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Use of Shear Wall and Reinforced Cement Concrete Bracing System Both in High Rise Commercial Buildings Using Staad Pro Software

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ABSTRACT- In earthquake prone zones the structures are designed to withstand seismic or lateral forces along with the gravity loads. In that respect shear wall system, bracing system, diagrid etc., have been suggested over a period of time. This study observed the combined performance of shear wall and RCC bracing system, and also the effect of their relative position in high rise commercial building (G+10).The study aimed the comparison of performance of shear wall and RCC bracing system in high rise commercial buildings under seismic loading. The total of 6 structural configurations viz., Moment resisting frame (Model 1), MRF stiffened with RCC bracing system (Model 2), MRF stiffened with shear wall system (Model 3), MRF stiffened with both shear wall and RCC bracing system (Model 4A, Model 4B, and Model 4C – Based on different relative location of shear wall and RCC bracing system) were modelled and then analysed. Analysis has been done in accordance with 1893:2002 using STAAD Pro V8i software. The post analysis results concluded that The bracing system improves not only the stiffness and strength capacity but also the displacement capacity of the structure. And in model 4(RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3) is more efficient, safe and economical in earthquake as compared to other analysed models.

KEYWORDS- Keywords- Stiffness, Strength, Bracing System, Shear wall System , Seismic zone v, IS 1893:2002 and STAAD -PRO v 8i

I. INTRODUCTION

Nowadays high rise building is constructed for the purpose of stiffness and lateral load resistance. Larger seismic waves strike the earth surface caused shaking the earth surface in all possible direction , as Earthquake causes shaking of the ground [1]. So, a building resting on it will experience motion at its base. The structure also gets affected with the duration & intensity of the earthquake.Structural damage due to an earthquake is not solely a function of the earthquake ground motion [2]. Bracing are the most prominent method used by structural engineers. Increase the lateral load resistance by bracing system.

EARTHQUAKE RESISTANT STRUCTURE DESIGN

Translational inertia forces have significant effects on building than vertical and rotational shaking components. So Earthquake resistant design concentrates particularly on the translational inertia forces.

There are many steel and reinforced cement concrete systems used for seismic design. The main popular systems for earthquake resistance are:

1. Moment-Resisting Frames, 2. Shear Walls, 3. Bracing System, 4. Frame-Wall System.

Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. Lateral bracing systems provides stiffness and stability to the structure, and is economical.

Here is the analysed structure stiffened with both RCC bracing and shear wall system. In this study 6 models have been prepared.

II. OBJECTIVE

- To understand various types of structures bracing systems and Shearwall system.
- To study the effect on seismic performance of high rise commercial building due to different relative positions of shear wall and RCC X-bracing system.
- To analysis the seismic parameters for RCC frame, RCC frame with RCC Bracing system, and RCC frame with shear wall.
- To compare the results of different models based on use and relative position of shear wall and RCC X-bracing system.
- To figure out the safest and economical model as per seismic parameters namely base shear and storey displacement.

III. LITERATURE REVIEW

Mehul M. kanthariya In general the structures are analysis as RC structure RCC high rise building of G + 10 Storey is used for bracing system to improve seismic resistance using various type of R.C.C. bracing system such as single diagonal bracing, Double diagonal bracing in seismic zone III using IS-1893:2002 for RC structure. Compare base shear, bending moment, deflection of a structure analysis by using STAAD PRO V8i. Bracing, which provides stability and resists lateral loads, may be from diagonal steel members or, from a concrete 'core'. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads.[3]

Abhinav et al. (2016) analysed 11-storey RCC building with shear walls using STAAD Pro software. The location of shear walls was main objective. an RCC building of 11 floors placed exposed to earthquake loading in zone V is considered and earthquake load has calculated by a seismic coefficient method using IS 1893 (Part I): 2002. The comparative study of deflection of building with and without a shear wall is carried out in X and Z directions. The lateral deflection for building with the shear wall along periphery is reduced in comparison to other models. Hence, it has been concluded that the building with the shear wall along periphery is much more efficient than all other model with a shear wall.[4]

Numan and Islam concluded from their study the maximum displacement of the structure decreases after application of X-braced system as compared to different types of steel system. [5]

