

Analytical Practices to Obtain Efficient Concrete Grade in Outrigger Walls below Plinth Level in Multistorey Building

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Abstract— To make the structure that would be free from lateral effects, some of the additional components should be implemented to it to make it safe. Some of the supplementary components are shear wall, bracing elements, belt supported system, outrigger wall system etc. These supplementary components when added to the multistoried fascinating and high rise structure can make it stiffer that ultimately fulfill the living needs. These add-ons make the structure safer for various horizontal and vertical irregularities. In this study outrigger system is taken for analysis by implementing the outrigger walls below the plinth level. Previous studies shows the outrigger system used at a particular height, but none of the researches shows this kind of the structural stability research approach. The main objective of the current theme is to prove the optimum grade of concrete that can be used when this kind of approach is adopted. Total 8 cases were selected, analyzed and compared among each other to select the optimum one. Building case OT8 observed and obtained as efficient case and should be recommended when this type of stability in building will be provided.

Keywords— *Efficient Concrete Grade, Lateral load capacity, Outrigger Walls, Plinth Level Stability, Shear wall.*

I. INTRODUCTION TO STABILITY ENHANCEMENT CRITERIA

The tall structures needs firm stable ground to achieve lateral stability with lesser ground area for living and commercial purposes. The stabilization of the structure has done when using the current guidelines of the Indian Standardization. The dual structural configurations are now the main criteria for current tall structures. Since the construction an industry expand day by day and follows the financial customs that operates cost effective structures.

The only view in this industry matter is financial along with reallocation and liquidity of funds for operation and maintenance of the construction. With this financial operation in this industry, structural engineers needs to do a very tough task to make the stability of the structures at each part or at each stages when design steps has going on. When construction work on site is going on, it sometimes loses the financial trend when the structural stability is there to make the structure heavy that sustain the hazardous seismic activities.

To make the structure more sustainable in these seismic activities, some supplementary stiffening structural members are needed like heavy weight R. C. C. components, belt supported systems, outrigger systems, dual structural systems, truss belt systems etc. These supplementary components on one hand, it stabilizes the structure more effectively, but on the other hand, it increases the mass of the structure that ultimately increases the base shear. Hence it is essential to make the structure more light and stable, subsequently it lessen the financial trend in the project.

As per the generalized theory of stability, many research activities are going on numerous researches done in this field established many things in terms of stability of the structure by means of and without adding the supplementary components. Practices that stability escalates could be achieved by:-

1. By implementing some stability improvement structural components that resist the lateral and vertical loads.
2. Altering the size of the structural elements.

3. By elimination of the structural elements.
4. By decreasing the bulkiness of the structure.
5. By changing the grade of concrete in overall or in the part of the structure.

II. OBJECTIVES OF THE CURRENT STUDY

The current study consists of providing the outrigger wall system below the plinth level to increase the lateral load handling capacity in multistoried building. A complete analytical procedure has followed to obtain the each parametric result, compared among all eight cases to obtain most efficient case. As per Indian standard under earthquake Zone III, the following objectives selected in this study:-

1. Determination of effective case among general and Outrigger Wall supported system provided below plinth level.
2. To determine Base shear response when seismic forces are applied in X and Z direction to the structure.
3. To find member Shear Forces values in Beam with efficient case among all eight cases.
4. To examine Bending Moment values in Beam with efficient case among all eight cases.
5. To determine and compare member Torsion values in Beam.
6. To examine column Axial Forces for total eight cases with efficient case to determine minimum axial force.
7. To find member Shear Forces values in Column with efficient case among all eight cases.
8. To examine Bending Moment values in Column with efficient case among all eight cases.
9. To determine and compare member Torsion values in Column.
10. To analyze the maximum nodal displacement case in X direction with most efficient case that provides more stability among others.
11. To obtain the maximum nodal displacement values in Z direction with most efficient case among all eight cases.
12. To demonstrate and recommend the efficiency of wall belt below plinth level with optimum concrete grade to stabilize the structure.

