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Comparative Static Analysis of RCC Structure with Soft Storey at Different Level Subjected to Earthquake Forces

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ABSTRACT

The concept of Soft storey has taken its place in the Indian urban environment due to the fact that it provides the parking facility in the soft storey of the building. The cost of construction of this type of building is much less than that of a building with basement parking. The collapse mechanism of such type of building is predominantly due to the formation of soft-storey behavior in the ground storey of this type of building. The sudden reduction in lateral stiffness and mass in the ground storey results in higher stresses in the columns of soft storey under seismic loading. The study of behaviour of RCC structure with change in soft storey location for that G+4 RCC structure with parameter define liner is modeled and analysis 6 times. In which case 1 is for the structure without infill wall where case 2 to case 6 is for the RCC structure with infill wall except soft storey at particular levels. The result are considered under maximum bending moments shear force, storey displacement, base shear value. From the analysis, it is observe very clearly that the displacement of structure without infill wall is considerable very high as that compared to structure with infill wall. Further it is observe that, when the soft storey at ground level the nodal displacement are more and as the location of soft storey moves to the upper floor of displacement value decrease when the soft storey at the top. The reaction value increase when the soft storey location changes from top to bottom. The nature in base shear distribution changes with the change in soft storey location from the study done

1. Introduction

Soft story (also known as open ground story) buildings are commonly used in the urban environment nowadays since they provide parking area which is most required. This type of building shows comparatively a higher tendency to collapse during earthquake because of the soft storey effect. Large lateral displacements get induced at the first floor level of such buildings yielding large curvatures in the ground storey columns. In the present study, seismic performance of 3D building structure with intermediately infill frame was studied. Performance of R.C. structure was evaluated considering different models for the soft storey. The soft storey buildings are designed as framed structures with or without consider to structural action of masonry infill wall. The study behaviour of RCC structure with change in soft storey location. For that G+4 RCC structure with parameter define the modeled and analysis 6 times. In which case-1 is for structure without infill wall whereas case-2 to case -6 is for RCC structure with infill wall except soft storey at particular levels

2. Literature Review

Bhola M. Sontakke at all, Feb (2015) et.al[1] in this paper explains soft storey is one of the main reasons for building damage during an earthquake and has been mentioned in all investigation report. Soft storey due to increase storey height is well known subject. Change in amount infill walls between stories also results in soft story. These are usually not considered as a part of load bearing system. This study investigates the soft storey behaviour due to increase in storey height, lack of in fills at ground floor storey and existence of both these cases by means of nonlinear static and dynamic response history analysis for midrise reinforced concrete building displacement increases, unwanted risk and sudden collapse. Similarly, Devendra Dohare, Dr. Savita Maru. Oct-Nov (2014) et. al[2] in the paper explained about the soft storey is a common feature in the modern multi-storey constructions in our country. Though multi-storied buildings with soft storey floor are naturally at risk to collapse due to earthquake, but their construction is still widespread in the country. It is observed that, providing infill improves resistant behaviour of the structure when compared to soft storey provided. D.R. Deshmukh, A.K. Yadav, S. N Supekar, A. B. Thakur, H. P Sonawane, I. M. Jain July (2016) et al (3) in this paper high-rise structures need much time for its time consuming and cumbersome calculations using conventional manual methods. We conclude that STAAD-PRO is a very powerful tool which can save much time and is very accurate in designs. In this project, G+19 storied building is considered and applied various loads like wind load, static load, earthquake load and results are studied and compared by manual calculations. Similarly R.B.Kargal, S.B.Patil, N.S.Kapse (2015) et at (4) in this paper is an updated literature review of the capacity-based Seismic design method. Earthquakes in different parts of the world demonstrated the disastrous consequences and vulnerability of inadequate structures.

