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# Criteria of Using Optimum Size Approach for Reduction of Axial Forces in Column in Multi Storied Building under Seismic Zone III

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***Abstract:*** ***In India, every industry has its own importance to make the country shift towards its future goal. The construction industry plays a very significant role with the introduction of high-rise structures that has been increasing regularly. Beside this, the structure should be strong enough that each element should be economic and strong. The criteria of using optimum size approach for reduction of axial forces in column in multi storied building under seismic zone is a new idea. It reduces the size of beams and columns at the different levels of the building. On other hand, the structural weight should be minimized when the self-weight of the same will be reduced and proved to be an economic structure.***
***In this project a G+13 Storey structure is analyzed using six different cases named as AFR Case A to AFR Case F assumed to be situated in seismic Zone III. The plinth area is in use as 625 m$^2$ and all the cases have compared with each parameter. The project concluded that efficient Case is AFR Case C on comparing 6 maximum axial force reduction cases that ultimately reduce the overall cost of the project.***
***Keywords: Axial forces, Columns, Strength, Durability, Software Models, High-Rise Structures***

## I. INTRODUCTION

In India, Multistorey building construction is at its peak in big cities because land cost for the construction is going high day by day in large cities of India. The land is minimum against population in the large cities therefore to reduce these problems multistory buildings are the only option where minimum land is caused and provide more convenience and safety to the people. To reduce the chances of failure and provide more stability to multistorey structures under seismic and wind forces many methods and analysis are in trend.

### *A. Axial Force*

If the load on a column is applied through the center of gravity of its cross section, it is called an axial load. Axial force is the compression or tension force acting in a member. If the axial force acts through the centroid of the member it is called concentric loading. If the force is not acting through the centroid it's called eccentric loading. Eccentric loading produces a moment in the beam as a result of the load being a distance away from the centroid.

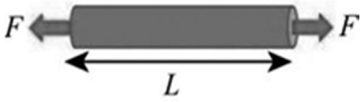



Fig. 1: Forces applied on a member of length L

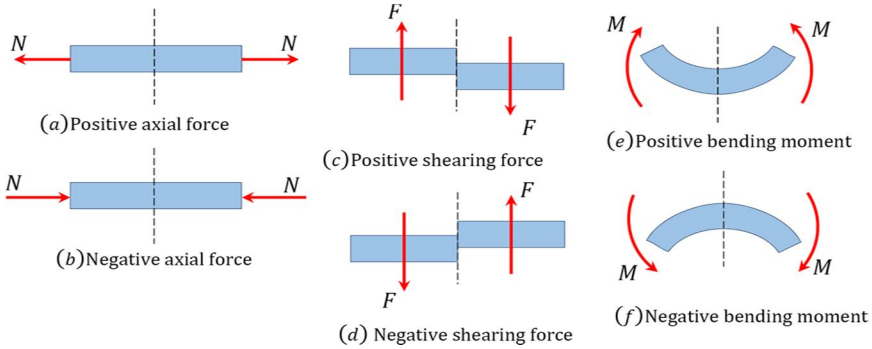



Fig. 2: Axial, Shear, Bending moment loading of member

## II. MODELING OF STRUCTURE AND ASSIGNING PROPERTY

The space frame has been modeled using software approach. The descriptions of the structure and different beam and column sizes are listed in Table 1.

Table 1: Description of parameters taken for analysis

| | |
|---|---|
| Building configuration | G + 13 |
| Building type | Semi - commercial building |
| Total plinth area | 625 $m^2$ |
| Building Length | 5m @ 5 bays = 25m |
| Building Width | 5m @ 5 bays = 25m |
| Height of building from Foundation level | 57 m |
| Height of each floor | 3.5 m |
| Depth of footing | 4 m |
| Beam dimensions 1 | 550 mm x 400 mm |
| Beam dimensions 2 | 550 mm x 350 mm |
| Beam dimensions 3 | 500 mm x 350 mm |
| Beam dimensions 4 | 500 mm x 300 mm |
| Column dimensions 1 | 650 mm x 600 mm |
| Column dimensions 2 | 600 mm x 500 mm |
| Column dimensions 3 | 600 mm x 450 mm |
| Slab thickness | 135 mm |
| Staircase waist slab | 135 mm |
| Shear wall thickness | 130 mm |
| Material properties | Concrete (M30),<br>Steel (Fe 500) |

Table 2: List of models framed with assigned abbreviation

| S. No. | Abbreviation | Models framed for analysis | | |
|---|---|---|---|---|
| | | Column Size | Beam Size | Applied Storey |
| 1. | AFR Case A | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 13 |
| 2. | AFR Case B | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 12 |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |
| 3. | AFR Case C | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 11 |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |
| 4. | AFR Case D | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 10 |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |
| 5. | AFR Case E | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 9 |
| | | 0.60m x 0.45m | 0.50m x 0.30m | Up to G + 13 |
| 6. | AFR Case F | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 8 |
| | | 0.60m x 0.45m | 0.50m x 0.30m | Up to G + 13 |

Note: Here AFR means Axial Force Reduction case.

