Evaluation of Seismic performance of R.C.C frames with different shearwall orientations: A comparative study

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Abstract:

Provision of shearwalls is one of the most widely adopted lateral load resisting system in case of multistoried R.C.C buildings. In this study the main focus is laid on determining the most effective orientation of the shearwall system to impart adequate seismic resistance in the structure. In the present study modeling of a G+4 storied building with plan dimension 24mx18m located in zone-III has been considered. shearwalls are incorporated in the building with different peripheral and central patterns. The seismic analysis was done by using response spectrum method in STAAD pro v8i software. In this study an effort has also been made to study the variation in lateral load resisting capacity of each model with various shearwall orientations curtailed at G+2 storey. The seismic performance of each orientation is evaluated by the parameters like base shear, inter storey drift, top storey deflection, maximum nodal displacement and time period.

Key words: Shear wall, Lateral loads, Base shear, Inter storey drift, Time period, Maximum nodal displacement

INTRODUCTION

In case of multistoried R.C.C frames provision of shear walls is one of the most widely used lateral stiffening construction practices in India. When the shear walls are provided with appropriate orientation and designed properly the structure performs better when subjected to lateral forces. Therefore choosing the most effective location of the shear wall has always been a vital deciding factor for the construction of a lateral load resisting frame.

RELATED WORKS

I. U.L Salve and R.S Londhe studied the effect of curtailment of shearwalls in multi storied buildings. Shearwalls upto 60% of total height of structure was found to be effective in minimizing the lateral displacement of the structure.

II. Juveria Fatima, Dr. Mohd Humraz, Kiranmayeevuyyuru evaluated the seismic performance of r.c.c structure with optimum curtailment of shearwall. The seismic analysis was done by both static and dynamic analysis. Even if when the shearwall is curtailed at G+2 it has marginal effect on the seismic performance of the building.

III. Karim M Pathan, Huzaifa Nakhwa, Choudhary Usman, Yadav Neeraj, Shaikh Kashif studied the performance high rise r.c.c buildings with effective height of curtailed shearwall. It was concluded that curtailment of shearwall about two third of height of the building does not affect much the lateral load resisting capacity of the building.

DESCRIPTION OF MODELS

In this study a G+4 building with plan dimension 24m x 18m has been considered in zone-III for seismic analysis. The seismic analysis has been carried out in STAAD pro. v8i software using Response Spectrum method. The structural properties of the building and dimensions are tabulated below.

Table-1: Dimensional properties of structure

S.no	Properties	Dimensions
1	Basement columns	0.60 x 0.50 m
2	Storey columns	0.55 x 0.50 m
3	Beams	0.45 x 0.35 m
4	Member weight on floor beams	12.5 kN/m

5	Member weight on roof beams	4.2 kN/m
6	Slab thickness	0.125 m
7	Shearwall thickness	0.250m
8	Imposed load on floors	3.0 kN/m^2
9	Imposed load on roof	1.5 kN/m^2
10	Seismic zone	III
11	Soil condition	Medium
12	Response reduction factor	5
13	Importance factor	1
14	Damping	5%

