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COMPARISON OF PERCENTAGE OF STEEL QUANTITIES AND COST OF ANASYMETRYCOMMERCIAL BUILDING (G+4) UNDER GRAVITY LOADS AND SEISMIC LOADS

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ABSTRACT

Commercial buildings are top priority buildings with a lot of demand to business activities. They will be located probably at city centers there by putting intense pressure on available land space. In present scenario, commercial buildings are often constructed with structural asymmetry. Earthquakes strike suddenly, violently and without warning at any time of the day or night. If an earthquake occurs in a business area including commercial buildings, it may cause many deaths and injuries and extensive property damage. Hence it is mandatory to do the seismic analysis and design to any structure against collapse. Dynamic analysis is done on seismic loaded structures using E-Tabs software package and manual design is performed. This study addresses the variation of percentage steel of R.C framed structure for gravity loads as per IS 456:2000 and seismic loads added to gravity loads as per IS 1893 - 2002. The overall percentage cost variation of a gravity loaded and seismic loaded buildings was found to be 23.99%.

Keywords: Commercial buildings, Seismic Forces, Ductility, Reinforcement, E-Tabs.

I. INTRODUCTION

A Commercial building is one of the most important public buildings; these remain busy all along the day. So design of these type of buildings against natural hazards like earthquakes plays major role. The most determinant effect on a structure is generally caused by lateral component of earth quake load. As compared to gravity load effect, earthquake load effects on buildings are quite variable and increase rapidly as the height of building increases. For gravity loads, structure is designed by considering area supported by a column and spans of beam; whereas for earthquake loads, design is a function of total mass, height. From the past 25 years seismic design of building is confined to only major seismic prone zones. Natural calamities like earthquakes shall never be expected on beforehand. Hence there is urgent need for including seismic design to the design office. Thereis a blind belief that seismic design is a distant dream for common buildings. Present paper aim is to enlighten that there is no much difference in overall cost and reinforcement with addition of seismic loads to gravity loads.

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II. GEOMETRY OF BUILDING

The present commercial building is asymmetric in plan and in elevation having story height of 3.0m where all storey's are of the same height. The building has a length L_b= 82 m and width B_b= 42 m.Plinth area of structure is 1797.47 m^2.This study mainly focus on the comparison of percentage steel quantities and cost of the main structural elements when the building is designed for gravity loads as per IS: 456-2000 and when the building is designed for earthquake forces in as per IS 1893:2002.This gives the approximate percentage in the economy compared with normal design.

III. METHODOLOGY

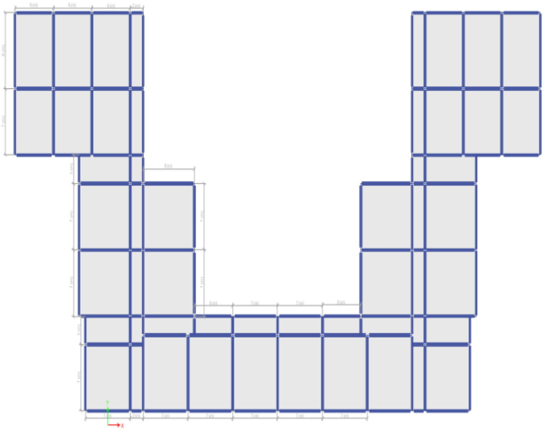
Conventional design of the structure is carried out based on the gravity loads and live loads estimated on the structure based on IS456: 2000. Initially preliminary design is carried out to know approximate dimensions required for beams, columns and slabs. Analysis is done using E-Tabs software and maximum moments were used to design those structural members manually.

Seismic analysis of the structures is carried out on the basis of lateral force assumed to act along with the gravity loads. The base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode of shape. The base shear is distributed along the height of the structure in terms of lateral forces according to codal provisions. In this study, a five (G+4) storied RC building has been analyzed using the Response spectrum method using E-Tabs. The plan of the building taken for analysis is shown in Fig.1. The nomenclature of columns is shown in Fig.2. Three Dimensional view of the whole structure is shown in Fig.3. Fig.4 is showing the structure subjecting to the vertical loading and Fig.5 & Fig6.are showing the structure subjected to loading of earthquake in "+X" and "+Y" directions. Dynamic analysis is done using E-Tabs software and maximum moments of the structural member are found. Using those moments structural members are designed manually.

