Buildings with RC shear wall and Composite shear wall provided at corners/edges

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Abstract - This study compares the seismic behaviour of tall building with RC shear wall and Composite shear wall. Composite shear wall (CSW) consists of steel plates incased in the middle of a reinforced concrete shear wall. This arrangement aims at improving the performance of the wall, as steel plate can effectively increase the seismic behaviour and concrete can protect steel plate from bulking and corrosion. To improve the strength and ductility of core walls in tall buildings which would be subjected to combined high axial compressive force and bending moment during the earthquake, an innovative concrete filled double skin steel plate composite (CFSDC) wall is proposed. RC shear wall building and CSW building are compared by providing both shear walls at corners/edges of building in X and Y direction using ETABS. The structural response in is investigated comparing various parameters that are time period, base shear, storey displacement, storey drift and stiffness. Multi storey building (G+24) is taken in Zone IV with medium soil.

Keywords: Composite shear wall,CFSDC wall, ETABS,Seismic behaviour

INTRODUCTION

Structural shear walls have played an important role in resisting lateral force, imposed by the earthquake or wind in tall buildings. However, the application of RC shear walls has been limited because of Composite shear walls.

The double skin steel concrete composite shear walls composed of two steel plates and infilled concrete have been proposed. The steel plates improve the shear resistance and seismic behaviour of shear walls. The composite shear wall takes advantage of both RC wall and steel plate wall. The infill concrete could prevent the local buckling of steel plates, and thus improve the anti-local buckling capacity of the steel faceplates, while the strength and ductility of inner concrete are enhanced due to confinement from the outer steel plates. By the reason of its excellent mechanics performance, the thickness of Composite shear wall could be much smaller than that of conventional RC shear wall, which could reduce the weight of the building and increase the usable floor area. The construction process of Composite shear wall is also quite efficient since the steel faceplates could act as permanent formwork. Thus, in several tall buildings RC shear walls have been replaced by Composite shear walls.

This research addresses the behaviour of 3 structures subjected to earthquakes in Zone IV. Multi storey building(G+24) without shear wall, with RC shear wall and with Composite shear wall are analysed and compared. Seismic parameters that are time period, base shear, storey displacement, storey drift, stiffness are compared of all the three bare frame structures.

Cross section of shear wall

RC shear wall of 250mm thickness is provided in Model 2. These are provided at corners/edges of building.

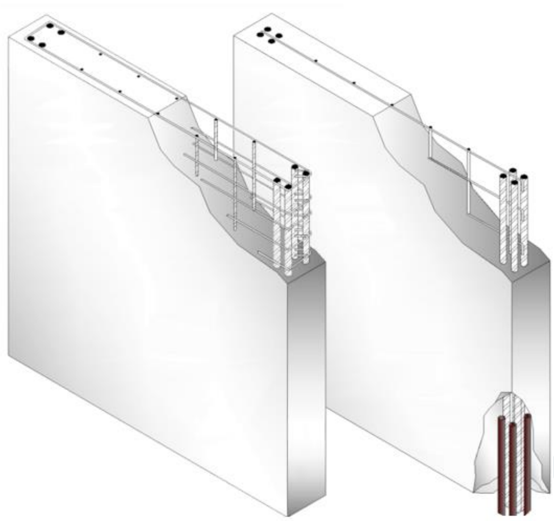

Fig 1 – RC shear wall design

Composite shear wall of 250mm thickness with two steel plates of 4mm thickness is provided in Model 3. These are provided at corners/edges of building.

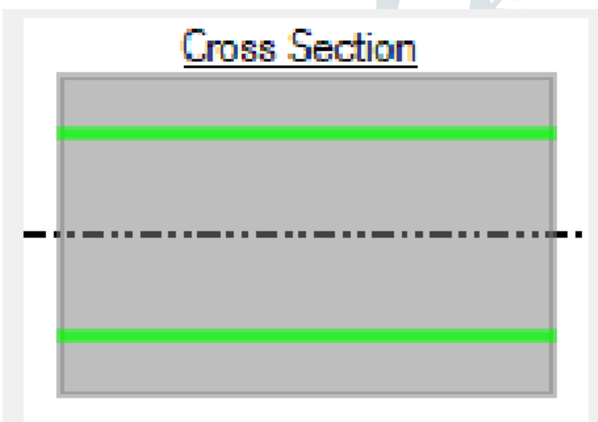

Fig 2 – Cross section of Composite shear wall provided

---- SHOWS STEEL PLATES(4mm)