IV. MODELLING OF STRUCTURE

A. Details of a Structure

Table:1 shows the preliminary details of structure

Table 1: Preliminary details of a structure

Structure	SMRF
Number of Storey	G+10
Type of building	Commercial
Storey Height	4.0 meters
Neck Column Height	2.0 meters
Grade of concrete	M35
Grade of steel	Fe 415
Young's modulus of concrete	2.74 X 10^7kN/m^2
Young's modulus of steel	2.00 X 10^8kN/m^2
Density of RCC	25 kN/m^2
Thickness of slab	0.150mm
Beam size i. Plinth Beam ii. Beam (GF and 1st Storey) iii. Beam (2nd– 10th storey)	0.75m x 0.65m 0.65m x 0.55m 0.55m x 0.45m
Column size i. Neck column ii. Column (GF and 1st Storey) iii. Column (2nd– 10th storey)	0.75m x 0.65m 0.65m x 0.55m 0.55m x 0.45m
Bracing size	0.45m x 0.45m
Shear wall thickness	0.23m

Table 2: Loading details as per IS 875

Load Type	Load Intensity
Dead Load i. Self-weight of RCC ii. Self-weight of Brick masonry	25 kN/m^3 20 kN/m^3
Live Load i. On floors ii. On roofs	5 kN/m^2 2 kN/m^2

Table 3: Zone Factor, Z

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

B. Plan of Building

The plan of the G+10 RCC high rise building with 3 bays 5m each along both transverse and longitudinal direction is shown below:

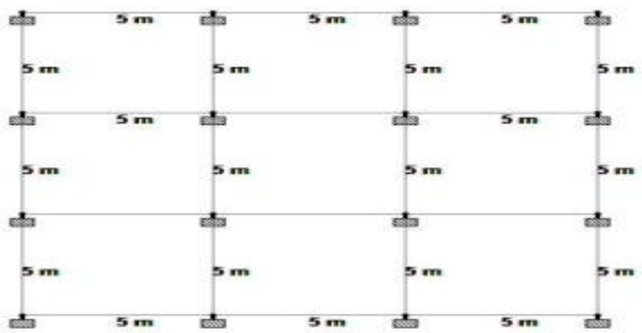

Figure 1: Plan of Structure

C. Material Properties

CONCRETE: M35 grade of concrete is used for all the members of structure. The elastic modulus of M35 concrete confirming to IS 456:2000 can be calculated as,
Ec = 5000√fck N/mm2
Ec = 5000√35 N/mm2
Ec = 29580N/mm2
STEEL :The Fe415 grade of steel is used throughout because of its high ultimate strength than Fe250 and more ductility than Fe500.
The IS 1786 is taken as criterion for use of Fe415.

D. Analysis of Structure

The STAAD Pro software is used for modelling and to carry out the analysis. The different types of building frames considered for analysis are:
I. Moment Resisting Frame (MRF)
II. RCC building with RCC X-bracing system
III. RCC building with Shear wall system.
IV. RCC building with both shear wall and RCC X-bracing system.

E. Analysis of Model 1

The model 1 is the bare moment resisting frame
The lateral force results from STAAD Pro shown in Table:4 and Model for Storey displacements and storey drift 1 shown in Table 5

Table 4: Lateral force results for model 1

Storey	Height (m)	Lateral Force (kN)
12	2	441.410
11	6	415.844
10	10	340.407
9	14	272.515
8	18	212.165
7	22	159.36
6	26	114.098
5	30	76.380
4	34	46.205
3	38	25.692
2	42	9.410
1	46	1.106