Table 1: Preliminary Data of the structure considered for seismic analysis

Type of the structure	RCC Framed structure
Number of stories	G+4
Floor to floor height	3.6 m
Plinth height	0.6 m
Walls thickness	230 mm
Grade of concrete	M 30
Grade of steel	Fe 415
Earthquake load	As per IS1893 (Part 1): 2002
Size of the columns	0.3mx0.6m
Size of the beams	0.3mx0.45m
Slab thickness	0.15m

SBC of soil taken	200kN/m²
Type of soil	Medium soil
Live load	3kN/m²
Floor finishes	1kN/m²
Seismic zone considered	II
Type of wall	Brick masonry



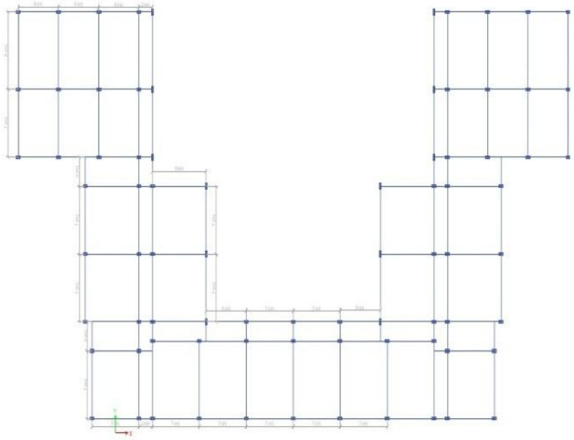
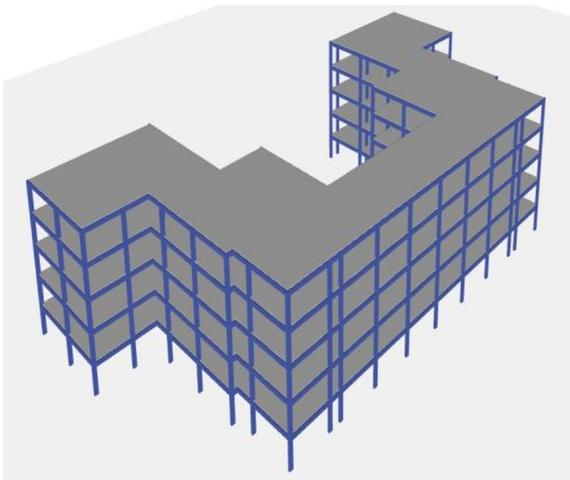


Fig 1: Plan of Commercial Building (G+4) Fig 2: Beam- Column Layout of the Structure



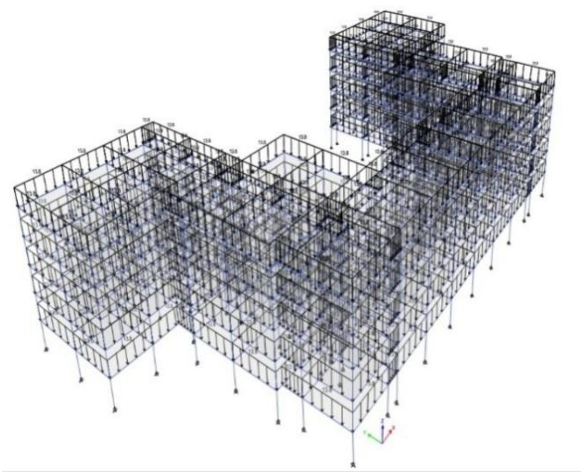


Fig 3: 3-D View of Commercial Building **Fig 4: Vertical Loading on the Structure**

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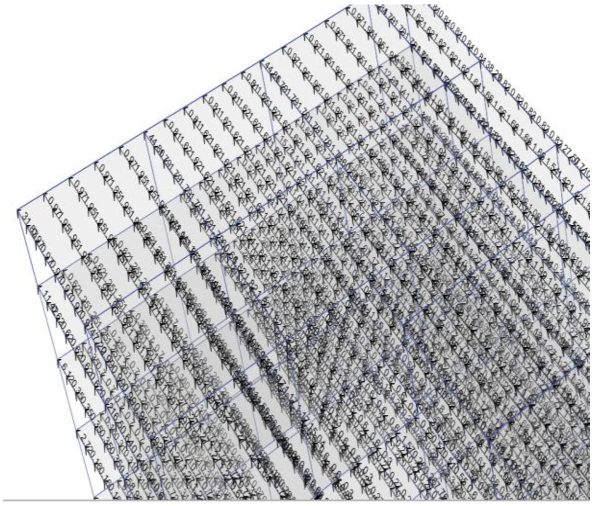


