Efficiency of Lateral System in Tall RC Building

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Abstract*: *Shear walls have the important properties of lateral resistance in high rise building for earthquake and wind load forces. The sway developed by the lateral forces causes damage to the life and property. Thus, shear walls are initiated in the building to achieve necessary resistance to the lateral forces. Double core shear wall or box section shear wall is important to ensure adequate stiffness, strength and durability. The study has been done to analyze the affect of perimeter frames for structural systems in lateral performance of an irregular shape 30 storey 'L-shape' building for the subsequent cases 1: 125mm flat slab with drop, 2: 150mm flat slab without drop, 3: increase in diaphragm's rigidity with 250mm at regular intervals, 4: outrigger + increase in diaphragm's rigidity with 250mm at regular intervals.

Keyword: stiffness, strength and durability

I. INTRODUCTION

The trend of uneven plan structures shows a type of tall building due to increase of population in metropolitan cities. To promote the demand of tall building structures, different types of structural systems have been used. The study has been done for the control of drift with the following lateral resisting systems. Case 1: It's a 30 storied building with 90m of height. The typical floor height is 3.00 m. The entire column size up to 14^{th} floor is 1.50 X 1.50 m, 15^{th} floor is 1.20 X 1.20 m and rests of the floors with size of 0.80 X 0.80 m. The columns are provided at 6.00 m spacing. Beam framing at perimeter is of size 0.40 X 0.60 m which connects all periphery columns. The thickness for all flat slabs is 0.125 m with drop panels. A shear wall core of 12.00 X 12.00 m with 0.25m thickness upto 15^{th} floor and remaining with 0.15m is added. Case 2: From the case: 1, 150mm flat slab without drop is introduced by deleting the 125mm slab with drop panels. Case 3: From the case 2, the flat slabs are changed into a floor plate with 0.150m thickness except multiplies of 5^{th} floor with a thickness of 0.250 m. Case 4: At top floor, 22^{nd} floor and 14^{th} floor Outrigger system is initiated. To conclude how important it is to choose a structural system that combines proven technologies with local materials and expertise in order to implement a particular architectural design in a particular location. Some options for structural system include: 1) Moment-resisting frames: rigidly jointed frames or sway frames are those with moment resisting relations among beams and columns. 2) Shear walls, 3) braced frames, 4) Framed-Tube structures: the frame consists of closely spaced column which are joined by deep girders. 5) Braced-Tube structures: By using the cross bracing frame with X-bracings, further improvement can be made for tubular system over many stories. 6) Tube-in-Tube structures: In this type the outer-frame is added together with an internal elevator and service core. 7) Bundled-Tube structures: The bundled tube system can be seen as a group of individual tubes resulting in collective cell tube. 8) Core and perimeter frame interactive structures: Included here are systems that interconnect perimeter frames and core towers through outrigger trusses. 9) Mega structures.

II. LITERATURE REVIEW

ALPA SHETH Concluded that in building with a central shear wall core and with length to width ratio exceeding to the performance is enhanced by adding outriggers and perimeter frames. A perimeter frame without outriggers does not help significantly in resisting lateral loads.

K.M.LAM,' ET AL' Reports dynamic wind loads measurement data of a wind tunnel on various number of H-shaped tall buildings with a high frequency force balance. For normal wind occurrence on the building face with cavity fluctuations in the crosswind moment on H-shaped building are observed to have lesser magnitudes than that in the square building.

E.F.CRUZ, 'ET AL' the effect of irregularity in height is important when the behavior of the structure remains in the elastic limit as well as when it goes into the inelastic Reigns. On the other hand, the maximum element forces are not very sensitive to irregularities in height and tend to become smaller as it increases.

DONG-GUEN LEE, 'ET AL' presents an efficient model for the analysis of a high rise building structure using super elements. The refined finite element model of a high rise building structure with shear wall is expected to cost a significant amount of computational time and memory while it would provide the most accurate results.

YOUNG S.CHO, 'ET AL' a study for the reinforcing method of flat plate column connection has been done in this paper. Four tests specimens were modeled for the interior bay flat plate slab column connections in a typical flat plate slab building. Based on the study it is concluded that the bay specimens failed due to punching shear produced from gravity loading. The most ductile behavior under the gravity loading was showed by the stud containing specimen with steel plate.

J.M.REYNOUARD, 'ET AL' in this paper, investigation is done on the modeling of the seismic response of RC walls with different reinforcement ratios. For a specimen and interpretation of the experimental results is attempted through a finite element nonlinear cyclic model.

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KING-LE CHANG, 'ET AL' demonstrates the effectiveness of the outrigger system for the central cored building structure with 2 outrigger floors and perimeter columns and also considered the slab stiffness at the typical floors. The conclusion is to enhance the effective depth of the building structure, beyond those provided by the central core by inducing tension and compression in the perimeter columns.

Z. BAYATI1, 'ET AL' presents the result of an analysis on reduction of drift in uniform belted structures with the help of rigid outriggers. It is concluded from the results that using optimized multi outriggers system can effectively help in reducing the seismic response of the building and can decrease the elements and foundation dimensions.