Table 5: Storey displacements and storey drift for model 1

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STATUS
			X	Z	X	Z	
1	0.0	11	0.0000	0.0000	0.0000	0.0000	PASS
		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2.0	11	0.1047	0.0000	0.1047	0.0000	PASS
		12	-0.1047	0.0000	0.1047	0.0000	PASS
		13	0.0000	0.1163	0.0000	0.1163	PASS
		14	0.0000	-0.1163	0.0000	0.1163	PASS
3	6.0	11	1.0169	0.0000	0.9122	0.0000	PASS
		12	-1.0169	0.0000	0.9122	0.0000	PASS
		13	0.0000	1.1993	0.0000	1.0830	PASS
		14	0.0000	-1.1993	0.0000	1.0830	PASS
4	10.0	11	2.2150	0.0000	1.1981	0.0000	PASS
		12	-2.2150	0.0000	1.1981	0.0000	PASS
		13	0.0000	2.5662	0.0000	1.3669	PASS
		14	0.0000	-2.5662	0.0000	1.3669	PASS
5	14.0	11	4.1711	0.0000	1.9561	0.0000	*FAIL
		12	-4.1711	0.0000	1.9561	0.0000	*FAIL
		13	0.0000	4.9306	0.0000	2.3644	*FAIL
		14	0.0000	-4.9306	0.0000	2.3644	*FAIL
6	18.0	11	6.4450	0.0000	2.2739	0.0000	*FAIL
		12	-6.4450	0.0000	2.2739	0.0000	*FAIL
		13	0.0000	7.6172	0.0000	2.6866	*FAIL
		14	0.0000	-7.6172	0.0000	2.6866	*FAIL

7	22.0	11	8.7105	0.0000	2.2655	0.0000	*FAIL
		12	-8.7105	0.0000	2.2655	0.0000	*FAIL
		13	0.0000	10.2718	0.0000	2.6545	*FAIL
		14	0.0000	-10.2718	0.0000	2.6545	*FAIL
8	26.0	11	10.8868	0.0000	2.1763	0.0000	*FAIL
		12	-10.8868	0.0000	2.1763	0.0000	*FAIL
		13	0.0000	12.8140	0.0000	2.5422	*FAIL
		14	0.0000	-12.8140	0.0000	2.5422	*FAIL
9	30.0	11	12.9149	0.0000	2.0281	0.0000	*FAIL
		12	12.9149	0.0000	2.0281	0.0000	*FAIL
		13	0.0000	15.1774	0.0000	2.3634	*FAIL
		14	0.0000	15.1774	0.0000	2.3634	*FAIL
10	34.0	11	14.7318	0.0000	1.8169	0.0000	*FAIL
		12	14.7318	0.0000	1.8169	0.0000	*FAIL
		13	0.0000	17.2888	0.0000	2.1114	*FAIL
		14	0.0000	17.2888	0.0000	2.1114	*FAIL
11	38.0	11	16.2685	0.0000	1.5367	0.0000	PASS
		12	16.2685	0.0000	1.5367	0.0000	PASS
		13	0.0000	19.0670	0.0000	1.7783	*FAIL
		14	0.0000	19.0670	0.0000	1.7783	*FAIL
12	42.0	11	17.4516	0.0000	1.1831	0.0000	PASS
		12	17.4516	0.0000	1.1831	0.0000	PASS
		13	0.0000	20.4241	0.0000	1.3571	PASS
		14	0.0000	20.4241	0.0000	1.3571	PASS
13	46.0	11	18.2323	0.0000	0.7807	0.0000	PASS
		12	18.2323	0.0000	0.7807	0.0000	PASS
		13	0.0000	21.2931	0.0000	0.8690	PASS
		14	0.0000	21.2931	0.0000	0.8690	PASS

F. Analysis of Model 2

The RCC bracing system with X-configuration is paced at the 4 corners on both transverse as well as longitudinal bays of a RCC frame. Data of lateral force are given below in Table:6

Table 6: Lateral force distribution for model 2

Storey	Height (m)	Lateral force (kN)
12	46	468.595
11	42	461.594
10	38	377.858
9	34	302.496
8	30	235.507
7	26	176.892
6	22	126.650
5	18	84.783
4	14	51.288
3	10	28.283
2	6	10.342
1	2	1.157

Data for storey displacement and storey drift model 2 is given in Table 7

Table 7: Storey displacement and storey drift of model 2

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STATUS
			X	Z	X	Z	
1	0.00	11	0.0000	0.0000	0.0000	0.0000	PASS
		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2.00	11	0.0755	0.0000	0.0755	0.0000	PASS
		12	-0.0755	0.0000	0.0755	0.0000	PASS
		13	0.0000	0.0863	0.0000	0.0863	PASS
		14	0.0000	-0.0863	0.0000	0.0863	PASS
3	6.00	11	0.3420	0.0000	0.2665	0.0000	PASS

