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Effect of Curtailed Shear Wall on Storey Drift of High Rise Buildings Subjected To Seismic Loads

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Abstract: *Shear wall is a structural element used to resist horizontal forces parallel to the plane of the wall. Shear wall has highly in plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. Shear Walls are specially designed structural walls include in the buildings to resist horizontal forces that are induces in the plane of the wall due to wind, earthquake and other forces. To bring the maximum drift down to allowable limits, cross sectional dimensions of beams and columns have to be increased in many cases. For the study, two Symmetrical Structures of 15-storey and 21-storey are analyzed by using standard software package STAAD.Pro V8i. The parameters considered for the analysis are Shear wall, No. of Storey's, No. of bays (x, z), bay Width.*
The main objectives of this study are
1. To compute the seismic response of reinforced concrete frame structures with curtailed shear walls.
2. To determine parameters like storey drift, storey shear and Lateral displacement.
Keywords*: Shear Wall, Storey Drift, Lateral Displacement*

I. Introduction

RC multi-storey buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, beam and column sizes are quite heavy and there is problem arises at these joint and it is congested to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in building member. Shear wall may become essential from the point of view of economy and control of horizontal displacement.

These walls generally start at foundation level and are continuous throughout the building height. Shear walls are a type of structural system that provides lateral resistance to a building or structure. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

II. Selection Of Various Parameters

For the study, two Symmetrical Structures 15-Storey and 21-Storey are analyzed by using standard software package STAAD.Pro V8i. The total plan dimension of building is 18.5m x 18.5m.

The parameters considered for the analysis are
1. Shear Wall
2. No. of Storey's
3. No. of Bays (x, z)
4. Bay Width (x, z)

III. Description of models

The designation used for the building models is as given in following Table 1.

Table 1. Description of building model

Model No.	Type of Structure	Designation
1	G+15 Storey RCC Structure without Shear Wall	G15WSW
2	G+15 Storey RCC Structure with Full Shear Wall	G15FSW
3	G+15 Storey RCC Structure with Shear Wall up to 14th floor	G15SW14
4	G+15 Storey RCC Structure with Shear Wall up to 13th floor	G15SW13
5	G+15 Storey RCC Structure with Shear Wall up to 12th floor	G15SW12
6	G+15 Storey RCC Structure with Shear Wall up to 11th floor	G15SW11
7	G+15 Storey RCC Structure with Shear Wall up to 10th floor	G15SW10
8	G+15 Storey RCC Structure with Shear Wall up to 09th floor	G15SW09
9	G+21 Storey RCC Structure without Shear Wall	G21WSW
10	G+21 Storey RCC Structure with Full Shear Wall	G21FSW
11	G+21 Storey RCC Structure with Shear Wall up to 20th floor	G21SW20
12	G+21 Storey RCC Structure with Shear Wall up to 19th floor	G21SW19
13	G+21 Storey RCC Structure with Shear Wall up to 18th floor	G21SW18

14	G+21 Storey RCC Structure with Shear Wall up to 17th floor	G21SW17
15	G+21 Storey RCC Structure with Shear Wall up to 16th floor	G21SW16
16	G+21 Storey RCC Structure with Shear Wall up to 15th floor	G21SW15
17	G+21 Storey RCC Structure with Shear Wall up to 14th floor	G21SW14

Dimensions Of Proposed Model

Plan dimension of structure = 18.5 m × 18.5 m
No of bays in X-direction = 5
No of bays in Y-direction = 5
Spacing of bays in X-direction = 4.5 m
Spacing of bays in Y-direction = 4.5 m
Height of all typical floors (including ground floor) = 3.0 m
Height of parapet wall = 1 m (all around the periphery of roof floor)

General Characteristics Of The Analyzed Structural Systems

The general characteristics of the structure are as per Table2. Which is given below.

Table 2. General Characteristics of the Analyzed Structural Systems

Type of Structural system	Column Groups for all Models		
	C1 (Corner Columns)	C2 (External Columns)	C3 (Internal Columns)
Slab (mm)	150	150	150
Column (mm)	700 X 700	850 X 700	1000 X 700
Beam (mm)	450 X 230		
Thickness of Shear Wall (mm)	230		
Material Properties	For Concrete M25 and For Steel Fe 415		
Height of each floor(m)	3		
Density (kN/m^2)	25		

IV. Results and Discussion

The seismic analysis of all the models that includes full and varying height of shear walls has been done by using standard software package STAAD.Pro V8i and the results are shown below. The parameters which are to be studied are lateral displacement, storey drift, axial force, shear force and bending moments.

