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Dynamic Behavior of Core Wall and Outrigger Structural System in Tall Building.

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Abstract
Tall building development has been rapidly increasing worldwide introducing new challenges that need to meet through engineering judgment. As the height of the building increases the stiffness of the building reduces. Therefore to improve the performance of the building under seismic loading, outrigger system is proposed in the present study of work. In the present work, contains a comparative study on regular building with and without outrigger and irregular building with and without outrigger with centrally rigid shear wall and steel bracings as outrigger. The modeling of the structure is done using "ETABS" program. The analysis of the model is carried out by equivalent static method and response spectrum method. The stiffness and efficiency characteristics of the structure is measured in terms of lateral displacement, drift, base shear and fundamental natural period for different types of buildings to provide stiffness against static and dynamic loads. The parameters should be minimized to prevent damage to the buildings.
Keywords – *ETABS , Response Spectrum Analysis , Vertical Irregularity , Outriggers System , High Rise RC Building.*

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I. INTRODUCTION

Now a day it is the most common trend in the world of structures to go for the tall buildings, this trend has raised many issues with it to be taken into consideration; the major issue that affects the design of tall structures is its sensitivity to the lateral load. One of the important criteria for the design of tall buildings is lateral sway (deflection) and storey drift together along with the strength criteria. The development of tall building has always fascinated mankind from the ancient times. From the past, tall structures have always seen as a symbolic example of power and development. The challenging task in the construction field is to assemble the tall building. The design of tall building is based on analysis of models with experience and fundamental mechanics. As the height of the building increases the risk of horizontal and vertical load forces also increases. The moment resisting frames and braced core at certain height becomes inefficient to provide stiffness against wind and seismic loads. The lateral deflections due this load should be prevented for both structural and non structural damage to achieve the building strength and also stiffness against lateral loads in the analysis and design of tall building. To increase stiffness action against wind and seismic load outriggers are provided by the shear core with exterior frames in tall buildings.

1.1Outrigger Structural System

In this system, the centrally rigid core is positioned, either RCC wall system or rigid column frame systems. The horizontal ties are associated from the core to the extreme end till the column. This method reduces the hindrance in the floors and increases the ;strength tremendously. The outrigger arms are used for circuiting and for other services.

There are two types of outrigger system

1. Conventional outrigger system
2. Virtual outrigger system

Conventional outrigger system

In the conventional outrigger system, the outrigger trusses or girders are connected directly to shear walls or braced frames at the core and to columns located outboard of the core. Typically (but not necessarily), the columns are at the outer edges of the building. Figure 1.9 is an idealized section through a tall building.

Virtual outrigger system

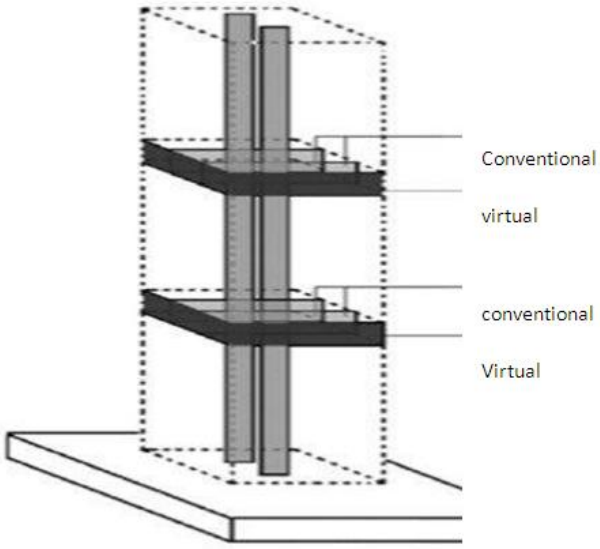

Fig. 1Types of Outrigger

Virtual outrigger system

In the conventional outrigger system, outrigger trusses connected directly to the core and to outboard columns convert the "virtual" outrigger concept, the same transfer of overturning moment from the core to elements outboard of the core is achieved, but without a direct connection between the outrigger trusses and the core. The elimination of a direct connection between the trusses and the core avoids many of the problems associated with the use of outriggers.

1.2Response Spectrum Analysis

In the response spectrum method of analysis, multiple mode of vibrations were used in the frequency domain. The response of a multi-storey structure is defined as a combination of various special modes i.e. in a vibrating string corresponds to the "harmonics". The co mputer program is used to determine this special mode of structure. For each mode, a response is recorded from the design response spectrum, based on the modal mass and the modal frequency; they are then combined to estimate the total response of the structure. In the present study, the magnitude of forces in all directions i.e. X, Y & Z were calculated and then the effects of lateral forces on the building were analysed. The design acceleration coefficient for different soil types and response spectrum graph obtained from the IS 1893:2016 (part 1) used in the present study is shown in the Fig. 1.

$$\frac{S_a}{g} = \begin{cases} \text{Rock or Hard soil} & \begin{cases} 1+15\,T & T<0.10\text{ s} \\ 2.5 & 0.10\text{ s}<T<0.40\text{ s} \\ \dfrac{1}{T} & 0.40\text{ s}<T<4.00\text{ s} \\ 0.25 & T>4.00\text{ s} \end{cases} \\ \text{Medium/stiff soil} & \begin{cases} 1+15\,T & T<0.10\text{ s} \\ 2.5 & 0.10\text{ s}<T<0.55\text{ s} \\ \dfrac{1.36}{T} & 0.55\text{ s}<T<4.00\text{ s} \\ 0.34 & T>4.00\text{ s} \end{cases} \\ \text{Soft Soils} & \begin{cases} 1+15\,T & T<0.10\text{ s} \\ 2.5 & 0.10\text{ s}<T<0.67\text{ s} \\ \dfrac{1.67}{T} & 0.67\text{ s}<T<4.00\text{ s} \\ 0.42 & T>4.00\text{ s} \end{cases} \end{cases}$$

