Effect of Different Lateral Load Resisting System on Seismic Behavior of Building

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Abstract— Lateral load resisting systems are widespread use today in the design of tall buildings especially to resisting lateral forces caused due Earthquakes. For tall structures within 20 storey range, earthquake is the representing horizontal force because of immense self-weight of the structure itself. These loads are opposed by the lateral load resisting system of any structure. Analysis is done with OMRF, Shear wall, Bracings and outrigger. Results demonstrate that for six, twelve and twenty storied building. And results are evaluated for Storey displacement, Storey shear and Base shear. This Project aims to determine storey displacements for the different floor structure using alternative lateral load resisting system and it was found that Outrigger and Shear wall systems are more effective in resisting earthquake forces compared to other systems.

Key words: OMRF, Bracings, Shear Wall, Outrigger, P-Delta Effects

I. INTRODUCTION

Of late multi-storeyed structures improvement is for the most part extended due to significantly growing cost of land and lack of land in metropolitan urban groups. These structures are delicate in imperviousness to wind and seismic forces. Behavior of such structures can be controlled by effective lateral force structural systems, which increases stiffness of building. In any case, exhibit days computer innovation takes into consideration exact investigation and outline of various frameworks for tall structures; it doesn't general information for picking among the choices of these frameworks to touch base at the best general design. While concentrate uncontrolled response it was watched that response as far as displacement and acceleration was surpassing IS code limits. The change in the performance of the building is concentrated under seismic forces by giving lateral load resisting system, for example, supporting framework and shear dividers outriggers and so for. These frameworks were connected at different positions with various cross-sectional properties so give lateral strength, stiffness and stability to skyscraper structures. Modeling and analysis was completed utilizing ETAB. It is clear from the perceptions that all the proposed arrangements enhance the execution of the working in controlling story displacements, accelerations and in storey drift. The present work is relied upon to utilization of shear walls, outrigger and bracings as a lateral force resisting systems to seismic forces energized tall structures in seismic region.

A. Shear Wall

Shear Walls are the most well-known structures built inside the structures keeping in mind the end goal to neutralize extreme earthquake forces. Seismic forces are a major concern for the engineers to offer stability to the structures. Properly designed and detailed structures with shear walls have shown very good performance in past quakes. Shear walls give lateral strength to oppose horizontal earthquake forces. At the point when shear walls are strong enough, they will transfer these horizontal forces to the following component in the load path beneath them.

B. Bracings

The vast majority of the RCC structures were failed In the past because of lateral load. Bracings frameworks are one of the lateral load opposing frameworks which have basic structural importance especially in reinforced concrete buildings. Diverse bracing systems are sufficiently proficient for seismic reactions. bracing systems have both reasonable and economical advantages. The utilization of steel bracings is speedier to execute. But we can also use concrete bracings; in this paper we made the use of concrete X type bracings of different depths according to number of floors.

C. Outrigger System

Outrigger structures work by tying together two structural systems – ordinarily a core system and a border of structures – to yield entire building basic practices that are greatly improved than those of the component systems. They do this by making a positive connection between the two systems. The gainful impact is most articulated where the responses of the component systems lateral loads are generally different. Outriggers find fantastic use, for instance, in tall structures that use dual lateral systems including a perimeter frame. Outriggers place important role while engaging perimeter columns that would otherwise be gravity-only elements.

D. P-Delta Effect

"P- Delta effect is the non-linear (Second order) effect that happens in each structure, where the components are subjected to horizontal and vertical forces. P-delta effect is the genuine effect that is related with the Magnitude of the connected Load (P) and the relocation (Delta)".

II. ANALYSIS

A. Computation of Seismic Forces on the Structure

Presently days, it is general practice to utilize the equivalent linear static analysis technique in design of structures. Because of late pattern have made the structures thinner and this has made structures more vulnerable to vibration harms. This has prompted advancement of dynamic analysis procedure for the most part under the seismic loading condition. For the unsymmetrical structures the vertical distribution of lateral shear forces are precisely figured by dynamic analysis procedure, because of this structures will have better seismic force resisting capacity.