		12	-0.3420	0.0000	0.2665	0.0000	PASS
		13	0.0000	0.3662	0.0000	0.2799	PASS
		14	0.0000	-0.3662	0.0000	0.2799	PASS
4	10.0	11	0.7264	0.0000	0.3844	0.0000	PASS
		12	-0.7264	0.0000	0.3844	0.0000	PASS
		13	0.0000	0.7605	0.0000	0.3943	PASS
		14	0.0000	-0.7605	0.0000	0.3943	PASS
5	14.0	11	1.2886	0.0000	0.5623	0.0000	PASS
		12	-1.2886	0.0000	0.5623	0.0000	PASS
		13	0.0000	1.3443	0.0000	0.5838	PASS
		14	0.0000	-1.3443	0.0000	0.5838	PASS
6	18.0	11	1.9765	0.0000	0.6878	0.0000	PASS
		12	-1.9765	0.0000	0.6878	0.0000	PASS
		13	0.0000	2.0528	0.0000	0.7085	PASS
		14	0.0000	-2.0528	0.0000	0.7085	PASS
7	22.0	11	2.7411	0.0000	0.7646	0.0000	PASS
		12	-2.7411	0.0000	0.7646	0.0000	PASS
		13	0.0000	2.8417	0.0000	0.7889	PASS
		14	0.0000	-2.8417	0.0000	0.7889	PASS
8	26.0	11	3.5574	0.0000	0.8163	0.0000	PASS
		12	-3.5574	0.0000	0.8163	0.0000	PASS
		13	0.0000	3.6863	0.0000	0.8445	PASS
		14	0.0000	-3.6863	0.0000	0.8445	PASS
9	30.0	11	4.4006	0.0000	0.8432	0.0000	PASS
		12	-4.4006	0.0000	0.8432	0.0000	PASS
		13	0.0000	4.5607	0.0000	0.8744	PASS
		14	0.0000	-4.5607	0.0000	0.8744	PASS
10	34.0	11	5.2458	0.0000	0.8452	0.0000	PASS
		12	-5.2458	0.0000	0.8452	0.0000	PASS
		13	0.0000	5.4395	0.0000	0.8788	PASS
		14	0.0000	-5.4395	0.0000	0.8788	PASS
11	38.0	11	6.0676	0.0000	0.8219	0.0000	PASS
		12	-6.0676	0.0000	0.8219	0.0000	PASS
		13	0.0000	6.2970	0.0000	0.8575	PASS

		14	0.0000	-6.2970	0.0000	0.8575	PASS
12	42	11	6.8370	0.0000	0.7693	0.0000	PASS
		12	-6.8370	0.0000	0.7693	0.0000	PASS
		13	0.0000	7.1032	0.0000	0.8062	PASS
		14	0.0000	-7.1032	0.0000	0.8062	PASS
13	46	11	7.5197	0.0000	0.6827	0.0000	PASS
		12	-7.5197	0.0000	0.6827	0.0000	PASS
		13	0.0000	7.8200	0.0000	0.7168	PASS
		14	0.0000	-7.8200	0.0000	0.7168	PASS

G. Analysis of Model 3

In this model the shear walls with uniform thickness of 0.230m are placed at the corners of the frame. Data for Lateral forces for model 3 is given in Table 8

Table 8: Lateral force distribution for model 3

Storey	Height (m)	Lateral force (kN)
12	46	921.190
11	42	389.319
10	38	318.694
9	34	255.132
8	30	198.632
7	26	149.195
6	22	106.820
5	18	71.508
4	14	43.258
3	10	24.053
2	6	8.809
1	2	1.996

Values of Displacement and Drift model 3 is given in Table 9

Table 9: Storey displacement and storey drift of model 3

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STAT US
			X	Z	X	Z	
1	0	11	0.0000	0.0000	0.0000	0.0000	PASS

		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2	11	0.0612	0.0000	0.0612	0.0000	PASS
		12	-0.0612	0.0000	0.0612	0.0000	PASS
		13	0.0000	0.0715	0.0000	0.0715	PASS
		14	0.0000	-0.0715	0.0000	0.0715	PASS
3	6	11	0.4272	0.0000	0.3660	0.0000	PASS
		12	-0.4272	0.0000	0.3660	0.0000	PASS
		13	0.0000	0.4877	0.0000	0.4163	PASS
		14	0.0000	-0.4877	0.0000	0.4163	PASS
4	10	11	0.9420	0.0000	0.5147	0.0000	PASS
		12	-0.9420	0.0000	0.5147	0.0000	PASS
		13	0.0000	1.0470	0.0000	0.5592	PASS
		14	0.0000	-1.0470	0.0000	0.5592	PASS
5	14	11	1.7588	0.0000	0.8168	0.0000	PASS
		12	-1.7588	0.0000	0.8168	0.0000	PASS
		13	0.0000	1.9826	0.0000	0.9356	PASS
		14	0.0000	-1.9826	0.0000	0.9356	PASS
6	18	11	2.6794	0.0000	0.9206	0.0000	PASS