III. PROCEDURE AND 3D MODELING OF THE STRUCTURE

A semi commercial (G+16) storied apartment is supposed to be situated at seismic zone III and rested on medium soil. This apartment has both vertical load along with horizontal loads acting over it and this seismic load creates the maximum deflection at the top of the structure. With 900 sq. m. area, Dimensions and different input parameters of the building are selected and applied over the structure and then seismic load is applied over it with various seismic parameters as mentioned in Table 1 and Table 2 respectively.

For the analysis of the optimum grade of outrigger, a total of eight different cases have chosen for the parametric analysis, its description shown below. Dead loads, Live loads, Response spectrum loads and load combinations as per Indian Standards are applied on the apartment. M20, M25, M30, M35, M40, M45 and M50 grade of concrete used with Fe 500 grade of steel is used.

Figures 1 to Figure 4 shows typical floor plan of the apartment, its front view without wall outrigger at plinth, with wall outrigger at plinth and finally last figure shows the description of different components of apartment with Wall Outrigger below plinth level.

Table 1: Dimensions and different input parameters of the building

Parameters	Values
Building configuration	G + 16
Building type	Semi-commercial apartment
Total plinth area	900 m ²
Building Length	6m @ 5 bays
Building Width	5m @ 6 bays
Height of building from Ground level	64.5 m
Height of each floor	3.5 m
Depth of footing	4 m
Beam dimensions	550 mm x 350 mm
Column dimensions	600 mm x 550 mm
Slab thickness	165 mm
Staircase waist slab	150 mm
Shear wall thickness	140 mm
Outrigger wall thickness	135 mm
Material properties	Concrete (M20), (M25), (M30), (M35), (M40), (M45), (M50) Steel (Fe 500)

Table 2: Seismic parameters applied on the structure

Parameters	Values
Importance factor I	1.2
Fundamental natural period (Ta) in X and Z direction	1.1256 seconds
Response reduction factor R	4
Zone factor	0.16
Structure Type	RC frame Structure
Zone	III
Soil type	Medium soil

Different building model cases selected for analysis using analytical software

1. **Case OT1** = Outrigger Stability Case – Regular Building without Wall Outrigger below Plinth.
2. **Case OT2** = Outrigger Stability Case – Wall Outrigger of M20 grade Connection below Plinth level.
3. **Case OT3** = Outrigger Stability Case – Wall Outrigger of M25 grade Connection below Plinth level.
4. **Case OT4** = Outrigger Stability Case – Wall Outrigger of M30 grade Connection below Plinth level.
5. **Case OT5** = Outrigger Stability Case – Wall Outrigger of M35 grade Connection below Plinth level.
6. **Case OT6** = Outrigger Stability Case – Wall Outrigger of M40 grade Connection below Plinth level.
7. **Case OT7** = Outrigger Stability Case – Wall Outrigger of M45 grade Connection below Plinth level.
8. **Case OT8** = Outrigger Stability Case – Wall Outrigger of M50 grade Connection below Plinth level.