There are mainly two types of examination method they are – linear and nonlinear methodology, these two can be again divided as equivalent static and dynamic analysis procedure. Generally linear analysis process are used to analyze the structures. When the building with complete irregularity or the actual strength of existing structure is to be evaluated for retrofitting purposes, the non-linear methods ought to be utilized comprehend the responses of the structure Preferences of a nonlinear analysis are as follows

1) Gives a more exact value of displacement and force.
2) Nonlinear analysis considers the effects of stiffness degradation.
3) This likewise gives a accurate estimation of between story drift

B. Linear Static Procedure (LSP)

This technique is called as "seismic coefficient strategy". "seismic coefficient method". Response spectrum is utilized to join the components of dynamic analysis. Indian standard code IS: 1893-2002 determines the conditions when this strategy is not legitimate. In this method a equivalent viscous damping and an elastic stiffness are assumed. In this manner, this method can be adopted to only regular building in the elastic ranges. This strategy is outstanding because of its simplicity of calculations.

C. Linear Dynamic Procedure (LDP)

This technique permits the several modes of response of the structure to be taken into consideration. The response of the building is calculated utilizing modal analysis. The reactions of the structure are very much characterized as mix of a few exceptional modes that in vibrating string corresponds to the harmonics and these modes of the structure can be calculated from computer examination. In this technique an equivalent viscous damping coefficient are assumed and it is also assumed that stiffness of Member is constant throughout the design procedure.

III. OBJECTIVE

Effect of different lateral load resisting system on seismic behavior of building

– Computation of loading of structures (building) IS-875 (Gravity, EQ load Provisions, load combinations)
– ETABS: Analysis of tall structures for P-Δ and P-δ effects RCC-Shear wall, Bracings, Prepare Your Paper Before Styling.

IV. BUILDING AND MATERIAL DESCRIPTION

A 6, 12 and 20 story building of symmetric plan dimensions of 20m x 25m, bay spacing of 5m along each direction and story height of 3m is considered. The properties of material are as shown in Table 1.

Properties of Concrete	
Grade of Concrete	M25
Elasticity Modulus	25000MPa
Poisson's Ratio	0.2
Properties of Reinforcement Steel	
Grade of Steel	Fe415
Modulus of Elasticity	210000MPa
Density of Concrete	25kN/m3
Poisson's Ratio	0.3
Properties of Masonry	
Density of brick wall including plaster	20kN/m3
Poisson's Ratio	0.2

Table 1: Properties of Concrete

Loads on Structure	
Live load on Roof and Floor	3kN/m2
Roof/Floor finish	1.5kN/m2
Brick wall on External Beams	230mm thick (13.8 KN/m)
Parapet wall on Roof	150mm thick (3 KN/m)
Slab Thickness	150mm thick
Story height	3m
Damping	5%
Seismic Parameters (IS 1893)	
Zone	III
Soil Type	Medium
Importance factor(I)	1

Table 2: Loads on Structure

V. INPUT DATA FOR ETABS

Load	Type	Self-weight Multiplier	Auto lateral load
Dead	Dead	1	
Live	Live	0	
EQX	Seismic	0	IS 1893 2002
EQY	Seismic	0	IS 1893 2002
SDL	Super dead		0

Table 3: Input data

Load Case Name	Load Case Type
Dead	Linear Static
Live	Linear Static
EQX	Linear Static
EQY	Linear Static
SDL	Linear Static
SPECX	Response Spectrum
SPECY	Response Spectrum

Table 4: Input data

Name	Load Type	Load Name	Function	Scale Factor	Modal Case	Modal Combination Method
SPECX	Acceleration	U1	Response Spectrum	981	Modal	CQC
SPECY	Acceleration	U2	Response Spectrum	981	Modal	CQC

