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Shear Wall as Lateral Load Resisting System

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Abstract- *Seismic Design of Reinforced concrete structure till at the moment is a matter of great anxiety; defeat of large human and economic resource is only due to earthquakes. For this cause it is needed to understand the behavior of structure subjected to dynamic loading. Better arrangement of RC shear wall building in new and earlier period earthquakes is observed and it encourages its use in high rise buildings. The work deals with the design of shear wall, behavior and stiffness of frame with shear wall using E-tab software. For this reason structures are modeled and analyzed using codes IS 1893:2002,IS 456:2000.The buildings are modeled with floor area of (25m x 15m) with 5 bays of 5m span along X Direction and 3 bays of 5m span along Y Direction. Floor to Floor height is taken as 3.5m. A Comparative has been done by placing shear walls at different locations in the building subjected to seismic load. Shear wall are placed at the pheriphry, inner core and at the intermediate position. Different parameters such as Base shear, story drift, story shear, story stiffness and natural period are observed for bare frame, frame with masonry walls and frame with masonry and shear walls to compare the structural behavior of Shear wall systems.*

***Keywords*: Shear walls, Stiffness, E-tabs, Story shear, Natural period.**

1. INTRODUCTION

The walls which resist the lateral loads such as wind or earthquake in a building are known as shear wall. Lateral strength and stiffness of the structure can be improved by shear wall and thereby providing good inter storey drifts control and energy dissipation capacity. Basic criterions that the structure should satisfy are stiffness, strength and ductility and these objectives can be pleased by the shear walls. The stiffness of the framed structure with shear walls is more compared to bare frame structure and therefore deformations under earthquake load gets reduced. The needed strength can be achieved by proper detailing of longitudinal and transverse reinforcement, to avoid damage

Reinforced concrete (RC) shear walls are typically provided between column lines, stair wells, and lift wells. Shear wall offer lateral load resistance by transferring the wind or earthquake loads to the foundation. Beside that they provide lateral stiffness to the structure and carry gravity loads. Seismic performance of a building can be drastically improved by well designed system of shear walls.

Shear wall is similar to column taking axial load but of very small thickness with respective to standard column size. It has been noted that the building provided with shear walls can easily bear stresses and stiffness can be enhanced against the lateral displacement of vertical structural members. The structural location of shear wall should be such that it allows maximum load to pass through it in lateral direction for reducing shear failure to other structural members.

2. STRUCTURAL PROPERTIES OF RC BUILDING:

- Stories : G+19
- Story height: 3.5m
- Beam dimension : 230x850 (1st 5 stories)
  : 230x800 (2nd 5 stories)
  : 230x700 (3rd 5 stories)
  : 230x450 (4th 5 stories)
- Column dimension : 650x650 (1st 5 stories)
  : 550x550 (2nd 5 stories)
  : 500x500 (3rd 5 stories)
  : 450x450 (4th 5 stories)
- Shear wall thickness : 230mm
- Grade of concrete : M30
- Grade of steel : Fe-500
- Zone considered – V
- Importance factor:1
- Response reduction factor-5
- Dead load on the structure-1kN/m²
- Live load on the structure- 3kN/m²

2.1: Location of shear walls:

Fig 1.1:Shear wall with 1st configuration

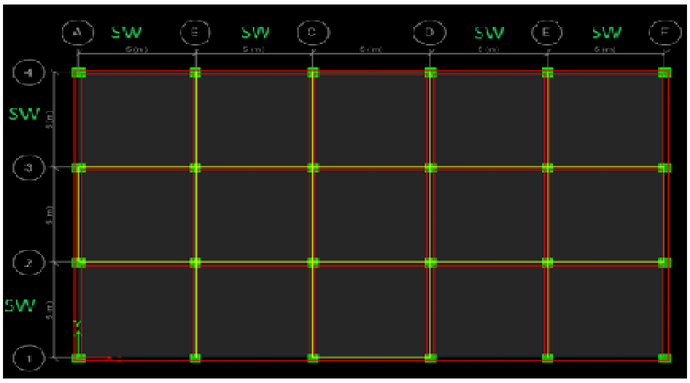

Fig 1.2:Shear wall with 2nd configuration

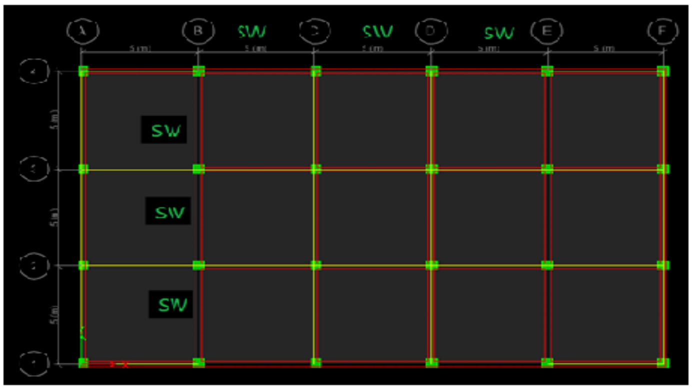

Fig 1.3:Shear wall with 3rd configuration

2.2 : Observations in Various Parameters:

Story	Load	1st model Bare frame	2nd model with MW	3rd model SW1	4th model SW2	5th model SW3
20	SPECX	288.47	655.64	611.33	627.03	611.80
19	SPECX	508.19	1326.01	1313.90	1341.35	1314.81
18	SPECX	641.06	1975.03	1994.54	2028.21	1995.87
17	SPECX	726.41	2597.38	2647.59	2682.96	2649.34
16	SPECX	798.95	3191.32	3270.29	3303.72	3272.49
15	SPECX	871.82	3764.59	3867.06	3897.16	3869.31
14	SPECX	949.88	4314.77	4437.07	4461.34	4439.45
13	SPECX	1023.68	4835.88	4974.49	4990.89	4977.05
12	SPECX	1090.70	5326.73	5478.70	5485.59	5481.47
11	SPECX	1150.06	5786.12	5949.28	5945.39	5952.22
10	SPECX	1202.31	6217.53	6389.41	6374.58	6394.03
9	SPECX	1251.73	6619.52	6799.08	6772.40	6805.24
8	SPECX	1298.37	6986.06	7172.89	7133.75	7180.38
7	SPECX	1346.81	7315.12	7509.07	7457.01	7517.67
6	SPECX	1402.91	7604.83	7805.57	7740.32	7815.05
5	SPECX	1469.84	7858.40	8066.72	7986.54	8075.93
4	SPECX	1545.18	8074.02	8287.86	8192.63	8296.70
3	SPECX	1614.70	8242.17	8459.48	8350.03	8467.91
2	SPECX	1664.39	8357.66	8576.86	8455.20	8584.92
1	SPECX	1685.35	8414.85	8635.40	8505.89	8643.22

Table 1.0: Story shear in KN

Story	Load	1st model Bare frame	2nd model with MW	3rd model SW1	4th model SW2	5th model SW3
20	SPECX	34.38	288.82	2764.85	1616.48	2763.94
19	SPECX	29.95	229.62	413.69	370.95	414.15
18	SPECX	12.50	193.16	378.01	349.21	377.98
17	SPECX	3.05	157.93	329.85	303.34	329.50
16	SPECX	0.10	93.92	235.81	208.61	237.20
15	SPECX	2.07	89.49	210.68	197.73	208.48
14	SPECX	1.58	98.18	224.74	208.55	224.40
13	SPECX	2.42	90.90	207.53	191.50	204.87
12	SPECX	2.55	85.49	191.13	177.19	190.19
11	SPECX	2.45	70.12	160.22	145.75	151.50
10	SPECX	1.13	69.38	151.54	141.30	150.78
9	SPECX	1.11	78.28	168.40	156.52	167.73
8	SPECX	0.69	78.39	167.98	156.74	167.49
7	SPECX	2.84	78.54	170.28	159.84	169.84
6	SPECX	4.01	69.25	146.09	144.83	150.20
5	SPECX	3.82	72.68	164.65	157.41	163.05
4	SPECX	2.53	88.10	198.87	189.44	198.23
3	SPECX	9.02	95.90	215.22	206.44	213.41
2	SPECX	13.06	104.13	230.75	224.19	229.34
1	SPECX	14.97	109.34	241.91	234.69	239.90

