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Seismic Analysis of Building with and Without Shear Wall for Building with RCC and Composite Column

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***Abstract* - Shear wall is a structural element which is provided for resisting horizontal forces (like wind force, earthquake force, etc) parallel to the plane of the wall and for supporting gravity loads simultaneously. These are basically flexural members which are generally provided in high rise buildings to avoid the total collapse of the building exposed to seismic forces. For seismic design of buildings, RC structural walls or shear walls are major earthquake resisting members which offer lateral load resistance by providing an efficient bracing system.**

The response of the buildings is dominated by the properties of seismic shear walls and so it becomes important to evaluate the seismic response of the shear walls appropriately. In this study, the effect of presence of shear walls in RCC and composite structures in being analysed on basis of storey displacement, storey drift, stiffness, lateral force and base shear for G+19 buildings. Effectiveness of shear wall is being studied with the help of four different models. Model 1 is RCC building without shear wall, Model 2 is RCC building with shear wall, Model 3 is building with composite columns having no shear wall and Model 4 is building with composite columns in presence of shear wall. The earthquake load is applied to a building in zone IV and the analysis is done using both static analysis method and response spectrum analysis method.

Keywords: ETAB 2017, RCC buildings, Building with steel-concrete composite columns, Seismic analysis, Shear wall.

I. INTRODUCTION

In recent time, a lot of effort is given to develop the structural control devices so that seismic impact in buildings can be reduced. One such practice is introduction of shear wall in the buildings. Shear walls are one of the best means to provide earthquake resistance in multi-storied building**.** Behaviour of building under earthquake load depends on how the weight, stiffness and strength are distributed in the horizontal and lateral direction. Shear walls are used in the building to reduce the effect of earthquake by improving the seismic response of buildings. It becomes important to ensure adequate lateral stiffness to resist lateral load. For high- rise buildings, beam and column sizes are very heavy and requirement of steel is large because of which there is a lot of congestion at the joints and making it difficult to vibrate concrete at the joints and also the displacement is quite heavy.

In India most of the buildings are low rise. So, RCC members are used widely as it is easy to construct and is economical. However with the growth of population there is increasing growth in high-rise buildings in metropolis. It is observed that the use of composite members over RCC members is much more effective and economical in high rise buildings. When a steel component like I-beam is attached to a concrete component like floor slab or bridge deck, a composite member is formed. In composite structures the high strength of the concrete in compression and high strength of the steel in tension are utilized in combination. Thus steel- concrete composite construction makes use of compressive strength of concrete and tensile strength of steel together to give more economical and effective structure. Such an advanced system is gaining recognition in high rise buildings.

In this paper effectiveness of shear wall in RCC building and building with composite columns have been studied with the help of four different models using Etabs in zone IV . The analysis is done by response spectrum analysis method and static analysis method. The models considered for the analysis are as follows:

Model 1 is RCC building without shear wall,
Model 2 is RCC building with shear wall,
Model 3 is building with composite columns having no shear wall and
Model 4 is building with composite columns in presence of shear wall.

II. BUILDING MODELING

For the analysis 20 storey building has been considered having a height of 3m for each story including the ground storey. The structure modelled in symmetrical about both the axis. The modelling has been done in accordance to IS 456 and IS 1893 .The buildings has the fixed support at the base. The buildings are modelled using software ETAB for zone IV. Centre to centre distance between the two consecutive columns are 4m, the columns provided is square as they resist earthquake loading better. The study is carried out for the same building plan with and without shear wall for both RCC columns and composite columns by making four different models. Equivalent static method and response spectrum method have been used for the analysis and analysis has been done considering the parameters like storey displacement, storey drift, stiffness , lateral force and base shear .