Number of Layers: 3

Total Section Thickness: 250 mm

Sum of Layer Overlaps: 8 mm

Sum of Gaps Between Layer: 0 mm

2. OBJECTIVES OF WORK

1. To study the behaviour of building for regular plan under seismic loads and load combinations as per IS 1893:2016.
2. To evaluate the response of RC multi-storey building (G+24) with RC shear wall (RSW) and Composite shear wall (CSW).
3. To determine seismic parameters that are time period, storey displacement, storey drift, stiffness.

3. DESCRIPTION OF BUILDING

3.1 Dimensions of building

Commercial building with 25 storey located in Zone IV (Delhi)

S. No.	Structural part	Dimension
1	Length in X-direction	48m
2	Length in y-direction	48m
3	No of bay in X-direction	8No.@6m
4	No of bay in Y-direction	8No.@6m
5	Floor to floor height	3m
6	Total height of building	75m
7	Thickness of slab	150 mm
8	Thickness of RC shear wall	250 mm
9	Thickness of Composite shear wall	250 mm
10	Column size	(600x600)mm
11	Beam size	(350x500) mm

3.2 Material properties-

S.No.	Material	Grade (N/mm^2)
1	Column	M35
2	Beam, Slab	M30
3	Rebar	Fe-500

3.3 Seismic data-

1	Zone Factor	0.24 (clause 6.4.2)
2	Damping ratio	5%
3	Importance factor (I)	1.2 (clause 7.2.3)
4	Response reduction factor (R)	5 (SMRF) (clause 7.2.6)
5	Type of soil	Medium soil (II)

3.4 Loading

- Live load 4kN/m^2 as per IS 875 (II)
- Earthquake load as per IS 1893-2016 (I)