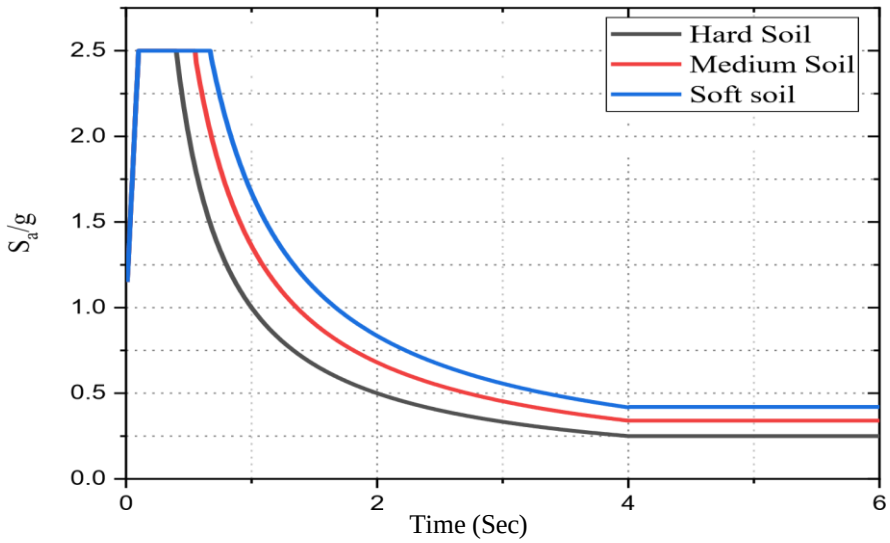

Figure 2. Design Response Spectrum for different soil (5% damping)

1.3 Vertical irregularity:

The structural irregularity is widely observed in buildings as a result of the architectural and service requirements in the design process, errors and modifications during the construction phase, and changes in the building use throughout its service life. Modern seismic design codes distinguish between the plan and vertical irregularity . The plan (horizontal) irregularity occurs as a result of several reasons such as when the structure is significantly subjected to torsion or exhibit a discontinuity in the lateral force resisting system (LFRS) out of its plane (out of plane offset). The vertical irregularity may occur due to significant changes in the stiffness, strength, mass, dimensions, or a discontinuity in the LFRS plane. The tendency to distinguish between irregularity in plan and in elevation also characterizes the scientific literature. The growing interest in investigating the seismic behavior of building irregularity has been shown in the literature, particularly for vertical irregularity . However, the impacts of different types of vertical irregularity on the seismic design of buildings have not been systematically covered in the literature, particularly the extreme irregularity of real-life high-rise structures.

1.4 OBJECTIVES:

- To study the effects of Tall structural system as per the IS 16700-2017.
- To know the effects of core wall on dynamic behavior of tall structural RC structural systems.
- The Tall building with outriggers are compared for different zones (zone 2).
- Outriggers are located at one fourth of the building i.e at (story 8, story 16, story 24, story 32)
- To compare the effects of outriggers dynamic analysis method is used (response spectrum method).
- The results of story shear,drift ,displacement and overturning moments are studied .

II. METHODOLOGY

- Initially as per the clause 3.12 of IS 16700:2017 ‘Criteria of Structural Safety of Tall Concrete Buildings’ three types of structural systems are considered:
  - Moment Frame System .
  - Moment Frame Structural Wall System and
  - Core and Outrigger Structural System.
- Height limit, Slenderness ratio and Plan aspect ratio are considered as per the Clause 5.1 and 5.2 of IS 16700:2017.
- Three types of outrigger structural forms are considered for connecting core wall to peripheral shear walls.
  - Structural Steel outrigger
  - RC deep girder beam type outrigger
  - RC Wall type outrigger
- All the 5 types of structural forms are modelled in ETABS 2016 by considering optimum frame sections, area sections and wall section properties.
- Key responses like modal analysis results, later drifts and displacements, member forces, overturning moments are extracted and evaluated.

- Based on the overall performance, the best outrigger system out of three types with core wall is recommended.

2.1 MATERIAL SPECIFICATION:

Concrete:

- M45 grade concrete is used for footing, beams, slabs and columns.

Reinforcement steel:

- HYSD550

Loads and combinations:

- Any structure is made up of structural and non structural elements. The structural elements put together is known as structural system.
- This refers to a load resisting system of a structure.
- The load is transfered from slabs to beams, then to columns, then to foundation.

SEISMIC LOADS

- Seismic design shall be done in accordance with IS: 1893:2002. The building is situated in earthquake zone II.
- The parameters to be used for analysis and design are given below (As per IS: 1893:2002 (Part I)).
  - Zone : 2,
  - Zone factor : 0.1
  - Importance factor : 1.5(Refer Table 6)
  - Response reduction Factor : 5(Refer Table 7) Ordinary RC Moment Resisting frame (OMRF)
  - Soil Type : Medium
  - Structure Type : RC Frame Structure.

Model Geometry

The Building consider is a 32 -story height. It Is a RCC framed structure. The floors are modelled as rigid slab section.

III. ANALYSIS RESULTS AND DISCUSSIONS

General :

In the present work, the effect of core wall and outrigger on dynamic behavior of the tall structural systems are studied. The tall structural systems are considered as per the recommendation from IS 16700-2017 code.

MODEL ANALYSIS:

Max story displacement for combo:0.9deadload+0.9superdead load+1.5RS-X(DCON12-ZONE2)

Table 1 Max Story Displacement-X Direction

TABLE: Story Response			STORY8	STORY16	STORY24	STORY32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	M		mm	Mm	mm	Mm
32	96	Top	309.694	288.834	294.941	309.694
31	93	Top	296.853	277.386	283.131	296.853
30	90	Top	283.974	265.896	271.283	283.974
29	87	Top	271.121	254.408	259.445	271.121
28	84	Top	258.294	242.931	247.618	258.294
27	81	Top	245.572	231.534	235.879	245.572
26	78	Top	232.956	220.214	224.226	232.956
25	75	Top	220.475	208.993	212.682	220.475
24	72	Top	208.167	197.938	200.153	208.167
23	69	Top	196.125	187.084	190.237	196.125
22	66	Top	184.316	176.386	179.239	184.316
21	63	Top	172.649	165.843	168.312	172.649

20	**60**	**Top**	**161.196**	**155.409**	**157.573**	**161.196**
19	**57**	**Top**	**149.884**	**145.044**	**146.962**	**149.884**
18	**54**	**Top**	**138.901**	**134.963**	**136.618**	**138.901**
17	**51**	**Top**	**128.175**	**125.02**	**126.459**	**128.175**
16	**48**	**Top**	**117.733**	**115.341**	**116.61**	**117.733**
15	**45**	**Top**	**107.663**	**105.98**	**106.94**	**107.663**
14	**42**	**Top**	**97.762**	**96.687**	**97.449**	**97.762**
13	**39**	**Top**	**88.192**	**87.63**	**88.256**	**88.192**
12	**36**	**Top**	**79.001**	**78.7**	**79.192**	**79.001**
11	**33**	**Top**	**69.953**	**69.883**	**70.296**	**69.953**
10	**30**	**Top**	**61.067**	**61.215**	**61.486**	**61.067**
9	**27**	**Top**	**52.624**	**52.888**	**53.084**	**52.624**
8	**24**	**Top**	**44.552**	**44.909**	**45.045**	**44.552**
7	**21**	**Top**	**37.071**	**37.643**	**37.699**	**37.071**
6	**18**	**Top**	**29.96**	**30.269**	**30.289**	**29.96**
5	**15**	**Top**	**23.114**	**23.41**	**23.417**	**23.114**
4	**12**	**Top**	**16.581**	**16.8**	**16.804**	**16.581**
3	**9**	**Top**	**10.953**	**11.116**	**11.117**	**10.953**
2	**6**	**Top**	**6.141**	**6.282**	**6.266**	**6.141**
1	**3**	**Top**	**2.355**	**2.443**	**2.448**	**2.355**
0	**0**	**Top**	**0**	**0**	**0**	**0**

