iJRASET
International Journal For Research in Applied Science and Engineering Technology



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 8 **Issue:** VII **Month of publication:** July 2020

**DOI:** https://doi.org/10.22214/ijraset.2020.30669

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
*Volume 8 Issue VII July 2020- Available at www.ijraset.com*

# An Efficient Approach to Determine the Effects of Different Grades of Concrete in Outrigger and Wall Belt Supported System

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***Abstract:*** ***The sole purpose of the stability improvement techniques system is to the enhance the increasing demand of the multistoried buildings with building type of semi commercial apartment having different configurations such as horizontal irregularities, vertical irregularities, different building structural theme and so on. Since the major point in this is living area of horizontal land is converted now into vertical apartments that lead to new challenges and requirement of new safety measures. To counteract the seismic forces to the multistoried structures, stiffness of the structure has to increase with increase in elevation that's why we need to implement certain structural system add on such as shear wall, bracings, wall belt system, outrigger system etc. It has been found that the best ideal structure for multistoried buildings is outrigger and wall belt structural stability system is taken for analysis in the current study approach. External columns are tied to the central inner shear core by the help of wall outrigger in this system that struggle against rotation and sway action due to lateral effects. Since for the analysis of seismic effects, total 8 cases have been selected which are abbreviated as Case OTB1 to Case OTB8, that are supposed to be situated at seismic zone III and rested over medium soil. Various loads along with load combinations applied on all the cases and reflective result parameters have been analysed with each other to determine the efficient case. After comparative analysis of each parameter, it has been observed that Structural Stability Case OTB7 and OTB8 observed and obtained as efficient case and should be recommended when this type of approach will be adopted in earthquake zone III.***
***Keywords: Concrete grades, Optimization, Outrigger, Seismic analysis, Shear Wall, Wall belt supported system.***

## I. AN OVERVIEW OF OUTRIGGER AND WALL BELT SUPPORTED SYSTEM

The amalgamation of shear wall plates or thin long beams connected to the columns and shear wall core of the building that transfers the lateral load of the structure are known as Outriggers. The outrigger members connected from the core to external columns and act as frame connections in both the directions that grip the structure. Shear wall core provided around lift area holds the entire construction that receives the lateral loads from the transmission of the framed structure uniformly to the external columns. This system provides more rigidity to the structure than traditional arrangements.

The wall belt or truss belt system is a kind of mainly capable and adaptable system used in elevated multistoried building. The main work of this system is to provide the linkage of the external column members to each other that resist the side effects of the lateral forces of wind and earthquake. Another main purpose to provide the wall belt is to tie up the nodes of the construction. It is called as belt supported system because this belt generally tied up from a certain height that holds the entire slender construction, resist it from sway in to both the longitudinal and transverse direction by the means of thin shear wall belt or truss belt components.

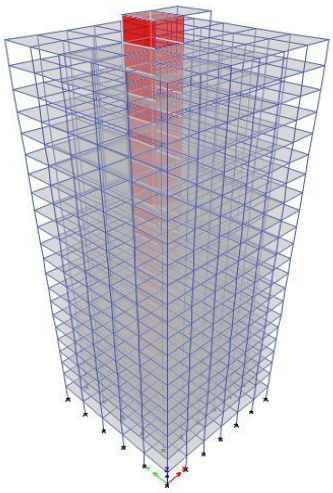


Fig. 1: 3D Observation of the Structure without Outrigger and Wall Belt

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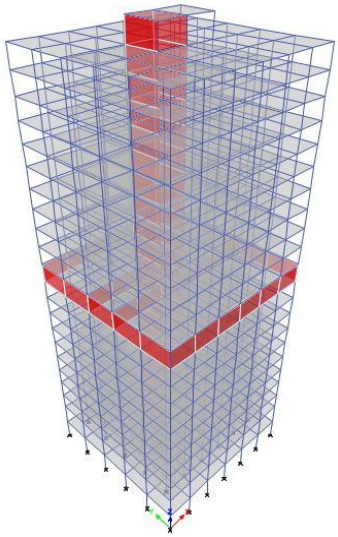


Fig. 2: 3D Observation of the Structure with Outrigger and Wall Belt

## II. OBJECTIVES OF THE CURRENT STUDY

The study consists of change in grading of concrete in outrigger and wall belt supported dual structural system with comparison of total 8 model cases. This comparative analysis will be done on different parameters include shear forces, moments, displacements, base shear etc. in longitudinal and transverse direction. All these grade change cases of the multistoried building rests on medium soil under the existence of seismic forces as per Indian standard earthquake Zone III. The following objectives have been used in this study:-

*1)* Determination of Base shear in X and Z direction to the structure response when seismic forces are applied by conducting grade change of outrigger and wall belt supported system.
*2)* Shear Forces values in Beam and column with effective grade change case of outrigger and wall belt supported system.
*3)* To examine Bending Moment values in Beam with efficient case of grade change of outrigger and wall belt supported system.
*4)* To determine and compare member Torsion values in Beam members.
*5)* To find column Axial Forces to determine minimum axial forces by changing the grade of outrigger and wall belt supported structural stability dual system.
*6)* To examine Bending Moment values in Beam with efficient case of grade change of outrigger and wall belt supported system.
*7)* To determine and compare member Torsion values in Beam with efficient case of grade change of outrigger and wall belt supported system.
*8)* To get the efficient case of grade change of outrigger and wall belt supported system, it is necessary to examine the maximum nodal displacement in lateral and transverse direction

To demonstrate and recommend the effect of stability of multistoried building by changing the grade of concrete in outrigger and wall belt supported dual structural system.