4. PROBLEM DESCRIPTION

Model 1 – Multi storey building without shear wall

Model 2 – Multi storey building with RC shear wall

Model 3 – Multi storey building with Composite shear wall

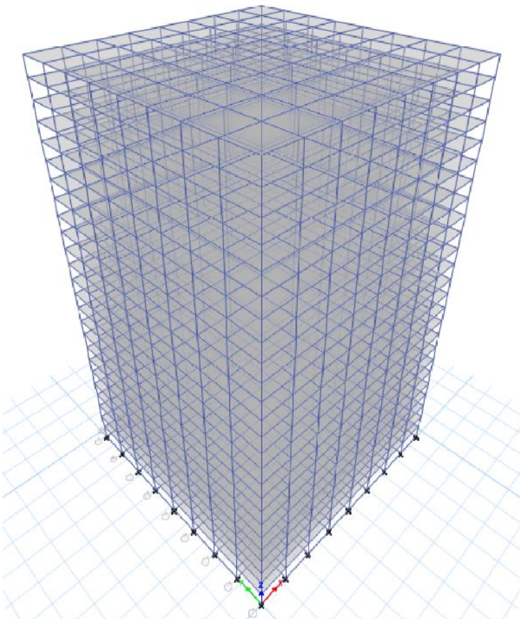

Fig 4.1 – 3-D view of structure without shear wall

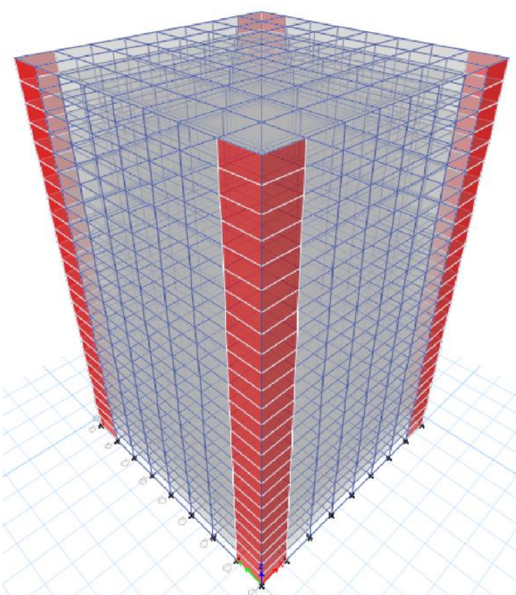

Fig 4.2 – 3-D view of structure with RC shear wall provided at corners

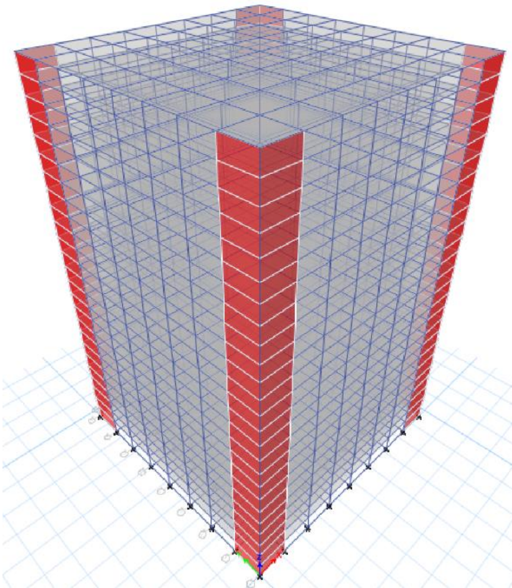

Fig 4.3 – 3-D view of structure with Composite shear wall provided at corners

5. ANALYSISAND RESULTS

5.1 TIME PERIOD

As per **IS 1893 2016clause 7.6.2**, the approximate fundamental translational natural period'T_s'of oscillation in seconds shall be estimated by following expression:

$\mathbf{T_s = 0.075}\boldsymbol{h}^{\mathbf{0.75}}$(for moment resisting frame)   Where, h = height of building in meter

MODE	TIME PERIOD (seconds)		
	MODEL 1	**MODEL 2**	**MODEL 3**
Mode1	3.438	2.606	2.608
Mode2	3.438	2.606	2.608
Mode3	3.154	1.864	1.869
Mode4	1.133	0.718	0.719
Mode5	1.133	0.718	0.719
Mode6	1.041	0.442	0.443
Mode7	0.661	0.349	0.349
Mode8	0.661	0.349	0.349
Mode9	0.612	0.225	0.225
Mode10	0.461	0.225	0.225
Mode11	0.461	0.199	0.2
Mode12	0.428	0.168	0.169

TABLE 5.1 – Time Period in seconds

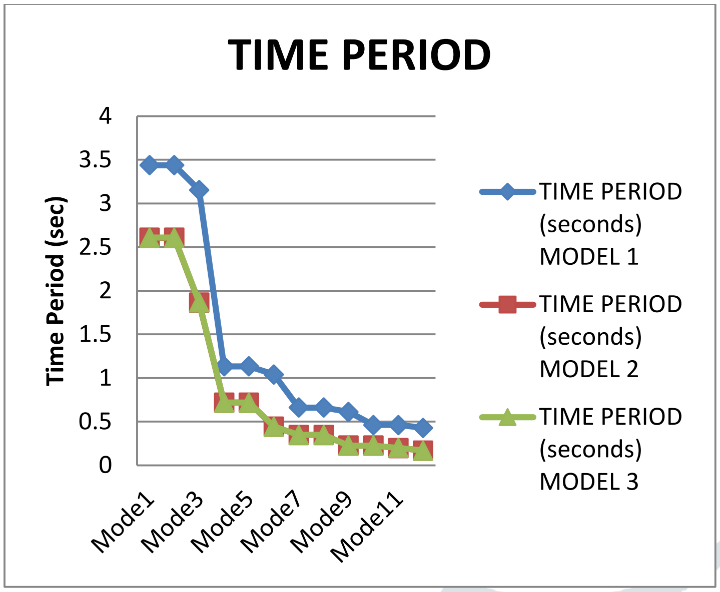

Fig 5.1 – Graph showing Time period

Time period of model 1 is maximum and decreases rapidly at each interval of 3 modes.

Time period of model 2 and model 3 is almost same.