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Table 1: Building description

Building storey	G+19
Total height of building	60 m
Height of each storey	3.0 m
Beam size	350mm x700mm
Column size	600 mm X 600 mm
Shear wall thickness	250 mm
Slab thickness	225 mm
Thickness of external walls	230m
Thickness of internal walls	115
Live load	3 KN/m^2
Floor finish	2 KN/m^2
Grade of Concrete	M30
Grade of reinforcing Steel	HYSD 415
Grade of Steel	Fe250
Density of Concrete	25 KN/m3
Zone	IV
Importance factor	1.2
Soil condition	Medium soil
Response reduction factor	5.0
Damping ratio	5%

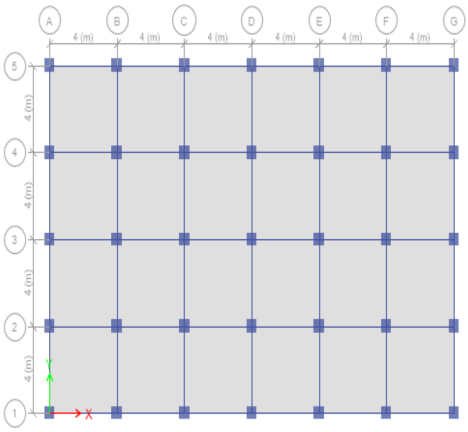

Fig 1: Plan view of building without shear wall

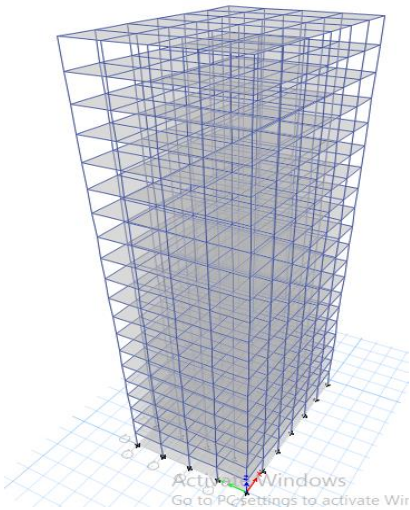

Fig 2: Elevation view of building without shear wall

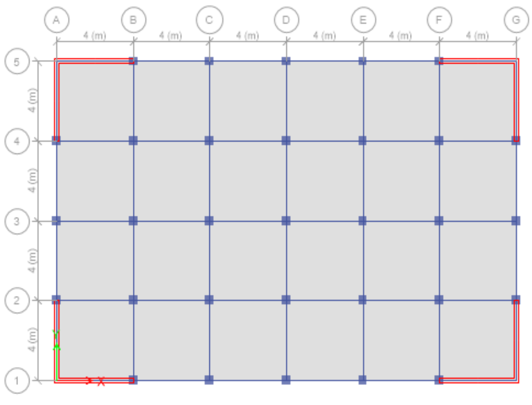

Fig 3: Plan view of building with shear

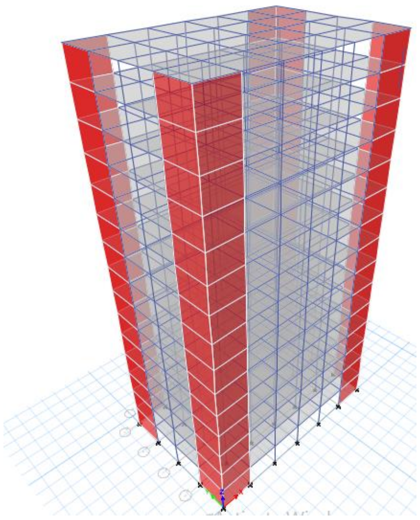

Fig 4: Elevation view of building with shear wall

III. RESULTS AND DISCUSSIONS

Equivalent static method and response spectrum method is used to analyse the results of all four models. Loads are calculated and distributed as per IS 1893:2016 and results obtained is compared as per following parameters.

3.1 STATIC ANALYSIS OF G+19 BUILDINGS

1. **Lateral Displacement-** From the observed results it was found that building with composite column in presence of shear wall showed minimum displacement. Also it is observed that the building on introduction of shear wall reduced displacement in the building substantially.