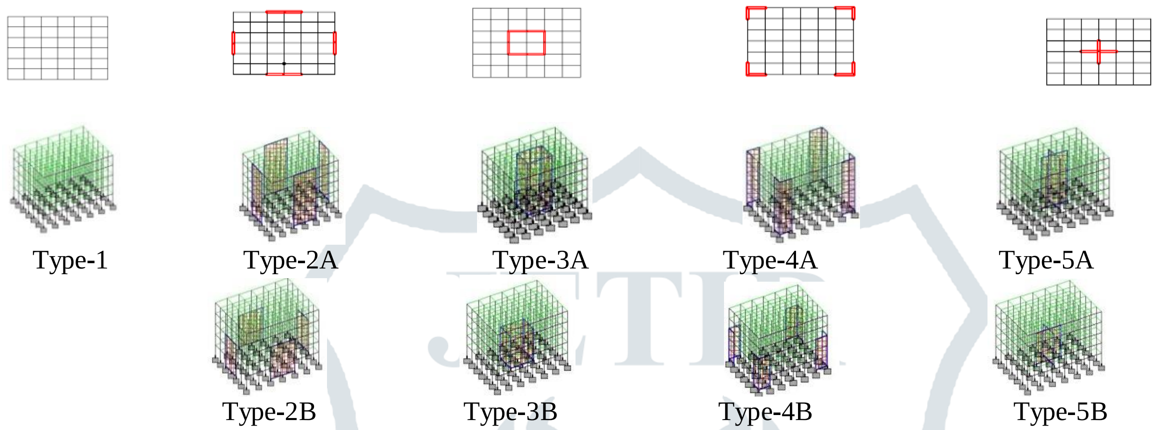

Table-2: Representation of Models

TYPE OF MODEL	REPRESENTATION
Bare frame	Type 1
Frame with shearwall at mid peripheral bays for entire height	Type 2A
Frame with shearwall at mid peripheral bays upto G+2	Type 2B
Frame with shearwall at core for entire height	Type 3A
Frame with shearwall at core upto G+2	Type 3B
Frame with L-type shearwall at corners	Type 4A
Frame with L-type shearwall at corners upto G+2	Type 4B
Frame with cross type shearwall at core	Type 5A
Frame with cross type shearwall at core upto G+2	Type 5B

RESULTS AND DISCUSSION

The seismic analysis of all models has been done by using standard software package STAAD pro. v8i and the results were tabulated. The parameters to be studied are base shear, time period, inter storey drift, top storey deflection and maximum nodal displacement.

Base Shear:

Base shear in a structure may be interpreted as the maximum expected lateral force that will occur due to the seismic ground motion at the base of a structure.

Table-2: Base shear in X and Z direction

Type of Model	Base shear in X direction (kN)	Percentage change	Base shear in Z direction (kN)	Percentage Change
Type-1	1422.90	-	1475.59	-
Type-2A	1567.91	10.19	1590.71	7.80
Type-2B	1481.41	4.11	1571.93	6.52

Type-3A	1538.16	8.10	1582.87	7.27
Type-3B	1476.93	3.79	1533.87	3.94
Type-4A	1543.62	8.48	1557.15	5.52
Type-4B	1450.51	1.94	1537.44	4.02
Type-5A	1534.75	7.86	1541.37	4.45
Type-5B	1460.43	2.63	1531.06	3.75

Being a function of mass and stiffness, the base shear is observed to be increasing from bare frame to shear wall frame. Among the shear wall frames maximum base shear in both X and Z direction is observed in Type-2A and minimum for Type-5A. When the shear wall is curtailed at G+2 storey, for both X and Z direction, maximum base shear is observed in Type-2B and minimum base shear is observed in Type-5B.

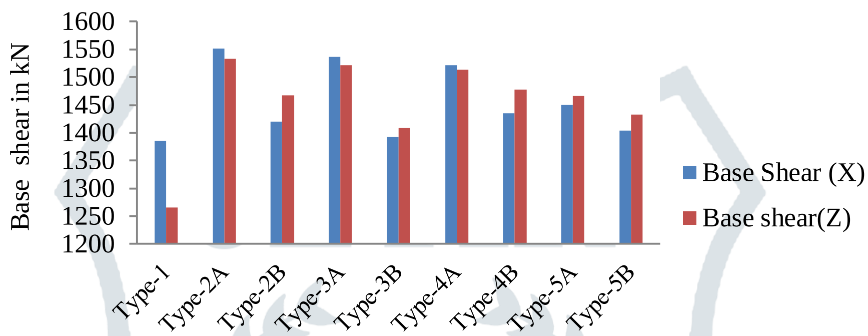

Fig 6: Comparison of base shear

Time Period: In this study it was found that fundamental time period of the bare frame is longer than that of the shear wall frame. There is a gradual decrease in time period from bare frame to the frames with curtailment of shearwall at G+2 to the frames with shearwall for the entire height.