5.2 STOREY DISPLACEMENT

According to EURO CODE, the maximum allowable deflection is calculated as **h/250**,

Where,

h= height of the storey above ground level

5.2.1 STOREY DISPLACEMENT IN X DIRECTION

STORY	STOREY DISPLACEMENT (mm)			
	MODEL 1	MODEL 2	MODEL 3	IS Code Limit
Story25	363.844	230.574	158.5	300
Story24	352.672	222.578	152.994	288
Story23	337.284	214.661	147.55	276
Story22	320.05	206.264	141.773	264
Story21	302.172	197.544	135.775	252
Story20	284.168	188.509	129.56	240
Story19	266.174	179.168	123.136	228
Story18	248.726	169.539	116.515	216
Story17	231.886	159.642	109.712	204
Story16	215.395	149.495	102.737	192
Story15	199.476	139.118	95.605	180
Story14	183.598	128.532	88.332	168
Story13	168.597	117.765	80.936	156
Story12	154.043	106.854	73.441	144
Story11	139.994	95.845	65.88	132
Story10	126.034	84.794	58.292	120

Story9	112.46	73.773	50.724	108
Story8	99.461	62.871	43.238	96
Story7	87.184	52.197	35.908	84
Story6	75.064	41.885	28.826	72
Story5	63.086	32.099	22.103	60
Story4	51.881	23.037	15.876	48
Story3	42.056	14.947	10.311	36
Story2	33.951	8.081	5.581	24
Story1	27.874	2.808	1.957	12

TABLE 5.2.1 – Storey displacement in X Direction

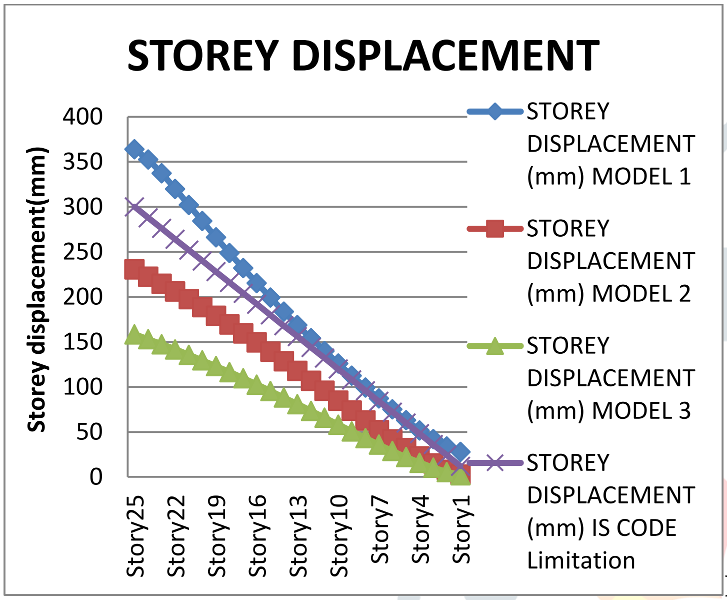

Fig 5.2.1 – Graph showing Storey displacement

5.2.2 STOREY DISPLACEMENT IN Y DIRECTION

STORY	STOREY DISPLACEMENT (mm)			
	MODEL 1	**MODEL 2**	**MODEL 3**	**IS Code Limit**
Story25	363.844	230.574	158.5	300
Story24	352.672	222.578	152.994	288
Story23	337.284	214.661	147.55	276
Story22	320.05	206.264	141.773	264
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Story15	199.476	139.118	95.605	180
Story14	183.598	128.532	88.332	168
Story13	168.597	117.765	80.936	156
Story12	154.043	106.854	73.441	144
Story11	139.994	95.845	65.88	132
Story10	126.034	84.794	58.292	120
Story9	112.46	73.773	50.724	108
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Story6	75.064	41.885	28.826	72
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Story3	42.056	14.947	10.311	36
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Story1	27.874	2.808	1.957	12