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## III.DETAILS OF THE MODELS

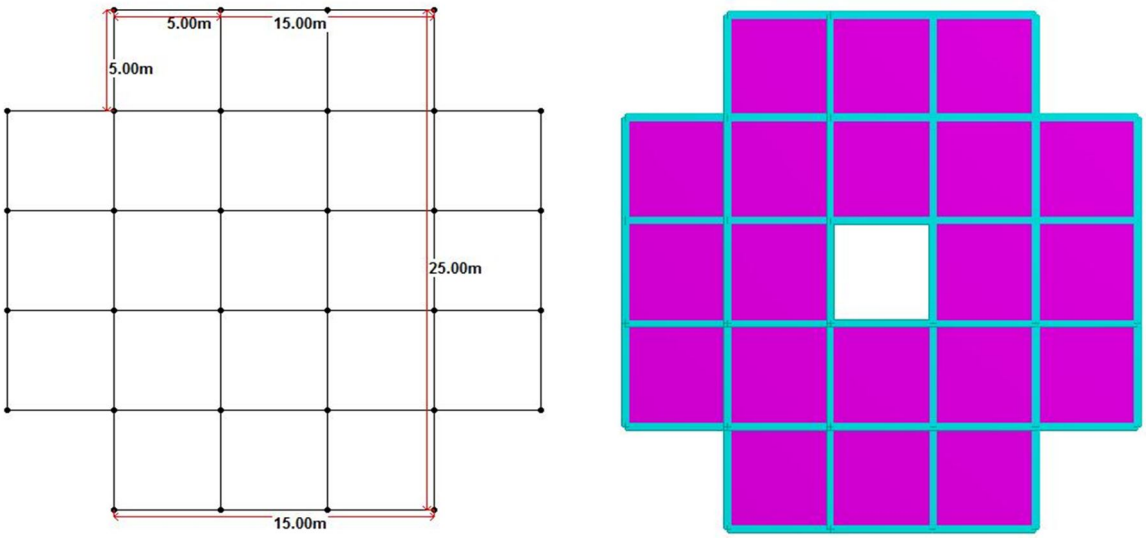



Fig. 3: 2D and 3D Plan of the Structure

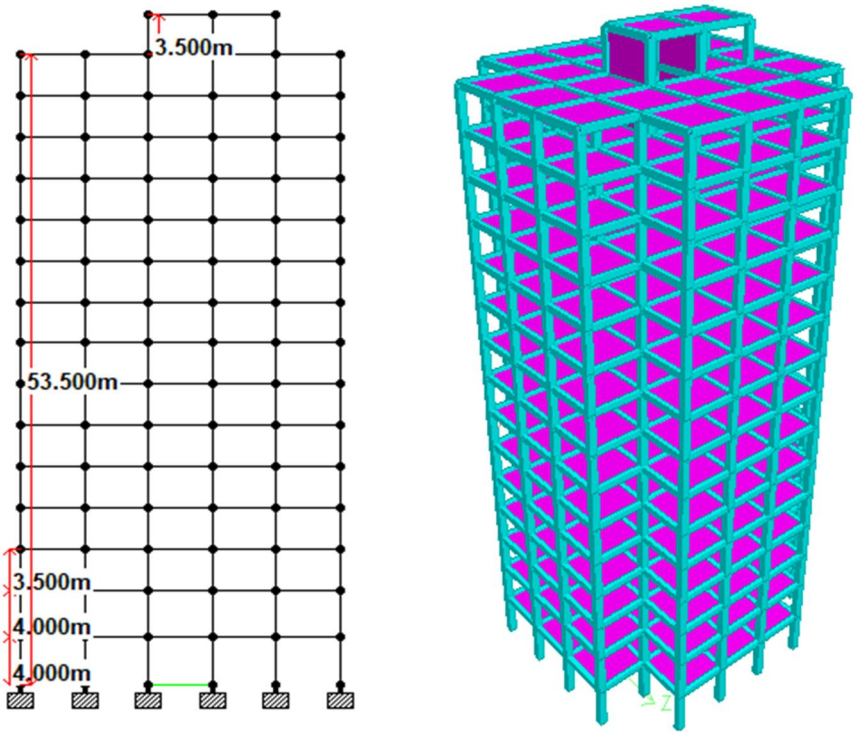



Fig. 4: Front View and 3D view of the Structure

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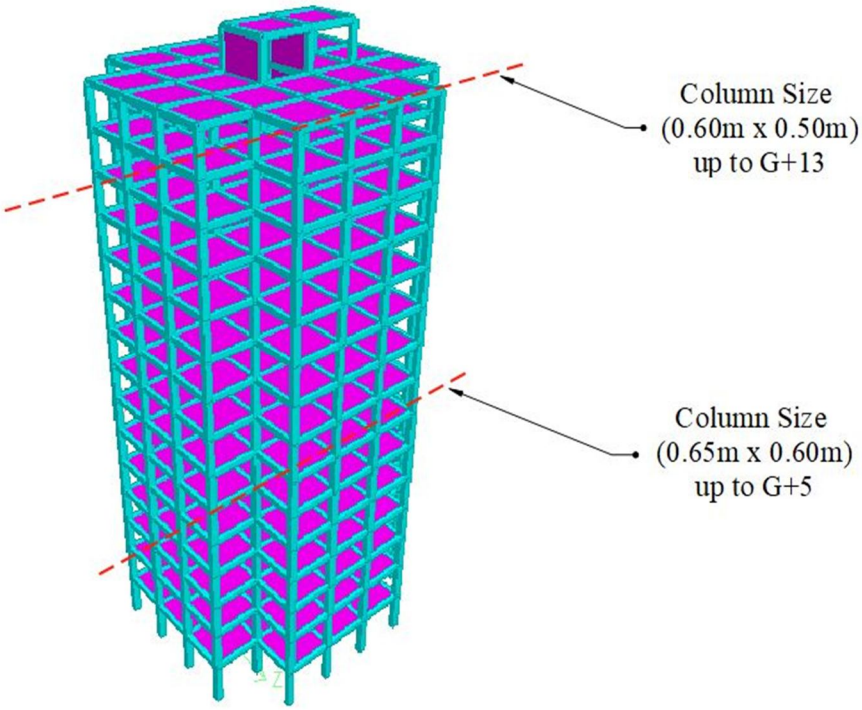