Table 3: Time Period

Model type	Time Period (sec)
Type-1	0.736
Type-2A	0.361
Type-2B	0.442
Type-3A	0.311
Type-3B	0.407
Type-4A	0.416
Type-4B	0.490
Type-5A	0.664
Type-5B	0.665

From the analysis it was observed that the building with shearwall at core for the entire height i.e. Type-3A possess lesser time period which shows significant stiffness of the model. And when the shearwall was curtailed at G+2, minimum time period was observed in Type-3B.

Inter Storey Drift:

As per IS 1893-2002 (Part-1) storey drift should be within 0.4% of the storey height which is satisfied for the bare frame as well as for the frames with shearwalls for the entire height. Minimum inter storey drift was observed in Type-3A and maximum inter storey drift was observed in Type-5A. After curtailing the shearwalls at G+2 storey for each orientation drift limitation was satisfied only in Type-2B.

Table 4: Inter Storey Drift in X direction (mm)

Storey	Inter Storey Drift in mm								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type 5A	Type 5B
1	21.887	2.879	0.836	2.179	2.471	3.391	3.253	4.103	2.934
2	33.569	3.167	2.313	2.333	4.454	4.194	5.807	5.319	6.328
3	26.909	2.960	1.821	2.087	2.305	4.158	3.307	4.981	4.618
4	16.915	2.621	10.770	1.758	10.40	3.760	12.503	4.249	12.203
5	7.718	1.922	6.269	1.254	6.154	2.993	6.764	2.880	6.563

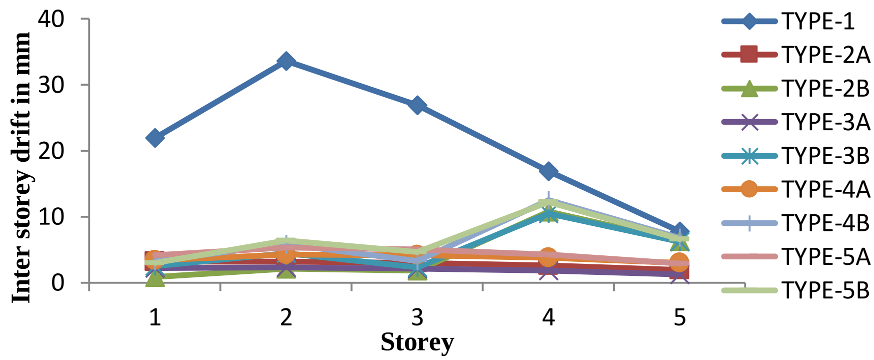

Fig 8: Comparison of Inter storey drift in X directio

Table 5: Inter Storey Drift in Z direction (mm)

Storey	Inter Storey Drift in mm								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type 5A	Type 5B
1	24.375	4.087	1.995	3.063	3.660	4.863	4.958	5.780	4.921
2	31.983	4.477	3.320	3.255	5.636	5.905	7.583	7.097	8.083
3	24.548	4.217	2.372	2.938	2.749	5.721	4.234	6.591	5.280
4	15.227	3.667	11.001	2.469	10.725	4.996	13.103	5.488	12.484
5	6.687	2.650	5.756	1.739	5.629	3.849	6.341	3.539	6.022

