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Seismic Response Analysis of Structural Buildings with and Without Mass Abnormalities Using RSM in ETABS

Md Miraz

Master of Technology, Dept. Of. Civil Engineering,
CBS Group of Institutions, Jhajjar, Haryana.

Mr. Abhishek Sharma

Assistant Professor, Dept. Of. Civil Engineering, CBS Group of Institutions, Jhajjar, Haryana.

ABSTRACT

The present study investigates the seismic behavior of structural building models with and without mass abnormalities using Response Spectrum Method (RSM) in ETABS software. The models were analyzed under RS-X and RS-Y load cases to evaluate key structural parameters such as story displacement, drift, shear, stiffness, and acceleration. The analysis revealed that regular buildings exhibited higher story displacement along the X-axis compared to mass abnormal models, attributed to increased stiffness in the latter. It was also observed that story drift reduced in mass abnormal models, with higher values concentrated at the lower stories due to increased stiffness. Story shear forces showed a greater concentration at the base and declined with height, especially in mass abnormal models. Similarly, story stiffness peaked near the base and declined with elevation, but was notably higher in mass abnormal buildings where added mass resulted in increased time periods. Lastly, story acceleration increased with height but showed a significant drop in regions with mass irregularity. These findings highlight the dynamic response of mass abnormal structures and emphasize the need for detailed analysis in seismic design to ensure structural safety and performance.

Key Words: *Mass Abnormality, Story Drift, Seismic Response*.

1. INTRODUCTION

Structural abnormalities in buildings arise from inconsistencies in the distribution of mass, stiffness, and strength throughout the structural system. These inconsistencies affect the seismic force-resisting elements (SFR elements), also known as the lateral force-resisting system (LFRS), which include shear walls, special moment-resisting frames, and dual frame-shear wall systems. The presence of structural weak planes or discontinuities increases susceptibility to damage and, in extreme cases, leads to partial or full structural collapse. In modern constructions, different floors often serve different purposes—such as parking, mechanical storage, or observatories—leading to irregularities in load distribution, mass, and stiffness across stories. Structural abnormalities are broadly categorized into two main types: **vertical** and **plan (horizontal)**. Vertical abnormalities occur when there is a sudden variation in mass, geometry, or stiffness along the height of the building. Such irregularities disturb the uniform load path required for safe energy dissipation during seismic events, causing concentration of stress and potential failure. Horizontal or plan abnormalities, on the other hand, are caused by irregular shapes, abrupt changes in floor layouts, re-entrant corners, and wide openings that lead to torsional effects, diaphragm distortions, and uneven stress distribution. As per IS 1893:2016 (Part 1), these abnormalities are critical considerations in seismic design. Addressing these abnormalities is essential to ensure a building's ability to withstand lateral loads during earthquakes. Failure to recognize and correct such flaws can result in abnormal stress

concentrations, leading to stiffness degradation, strength loss, and dynamic instabilities. Modern codes and design guidelines, such as IS 1893, emphasize identifying and mitigating these irregularities through dynamic analysis and proper design detailing. A structurally sound building must have a continuous and well-connected load transfer path, with lateral-force-resisting elements distributed appropriately in both vertical and horizontal axes.

To compare the mass abnormality of structure by modelling and analysis. The investigation was performed on a G+15 RC Str. building in India's zone IV, as per IS 1893(Part1):2016. Structures were subjected to LSA and RSA under gravity and seismic loads. The study examined at five models with different loading criteria, four of which had mass abnormality criteria and one had a regular structure were analyzed in E-tabs Software and comparing the result of structure with the help of graph and tables. The following checks are done according to the IS code which need to be performed to ensure the strength, serviceability and safety criteria. The checks are performed under serviceability condition of the Str. building according to the IS codes.

i) Check of p-δ effect.
ii) Check of story drift.
iii) Check of torsional abnormality.
iv) Check of soft story.
v) Check of over-turning moment.
vi) Elevation checks.

Results accumulated from the LDA for the abnormal and Regular Str. buildings are compared, and the graphical representation is presented for better understanding of effect of abnormalities of Mass.

2. RESULTS

Reconciliation of Story-Displacement in X-Axis Under Rs-X Load Case

Table: Story-Displacement in RS-X Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	mm	mm	mm	mm	mm
Head room	61	56.3	53.0	54.7	54.2	52.8
F15	58	54.9	51.5	53.3	53.3	51.7
F14	54.5	53.5	49.9	51.9	52.4	50.6
F13	51	51.8	48.0	50.2	51.3	49.2
F12	47.5	49.7	45.7	48.2	50.0	47.5
F11	44	47.3	43.0	45.8	48.3	45.4
F10	40.5	44.6	40.0	43.2	46.0	43.1
F9	37	41.6	36.8	40.4	43.1	40.4
F8	33.5	38.4	33.3	37.8	39.7	37.5
F7	30	34.8	29.6	35.2	36.1	34.3
F6	26.5	31.0	25.8	32.5	32.2	31.0
F5	23	27.0	22.0	29.4	28.1	27.3
F4	19.5	22.8	18.6	25.6	23.7	23.5
F3	16	18.5	15.5	20.9	19.2	19.4
F2	12.5	14.0	12.4	16.0	14.5	15.2
F1	9	9.5	9.1	10.8	9.8	10.7
Ground floor	5.5	5.0	5.3	5.8	5.2	5.8