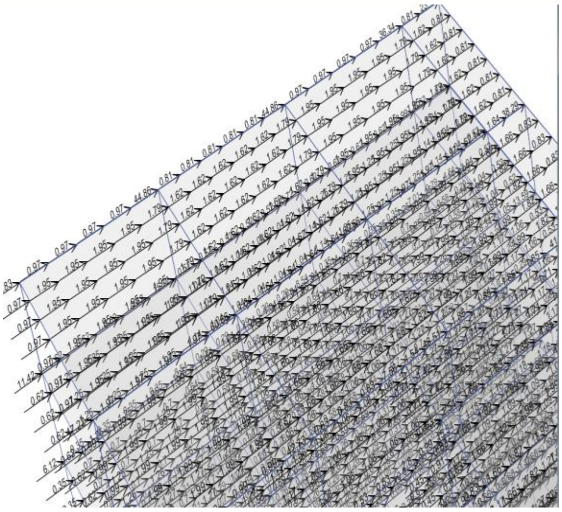


Fig 5: Earthquake Loads in X-Direction Fig 6: Earthquake Loads in Y-Direction

3.1 Loading Data

3.1.1 Dead Load (DL)

Self-weight of slab = 0.15x25 = 3.75kN/m^2

Floor finishes = 1.00kN/m^2

Total DL = 4.75kN/m^2

(Assume 130mm total depth of slab)

Weight of walls = 0.23x20x 3.0 = 13.80kN/m

3.1.2 Live Load (LL)

Live Load on each slab = 3.00kN/m2

3.1.3 Earth quake Load (EQL)

As per IS-1893 (Part 1): 2002

3.1.4 Load Combinations:

The following load combinations are used in the seismic analysis, as mentioned in the code IS 1893(Part-1): 2002, Clause no. 6.3.1.2.

1. 1.5(DL+LL)
2. 1.2(DL+LL+EQX)
3. 1.2(DL+LL- EQX)
4. 1.2(DL+LL+ EQZ)
5. 1.2(DL+LL- EQZ)
6. 1.5(DL+ EQX)
7. 1.5(DL- EQX)
8. 1.5(DL+ EQZ)
9. 1.5(DL-EQZ)
10. 0.9DL+ 1.5EQX
11. 0.9DL- 1.5EQX
12. 0.9DL+ 1.5EQZ

13. 0.9DL-1.5EQZ

Earthquake load was considered in +X,-X, +Y and –Y directions. Thus a total of 13 load combinations are taken for analysis. Since large amount of data is difficult to handle manually, all the load combinations are analyzed using software E-Tabs. All the load combinations are mentioned above.

IV. ANALYTICAL ANALYSIS

The main objective of the analysis is to study the different forces like moments, shear forces and axial forces acting on a building. The analysis is carried out in E-Tabs 2013 software package. Results of conventional R.C.C structure i.e slab, beam and column were found and maximum moments were taken for manual design. Similarly dynamic analysis was done on seismic loaded structures and maximum forces were taken to design structural elements like slab, beam column and footings adopting ductile detailing codeIS 13920:1993. Fig.7 is showing BMD of the structure,Storey shears and maximum storey displacements were shown in Fig.8 and Fig.9. Fig.10 shows maximum storey drifts.