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Many reinforced concrete (RC) framed structures located in zones of high seismicity in India are constructed without considering the seismic code provisions. The vulnerability of inadequately designed structures represents seismic risk to occupants. The seismic inertia forces generated at its floor levels are transferred through the various beams and columns to the ground. Similarly, Ricardo A. Medina. March (2004) et.at[5] in this paper the magnitude and the distribution of story ductility demands over the height of regular frames on the design story shear strength distribution. Regular frames subjected to ordinary ground motions with story shear strength distributions based on parabolic, triangular, and uniform design load patterns are studied. Results from this work suggest that for no deteriorating, regular frames, the parabolic load pattern is more effective to limit the story ductility demands at the top of the structure, while the triangular and uniform load patterns are more effective to limit the story ductility demands at the bottom stories. Design story shear strength patterns are proposed based on the premise that an optimum design lateral load pattern would result in a uniform distribution of story ductility over the height.

3. Detailed Study –

3.1Case Consideration Staad- Pro Modeling And Analysis:

❖Basic considerations, and details of cases considered:-

The building modeled and analyzed over here is RCC made up of M20 grade concrete and Ground + 4 storey , located in seismic zone four on medium soil condition , the loadings and combinations are taken as per IS 1893-2002 considerations.

- **Structural data –**

Size of beams = 300mm x 400mm
Size of Columns = 300mm x 450mm
Thickness of slab = 120 m.
Floor Height = 3.2m.
Live Loads on Floor = 3.0 KN/m^2
Terrace water proofing = 1.5 KN/m^2
Floors = G + 4
Floor Finishing = 1.0 KN/m^2
Roof Finishing = 1.0 KN/m^2
Wall thickness = 230mm
Materials = M20 and Fe415
Density of RCC = 25 KN/m^2
Density of masonry = 20 KN/m^2

- **Seismic parameters are –**

Zone factor, Z = IV = 0.24
Response reduction factor, R = Ordinary RC moment resisting frame (OMRF)= 3
Importance factor, I = All general building =1
S_a/g = 2.5 for medium soil.
Damping ratio = 5%
Type of soil: medium soil.

- **Soft storey cases:**

The following 6 cases have been framed for analysis purpose-
CASE- 1: RCC frame structure with infill wall.
CASE- 2: RCC structure with infill wall first floor.
CASE- 3: RCC structure with infill wall second floor.
CASE- 4: RCC structure with infill wall third floor.
CASE- 5: RCC structure with infill wall fourth floor.
CASE- 6: RCC structure with infill wall fifth floor .

3.2Analysis, Design and calculation of G+4 buildings in STAAD Pro:

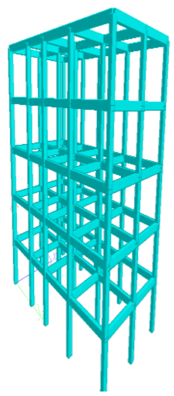

Fig 3.2. 3D rendering for RCC Frame structure.

