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STUDY ON SEISMIC ANALYSIS OF DIFFERENT STRUCTURAL CHANGES OF G+7 BUILDING

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ABSTRACT

Analysis of any structural system to determine the deformations and forces induced by applied loads or ground excitation is an essential step in the design of a structure to resist earthquake. There is a range of methods from a linear analysis to a sophisticated nonlinear analysis depending on the purpose of the analysis in the design process. In this paper seismic response of a residential G+7 RC frame building is analysed by the Response Spectrum method using the software STAAD-Pro V8i as per the IS- 1893-2002-Part-1.The building is being modelled as an 3D space frame with six degrees of freedom at each node using the software STAAD-Pro V8i. The analysis is carried out considering SMRF frame type and medium soil type and earthquake Zone V for Bare Frame, Bare frame having open ground storey, Frame with infill wall and open ground story frame with infill walls.Different response like lateral force, overturning moment, story drift, displacements and base shear are plotted in order to compare the results.

KEYWORDS

Seismic Analysis,Soft Storey, Infill walls ,multi-storey, SMRF , Dynamic Analysis, Storey Deflection, Storey Shear, Base Shear,Response Spectrum Analysis, Lateral Force, Overturning Moment, Story Drift, Story Stiffness.

DESIGN PARAMETERS

Analysis is being done for G+7 multi- storey building(rigid joint frame) using STAAD PRO using the preliminary data as follows:-

1. Type of structure- high rise RC frame structure (SMRF)
2. No of storey- G+7, 7 stories.
3. Seismic Zones-V.
4. Floor height- 3.0m.
5. Building height- 25.5 m.
6. Plan size- 30 m *20 m
7. Total area- 600 m^2
8. Size of columns-0.60 m* 0.35 m
9. Size of beams- 0.65m * 0.30m
10. Thickness of external wall- 230 mm
11. Thickness of internal wall – 115mm
12. Thickness of slab- 150 mm
13. UDL due to external walls- 6.75 KN/m
14. UDL due to internal walls –4.75 KN/m

15. UDL due to parapet -2.25 KN/m
16. LL for all floors except roof- 2 KN/m^2
17. LL for roof – 1.5 KN/m^2
18. Material used- Concrete M-30KN/m^2 and Reinforcement Fe-415(HYSD).
19. Earthquake load - As per IS- 1893-2002
20. Type of soil -Medium soil as per IS-1893.
21. E_c - 5000√fck N/ mm^2 (E_c is modulus of elasticity in N/mm^2).
22. Dynamic analysis –Response Spectrum method.
23. Software used – STAAD -Pro dynamic analysis by Response Spectrum analysis method.
24. Zone factor Z - 0.36(as per IS 1893: 2002 for Zone V)

MODELLING

The G+7 multi-storeyed building is framed as a 3D space frame with rigid joints using STAAD PRO software for simulation of behaviour under DL, LL, Seismic and Response Loading. The support conditions are considered as fully fixed.

The plan of the building is as follows:-

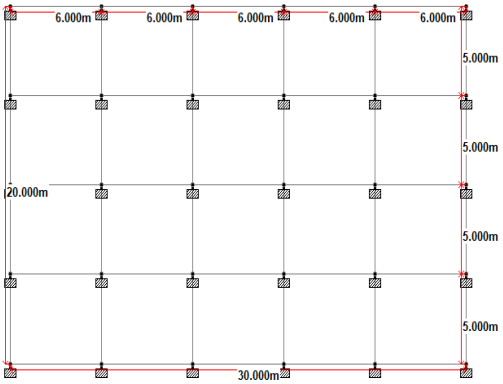


FIGURE 1:- PLAN OF G+7 MULTI-STOREYED BUILDING

The G+7 multi-storeyed building is being analysed for 4 cases viz, (i) G+7 bare frame multi-storeyed building without infill walls, (ii) G+7 multi-storeyed building with infill walls, (iii) G+7 multi-storeyed building with soft storey and without infill walls and (iv) G+7 multi-storeyed building with soft storey and with infill walls.