Fig. 5: Figure of Axial Force Reduction Case – AFR Case A

Table 3: Details of Axial Force Reduction Case – AFR Case A

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 13 |

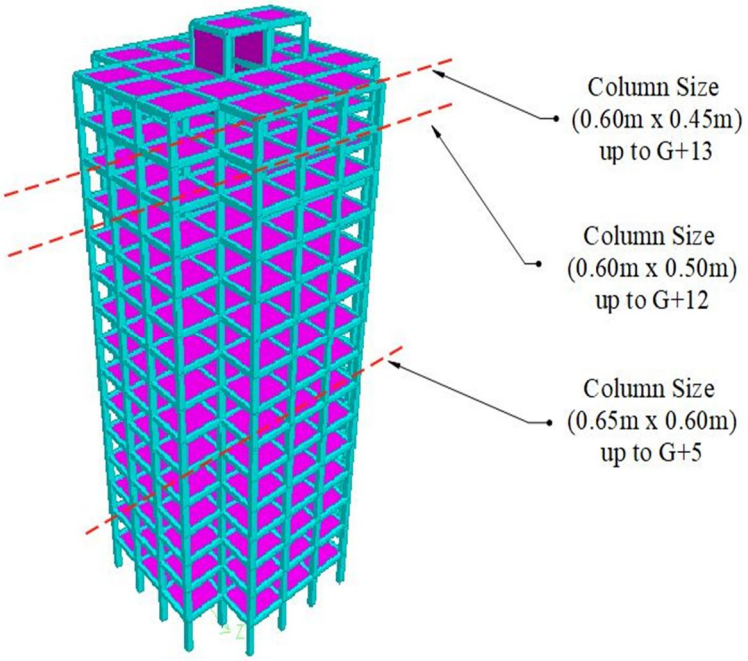



Fig. 6: Figure of Axial Force Reduction Case – AFR Case B

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Table 4: Details of Axial Force Reduction Case – AFR Case B

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 12 |
| 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |

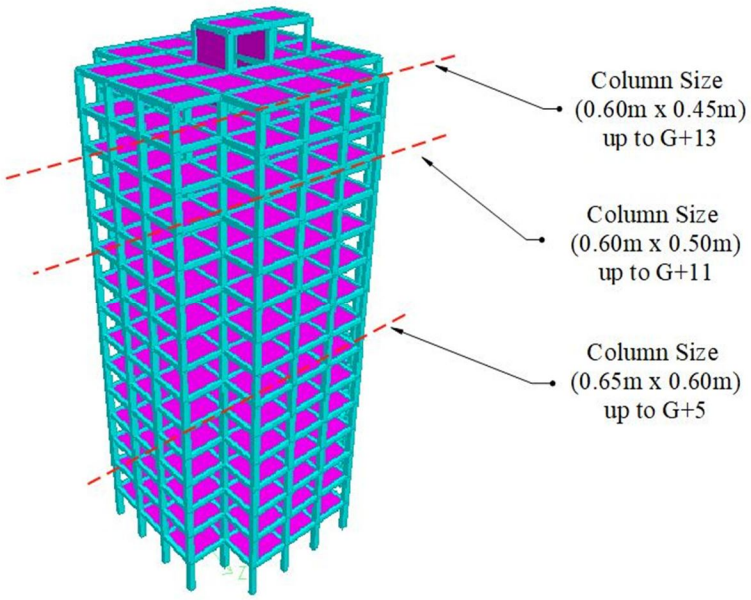



Fig. 7: Figure of Axial Force Reduction Case – AFR Case C

Table 5: Details of Axial Force Reduction Case – AFR Case C

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 11 |
| 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |

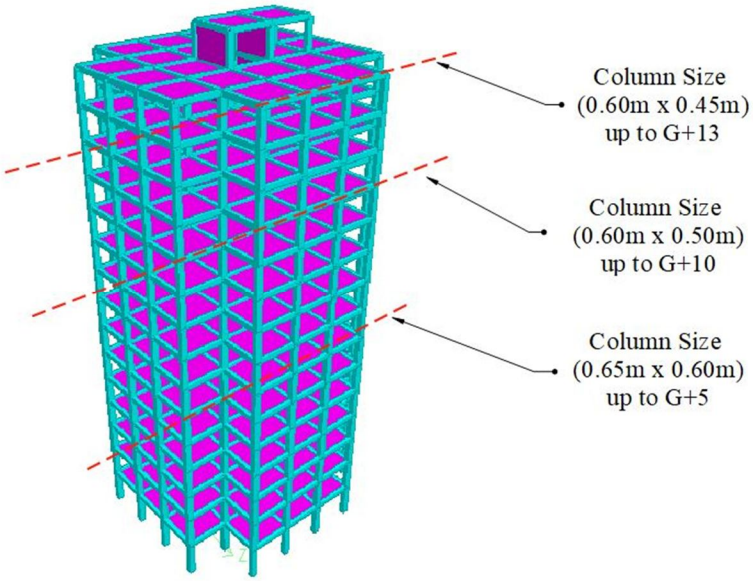



Fig. 8: Figure of Axial Force Reduction Case – AFR Case D

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Table 6: Details of Axial Force Reduction Case – AFR Case D

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 10 |
| 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 |