Table 2: Storey displacement

STOREY	RCC (mm)	RCC WITH SHEAR WALL (mm)	COMPOSITE (mm)	COMPOSITE WITH SHEAR WALL (mm)
1	6.562	1.427	4.123	1.154
2	17.534	4.305	12.168	3.458
3	29.419	8.29	21.505	6.599
4	41.539	13.165	31.266	10.43
5	53.728	18.744	41.146	14.814
6	65.909	24.868	51.019	19.637
7	78.016	31.398	60.809	24.794
8	89.979	38.211	70.457	30.192
9	101.723	45.199	79.902	35.748
10	113.168	52.261	89.078	41.386
11	124.227	59.311	97.917	47.037
12	134.808	66.271	106.344	52.638
13	144.813	73.071	114.28	58.137
14	154.139	79.655	121.64	63.486
15	162.678	85.977	128.336	68.647
16	170.318	92.002	134.274	73.591
17	176.943	97.714	139.363	78.302
18	182.435	103.115	143.517	82.774
19	186.693	108.234	146.69	87.029
20	189.744	113.06	148.965	91.014

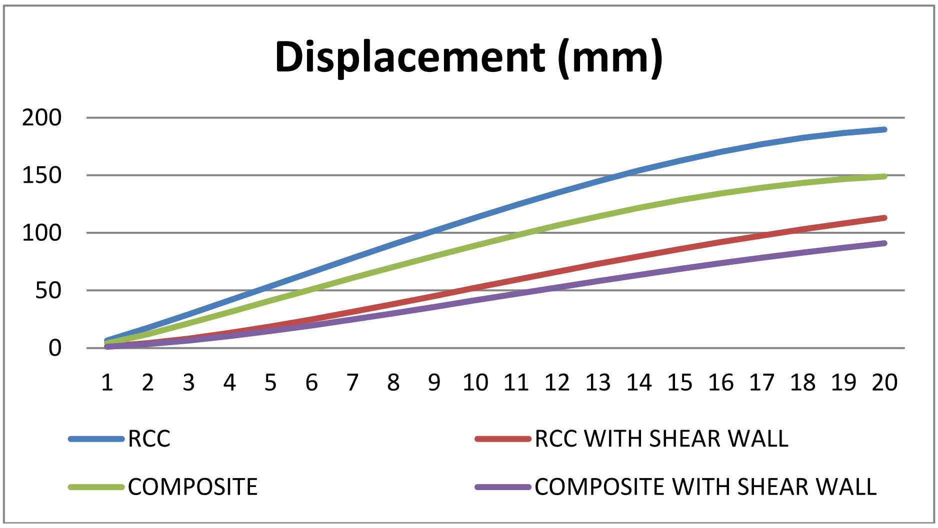

Fig 5: Comparison of storey displacement

2. **Storey Drift-**Decrease in storey drift was observed in presence of shear wall in both building with RCC column as well as building with Composite column. Maximum drift was observed in RCC building without shear wall.

Table 3: Storey drift

STOREY	RCC (mm)	RCC WITH SHEAR WALL (mm)	COMPOSITE (mm)	COMPOSITE WITH SHEAR WALL (mm)
1	6.562	1.427	4.123	1.154
2	10.972	2.879	8.045	2.304
3	11.885	3.985	9.337	3.141
4	12.12	4.875	9.761	3.83
5	12.189	5.579	9.88	4.385
6	12.181	6.124	9.872	4.823
7	12.107	6.53	9.791	5.157
8	11.963	6.814	9.648	5.398

9	11.744	6.987	9.444	5.556
10	11.445	7.063	9.176	5.638
11	11.059	7.05	8.839	5.651
12	10.581	6.959	8.427	5.602
13	10.005	6.801	7.936	5.499
14	9.326	6.584	7.36	5.349
15	8.539	6.321	6.696	5.161
16	7.64	6.025	5.939	4.944
17	6.624	5.712	5.089	4.511
18	5.492	4.702	4.154	3.673
19	4.258	3.719	3.172	2.855
20	3.051	2.64	2.276	1.984