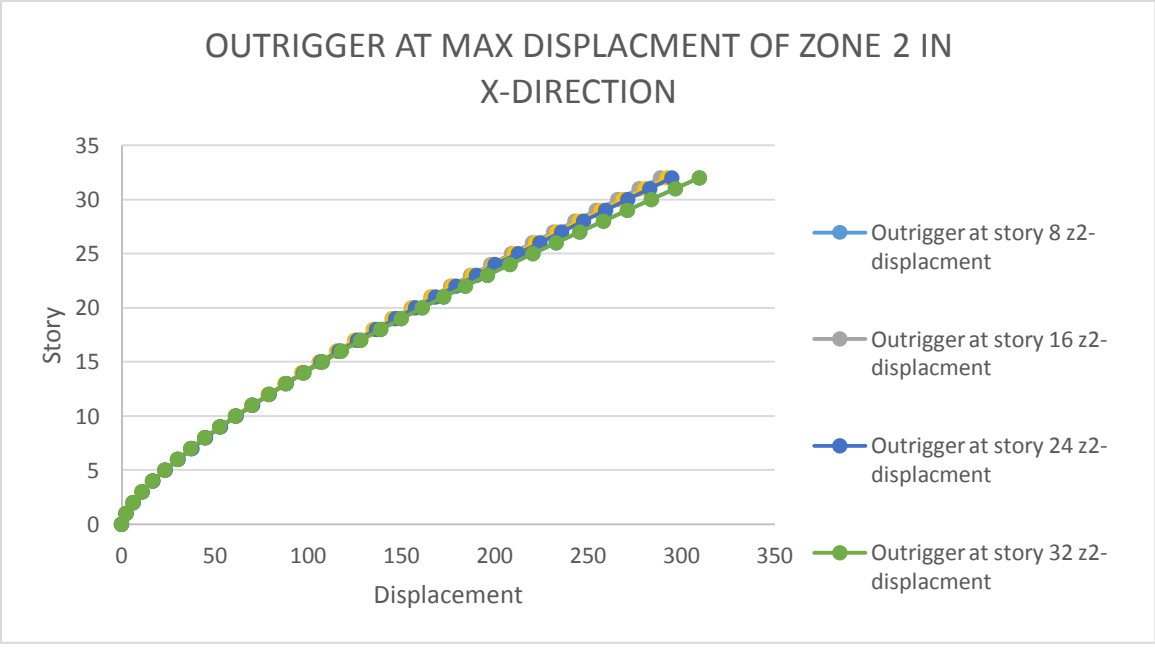

FIGURE 3: .STORY DISPLACEMENT VS STORY

- From the above table, it clearly shows that mini displacement is 288.83mm at story16 and max displacement is story11 at 340.38 for zone 2.
- Max displacement for story8 is 309.69mm, story21 is 292.39mm , story24 is 294.94mm and story32 309.69mm.
- By considering different stories , story 16 is getting minimum displacement and story 11 getting maximum story displacement which contains maximum zone factor 0.1(zone2).

Table 2. Max Story Displacement-Y Direction

TABLE: Story Response			stoey8	story 16	story24	story32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	m		M	m	M	M
32	96	Top	18.155	1.436	21.164	18.155
31	93	Top	17.398	1.391	20.332	17.398
30	90	Top	16.636	1.354	19.501	16.636
29	87	Top	15.861	1.308	18.654	15.861
28	84	Top	15.08	1.258	17.802	15.08
27	81	Top	14.32	1.212	16.958	14.32
26	78	Top	13.565	1.166	16.115	13.565
25	75	Top	12.816	1.118	15.273	12.816
24	72	Top	12.073	1.083	14.174	12.073
23	69	Top	11.337	1.03	13.615	11.337
22	66	Top	10.656	0.997	12.822	10.656
21	63	Top	9.935	0.955	12.008	9.935
20	60	Top	9.22	0.907	11.196	9.22
19	57	Top	8.446	0.825	10.329	8.446
18	54	Top	7.752	0.768	9.532	7.752
17	51	Top	7.079	0.737	8.764	7.079
16	48	Top	6.431	0.681	7.986	6.431
15	45	Top	5.813	0.613	7.247	5.813
14	42	Top	5.222	0.547	6.533	5.222
13	39	Top	4.741	0.558	5.924	4.741
12	36	Top	4.211	0.512	5.258	4.211
11	33	Top	3.678	0.458	4.608	3.678
10	30	Top	3.06	0.335	3.899	3.06
9	27	Top	2.577	0.286	3.303	2.577
8	24	Top	2.133	0.259	2.753	2.133
7	21	Top	1.848	0.293	2.333	1.848
6	18	Top	1.522	0.262	1.86	1.522
5	15	Top	1.22	0.226	1.425	1.22
4	12	Top	0.825	0.099	0.91	0.825
3	9	Top	0.58	0.068	0.578	0.58
2	6	Top	0.353	0.044	0.31	0.353
1	3	Top	0.148	0.027	0.115	0.148
0	0	Top	0	0	0	0

