Optimization of Outriggers System in High-rise Buildings

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Abstract : In High rise buildings, lateral loads induced by wind & earthquake are often resisted by a shear walls. But as height of building increases, the stiffness of the structure is note as more important and introduction of outrigger beams connect to the central core walls and external columns. It is provide sufficient lateral stiffness to the structure. In this paper, analysis of High rise building is carried out to find the optimizing position of outrigger system by using lateral loads. The model is analyzed in ETABS. The objective of this paper was to optimize the outrigger location. Comparing when Two , Three & Four no. of outriggers located in the structure. From the analysis, To find out result that the performance of the outrigger was efficient and three optimum position of outrigger has been found i.e. at mid height of building, second at Ht/3 and third at Ht/4 of building. In which one outrigger fixed at terrace floor.

Keywords: RCC + Steel Structure building, Control stiffness, storey Drift & Displacement, Optimum outrigger

I. INTRODUCTION

All The major factor that affects the design of High-rise structures is its sensitivity to the lateral load. One of the important criteria for the design of High-rise buildings is lateral drift at top. Structural system like moment resisting frame & shear wall gives primary need of building but as building as height increases there lateral load i.e. wind and earthquake effects on building structure. Two categories of structural system i.e. Interior structures and Exterior structures. When the maximum part of the lateral load resisting system is located within the internal in perimeter of the building it is called as interior structure and if the maximum part of the lateral load resisting system is located at the building perimeter, a system is categorized as an exterior structure. Recently, belt truss and outrigger system is widely used to reduce lateral drift & displacement. The placement of outrigger trusses increases the effective depth of the structure and significantly improves the lateral stiffness under lateral load.

The outrigger structural systems not only pro-efficient in controlling the top displacements but also plays good role in reducing the drift of stories. The outrigger systems can produce in any combination of steel members, concrete , Concrete core and composite construction. Outrigger trusses increases the effective depth and significantly improves the lateral stiffness under lateral load. Outrigger may connected to all side of central core to peripheral columns of building.

Objectives:

1) To obtain the optimized location of outrigger to reduce lateral drift.
2) To obtain the optimized location of outrigger to reduce lateral displacement.
3) To compare building with or without outrigger system.

II. WORK CARRIED OUT

A Basement + 2Parking + 40Floors + Terrace reinforced concrete building was analysed using ETABS software. The lateral loads to be applied on the buildings were based on the Indian Standard. Building was analysed under wind and earthquake loads as per the recommendation of IS: 875 (Part III) 1987 & IS 1893 (Part I) 2002 resp. The building was analysed for Pune city considering its respective seismic zone III wind speed. To improve the performance of building in lateral load outrigger trusses are provided. The analysis was carried out for building with central core connected by outrigger with peripheral outrigger connected of 300mm thick concrete wall upto 10th floor & upto Terrace 450mm thick concrete wall provided at each floor from bottom to top respectively.

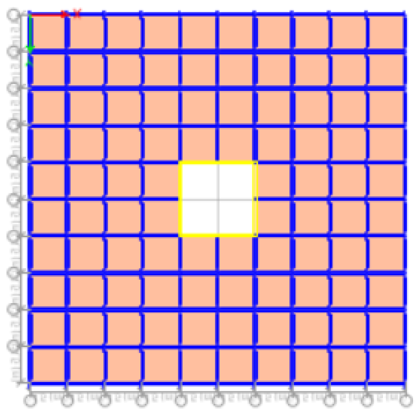
After running analysis for without outrigger system the maximum deflection & drift of building were calculated. To find the position of outrigger system, two number of outrigger system were located at top & center of building & it is analyzed that maximum deflection & drift reduction at level of outrigger system provided.

Then to find second position of outrigger first outrigger were fixed at its position and second outrigger were provided at each floor from bottom to top respectively and maximum deflection reduction were calculated. Same procedure were followed for minimizing displacement & drift by providing different position of outrigger system where outrigger provided by dividing building equally by three & four parts respectively. Comparative graphs have been plotted for building with and without outrigger.