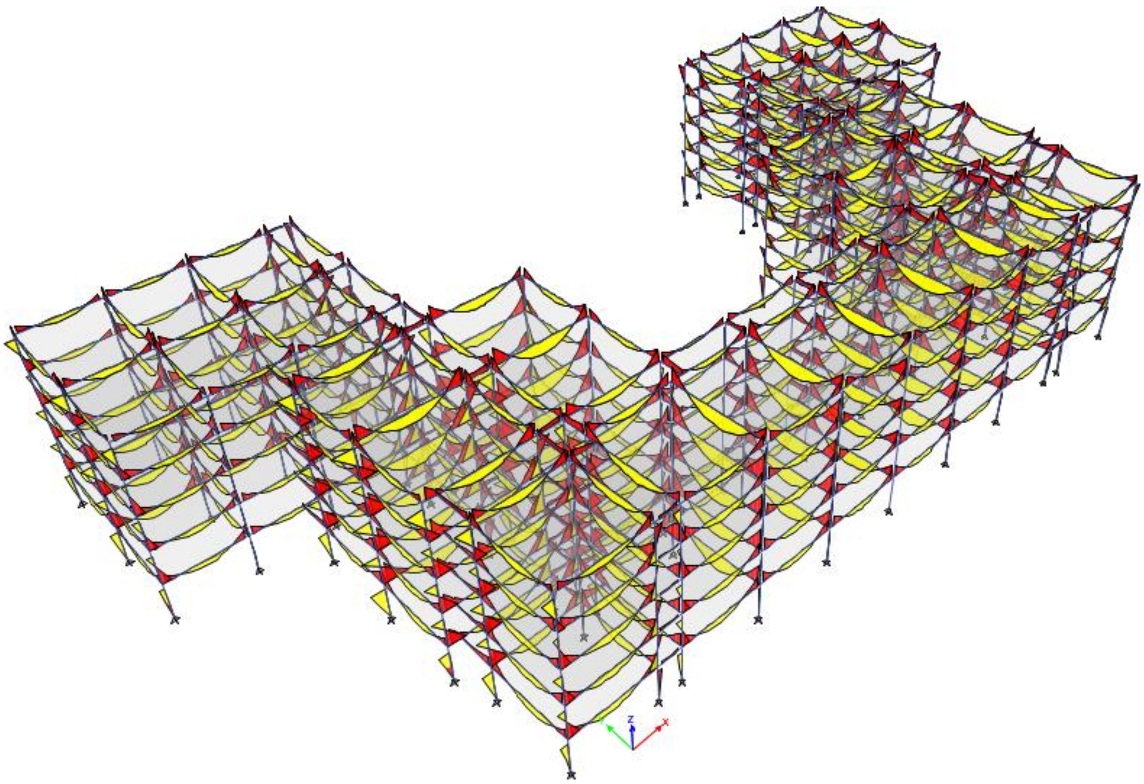
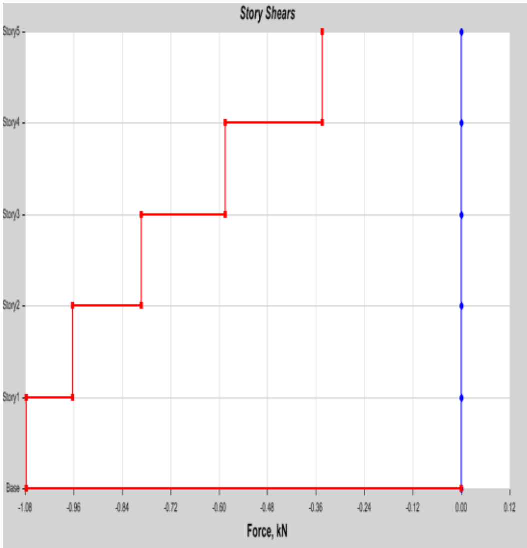