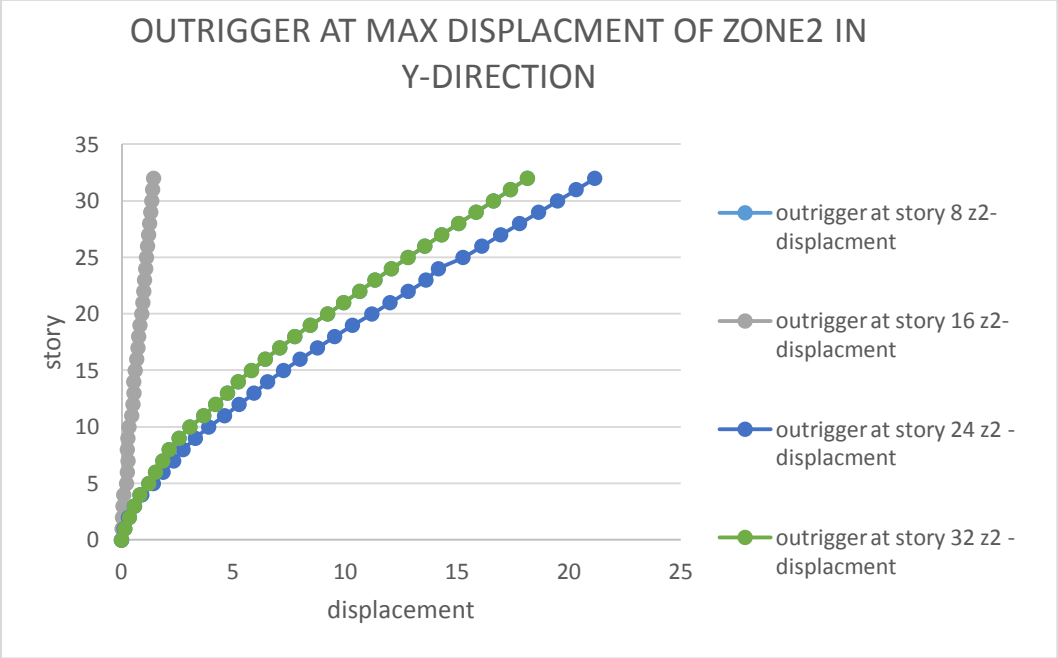

FIGURE 4. STORY DISPLACEMENT VS STORY

- Max story displacement for combo:0.9deadload+0.9superdead load+1.5RS-Y(DCON13-ZONE2).
- From the above table, it clearly shows that mini displacement is 143.6 mm at story16 and max displacement is story11 at 391.83 for zone 2.
- Max displacement for story8 is 181.55mm, story21 is 230.33mm , story24 is 211.64mm and story32 is 181.55mm.
- By considering different stories , story 16 is getting minimum displacement and story 11 getting maximum story displacement which contains maximum zone factor 0.1(zone2).

Table shows the variation of displacements with respect to each story along X and Y directions respectively. Corresponding variation of displacement along X and Y directions is presented in the form of graphs in Fig .

Max story drifts for combo:0.9deadload+0.9superdead load+1.5RS-X(DCON12-ZONE2)

Table .3 Max Story Drifts X-Direction

TABLE: Story Response			story8	story16	story21	story32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	m					
32	96	Top	0.00454	0.004072	0.004178	0.00454
31	93	Top	0.00458	0.004117	0.004244	0.00458
30	90	Top	0.004592	0.00414	0.004237	0.004592
29	87	Top	0.004619	0.004165	0.004269	0.004619
28	84	Top	0.004611	0.004164	0.004262	0.004611
27	81	Top	0.004604	0.004166	0.00426	0.004604
26	78	Top	0.004585	0.004157	0.004244	0.004585
25	75	Top	0.004548	0.004124	0.004208	0.004548
24	72	Top	0.004472	0.004064	0.00416	0.004472
23	69	Top	0.004433	0.004055	0.004111	0.004433
22	66	Top	0.004366	0.003987	0.004099	0.004366
21	63	Top	0.004292	0.003949	0.003974	0.004292
20	60	Top	0.004249	0.003906	0.003969	0.004249
19	57	Top	0.00411	0.003795	0.003843	0.00411

18	54	Top	0.004008	0.003725	0.003766	0.004008
17	51	Top	0.003896	0.003615	0.003652	0.003896
16	48	Top	0.003785	0.003469	0.003477	0.003785
15	45	Top	0.003647	0.00343	0.003447	0.003647
14	42	Top	0.00357	0.003354	0.003385	0.00357
13	39	Top	0.003371	0.003271	0.003277	0.003371
12	36	Top	0.003268	0.003181	0.00319	0.003268
11	33	Top	0.003194	0.003107	0.00313	0.003194
10	30	Top	0.002994	0.002944	0.00296	0.002994
9	27	Top	0.002847	0.002809	0.002826	0.002847
8	24	Top	0.002682	0.002649	0.002673	0.002682
7	21	Top	0.002493	0.002542	0.002497	0.002493
6	18	Top	0.002345	0.002359	0.002355	0.002345
5	15	Top	0.002228	0.002245	0.002235	0.002228
4	12	Top	0.001897	0.001914	0.001905	0.001897
3	9	Top	0.001616	0.001622	0.001627	0.001616
2	6	Top	0.001267	0.001285	0.001273	0.001267
1	3	Top	0.000785	0.000814	0.000789	0.000785
0	0	Top	0	0	0	0

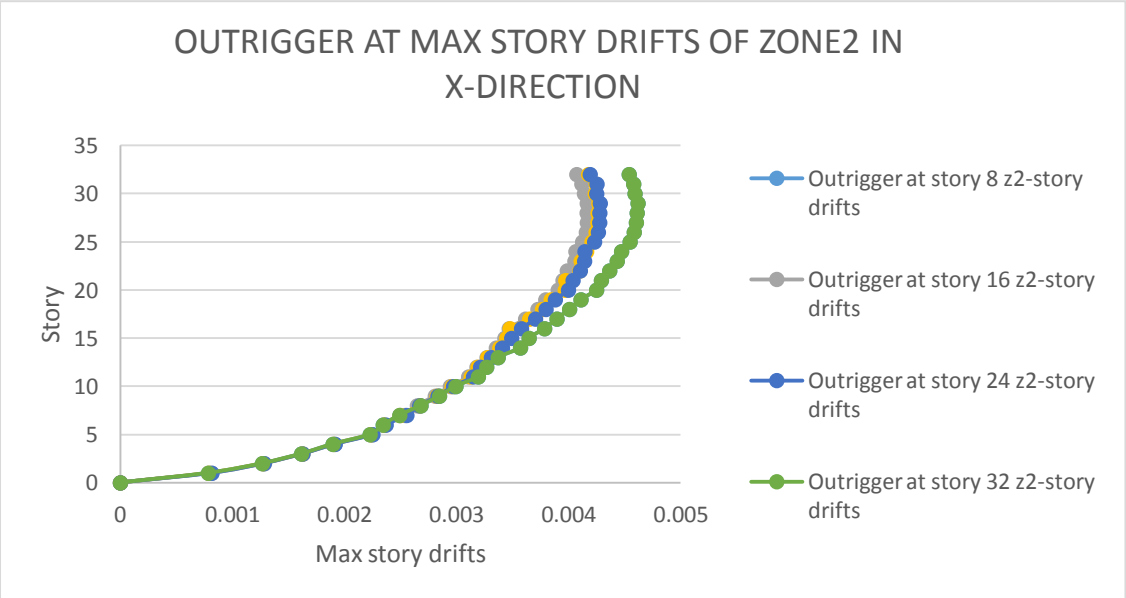

FIGURE 5. MAX STORY DRIFTS VS STORY

- From the above table, it clearly shows that max story drifts is minimum at story16 0.000018 and maximum is story11 at 0.000696 for zone 2.
- Max story drifts for story8 is 0.000273mm, story21 is 0.00287mm ,story24 is 0.000287mm and story32 is 0.00273mm
- By considering different stories,story16 getting minimum story drifts which contains maximum zone factor 0.1 (zone2).