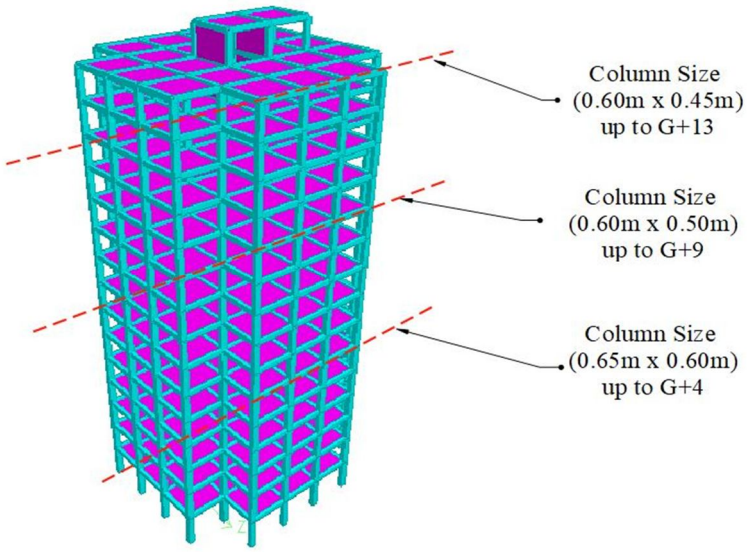



Fig. 9: Figure of Axial Force Reduction Case – AFR Case E

Table 7: Details of Axial Force Reduction Case – AFR Case E

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 9 |
| 0.60m x 0.45m | 0.50m x 0.30m | Up to G + 13 |

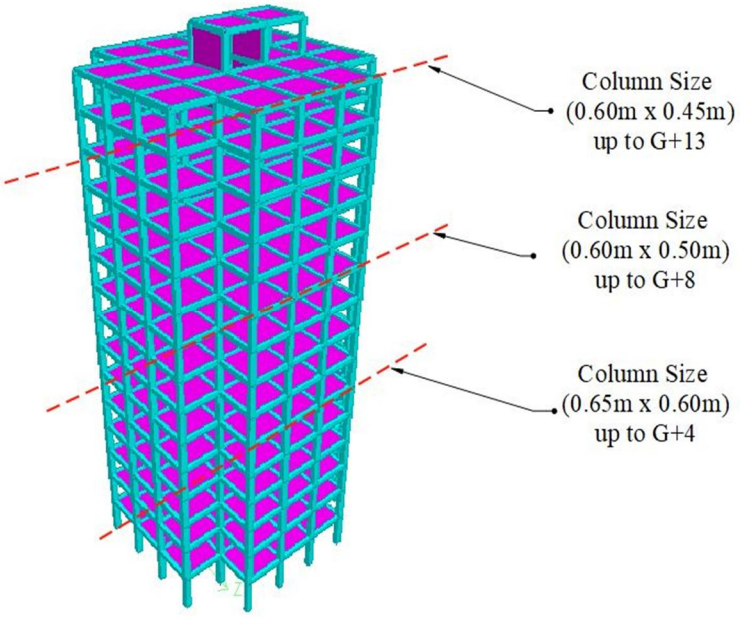



Fig. 10: Figure of Axial Force Reduction Case – AFR Case F

Table 8: Details of Axial Force Reduction Case – AFR Case F

| Column Size | Beam Size | Applied Storey |
|---|---|---|
| 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 |
| 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 8 |
| 0.60m x 0.45m | 0.50m x 0.30m | Up to G + 13 |

Table 9: Seismic parameters on the structure

| | |
|---|---|
| Importance factor I | 1.2 |
| Fundamental natural period of vibration ($T_a$) | $0.09*h/(d)^{0.5}$<br>$Ta_x = Ta_z$ |
| Fundamental natural period ($Ta_x$) for X direction | 1.026 seconds |
| Fundamental natural period ($Ta_z$) for Z direction | 1.026 seconds |
| Response reduction factor R | 4 |
| Damping ratio | 5% |
| Zone factor | 0.16 |
| Zone | III |
| Soil type | Medium soil |

## IV. POINT OF COMPARISON

Following heads shows the point of comparison of result parameters between various models during earthquake forces for building and its various cases. They are as follows:-

1) To determine Base shear response when seismic forces are applied in X and Z direction to the structure when size of beams and columns changes at different floor levels.
2) To find member Shear Forces and Bending Moment values in beams with efficient case among all 6 axial force reduction cases.
3) To examine Shear Forces and Bending Moment values in columns with efficient case among all 6 axial force reduction cases.
4) To determine and compare member Torsion values in beams parallel to X and Z directions with efficient case among all 6 axial force reduction cases.
5) To examine column Axial Forces with efficient case among all 6 axial force reduction cases.
6) To find Storey drift values in with efficient case among all 6 axial force reduction cases.
7) To analyze the maximum nodal displacement in X and Z horizontal plane direction with most efficient case that provides more stability among 6 axial force reduction cases.

The main theme of the current work is to demonstrate and recommend the efficiency of semi commercial apartment by using the reduced axial forces approach by changing the size of beam member and column member at different floor levels.