Table 5: Input data

Mass Source	
Element self-weight	No
Additional Mass	No
Specified load patterns	Yes
Mass multiplier for loads	
Dead	1
Live	0.25
SDL	1
Include lateral mass	Yes
Lump Lateral Mass at story Level	No

Table 6: Input data

A. Calculation of Scale Factor

Importance Factor, I=1

Response Reduction Factor= 5

Acceleration due to gravity, g=9810mm/sec2

Scale factor = [1/2 X I/R X g] = [1/2 X 1/5 X 9810] = 981

Storey 6		Storey 12		Storey 20	
Column	Column Dimensions (mm)	Column	Column Dimensions (mm)	Column	Column Dimensions (mm)
C6	600X600	C12	450X650	C20	850X650
C5	600X600	C11	450X650	C19	850X650
C4	600X600	C10	450X650	C18	850X650
C3	600X600	C9	450X650	C17	850X650
C2	600X600	C8	800X800	C16	850X650
C1	600X600	C7	800X800	C15	850X650
		C6	800X800	C14	850X650
		C5	800X800	C13	850X650
		C4	800X800	C12	850X650
		C3	800X800	C11	1100X1100
		C2	800X800	C10	1100X1100
		C1	800X800	C9	1100X1100
				C8	1100X1100
				C7	1100X1100
				C6	1100X1100
				C5	1100X1100
				C4	1100X1100
				C3	1100X1100
				C2	1100X1100
				C1	1100X1100

Table 7: Data

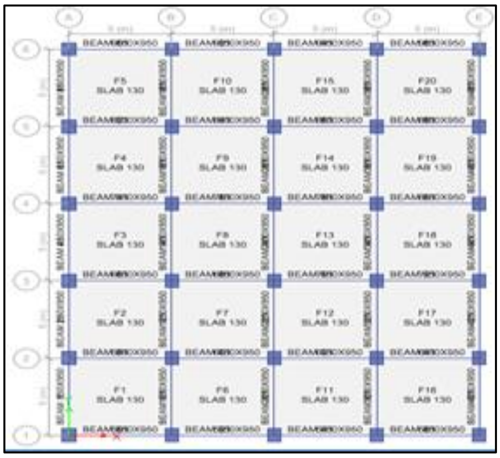

Fig. 1: Plan of building

VI. DEFINING OF PROCEDURE AND MODELLING FOR ANALYSIS

Analysis of structure is done using ETABS. The models were prepared in the ETAB S. Software by using different structural system by placing Shear wall,Bracing at Outer peripheri of strutcure. Analysis is done with OMRF, Shear wall, Bracings and outrigger. Results demonstrate that for six, twelve and twenty storied building. And results are evaluated for Storey displacement, Storey shear and Base shear. This Project aims to determine storey displacements for the different floor structure using alternative lateral load resisting systems.

VII. OBSERVATIONS OF THE ANALYSED FRAMES

The different structures of 6 storey, 12 storey, and 20 storey are analyzed in ETABS software. In the models alternate lateral load resisting properties like OMRF "(ordinary moment resisting frames)", Shear wall system and Bracings were introduced in the model and analyzed .The lateral loads, dead load and live load are taken in to account in analysis of structure as IS standards for Seismic Zone III.