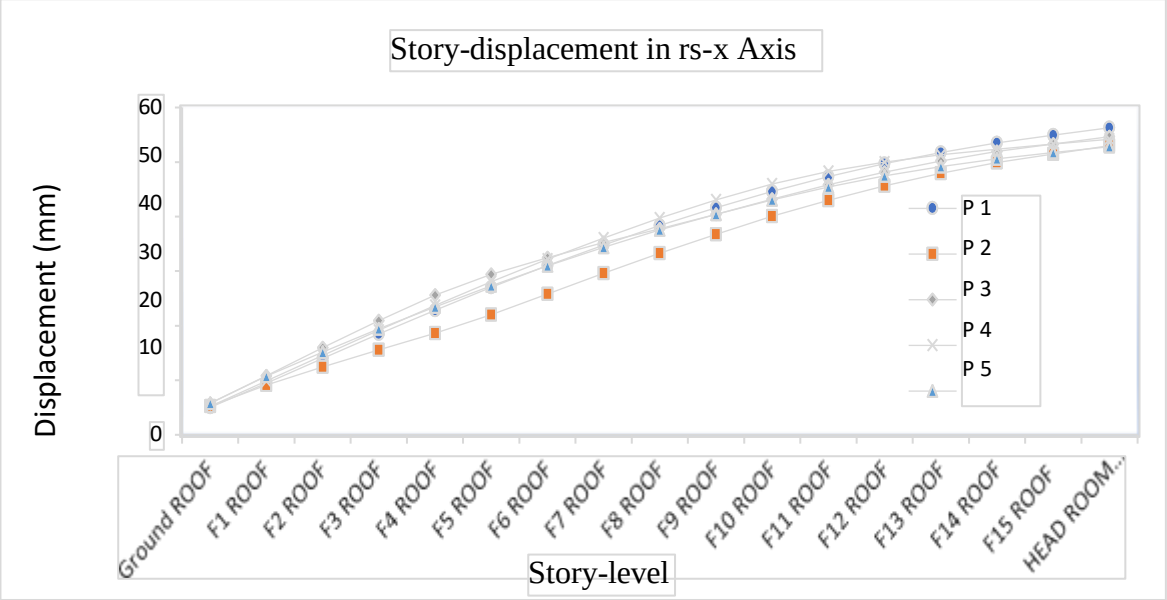

Fig: Story-Level vs Story-Displacement in RS-X Axis

Reconciliation of Story-Displacement in Y-Axis Under Rs-Y Load Case

Table: Story-Displacement in RS-Y Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	mm	mm	mm	mm	mm
Head room	61	40.6	38.4	39.8	38.3	38.2
F15	58	44.5	41.7	43.6	42.4	41.8
F14	54.5	43.2	40.2	42.2	41.5	40.7
F13	51	41.5	38.4	40.5	40.4	39.3
F12	47.5	39.5	36.2	38.5	39.0	37.6
F11	44	37.3	33.8	36.3	37.5	35.7
F10	40.5	34.9	31.3	33.9	35.5	33.5
F9	37	32.3	28.5	31.4	33.0	31.2
F8	33.5	29.5	25.6	29.0	30.2	28.7
F7	30	26.6	22.6	26.9	27.2	26.1
F6	26.5	23.5	19.5	24.5	24.1	23.3
F5	23	20.3	16.4	22.1	20.8	20.3
F4	19.5	17.0	13.7	19.0	17.4	17.3
F3	16	13.6	11.3	15.3	14.0	14.1
F2	12.5	10.2	8.9	11.5	10.5	10.9
F1	9	6.8	6.5	7.7	7.0	7.6
Ground floor	5.5	3.4	3.5	3.8	3.5	3.9

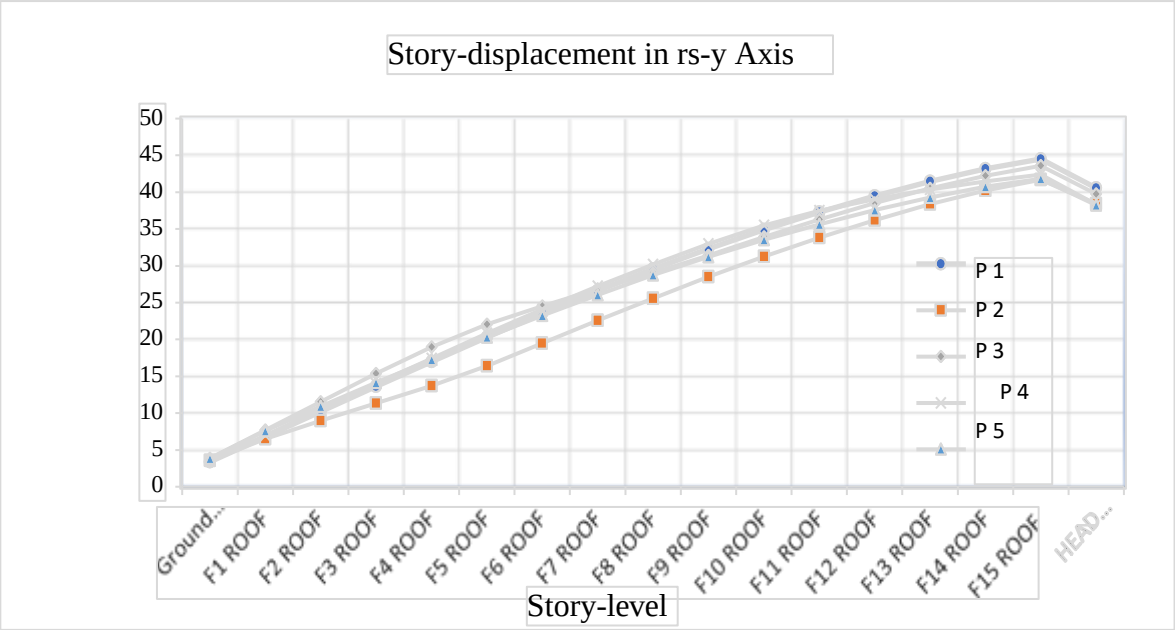

Fig: Story-Level vs Story-Displacement in RS-Y Axis

Reconciliation of Story-Drift in X-Axis Under Rs-X Load Case

Table: Story-Drift in RS-X Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
Head room	61	0.000538	0.000586	0.000519	0.000356	0.000436
F15	58	0.000519	0.000566	0.000505	0.000329	0.00041
F14	54.5	0.000608	0.000665	0.000594	0.00038	0.000502
F13	51	0.000719	0.000793	0.000702	0.000475	0.0006
F12	47.5	0.000815	0.000905	0.000792	0.000588	0.000707
F11	44	0.000899	0.000998	0.000862	0.000767	0.000782
F10	40.5	0.000973	0.001074	0.000904	0.000959	0.000866
F9	37	0.001041	0.001133	0.000841	0.00106	0.000925
F8	33.5	0.001104	0.001175	0.000795	0.001137	0.000994
F7	30	0.00116	0.001195	0.000836	0.001199	0.001043
F6	26.5	0.001208	0.001183	0.00093	0.001251	0.001101
F5	23	0.001248	0.00104	0.001134	0.001292	0.001141
F4	19.5	0.001278	0.000925	0.001357	0.001325	0.00119
F3	16	0.001299	0.000916	0.001438	0.001348	0.001229
F2	12.5	0.001307	0.000958	0.001477	0.001358	0.001287
F1	9	0.001301	0.001129	0.001485	0.001352	0.001443
Ground floor	5.5	0.001149	0.001192	0.001314	0.001194	0.001319
Plinth	2	0.000502	0.000577	0.000576	0.00052	0.000598