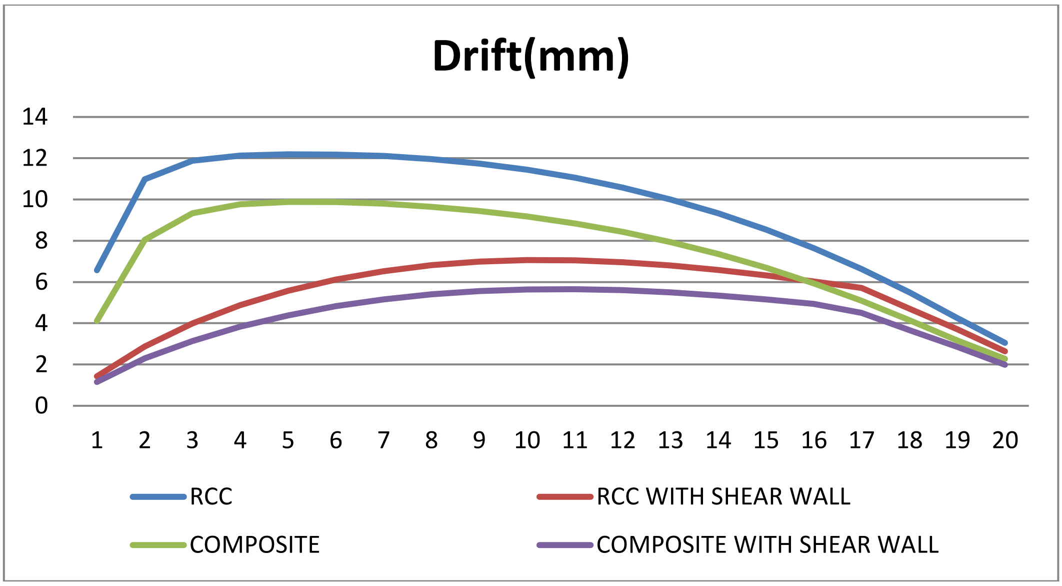

Fig 6: Storey drift

3. **Stiffness-** It is observed that building with composite column having shear wall has maximum stiffness and RCC building without shear wall shows minimum stiffness as evident from the graph below.

Table 4: Stiffness

STOREY	RCC (KN/m)	RCC WITH SHEAR WALL (KN/m)	COMPOSITE (KN/m)	COMPOSITE WITH SHEAR WALL (KN/m)
Base	0	0	0	0
1	1268830	6058615.79	2062814.746	7645668.716
2	758607.9	3000926.082	1056867.359	3827626.858
3	699311.8	2164984.441	909335.751	2803316.998
4	683496.6	1764036.19	867034.373	2291679.015
5	675719.4	1532494.518	851613.092	1990302.456
6	670043.4	1383341.694	844533.12	1793098.3
7	665269	1280102.383	840342.895	1654623.847
8	661009	1204476.322	837254.968	1551727.315
9	657014.2	1146030.216	834587.182	1471074.498
10	653038.4	1098099.278	831982.827	1404090.936
11	648797.8	1055899.696	829154.648	1344609.27
12	643937.4	1015525.479	825782.217	1287617.095
13	637982.4	973324.746	821441.032	1228487.908
14	630252.7	925436.317	815506.837	1162426.33
15	619704	867387.251	806971.279	1084005.722
16	604599.5	793723.815	794013.26	986762.678
17	581758.1	697717.153	772848.449	862871.81
18	544364.9	571451.642	734022.261	703273.343
19	474687.1	405781.908	649120.953	497137.915
20	308690.8	197581.503	419907.19	242734.859