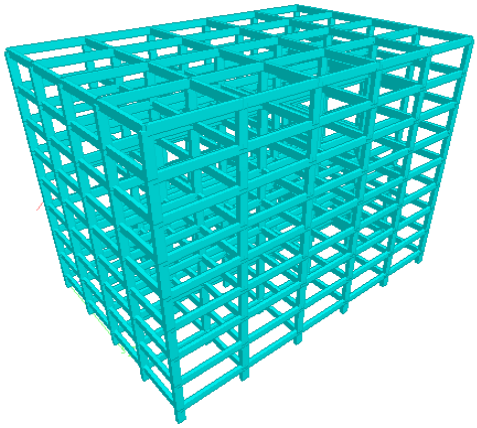


FIGURE 2:- 3D MODEL OF G+7 MULTI-STOREYED BUILDING WITH AND WITHOUT INFILL WALLS

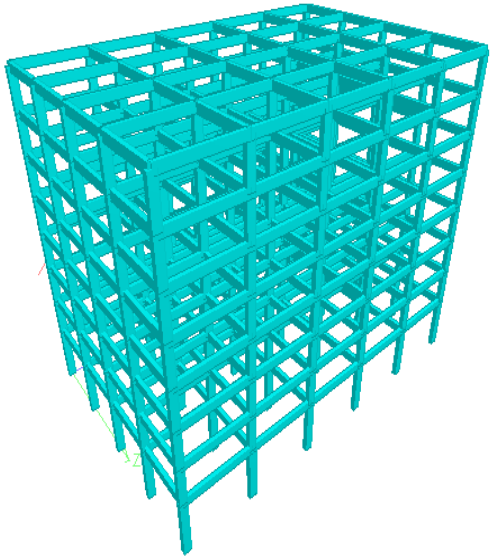


FIGURE 3:- 3D MODEL OF G+7 MULTI-STOREYED BUILDING WITH SOFT STOREY &WITH AND WITHOUTINFILL WALLS

Loading And Load Combinations

Different types of loads being applied on the G+7 multi-storeyed building model are Dead loads which includes self-weight of the structure comprising of the weight of the beams, columns, slabs, finishings, water proofing etc. Uniform loading due to external walls, internal walls and parapet also comes under dead load taken in the analysis. All the dead loads being considered is as per the dimensions of the building under consideration and as per IS 875 Part 1: 2016. Live loads on the slabs and on the roof are as per IS 875 Part 2. Seismic forces in X and Z dir. considering zone V with zone factor 0.36 as per IS 1893: 2002 are used. Response Spectrum Loading in X and Z dir. are being considered in the analysis.

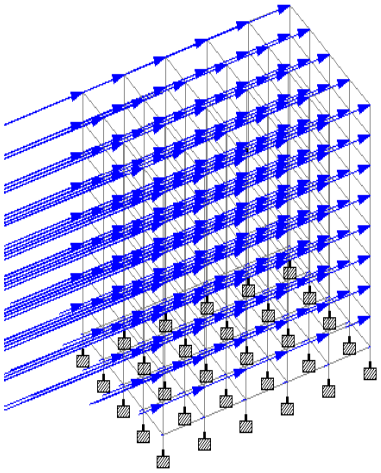


FIG 4 :- MODEL SUBJECTED TO SEISMIC LOADING

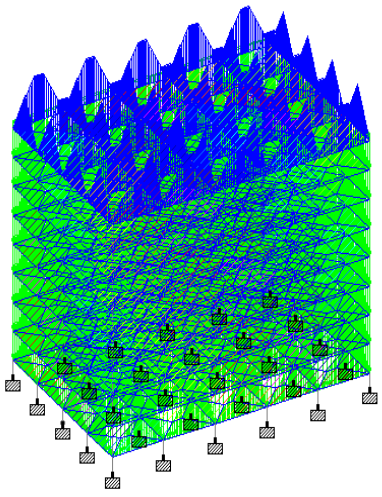


FIG 5:- MODEL SUBJECTED TO DEAD LOADING

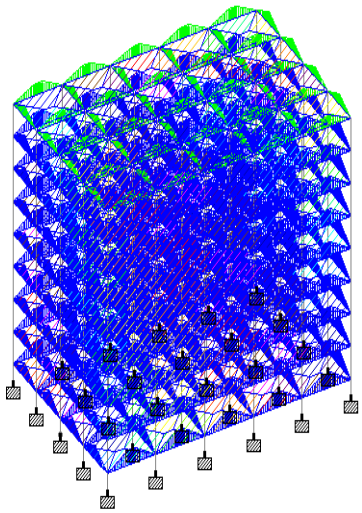


FIG 6:- MODEL SUBJECTED TO LIVE LOADING

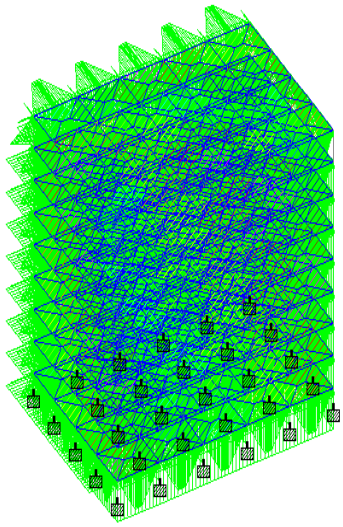


FIG 7:- MODEL SUBJECTED TO RESPONSE SPECTRUM LOADING

Various load combinations being considered in the analysis of the G+7 multi storeyed building are as follows:-