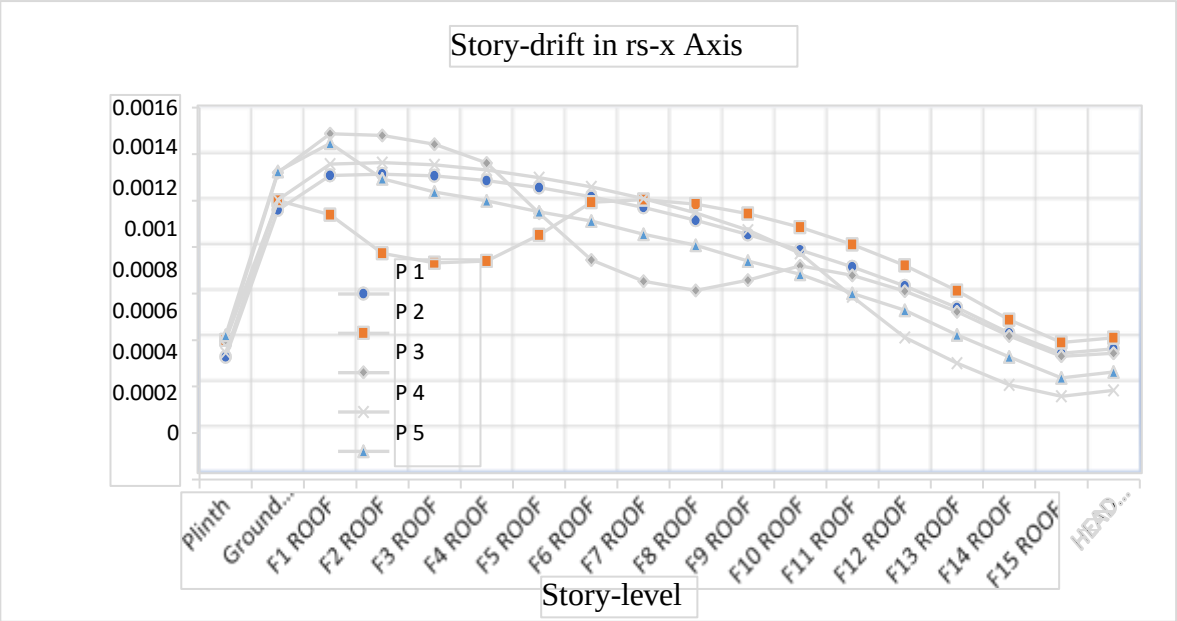

Fig: Story-Level vs Story-Drift in RS-X Axis

Reconciliation of Story-Drifts in Y-Axis Under Rs-Y Load Case

Table: Story-Drift in RS-Y Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
Head room	61	0.000509	0.000549	0.000503	0.000377	0.000445
F15	58	0.000492	0.000533	0.00049	0.000344	0.000422
F14	54.5	0.000566	0.000614	0.000565	0.000374	0.000486
F13	51	0.000657	0.000715	0.000658	0.000448	0.000569
F12	47.5	0.000725	0.000789	0.000723	0.000513	0.000641
F11	44	0.00078	0.000847	0.000777	0.000656	0.000692
F10	40.5	0.000829	0.000892	0.000809	0.000809	0.000747
F9	37	0.000872	0.000926	0.000739	0.000873	0.000785
F8	33.5	0.00091	0.000948	0.000676	0.000917	0.000827
F7	30	0.000941	0.000962	0.000703	0.000955	0.000856
F6	26.5	0.000966	0.000952	0.000742	0.000984	0.000886
F5	23	0.000983	0.000824	0.0009	0.001005	0.000906
F4	19.5	0.000989	0.000704	0.001064	0.001013	0.00092
F3	16	0.00099	0.000696	0.0011	0.001015	0.000927
F2	12.5	0.000989	0.000712	0.001112	0.001016	0.000956
F1	9	0.000971	0.000845	0.0011	0.000998	0.001073
Ground floor	5.5	0.000795	0.000826	0.000904	0.000817	0.000906
Plinth	2	0.000379	0.00044	0.000433	0.00039	0.000451

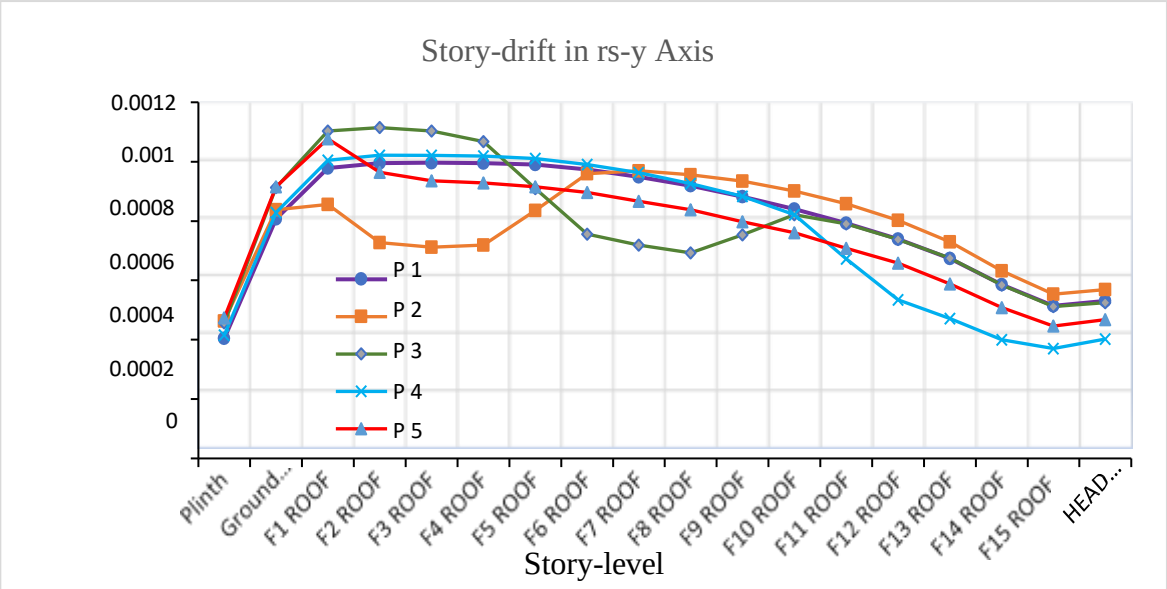

Fig: Story-Level vs Story-Drift in RS-Y Axis

Reconciliation of Story-Shear in X-Axis Under Rs-X Load Case

Table: Story-Shear in RS-X Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P – 5
	m	kN	kN	kN	kN	kN
Head room	61	39.7	39.6	39.6	34.9	36.4
F15	58	490.5	502.1	490.3	433.0	458.8
F14	54.5	1097.8	1160.2	1098.9	1122.8	1213.8
F13	51	1503.3	1636.3	1515.2	1613.1	1652.4
F12	47.5	1782.1	1982.0	1817.2	1968.7	2058.5
F11	44	1991.2	2239.3	2063.9	2245.3	2311.4
F10	40.5	2172.0	2443.7	2296.5	2419.5	2578.3
F9	37	2346.8	2622.3	2522.3	2560.2	2775.1
F8	33.5	2520.4	2793.1	2807.4	2695.8	3008.6
F7	30	2687.1	2959.7	3085.0	2833.4	3188.7
F6	26.5	2841.4	3118.5	3330.4	2969.7	3398.4
F5	23	2984.6	3270.1	3549.0	3105.8	3559.7
F4	19.5	3124.9	3480.2	3698.8	3246.0	3755.5
F3	16	3280.1	3730.8	3841.7	3404.8	3922.9
F2	12.5	3455.6	4002.5	4002.4	3584.1	4147.2
F1	9	3646.4	4279.1	4179.0	3774.5	4334.9
Ground floor	5.5	3811.5	4451.7	4334.6	3937.6	4484.4
Plinth	2	3822.8	4462.9	4345.5	3948.8	4494.7