Table 3. Lateral displacement of 15- Storey Structure with all column groups

MODEL NAME	C1		C2		C3	
	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)
G15WSW	159.542	_____	162.682	_____	162.617	_____
G15FSW	142.934	0.3380	142.877	0.3380	141.198	0.1710
G15SW14	142.596	0.0230	142.539	0.0230	141.027	0.1140
G15SW13	142.573	0.0500	142.516	0.0500	140.913	0.1240
G15SW12	142.523	0.0620	142.466	0.0620	140.789	0.0810
G15SW11	142.461	0.0110	142.404	0.0110	140.708	-0.0570
G15SW10	142.450	-0.1200	142.393	-0.1190	140.765	-0.2820
G15SW09	142.570	0.0000	142.512	0.0000	141.047	0.0000

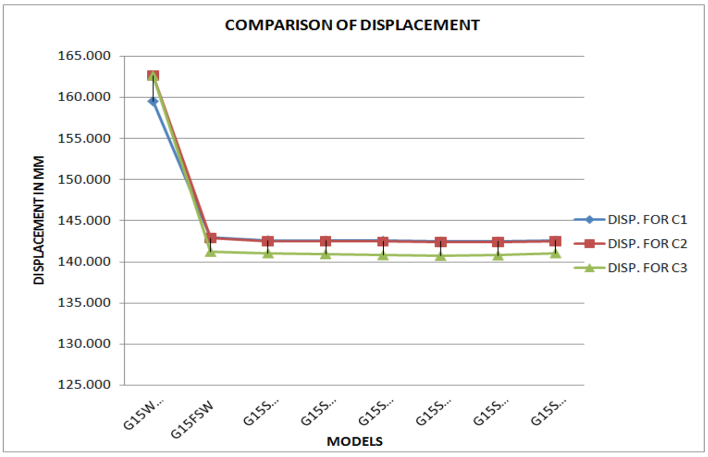

Fig.1. Comparison of Lateral displacement 15 Storey Structure with all column groups

Table 4. Lateral displacement of 21- Storey Structure with all column groups

MODEL NAME	C1		C2		C3	
	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)	MAX. DISPLACEMENT (mm)	STOREY DRIFT (mm)
G21WSW	294.384	_____	262.188	_____	262.118	_____
G21FSW	237.120	0.1330	237.056	0.1330	235.495	0.2170
G21SW20	236.987	0.0320	236.923	0.0320	235.278	0.1240
G21SW19	236.955	0.0480	236.891	0.0070	235.154	0.0067
G21SW18	236.907	0.0950	236.884	0.1360	234.954	0.1540
G21SW17	236.812	0.1200	236.748	0.1200	234.800	0.1760
G21SW16	236.692	0.1050	236.628	0.1040	234.624	0.1060
G21SW15	236.587	-0.0510	236.524	-0.1500	234.518	-0.0060
G21SW14	236.638	0.0000	236.674	0.0000	234.524	0.0000

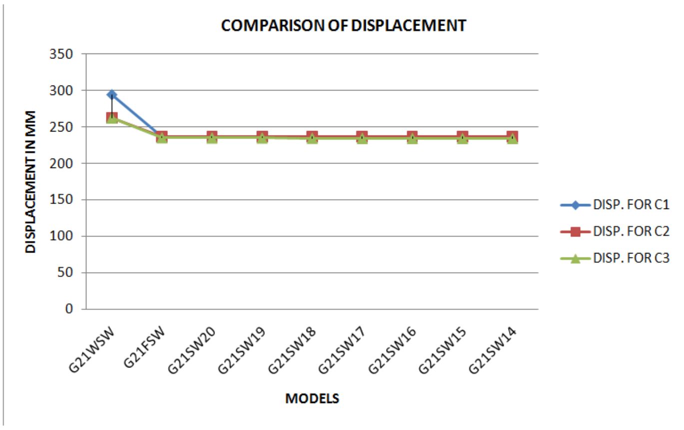

Fig. 2. Comparison of Lateral displacement 21-Storey Structure with all column groups