## V. RESULTS AND DISCUSSION

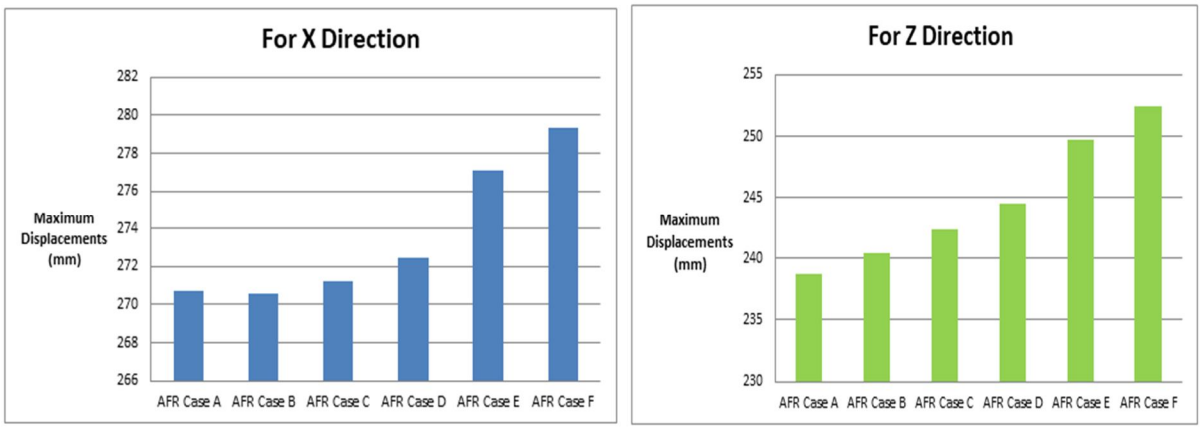



Fig. 11: Graphical Representation of Maximum Displacement in X and Z directions for all Axial Force Reduction cases

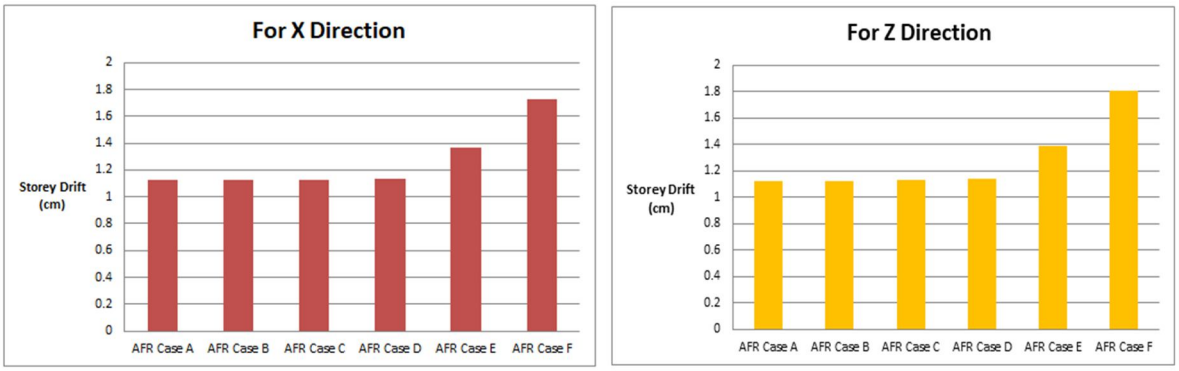



Fig. 12: Graphical Representation of Storey Drift in X and Z directions for all Axial Force Reduction cases

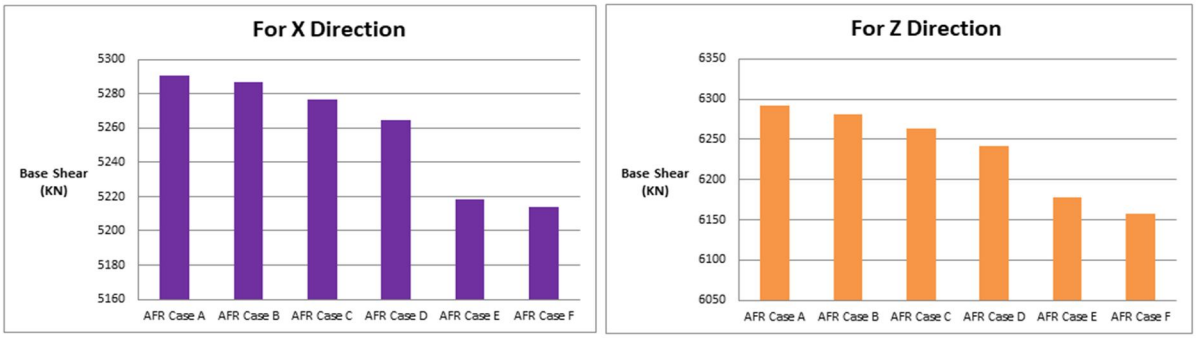



Fig. 13: Graphical Representation of Base Shear in X and Z directions for all Axial Force Reduction cases

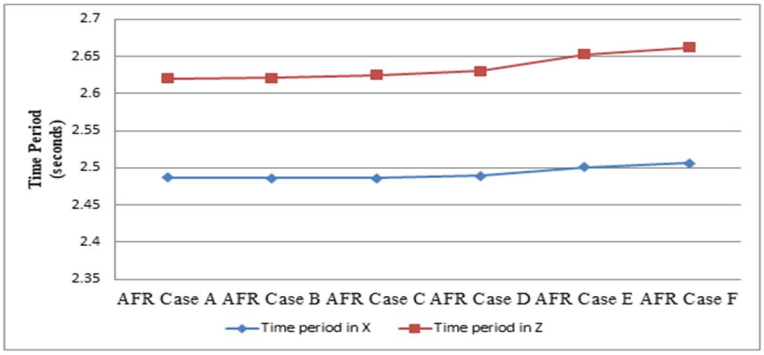



Fig. 14: Graphical Representation of Time Period Time Period for all Axial Force Reduction cases