		12	-2.6794	0.0000	0.9206	0.0000	PASS
		13	0.0000	3.0118	0.0000	1.0292	PASS
		14	0.0000	-3.0118	0.0000	1.0292	PASS
7	22	11	3.5547	0.0000	0.8753	0.0000	PASS
		12	-3.5547	0.0000	0.8753	0.0000	PASS
		13	0.0000	3.9782	0.0000	0.9664	PASS
		14	0.0000	-3.9782	0.0000	0.9664	PASS
8	26	11	4.3319	0.0000	0.7772	0.0000	PASS
		12	-4.3319	0.0000	0.7772	0.0000	PASS
		13	0.0000	4.8261	0.0000	0.8478	PASS
		14	0.0000	-4.8261	0.0000	0.8478	PASS
9	30	11	4.9631	0.0000	0.6312	0.0000	PASS
		12	-4.9631	0.0000	0.6312	0.0000	PASS
		13	0.0000	5.5002	0.0000	0.6741	PASS
		14	0.0000	-5.5002	0.0000	0.6741	PASS
10	34	11	5.3958	0.0000	0.4328	0.0000	PASS
		12	-5.3958	0.0000	0.4328	0.0000	PASS
		13	0.0000	5.9386	0.0000	0.4384	PASS
		14	0.0000	-5.9386	0.0000	0.4384	PASS
11	38	11	5.5766	0.0000	0.1808	0.0000	PASS

		12	-5.5766	0.0000	0.1808	0.0000	PASS
		13	0.0000	6.0747	0.0000	0.1361	PASS
		14	0.0000	-6.0747	0.0000	0.1361	PASS
12	42	11	5.4864	0.0000	0.0903	0.0000	PASS
		12	-5.4864	0.0000	0.0903	0.0000	PASS
		13	0.0000	5.8665	0.0000	0.2082	PASS
		14	0.0000	-5.8665	0.0000	0.2082	PASS
13	46	11	5.4769	0.0000	0.0094	0.0000	PASS
		12	-5.4769	0.0000	0.0094	0.0000	PASS
		13	0.0000	5.6849	0.0000	0.1816	PASS
		14	0.0000	-5.6849	0.0000	0.1816	PASS

H. Analysis of Model 4a

shear walls are positioned at the transverse bays of each corner while as RCC X-bracing system is positioned at the longitudinal bay of each corner. Lateral forces for model 4A is given in Table 10

Table 10: Lateral force distribution for model 4A

Storey	Height (m)	Lateral Force (kN)
12	46	701.429
11	42	423.826
10	38	346.942
9	34	277.745
8	30	216.238
7	26	162.419
6	22	116.288
5	18	77.846
4	14	47.092
3	10	26.071

2	6	9.541
1	2	1.588

Values of Displacement and Drift of model 4A is given in Table 11

Table 11: Storey displacement and storey drift of model 4A

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STATUS
			X	Z	X		
1	0	11	0.0000	0.0000	0.0000	0.0000	PASS
		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2	11	0.0848	0.0000	0.0848	0.0000	PASS
		12	-0.0848	0.0000	0.0848	0.0000	PASS
		13	0.0000	0.0704	0.0000	0.0704	PASS
		14	0.0000	-0.0704	0.0000	0.0704	PASS
3	6	11	0.3777	0.0000	0.2928	0.0000	PASS
		12	-0.3777	0.0000	0.2928	0.0000	PASS
		13	0.0000	0.5205	0.0000	0.4502	PASS
		14	0.0000	-0.5205	0.0000	0.4502	PASS
4	10	11	0.7895	0.0000	0.4118	0.0000	PASS
		12	-0.7895	0.0000	0.4118	0.0000	PASS
		13	0.0000	1.1399	0.0000	0.6193	PASS
		14	0.0000	-1.1399	0.0000	0.6193	PASS
5	14	11	1.4027	0.0000	0.6133	0.0000	PASS
		12	-1.4027	0.0000	0.6133	0.0000	PASS