III. THOERY OF DYNAMIC AND SEISMIC RESPONSE

Damped free vibration: - the differential equation governing free vibration of SDOF with damping is

$$M\ddot{u} + c\dot{u} + Ku = 0$$

Dividing by m gives

$$\ddot{u} + 2\,\xi\,\omega\,\dot{u} + \omega^2 u = 0$$

$$\text{Where } \omega^2 = K/m,\ \xi = c/2m\omega = C/C_r$$

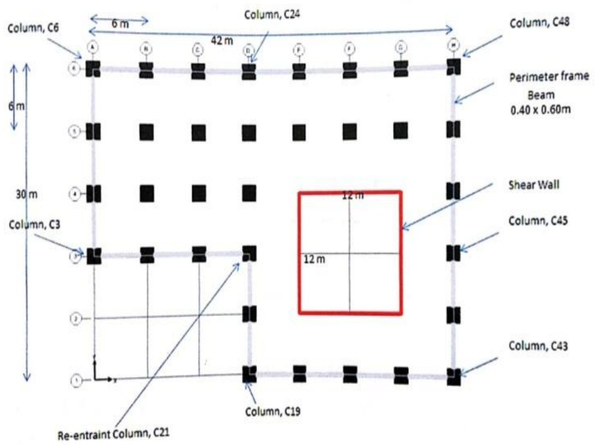
$$c_r = 2m\omega = 2\sqrt{km} = 2K/\omega$$

Where c_r is critical damping coefficient

Analytical model and solution procedures:

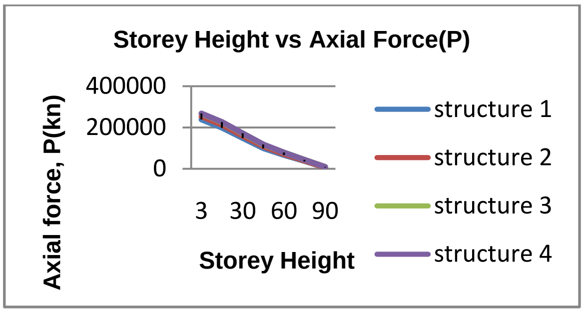
The analysis is done for the influence of perimeter frames in lateral performance of an irregular shape 30 storey 'L Shape' building. The load combinations of Load Case (0.9 DL + 1.5 WLX) is considered to carry out Storey and Columns forces, and the serviceability load combinations of Load Case 1.0(DL + WLX) is considered to carry out Storey and Columns displacements, as the lateral forces caused by wind load governs more than seismic loads.

Columns considered for comparison of Analysis are C3, C19, C21, C24 and C45 columns where C3 and C45 lies in X-direction left outer and right outer columns, C19 & C24 lies in Y-direction bottom outer and top outer columns in the line of Re-entrant column C21.

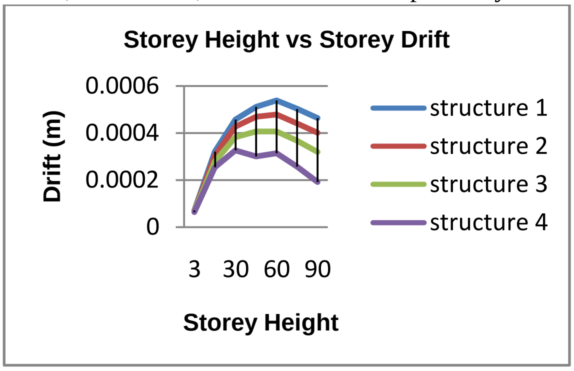


IV. DISCUSSIONS ON RESULTS

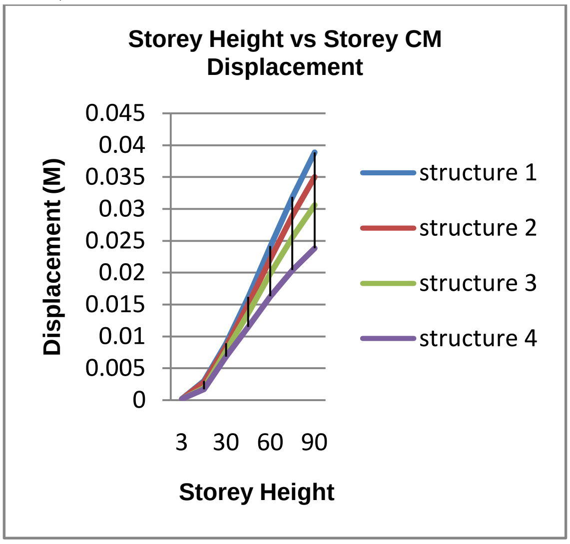
- The maximum storey axial forces in structure 1 is 237763 which is 6.93%, 12.04% and 12.45% less compare to structure 2,structure 3 and structure 4 respectively.



