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Reduction of Base Shear Over Actual Soil In Multistorey Building under Earthquake Effects

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Abstract: Multi-storeyed buildings are tall structures with multiple floors designed for diverse purposes. Base shear represents the total lateral force a building's foundation must withstand during seismic events. Reducing base shear enhances structural safety, design efficiency, and overall building performance. It enables cost-effective designs and fosters sustainability in multi-storeyed constructions. Effective management of base shear is pivotal for ensuring safety and optimizing the structural integrity of high-rise buildings. This research paper aims to reduce the base shear in multi-storeyed buildings. To achieve this objective, a comprehensive analysis was conducted on a G+15 storey building with series of seven model cases abbreviated form BSR Case 1 to BSR Case 7. The comparative analysis revealed that when sizes of the column at a particular level decreases, the base shear decreases that enhances the structural parameters and hence BSR Case 7 observed as optimum case that reduces the base shear and performance of multi-storeyed building.
Keywords: Base Shear Reduction, Column Sizes, Size Change Levels, Multi-Storey Building, Seismic Activities.

I. MULTISTOREY BUILDING: AN INTRODUCTION

A multistorey building, often referred to as a high-rise or skyscraper, is a tall structure that contains multiple floors or stories. These buildings are designed to accommodate a large number of occupants, often for residential, commercial, or mixed-use purposes, within a relatively small footprint. The construction and design of multistoried buildings require meticulous planning, advanced engineering techniques, and adherence to strict safety standards due to the challenges posed by their height and complexity.

A. Base Shear: Understanding the Concept

In structural engineering, base shear is a fundamental concept used to describe the total lateral force that a building's foundation must withstand during an earthquake or other lateral load conditions. It represents the total horizontal force exerted on the base of the structure, which is generated due to the building's mass and its dynamic response to ground motions. Base shear is crucial in designing the foundation and structural elements of multistoried buildings to ensure their stability and safety during seismic events.

B. Benefit of Reducing Base Shear in Multistoried Buildings

Reducing the base shear in multistoried buildings offers several significant benefits:

1) *Enhanced Structural Safety:* By minimizing the lateral forces exerted on the foundation, the risk of structural damage or failure during seismic events is reduced. This ensures the safety of occupants and minimizes the potential for catastrophic consequences.
2) *Optimized Design Efficiency:* Implementing strategies to decrease base shear allows engineers to design more efficient and cost-effective structural systems. This can lead to savings in construction materials and overall project costs.
3) *Improved Performance:* A reduction in base shear can enhance the overall performance of multistoried buildings, enabling them to withstand a wider range of lateral loads and environmental conditions without compromising structural integrity.
4) *Increased Sustainability:* By incorporating measures to decrease base shear, such as the use of innovative structural systems or advanced materials, multistoried buildings can achieve higher levels of sustainability. This includes reduced energy consumption, extended lifespan, and lower environmental impact over the building's lifecycle.

After understanding and effectively managing base shear it is essential for the safe and efficient design of multistoried buildings. By implementing strategies to reduce base shear, engineers and designers can enhance the structural performance, safety, and sustainability of these iconic structures.

II. PROCEDURE AND 3D MODELLING OF THE STRUCTURE

Seismic analysis of semi commercial building is conducted using a software-based approach. The earthquake data is collected according to the IS 1893(PART1):2016 standards. The analysis of the building is performed utilizing the response spectrum analysis method. Detailed information about the model and input parameters is provided below.

Table 1: Model Description

Models	Description
BSR 1	Columns of same sizes over entire building
BSR 2	Columns of same sizes upto G+15 and change above G+15
BSR 3	Columns of same sizes upto G+14 and change above G+14
BSR 4	Columns of same sizes upto G+13 and change above G+13
BSR 5	Columns of same sizes upto G+12 and change above G+12
BSR 6	Columns of same sizes upto G+11 and change above G+11
BSR 7	Columns of same sizes upto G+10 and change above G+10