TABLE 5.2.2 – Storey displacement in X Direction

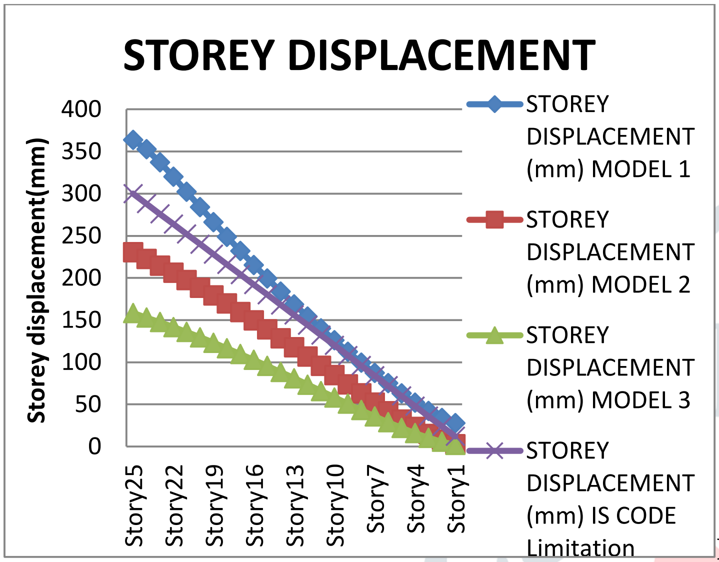

Fig 5.2.2 – Graph showing Storey displacement

Building without shear wall i.e. Model 1 shows larger displacement of 363.85 mm which exceeds the euro code limit and therefore the structure fails.

Building with RC shear wall is safe and values are within the permissible limit whereas building with Composite shear wall shows least displacement.

5.3 STOREY DRIFT

As per **IS 1893:2016** (clause 7.11.1) storey drift in any case shall not exceed 0.004 times of the storey height.

5.3.1 STOREY DRIFT IN X DIRECTION

STORY	STOREY DRIFT (mm)			
	MODEL 1	MODEL 2	MODEL 3	
Story25	11.172	8.084	5.562	12
Story24	15.388	9.027	6.208	12
Story23	17.234	9.571	6.583	12
Story22	17.878	9.968	6.855	12
Story21	18.004	10.323	7.099	12
Story20	17.994	10.634	7.312	12
Story19	17.448	10.894	7.49	12
Story18	16.84	11.107	7.636	12
Story17	16.491	11.278	7.752	12
Story16	15.919	11.411	7.843	12

Story15	15.878	11.512	7.911	12
Story14	15.001	11.579	7.957	12
Story13	14.554	11.61	7.977	12
Story12	14.049	11.599	7.968	12
Story11	13.96	11.538	7.925	12
Story10	13.574	11.416	7.84	12
Story9	12.999	11.213	7.7	12
Story8	12.277	10.908	7.492	12
Story7	12.12	10.476	7.194	12
Story6	11.978	9.886	6.792	12
Story5	11.205	9.106	6.26	12
Story4	9.825	8.091	5.562	12
Story3	8.105	6.799	4.678	12
Story2	6.077	5.196	3.591	12
Story1	4.063	2.691	1.854	12