Table 1.1: Story stiffness in kN/mm

Story	Load	1st model Bare frame	2nd model with MW	3rd model SW1	4th model SW2	5th model SW3
20	SPECX	53.6	7.407	3.513	3.794	3.536
19	SPECX	51.6	7.356	3.48	3.74	3.503
18	SPECX	48.7	7.263	3.427	3.666	3.45
17	SPECX	44.9	7.125	3.354	3.574	3.377
16	SPECX	40.7	6.945	3.262	3.462	3.285
15	SPECX	37.2	6.725	3.152	3.331	3.174
14	SPECX	34.7	6.467	3.025	3.183	3.046
13	SPECX	32	6.171	2.88	3.017	2.901
12	SPECX	29.2	5.838	2.72	2.835	2.739
11	SPECX	26.2	5.47	2.544	2.638	2.562
10	SPECX	23.3	5.071	2.354	2.428	2.371
9	SPECX	20.8	4.647	2.153	2.206	2.168
8	SPECX	18.3	4.194	1.94	1.973	1.953
7	SPECX	15.7	3.716	1.716	1.73	1.727
6	SPECX	13	3.215	1.483	1.48	1.492
5	SPECX	10.3	2.693	1.241	1.224	1.249
4	SPECX	8.1	2.171	0.998	0.969	1.003
3	SPECX	5.8	1.632	0.749	0.712	0.753
2	SPECX	3.6	1.083	0.497	0.459	0.499
1	SPECX	1.4	0.523	0.242	0.216	0.243

Table 1.2: Story displacement in mm

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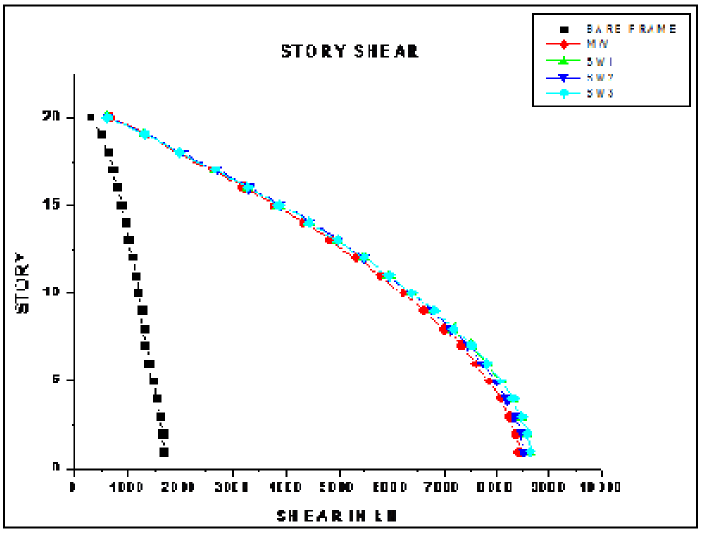