- The Maximum Storey Drift in Structure 1 is 0.55 mm which is 12.72%, 23.63% and 40% more compare to Structure 2, Structure 3, and Structure 4 respectively.



- The Maximum CM displacement in structure 1 is 38.9 mm which is 10.02%, 21.33% and 38.82% more compare to structure 2, structure 3 and structure 4



- As per IS 1893 (Part 1): 2002 clause 7.11.1 limiting storey drift is 0.004 times storey height. i.e. 0.004 x 3.0 m = 0.012 or 12mm. The Maximum Storey Drift for all the structures in both the directions for the load cases D.L + WLX is less than the limiting value.
- All the structures are Re-entrant column structures as $A_1/L_1 = 0.4285$ and $A_2/L_2 = 0.40$ which are greater than 0.15.
- For structure 4, Moment in Re-entrant column, C21 is 894 KN-m which is 0.6%, 0.66%, 4.31% more and 5.76% less compare to C3, C45, C19 and C24 columns respectively.

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Type of structure	C19	C21	C24	C3	C45
Structure 1	944	984	1038	979	978
Structure 2	922	960	1011	955	954
Structure 3	893	930	980	925	924
Structure 4	855	894	945	888	888

- For structure 4, Axial forces in Re-entrant column, C21 is -7489 KN which is 38.12%, 40.27%, 13.26% more and 0.07% less compare to C3, C19, C24 and C45 columns respectively.

Type of structure	C19	C21	C24	C3	C45
Structure 1	-3970	-7303	-5876	-3948	-6239
Structure 2	-4189	-7481	-6213	-4208	-6743
Structure 3	-4376	-7529	-6511	-4451	-7244
Structure 4	-4473	-7489	-6496	-4634	-7494

V.CONCLUSIONS

From the analysis of the data the following results have been arrived at.

1. Structure 2: 150 mm Flat slab without drop significantly improve the behavior than structure 1 :(125 mm flat slab with drop) due to increase in the diaphragm's rigidity.
2. There is further improvement in performance of the structure with increase of diaphragm at regular intervals. Hence structure 3: (increase in diaphragm's rigidity with 250mm at regular intervals) shows better performance.
3. The outriggers, mainly those aligned to shorter edge helps greatly in increase of effective depth of the building structure which participates in resisting the lateral loadings. Hence it is concluded that lateral resistance transverse to shorter edge in structure 4(outriggers + increase in diaphragm's rigidity with 250mm at regular intervals) gives better Lateral resistance than all the structures due to addition of outriggers parallel to shorter edge.
4. Further it is concluded due to not providing outriggers parallel to longer edge at left side of the shear wall and due to torsion effect, the CM displacement and storey drift in Y-Direction are increased in structure 4 than structure 1.

VI. SCOPE OF FURTHER STUDY

Study can be made further by **providing shear wall core with perimeter frame with outrigger systems at different floor levels** for further increase in height of the building.

REFERENCES

1. Dr.H.M.Somasekharaiah, MadhuSudhana, MuddasarBasha, "A Compressive Study on Lateral Force Resisting System For Seismic Loads" (IRJET) Aug-2016
2. K.M.Lam, 'et-al.' "Dynamic wind loading of H-Shaped Tall buildings" – for 7th APCWE, November 8-12, 2009, Taipel, Taiwan.
3. PankajAgarwal& Manish Shrikhande (2009) "Earthquake Resistant Design of Structures".
4. Alpha Sheth, "Effect of perimeter frames in seismic performance of tall concrete buildings with shear wall core and flat slab system" – for 14 WACEE on 12-10-2008 Beijing, China.
5. Z.Bayatil, 'et-al.' "Optimized use of Multi-outrigger System to stiffen Tall Buildings" – for 14 WCEE on 12-10-2008, Beijing, China.
6. Chopa A.K (2005):- "Dynamics of structures theory and applications to Earthquake Engineering", second edition.
7. King-Le Chang and Chun-Chung Chen, "Outrigger System Study for Tall Building with Central Core and Square Floor Plate" – for CTBUH 2004 October 10-13, Seoul, Korea.
8. Dong-Gyen Lee, 'et-al' "Use of Super Elements for an efficient analysis of high- rise building structures" – for CTBUH 2004 October 10-13, Seoul, Korea.
9. Young S.Cho, 'et-al.' "A study of Flat Plate Slab – Column connections with Shear Plate in Tall concrete building using Experimental and Numerical Analysis" – for CTBUH 2004 October 10-13, Seoul, Korea.
10. J.M.Reynuouard and J.F.Georgin, "Non linear response and modeling of RC walls subjected to seismic loading", -paper no: 415, vol. 39, march-june2002 of ISET journal of EQ technology.
11. E.F.Cruz and S.Cominetti, "Influence of Irregularities in Height and Different Design criteria on the inelastic response of building models" –Paper No: 631 for 11th WCEE, 1996.
12. NirjharDhang, "Structural Dynamics: An Over View" Chapter 12-SE101, NPCBEERM, MHA(DM)
13. U.H.Varyani "Structural Design of multi-storied buildings", second edition.