## III.PROCEDURE AND 3D MODELING OF THE STRUCTURE

Various semi commercial buildings (G+20) with plinth area 900 sq. m. were taken for analysis as per criteria for earthquake resistance design of structures. A total of eight different cases have been chosen for parametric analysis, its description shown below. Various dimensions of structure are shown in Table 1, seismic parameters taken have shown in Table 2 respectively.
Dead loads, Live loads, Response spectrum loads are applied on the structure with various load combinations. M20 grade to M 50 grade of concrete used with Fe 500 HYSD grade of steel was used. After then the selected 8 building cases were undergone the performance analysis and each of them abbreviated from Case OTB1 to OTB8. Figure 1 shows typical floor plan as per selected grid system. After then, comparative results of various parameters shown in tabular form with graph is provided to compare each parameter figuratively.

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Table 1: Dimensions of different components of building

| Parameters | Values |
|---|---|
| Plinth area | 900 sq. m |
| Height of Building from G.L. & Depth of Foundation | 78m & 4m |
| Type of Building | Semi Commercial Apartment |
| Beam dimensions | 0.55 m x 0.40 m |
| Column dimensions | 0.60 m x 0.55 m |
| Slab thickness (staircase waist slab) | 0.145 m |
| Shear wall thickness | 0.155 m |
| Slab thickness | 0.150m |
| Height of each floor | Ground = 4.5m,<br>Each floor height = 3.5m |
| Building Length | 6m @ 5 bays = 30m |
| Building Width | 5m @ 6 bays = 30m |

Table 2: Seismic parameters on the structure

| Parameters | Values |
|---|---|
| Importance factor I | 1.2 |
| Fundamental natural period (Ta) in X and Z direction | 1.3474 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 software technique

*1)* Structural Stability Case OTB1= Regular Structure with no Outriggers and Belt Supported system.
*2)* Structural Stability Case OTB2 = Outrigger and Wall Belt Supported System with Dual Core and M20 Grade Concrete used.
*3)* Structural Stability Case OTB3 = Outrigger and Wall Belt Supported System with Dual Core and M25 Grade Concrete used.
*4)* Structural Stability Case OTB4 = Outrigger and Wall Belt Supported System with Dual Core and M30 Grade Concrete used.
*5)* Structural Stability Case OTB5 = Outrigger and Wall Belt Supported System with Dual Core and M35 Grade Concrete used.
*6)* Structural Stability Case OTB6 = Outrigger and Wall Belt Supported System with Dual Core and M40 Grade Concrete used.
*7)* Structural Stability Case OTB7 = Outrigger and Wall Belt Supported System with Dual Core and M45 Grade Concrete used.
*8)* Structural Stability Case OTB8 = Al Outrigger and Wall Belt Supported System with Dual Core and M50 Grade Concrete used.

## IV. RESULT ANALYSIS

For the stability of the structure by changing the grade of concrete in Outriggers along with Wall belt that has supposed to be applied in assumed structure. Since for different parameters like nodal displacement, base shear, column axial forces, column shear and moment values, beam shear and moment values, torsion values and stresses were selected and the cases were compared among each other to obtain the best case among all. The above parameters obtained by the application of loads and their combinations on various cases of the multistorey building as per Indian Standard 1893: 2016 code of practice.

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Comparative result of each parameter has shown by graphical representation below:-

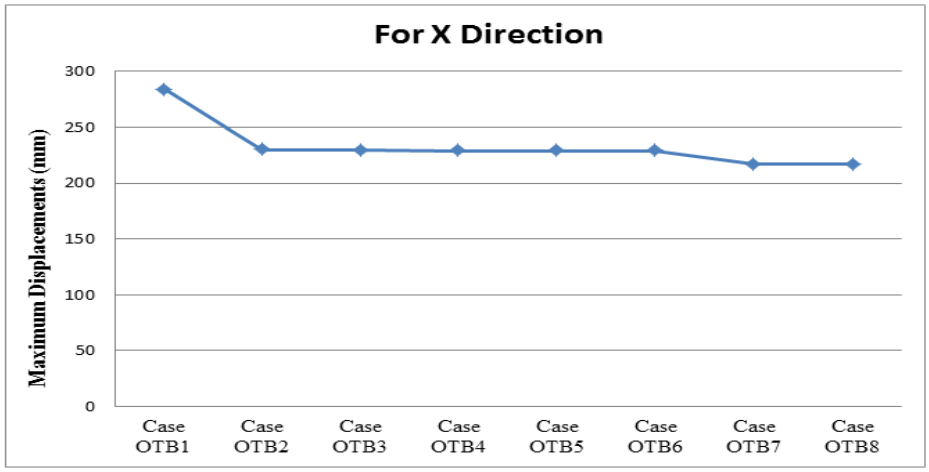



Fig. 3: Graphical Representation of Maximum Displacement in X direction for all Outrigger and Wall Belt Structural Stability Cases