A. Comparison of Displacement of 20 floor Building in Ordinary Building (OMRF)

Story	Response Spectrum	Eq. Static	% increase in displacement	Response Spectrum	Eq. Static	% increase in displacement
	Displacement in x Direction			Displacement in y direction		
Story 20	17.8	27.5	54.48	16.3	24.8	52.14
Story 19	17.3	26.8	54.91	16	24.2	51.25
Story18	16.7	25.8	54.49	15.5	23.4	50.96
Story17	16	24.5	53.125	14.9	22.5	51.00
Story16	15.1	23.1	52.98	14.3	21.3	48.95
Story15	14.2	21.4	50.70	13.5	20	48.14
Story14	13.1	19.6	49.61	12.6	18.5	46.82
Story13	12	17.7	47.5	11.7	16.9	44.44
Story12	10.8	15.7	45.37	10.7	15.3	42.990
Story11	10	14.3	43	9.9	14	41.41
Story10	9.1	12.9	41.75	9.1	12.7	39.56
Story9	8.2	11.5	40.24	8.2	11.3	37.80
Story8	7.3	10	36.98	7.3	9.9	35.61
Story7	6.4	8.6	34.37	6.4	8.5	32.81
Story6	5.4	7.1	31.48	5.4	7.1	31.48
Story5	4.4	5.7	29.54	4.4	5.7	29.54
Story4	3.4	4.3	26.470	3.4	4.3	26.47
Story3	2.3	3	30.43	2.4	3	25

Story2	1.4	1.7	21.42	1.4	1.7	21.42
Story1	0.5	0.6	20	0.5	0.6	20

Table 8: Comparison of Displacement of 20 floor Building in Ordinary Building (OMRF)

B. Comparison of Displacement of 20floor Building in Shear wall system

20 story- shear wall system vs. OMRF Displacements						
Story	OMRF	Shear wall	% increase in displacement	OMRF	Shear wall	% increase in displacement
	Displacement in x Direction			Displacement in y Direction		
Story 20	27.5	13.4	51.277	24.8	12.4	50
Story 19	26.8	12.8	52.23	24.2	12	50.41
Story 18	25.8	12.2	52.7	23.4	11.4	51.28
Story 17	24.5	11.5	53.06	22.5	10.8	52
Story 16	23.1	10.8	53.24	21.3	10.2	52.11
Story 15	21.4	10	53.27	20	9.5	52.5
Story 14	19.6	9.2	53.06	18.5	8.8	52.432
Story 13	17.7	8.3	53.10	16.9	8	52.669
Story 12	15.7	7.4	52.86	15.3	7.2	52.94
Story11	14.3	6.7	53.14	14	6.5	53.57
Story 10	12.9	5.9	54.26	12.7	5.8	54.33
Story9	11.5	5.1	55.65	11.3	5	55.75
Story8	10	4.4	56	9.9	4.3	56.56
Story7	8.6	3.7	56.97	8.5	3.6	57.64
Story6	7.1	3	57.74	7.1	2.9	59.15
Story5	5.7	2.3	59.64	5.7	2.3	59.64
Story4	4.3	1.7	60.46	4.3	1.7	60.46
Story3	3	1.1	63.33	3	1.1	63.33
Story2	1.7	0.6	64.70	1.7	0.6	64.70
Story1	0.6	0.2	66.66	0.6	0.2	66.6
Base	0	0	0	0	0	0

Table 9: Comparison of Displacement of 20floor Building in Shear wall system

C. Comparison of Displacement of 20floor Building in Bracing system and OMRF system

20 Story- Bracing Vs. OMRF Displacements						
Story	OMRF	Bracing	% increase in displacement	OMRF	Bracing	% increase in displacement
	Displacement in x direction			Displacement in y direction		
Story20	27.5	14.8	46.18	24.8	13.5	45.564
Story19	26.8	14.2	47.017	24.2	13	46.28
Story18	25.8	13.5	47.674	23.4	12.5	46.581
Story17	24.5	12.7	48.16	22.5	11.8	47.55
Story16	23.1	11.9	48.48	21.3	11.1	47.88
Story15	21.4	11	48.59	20	10.4	48
Story14	19.6	10.1	48.46	18.5	9.5	48.64
Story13	17.7	9.1	48.587	16.9	8.7	48.52
Story12	15.7	8.1	48.40	15.3	7.8	49.01
Story11	14.3	7.3	48.95	14	7.1	49.28
Story10	12.9	6.5	49.61	12.7	6.3	50.39
Story9	11.5	5.7	50.43	11.3	5.6	50.44
Story8	10	4.9	51	9.9	4.8	51.51
Story7	8.6	4.1	52.32	8.5	4.1	51.76
Story6	7.1	3.4	52.11	7.1	3.3	53.521
Story5	5.7	2.6	54.38	5.7	2.6	54.38
Story4	4.3	1.9	55.81	4.3	2	53.48
Story3	3	1.3	56.66	3	1.3	56.66
Story2	1.7	0.8	52.94	1.7	0.8	52.94
Story1	0.6	0.3	50	0.6	0.3	50