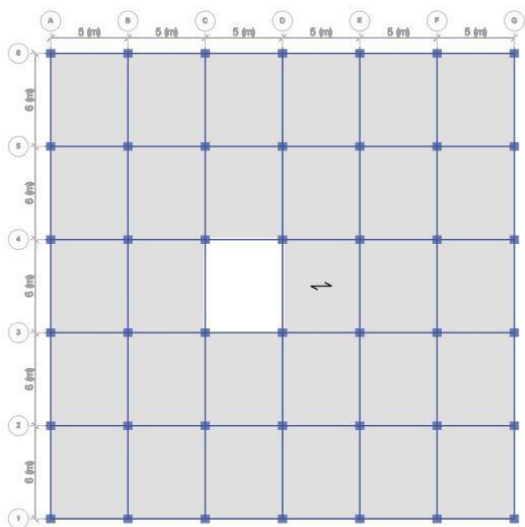


Fig. 1: Typical floor plan

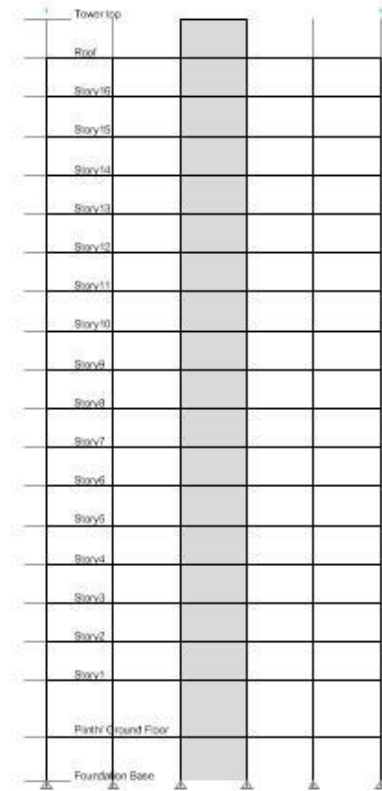


Fig. 2: Front View of the Structure without Wall Outrigger

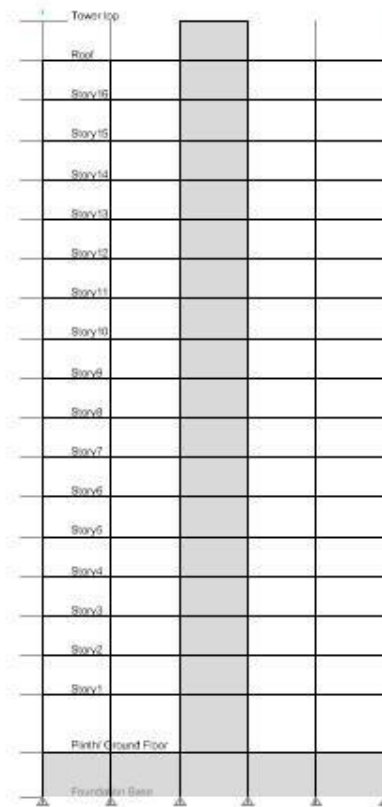


Fig. 3: Front View of the Structure with Wall Outrigger

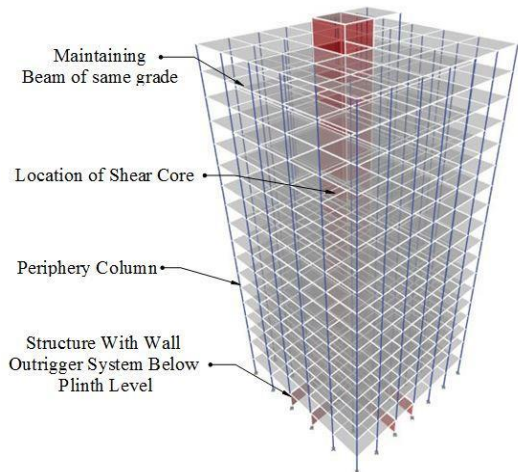
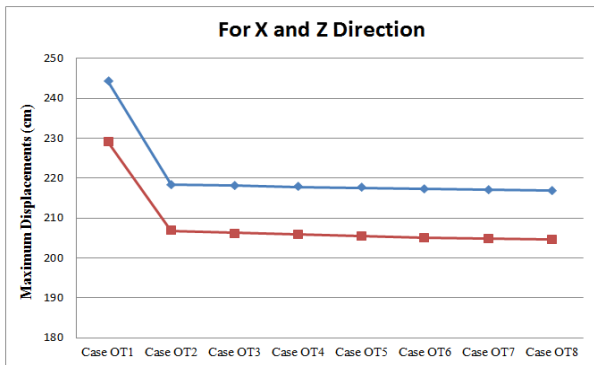


Fig. 4: Description of different components of Structure with Wall Outrigger below Plinth Level