TABLE 5.3.1 – Storey drift in X direction

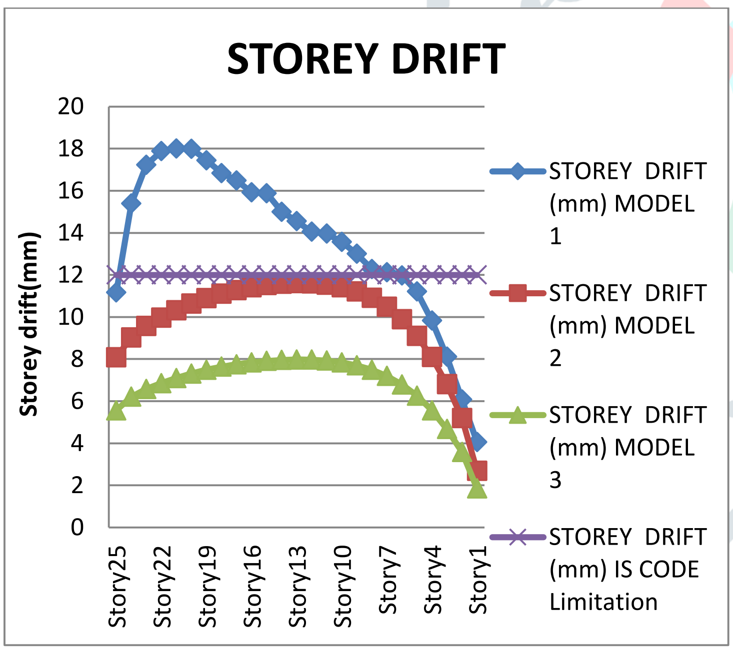

Fig 5.3.1 – Graph showing Storey drift

5.3.2 STOREY DRIFT IN Y DIRECTION

STORY	STOREY DRIFT (mm)			
	MODEL 1	MODEL 2	MODEL 3	
Story25	11.172	8.084	5.562	12
Story24	15.388	9.027	6.208	12
Story23	17.234	9.571	6.583	12
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Story15	15.878	11.512	7.911	12
Story14	15.001	11.579	7.957	12
Story13	14.554	11.61	7.977	12
Story12	14.049	11.599	7.968	12
Story11	13.96	11.538	7.925	12
Story10	13.574	11.416	7.84	12
Story9	12.999	11.213	7.7	12
Story8	12.277	10.908	7.492	12
Story7	11.172	10.476	7.194	12
Story6	15.388	9.886	6.792	12
Story5	17.234	9.106	6.26	12
Story4	17.878	8.091	5.562	12
Story3	18.004	6.799	4.678	12
Story2	17.994	5.196	3.591	12
Story1	17.448	2.691	1.854	12

TABLE 5.3.2 – Storey drift in Y direction

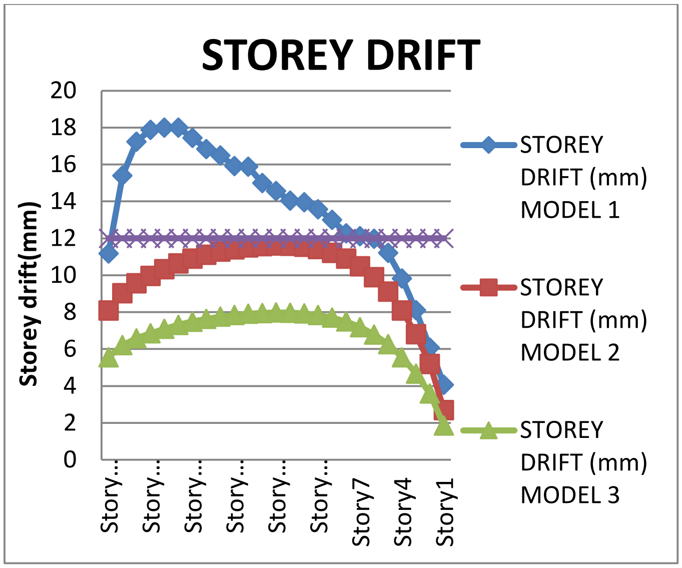

Fig5.3.2 – Graph showing Storey drift

Building without shear wall exceeds the permissible limit of storey drift i.e. the structure fails in storey drift. Building with Composite shear wall shows least storey drift.

5.4 STOREY STIFFNESS

5.4.1 STOREY STIFFNESS IN X DIRECTION

STOREY	**STOREY STIFFNESS (kN/m)**		
	MODEL 1	**MODEL 2**	**MODEL 3**
Story25	1080323.098	776667.401	773987.281
Story24	1417390.413	1311104.274	1307607.768
Story23	1505332.038	1674026.713	1669724.218
Story22	1532860.052	1908520.827	1904526.737
Story21	1539757.057	2049458.918	2045520.053
Story20	1540258.425	2136337.656	2132449.18
Story19	1541214.452	2193999.453	2190231.732
Story18	1545374.53	2234522.839	2230869.902
Story17	1552181.444	2266432.214	2262995.163
Story16	1559582.096	2298766.161	2295565.069
Story15	1566074.214	2339726.673	2336760.568
Story14	1571597.669	2393611.053	2390901.729
Story13	1577111.903	2461546.07	2459109.852
Story12	1583528.089	2545955.708	2543811.711
Story11	1590874.681	2653095.21	2651222.104
Story10	1598325.009	2792054.36	2790225.705
Story9	1604965.096	2971943.909	2970297.006
Story8	1610621.191	3200862.63	3198706.079
Story7	1616198.736	3492834.415	3491039.415
Story6	1623462.616	3875704.724	3872137.672
Story5	1634991.964	4399634.012	4393148.104
Story4	1656961.625	5159836.689	5152382.985
Story3	1713850.827	6351424.72	6337485.752
Story2	1926350.012	8497911.926	8441401.447
Story1	3541171.614	16552257	16492486