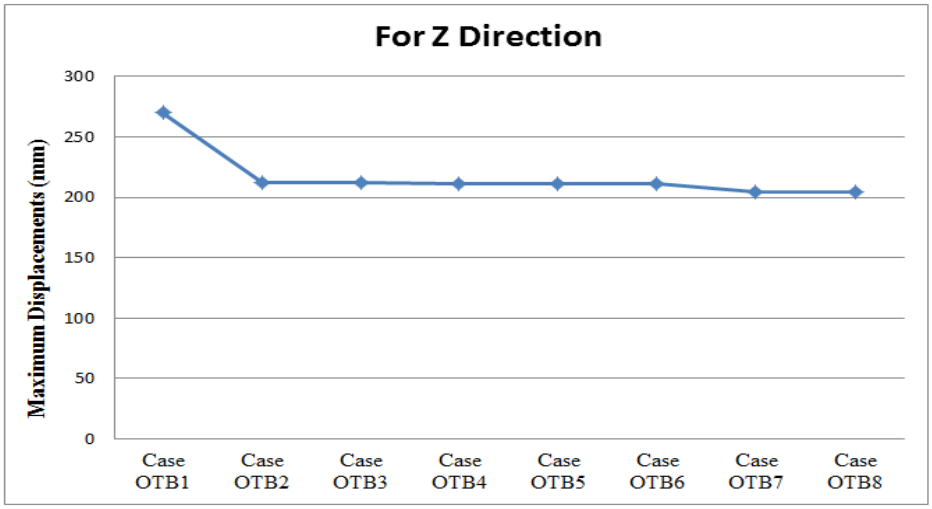



Fig. 4: Graphical Representation of Maximum Displacement in Z direction for all Outrigger and Wall Belt Structural Stability Cases

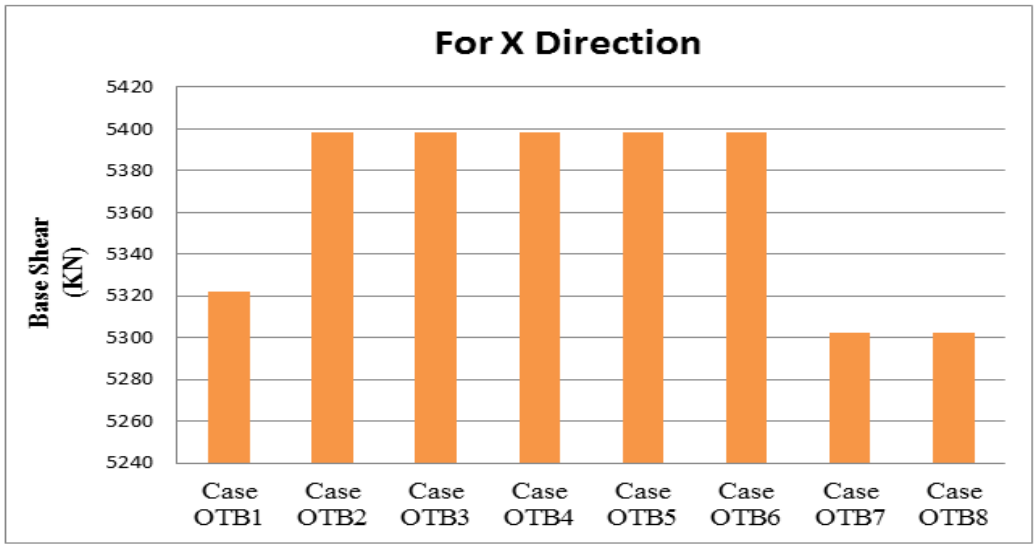



Fig. 5: Graphical Representation of Base Shear in X direction for all Outrigger and Wall Belt Structural Stability Cases

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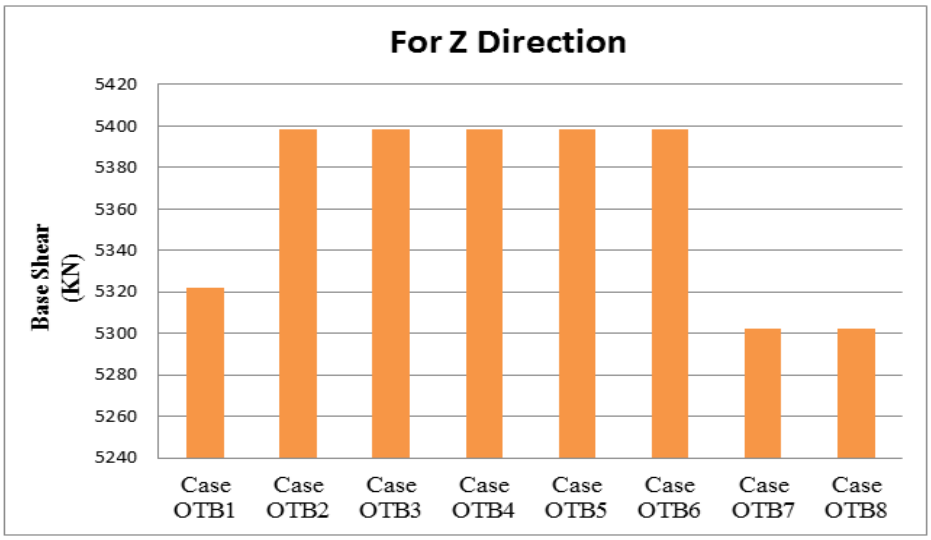