III. Project Description

Sr. No.	Description	Parameter
1	Plan Of Building	45M X 45M
2	Height Of Building	138.4m
3	No. Of stories	45
4	Floor to Floor height	3m
5	Seismic Zone	III
6	Basic Wind Speed	44m/s
7	Steel Section Size	
	Angular	ISMB350
	Horizontal	ISMB450
8	Column Size	
	Base to 10th	C600 X 1200
	11th to 20th	C500 X 1200
	21st to 30th	C450 X 1200
	31st to Terrrace	C400 X 1200
9	Core Beam Size	B300 X 600
10	Core Wall width	
	Base to 10th	450mm
	11th to Above	300mm
11	Thickness of Slab	200mm
12	Type Of main steel	Fe500
13	Type Of distribution steel	Fe415
14	Grade Of Concrete	
	Column	M50
	Beam	M40
	Slab	M35

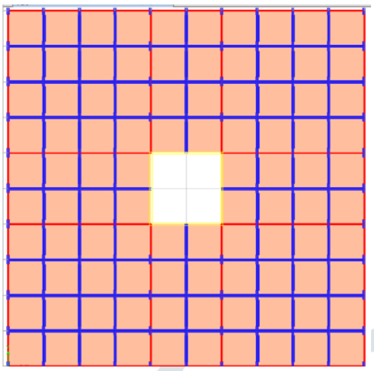
IV. Plan Of Building without outrigger system

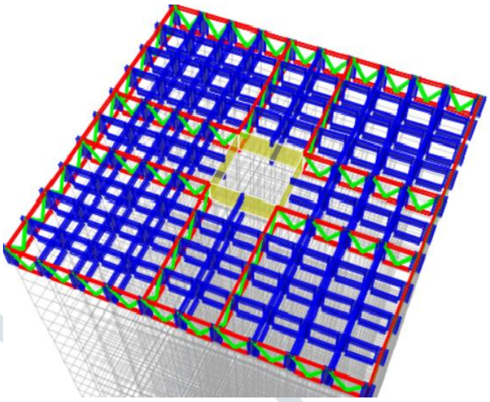


V. Modelling:

Building consists of reinforced concrete flat slab model without drop and column head. The model is regular shaped symmetrical plan with dimensions 45m x 45m and Basement + 2Parking + 40Floors + Terrace. The plan has centrally located concrete core of size 9m x 9m. The storey height is assumed to be 3m. The three dimensional analysis for the model is carried out. After performing the wind and seismic analysis on building model deflection and drift result where evaluated. To control deflection and drift outrigger were provided in the building and their positions were calculated for maximum deflection reduction.

VI. Plan Of Building with outrigger system and 3D View





VII. Result

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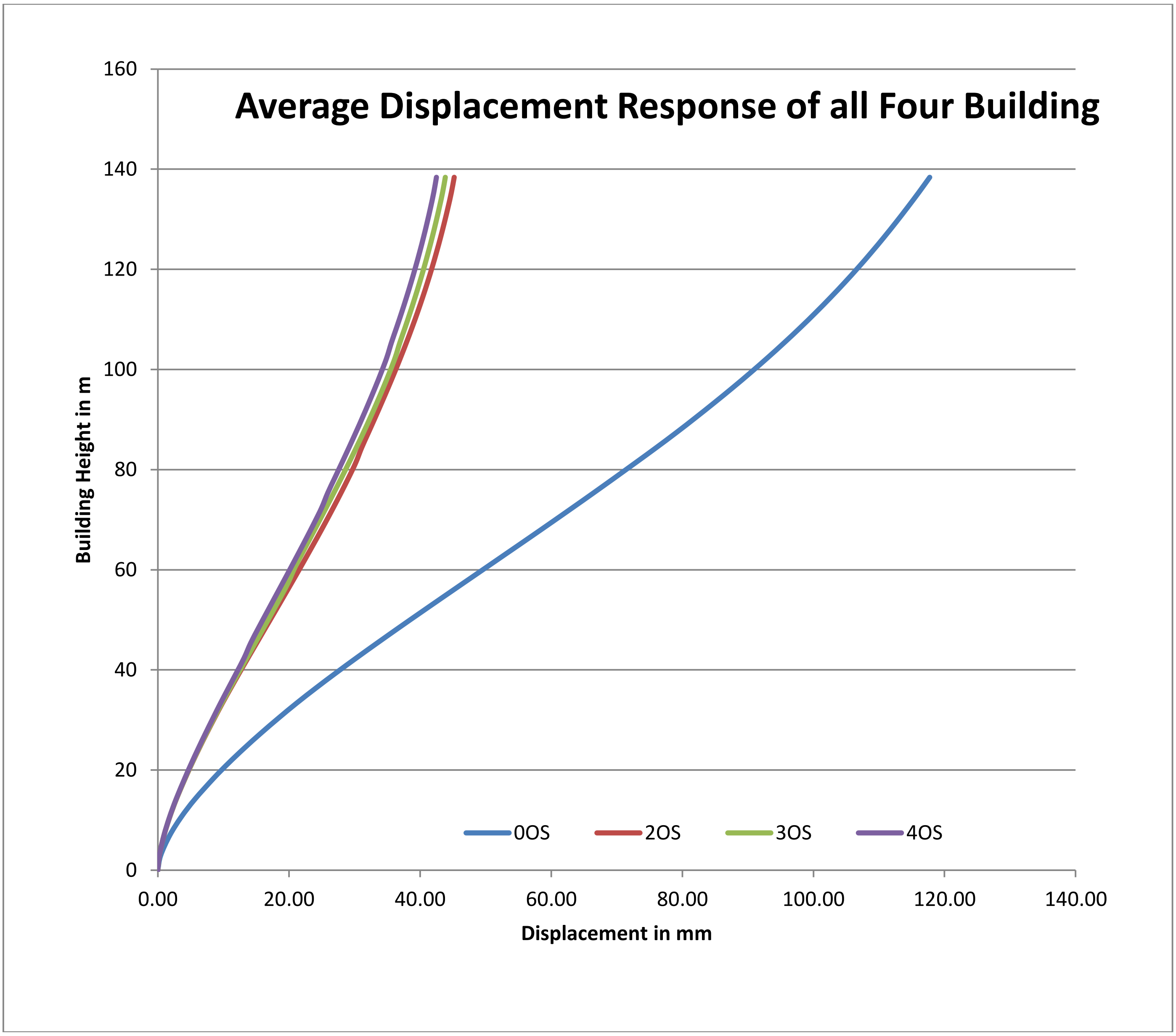
VIII. Prepare Your Paper Before Styling