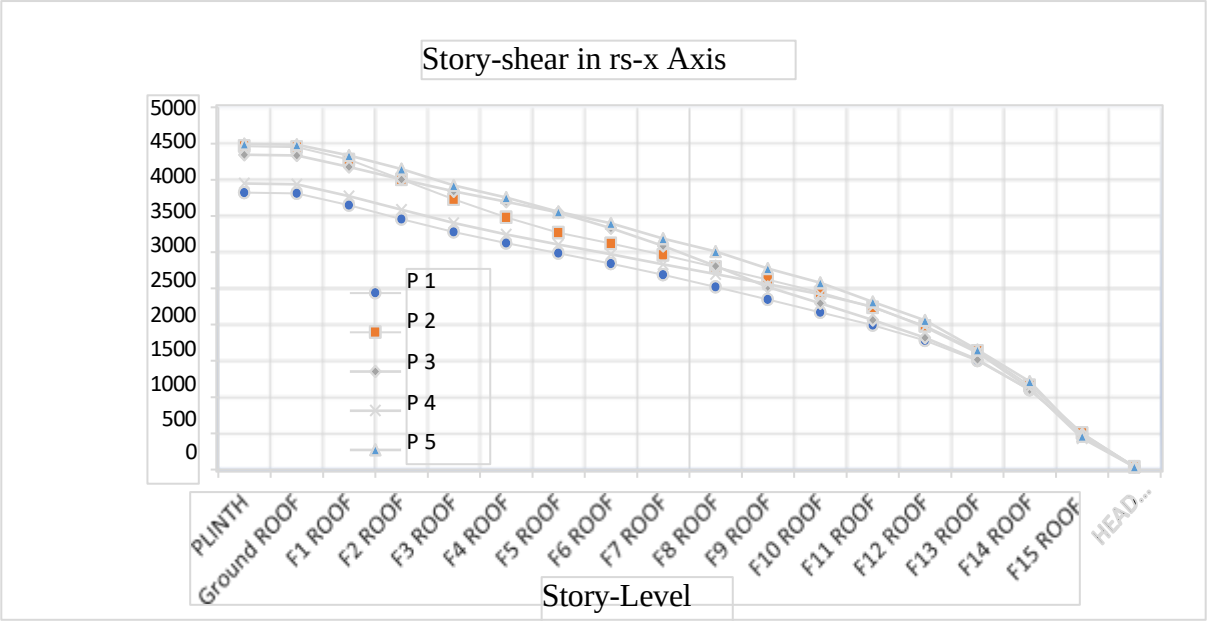

Fig: Story-Level vs Story-Shear in RS-X Axis

Reconciliation of Story-Shear in Y-Axis Under Rs-Y Load Case

Table: Story-Shear in RS-Y Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	kN	kN	kN	kN	kN
Head room	61	31.61	32.77	32.22	28.31	30.28
F15	58	397.16	417.72	406.23	353.67	383.84
F14	54.5	892.26	962.16	915.02	915.75	1012.81
F13	51	1212.20	1338.19	1253.78	1299.90	1365.66
F12	47.5	1419.66	1592.17	1487.91	1561.80	1672.83
F11	44	1567.77	1767.69	1672.85	1757.57	1855.13
F10	40.5	1690.85	1898.40	1842.20	1876.25	2040.73
F9	37	1811.89	2013.68	2004.24	1969.71	2177.56
F8	33.5	1932.29	2128.31	2207.11	2060.59	2341.49
F7	30	2049.05	2246.74	2404.74	2154.81	2469.31
F6	26.5	2161.64	2366.94	2581.73	2253.04	2622.41
F5	23	2268.73	2485.72	2742.63	2356.53	2743.77
F4	19.5	2382.36	2661.96	2858.48	2470.57	2899.00
F3	16	2514.59	2879.10	2975.37	2605.50	3038.80
F2	12.5	2665.20	3116.00	3110.42	2758.54	3230.52
F1	9	2830.30	3358.53	3261.10	2920.26	3393.43
Ground floor	5.5	2966.18	3505.35	3389.90	3053.85	3519.47
Plinth	2	2975.14	3514.58	3398.72	3062.81	3527.86

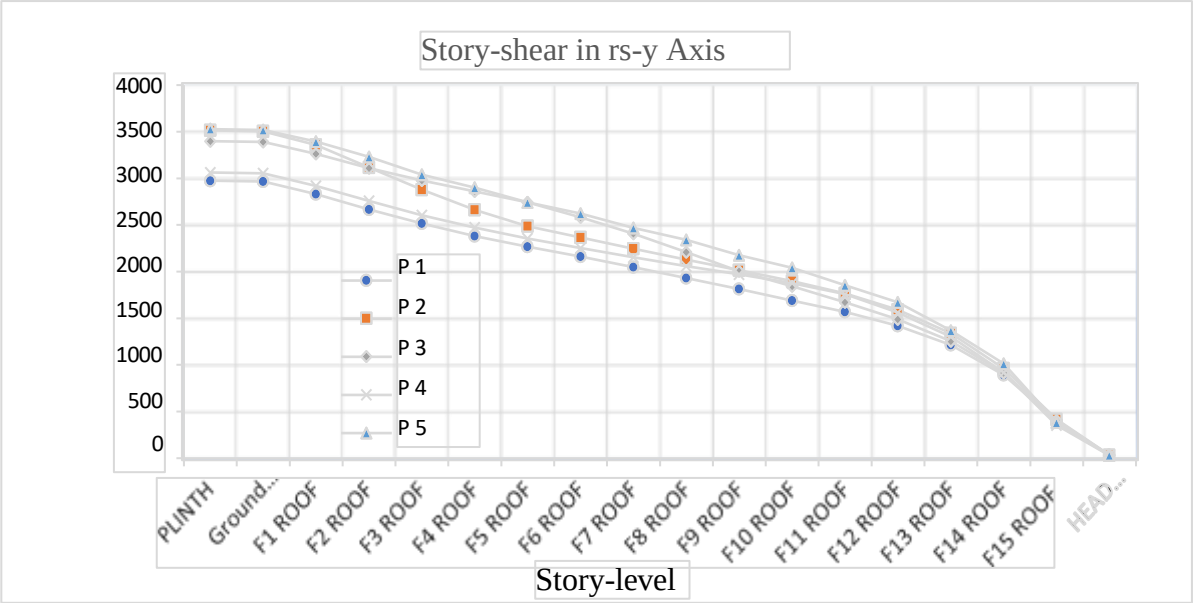

Fig: Story-Level vs Story-Shear in RS-Y Axis

Reconciliation of Story-Stiffness in X-Axis Under Rs-X Load Case

Table: Story-Stiffness in RS-X Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	kN/m	kN/m	kN/m	kN/m	kN/m
Head room	61	25999.6	24036.6	27013.6	34983.2	30017.1
F15	58	292928.1	275635.1	300892.0	412329.4	352038.5
F14	54.5	524577.7	506878.2	538824.8	849140.3	697494.3
F13	51	612318.2	605139.5	634219.4	975796.7	807369.9
F12	47.5	645898.9	649630.1	682426.8	957895.8	856057.7
F11	44	658497.7	671009.7	722377.9	834824.5	884949.3
F10	40.5	666117.4	685295.5	778408.8	747469.2	886414.8
F9	37	674918.7	701131.4	930837.8	722193.5	908549.6
F8	33.5	686028.2	724979.2	1080634.0	713502.0	906983.3
F7	30	698418.4	759644.4	1106381.0	713799.6	934139.5
F6	26.5	711480.2	821658.8	1056719.6	719819.1	930136.8
F5	23	726172.5	999698.5	911808.3	730791.7	964502.4
F4	19.5	744956.6	1173811.5	823600.0	747576.4	954643.1
F3	16	773216.6	1247657.0	815929.9	774612.9	991856.0
F2	12.5	813193.7	1256758.8	838702.3	813523.5	970759.6
F1	9	907807.1	1214243.4	918843.3	906677.1	979904.2
Ground floor	5.5	1077687.5	1247955.2	1074473.7	1072797.3	1110797.6
Plinth	2	4385907.3	4575391.4	4368202.9	4375987.4	4410374.6