Table 5. Comparative statement of 15-Storey and 21 Storey models for Lateral Displacement

A. Displacement of 15-Storey model

Model	C1		C2		C3	
	DISP.(mm)	STOREY DRIFT (mm)	DISP.(mm)	STOREY DRIFT (mm)	DISP.(mm)	STOREY DRIFT (mm)
G15FSW	142.934	0.484	142.877	0.484	141.198	0.433
G15SW10	142.450		142.393		140.765	

From the result presented in Table 5 (A) . The displacement for model G15FSW is 142.934 and for the model G15SW10 is 142.450 for Column group C1 so the increase in the displacement with full height of shear wall and varying height is only 0.5 % and is same for the column group C2 and C3.

The storey drift as per IS 1893:2002 shall not exceed 0.004 times the storey height i.e. 0.004 X 3000 = 12 mm. So storey drift from above comparison is 0.484 mm which is satisfying the IS recommendation.

B. Displacement of 21-Storey model

Model	C1		C2		C3	
	DISP.(mm)	STOREY DRIFT (mm)	DISP.(mm)	STOREY DRIFT (mm)	DISP.(mm)	STOREY DRIFT (mm)
G21FSW	237.120	0.533	237.056	0.532	235.495	0.977
G21SW15	236.587		236.524		234.518	

From the result presented in Table 5 (B) . The displacement for model G21FSW is 237.120 and for the model G21SW15 is 236.587 for Column group C1 so the increase in the displacement with full height of shear wall and varying height is only 0.5 % and is same for the column group C2 and C3.

The storey drift as per IS 1893:2002 shall not exceed 0.004 times the storey height i.e. 0.004 X 3000 = 12 mm. So storey drift from above comparison is 0.533 mm which is satisfying the IS recommendation.

Table 6. Comparative statement of 15-Storey and 21 Storey models for Axial Force

A. Axial Force of 15-Storey model

Model	C1	C2	C3
G15FSW	4450	5800	10530
G15SW10	4450	5790	10600

B. Axial Force of 21-Storey model

Model	C1	C2	C3
G21FSW	6340	8100	13000
G21SW15	6340	8090	13000

Table 7. Comparative statement of 15-Storey and 21 Storey models for Shear Force

A. Shear Force of 15-Storey model

Model	C1		C2		C3	
	Fy	Fz	Fy	Fz	Fy	Fz
G15FSW	91.330	95.368	168.362	152.515	263.886	154.483
G15SW10	91.083	95.255	167.976	152.530	262.566	163.013

B. Shear Force of 21-Storey model

Model	C1		C2		C3	
	Fy	Fz	Fy	Fz	Fy	Fz
G21FSW	97.522	102.357	186.162	172.380	297.371	183.752
G21SW15	97.428	102.256	186.119	172.501	295.450	183.566

Table 8. Comparative statement of 15-Storey and 21 Storey models for Bending Moments

A. Bending Moments of 15-Storey model

Model	C1		C2		C3	
	My	Mz	My	Mz	My	Mz
G15FSW	372.424	362.273	466.803	640.118	469.882	834.425
G15SW10	374.253	361.119	469.123	638.043	471.750	832.117

B. Bending Moments of 21-Storey model

Model	C1		C2		C3	
	My	Mz	My	Mz	My	Mz
G21FSW	408.201	395.453	512.105	699.795	519.429	917.052
G21SW15	409.145	394.999	513.295	698.988	519.341	915.154

From the result presented in Table 6, 7 and 8 there is no significant increase in the values of Axial force, Shear force and Bending moments for all the column groups since the shear wall is decreased up to considerable floors.

VI. Conclusion

Following conclusions are drawn based on the experimental results.

I. As far as lateral displacement is concerned there is no there is significant increase in the value of lateral displacement.
II. The total increase in the value of Lateral displacement is only 0.5 % for full height of shear wall and varying height of shear wall.
III. The storey drift as per IS 1893:2002 shall not exceed 0.004 times the storey height. i.e. 0.004 X 3000 = 12 mm which is also satisfied.
IV. There is no significant increase in the values of axial force, Shear force and bending moments for all the column groups since the shear wall is decreased up to considerable floors.
V. Shear wall can be used up to 60 % of total height of the structure without reduction of lateral loads and hence reduction in concrete cost also.

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