Fig 1.4:Story shear vs story

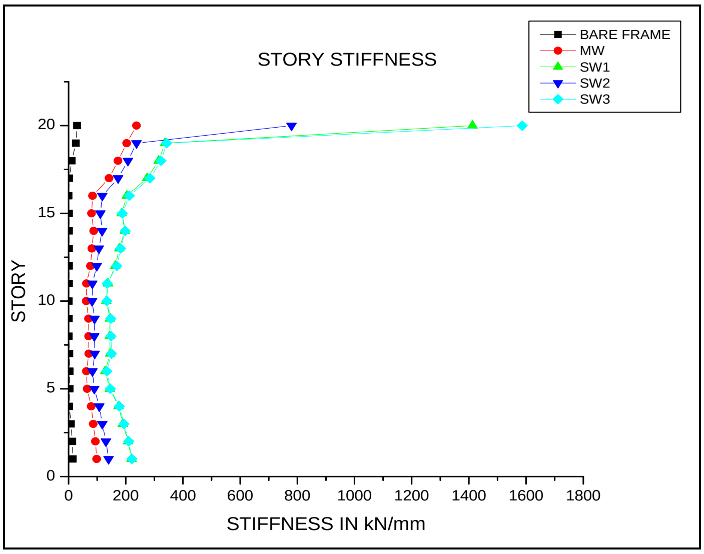

Fig 1.5:Story stiffness vs story

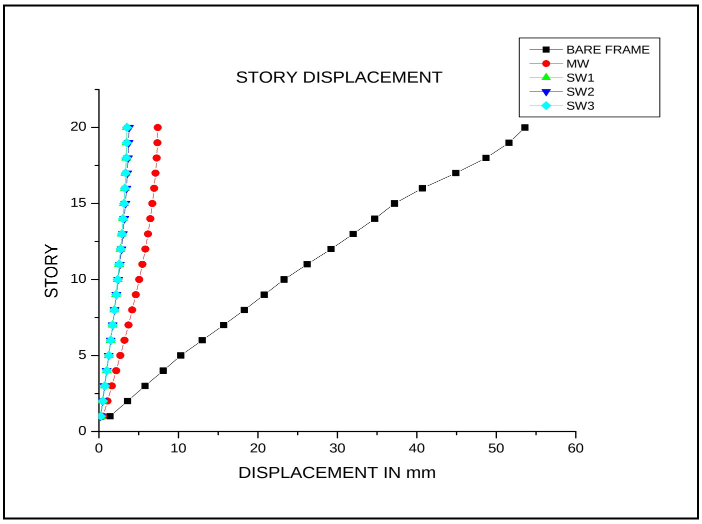

Fig 1.6:Story displacement vs story

		1st model	2nd model	3rd model	4th model	5th model
Story	Load	Bare frame	with MW	SW1	SW2	SW3
20	SPECY	278.97	657.37	629.23	637.16	625.30
19	SPECY	486.41	1328.99	1346.04	1357.76	1339.42
18	SPECY	606.90	1978.67	2034.51	2045.81	2027.13
17	SPECY	681.83	2601.21	2690.20	2698.54	2683.18
16	SPECY	746.22	3194.97	3311.54	3315.96	3305.36
15	SPECY	811.18	3767.82	3903.37	3905.44	3898.21
14	SPECY	880.24	4317.40	4465.08	4465.20	4461.90
13	SPECY	944.89	4837.71	4991.53	4990.18	4991.16
12	SPECY	1003.97	5327.52	5483.17	5480.61	5485.86
11	SPECY	1057.52	5785.69	5940.33	5936.31	5946.00
10	SPECY	1105.74	6215.78	6366.32	6360.77	6376.62
9	SPECY	1151.65	6616.46	6761.33	6752.72	6776.45
8	SPECY	1194.83	6981.74	7120.66	7107.23	7140.52
7	SPECY	1239.99	7309.57	7443.32	7423.18	7467.33
6	SPECY	1293.60	7598.07	7727.57	7698.89	7755.11
5	SPECY	1359.25	7850.44	7977.39	7937.11	8007.34
4	SPECY	1434.11	8065.02	8188.45	8135.40	8220.68
3	SPECY	1503.48	8232.33	8352.14	8286.14	8386.06
2	SPECY	1552.89	8347.20	8464.25	8386.28	8498.99
1	SPECY	1573.47	8403.94	8520.22	8433.64	8555.14

Table 1.3: Story shear in KN

		1st model	2nd model	3rd model	4th model	5th model
Story	Load	Bare frame	with MW	SW1	SW2	SW3
20	SPECY	29.81	237.50	1412.74	779.81	1586.25
19	SPECY	25.57	203.07	337.44	237.59	343.07
18	SPECY	11.11	172.94	315.18	207.75	323.10
17	SPECY	2.29	141.76	274.82	173.09	284.56
16	SPECY	0.15	83.96	203.46	117.90	212.58
15	SPECY	1.46	80.24	185.97	111.34	188.10
14	SPECY	1.47	88.16	196.97	117.05	197.85
13	SPECY	1.74	81.76	177.64	106.00	181.93
12	SPECY	1.73	76.99	163.38	98.68	168.59
11	SPECY	1.66	62.97	138.50	83.06	134.81
10	SPECY	0.89	62.16	131.90	82.54	133.83
9	SPECY	1.01	70.13	144.97	90.63	147.82
8	SPECY	0.71	70.37	143.84	89.88	148.42
7	SPECY	2.91	70.73	145.51	91.45	150.12
6	SPECY	4.16	62.31	127.98	83.51	133.64
5	SPECY	4.00	65.15	144.60	89.93	146.20
4	SPECY	2.39	79.32	174.85	107.81	177.64
3	SPECY	8.31	86.23	189.58	117.97	193.55
2	SPECY	13.11	93.92	207.97	130.64	210.29
1	SPECY	14.70	99.27	220.33	140.11	221.07