		13	0.0000	2.1625	0.0000	1.0226	PASS
		14	0.0000	-2.1625	0.0000	1.0226	PASS
6	18	11	2.1476	0.0000	0.7449	0.0000	PASS
		12	-2.1476	0.0000	0.7449	0.0000	PASS
		13	0.0000	3.3039	0.0000	1.1414	PASS
		14	0.0000	-3.3039	0.0000	1.1414	PASS
7	22	11	2.9601	0.0000	0.8125	0.0000	PASS
		12	-2.9601	0.0000	0.8125	0.0000	PASS
		13	0.0000	4.3940	0.0000	1.0901	PASS
		14	0.0000	-4.3940	0.0000	1.0901	PASS
8	26	11	3.8078	0.0000	0.8477	0.0000	PASS
		12	-3.8078	0.0000	0.8477	0.0000	PASS
		13	0.0000	5.3704	0.0000	0.9764	PASS
		14	0.0000	-5.3704	0.0000	0.9764	PASS
9	30	11	4.6587	0.0000	0.8509	0.0000	PASS
		12	-4.6587	0.0000	0.8509	0.0000	PASS
		13	0.0000	6.1741	0.0000	0.8037	PASS
		14	0.0000	-6.1741	0.0000	0.8037	PASS
10	34	11	5.4812	0.0000	0.8225	0.0000	PASS
		12	-5.4812	0.0000	0.8225	0.0000	PASS
		13	0.0000	6.7392	0.0000	0.5651	PASS
		14	0.0000	-6.7392	0.0000	0.5651	PASS
11	38	11	6.2447	0.0000	0.7636	0.0000	PASS

		12	-6.2447	0.0000	0.7636	0.0000	PASS
		13	0.0000	6.9955	0.0000	0.2563	PASS
		14	0.0000	-6.9955	0.0000	0.2563	PASS
12	42	11	6.9184	0.0000	0.6736	0.0000	PASS
		12	-6.9184	0.0000	0.6736	0.0000	PASS
		13	0.0000	6.9042	0.0000	0.0913	PASS

I. Analysis of Model 4b

shear walls and X-bracing system are positioned at alternate bays on each corner. Values of Lateral force for model 4B given in Table 12

Table 12: Lateral force distribution for model 4B

Storey	Height (m)	Lateral Force (kN)
12	46	701.429
11	42	423.826
10	38	346.942
9	34	277.745
8	30	216.238
7	26	162.419
6	22	116.288
5	18	77.846
4	14	47.092
3	10	26.071
2	6	9.541
1	2	1.588

Values for displacement and drift of model 4B given in Table 13.

Table 13: Storey displacement and storey drift of model 4B

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STATUS
			X	Z	X	Z	
1	0.0	11	0.0000	0.0000	0.0000	0.0000	PASS

		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2.0	11	0.0742	-0.0011	0.0742	0.0011	PASS
		12	-0.0742	0.0011	0.0742	0.0011	PASS
		13	0.0010	0.0854	0.0010	0.0854	PASS
		14	-0.0010	-0.0854	0.0010	0.0854	PASS
3	6.0	11	0.3851	-0.0034	0.3109	0.0024	PASS
		12	-0.3851	0.0034	0.3109	0.0024	PASS
		13	0.0027	0.4145	0.0017	0.3291	PASS
		14	-0.0027	-0.4145	0.0017	0.3291	PASS
4	10.0	11	0.8210	-0.0001	0.4359	0.0033	PASS
		12	-0.8210	0.0001	0.4359	0.0033	PASS
		13	-0.0011	0.8655	0.0038	0.4510	PASS
		14	0.0011	-0.8655	0.0038	0.4510	PASS
5	14.0	11	1.4655	0.0211	0.6445	0.0212	PASS
		12	-1.4655	-0.0211	0.6445	0.0212	PASS
		13	-0.0211	1.5436	0.0201	0.6781	PASS
		14	0.0211	-1.5436	0.0201	0.6781	PASS
6	18.0	11	2.2339	0.0489	0.7684	0.0279	PASS
		12	-2.2339	-0.0489	0.7684	0.0279	PASS
		13	-0.0479	2.3439	0.0268	0.8003	PASS
		14	0.0479	-2.3439	0.0268	0.8003	PASS
7	22.0	11	3.0520	0.0764	0.8182	0.0275	PASS