Table 2: Input details for Semi-Commercial Building for all cases

Constraint	Assumed data for all buildings
Total cases	1+6 =7 cases
Type of Building	Semi commercial G+15
Plinth area	784 sq. m
Depth of foundation	3.5m
GF height	4.2m
Height of each floor	3.66m
Total height of building	66.26m
Size of beam	0.55 x 0.40
Size of column	0.50 x 0.65
	0.50 x 0.45
Slab thickness	140 mm
Shear wall thickness	200 mm
Staircase waist slab	135 mm

Table 3: Input details for seismic analysis

Constraint	Assumed data for all buildings
Soil used	Actual soil
	Depth of footing 3.5 m
	Soil resistance = 11.02 Ton / sq. m = 11020 KN / sq. m
	Deflection = 215 mm = 0.215m
	K = P/ Delta = 11020/0.215 =51255.813 KN/m
Seismic zone	III
Zone factor (Z)	0.16
Damping ratio	5% = 0.05
Response reduction factor (RF)	Ordinary shear walls with special moment resisting frames = 4
Importance factor	1.2

III. RESEARCH OBJECTIVES

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 the minimum nodal displacement case in X and Z direction with most efficient case that reduces base shear of building under earthquake effects.
2) To determine minimum base shear response case in X and Z direction with most efficient case that reduces base shear of building under earthquake effects.
3) To determine minimum axial forces case with most efficient case that reduces base shear of building under earthquake effects.
4) To determine minimum column shear forces response case in YY and ZZ axis with most efficient case that reduces base shear of building under earthquake effects.
5) To determine minimum column bending moment response case in YY and ZZ axis with most efficient case that reduces base shear of building under earthquake effects.
6) To determine minimum torsional moment in column and beam member response case with most efficient case that reduces base shear of building under earthquake effects.
7) To determine minimum beam shear forces response case in YY and ZZ axis with most efficient case that reduces base shear of building under earthquake effects.
8) To determine minimum beam bending moment response case in YY and ZZ axis with most efficient case that reduces base shear of building under earthquake effects.

The main theme of the current work is to demonstrate and recommend the efficiency of reduction of base shear by changing the size of column member at different floor levels.