TABLE 5.4.1– Storey stiffness in X direction

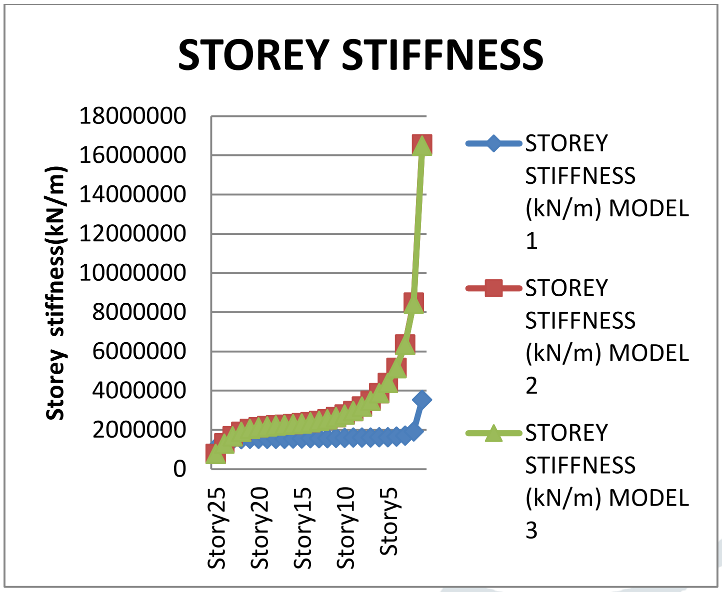

Fig5.4.1 – Graph showing storey stiffness

5.4.2 STOREY STIFFNESS IN Y DIRECTION

STOREY	STOREY STIFFNESS (kN/m)		
	MODEL 1	MODEL 2	MODEL 3
Story25	1080323.098	776667.401	773987.281
Story24	1417390.413	1311104.274	1307607.768
Story23	1505332.038	1674026.713	1669724.218
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Story1	3541171.614	16552257	16492486

TABLE 5.4.2 – Storey stiffness in Y direction

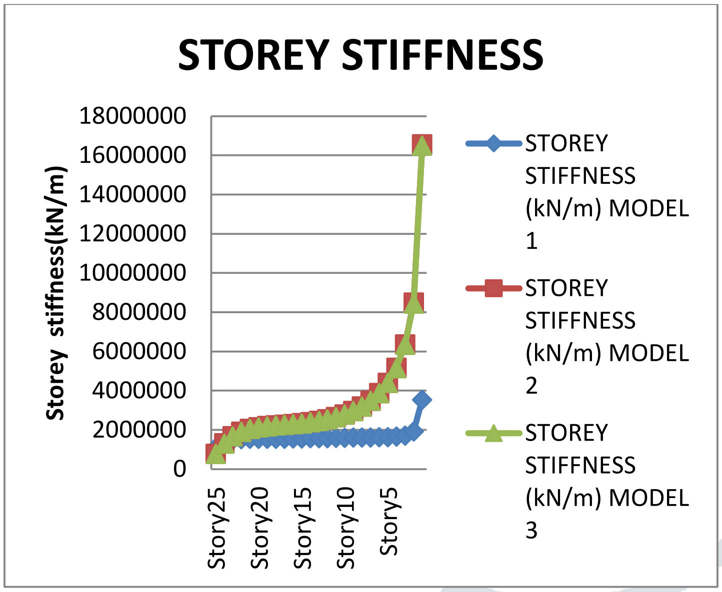

Fig5.4.2 – Graph showing storey stiffness

6. RESULTS AND DISCUSSION

1. The story displacement in Model 1 in X and Y direction is observed to be 363.84 mm which exceeds Euro code limit therefore the structure fails.
2. The story displacement in Model 3 in X and Y direction is observed to be least i.e. 158.05 mm compared to other models.
3. The story drift observed in Model 1 in X and Y direction is 18.004 mm which exceeds the IS code recommended value 12 mm (4% of storey height).
4. The story drift observed in Model 3 in X and Y direction is 7.97 mm which is within the IS code recommended value 12 mm (4% of storey height).
5. The time period of the building is found to be higher in Model 1. Model 2 and Model 3 have almost same time period.
6. The stiffness of building is found to be most in Model 2 & 3.

7. CONCLUSIONS

From the above results, it can be concluded that Composite shear wall provided at corners/edges is best for this structure.

Composite shear walls are cost effective and gives lesser displacement. Composite shear walls can be used with lesser thickness as compared to RC shear walls.

The strength and ductility of core walls is increased by providing Composite shear walls in the structure.

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