Similar to story displacements, story drifts are found to be high in X direction in comparison to Y direction shown in table

and table with respect to graphs fig 5.

Max story shears forcombo:0.9deadload+0.9superdead load+1.5RS-X(DCON12-ZONE2)

Table: 4 Max Story Shears –X Direction

TABLE: Story Response			story8	story16	story24	story32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	m		kN	kN	kN	kN
Story32	96	Top	-2283.6	-2279.83	-2276.68	-2283.6
Story31	93	Top	-4604.33	-4612.37	-4602.52	-4604.33
Story30	90	Top	-6604.25	-6632.7	-6611.64	-6604.25
Story 29	87	Top	-8283.97	-8342.65	-8309.39	-8283.97
Story 28	84	Top	-9648.03	-9746.28	-9697.71	-9648.03
Story 27	81	Top	-10709.1	-10853.3	-10788.7	-10709.1
Story 26	78	Top	-11485	-11680.8	-11599.4	-11485
Story25	75	Top	-12000.2	-12253.6	-12154.2	-12000.2
Story 24	72	Top	-12643.8	-13025.7	-12889.2	-12643.8
Story 23	69	Top	-12986.1	-13501.1	-13329.9	-12986.1
Story 22	66	Top	-13139.1	-13777.3	-13572.5	-13139.1
Story 21	63	Top	-13226.5	-13973.7	-13735.8	-13226.5
Story 20	60	Top	-13355.5	-14186.9	-13920	-13355.5
Story 19	57	Top	-13594.8	-14480.6	-14192.2	-13594.8
Story 18	54	Top	-13967.3	-14878.9	-14577.1	-13967.3
Story 17	51	Top	-14448.9	-15364.8	-15056	-14448.9
Story 16	48	Top	-15501.6	-16407.2	-16082.6	-15501.6
Story 15	45	Top	-16785.6	-17662.9	-17330.1	-16785.6
Story 14	42	Top	-18095.3	-18932.5	-18595.8	-18095.3
Story 13	39	Top	-19326.2	-20117.8	-19779.2	-19326.2
Story 12	36	Top	-20475.2	-21194.9	-20856.8	-20475.2
Story 11	33	Top	-21579	-22220	-21883.2	-21579
Story 10	30	Top	-22738	-23295	-22960.7	-22738
Story 9	27	Top	-24040.5	-24511.3	-24182.5	-24040.5
Story 8	24	Top	-26472.8	-26822.9	-26508.4	-26472.8
Story 7	21	Top	-29516.9	-29740.7	-29444.4	-29516.9
Story 6	18	Top	-32896.3	-32956.9	-32679.1	-32896.3
Story 5	15	Top	-36190.2	-36112.4	-35850.4	-36190.2
Story4	12	Top	-39019.9	-38837.9	-38586.5	-39019.9
Story3	9	Top	-41182.2	-40936.6	-40691.8	-41182.2
Story2	6	Top	-42568	-42289	-42048.2	-42568
Story1	3	Top	4316.9	42879.4	42641.6	43167.9
Base	0	Top	0	0	0	0

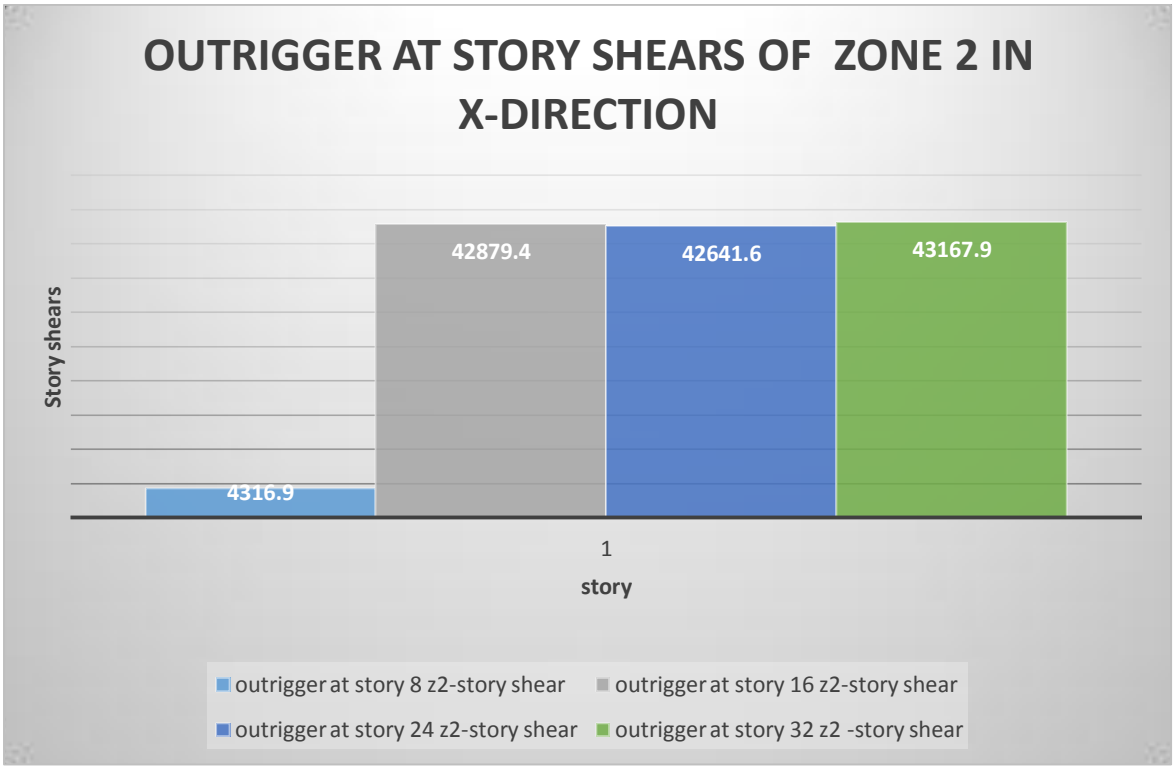

FIGURE 6: STORY SHEAR VS STORY

- From the above table, it clearly shows that max story shears is at story21 at 43219.9mm for zone 2.
- Max story drifts mm for story8 is 4316.9 mm, story11 37361.9 is mm, story16 is 42879.99 mm , story24 is 42641.9mm and story32 is 43167.9 mm
- By considering different stories , story 21 getting maximum story shears which contains maximum zone factor 0.1(zone2)