Fig. 6: Graphical Representation of Base Shear in Z direction for all Outrigger and Wall Belt Structural Stability Cases

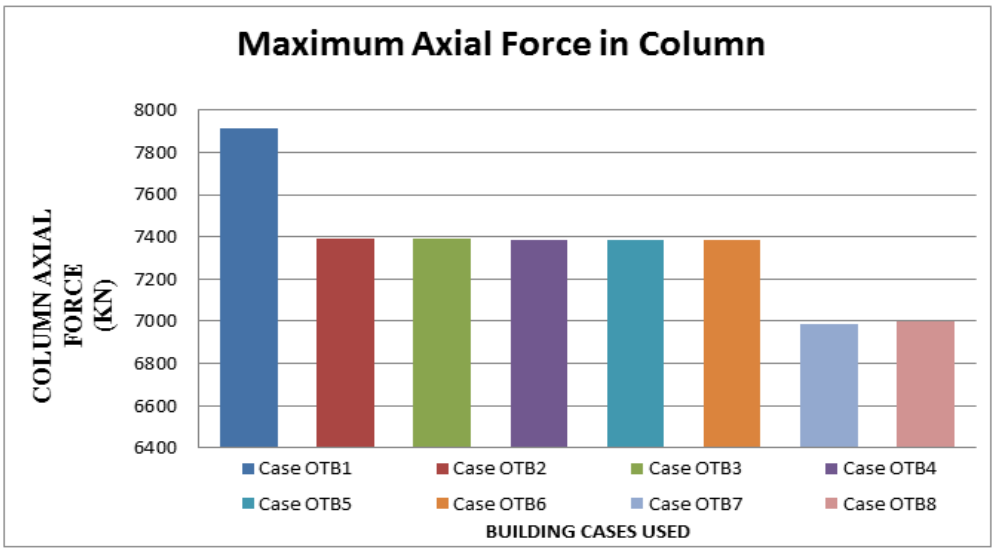



Fig. 7: Graphical Representation of Maximum Axial Forces in Column for all Outrigger and Wall Belt Structural Stability Cases

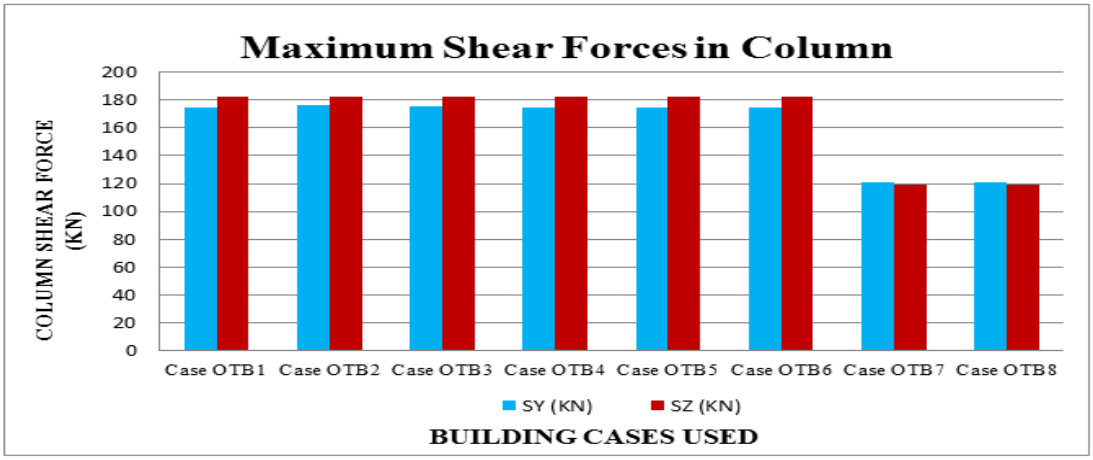



Fig. 8: Graphical Representation of Maximum Shear Force in Column for all Outrigger and Wall Belt Structural Stability Cases