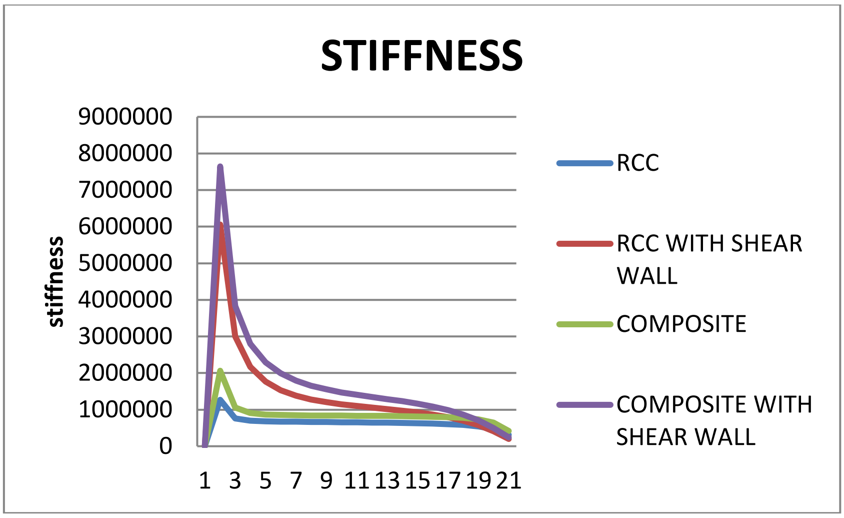

Fig 7: Comparison of stiffness

Fig 9: Representation of base shear for different models

3.2 RESPONSE SPECTRUM ANALYSIS OF G+19 BUILDINGS

1. **Lateral displacement-** It is observed that displacement is reduced substantially in presence of shear wall. Building with composite column in presence of shear wall showed minimum displacement while the RCC building without shear wall showed maximum displacement.

Table 6: Lateral displacement by response spectrum

STOREY	RCC (mm)	RCC WITH SHEAR WALL (mm)	COMPOSITE (mm)	COMPOSITE WITH SHEAR WALL (mm)
1	4.295	0.835	2.682	0.678
2	11.3	2.413	7.815	1.947
3	18.614	4.509	13.597	3.601
4	25.759	6.984	19.422	5.546
5	32.64	9.725	25.084	7.699
6	39.241	12.64	30.519	9.993
7	45.563	15.659	35.711	12.376
8	51.605	18.726	40.653	14.805
9	57.358	21.798	45.341	17.25
10	62.811	24.844	49.767	19.686
11	67.948	27.842	53.918	22.095
12	72.752	30.774	57.781	24.464
13	77.205	33.627	61.341	26.782
14	81.289	36.393	64.584	29.042
15	84.985	39.062	67.495	31.235
16	88.27	41.63	70.056	33.356
17	91.115	44.092	72.244	35.399
18	93.486	46.45	74.034	37.362
19	95.346	48.713	75.414	39.251
20	96.714	50.871	76.423	41.038

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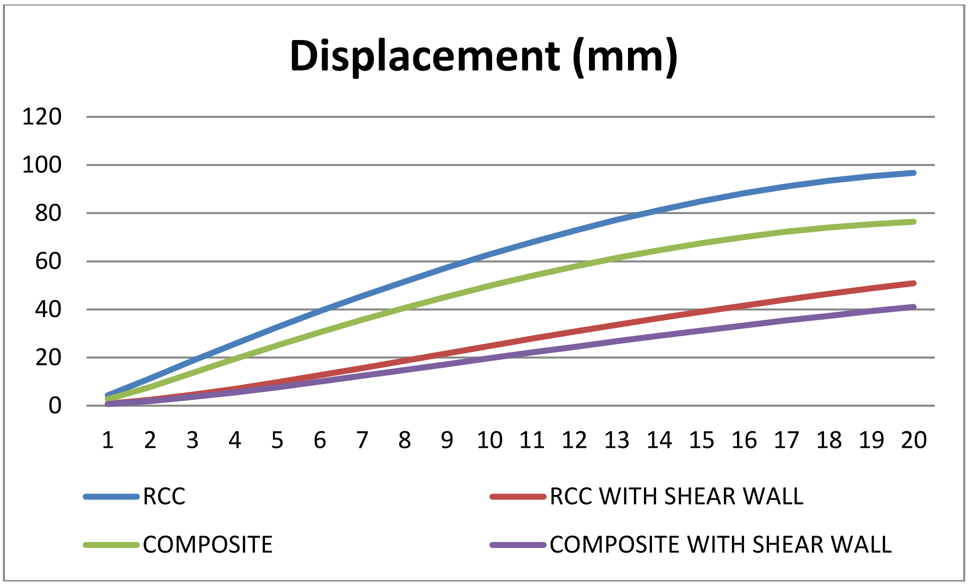