Table 5: Max Story Shears –Y Direction

TABLE: Story Response						
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	m		kN	kN	kN	kN
Story32	96	Top	-306.815	-12.4224	-68.8354	-306.815
Story31	93	Top	-588.954	-24.1973	-142.262	-588.954
Story30	90	Top	-794.282	-33.2382	-209.377	-794.282
Story 29	87	Top	-921.792	-39.5817	-270.371	-921.792
Story 28	84	Top	-973.2	-43.391	-325.235	-973.2
Story 27	81	Top	-954.778	-45.0307	-374.106	-954.778
Story 26	78	Top	-876.395	-45.0551	-417.162	-876.395
Story25	75	Top	-753.084	-44.2221	-454.706	-753.084
Story 24	72	Top	-486.731	-44.2916	-523.693	-486.731
Story 23	69	Top	-500.811	-50.1115	-584.366	-500.811
Story 22	66	Top	-830.434	-60.8371	-636.337	-830.434
Story 21	63	Top	-1211.67	-73.6271	-681.037	-1211.67
Story 20	60	Top	-1539.36	-85.6293	-719.672	-1539.36
Story 19	57	Top	-1764.92	-95.1263	-753.583	-1764.92
Story 18	54	Top	-1868.55	-101.191	-784.004	-1868.55

Story 17	51	Top	-1842.02	-103.629	-812.114	-1842.02
Story 16	48	Top	-1594.24	-102.895	-859.406	-1594.24
Story 15	45	Top	-1198.81	-100.408	-911.359	-1198.81
Story 14	42	Top	-814.198	-99.9725	-967.344	-814.198
Story 13	39	Top	-807.187	-104.484	-1027.02	-807.187
Story 12	36	Top	-1236.64	-114.058	-1089.34	-1236.64
Story 11	33	Top	-1711.32	-125.408	-1152.8	-1711.32
Story 10	30	Top	-2045.59	-135.025	-1215.58	-2045.59
Story 9	27	Top	-2189.45	-140.615	-1276.04	-2189.45
Story 8	24	Top	-2096.58	-142.132	-1362.33	-2096.58
Story 7	21	Top	-1719.72	-138.43	-1442.91	-1719.72
Story 6	18	Top	-1296.86	-134.777	-1513.52	-1296.86
Story 5	15	Top	-1305.42	-136.991	-1572.02	-1305.42
Story4	12	Top	-1800.77	-145.886	-1616.81	-1800.77
story 3	9	Top	-2393.25	-158.046	-1647.96	-2393.25
Story2	6	Top	-2853.02	-168.757	-1666.32	-2853.02
Story1	3	Top	3077	174.3	1674	3077
Base	0	Top	0	0	0	0

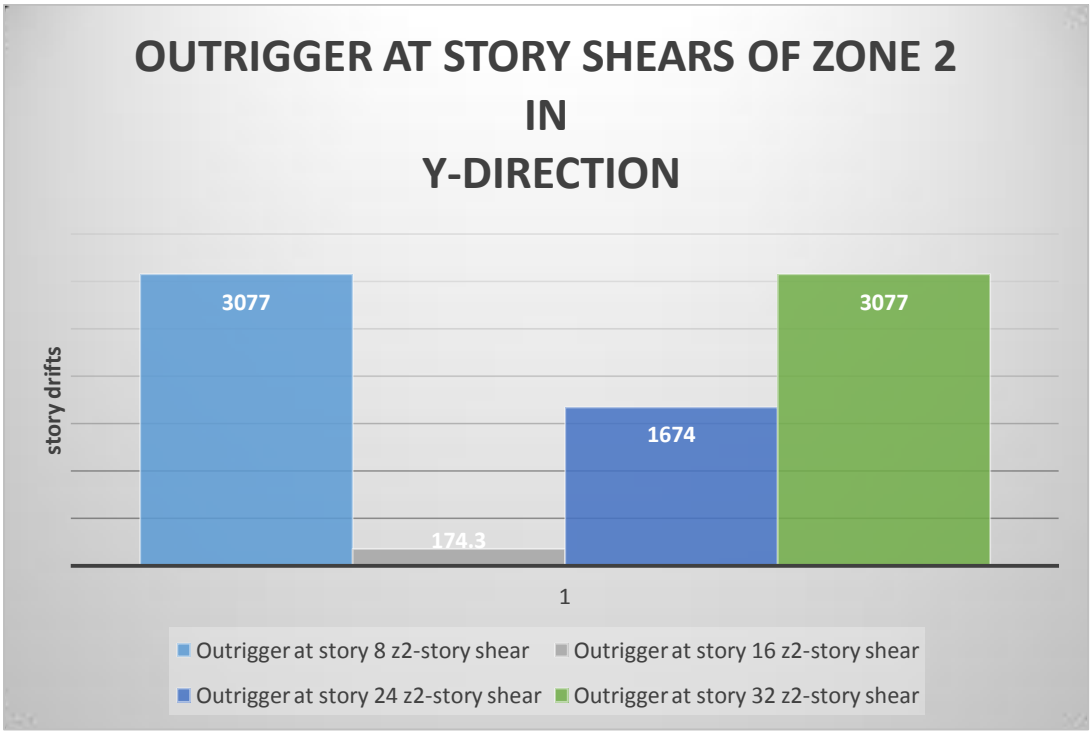

FIGURE :7 STORY SHEARS VS STORY

- Max story shears for combo:0.9deadload+0.9superdead load+1.5RS-Y(DCON13-ZONE2)
- From the above table, it clearly shows that max story shears is at story11 at 8110 mm for zone 2.
- Max story drifts mm for story8 is 3077 mm, story16 is 1743.3 mm, story21 is 2007 mm , story24 is 1674mm and story32 is 3077 mm
- By considering different stories, story11 getting maximum story shears which contains maximum zone factor 0.1(zone2).

Max overturning moments forcombo:0.9deadload+0.9superdead load+1.5RS-X(DCON12-ZONE2).