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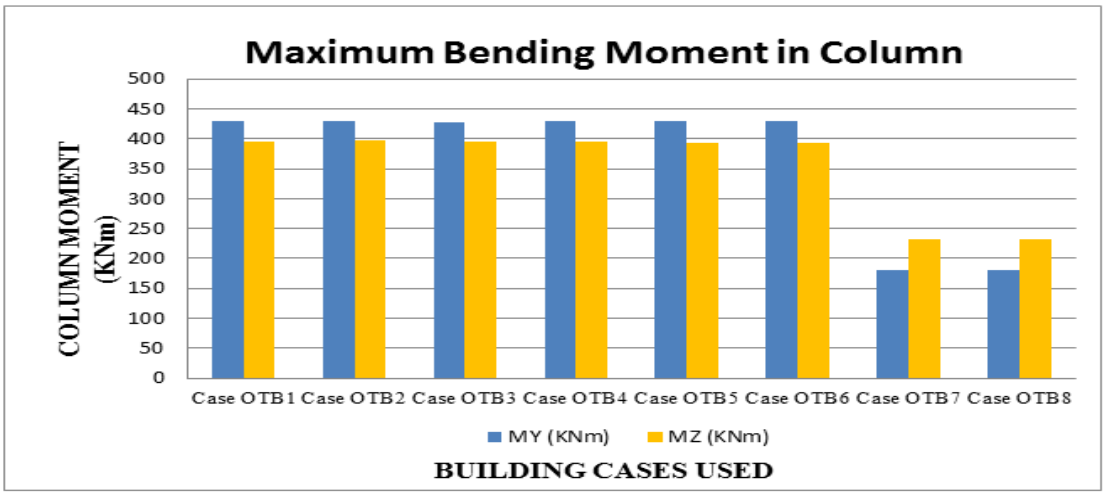



Fig. 9: Graphical Representation of Maximum Bending Moment in Column for all Outrigger and Wall Belt Structural Stability Cases

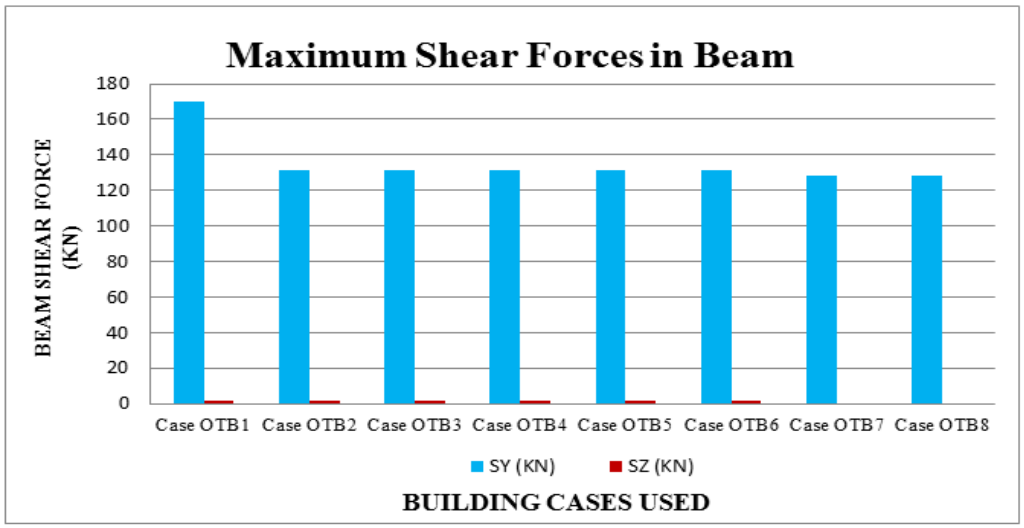



Fig. 10: Graphical Representation of Maximum Shear Force in Beam for all Outrigger and Wall Belt Structural Stability Cases

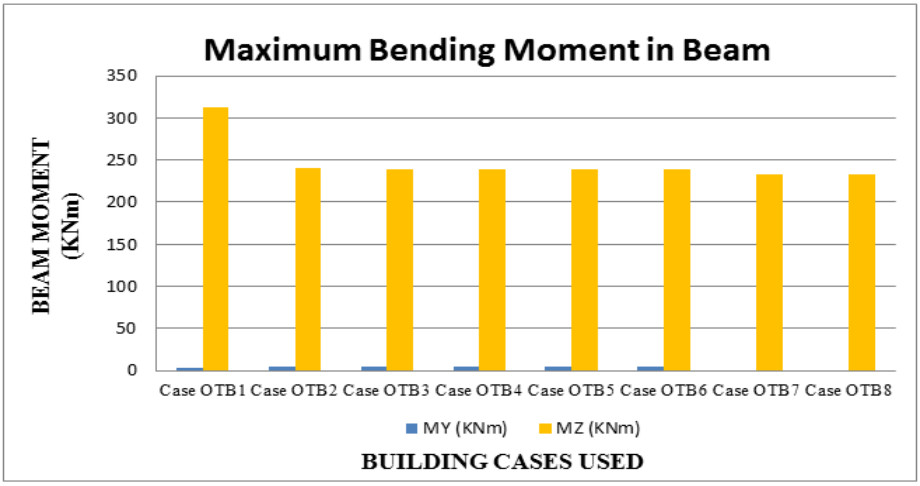



Fig. 11: Graphical Representation of Maximum Bending Moment in Beam for all Outrigger and Wall Belt Structural Stability Cases