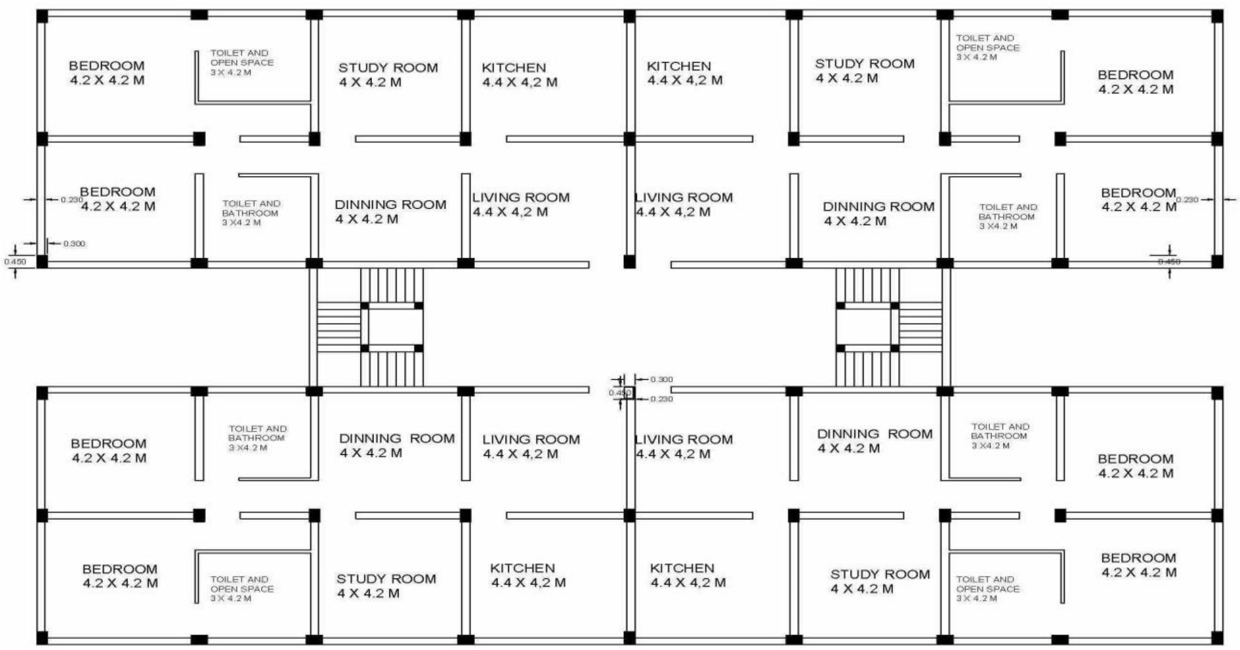

Fig 3.1. Plan of G+4 building.

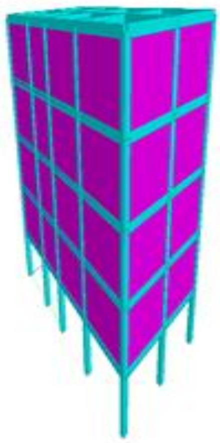

Fig 3.3. 3D rendering for soft storey at Ground level.

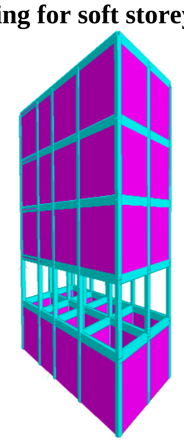

Fig 3.4. 3D rendering for soft storey at First Floor.

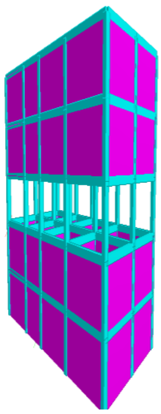

Fig 3.4. 3D rendering for soft storey at Second Floor.

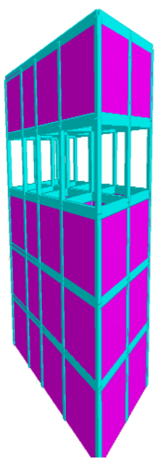

Fig 3.4. 3D rendering for soft storey at Third Floor.

Fig 3.4. 3D rendering for soft storey at Fourth Floor.

4. Observation and remark:

In this project for finding out the effect infill wall and structure seismic response with change in soft storey location. A building G+4 located in zone 4 is analysis compute by static equivalent method. And all other method as IS 1893:2002. The structure modular analysis 6 times which as below:

- CASE -1:- RCC frame structure with infill wall.
- CASE -2:- RCC structure with in fill wall except ground level.
- CASE -3:- RCC structure with in fill wall except first floor.
- CASE -4:- RCC structure with in fill wall except second floor.
- CASE -5:- RCC structure with in fill wall except third floor.
- CASE -6:- RCC structure with in fill wall except fourth floor.

Table no.4.1. Transaction and Rotational Node Displacement.

	Node No.	**16**	**13**	**10**	**7**	**4**	**0**
	Location	**16 m**	**12.8m**	**9.6 m**	**6.4 m**	**3.2 m**	**0m**
Case 1	Transaction (mm)	48.065	42.141	32.718	21.302	9.177	0
	Rotational (red)	0	0	0	0	0	0
Case 2	Transaction (mm)	13.097	12.894	12.728	12.564	12.456	0
	Rotational (red)	0	0	0	0	0	0
Case 3	Transaction (mm)	12.925	12.737	12.596	12.475	0.368	0
	Rotational (red)	0	0	0	0	0	0
Case 4	Transaction (mm)	11.964	11.815	11.717	0.461	0.180	0
	Rotational (red)	0	0	0	0	0	0
Case 5	Transaction (mm)	9.611	9.476	0.508	0.303	0.165	0
	Rotational (red)	0	0	0	0	0	0
Case 6	Transaction (mm)	4.974	0.508	0.388	0.279	0.156	0
	Rotational (red)	0	0	0	0	0	0