		12	-3.0520	-0.0764	0.8182	0.0275	PASS
		13	-0.0739	3.1969	0.0259	0.8530	PASS
		14	0.0739	-3.1969	0.0259	0.8530	PASS
8	26.0	11	3.8813	0.0974	0.8293	0.0210	PASS
		12	-3.8813	-0.0974	0.8293	0.0210	PASS
		13	-0.0928	4.0627	0.0189	0.8658	PASS
		14	0.0928	-4.0627	0.0189	0.8658	PASS
9	30.0	11	4.6850	0.1051	0.8037	0.0077	PASS
		12	-4.6850	-0.1051	0.8037	0.0077	PASS
		13	-0.0980	4.9023	0.0052	0.8396	PASS
		14	0.0980	-4.9023	0.0052	0.8396	PASS
10	34.0	11	5.4297	0.0923	0.7447	0.0128	PASS
		12	-5.4297	-0.0923	0.7447	0.0128	PASS
		13	-0.0827	5.6798	0.0153	0.7776	PASS
		14	0.0827	-5.6798	0.0153	0.7776	PASS
11	38.0	11	6.0867	0.0532	0.6571	0.0391	PASS
		12	-6.0867	-0.0532	0.6571	0.0391	PASS
		13	-0.0414	6.3653	0.0413	0.6854	PASS
		14	0.0414	-6.3653	0.0413	0.6854	PASS
12	42.0	11	6.6275	-0.0135	0.5407	0.0666	PASS
		12	-6.6275	0.0135	0.5407	0.0666	PASS
		13	0.0273	6.9294	0.0687	0.5642	PASS
		14	-0.0273	-6.9294	0.0687	0.5642	PASS

J. Analysis of Model 4c

shear wall is placed at two longitudinal bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3. Values of Lateral force for Model 4C is given in Table 14.

Table 14: Lateral force distribution for model 4C

Storey	Height (m)	Lateral Force (kN)
12	46	707.934
11	42	381.004
10	38	330.376
9	34	265.521
8	30	218.243
7	26	155.270
6	22	117.366
5	18	74.419
4	14	47.529
3	10	25.033
2	6	9.514
1	2	1.590

Values for displacement and drift of model 4C in given in Table 15.

Table 15: Storey displacement and storey drift of model 4C

STORY	HEIGHT (m)	LOAD	AVG. DISPLACEMENT (CM)		STOREY DRIFT (CM)		STATUS
			X	Z	X	Z	
1	0.0	11	0.0000	0.0000	0.0000	0.0000	PASS
		12	0.0000	0.0000	0.0000	0.0000	PASS
		13	0.0000	0.0000	0.0000	0.0000	PASS
		14	0.0000	0.0000	0.0000	0.0000	PASS
2	2.0	11	0.0736	0.0011	0.0736	0.0011	PASS
		12	-0.0783	0.0009	0.0783	0.0009	PASS
		13	-0.0004	0.0876	0.0004	0.0876	PASS
		14	-0.0043	-0.0857	0.0043	0.0857	PASS

3	6.0	11	0.4095	0.0143	0.3359	0.0131	PASS
		12	-0.4386	-0.0269	0.3603	0.0277	PASS
		13	0.0140	0.4560	0.0144	0.3683	PASS
		14	-0.0431	-0.4686	0.0388	0.3829	PASS
4	10.0	11	0.8257	0.0345	0.4161	0.0203	PASS
		12	-0.8644	-0.0729	0.4258	0.0461	PASS
		13	0.0460	0.8750	0.0320	0.4190	PASS
		14	-0.0848	-0.9134	0.0417	0.4448	PASS
5	14.0	11	1.4822	0.0695	0.6565	0.0349	PASS
		12	-1.5283	-0.1546	0.6639	0.0817	PASS
		13	0.1019	1.5659	0.0559	0.6909	PASS
		14	-0.1480	-1.6510	0.0632	0.7376	PASS
6	18.0	11	2.2467	0.0941	0.7646	0.0246	PASS
		12	-2.2880	-0.2397	0.7597	0.0851	PASS
		13	0.1633	2.3472	0.0614	0.7814	PASS
		14	-0.2045	-2.4928	0.0565	0.8419	PASS
7	22.0	11	3.0061	0.1016	0.7594	0.0075	PASS
		12	-3.0161	-0.3264	0.7282	0.0868	PASS
		13	0.2286	3.0853	0.0653	0.7381	PASS
		14	-0.2386	-3.3101	0.0341	0.8173	PASS
8	26.0	11	3.7691	0.0676	0.7630	0.0339	PASS
		12	-3.7371	-0.3880	0.7210	0.0616	PASS
		13	0.2661	3.8251	0.0374	0.7398	PASS
		14	-0.2340	-4.1455	0.0046	0.8353	PASS