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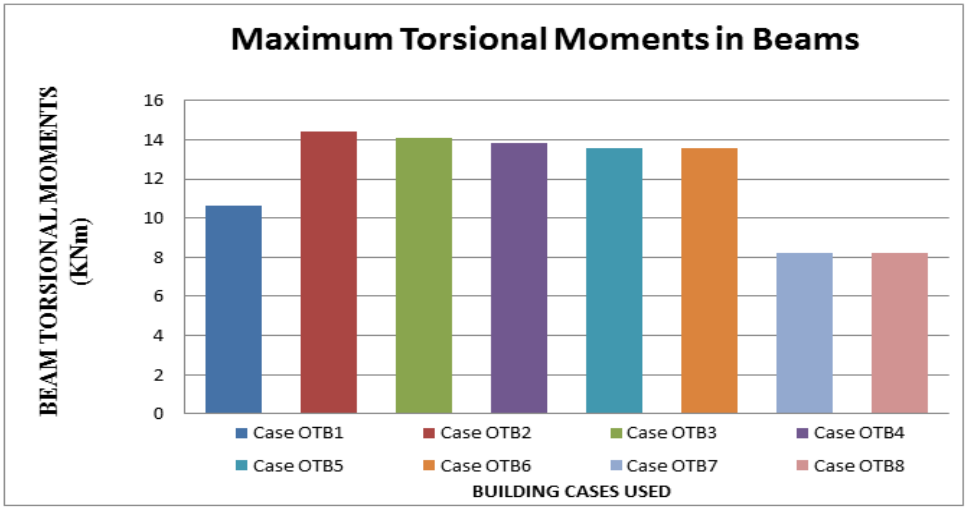



Fig. 12: Graphical Representation of Maximum Torsional Moments in Beam for all Outrigger and Wall Belt Structural Stability Cases

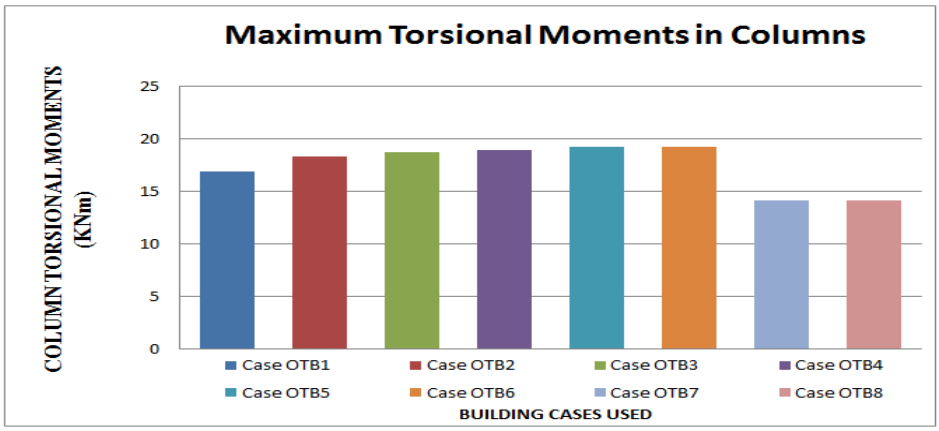



Fig. 13: Graphical Representation of Maximum Torsional Moments in Columns for all Outrigger and Wall Belt Structural Stability Cases

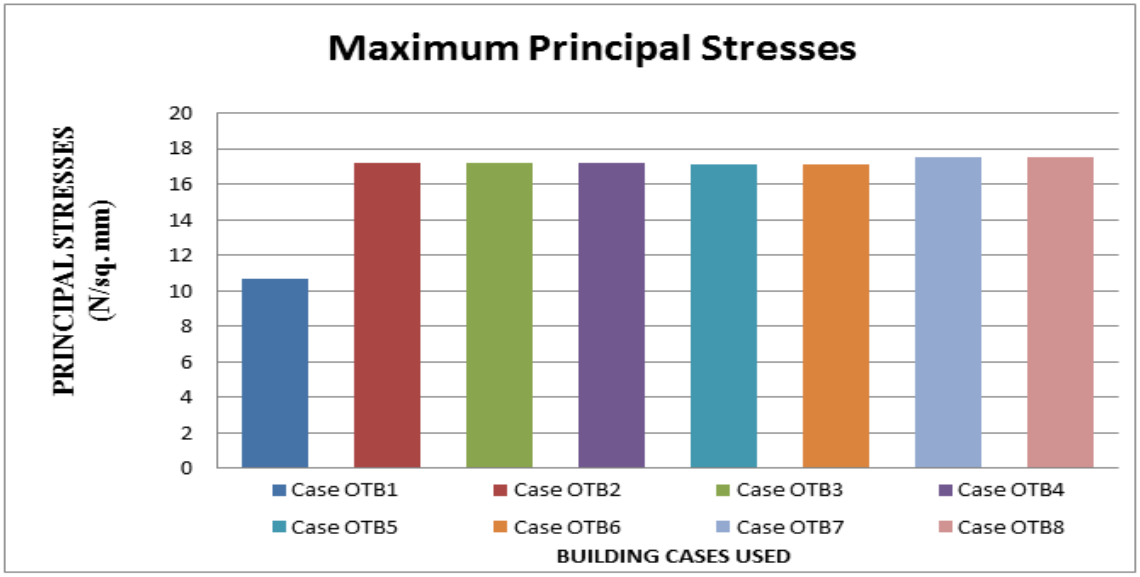



Fig. 14: Graphical Representation of Maximum Principal Stresses for all Outrigger and Wall Belt Structural Stability Cases