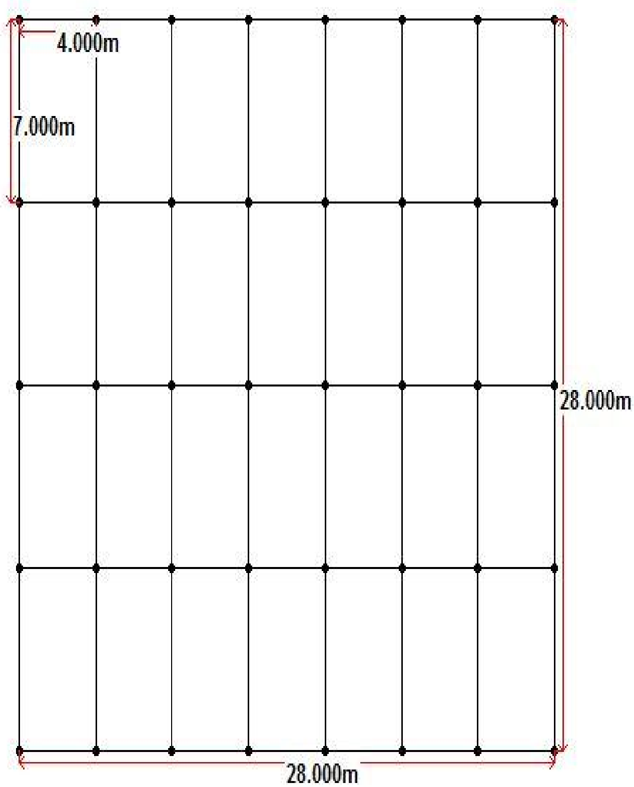


Fig. 1: Plan of Structure

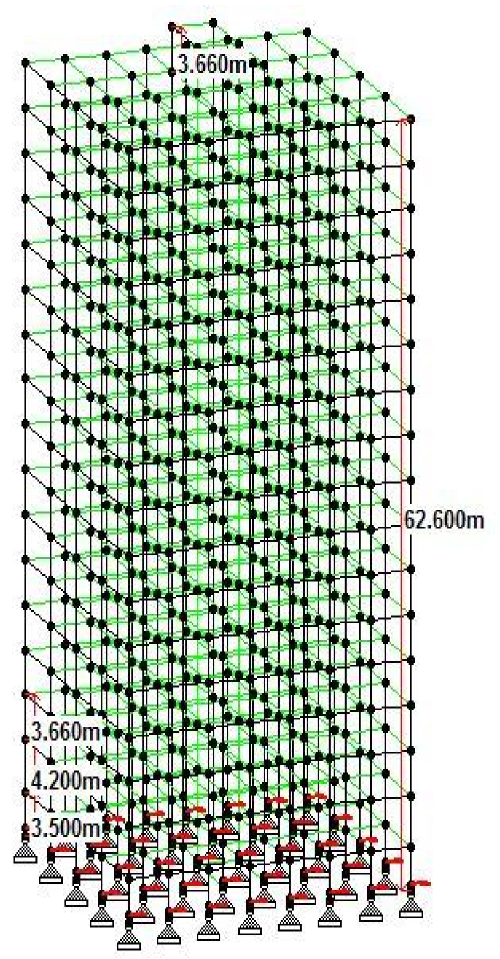


Fig. 2: 3D Beam Column Frame view

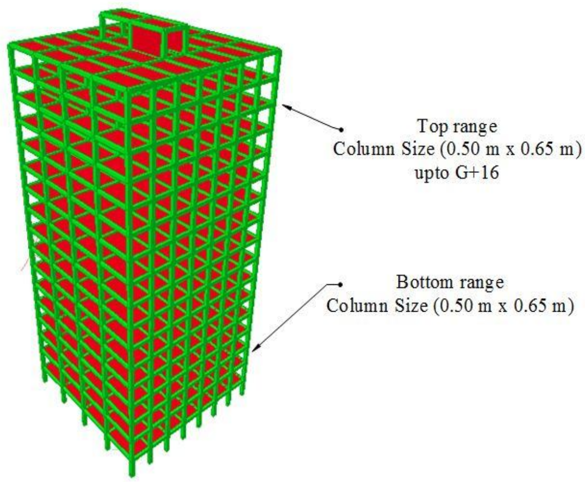


Fig. 3: 3D view of BSR Case 1

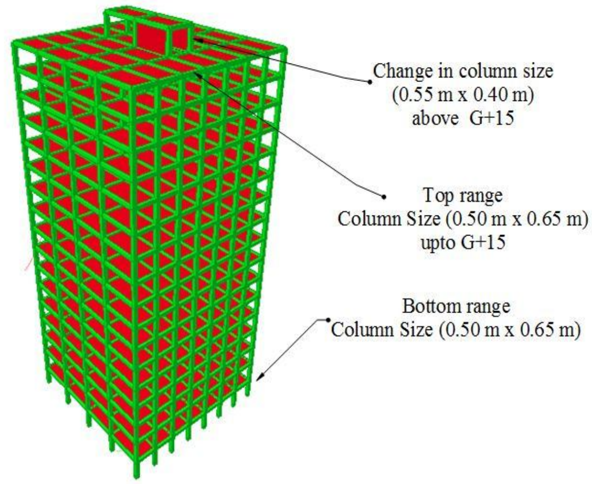


Fig. 4: 3D view of BSR Case 2

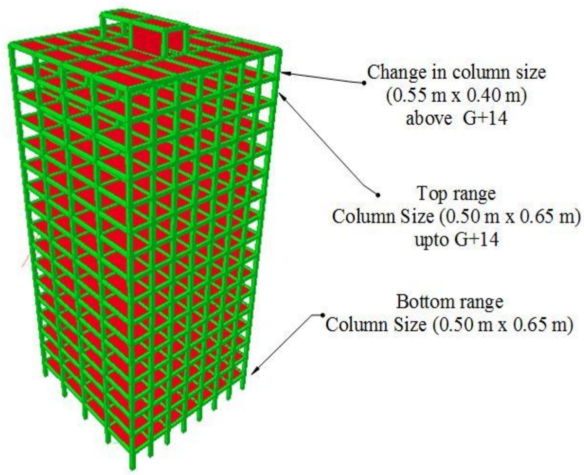


Fig. 5: 3D view of BSR Case 3

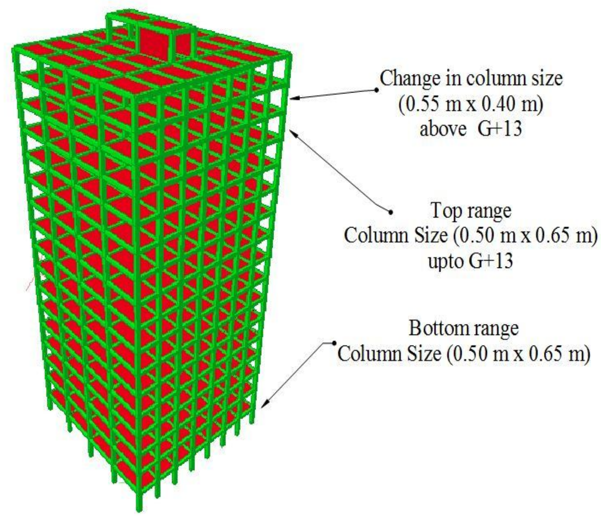