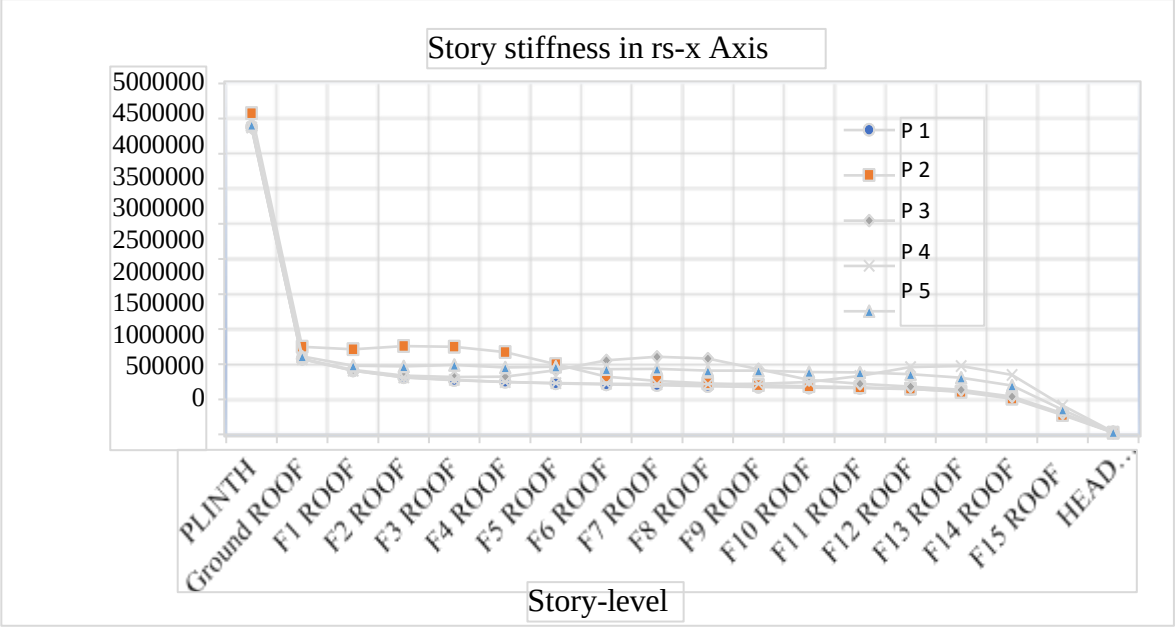

Fig: Story-Level vs Story-Stiffness in RS-X Axis

Reconciliation of Story Stiffness in Y-Axis Under Rs-Y Load Case

Table: Story-Stiffness in RS-Y Axis

Story	Elevation	P - 1	P - 2	P – 3	P - 4	P - 5
	m	kN/m	kN/m	kN/m	kN/m	kN/m
Head room	61	21376.2	20504.1	21961.7	26516.3	23615.4
F15	58	244617.8	237457.2	250038.5	315109.8	282247.7
F14	54.5	472066.7	468283.7	484229.4	711269.2	621219.1
F13	51	563375.0	570859.9	582127.2	869908.1	729344.1
F12	47.5	600125.7	617090.2	631592.6	878550.1	798223.2
F11	44	614797.1	637664.4	666835.3	813216.7	816000.8
F10	40.5	623736.3	649787.3	716114.6	726064.2	833959.4
F9	37	635332.8	664594.2	840059.3	697146.2	843629.2
F8	33.5	649846.7	687433.4	974909.5	688430.6	863615.5
F7	30	666426.4	726096.7	1026954.1	690344.8	878645.7
F6	26.5	685848.2	791065.2	1030392.1	700933.4	903690.5
F5	23	708753.1	952941.8	933566.7	719733.7	928095.7
F4	19.5	743363.1	1143343.4	848925.3	751787.0	964367.3
F3	16	793764.2	1256682.9	849633.2	800939.2	1011771.2
F2	12.5	861551.9	1341306.1	894735.7	867590.8	1051606.8
F1	9	964302.6	1314183.4	981318.6	967424.9	1056597.9
Ground floor	5.5	1202799.9	1412902.5	1209380.2	1204112.7	1261693.4
Plinth	2	4590387.4	4808440.1	4601479.8	4590452.6	4643295.4

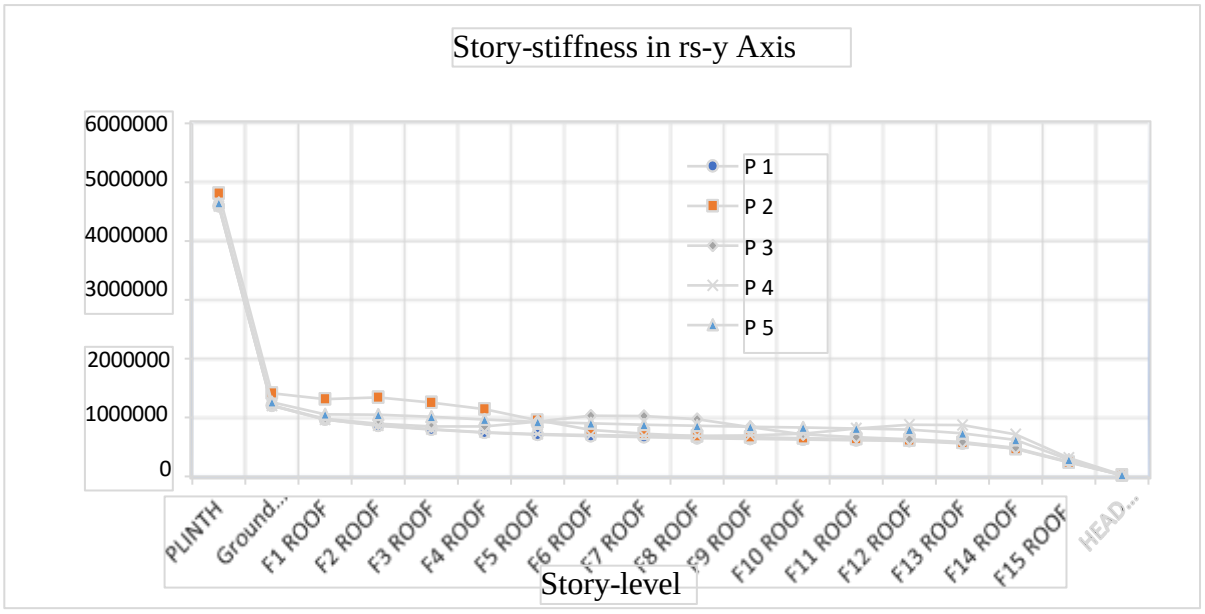

Fig: Story-Level vs Story-Stiffness in RS-Y Axis

Reconciliation of Story-Force in X-Axis Under Rs-X Load

Table: Story-Force in RS-X Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	kN	kN	Kn	kN	kN
Head room	61	39.7	39.6	39.6	34.9	36.4
F15	58	487.7	499.1	487.5	430.5	456.0
F14	54.5	1095.8	1158.0	1097.0	1120.6	1211.3
F13	51	1502.0	1634.7	1513.8	1611.5	1651.0
F12	47.5	1781.2	1980.8	1816.1	1967.5	2057.0
F11	44	1990.4	2238.4	2063.0	2244.3	2310.5
F10	40.5	2171.3	2443.0	2295.6	2418.8	2577.3
F9	37	2346.1	2621.6	2521.4	2559.6	2774.4
F8	33.5	2519.7	2792.4	2806.2	2695.2	3007.7
F7	30	2686.5	2959.0	3083.9	2832.9	3188.1
F6	26.5	2840.8	3117.8	3329.5	2969.2	3397.6
F5	23	2984.0	3269.4	3548.2	3105.2	3559.1
F4	19.5	3124.3	3479.2	3698.2	3245.4	3754.7
F3	16	3279.5	3729.8	3841.1	3404.1	3922.3
F2	12.5	3454.9	4001.4	4001.7	3583.3	4146.2
F1	9	3645.6	4278.1	4178.3	3773.7	4334.2
Ground floor	5.5	3810.9	4451.2	4334.1	3937.0	4483.9
Plinth	2	3822.8	4462.9	4345.5	3948.8	4494.7