Table 1.4: Story stiffness in kN/mm

		1st model	2nd model	3rd model	4th model	5th model
Story	Load	Bare frame	with MW	SW1	SW2	SW3
20	SPECY	58.2	8.254	4.097	6.654	4.011
19	SPECY	55.8	8.194	4.035	6.547	3.955
18	SPECY	52.4	8.086	3.951	6.41	3.878
17	SPECY	48.3	7.929	3.847	6.24	3.78
16	SPECY	43.7	7.726	3.722	6.036	3.661
15	SPECY	39.9	7.477	3.577	5.799	3.523
14	SPECY	37.1	7.187	3.415	5.532	3.368
13	SPECY	34.1	6.855	3.236	5.235	3.194
12	SPECY	30.9	6.482	3.04	4.909	3.004
11	SPECY	27.7	6.071	2.829	4.557	2.799
10	SPECY	24.5	5.625	2.604	4.181	2.58
9	SPECY	21.9	5.152	2.369	3.787	2.35
8	SPECY	19.2	4.647	2.123	3.374	2.108
7	SPECY	16.4	4.115	1.868	2.945	1.857
6	SPECY	13.5	3.559	1.604	2.505	1.597
5	SPECY	10.6	2.979	1.335	2.056	1.331
4	SPECY	8.3	2.399	1.067	1.612	1.065
3	SPECY	6	1.803	0.796	1.171	0.795
2	SPECY	3.6	1.195	0.524	0.742	0.524
1	SPECY	1.4	0.576	0.254	0.338	0.254