Table 10: Comparison of Displacement of 20floor Building in Bracing system and OMRF system

D. Comparison of Displacement of 20floor Building in Outrigger and Shear wall system

Story	20 Story- Outrigger Vs Shear Wall System					
	Outrigger	Shear wall	% increase in displacement	Outrigger	Shear wall	% increase in displacement
	Displacement in x direction			Displacement in y Direction		
Story20	12.6	13.4	6.34	12.8	12.4	3.125
Story19	12	12.8	6.66	12.4	12	3.22
Story18	11.4	12.2	7.01	11.9	11.4	4.20
Story17	10.7	11.5	7.47	11.3	10.8	4.42
Story16	9.9	10.8	9.09	10.6	10.2	3.77
Story15	9.2	10	8.69	9.9	9.5	4.0
Story14	8.4	9.2	9.52	9.1	8.8	3.29
Story13	7.6	8.3	9.210	8.3	8	3.61
Story12	6.8	7.4	8.82	7.5	7.2	4
Story11	6.1	6.7	9.83	6.8	6.5	4.41
Story10	5.4	5.9	9.2	6.2	5.8	6.45
Story9	4.7	5.1	8.51	5.6	5	10.7
Story8	4	4.4	10	4.8	4.3	10.41
Story7	3.4	3.7	8.82	4.1	3.6	12.19
Story6	2.7	3	11.11	3.4	2.9	14.70
Story5	2.1	2.3	9.52	2.7	2.3	14.81
Story4	1.5	1.7	13.33	2	1.7	15
Story3	1	1.1	10	1.3	1.1	15.38
Story2	0.6	0.6	0	0.8	0.6	25
Story1	0.2	0.2	0	0.3	0.2	33.33

Table 11: Comparison of Displacement of 20floor Building in Outrigger and Shear wall system

E. Comparison of Displacement of 20floor Building in Bracing system and Shear wall system

Story	20 story- bracing system vs. shear wall system					
	Bracing	Shear wall	%increase in displacement	Bracing	Shear wall	%increase in displacement
	Displacement in x direction			Displacement in y direction		
Story20	14.8	13.4	9.45	13.5	12.4	8.14
Story19	14.2	12.8	9.85	13	12	7.69
Story18	13.5	12.2	9.62	12.5	11.4	8.8
Story17	12.7	11.5	9.44	11.8	10.8	8.47
Story16	11.9	10.8	9.24	11.1	10.2	8.10
Story15	11	10	9.09	10.4	9.5	8.65
Story14	10.1	9.2	8.91	9.5	8.8	7.36
Story13	9.1	8.3	8.79	8.7	8	8.04
Story12	8.1	7.4	8.64	7.8	7.2	7.69
Story11	7.3	6.7	8.21	7.1	6.5	8.4
Story10	6.5	5.9	9.23	6.3	5.8	7.93
Story9	5.7	5.1	10.52	5.6	5	10.71
Story8	4.9	4.4	10.20	4.8	4.3	10.41
Story7	4.1	3.7	9.75	4.1	3.6	12.19
Story6	3.4	3	11.76	3.3	2.9	12.12
Story5	2.6	2.3	11.53	2.6	2.3	11.53
Story4	1.9	1.7	10.52	2	1.7	15
Story3	1.3	1.1	15.38	1.3	1.1	15.38
Story2	0.8	0.6	25	0.8	0.6	25
Story1	0.3	0.2	33.33	0.3	0.2	33.33