Fig 7: Bending Moment diagram of the proposed commercial building



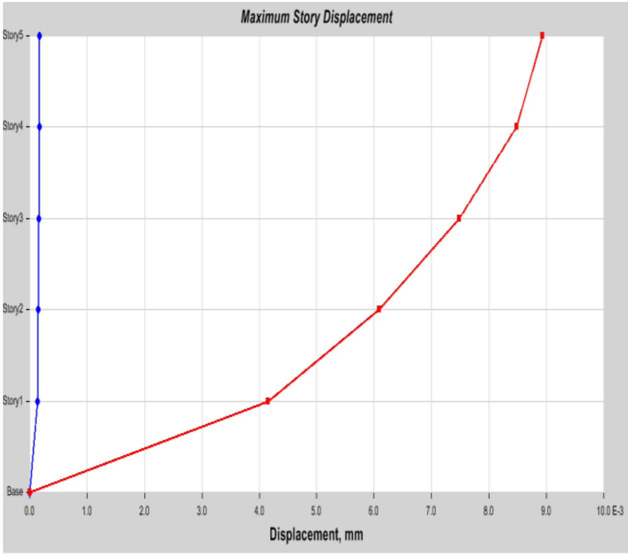


Fig 8: Maximum Storey Shears **Fig 9: Maximum Storey Displacements**

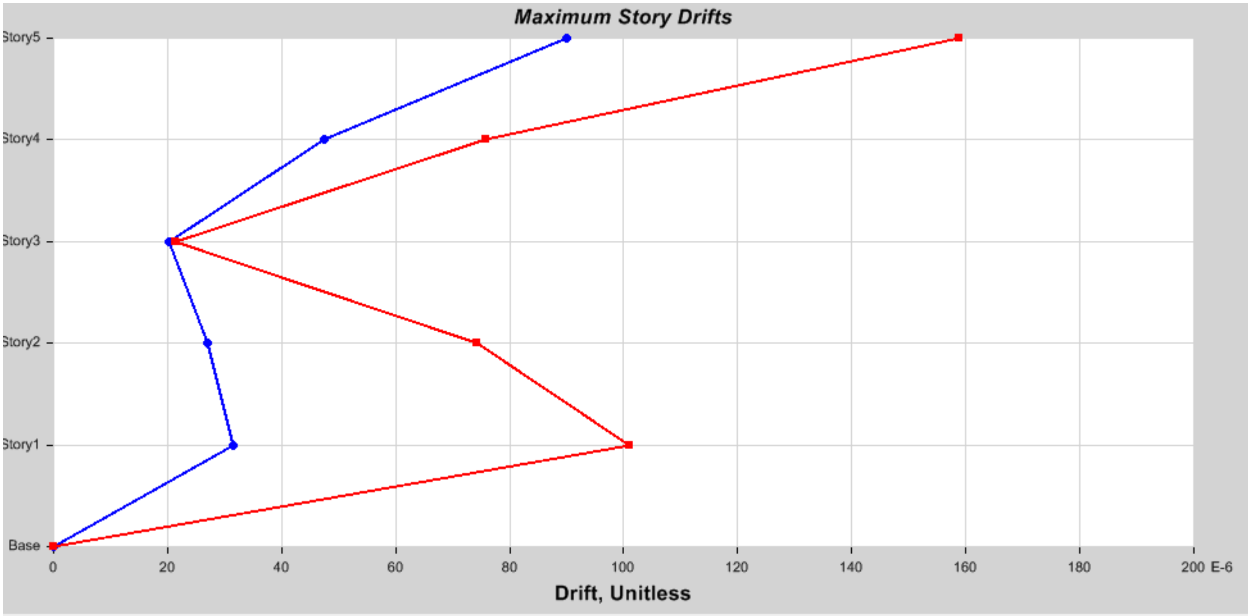


Fig 10: Maximum Storey Drifts Under Gravity and Seismic Loading

V. DESIGN OF STRUCTURAL MEMBERS

Design of all the structural members were performed manually using the the moments achieved from E-Tabs software.

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5.1 Variation of Reinforcement in Beams:

Table 2: Variation of reinforcement for gravity and seismic loading in beams

SPAN in (m)	SIZE OF BEAM (m x m)	SHAPE OF BEAM	REINFORCEMENT OF GRAVITY LOADED STRUCTURE		REINFORCEMENT OF SEISMIC LOADED STRUCTURE	
			MAIN	SHEAR	MAIN	SHEAR
7	0.3 x 0.45	T - BEAM	4-25dia	8 mm @ 150 mm c/c	5-25dia	8 mm @ 100 mm c/c
6	0.3 x 0.45	T – BEAM	3-25dia	10 mm @ 150 mm c/c	4-22dia	10 mm @ 120 mm c/c
4.5	0.23 x 0.3	T – BEAM	3-22dia	8 mm @ 100mm c/c	4-20dia	8 mm @ 80mm c/c
3	0.23 x 0.3	T – BEAM	3-16dia	8 mm @ 100 mm c/c	4-16dia	8 mm @ 120 mm c/c
8	0.3 x 0.45	L - BEAM	5-25dia	8 mm @ 150 mm c/c	4-25dia	8 mm @ 130 mm c/c
7	0.3 x 0.45	L - BEAM	4-25dia	8 mm @ 150 mm c/c	4-25dia	8 mm @ 100 mm c/c
6	0.3 x 0.45	L - BEAM	4-22dia	12 mm @ 150 mm c/c	4-20dia	8 mm @ 150 mm c/c
4.5	0.23 x 0.3	L - BEAM	4-16dia	8 mm @ 100mm c/c	4-16dia	8 mm @ 100mm c/c
3	0.23 x 0.3	L – BEAM	4-12dia	8 mm @ 100 mm c/c	3-16dia	8 mm @ 100 mm c/c