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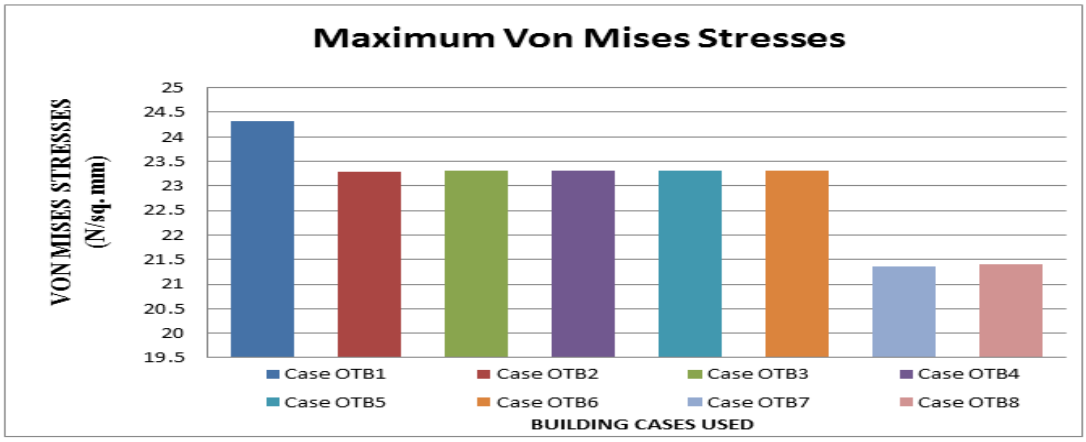



Fig. 15: Graphical Representation of Maximum Von Mises Stresses for all Outrigger and Wall Belt Structural Stability Cases

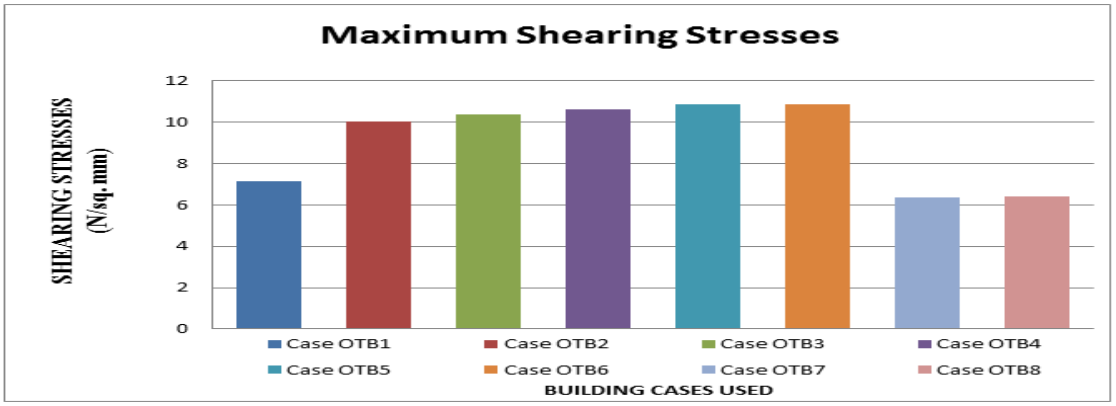



Fig. 16: Graphical Representation of Maximum Shearing Stresses for all Outrigger and Wall Belt Structural Stability Cases

## V. CONCLUSIONS AND RECOMMENDATION

Attractive result has been found when comparing outrigger and wall belt supported dual structural system and after analysis of numerous parameters, the conclusion can be pointed out are as follows:-

*A.* Maximum displacement in X direction has a minimum value of around 216.978 mm for Structural Stability Case OTB8 since the values keep on decreasing when there is an increment of the concrete grade.

*B.* Again, the maximum displacement values obtain in Z direction behaves same as that in X direction, since additional stability components when altered with grade change effect, shows increasing stability effect. Case OTB8 shows good results.

*C.* Base Shear obtain in X direction for all structural Stability Cases shows best values, since the values keep on decreasing when there is an increment of the concrete grade.

*D.* Again, when additional mechanisms were added, the Base Shear in Z direction behaves same as that trend obtained in X direction. Structural Stability Case OTB7 and OTB8 show least value.

*E.* The maximum Axial forces in Column keep on decreases to Structural Stability Case OTB7 and OTB8. Observing the least parameter, Case OTB7 and OTB8 obtained as an efficient case with a parametric value of 6990.1012 KN and 6999.0902 KN respectively.

*F.* The sectional Shear Forces along both Y-Y axis and Z-Z axis in column members shows least values in Structural Stability Case OTB7 and OTB8.

*G.* The Bending Moment along both Y-Y axis and Z-Z axis in column decreases gradually to Structural Stability Case OTB7 and OTB8 and proves to be an efficient case with values of 180.3034 KNm and 231.6439 KNm respectively.

*H.* For beams in the structures, the minimum value of Shear Forces along both Y-Y axis and Z-Z decreases gradually to Structural Stability Case OTB7 and OTB8 and proves to be an efficient case with values of 128.0658 KN and 128.0978 KN respectively.

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*I.* Bending Moments in beams Shows least value Structural Stability Case OTB7 and OTB8 along both in Y-Y axis and in Z-Z axis.

*J.* The same grade change effect criterion has seen in torsion effects in beams. The values keep on decreasing. For this parameter, again Structural Stability Case OTB7 and OTB8 seem to be efficient among all.