Fig. 6: 3D view of BSR Case 4

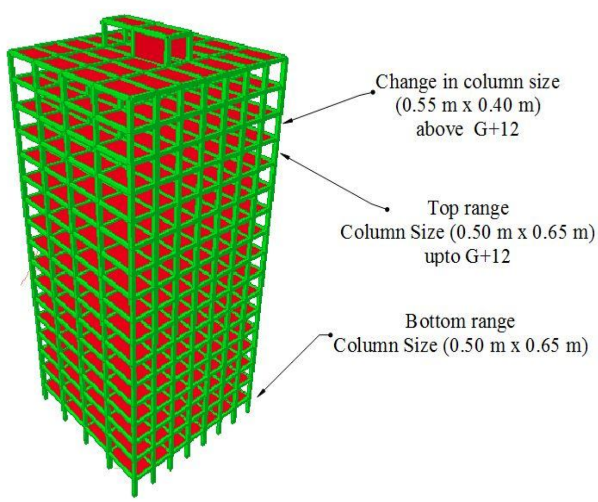


Fig. 7: 3D view of BSR Case 5

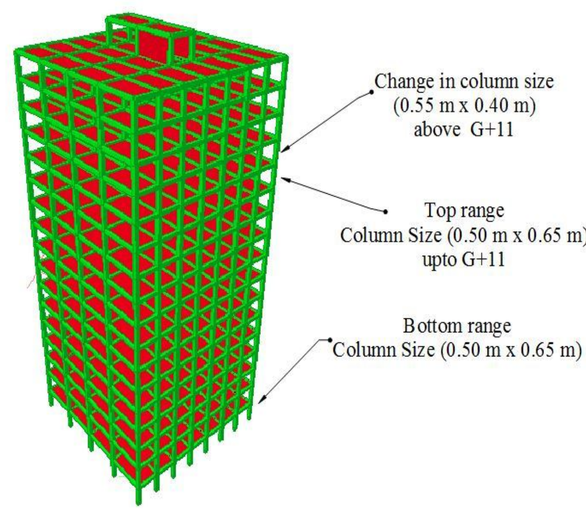


Fig. 8: 3D view of BSR Case 6

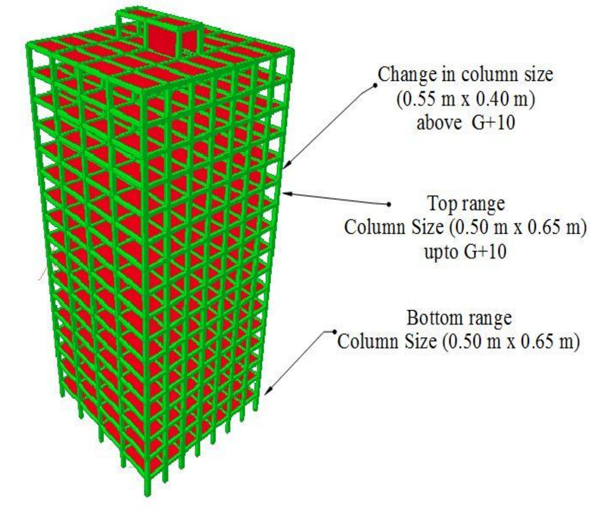


Fig. 9: 3D view of BSR Case 7

IV. RESULTS ANALYSIS

The application of loads and their combinations on different cases as per the Indian Standard 1893:2016 code of practice yield result parameters:-