Table 12: Comparison of Displacement of 20floor Building in Bracing system and Shear wall system

1) *Storey Drifts*

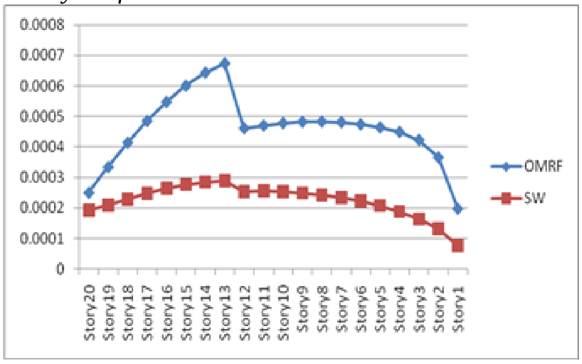

Fig. 2: Story Drift of 20 storey OMRF vs. Shear wall system

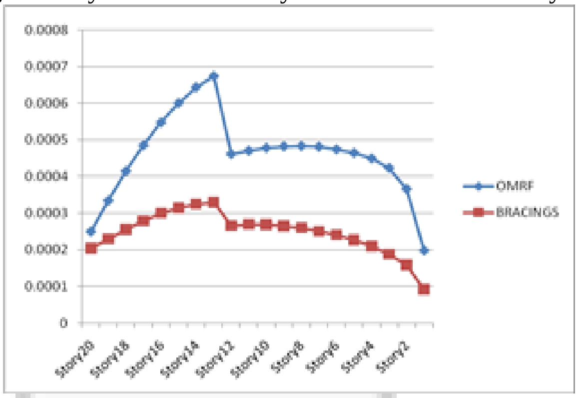

Fig. 3: Story Drift of 20 storey OMRF vs. Bracing system

VIII. CONCLUSION

Analysis of structure for 6,12 &20 floor is done by using various structural components like shear wall, OMRF, bracing and outrigger .The structures are analyzed using E-TAB software and its performance are studied. On the bases of analysis data, the following conclusions are made as follows:

It is observed that displacement of Equivalent static analysis are greater than that of Dynamic (Response spectrum) analysis. The differences in the displacement values of both Equivalent static and dynamic analysis in lower stories are insignificant but it increases in higher stories, reaches at its maximum value in the top story or roof.

- The story shear due to Equivalent static procedure is greater than the story shear of the dynamic analysis procedure. The results of Equivalent static analysis are not efficient as compared to Dynamic analysis. The design base shear of OMRF structure is higher compared to SMRF structures; this is observed due to increase in average response acceleration coefficient of SMRF structure, thereby decreasing the base shear of SMRF structures. Therefore SMRF structure will be economical when it is subjected to seismic loads.
- The displacements in Shear wall system is low as compare to OMRF and Bracing systems. So use of Shear walls are most effective for controlling lateral loads .shear walls also effective in reducing bending moments as compare to other system. Therefore addition of shear wall in frame system is effective method to controlling the lateral drift and lateral displacements of the structure, thereby reducing the damages to the structures.
- The base shear in Shear Wall system is 2 to 4% greater than that of OMRF structure. This may vary as sizes of components are changes. So it is seen that there is little increase in seismic weight, Base shear and story shear due to placing of Shear wall and Bracings.
- The displacement in Bracings are little low as compared to OMRF, but it is greater than the Shear wall system .So conditions where the placing of shear wall are difficult and if the place is less prone to earthquake forces we can use the bracing system.
- P-Delta analysis has been done in this analysis. P-Delta Effect is very important in structures (15 Story and above), and not significant in short buildings (Less than 10 story). P-Delta effect is effective for OMRF structure .but The P-Delta effect has less effect on shear wall system and bracing system. This is observed because as the stiffness of increases, the P-Delta effect decreases.
- Outrigger for 20 story structure shows that that lateral displacements are low compared to shear wall and bracing system. So use of outriggers is also effective in high rise building, especially above 20 floor structures.

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