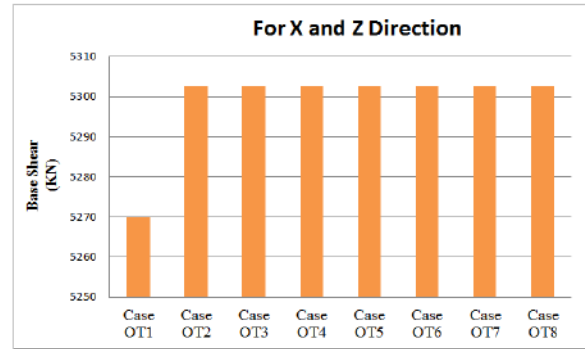
IV. RESULT ANALYSIS

As per Indian Standard 1893: 2016 code of practice, the stability of the building criteria by changing the grade of concrete in outrigger walls below the plinth level by fulfilling all the objectives.

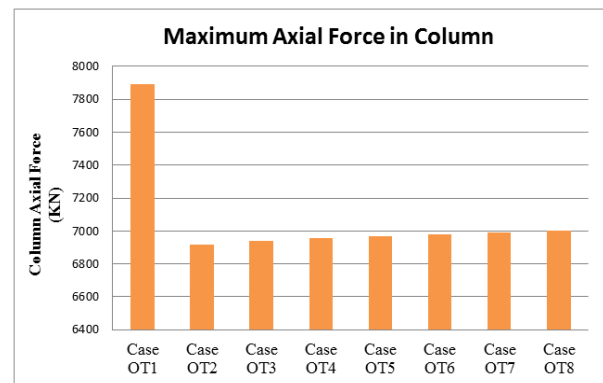
Graphical representation of each result parameters has discussed as per different wall outrigger case shown below:-



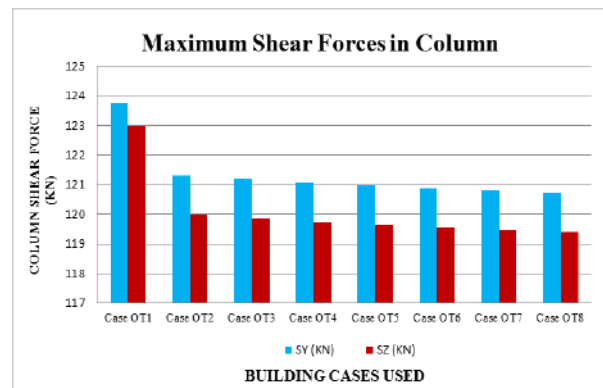
Graph 1: Graphical Representation of Comparison of Maximum Displacement in X and Z direction for all Outrigger Wall Cases below Plinth Level



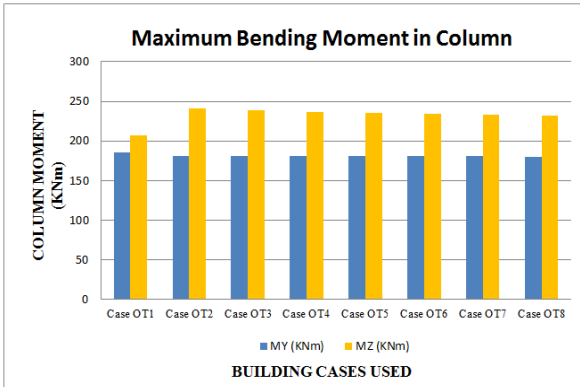
Graph 2: Graphical Representation of Comparison of Base Shear in X and Z direction for all Outrigger Wall Cases below Plinth Level



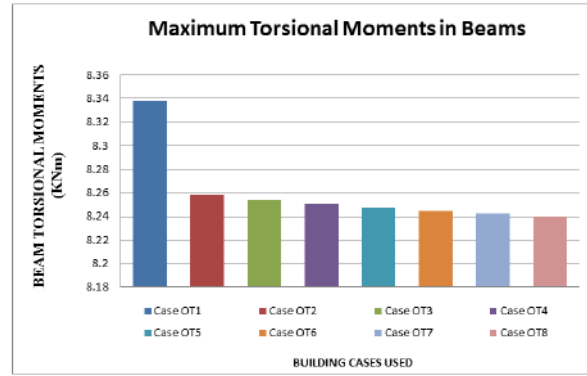
Graph 3: Graphical Representation of Comparison of Maximum Axial Forces in Column for all Outrigger Wall Cases below Plinth Level



