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MODEL ANALYSIS OF RESIDENTIAL TOWER UNDER SEISMIC LOAD USING BRACING AND SHEAR WALL

Er. Bhupinder Singh[1], Er. Manjit singh[2]

[1]*Assistant professor, Department of Civil Engineering,*
Indo-global group of Colleges, Abhipur, Mohali,(India)
[2]*Research Scholar, Department of Civil Engineering,*
Indo-global group of Colleges, Abhipur, Mohali,(India)

ABSTRACT

The use of steel bracing system is a viable option for retrofitting a reinforced concrete frame for improved seismic performances. Steel braces provide required strength and stiffness, takes up less space, easy to handle during construction, can also be used as architectural element and is economic. Steel braces are effective as they take up axial stresses and due to their stiffness, reduce deflection along the direction of their orientation.

Shear wall is a vertical member that can resist lateral forces directed along its orientation. Shear walls are structural system consisting of braced panels, also known as Shear Panels. Concrete Shear walls are widespread in many earthquake-prone countries like Canada, Turkey, Romania, Colombia, Russia. It has been in practice since 1960's, used in buildings ranging from medium- to high-rise structures. Shear walls should always be placed symmetrically in the structure and on each floor, including the basement. Reinforced concrete Shear walls transfer seismic forces to foundation and provide strength and stiffness

I. INTRODUCTION

As more and more people inhabit this planet, the inhabitants are forced to live in more dense cities, in tall buildings that must be able to offer them safety from the dangers that plague certain areas of the globe. Earthquakes are not only limited to the area around fault lines, but unknown fault lines, sleeping for hundreds of years pose a real danger to densely populated areas. Earthquakes can happen virtually anywhere on the globe, though not in the same kind of degree that the areas near famous faults experience them.

Unfortunately some of these biggest cities in the world reside along some of the most dangerous fault lines. But due to this, lots of research about the effects of earthquakes on buildings has been done, which has made the modern high-rise buildings some of the safest places to be during an earthquake. Present work focuses on the model analysis of building under seismic forces using bracing and shear wall.

Reinforced Concrete frames are the most common construction practices in India, with increasing numbers of high-rise structures adding up to the landscape. There are many important Indian cities that fall in highly active seismic zones. Such high-rise structures, constructed especially in highly prone seismic zones, should be analyzed and designed for ductility and should be designed with extra lateral stiffening system to improve their

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seismic performance and reduce damages. Two of the most commonly used lateral stiffening systems that can be used in buildings to keep the deflections under limits are bracing system and shear walls.

One is the use of steel bracing system is a viable option for retrofitting a reinforced concrete frame for improved seismic performances. Steel braces provide required strength and stiffness, takes up less space, easy to handle during construction, can also be used as architectural element and is economic. Steel braces are effective as they take up axial stresses and due to their stiffness, reduce deflection along the direction of their orientation.

And Second is Shear wall is a vertical member that can resist lateral forces directed along its orientation. Shear walls are structural system consisting of braced panels, also known as Shear Panels. Concrete Shear walls are widespread in many earthquake-prone countries like Canada, Turkey, Romania, Colombia, and Russia. It has been in practice since 1960's, used in buildings ranging from medium- to high-rise structures. Shear walls should always be placed symmetrically in the structure and on each floor, including the basement. Reinforced concrete Shear walls transfer seismic forces to foundation and provide strength and stiffness.

II. LITERATURE REVIEW

2013; Shaik and Vinod; They have conducted the study on Seismic performance evaluation of multistoried R.C framed building with shear wall. The elastic as well as in-elastic analysis were carried out for the evaluation of seismic performance on 6,12,24 and 36 storied moment resisting R.C. framed building using E TAB software. Eight models were prepared for each type of storey with plan area of 30m x 20m and height of 3m. Approximate method was used for lateral static and dynamic analysis of wall frame based on the continuum approach and one dimensional finite element method. Structure was analyzed for various load combination as per I.S 1893(part-1)-2002 for seismic zone.