5.2 Variation of Reinforcement in Columns:

Table 3: Variation of reinforcement for gravity and seismic loading in Columns

S.NO.	COLUMN DIMENSIONS (mm)	REINFORCEMENT OF GRAVITY LOADED STRUCTURE		REINFORCEMENT OF SEISMIC LOADED STRUCTURE	
		MAIN	LATERAL TIES	MAIN	LATERAL TIES
1	300 x 600	6- 22 mmΦ	6 mm Φ 200 mm c/c	8- 22 mm Φ	6 mm Φ 150 mm c/c
2	350 x 550	6- 22 mmΦ	6 mm Φ 200 mm c/c	6- 22 mm Φ	6 mm Φ 180 mm c/c
3	350 x 450	6- 16 mmΦ	8 mm Φ 255 mm c/c	6- 20 mm Φ	8 mm Φ 220 mm c/c

VI. COMPARISON OF AREA OF STEEL

The total area of steel required for a gravity loaded structure (structural elements) like Beam, Column and Footings was found as 23698mm^2 and for combination of seismic and gravity loads is 28897mm^2. The variation in reinforcement is calculated only for structural elements with variation in span and cross-section. The highest loading elements for analysis and design. The percentage variation is found as 21.93%. Fig 11.0 shows the area of steel required for a gravity and seismic loaded structure.