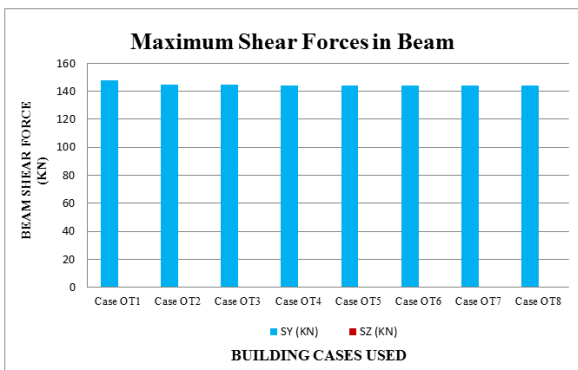
Graph 4: Graphical Representation of Comparison of Maximum Shear Force in Column for all Outrigger Wall Cases below Plinth Level



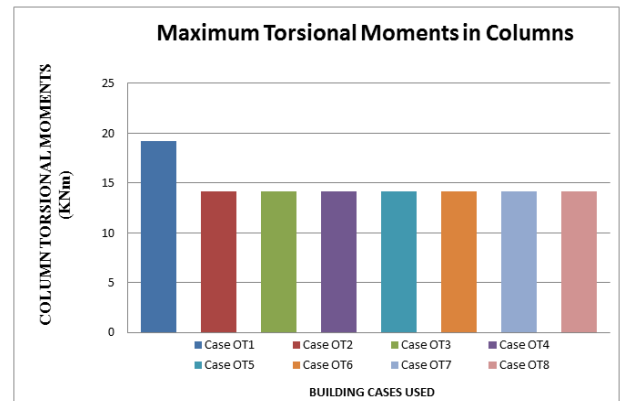
Graph 5: Graphical Representation of Maximum Bending Moment in Column for all Outrigger Wall Cases below Plinth Level



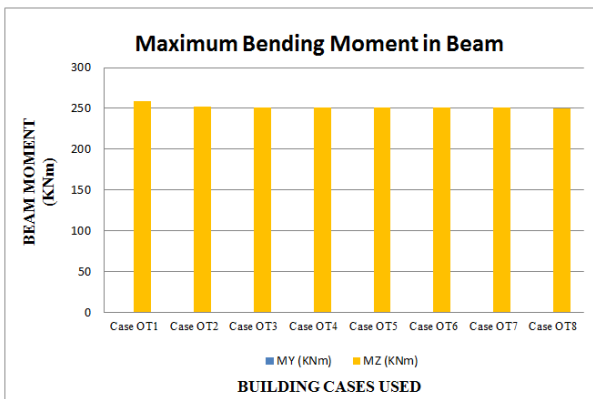
Graph 8: Graphical Representation of Comparison of Maximum Torsional Moments in Beam for all Outrigger Wall Cases below Plinth Level



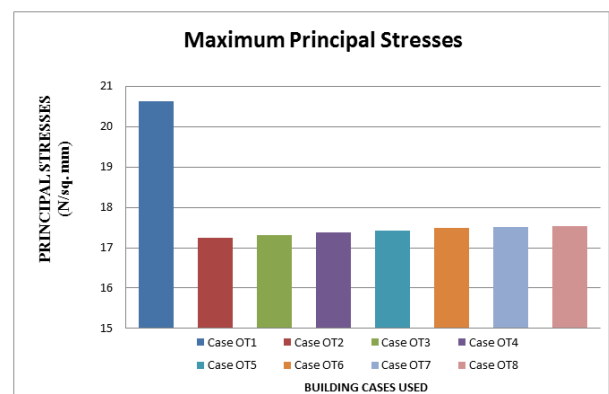
Graph 6: Graphical Representation of Comparison of Maximum Shear Force in Beam for all Outrigger Wall Cases below Plinth Level