2013; Chandurkar and Pajgade; They conducted a study on seismic analysis of RCC building with and without shear wall using software ETAB v 9.5.0. They compared parameters like lateral displacement, story drift and cost required for economy and effectiveness of shear wall. 10 story building model with 3m height for each story was studied on the software. The buildings were assumed to be fixed at the base. Four models were prepared and the models were, Model 1 was bare framed structure, Model 2 was dual system with shear wall one on each side, Model 3 was with shear wall on corner with L=4.5m and Model 4 was with shear wall on corner with L=2m. The analysis was done for zone II, III, IV and V. The results obtained were: displacement of all models for zone II, III, IV was reduced upto 40% as compared to zone V

2014; ainawala and Pajgade; They have performed analysis on building with and without shear wall using E TAB v9.0.7 software. Models were prepared for G+12, G+25 and G+38 located in zone 2, 3, 4 and 5 with square plan area of 16m x 16m and 3.5m height. Structure without shear wall were heavy due to large beam and column size and become uneconomical. The building was assumed to be fixed at the base and the floors act as rigid diaphragms. The section dimension of structural elements are changed for different buildings. Displacement curve and storey drift curve was drawn of all the model for different earthquake zone. Quantity of material required for each type of model was calculated and dynamic analysis was carried out. Result showed that displacement and drift in model 3(shear wall at corner) is less as compared to other model which is within limit as per I.S.1893 (part 1):2000.

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2014; Kumar.n et al; has presented a review of shear wall systems. The main focused of this research has been found that the behaviour and resistance of miscellaneous type shear wall against cyclic loads. The output of this analysis shows the suitability of inner shear walls comparing with outer shear walls.

2015; Gowardhan et al; reviewed on comparative seismic analysis of steel frame with and without bracing by using software. This research has depended upon the affectivity of steel bracings in steel structures. A comparison has been deliberated between structure with and without steel bracings resistant to seismic effects. It has been found that seismic bracings increase the stiffness against lateral loadings and it might be a good practice to use bracings as retrofitting scheme.

2015; Ali et.al.; They studied that 2005 earthquake brought vast destruction in Pakistan which resulted in revision of building code of Pakistan (BCP). Also studied that the inclusion of shear wall adds stiffness to structure and aids in lateral drift under seismic load. Comparative study was carried out using ETABS software by varying location and cross section shear wall for stock exchange building, Islamabad. Important parameter was considered like maximum storey drift, storey drift, base shear forces and time period of structure. Response spectrum analysis has been carried out on 4 cases depending upon location of shear wall and best possible case was selected which is finally compared with actual building.

2017; Janakkumar M. Mehta; study the (G+17) storey building was analyze with different shear-wall configuration. The modeling is done to examine the effect of different cases on seismic parameters like base shear, lateral displacements, lateral drifts and model time period for the zone-V in medium soil as specified in IS: 1893-2002

III. OBJECTIVE OF THE STUDY

- IS code compatible ground motion, Imperial Valley ground motion and San Francisco ground motion will be considered for different ground vibrations and building behavior will be examined.
- Response spectrum method will be used for dynamic analysis of the building
- Fact-finding of response change with altered lateral stiffness systems.
- Optimized lateral stiffness system on the basis of comparison.

IV. METHODOLOGY

Table - 1.1: Specifications of the building

Specifications	Data
Storey Height	3.0m
No. of bays along X direction	3
No. of bays along Z direction	4
Bay Length along X direction	6m
Bay Length along Z direction	6m
Concrete grade used	M 40
Columns	0.50m X 0.30m

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Longitudinal Beams	0.40m X 0.25m
Transverse Beams	0.30m X 0.25m
Slab Thickness	0.15m
Unit Weight of Concrete	25 kN/m3
Live Load	4.0 kN/m3
Zone	IV
Soil Conditions	Medium Soil
Damping Ratio	5%