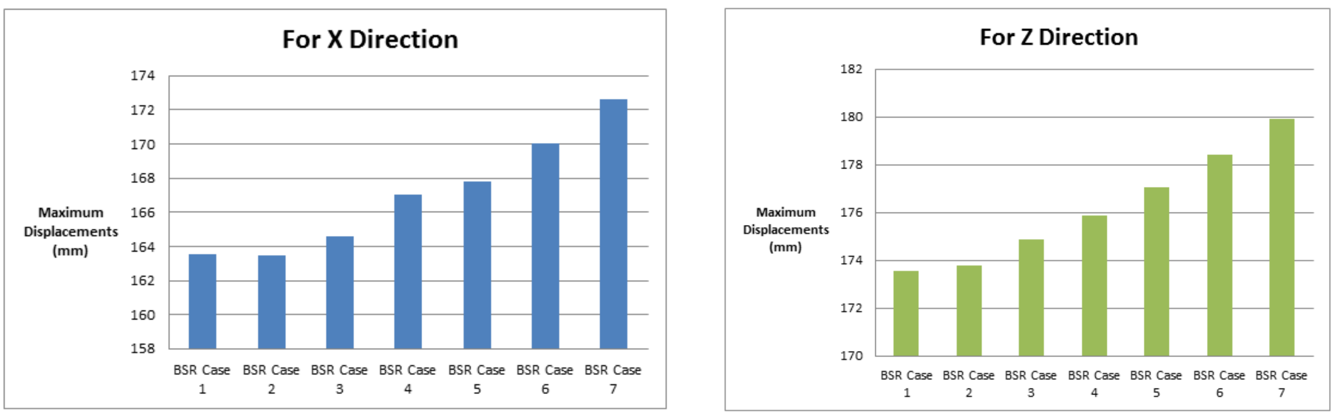


Fig. 10: Maximum Displacement in X and Z direction

Fig. 11: Base Shear in X and Z direction

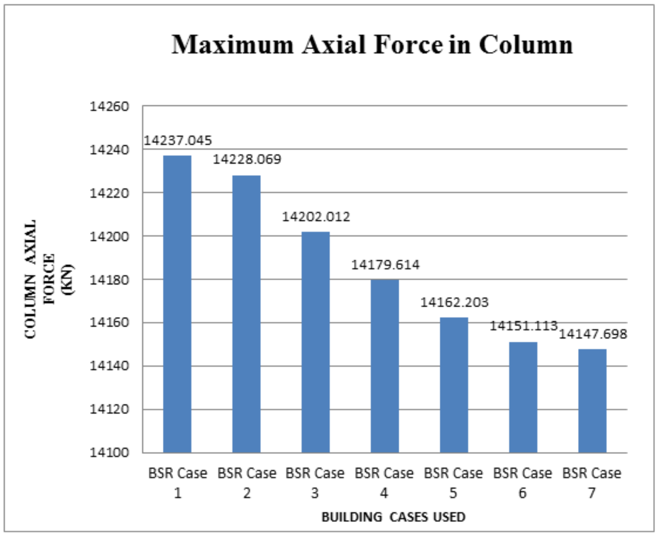
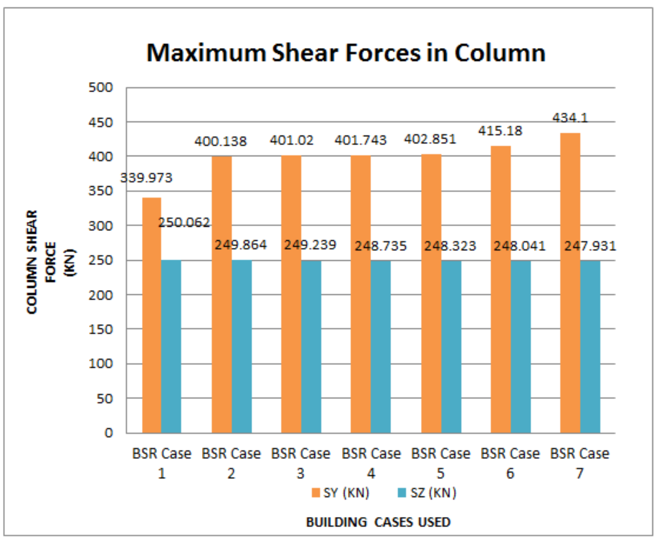