Table 6: Max Overturning Moments-X Direction

TABLE: Story Response			story 8	story16	story24	story32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	m		kN-m	kN-m	kN-m	kN-m
Story32	96	Top	0	0	-7.5966	0
Story31	93	Top	-919.779	-37.2189	-155.398	-919.779
Story30	90	Top	-2685.87	-109.665	-618.631	-2685.87
Story 29	87	Top	-5067.41	-209.155	-1250.42	-5067.41
Story 28	84	Top	-7830.24	-327.579	-2066.4	-7830.24
Story 27	81	Top	-10744.7	-457.137	-3047.84	-10744.7
Story 26	78	Top	-13597.9	-590.887	-4176.4	-13597.9
Story25	75	Top	-16202.5	-723.141	-5441.85	-16202.5
Story 24	72	Top	-18405.8	-871.08	-6788.94	-18405.8
Story 23	69	Top	-19522.9	-816.653	-8160.65	-19522.9
Story 22	66	Top	-19477.3	-963.004	-9874.69	-19477.3
Story 21	63	Top	-18389.4	-1088.54	-11629.3	-18389.4
Story 20	60	Top	-16667.5	-1182.76	-13560.6	-16667.5
Story 19	57	Top	-15080.4	-1261.77	-15596.9	-15080.4
Story 18	54	Top	-14692.7	-1509.05	-17682.8	-14692.7
Story 17	51	Top	-16188.4	-1679.98	-19928.5	-16188.4
Story 16	48	Top	-20160.7	-1949.58	-23058.8	-20160.7
Story 15	45	Top	-24127.4	-2181.88	-25729.6	-24127.4
Story 14	42	Top	-27216.4	-2562.6	-28328.1	-27216.4
Story 13	39	Top	-29354.4	-2848.54	-30905.4	-29354.4
Story 12	36	Top	-30419.4	-3241.97	-33662.4	-30419.4
Story 11	33	Top	-30759.3	-3449.42	-36479.2	-30759.3
Story 10	30	Top	-31085	-3807.4	-39242.1	-31085
Story 9	27	Top	-32184.5	-4107.73	-42280.2	-32184.5
Story 8	24	Top	-34483.7	-4422.91	-45390.8	-34483.7
Story 7	21	Top	-37580.4	-4706.71	-48717.1	-37580.4
Story 6	18	Top	-41091.1	-5102.7	-52249.5	-41091.1
Story 5	15	Top	-44136.3	-5501.72	-55962.2	-44136.3
Story4	12	Top	-46479.6	-5899.95	-59600.3	-46479.6
Story3	9	Top	-48488.5	-6299.31	-63570.1	-48488.5
Story2	6	Top	-50834.5	-6701.56	-67999.4	-50834.5
Story1	3	Top	-54178.9	-7172.5	-72244.5	-54178.9
Base	0	Top	57029.56	7766.451	75689.4	57029.56

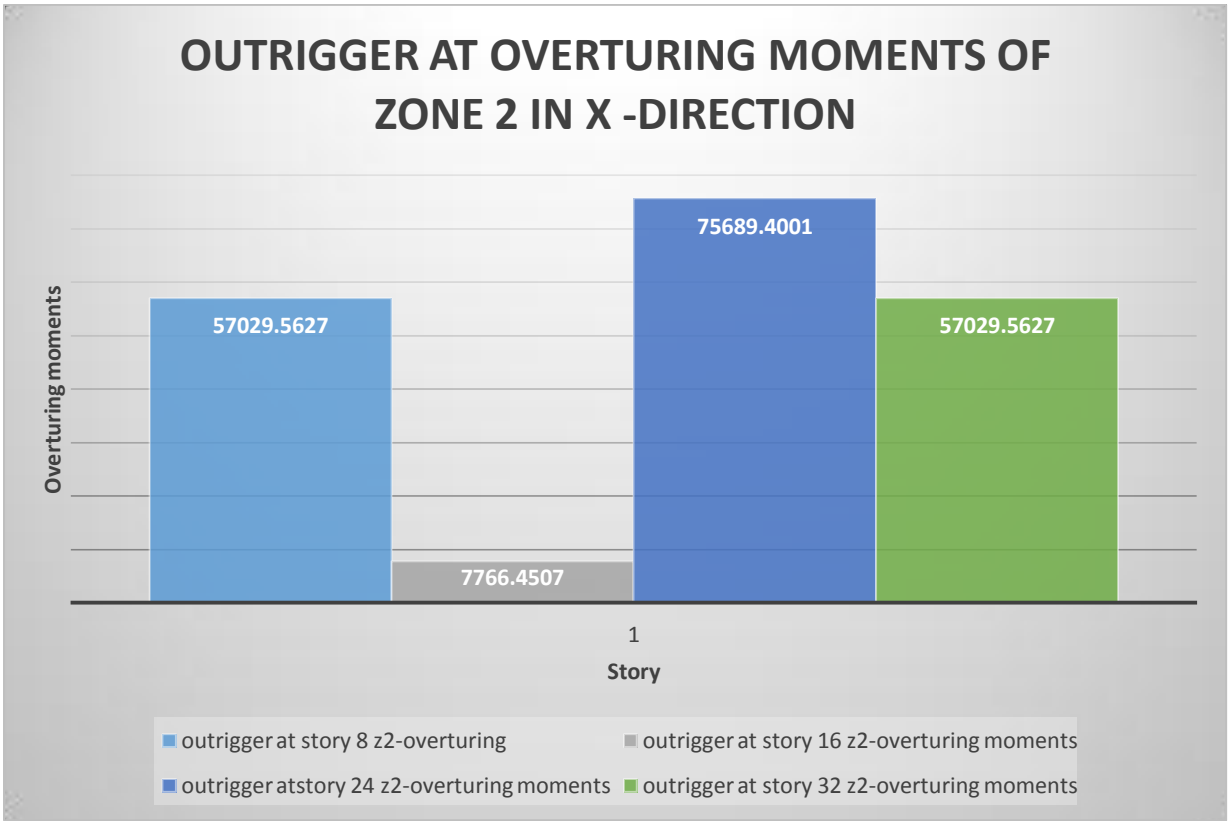

FIGURE 8: OVERTURNING MOMENTS VS STORY

- From the above table, it clearly shows that max overturning moments is at story11 at 86902.36 for zone 2.
- Max overturning moments mm for story8 is 57029.56 mm, story16 is7766.541 mm, story21 is 16579.11 mm ,
- story24 is 75689.1mm and story32 57029.56mm
- By considering different stories , story 11 getting maximum overturning moments which contains maximum zone factor 0.1(zone2).