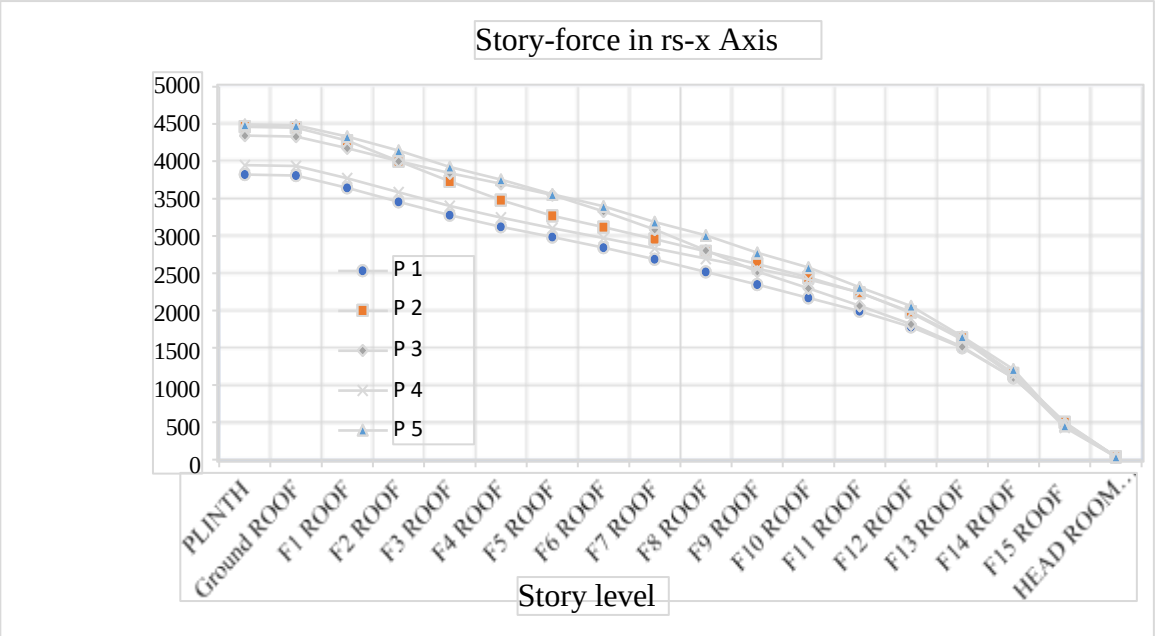

Fig: Story-Level vs Story-Force in RS-X Axis

Reconciliation of Story-Force in Y-Axis Under Rs-Y Load Case

Table: Story-Force in RS-Y Axis

Story	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	kN	kN	kN	kN	kN
Head room	61	31.6	32.8	32.2	28.3	30.3
F15	58	394.9	415.3	403.9	351.7	381.6
F14	54.5	890.7	960.4	913.4	914.0	1010.8
F13	51	1211.2	1337.0	1252.7	1298.7	1364.5
F12	47.5	1419.0	1591.4	1487.1	1561.0	1671.8
F11	44	1567.3	1767.1	1672.2	1756.9	1854.5
F10	40.5	1690.4	1897.9	1841.6	1875.9	2040.0
F9	37	1811.4	2013.2	2003.6	1969.4	2177.1
F8	33.5	1931.8	2127.9	2206.3	2060.2	2340.8
F7	30	2048.6	2246.3	2404.0	2154.4	2468.8
F6	26.5	2161.2	2366.5	2581.1	2252.7	2621.8
F5	23	2268.3	2485.2	2742.1	2356.1	2743.3
F4	19.5	2381.9	2661.2	2858.0	2470.1	2898.4
F3	16	2514.0	2878.2	2974.9	2604.9	3038.2
F2	12.5	2664.6	3115.1	3109.9	2757.9	3229.7
F1	9	2829.7	3357.7	3260.5	2919.7	3392.8
Ground floor	5.5	2965.8	3504.9	3389.5	3053.4	3519.1
Plinth	2	2975.1	3514.6	3398.7	3062.8	3527.9

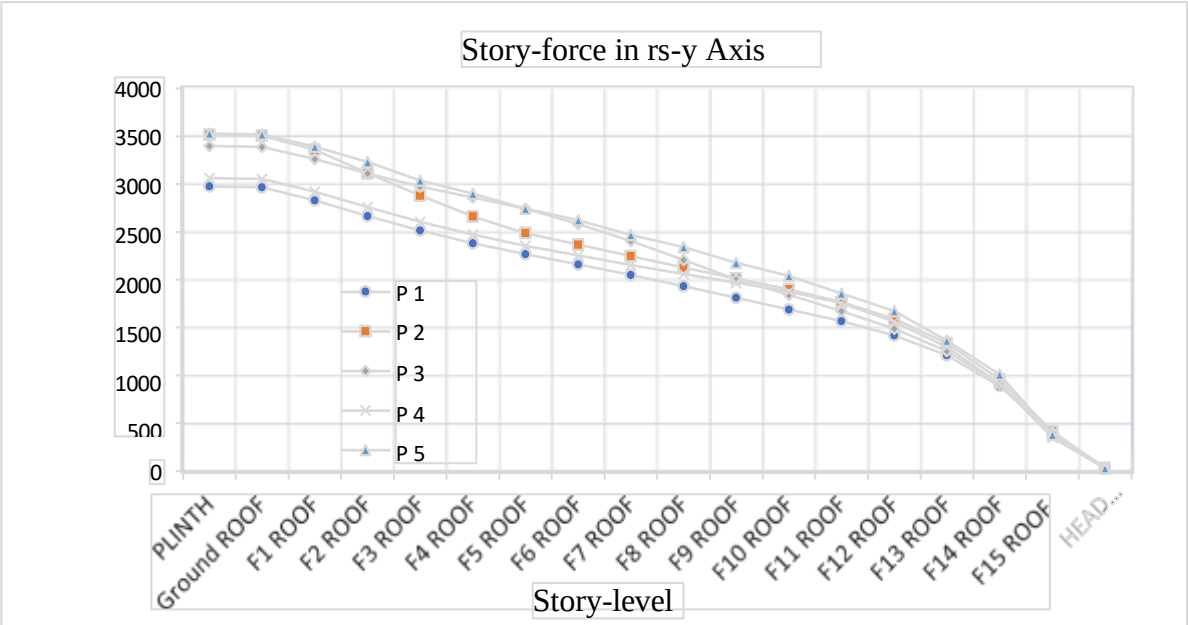

Fig: Story-Level vs Story-Force in RS-Y Axis

Reconciliation of Modal-Time-Period

Table: Modal-Time-Period

Mode	P - 1	P - 2	P - 3	P - 4	P - 5
	sec	sec	sec	sec	sec
Mode 1	3.39	3.02	3.16	3.52	3.16
Mode 2	3.18	2.86	2.98	3.29	2.99
Mode 3	2.96	2.63	2.78	3.07	2.77
Mode 4	1.00	0.99	0.98	0.95	0.95
Mode 5	0.94	0.93	0.95	0.89	0.90
Mode 6	0.91	0.90	0.90	0.86	0.86
Mode 7	0.52	0.53	0.49	0.49	0.50
Mode 8	0.49	0.50	0.46	0.46	0.47
Mode 9	0.48	0.49	0.46	0.45	0.47
Mode 10	0.34	0.33	0.33	0.33	0.33