9	30.0	11	4.4478	0.0108	0.6787	0.0569	PASS
		12	-4.3472	-0.4441	0.6101	0.0561	PASS
		13	0.2990	4.4339	0.0329	0.6088	PASS
		14	-0.1983	-4.8672	0.0357	0.7218	PASS
10	34.0	11	5.0641	-0.0900	0.6163	0.1008	PASS
		12	-4.8805	-0.4646	0.5333	0.0205	PASS
		13	0.2976	4.9820	0.0014	0.5481	PASS
		14	-0.1140	-5.5367	0.0844	0.6694	PASS
11	38.0	11	5.4984	-0.2044	0.4343	0.1144	PASS
		12	-5.2034	-0.4875	0.3229	0.0229	PASS
		13	0.2978	5.2782	0.0002	0.2962	PASS
		14	-0.0028	-5.9702	0.1112	0.4336	PASS
12	42.0	11	5.8079	-0.3099	0.3094	0.1055	PASS
		12	-5.3850	-0.5306	0.1816	0.0430	PASS
		13	0.2958	5.4200	0.0021	0.1418	PASS
		14	0.1271	-6.2605	0.1299	0.2903	PASS
13	46.0	11	5.9570	-0.4115	0.1491	0.1015	PASS
		12	-5.3774	-0.5922	0.0075	0.0616	PASS
		13	0.3135	5.3170	0.0178	0.1030	PASS
		14	0.2661	-6.3206	0.1389	0.0601	PASS

V. RESULTS

A. Comparative Study

The comparative study of seismic parameters such as base shear and storey displacement, on the basis of which the seismic behaviour of given high rise building is determined is performed as follows:

BASE SHEAR: The comparative study of given six models on the basis of maximum base shear is shown as below figure 2.

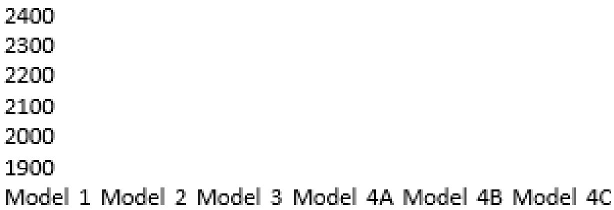

Figure 2: Graphical Comparison of Base Shear of all 6 models

The structure with maximum base shear is more rigid, thus showing better seismic performance. It is observed that base shear varies directly with stiffness of the structure. The stiffness in turn increases with increase in seismic weight. The maximum base shear among given six models is shown by model 3 (MRF with shear wall system at corners). But the model 3 is less economical of all the models.

Among the 6-models, model 3 (MRF with shear wall system) and model 4C (MRF with shear wall and RCC X-Bracing system) show the least storey displacement. The model 4C is economical than model 3, thus we found that the use and relative location of both shear wall and RCC X-Bracing system can enhance the seismic performance of the structure and makes it more economical.

VI. CONCLUSION

It is concluded that the storey displacement in case of structures stiffened with shear walls (Model 3) is more as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in lower storeys (storey 1-9), whereas the storey displacement in case of structures stiffened with shear walls (Model 3) is less as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in upper storeys (storey 10-12).

The model 3 and model 4C are the safest and show least storey displacement. VII. The model 4C is economical as compared to all other models.

It is found that the RCC bracing also increases the primary strength of the structure.

The most effective relative locations of shear wall and RCC X-bracing system is provided in Model 4C (shear wall is placed at two longitudinal bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3).

The model 4C is the safest and most economical of all the six models analysed.

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