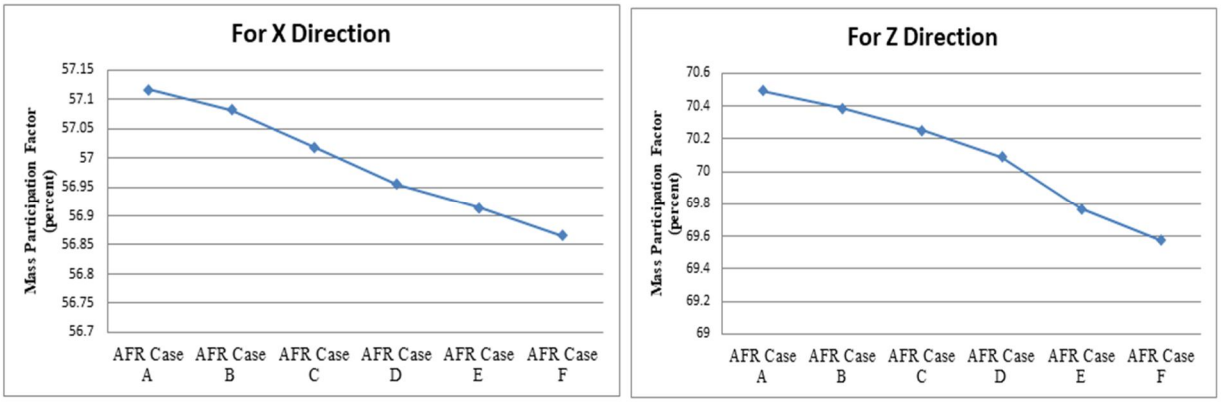



Fig. 15: Graphical Representation of Mass Participation Factor in X direction for all Axial Force Reduction cases

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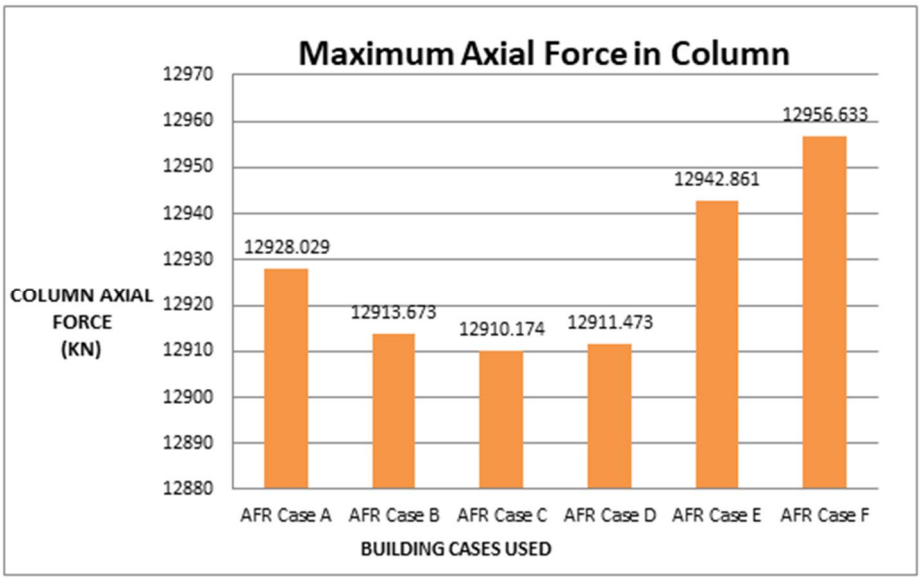



Fig. 16: Graphical Representation of Maximum Axial Forces in Column for all Axial Force Reduction cases

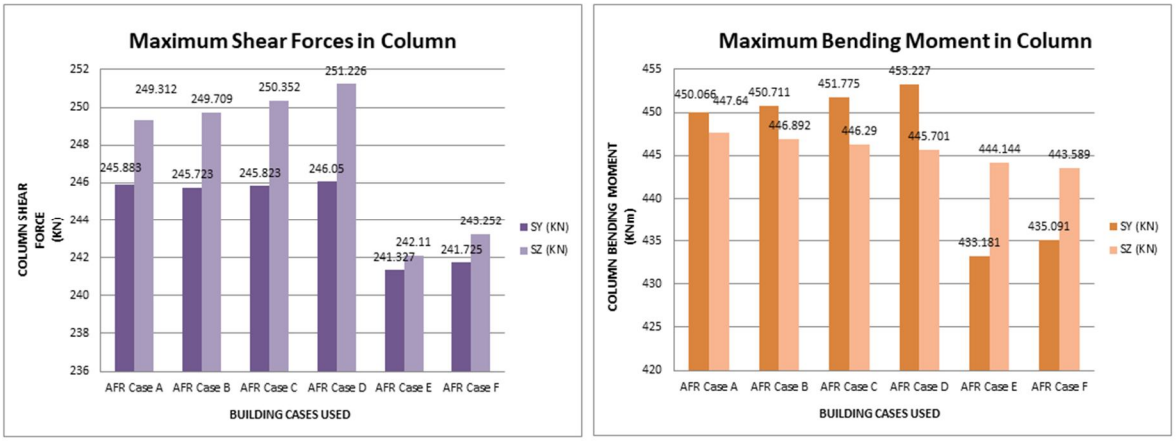



Fig. 17: Graphical Representation of Maximum Shear Force and Maximum Bending Moment in Columns for all Axial Force Reduction cases