Table 7: Max Overturning Moments –Y Direction

TABLE: Story Response	STORY8		STORY8	STORY16	STORY24	STORY32
Story	Elevation	Location	X-Dir	X-Dir	X-Dir	X-Dir
	M		kN-m	kN-m	kN-m	kN-m
Story32	96	Top	0	0	-7.5966	0
Story31	93	Top	-7213.27	-7311.16	-6781.33	-7213.27
Story30	90	Top	-21673	-21985.2	-20605.4	-21673
Story 29	87	Top	-42296.5	-42914.5	-40398.6	-42296.5
Story 28	84	Top	-68006.7	-69003	-65256.1	-68006.7
Story 27	81	Top	-97735	-99165.6	-94229.5	-97735
Story 26	78	Top	-130466	-132371	-126402	-130466
Story25	75	Top	-165258	-167665	-160912	-165258
Story 24	72	Top	-201257	-204220	-196909	-201257
Story 23	69	Top	-238151	-241551	-234341	-238151
Story 22	66	Top	-274846	-279037	-272351	-274846
Story 21	63	Top	-310623	-315797	-309733	-310623
Story 20	60	Top	-345096	-351501	-346011	-345096
Story 19	57	Top	-378159	-386114	-380799	-378159

Story 18	54	Top	-409860	-419880	-413945	-409860
Story 17	51	Top	-440352	-452692	-445676	-440352
Story 16	48	Top	-470776	-484861	-476981	-470776
Story 15	45	Top	-497796	-514336	-504878	-497796
Story 14	42	Top	-522232	-542002	-530742	-522232
Story 13	39	Top	-545427	-568411	-555677	-545427
Story 12	36	Top	-568291	-594633	-580822	-568291
Story 11	33	Top	-591815	-621284	-606808	-591815
Story 10	30	Top	-616982	-649599	-634132	-616982
Story 9	27	Top	-644659	-680168	-663641	-644659
Story 8	24	Top	-675630	-713729	-695688	-675630
Story 7	21	Top	-709204	-749637	-729904	-709204
Story 6	18	Top	-747609	-789779	-768382	-747609
Story 5	15	Top	-793058	-836148	-813587	-793058
Story4	12	Top	-847902	-890929	-867600	-847902
Story3	9	Top	-913750	-955757	-932259	-913750
Story2	6	Top	-990995	-1031219	-1007913	-990995
Story1	3	Top	-1078710	-1116761	-1092960	-1078710
Base	0	Top	1173122	1210684	1184908	1173122

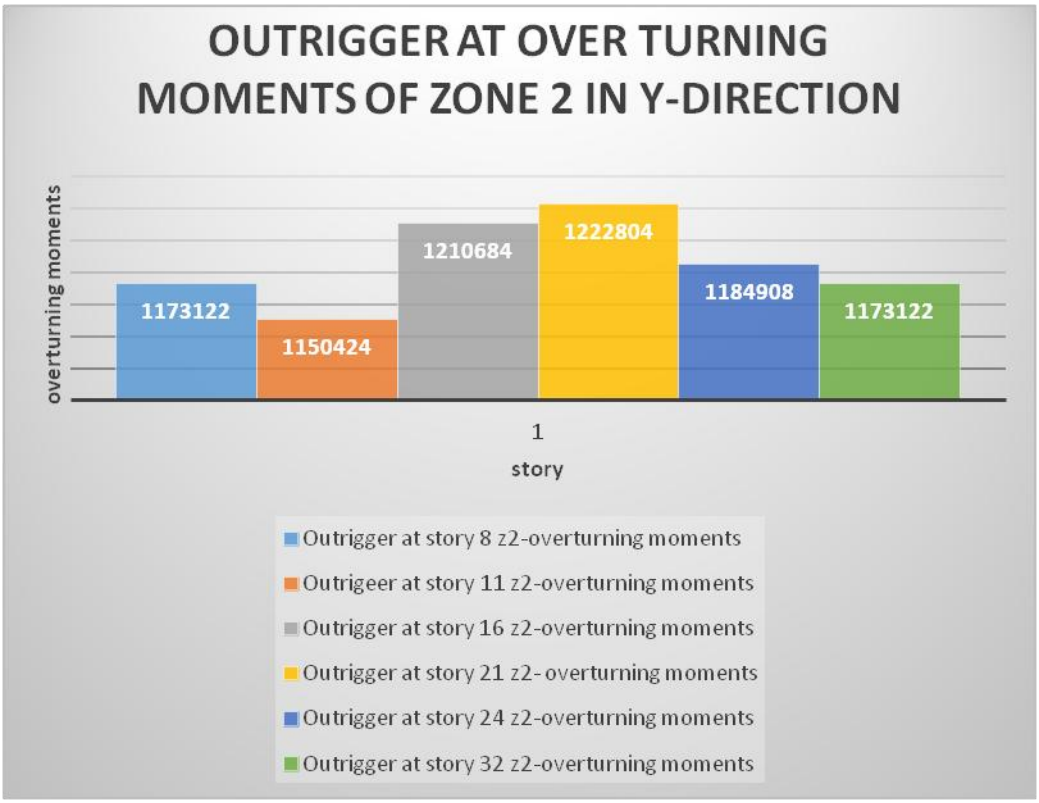

FIGURE 9 : OVERTURNING MOMENTS VS STORY

- Max overturning moments for combo:0.9deadload+0.9superdead load+1.5RS-Y(DCON13-ZONE2)
- From the below table, it clearly shows that max overturning moments is at story21 at 1222.840 for zone 2.
- Max overturning moments mm for story8 is 1173.122 mm, story11 is 1150.421mm, story16 is 1210.684 mm , Story24 is 1184.908mm and story32 is 1173.122mm
- By considering different stories , story 21 getting maximum overturning moments which contains maximum zone factor 0.1(zone2)

IV. CONCLUSIONS AND SCOPE OF FUTURE WORK

Conclusions:

- The present study of work compares the differences in the behavior of building when outrigger is used. The following conclusion were drawn based on project study.
- The usage of outrigger system in the building increases the efficiency of the building when compared to building without outrigger under the action of lateral loads
- From the modal analysis, it can be established that, core wall systems with outrigger will have tendency to vibrate with Response spectrum . This is due to the increase in overall stiffness of the structure due to introduction of shear walls and outriggers.
- From the existing study and investigations, it can be determined that, for tall structural system, conventional moment resisting frames incapable to resist lateral loads. To counteract this demand, the lateral resistance of the tall structural systems can be further enhanced by the core and outrigger system particularly wall type outrigger can be suggested as suitable system.
- The size of the outrigger members increases, the displacement in the tall building structural system decreases. provision of shear wall at the central core with outriggers in the building decreases the forces in the core .
- The irregular building with vertical floor irregularity due to the reduced self weight is more effectual than the regular building.

SCOPE OF FUTURE STUDY

1. A detail dynamic analysis of the building is carried out by collecting the response of tall building structure at every mode.
2. The building models are compared by changing the soil interaction or type of soil to provide better information about response
of the system.
3. The base isolation or springs technique may be used with outriggers
4. The building can be compared with other structural systems such as belt truss.

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