Table – 1.2: Material properties used for analysis

Material properties	
Grade of concrete	C-40, as used in practical applications of tall buildings.
Poisons ratio of concrete	0.2
Density of reinforced concrete	$25kN/m^3$
Modulus of elasticity of concrete	35GPa for C-40
Coefficient of thermal expansion of concrete	$10*10^{-6}$ per ^{o} C
Grade of steel(rebar)	S-420
Grade of steel (wide flange-section for bracing)	S-450
Density of reinforcing steel	$7880\ kg/m^3$
Coefficient of thermal expansion of steel	$10*10^{-6}$ per ^{o}C
Modulus of elasticity of steel	200GPa
Poisons ratio of steel	0.3

Table - 1.3: Nomenclature of shear wall and Bracings

Type	Nomenclature
Frame with Shear wall of thickness 100mm	Shear Wall Type A
Frame with Shear wall of thickness 150mm	Shear Wall Type B
Frame with Shear wall of thickness 200mm	Shear Wall Type C
Frame with X type bracing	Type A-Bracing
Frame with V type bracing	Type B-Bracing
Frame with ʌ type bracing	Type C-Bracing

According to figure 2 IS 1893, value of Sa/g = 2.5 for 0<T<0.55s, and Sa/g = 1.36/T for 0.55<T<6.0s for medium soil.

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V. RESULTS -RESPONSE SPECTRUM ANALYSIS

Table 1.5: Fundamental time Period when the shear wall and bracing is provided

Types of structural system	Period (T) in second	Reduction in % with Reference to base Frame
Base frame	2.35	
Type A-bracing	2.09	11.1
Type B-bracing	1.97	16.2
Type C-bracing	1.96	16.6
Shear wall Type A	1.88	20
Shear wall Type B	1.81	23
Shear wall Type C	1.79	23.8

Table – 1.6: Base shear for ground motion in X-direction

Cases	Base Shear (kN)	Increase in % Base Shear with reference to base frame
Base frame	482.72	
Type A-bracing	528.13	9.41
Type B-bracing	509.48	5.54
Type C-bracing	532.21	10.25
Shear wall Type A	564.69	16.98
Shear wall Type B	592.15	22.67
Shear wall Type C	613.55	27.10

Table – 1.7: Base shear for ground motion in Z-direction

Cases	Base Shear (kN)	Increase in % base shear with reference to base frame
Base frame	435.75	
Type A-bracing	451.58	4
Type B-bracing	468.25	7
Type C-bracing	472.12	8
Shear wall Type A	514.39	18
Shear wall Type B	508.96	17
Shear wall Type C	587.32	35

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Table – 1.8: Inter-Storey Drift for ground motion in X- direction

Storey	1	2	3	4	5	6	7	8	9	10
Base Frame	0	4.15	6.58	8.98	12.48	18.73	24.39	30.54	35.69	39.45
Bracing Type A	0	3.28	6.19	8.19	10.52	15.27	20.45	26.98	30.81	32.58
Bracing Type B	0	3.61	5.65	7.36	9.65	12.46	16.47	24.15	27.99	28.92
Bracing Type C	0	3.46	5.2	6.92	9.08	10.88	13.79	21.98	24.72	25.32
Shear Wall Type A	0	3.11	4.78	5.62	7.25	8.17	10.98	17.25	20.45	22.12
Shear Wall Type B	0	2.98	4.39	5.08	6.51	6.89	8.29	14.32	16.32	18.25
Shear Wall Type C	0	2.57	3.61	4.23	5.39	5.98	7.15	11.11	13.78	15.69

Table – 1.9:Inter-storey drift for ground motion in Z-direction for all the cases.