Fig. 12: Axial Forces in Column



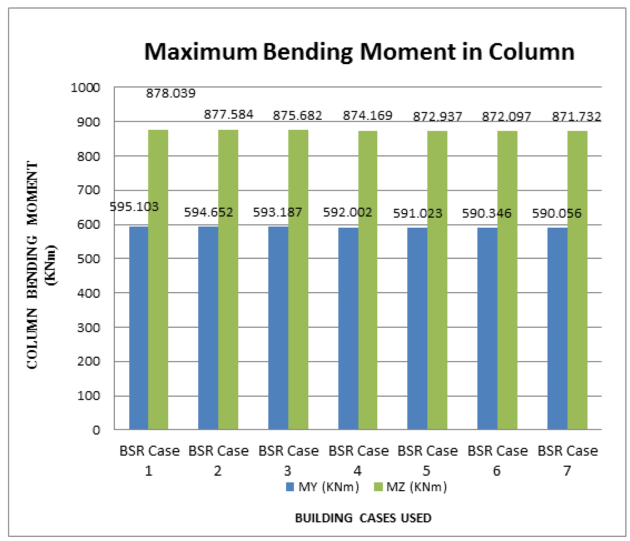
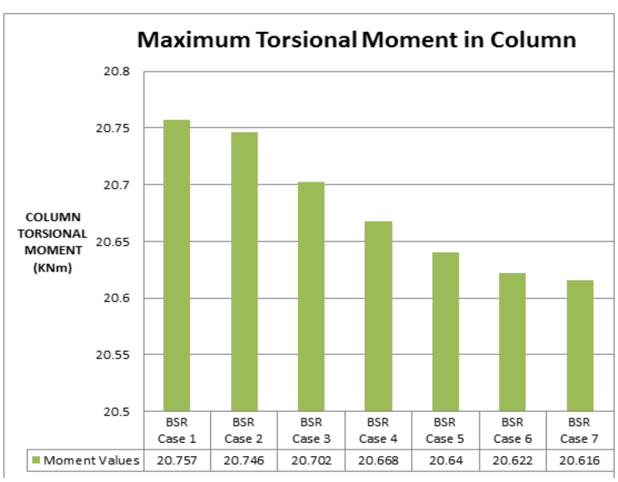