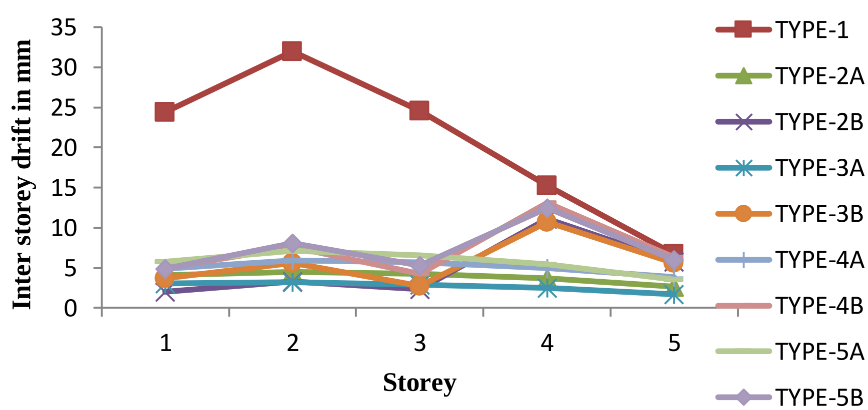

Fig 9: Comparison of Inter storey drift in Z direction

Top Storey Deflection:

Top storey deflection may be interpreted as the lateral displacement of the top storey with respect to the basement of the building. Top Storey deflections for models with different shearwall arrangements are tabulated below.

Table-6: Top storey deflection (mm)

Model Type	Top storey deflection in X direction	Top storey deflection in Z direction
Type-1	106.990	102.823
Type-2A	25.932	36.734
Type-2B	38.032	46.952
Type-3A	18.086	25.162
Type-3B	30.805	35.816
Type-4A	34.361	46.932
Type-4B	45.937	57.366
Type-5A	39.387	51.857
Type-5B	51.024	61.190

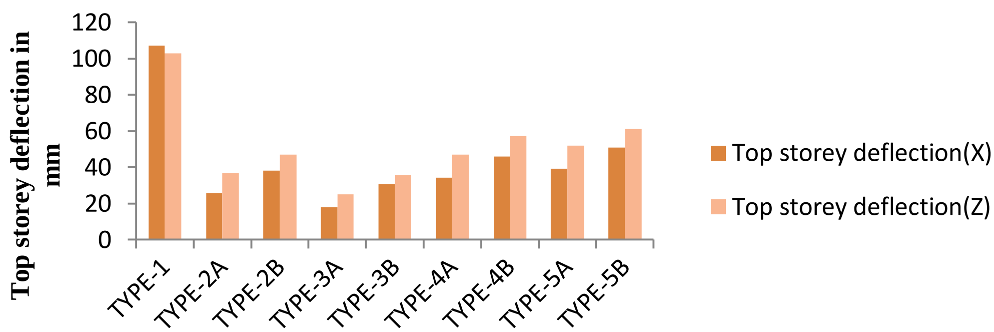

Fig 10: Comparison of Top storey deflection

Maximum Nodal Displacement:

The maximum nodal displacement observed in different models are tabulated below. The nodal displacement reduced significantly after incorporation of shearwalls. Even after the curtailment of shearwall at G+2 storey the nodal displacements were found to be decreased with respect to the bare frame.

Table-7: Maximum nodal displacement (cm/rad)

Model Type	**Maximum Nodal displacement (X)**	**Maximum Nodal displacement (Z)**
Type-1	10.704	10.28
Type-2A	2.618	3.721
Type-2B	3.807	9.227
Type-3A	1.825	2.549
Type-3B	3.805	3.593
Type-4A	3.513	4.745
Type-4B	4.610	5.752
Type-5A	3.956	5.237
Type-5B	5.106	6.124

Peak Storey Shear:

Peak storey shear is the maximum shear force occurring in a storey during the vertical distribution of base shear.
Table-8: Peak Storey shear in X direction

Storey	Peak storey shear in kN								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type5A	Type 5B
1	1422.90	1566.12	1477.07	1535.96	1406.91	1542.07	1448.21	1533.7	1459.06
2	1323.68	1441.32	1349.82	1402.54	1256.99	1425.32	1332.87	1414.2	1349.22
3	1083.89	1194.65	1129.96	1147.81	1048.75	1187.48	1109.08	1169.8	1121.30
4	729.50	828.46	854.91	778.88	833.34	832.55	814.59	810.14	808.48
5	258.39	300.60	330.90	276.14	333.45	308.81	309.59	296.82	302.16