*K.* Similarly, the same trend has seen in Torsional Moments in columns. The values gradually decrease to a minimum value of around 14.17 KNm for Structural Stability Case OTB7 and OTB8 and hence prove to be economical case.

*L.* The principal stresses in plates shows no such major grade change effect.

*M.* Von Mises stresses in plates Decreases to Structural Stability Case OTB7 and OTB8 under lateral effects along with combination of the vertical loads.

*N.* Maximum Shearing Stresses again shows the same trend as Von Mises stresses for all Structural Stability Cases. Case OTB7 and OTB8 shows efficient among all.

Observing all the parameters, the main theme of this work has achieved with increasing stability by changing grades of concrete in outrigger and wall belt system in both X and Z direction in Semi Commercial Apartment, (G+20) multistoried building under seismic loading. Structural Stability Case OTB7 and OTB8 observed and obtained as efficient case and should be recommended when this type of approach will be adopted in earthquake zone III.

## VI. ACKNOWLEDGMENT

I Mohammad Bilal Rasheed, would like to thank Mr. Sagar Jamle, Assistant Professor, Department of Civil Engineering, Oriental University, Indore for his continuous support and guidance for the completion of this entire work. I am glad that he simultaneously works with 16 research scholars and do support individual scholars intensively.

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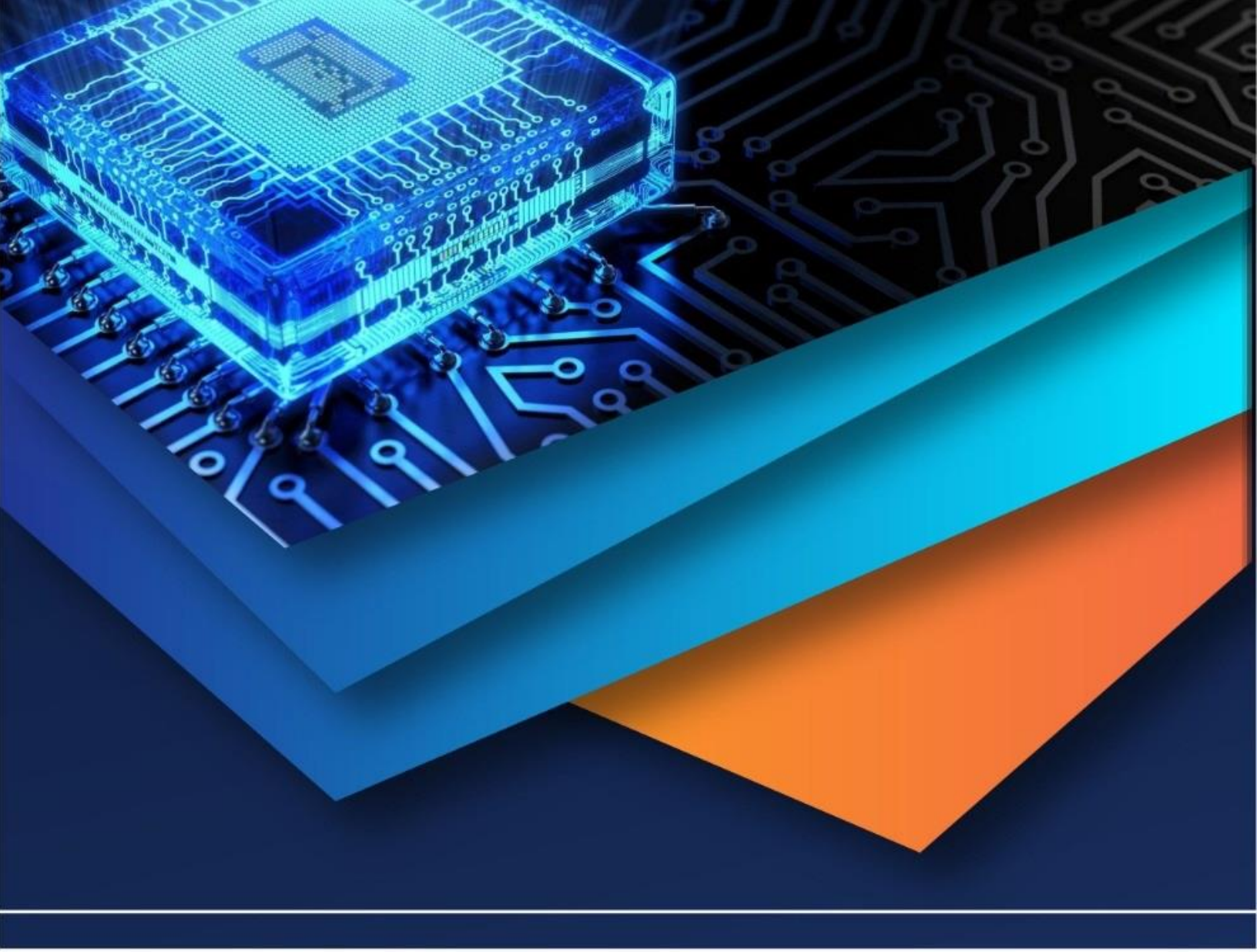
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