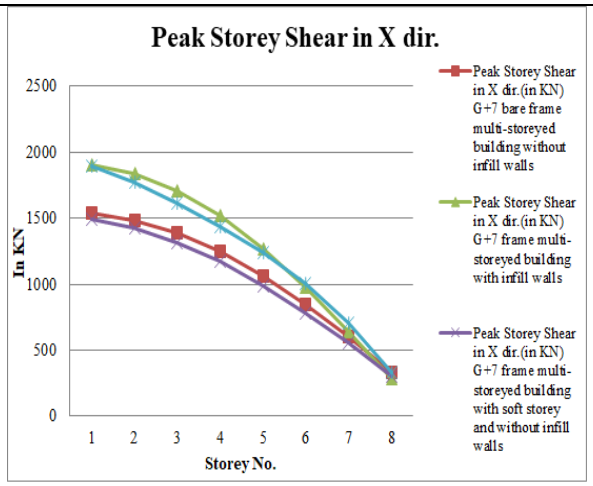
(i) Seismic Load in X dir.(ELX)
(ii) Seismic Load in Z dir.(ELZ)
(iii) Dead load including self-weight, wall loading, parapet loading, slab thickness, finishing and waterproofing etc.(DL)
(iv) Live load(LL)
(v) Response Spectrum Loading in X dir.(RSx)
(vi) Response Spectrum Loading in Z dir.(RSz)
(vii) 1.5(DL+LL)
(viii) 1.2(DL+LL)
(ix) 1.2(DL+LL±ELX)
(x) 1.2(DL+LL±ELZ)
(xi) 1.2(DL+LL±RSx)
(xii) 1.2(DL+LL±RSz)
(xiii) 1.5 DL
(xiv) 1.5(DL±ELX)
(xv) 1.5(DL±ELZ)
(xvi) 1.5(DL±RSx)
(xvii) 1.5(DL±RSz)
(xviii) 0.9 DL ± 1.5 ELX
(xix) 0.9 DL ± 1.5 ELZ
(xx) 0.9 DL ± 1.5 RSx
(xxi) 0.9 DL ± 1.5 RSz

ANALYSIS AND RESULTS

(i) Peak Storey Shear in X Direction :-

Peak Storey Shear in X dir.(in KN)

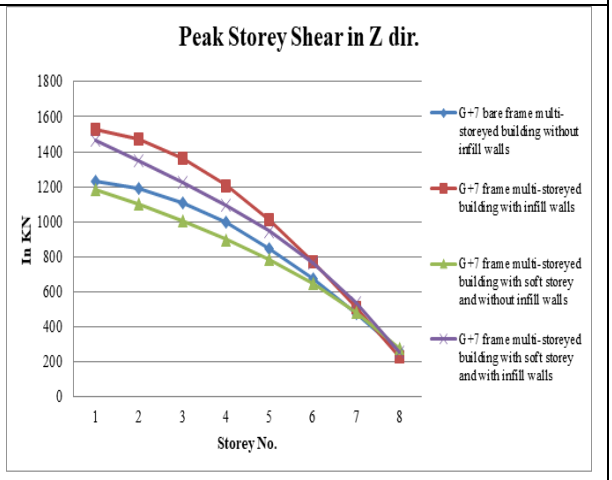
Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	1537.02	1909.41	1492.11	1891.58
2	1487.62	1841.93	1424.44	1770.18
3	1390.96	1710.06	1316.46	1613
4	1248.98	1516.82	1170.83	1438.42
5	1065.91	1268.59	991.63	1240.34
6	847.41	973.93	783.74	1003.36
7	600.32	643.1	552.86	706.38
8	332.46	287.52	305.37	335.68