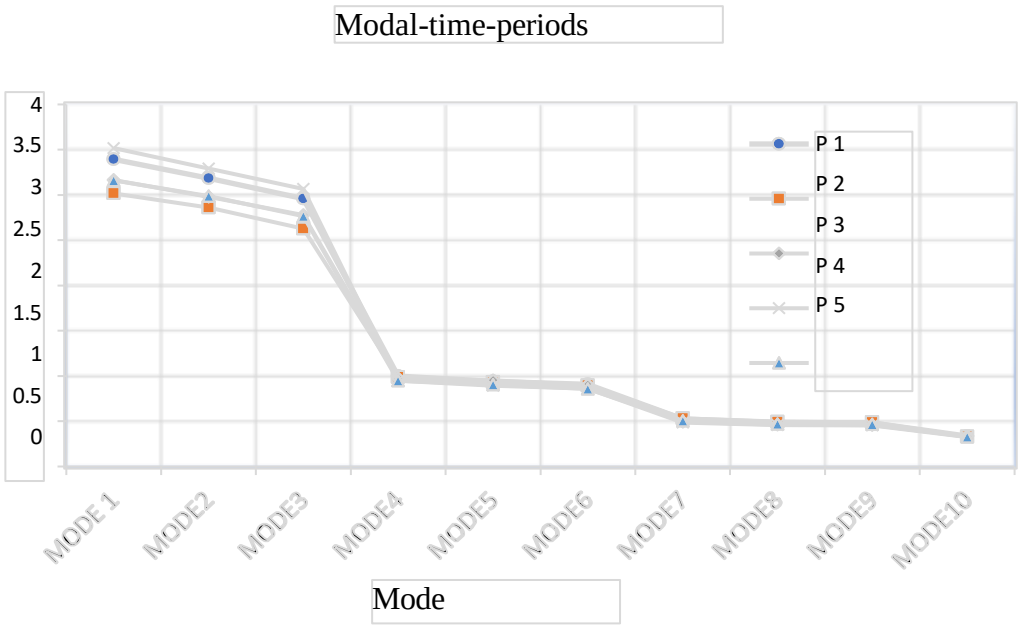

Fig: Mode vs Time-Period

Reconciliation of Story-Acceleration in X-Axis Under Rs-X Load

Table: Story-Acceleration in RS-X Axis

Story's	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	mm/s²	mm/s²	mm/s²	mm/s²	mm/s²
Head room	61	588.4	589.5	589.5	519.8	543.7
F15	58	465.0	479.8	467.5	413.3	440.5
F14	54.5	341.1	372.1	345.5	310.1	344.5
F13	51	270.8	301.1	279.1	248.4	279.8
F12	47.5	255.1	270.2	268.7	229.6	261.1
F11	44	266.8	267.7	283.5	238.8	258.5
F10	40.5	282.2	277.3	296.9	258.6	274.2
F9	37	286.9	288.0	289.2	278.5	272.7
F8	33.5	290.7	299.1	279.5	293.7	284.6
F7	30	283.1	296.0	255.8	293.0	274.2
F6	26.5	282.7	296.2	247.7	293.3	280.5
F5	23	288.1	298.1	257.0	297.7	279.1
F4	19.5	300.2	302.2	292.8	307.9	291.7
F3	16	319.2	302.2	324.5	324.7	303.4
F2	12.5	323.3	294.4	338.1	326.1	310.2
F1	9	325.9	288.7	338.1	325.6	304.7
Ground floor	5.5	258.3	223.6	268.4	257.5	245.6
Plinth	2	262.2	214.3	272.6	261.6	254.2

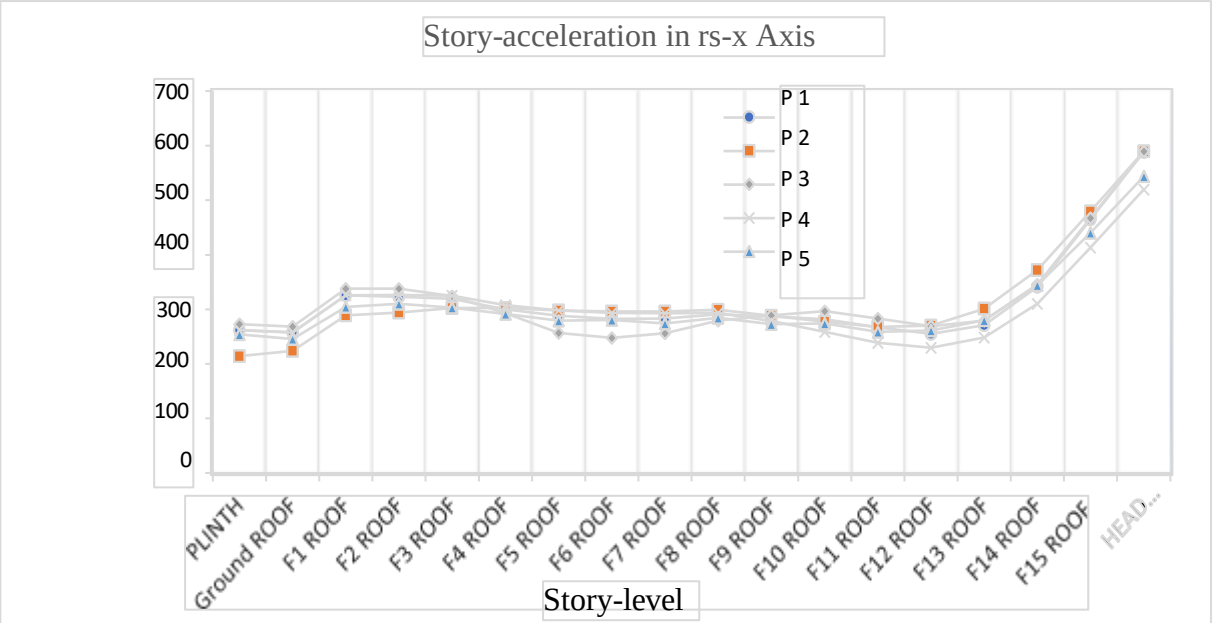

Fig: Story-Level vs Story-Acceleration in RS-X Axis

Reconciliation of Story-Acceleration in Y-Axis Under Rs-X Load

Table: Story-Acceleration in RS-Y Axis

Story's	Elevation	P - 1	P - 2	P - 3	P - 4	P - 5
	m	mm/s²	mm/s²	mm/s²	mm/s²	mm/s²
Head room	61	448.5	464.0	455.9	398.5	427.1
F15	58	377.1	391.9	380.5	328.1	355.0
F14	54.5	275.7	299.6	280.9	246.9	277.4
F13	51	208.6	229.7	227.7	193.9	220.7
F12	47.5	206.7	211.6	219.0	178.3	204.6
F11	44	216.9	213.3	230.9	188.1	203.9
F10	40.5	232.7	228.1	241.8	204.4	220.3
F9	37	240.7	242.6	237.0	229.6	224.7
F8	33.5	237.3	248.4	223.9	237.8	232.4
F7	30	239.7	252.0	210.2	241.7	227.1
F6	26.5	238.4	248.2	205.5	244.2	232.6
F5	23	241.7	248.7	216.0	247.2	231.6
F4	19.5	260.1	257.8	241.8	261.2	249.6
F3	16	268.3	251.3	272.8	268.7	253.5
F2	12.5	277.6	250.5	287.1	271.4	263.0
F1	9	278.0	247.1	287.2	272.0	259.4
Ground floor	5.5	194.3	171.2	209.0	197.4	193.2