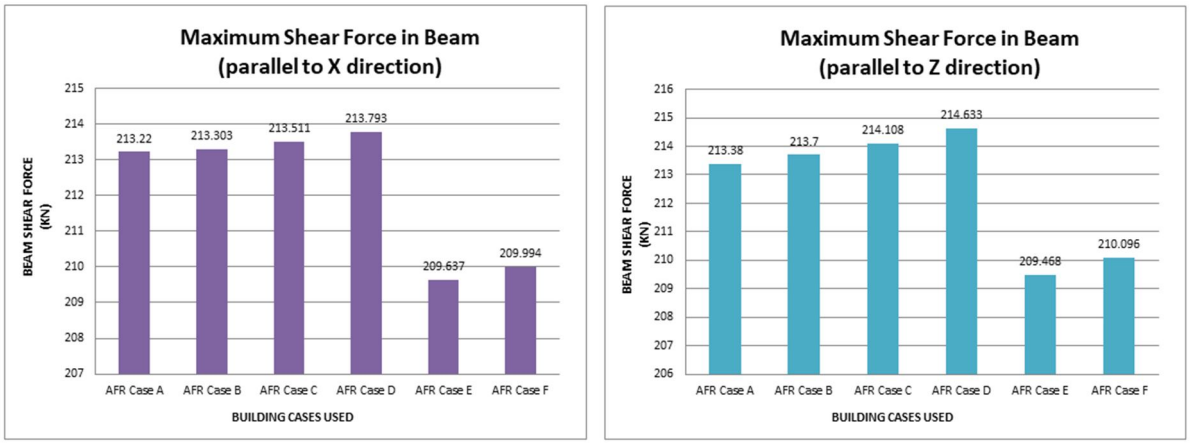



Fig. 18: Graphical Representation of Maximum Shear Forces in beams parallel to X and Z directions for all Axial Force Reduction cases

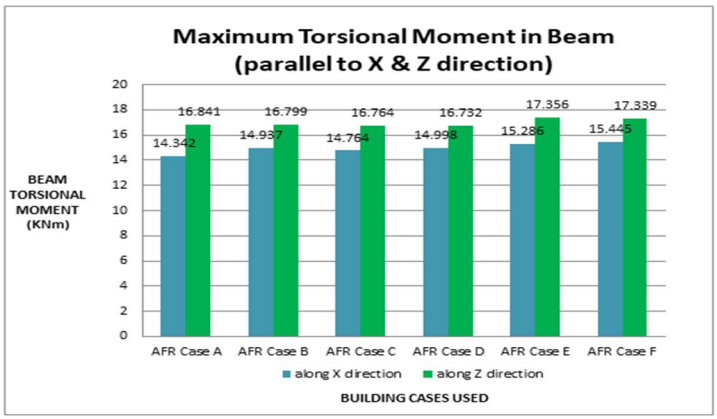



Fig. 19: Graphical Representation of Maximum Torsional Moment in beams along X and Z direction for all Axial Force Reduction cases

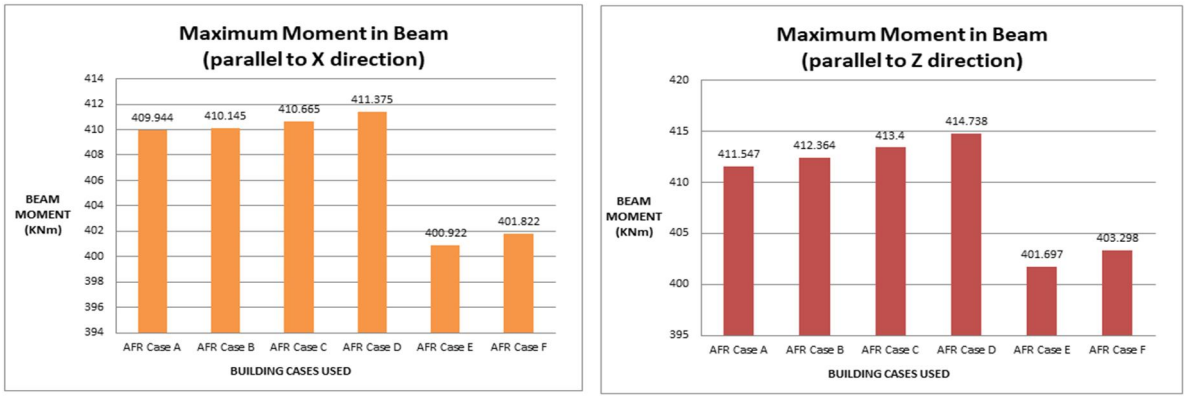



Fig. 20: Graphical Representation of Maximum Bending Moment in beams parallel to X and Z directions for all Axial Force Reduction cases

Table 10: Final conclusive outcomes

| S. No. | Abbreviation | Models framed for analysis | | | Member Status |
|---|---|---|---|---|---|
| | | Column Size | Beam Size | Applied Storey | |
| 7. | AFR Case A | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 | Passed |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 13 | |
| 8. | AFR Case B | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 | Passed |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 12 | |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 | |
| 9. | AFR Case C | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 | Passed |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 11 | |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 | |
| 10. | AFR Case D | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 5 | Passed |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 10 | |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 | |
| 11. | AFR Case E | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 | Passed |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 9 | |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 | |
| 12. | AFR Case F | 0.65m x 0.60m | 0.55m x 0.40m | Up to G + 4 | Fail |
| | | 0.60m x 0.50m | 0.55m x 0.35m | Up to G + 8 | |
| | | 0.60m x 0.45m | 0.50m x 0.35m | Up to G + 13 | |

## VI. CONCLUSION

Reduction of Axial Forces in Columns in Multistoried Building under seismic loading, as we investigate concerning the decrease of axial force of six different model made in Staad Pro software and here is such a sort of conclusion regarding each models for find out the minimum axial force in the structure. In term of given models subsequent outcome are take out from this proportional study.