(ii) Peak Storey Shear in Z Direction :-

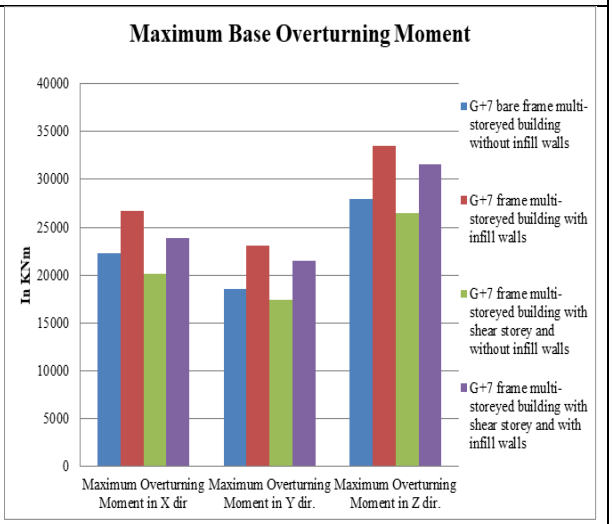
Peak Storey Shear in Z dir.(in KN)

Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	1231.14	1529.2	1181.75	1463.47
2	1189.4	1472.21	1099.89	1350.86
3	1110.16	1364.14	1002.48	1226.15
4	995.5	1208.1	898.72	1094.28
5	848.77	1009.2	785.65	946.86
6	674.34	774.2	650.46	767.82
7	477.53	510.98	480.46	540.54
8	264.39	228.29	274.99	256.38



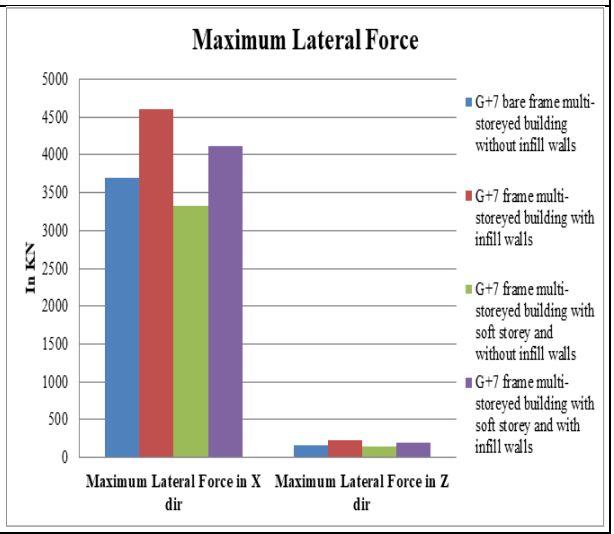
(iii) Maximum Base Overturning Moment :-

	Max. Base Overturning Moment in X dir	Max. Base Overturning Moment in Y dir.	Max. Base Overturning Moment in Z dir.
G+7 bare frame multi-storeyed building without infill walls	22310.64	18549.75	28009.9
G+7 frame multi-storeyed building with infill walls	26712.11	23052.96	33558.54
G+7 frame multi-storeyed building with soft storey and without infill walls	20130.01	17414.59	26480.89
G+7 frame multi-storeyed building with soft storey and with infill walls	23913.01	21486.37	31575.26



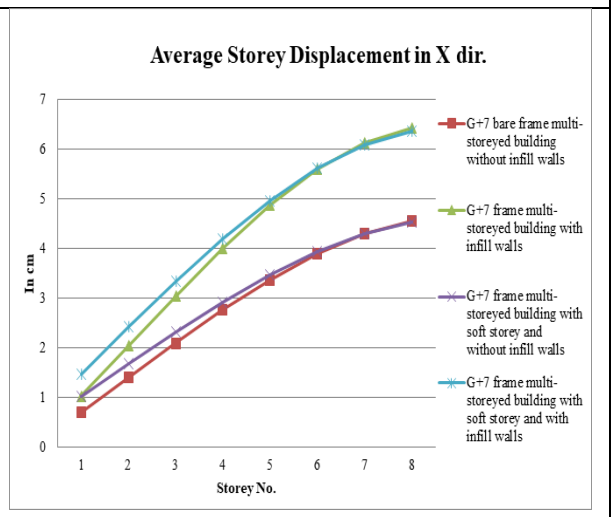
(iv) Maximum Lateral Force :-

	Maximum Lateral Force in X dir.(in KN)	Maximum Lateral Force in Z dir.(in KN)
G+7 bare frame multi-storeyed building without infill walls	3701.621	159.77
G+7 frame multi-storeyed building with infill walls	4609.039	230.057
G+7 frame multi-storeyed building with soft storey and without infill walls	3323.097	144.1
G+7 frame multi-storeyed building with soft storey and with infill walls	4116.953	202.686