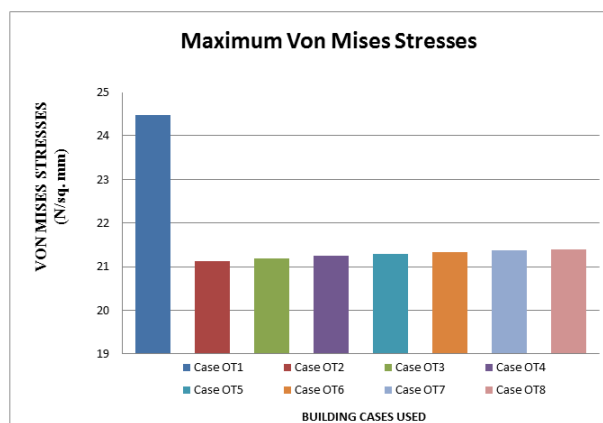
Graph 9: Graphical Representation of Comparison of Maximum Torsional Moments in Columns for all Outrigger Wall Cases below Plinth Level



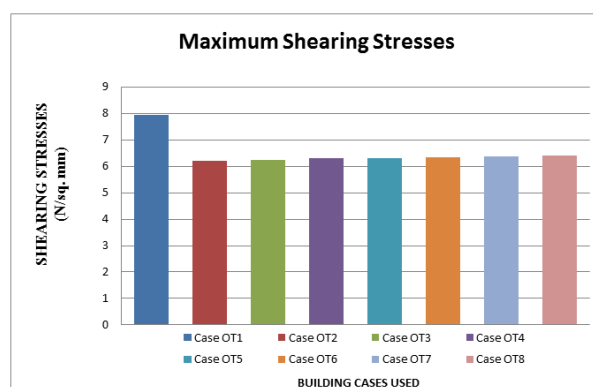
Graph 7: Graphical Representation of Comparison of Maximum Bending Moment in Beam for all Outrigger Wall Cases below Plinth Level



Graph 10: Graphical Representation of Comparison of Maximum Principal Stresses for all Outrigger Wall Cases below Plinth Level



Graph 11: Graphical Representation of Comparison of Maximum Von Mises Stresses for all Outrigger Wall Cases below Plinth Level



Graph 12: Graphical Representation of Comparison of Maximum Shearing Stresses for all Outrigger Wall Cases below Plinth Level

V. CONCLUSION

The conclusion can be pointed out are as follows:-

1. With a minimum value of 216.978 mm in X direction and minimum value of 204.664 mm in Z direction, Maximum displacement values drastically decreases since stiffness is more when outrigger wall cases used below plinth level.
2. Due to an addition of a new structural component, the Base shear values increases with increase in additional member in a structure. Case OT1 seems less but due to addition of outrigger wall, it seems an equal value of 5302.53 KN for all cases in both the directions.
3. Maximum Axial Forces in Column seems lesser in Case OT2 with a minimum value of 6916.3613 KN for all Outrigger Wall Cases provided below plinth level.
4. Shear forces in column gradually decreases when Outrigger Wall Cases provided below plinth level. In

both moment along Y and Z axis (M_y and M_z), the column bending moment parameter also decreases gradually after the application of Outrigger Wall Cases provided below plinth level.

5. Shear forces in beams along both Y and Z axis (S_y and S_z), after the application of Outrigger Wall Cases provided below plinth level the values declines.
6. The pattern that created in shear forces in beam follows same in Bending Moment in Beam for both M_y and M_z . The values decreases to Building case OT8.
7. With a minimum value of 8.2402 KNm, the Torsion parameter in beams seems less in Building case OT8 after the application of Outrigger Wall Cases provided below plinth level. The same trend follows in Torsional cases in column.
8. A big drop has seen in Maximum Principal Stresses observed after the application of Outrigger Wall Cases provided below plinth level. The same trend follows in Von Mises stresses and Shearing Stresses respectively.

Observing all the parameters, after the application of Outrigger Wall provided below plinth level, the Building case OT8 observed and obtained as efficient case and should be recommended when this type of stability in building will be provided.

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