Result Showing Average Displacement Results of all four Building Outrigger System

Story	Elevation	0OS	2OS	3OS	4OS
TERRACE	138.4	117.74	45.19	43.85	42.503
40	135.4	116.08	44.77	43.43	42.101
39	132.4	114.36	44.25	42.94	41.615
38	129.4	112.58	43.70	42.40	41.089
37	126.4	110.75	43.11	41.84	40.529
36	123.4	108.84	42.49	41.24	39.933
35	120.4	106.85	41.82	40.60	39.301
34	117.4	104.77	41.12	39.93	38.633
33	114.4	102.61	40.38	39.23	37.930
32	111.4	100.36	39.59	38.48	37.194
31	108.4	98.01	38.77	37.71	36.428
30	105.4	95.57	37.91	36.92	35.642
29	102.4	93.04	37.01	36.20	34.934
28	99.4	90.42	36.09	35.33	34.072
27	96.4	87.70	35.13	34.39	33.156
26	93.4	84.90	34.14	33.41	32.199
25	90.4	82.03	33.14	32.40	31.215
24	87.4	79.07	32.11	31.35	30.198
23	84.4	76.01	31.09	30.27	29.155
22	81.4	72.87	30.18	29.15	28.091
21	78.4	69.69	29.09	28.01	27.011
20	75.4	66.49	27.94	26.85	25.935
19	72.4	63.24	26.75	25.67	24.997
18	69.4	59.96	25.53	24.47	23.872
17	66.4	56.65	24.28	23.27	22.698
16	63.4	53.32	23.00	22.06	21.497
15	60.4	49.99	21.71	20.88	20.284
14	57.4	46.65	20.40	19.86	19.057
13	54.4	43.32	19.08	18.66	17.823
12	51.4	40.01	17.75	17.41	16.591
11	48.4	36.72	16.41	16.14	15.367

10	45.4	33.47	15.08	14.86	14.178
9	42.4	30.28	13.75	13.57	13.168
8	39.4	27.16	12.43	12.29	11.985
7	36.4	24.12	11.13	11.03	10.780
6	33.4	21.19	9.86	9.78	9.581
5	30.4	18.41	8.65	8.59	8.431
4	27.4	15.75	7.47	7.42	7.302
3	24.4	13.20	6.33	6.29	6.203
2	21.4	10.78	5.24	5.21	5.143
1	18.4	8.53	4.20	4.18	4.132
P2	14.2	5.66	2.83	2.82	2.796
P1	10.6	3.56	1.81	1.81	1.795
GR	7	1.84	0.96	0.96	0.952
B1	3	0.45	0.25	0.25	0.245
Base	0	0.00	0.00	0.00	0.000
	MAX =	117.7350	45.1923	43.8453	42.5028