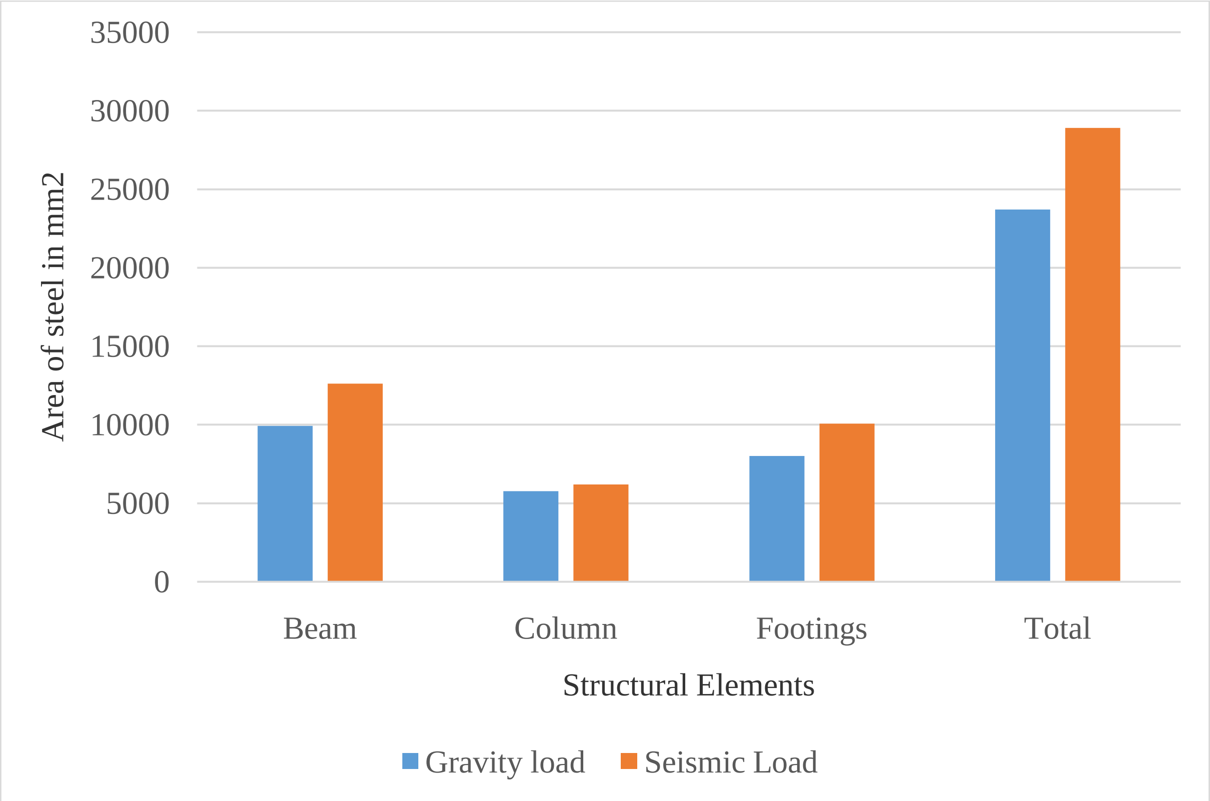

Fig 11 Comparison of area of steel required for gravity and seismic loaded structures

6.1 Cost Estimation and Comparison

The total cost required for a gravity loaded structure (structural elements) like Beam, Column and Footings was found as 47300 Rs and for combination of seismic and gravity loads is 58650 Rs.The percentage variation is found as 23.99%. Fig 12.0 shows the cost required for a gravity and seismic loaded structure. If the total structure is considered the cost may increase

Difference in cost for gravity and seismic loading = 23.99%

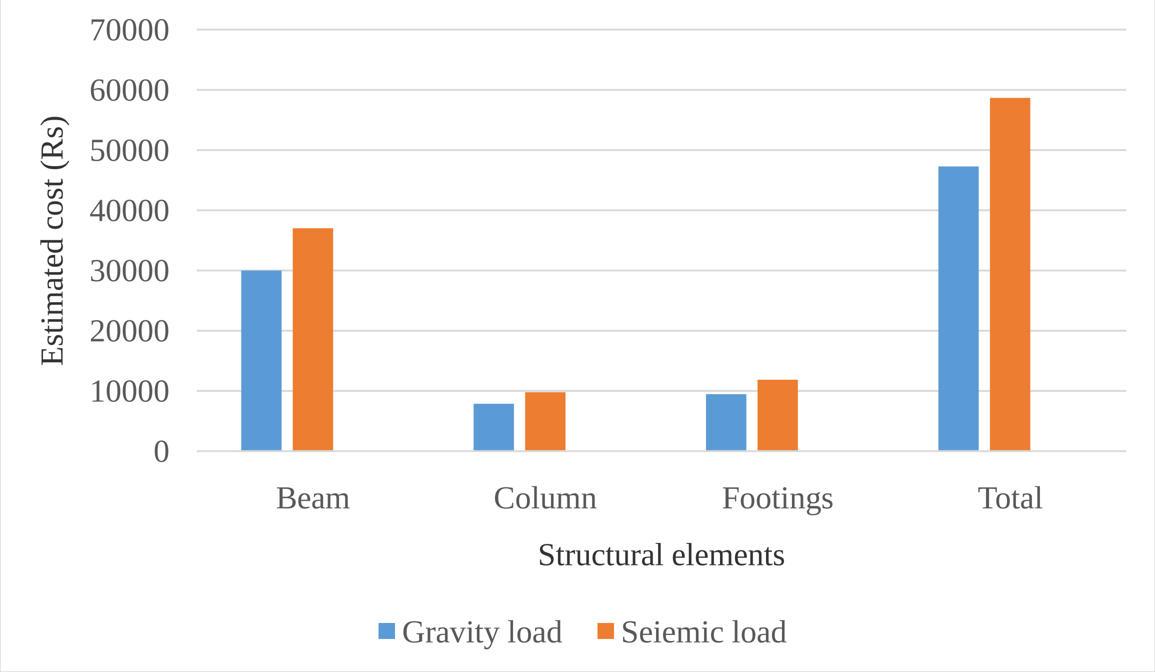

Fig 12.0 Comparison of Cost required for gravity and seismic loaded structures

VII. CONCLUSIONS

The following conclusions can be made based on the analysis and design of commercial building designed for gravity loads and earthquake forces in zone II.

1. The variation of percentage of steel of seismic loading when compared to gravity loading is 21.93%
2. The variation of estimated cost for those structural members analysed and designed under seismic loading is 23.99% greater than gravity loaded building.
3. Hence it is concluded that with a variation of around 25 % seismic design can be included in the design office.

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