Fig 10: Comparison of displacement by response spectrum method

2. **Lateral drift-** There is decrease in drift in building with composite column than building with RCC column. Building with composite column in presence of shear wall showed minimum drift among all the four models

Table 6: Lateral drift by response spectrum

STOREY	RCC (mm)	RCC WITH SHEAR WALL (mm)	COMPOSITE (mm)	COMPOSITE WITH SHEAR WALL (mm)
1	4.295	0.835	2.682	0.678
2	7.015	1.581	5.136	1.271
3	7.355	2.103	5.801	1.66
4	7.243	2.49	5.874	1.956
5	7.059	2.766	5.764	2.173
6	6.87	2.957	5.605	2.327
7	6.683	3.082	5.435	2.433
8	6.483	3.158	5.259	2.501
9	6.269	3.197	5.07	2.543
10	6.033	3.209	4.865	2.564
11	5.777	3.202	4.641	2.569
12	5.505	3.177	4.404	2.561
13	5.214	3.137	4.155	2.539
14	4.904	3.081	3.891	2.503
15	4.567	3.007	3.606	2.452
16	4.18	2.913	3.28	2.383
17	3.717	2.801	2.891	2.297
18	3.146	2.673	2.42	2.097
19	2.436	2.141	1.865	1.592
20	1.665	1.286	1.304	0.95

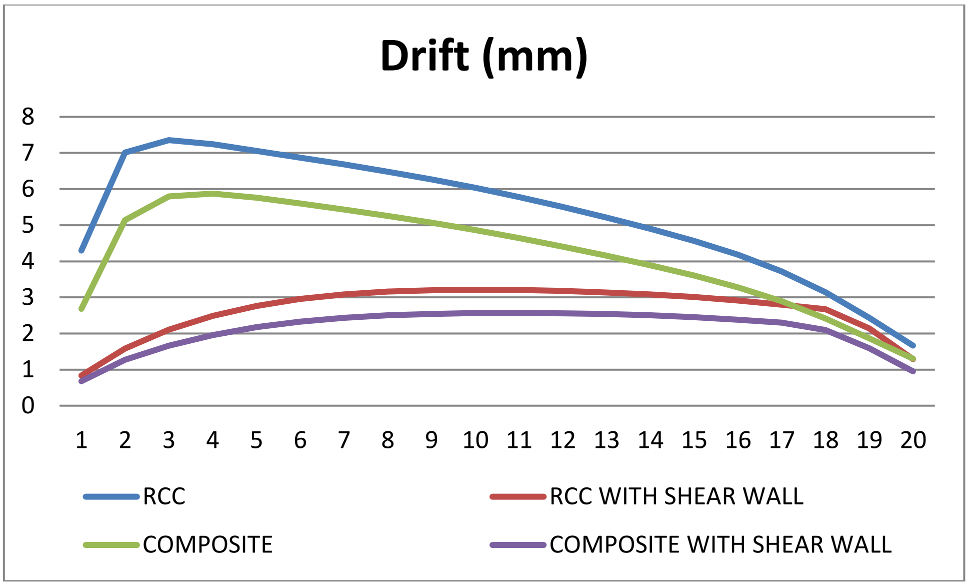

Fig 11: Comparison of drift by response spectrum method

4. **Stiffness-** It is observed that building with composite column having shear wall has maximum stiffness and RCC building without shear wall shows minimum stiffness as evident from the graph below.