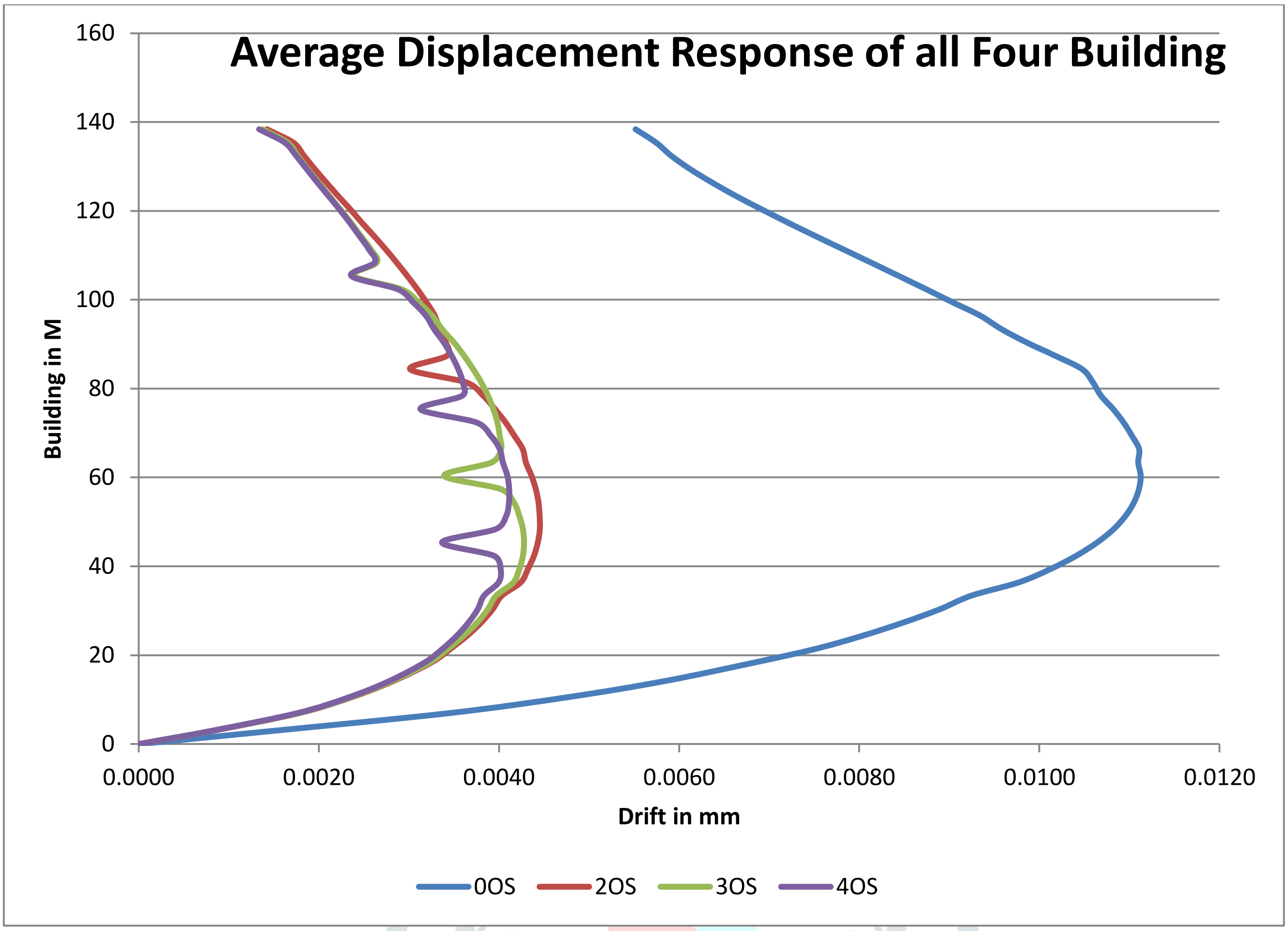
COMPARISON SHOWING AVERAGE DISPLACEMENT OF ALL OUR BUILDING OUTRIGGER SYSTEM



Result Showing Average Drift Results of all four Building Outrigger System

Story	Elevation	0OS	2OS	3OS	4OS
TERRACE	138.4	0.0055	0.0014	0.0014	0.0013
40	135.4	0.0057	0.0017	0.0017	0.0016
39	132.4	0.0059	0.0018	0.0018	0.0018
38	129.4	0.0061	0.0020	0.0019	0.0019
37	126.4	0.0064	0.0021	0.0020	0.0020
36	123.4	0.0066	0.0022	0.0021	0.0021
35	120.4	0.0069	0.0024	0.0022	0.0022
34	117.4	0.0072	0.0025	0.0024	0.0023
33	114.4	0.0075	0.0026	0.0025	0.0025
32	111.4	0.0078	0.0027	0.0026	0.0026
31	108.4	0.0081	0.0029	0.0026	0.0026
30	105.4	0.0084	0.0030	0.0024	0.0024
29	102.4	0.0087	0.0031	0.0029	0.0029
28	99.4	0.0090	0.0032	0.0031	0.0031
27	96.4	0.0093	0.0033	0.0033	0.0032
26	93.4	0.0096	0.0033	0.0034	0.0033
25	90.4	0.0099	0.0034	0.0035	0.0034
24	87.4	0.0102	0.0034	0.0036	0.0035
23	84.4	0.0105	0.0030	0.0037	0.0035
22	81.4	0.0106	0.0036	0.0038	0.0036
21	78.4	0.0107	0.0038	0.0039	0.0036
20	75.4	0.0108	0.0040	0.0039	0.0031
19	72.4	0.0109	0.0041	0.0040	0.0038
18	69.4	0.0110	0.0042	0.0040	0.0039
17	66.4	0.0111	0.0043	0.0040	0.0040
16	63.4	0.0111	0.0043	0.0039	0.0040
15	60.4	0.0111	0.0044	0.0034	0.0041
14	57.4	0.0111	0.0044	0.0040	0.0041
13	54.4	0.0111	0.0044	0.0042	0.0041
12	51.4	0.0110	0.0045	0.0042	0.0041
11	48.4	0.0108	0.0045	0.0043	0.0040
10	45.4	0.0106	0.0044	0.0043	0.0034
9	42.4	0.0104	0.0044	0.0043	0.0039
8	39.4	0.0101	0.0043	0.0042	0.0040
7	36.4	0.0098	0.0042	0.0042	0.0040
6	33.4	0.0092	0.0040	0.0040	0.0038
5	30.4	0.0089	0.0039	0.0039	0.0038