Fig. 13: Maximum Shear Forces and Bending Moments in Columns



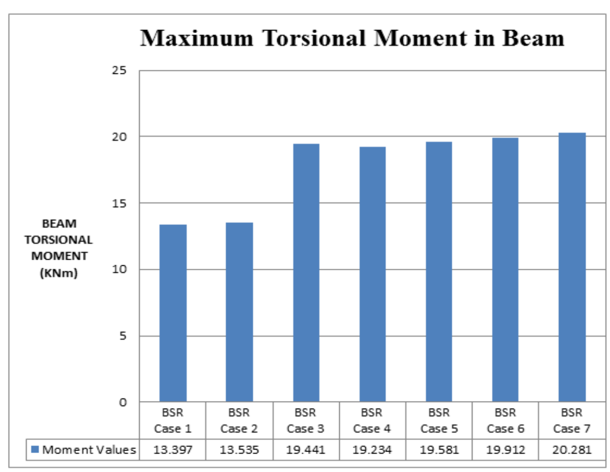


Fig. 14: Maximum Torsion in Beam and Column

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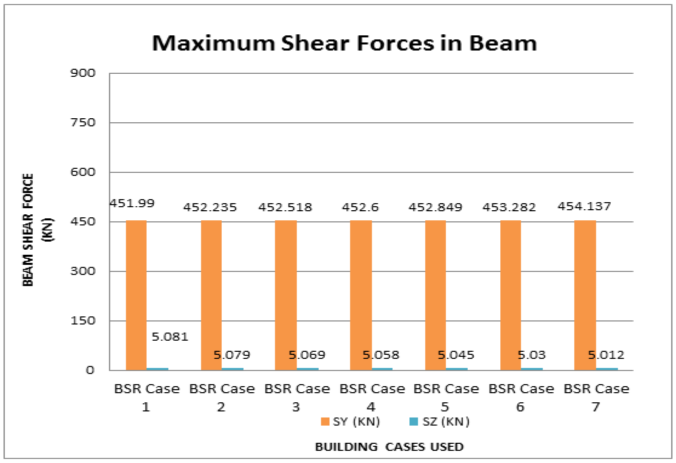

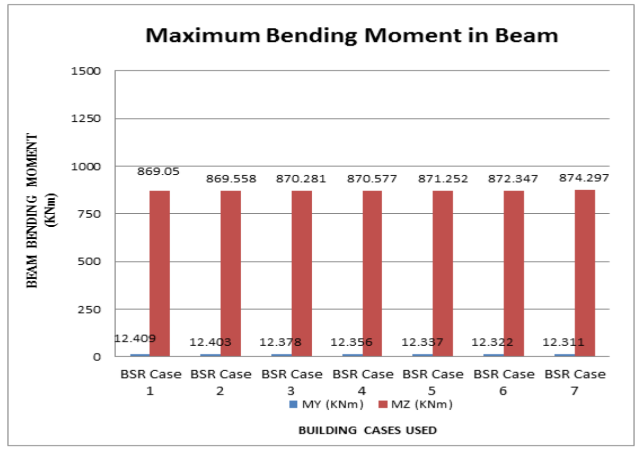

Fig. 15: Maximum Shear Forces and Bending Moments in Beams

V. CONCLUSIONS

The conclusion can be pointed out are as follows:-

1) Maximum displacement in X direction has a minimum value observed at BSR Case 1 and BSR Case 2 with a parametric value of 163.518 mm & 163.469 mm. For Z direction, it has a minimum value observed at BSR Case 1 and BSR Case 2 with a parametric value of 173.578 mm & 173.786 mm respectively.

2) Base Shear has gradually reduced and shows optimum above G+10 by implementing lesser size of column at top floors subsequently decreases the weight of the structure. For this parameter, BSR Case 7 proves to be an efficient parametric case for both X and Z directions.

3) The decreasing weight of the structure is directly proportional to the decrease in axial forces in column. Maximum Axial Forces in Column decreases gradually to BSR Case 7. Observing the least parameter, BSR Case 7 obtained as an efficient Case with a parametric value of 14147.698 KN among all base shear reduction.

4) The shear forces along both Y-Y axis increases and Z-Z axis it decreases and hence BSR Case 1 and BSR case 7 proves to be an efficient case for shear forces in column members.

5) The bending moment along both Y-Y axis and ZZ axis decreases with a minimum value to BSR case 7 with a value of 590.056 KNm and 871.732 KNm respectively.

6) The torsional moment in column decreases as the weight of the column with the structure decreases. With this, BSR Case 7 proves to be an efficient case with a minimum value of 20.616 KNm.

7) The torsional moment in beam increases from BSR Case 1 with least value of 20.281 KNm.

8) The shear forces in beam in both the directions shows minimum values of 451.990 KN in BSR Case 1 along Y axis and 5.012 KN in BSR Case 7 along Z axis.

9) Also, the Bending Moment along both Y-Y axis and Z-Z axis in column increases gradually from BSR Case 1 and decreases to BSR Case 7 for all base shear reduction cases.

10) Observing all the parameters, the main aim of this work has achieved with lessening the Base Shear parameter in both X and Z direction in semi commercial building (G+15) under seismic loading. Building BSR Case 7 observed and obtained as efficient case and should be recommended when this type of approach will be adopted in any earthquake zones.

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