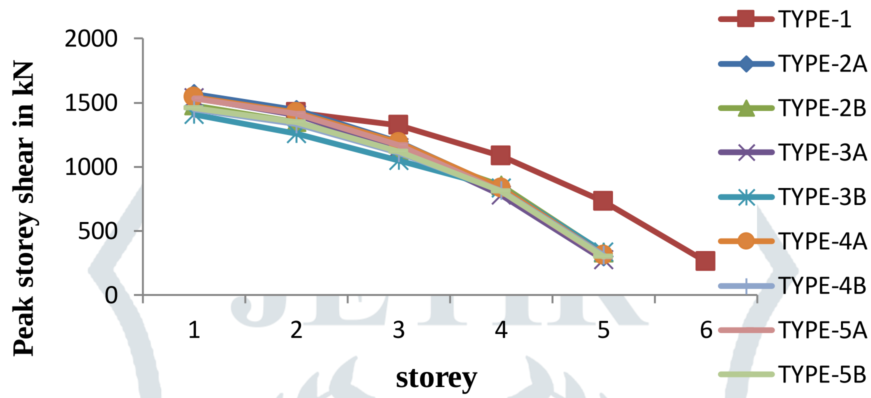

Fig 12: Comparison of peak storey shear in X direction

Table-9: Peak storey shear in Z direction

Storey	Peak storey shear in kN								
	Type 1	Type 2A	Type 2B	Type 3A	Type 3B	Type 4A	Type 4B	Type 5A	Type 5B
1	1475.59	1586.33	1570.31	1532.00	1507.55	1555.76	1534.94	1540.53	1529.70
2	1361.35	1449.71	1444.79	1400.24	1363.63	1437.67	1406.89	1419.44	1405.61
3	1107.12	1193.33	1199.93	1149.69	1136.49	1197.19	1151.14	1174.14	1150.72
4	739.12	857.31	833.49	784.42	863.43	833.88	808.59	811.60	801.12
5	258.07	315.54	304.33	279.53	329.59	309.31	293.84	296.00	288.36

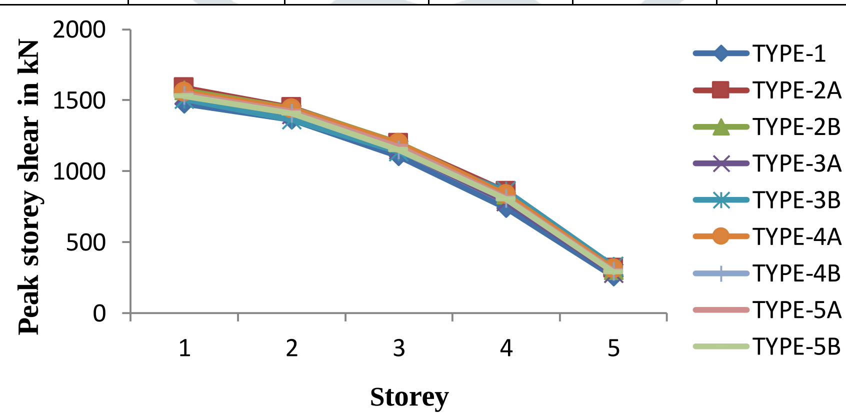

Figure 12: Comparison of Peak storey shear in Z direction

CONCLUSION

From the above study it can be concluded that when shearwalls are provided at the core of the building for the entire height, inter storey drift and storey displacement reduced significantly. Hence Type-3A may be considered as the stiffer orientation in comparison to peripheral and corner orientations of shearwalls.

When the shearwalls are curtailed at G+2 storey, drift limitation was satisfied only in Type-2B. Hence curtailment of shearwalls is recommended only with peripheral shearwall orientation without any special design consideration.

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