From the table no. 4.1 above it can be seen that the displacement of the node number 16. The topmost node of the structure is higher as that of any node e.g displacement of the node no. 16 is 48.065 mm and from the node 13 below it is

42.141mm in case no.1. Similarly, in all other cases the nodal displacement is maximum at top and decreases with decrease in height When the combination made in all case 6 it observe that the structure without infill wall are having higher node displacement. Whereas the structure with soft storey at the bottom is having the displacement 13.097 at the top of the structure as the soft storey location changes from ground to first floor. The nodal displacement value is decrease it is very clear that the structure with soft storey at the top is having comparatively less node displacement value e.g case no. 6 for node number 16 value is 4.979 mm.

Table no. 4.2. Moment and Shear force in column along the edges.

	Column No	23	20	17	14	11
	Location	Top	Top-2nd	Second	First	Bottom
Case 1	M_z(+) KM-m	9.39	23.4	32.8	40.6	66.4
	M_z(-)KM-m	-23.5	-34.6	-37.5	-36	-21.8
	$f_{y\ KN}$	10.5	18.1	22	23.9	27.6
	$f_{x\ KN}$	-10.7	-31.6	-60	-91.9	-121
Case 2	M_z(+)KM-m	1.77	2.4	4.36	8.03	96.3
	M_z(-)KM-m	-1.94	-2.89	-5.32	-9.52	-90.1
	$f_{y\ KN}$	-1.16	-1.65	-3.03	-5.48	58.2
	$f_{x\ KN}$	-1.94	-7.05	-16.2	-40.8	-232
Case 3	M_z(+)KM-m	3.2	4.48	7.87	90.7	5.89
	M_z(-)KM-m	-3.5	-5.41	-3.64	-88.7	-1.73
	$f_{y\ KN}$	2.09	-3.09	-5.47	56.1	-2.38
	$f_{x\ KN}$	-1.92	-6.81	-22.1	-158	-62.5
Case 4	M_z(+)KM-m	5.98	8.34	82.4	8.37	2.08
	M_z(-)KM-m	-6.54	-10.1	-81.4	-5.7	0.363
	$f_{y\ KN}$	-3.91	-5.77	51.2	4.24	-0.762
	$f_{x\ KN}$	-2.32	-9.25	-101	43.5	-35
Case 5	M_z(+)KM-m	11	64.1	7.14	2.83	0.658
	M_z(-)KM-m	-12.1	-62.3	-4.92	-1.85	0.286
	$f_{y\ KN}$	-7.23	39.5	-3.77	-1.46	-0.116
	$f_{x\ KN}$	-1.56	-49.7	-29.7	-21.7	-33
Case 6	M_z(+)KM-m	29	3.42	1.44	0.585	0.58
	M_z(-)KM-m	-17.3	-2.49	-1.02	-0.230	-0.072
	$f_{y\ KN}$	14.3	-1.85	-0.771	-0.254	0.204
	$f_{x\ KN}$	-7.76	-8.82	-10.7	-18.4	-29.1

From the table no.4.2 can be observe that he moment and the shear force value is less at the top the maximum at the bottom e.g for case 1, node 23 (top) i.e 9.99 bottom 16.4 kN/m . When the compared is made case 2, case 3, case 4, case 5 and case 6. It can be seen that the value of shear and bending moment is increasing serial no. of soft storey like for no.23 for case 2 the value is 1.77 KN-m, for case 3 the value is 3.2 KN-m, case 4 the value is 5.93 KN-m, case 5 the value is 11 KN-m, case 6 the value is 29 KN-m

Table no. 4.3. Reactions.