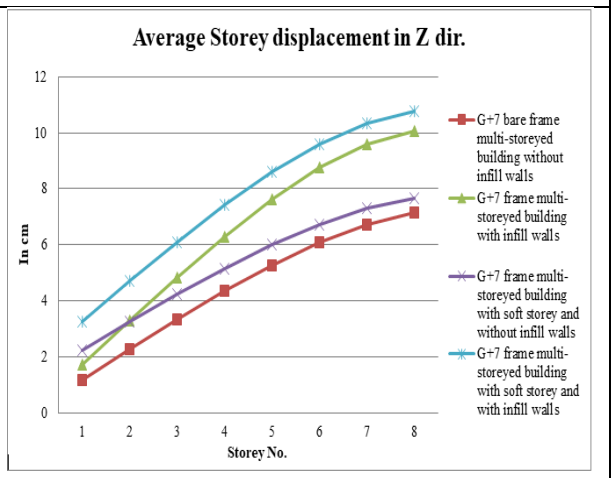
(v) Average Storey Displacement In X Direction :-

Average Storey displacement in X dir.(in cm)				
Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	0.7071	1.0313	1.0158	1.4686
2	1.4011	2.0418	1.681	2.4285
3	2.0943	3.0471	2.3116	3.3348
4	2.7574	4.0013	2.9103	4.1887
5	3.3655	4.864	3.4589	4.96
6	3.89	5.5885	3.932	5.6076
7	4.2979	6.1227	4.2999	6.0851
8	4.5575	6.4305	4.534	6.3602



(vi) Average Storey Displacement in Z Direction :-

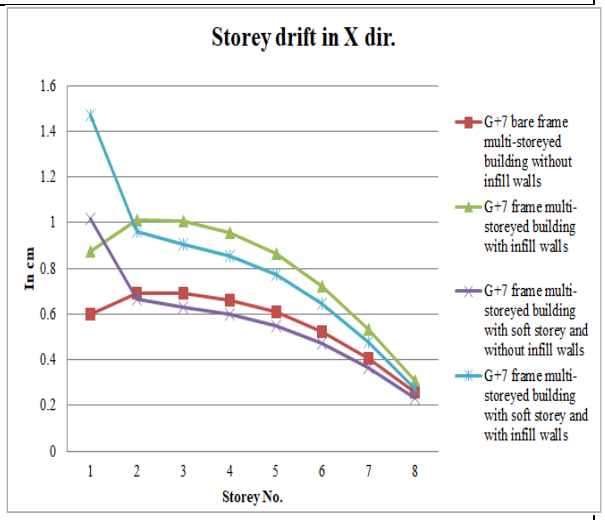
Average Storey displacement in Z dir.(in cm)				
Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	1.1704	1.7073	2.2389	3.2374
2	2.2498	3.2791	3.2598	4.7109
3	3.3145	4.8237	4.2221	6.0943
4	4.3344	6.2921	5.1421	7.4071
5	5.2736	7.6258	5.9893	8.5992
6	6.0866	8.753	6.7243	9.6068
7	6.7273	9.5895	7.3004	10.3546
8	7.131	10.0567	7.6646	10.7722



(vii) Storey Drift in X Direction :-

Storey drift in X dir.(in cm)

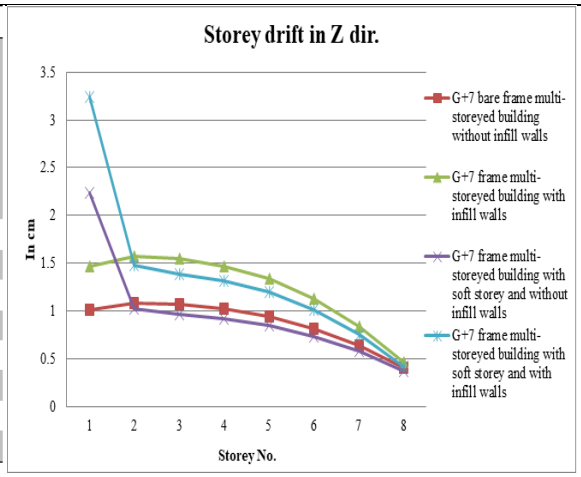
Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	0.599	0.8736	1.0158	1.4686
2	0.6941	1.0105	0.6652	0.96
3	0.6932	1.0053	0.6305	0.9063
4	0.663	0.9542	0.5988	0.854
5	0.6081	0.8627	0.5486	0.7713
6	0.5245	0.7245	0.4731	0.6476
7	0.4079	0.5342	0.3679	0.4775
8	0.2596	0.3077	0.2342	0.2751