Table 7: Lateral drift by response spectrum

STOREY	RCC (KN/m)	RCC WITH SHEAR WALL (KN/m)	COMPOSITE (KN/m)	COMPOSITE WITH SHEAR WALL (KN/m)
Base	0	0	0	0
1	1292503	6903487.031	2114177.636	8671133.005
2	774342.8	3580772.778	1084590.899	4557050.78
3	714501.7	2603232.877	931641.314	3380857.809
4	697616.7	2100287.83	885008.033	2744738.727
5	690112.3	1790395.946	868738.96	2341520.377
6	684098.4	1576977.717	860705.989	2056837.42
7	679372.2	1422627.942	857024.369	1845012.295
8	674405.3	1307964.745	853859.368	1683578.05
9	670043.8	1223756.894	851149.968	1562652.152
10	665350.3	1163540.138	848342.788	1475294.03
11	660542.6	1122271.362	844653.719	1415875.442
12	656247	1096152.405	841706.512	1378940.327
13	651791.5	1079304.053	839213.043	1355954.249
14	647886.4	1065735.302	837528.542	1337481.054
15	645048.4	1049062.173	838233.66	1313068.196
16	641406.4	1018441.574	839112.705	1268493.341
17	635356.8	960059.353	836997.76	1186967.922
18	622575.9	855676.38	826986.996	1046213.631
19	580528.6	670223.997	776934.689	806723.924
20	412496.8	361815.448	546004.379	430153.909

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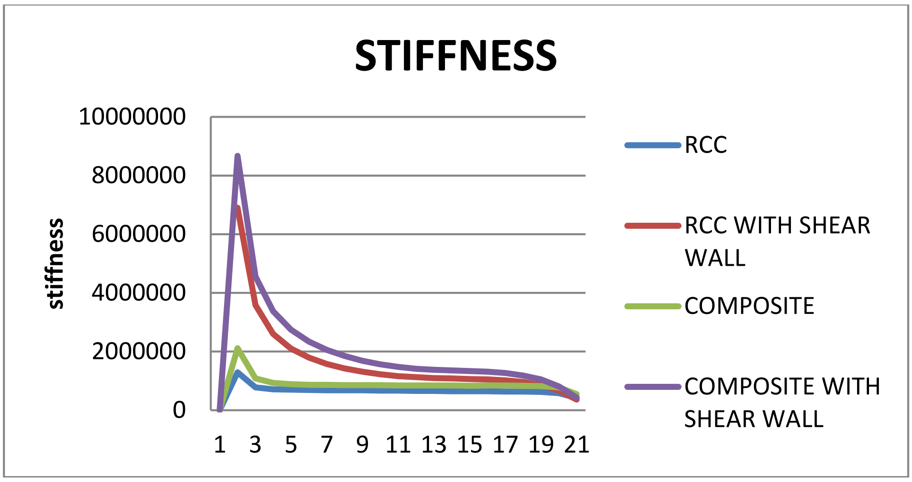

Fig 12: Comparison of stiffness by response spectrum method

IV. CONCLUSION

- From all the above analysis, it is observed that for high rise building of 20 storey, building with composite column is more efficient. It is observed that displacement and drift is reduced substantially and stiffness of the building increases in presence of shear walls. Hence it is concluded that composite column building with shear wall counter seismic force more as compared to other models.
- In case of RCC framed structure the lateral displacement is very high. It is observed that in presence of shear wall the displacement at top reduces by approx 40% in case of static analysis and 47% in case of response spectrum analysis in both RCC and composite column buildings. Also the building with composite column reduces the displacement by approx 20% as compared to RCC building.
- Hence the composite column building in presence of shear wall counters the seismic effect more efficiently.
- Storey-drift is the relative displacement, it means the drift of one level relative to the level below. It is observed that the drift at top is reduced by 13% in presence of shear wall in case of static analysis and 23% in case of response spectrum analysis.
- Building with composite columns reduces the drift by approx 25% compared to RCC column buildings.
- The stiffness of the building is more in case of composite column compared to RCC column building. The shear wall in the building makes the building increases the stiffness of the building.

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