		F_x max^m		F_y max^m		F_z max^m		M_x max^m		M_y max^m		M_z max^m	
		+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve	+Ve	-Ve
Case 1	Node No.	56	56	56	55	38	20	38	20	3	1	56	56
		60.38	-60.38	919.998	-132.190	55.79	-57.22	98.640	-100.098	0.380	-0.380	124.0	-124.0
Case 2	Node No.	55	57	39	55	2	74	2	74	3	3	57	55
		102.221	-102.142	1436.077	-261.405	98.314	-98.5	157.623	-157.863	1.875	-1.367	165.506	-165.610
Case 3	Node No.	56	56	39	37	20	56	21	55	57	55	74	74
		163.292	-163.292	1484.650	-284.086	144.666	-169.64	392.037	-334.255	5.733	-5.733	307.185	-307.185
Case 4	Node No.	56	56	57	55	20	56	73	3	19	21	73	75
		139.015	-139.015	1513.434	-310.035	129.093	147	328.170	-297.877	0.769	-0.769	290.918	-290.918
Case 5	Node No.	56	56	57	55	20	56	75	3	57	55	73	75
		145.725	-145.725	1542.770	-328.302	132.008	-156.00	321.548	-290.538	0.362	-0.362	275.014	-275.014
Case 6	Node No.	56	56	57	55	20	56	75	3	73	73	73	75
		154.539	-154.539	1532.23	-321.421	145.666	-170.6	311.065	-279.810	0.784	-0.784	266.027	-266.027

From the table no 4.3 for maximum and minimum reaction the building without infill wall is having low reaction value where as the building with soft storey at the top is having more reaction that is in case 6 node 56 it is 154.53 KN and decrease as the soft storey location moves downward as in case 2 maximum reaction Fx is 102.221 KN.

Table no. 4.4. Storey shear and Base Shear.

Case No.	Node No.	16	13	10	7	4	0	sum
Case 1	Storey Shear X dir (KN)	9.199	5.548	3.121	1.387	0.347	0	19.602
	Storey Shear Z dir (KN)	9.199	5.548	3.121	1.387	0.347	0	19.602
Case 2	Storey Shear X dir (KN)	15.548	13.493	7.593	3.375	0.600	0	40.543
	Storey Shear Z dir (KN)	15.548	13.493	7.593	3.375	0.600	0	40.543
Case 3	Storey Shear X dir (KN)	15.969	13.864	7.798	2.465	0.616	0	40.712
	Storey Shear Z dir (KN)	15.969	13.864	7.798	2.465	0.616	0	40.712
Case 4	Storey Shear X dir (KN)	16.724	14.520	5.810	2.582	0.907	0	40.543
	Storey Shear Z dir (KN)	16.724	14.520	5.810	2.582	0.907	0	40.543
Case 5	Storey Shear X dir (KN)	18.002	11.118	6.254	3.907	0.977	0	40.258
	Storey Shear Z dir (KN)	18.002	11.118	6.254	3.907	0.977	0	40.258
Case 6	Storey Shear X dir (KN)	12.195	12.379	9.789	4.350	1.088	0	39.81
	Storey Shear Z dir (KN)	12.195	12.379	9.789	4.350	1.088	0	39.81

From the table no 4.4 when the observation is made on the storey shear value in x and z directions it can be observe that the storey shear value is maximum at the top and minimum at the lower storey level. When the compared is mode among case no 2 to case no 6. It can be seen that with change in soft storey location moving upward up to third storey. This storey shear value is increase but when soft storey is at the top the storey shear value is considerable is low as from the node no 16 that is 12.195 KN. In case 6 on the basis of this observation is drawn in the next chapter.

5. Conclusion

The aim of the dissertation was the study behaviour of RCC structure with change in soft storey location. For that G+4 RCC structure with parameter define the modeled and analysis 6 times. In which case-1 is for structure without infill wall whereas case-2 to case -6 is for RCC structure with infill wall except soft storey at particular levels. From the analysis it is observe very clearly that the displacement of structure without infill wall is considerable very high as that compared to structure with infill wall. It observe that when the soft storey at ground level the nodal displacement are more and as the location of soft storey moves to the upper floor of displacement value decrease when the soft storey at the top. The moments and the shear force increase in the column when the soft storey location changes from bottom to top even. From the reaction analysis it is very clearly that is reaction value from case -1 (structure without infill wall) is less whereas the reaction value increase when the soft storey location changes from top to bottom. From the base shear calculation is observe that storey shear value also. The nature in base shear distribution changes with the change in soft storey location from the study done. It can be concluded that the behaviour of highly depend upon the location of soft storey and the building displacement, moment and base shear changes rapidly when the soft storey location changes.

Future Scope:

The behaviour can be study by static seismic analysis method.

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