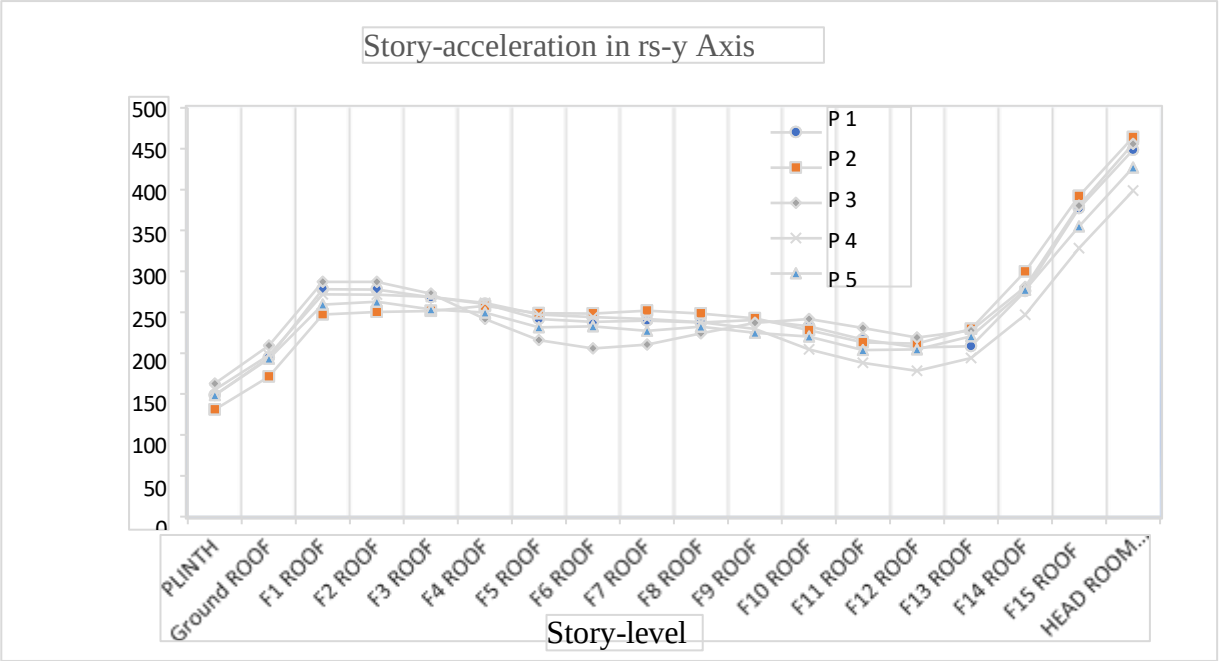

Fig: Story-Level vs Story-Acceleration in RS-Y Axis

Discussions

Story Displacement (From Fig Above)

- The displacement is coming maximum for both RS-Y & RS-X Axis in P-1 (Regular Str. building) when compared to the mass abnormal models.
- In mass abnormal P-2 Str. building (mass abnormality till 4th floor) the displacement up to 10th Story is more than it is lowered by 10% limit in Both RS-Y & RS-X Axis when compared to M -1.
- The Story displacement is coming relatively more for regular Str. building & not more for mass Str. buildings it is because of due to the increase of stiffness for the abnormal models in case of response Spectrum load in Y & X Axis.

Story Drift (From Figure above)

- The story drift for regular P-1(regular Str. building) is coming maximum at second story i.e., 29.48% limit and decreasing gradually.
- It is observed that the story drift decreasing where the mass abnormality is introduced for abnormal models (2, 3, 4), but for abnormal model 5 the Story drift is maximum at first story and decreasing gradually in Response Spectrum load case Y & X Axis.
- The story drift is coming higher at bottom storys because of due to higher stiffness.
- When comparing both the graphs for story drift it shows that variations in RS-Y is coming higher than RS-X Axis.

Story Shear (From Fig Above)

- The story shear values is higher at bottom and decreased towards the top for all models in Y and X Axis for Response Spectrum load cases.
- The story shear values where mass abnormality is introduced are coming higher by 17% 19% 12% and 20% limit respectively for mass abnormal P- 2,3,4 and 5 when comparing with regular P-1 in both RS-Y and RS-X Axis.

- The % variation of story shear is coming higher at bottom storys where the mass abnormality is added when comparing with regular storied Str. building i.e., for P-2 at 1st Story, P-3 at 5th Story, P-4 at 11th Story, P-5 at 4th story.
- Str. building which has alternate mass Abnormality (P-5) the Shear at all floors is increasing by 16% on an average.

Story Stiffness (From Fig Above)

- The Story stiffness is coming higher near the base level where the Str. building is fixed and as the story height increases, stiffness decreased in the Str. building for both RS-Y and RS-X Axis.
- The stiffness is coming relatively more where the mass abnormality is introduced for different models. This is because of when an additional mass is added in the story, also Time period increases.
- The % variation is coming maximum at story levels where the mass abnormality is introduced.
- It is observed that the story stiffness increased by 50% limit in respective story where mass abnormality introduced.

Story Force (From Fig Above)

- The story forces are coming higher at bottom and decreasing towards the top for all models in Y and X Axis due to Response Spectrum load cases.
- The story force values are coming higher where mass abnormality is introduced by 17% 19% 13% and 20% limit respectively for mass abnormal P- 2,3,4 and 5 when comparing with regular P-1 in both RS-Y and RS-X Axis.
- The % variation of story force is coming higher at bottom storys where the mass abnormality is added when comparing with regular story Str. building i.e., for P-2 at 1st Story, P-3 at 5th Story, P-4 at 11th Story, P-5 at 4th story.
- Str. building which has alternate mass abnormality the Story force at all floors is increased by 18% limit on an average.

Story Time Period (From Fig Above)

- As per graph (Fig 4.11) the time period decreasing with increasing modes.
- Time period is coming maximum at P-1 for P-4 and minimum for P-2.

Story Acceleration (From Fig Above)

- The story acceleration is increasing with the increase in story height for both RS-Y and RS-X Axiss.
- Story acceleration curve tends to drop downwards where the mass abnormality is introduced in both RS-Y & RS-X Axiss i.e., Story acceleration decreasing at floor levels where the mass abnormality introduced.
- The % change in story acceleration comparing w.r.t. to regular model it is decreasing by 10% at story levels where mass abnormalities added.

CONCLUSION

The models were analyzed by using RSM in ETABS, and w.r.t on the observations & findings, following are the conclusion's that can be listed out as.

- Story-displacement is coming more for regular Str. building and not more for mass abnormal Str. buildings in X-Axis for all models in Response-Spectrum-load cases because of due to the increase of stiffness for the abnormal models in both Y & X Axis.
- Story-drift decreasing where the mass abnormality is introduced and is coming higher at bottom story's because of due to higher stiffness. When comparing both the Axis for story-drift it shows that variations in RS-X is higher than RS-Y Axis.
- Story-shear forces are coming higher at bottom and decreasing towards the top for all models in Y and X Axis. The % variation of story shear is coming higher at bottom story's where the mass abnormality is added when comparing with regular Str. building.
- Story-stiffness is coming higher near the base level where the Str. building is fixed and as the story height increased, stiffness decreasing in the abnormal Str. building for both RS-Y and RS-X Axis. Stiffness is coming more where the mass abnormality is introduced for different models. This is because when an additional mass is added in the story, also it lead to increase in time-period.
- Story-acceleration increasing with increase in story-height for both RS-Y and RS-X Axis. The story acceleration curve tends to drop downwards where the mass abnormality is introduced in both RS-Y & RS-X Axis.

REFERENCES

1. Duggal S. K. (2010), "Earthquake Resistance Design of Structure".
2. Earth quake resistant design of structures by Pankaj Agarwal and Manish Shrikande.
3. BIS (2016). "IS 1893 (Part 1)2016: Indian standard Criteria for Earthquake Resistant Standards.
4. BIS (2017). "IS 16700 2017: Indian standard Criteria for Structural safety of tall Concrete Str. buildings.
5. BIS (1993). "IS 13920 1993(Reaffirmed 2003): Indian standard ductile detailing of Reinforced concrete structures subjected to seismic forces.
6. BIS (2000). "IS 456 2000: Indian standard Plain and Reinforced concrete code of practice.
7. BIS (1989). "IS 875 (Part-1, 2 &3) 1987 (Reaffirmed 2003): Indian standard Code of practice for Design Loads for Str. buildings and Structures.
8. IS 456:2000, "Plain and Reinforced concrete" Code of practice, Bureau of Indian standards.
9. Goel R.K, Chopra A.K. "Period formulas for moment resisting frame Str. buildings".
10. Journal Structural Engineering ASCE 123(11), pp. 1454-61. (1997).
11. S. Varadharajan, V.K. Sehgal* and Babita Saini (Journal of Structural Engineering Vol.39, No. 5, December 2012 - January 2013 pp. 538-563) "Review of different Structural Abnormalities in Str. buildings".