Storey	1	2	3	4	5	6	7	8	9	10
Base Frame	0	6.95	7.88	9.99	13.24	19.58	26.12	32.33	36.66	40
Bracing Type A	0	5.79	6.89	8.46	11.32	16.07	21.11	27.99	32.73	36.39
Bracing Type B	0	5.15	6.05	8.26	10.44	13.68	17.99	26.54	29.82	33.32
Bracing Type C	0	4.59	5.99	7.92	11.25	13.59	16.29	22.32	26.18	29.98
Shear Wall Type A	0	4.25	5.66	6.98	8.05	9.59	12.32	18.26	22.65	27.69
Shear Wall Type B	0	3.98	6.12	7.02	7.58	8.79	12.31	18.19	21.68	26.69
Shear Wall Type C	0	3.27	5.81	6.99	8.99	10.98	13.38	15.97	19.32	24.73

Table –1.10:Percentage decrease in Inter-Storey Drift for ground motion in X- direction by using bracing and shear wall w.r.t base frame

Storey	1	2	3	4	5	6	7	8	9	10
Base Frame	-	-	-	-	-	-	-	-	-	-
Bracing Type A	-	21	6	9	16	18	16	12	14	17
Bracing Type B	-	13	14	18	23	33	32	21	22	27
Bracing Type C	-	17	21	23	27	42	43	28	31	36
Shear Wall Type A	-	25	27	37	42	56	55	44	43	44
Shear Wall Type B	-	28	33	43	48	63	66	53	54	54
Shear Wall Type C	-	38	45	53	57	68	71	64	61	60

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Table – 1.11: Percentage decrease in Inter-Storey Drift for ground motion in Z- direction by using bracing and shear wall w.r.t base frame

Storey	1	2	3	4	5	6	7	8	9	10
Base Frame	-	-	-	-	-	-	-	-	-	-
Bracing Type A	-	17	13	15	15	18	19	13	11	9
Bracing Type B	-	26	23	17	21	30	31	18	19	17
Bracing Type C	-	34	24	21	15	31	38	31	29	25
Shear Wall Type A	-	39	28	30	39	51	53	44	38	31
Shear Wall Type B	-	43	22	30	43	55	53	44	41	33
Shear Wall Type C	-	53	26	30	32	44	49	51	47	38

VI. CONCLUSION

[1] There is a gradual reduction in time periods of the bracing and shear wall systems from the time period of bare frame, indicating increase in stiffness.

[2] Time Period in case of Shear Wall C is the highest, hence is the most stiff and better option for strengthening the structure.

[3] The base shear was found to be increasing from base frame to braced frame and is even more for frame with shear wall. In case of braced frame highest base shear is found in case of Bracing C in X-direction.

[4] In case of shear wall base shear is highest in case of Shear wall C in X-direction.

[5] Shear wall A shows the least base shear among all the shear wall cases because in case of Shear Wall A the frame is stiffened only along Y- direction and not along Z.

[6] In case of braced frame highest base shear is found in case of Bracing C in Z-direction. In case of shear wall base shear is highest in case of Shear wall C in Z-direction. Shear wall B shows the least base shear among all the shear wall cases because in case of Shear Wall B the frame is stiffened only along X-direction and not along Z.

[7] In case of bracing system, Bracing System C (inverted V type bracing) are the most effective one than other bracing systems, effectively reducing top-storey drift and inter storey drifts in both X- and Z-directions.

[8] Above all Shear Wall C is the best in all the stiffening cases considered

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VII. RECOMMENDATIONS

[1] In this study it is only considered concentrical type of bracing. A study for eccentrical bracing type under similar criteria of comparison is left for future investigation.

[2] The analysis takes place by selecting a medium flange steel section for bracing cross section. The next researcher is expected to check the structural behavior under another cross-section like angle section, tubular section, etc.

[3] It is also considered that the structure here considered fulfils plan and elevation regularity, the behaviors for irregular structures under those bracing type can be considered for future study.

[4] The shear wall of different types can be used instead along with different thicknesses.

[5] The location of the bracings and shear wall may be changed for future studies and it could be in two bays instead of one one bay used in this study.

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