Table 1.5: Story displacement in mm

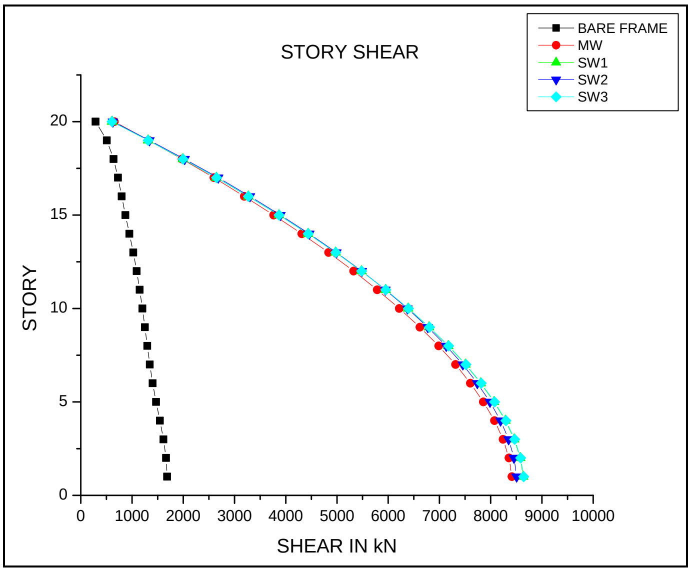

Fig 1.7:Story shear vs story

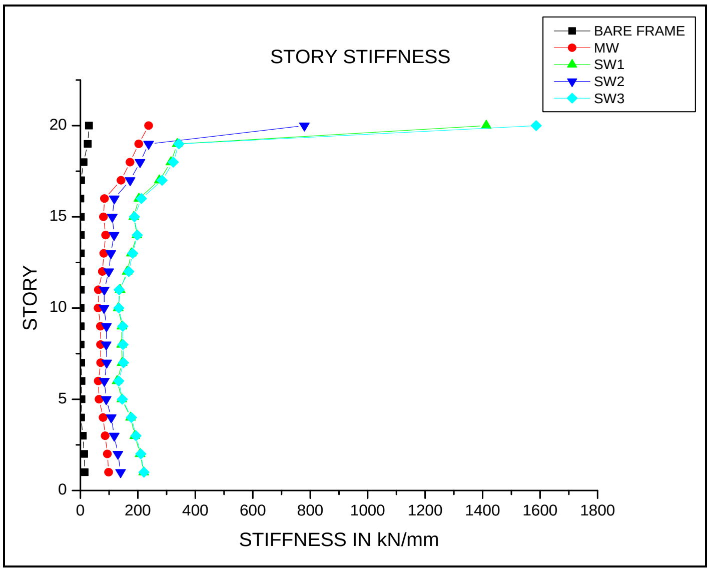

Fig 1.8:Story stiffness vs story

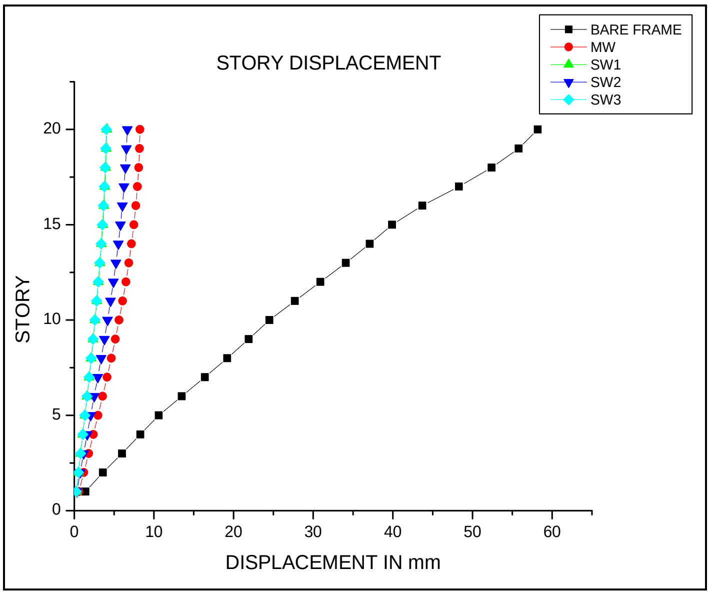

Fig 1.9:Story displacement vs story

2.3 Results and Discussion:

We have seen that if the resistance to the lateral force is more, then the displacement of the structure as well as drift is less. Most of the forces are resisted by shear walls. So in our analysis the better position of shear wall is at the outer periphery. From the above tables we can see that the displacement as well as stiffness of 1st configuration is better compared to other configurations in X (SPECX) direction. But in case of SPECY inner core performs better compared to other position of shear walls. The results were compared to bare frame and expressed in terms of percentage. When the analysis was carried out for 20 storied structures, story shear of (Model 2)(Masonry wall structure) is 56% greater than bare frame.(Model 3) is around 52.8%,(Model 4) is 54% and (Model 5) is 52% more than bare frame in X direction.

Similarly when the stiffness calculations were made we observed that (Model 2) is 88 %,(Model 3) is 98 %,(Model 4) is 97% and (Model 5) is 97.5% greater than bare frame structure. So when the stiffness parameter is considered we can see that the shear walls at the outer periphery performs well than the other configuration. Another important parameter to be discussed is story displacement. Story displacement of (Model 2) (MW) is 86% less than bare frame. (Model 3) is 93.3 %,(Model 4) is 92.9% and (Model 5) is 93.4% less than bare frame. In this case we can see that the displacement of Shear walls at the outer periphery is less compared to other positions. So the best configuration is that position of shear wall which has less displacement and has high stiffness. So the best position of shear wall is at the outer periphery i.e. (SW1). Similarly when the analysis was carried out in Y direction (Model 2) is 57.68% more than bare frame. (Model 3) is 55.8 %,(Model 4) is 56.35% and (Model 5) is 55.52% more than (Model 1).When it comes to stiffness of the structure masonry wall structure was 87% stiffer than bare frame structure,(Model 3) was 98%,(Model 4) was 96% and (Model 5) was 98.2% stiffer than bare frame. When story displacement was considered masonry wall structure was 86% less displaced compared to bare frame structure,(Model 3) was 93%,(Model 4) was 88% and (Model 5) was 93% less displaced compared to bare frame structure. Best position of shear wall here by observing the results was at the inner core.

2.4 Conclusion:

- To carry out the analysis 20 storied structures was modeled and results obtained by equivalent and response method were observed.
- The performance of the structure with shear wall performed very well compared to the structure with bare frame and masonry wall system.
- Introducing shear wall around 90% of stiffness is being increased and displacement is reduced by 95% when compared to bare frame and masonry wall structures.
- As the shear walls takes maximum amount of lateral forces the very important thing is the placing of shear walls. Models with different configuration are displayed above.
- From the analysis we come to know that the shear walls at the outer periphery performed very well compared to others as it takes high stiffness and less displacement. This is because the length of shear walls at the X direction is more compared to Y
- Similarly if the analysis is carried out at Y direction, Shear walls at the inner core performed very well because the length of shear wall in that direction is more.

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