(viii) Storey Drift in Z Direction :-

Storey drift in Z dir.(in cm)

Storeys	G+7 bare frame multi-storeyed building without infill walls	G+7 frame multi-storeyed building with infill walls	G+7 frame multi-storeyed building with soft storey and without infill walls	G+7 frame multi-storeyed building with soft storey and with infill walls
1	1.0066	1.4683	2.2389	3.2374
2	1.0794	1.5718	1.0209	1.4735
3	1.0648	1.5446	0.9623	1.3834
4	1.0199	1.4684	0.92	1.3128
5	0.9392	1.3336	0.8471	1.1921
6	0.8149	1.1273	0.735	1.0076
7	0.6387	0.8365	0.5761	0.7478
8	0.4038	0.4672	0.3642	0.4177



CONCLUSIONS:

The study focused on the seismic performance of reinforced concrete G+7 multi-storeyed building for Bare frame, Bare frame having open ground storey, Frame with sot storey and without infill walls and frame with infill walls and open ground storey.The seismic performances were estimated through the comparison between different response like lateral force, overturning moment, story drift, displacements and base shear obtained by Response Spectrum method of analysis. In the present study, an attempt has been made to compare the seismic behaviour of high rise buildings with complexities and the following are conclusions are drawn.

(i) Peak Storey shear in X dir. increases on an average by 15% with the introduction of infill walls for simple G+7 frame and 23.40% for G+7frame with open storey. This increase in the peak storey shear is maximum at the ground floor and gradually decreases with height.

(ii) Peak storey shear in X dir. decreases a little with the introduction of soft storey. for frame without infill walls.The decrease is 6.14% on an average with the decrease gradually increasing with height.For G+7 frame with infill walls introduction of soft storey increases the peak storey shear marginally about 1.46% on an average.

(iii) Peak Storey shear in Z dir. increases on an average by 14.91% with the introduction of infill walls for simple G+7 frame and 16.88% for G+7frame with open storey. This increase in the peak storey shear is maximum at the ground floor and gradually decreases with height.

(iv) Peak storey shear in Z dir. decreases a little with the introduction of soft storey. for frame without infill walls.The decrease is 4.66% on an average for G+7 frame without infill walls and about 2.63% For G+7 frame with infill walls with the decrease gradually increasing with height.

(v) Max. Overturning moment decreases in general with the introduction of soft storey and Increases with the introduction of infill walls. The max. Overturning moment is for the case of G+7 building with infill walls and without soft storey.

(vi) The average storey displacement in the X dir. increase significantly with the introduction of infill walls. The increase is 44.24% on an average for simple G+7 frame and 43.13% for G+7 frame with soft storey.

(vii) The average storey displacement in the X dir. increases significantly for soft storey. Displacement drastically reduces as onemoves up, with the top floor displacement being almost the same as the normal frame without soft storey.

(viii) The average storey displacement in the Z dir. increase significantly with the introduction of infill walls. The increase is 44.29% on an average for simple G+7 frame and 43.29% for G+7 frame with soft storey.

(ix) The average storey displacement in the Z dir. increases significantly for soft storey. Displacement drastically reduces as onemoves up with the top floor displacement being just 7 to 7.5% more than the frame without soft storey.

(x) The average storey drift in the X dir. increase significantly with the introduction of infill walls. The increase is 38.73% on an average for simple G+7 frame and 37.50% for G+7 frame with soft storey.

(xi) Storey Drift in X dir. is significantly high for the soft storey(i.e. ground floor of the G+7 building with soft storey). For other floors except the soft storey the storey drift for the building with soft storey is less than the normal G+7 frame without soft storey.

(xii) The average storey drift in the Z dir. increase significantly with the introduction of infill walls. The increase is 38.44% on an average for simple G+7 frame and 37.22% for G+7 frame with soft storey.

(xiii) Storey Drift in Z dir. is significantly high for the soft storey (i.e. ground floor of the G+7 building with soft storey). For other floors except the soft storey the storey drift for the building with soft storey is less than the normal G+7 frame without soft storey.

(xiv) Max. lateral forces decreases in general with the introduction of soft storey and increases with the introduction of infill walls. The maximum lateral forces are for the case of G+7 building with infill walls and without soft storey.

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