4	27.4	0.0085	0.0038	0.0038	0.0037
3	24.4	0.0080	0.0036	0.0036	0.0035
2	21.4	0.0075	0.0035	0.0034	0.0034
1	18.4	0.0068	0.0033	0.0032	0.0032
P2	14.2	0.0058	0.0028	0.0028	0.0028
P1	10.6	0.0048	0.0024	0.0024	0.0023
GR	7	0.0035	0.0018	0.0018	0.0018
B1	3	0.0015	0.0008	0.0008	0.0008
Base	0	0.0000	0.0000	0.0000	0.0000
	MAX=	0.0111	0.0045	0.0043	0.0041

COMPARISON SHOWING AVERAGE DRIFT OF ALL OUR BUILDING OUTRIGGER SYSTEM



IV. RESULTS AND DISCUSSION

1. The maximum deflection at the top of structure when only flat slab with core is employed is around 625.7mm and this is reduces up to 411.18mm by providing first outrigger at mid height of structure i.e. 29.45% deflection reduction occurs for first position of outrigger.
2. The maximum deflection at top of structure reduces up to 335.15mm by providing second outrigger at 3/4th height of structure i.e. 43.94% deflection reduction occurs for second position of outrigger.
3. The maximum deflection at top of structure reduces up to 272.77mm by providing third outrigger at 1/3rd height of structure i.e. 54.98 % deflection reduction occurs for third position of outrigger. The Axial force goes on decreasing as infill wall with different openings like corner and centre are provided.
4. The use of outrigger structural systems in high-rise buildings increases the stiffness and makes the structural form efficient under lateral load.
5. Outrigger system is not only proficient in controlling the overall lateral displacement but also very capable of reducing the inter-storey drifts in tall building.

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