*A.* On comparing all six models it has been concluded that the maximum displacement in AFR Case B in X and AFR Case A in Z direction found minimum among all.
*B.* On comparing all six models it has been concluded that the maximum Storey Drift in AFR Case B in X and Z direction found minimum among all.
*C.* As per comparative results in Base Shear, AFR Case F is very effective than other models in both X and Z.
*D.* As per comparative results in Time period and Mass Participation Factor, AFR Case F is very effective than other models in both X and Z.
*E.* As per comparative outcome in axial force, AFR Case C is very effective than other models.
*F.* Comparing the column shear force for all models, AFR Case E is the optimum than other models respectively in X and Z direction.
*G.* As per comparative results in column bending moment, AFR Case E is the optimum than other models respectively in X and Z direction.
*H.* Comparing the beam shear force in X direction all models, AFR Case E is the effective than other models.
*I.* Comparing the beam shear force in Z direction all models, AFR Case F is the effective than other models.
*J.* Comparing the Beam Bending Moment in X direction all models, AFR Case E is the effective than other models.
*K.* Comparing the Beam Bending Moment in Z direction all models, AFR Case E is the effective than other models.
*L.* On analyzing the Torsional Moment in beams along X direction and Z direction AFR Case C and AFR Case D is efficient respectively.

As far as concern the reduction of Axial Forces in Columns in Multistoried Building under seismic loading with different size of members in different top floors concluded that AFR Case C is very effective in axial force comparing AFR Case A to F the axial forces are decreased and AFR Case C is identified the least axial force. AFR Case F has failed in structural components when analysis has done and its axial force is higher than other cases.
As per the above analysis states that mention above all the cases AFR Case C is very effective and safe case among all and can be recommended when this type of construction will take place.

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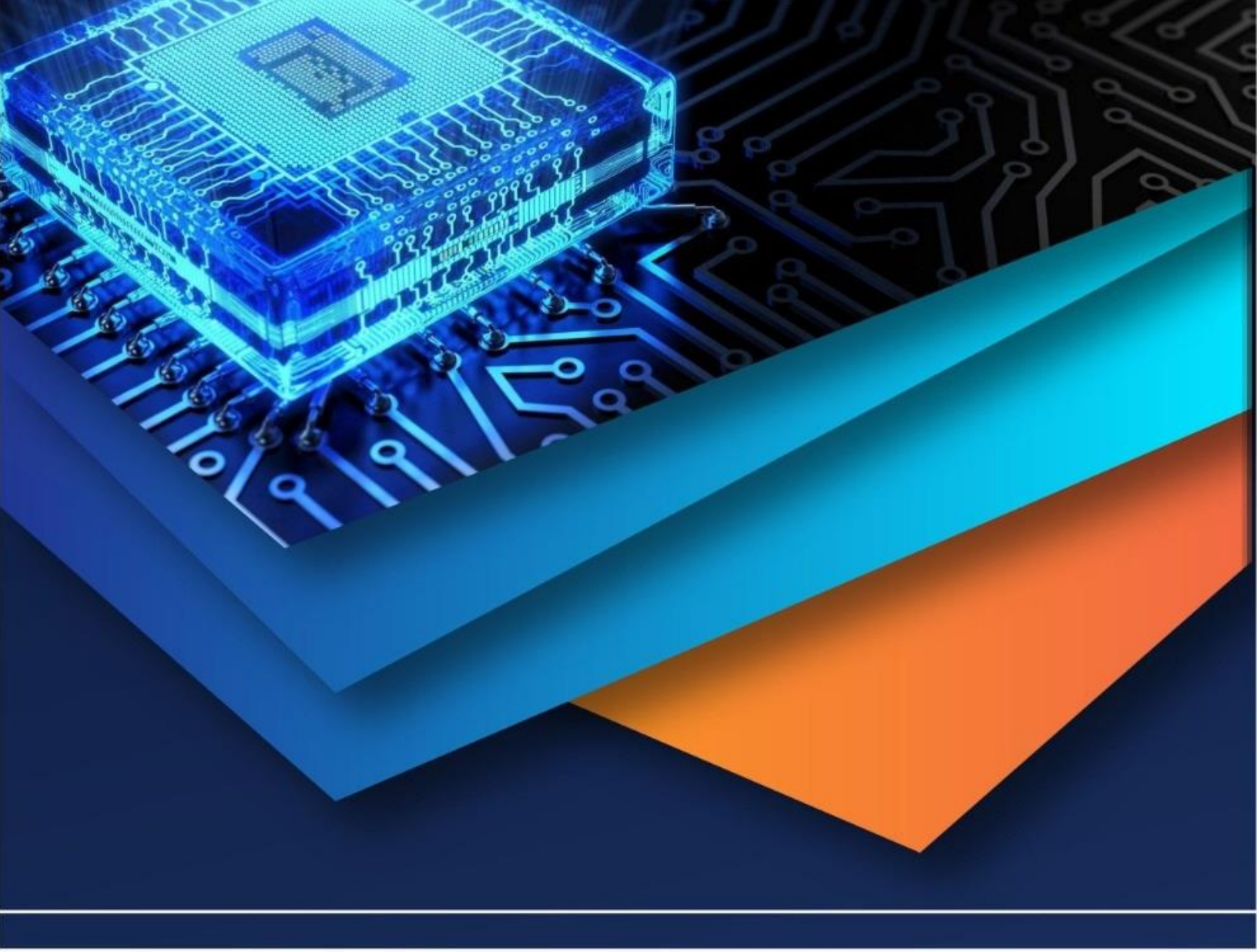
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