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Study on High Raised Frame Structures with Bracings under Lateral Loads Using Etabs

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ABSTRACT: India at present is fast growing economy which brings about demands in increase of infrastructure facilities along with growth of population. The demand of land in urban regions is increasing day by day. To cater the land demand in these regions, vertical development with fast construction of buildings is the only option. High rise buildings are damaged by lateral loads and at risk to seismic forces. Earthquake is the most disastrous natural reasons known to the society. Highrisebuildingsarebasicallysubjectedtolateralloads. By providing bracings at outer periphery one can avoid and can reduce the storey displacement, storey drift in high rise structures. In this present work the square columns and rectangular columns of a 10-Storey (G+9) building with different stiffness ratio of columns and with different earthquake Zones (Zone-Ⅱ and Zone-Ⅴ) are done. Study of beam moments, column moments, storey displacement and storey drift of a bare frame structure and bare frame structure with bracings at outer periphery of a regular building of sizes of 35 m X 50 m is considered for the analysis and modeling of the structure using ETABS Software. The comparison is made for square columns and rectangular columns of different stiffness ratio.

Keywords: - Bare frame structures, bare frame structures with bracings, Stiffness ratio, Square columns, Rectangular columns, Beam Moments, Column Moments, storeydisplacement, storeydrift, and storeyshear.

I. INTRODUCTION

In Modern day's rapid growth of urban population, high price of land and to avoid continues lateral urban spread, the high rise buildings is only feasible solution. For high rise building lateral loads (earthquake load, wind load and blast loads) governs the design. For the lateral loads influences beams and column reinforcements are heavy. We cannot avoid lateral loads but using good building construction practices we can reduce the effect of this loads. Solution for high rise structures and to resist lateral loads is to adopt structural systems properly. In structural system bracings system is one of the efficient systems to resist lateral loads. In a building stiffness of columns and beams are important. Stiffness is depending upon the member sizes. Building responses depends upon the stiffness of members. For this reason we have to take suitable member sizes and with introducing bracings at outer periphery or at inner periphery for the structures effectively get the good in withstanding of building against lateral loading. In the present study the effect of stiffness ratio's (Beam to Column) and response of multistory bare frame structure with bracings to the lateral and vertical loads have beendone.

BRACED FRAMES

Bracings are a kind of lateral load resisting systems. Used for reducing the responses and induced torsion in the building due to earthquakes. Although there are many techniques to brace a frame, the truss method is most commonly used. In the buildings, truss method is used for vertical bracing along with usual horizontal members. It is also possible sometimes to use trussed frame for horizontal members or else by combining vertical and horizontal trusses in a 3D trussed framework. The 3D framework is most common for open tower structures like electrical transmission line towers and radio and television transmission towers. A number of types of braced frame systems are available to be used in the structures to resist lateral forces. Some of these are discussed in the following section.

II. OBJECTIVES

Following are the main objective of the present work is to study the following:

- ❖ Effect of stiffness ratio K (stiffness beam to stiffness column) on the behavior of framed structure with and without bracings.
- ❖ Effect of position & size of bracings.
- ❖ To study the effect of stiffness ratio's (Beam/Column) on behavior of framed structures.
- ❖ To study the effect of position, size and material.

III. METHODOLOGY

- ➢ LITERATURESTUDY (SEARCHINGCODES, METHODS AND TECHNIQUES).
- ➢ DEFINIINGOBJECTIVESOFTHESTUDY.
- ➢ CALCULATIONSTIFFNESS RATIO.
- ➢ MODELGENERATION USING ETABS.
- ➢ APPLYING BRACINGS.
- ➢ APPLYING LOADS AND SEISMIC PARAMETERS AS CONSIDER FOR THISSTUDY.
- ➢ ANALYSIS OF BUILDING MODELS TO OBTAIN THE RESULTS.
- ➢ COMPARISION OF THE RESULTS AND CONCLUDING THE WORK WITH CONCLUSIONS.

IV Determination of Stiffness of Members

Beam Dimensions = (230X450) mm
Column Dimensions = (575X575) mm
bc = Column Width
Dc = Column Depth
b = Width of the beam
D = Depth of the beam
Icolumn = bcDc 3 /12=575 x 5753 /12 = 9109.40 X 106 mm 4
Ibeam = (bD3 /12) x Kt = (230 x4503 /12) x Kt =1746.56 X 106 x Kt mm 4
Assuming: Df =150 mm and bw =230mm
From IS: 456-2000
bf = (Lo/6) +bw + 6Df
= (4000/6) +230+ (6x150) = 1796.66 mm
K1 = bf/bw =1796.66/230 =7.8115
K2 = Df/D = 150/450 =0.3333
K = X/D
Where,
X ={ (bwD2 /2)+ [(bf-bw)Df 2 /2] }/[(bwD)+(bf-bw)Df]
= {(230x4502 /2) + [(1796.66-230)1502 /2]}/[(230x450) + (1796.66-230)150]
= 120.8641
K = X/D = 120.8641/450 = 0.2685
Kt = 4[K1K 3 + (1-K) 3 - (K1-1) (K-K2) 3]
= 4[7.8115x0.26853 + (1-0.2685)3 - (7.8115-1) (0.2685-0.3333)3]
= 2.1779
Ibeam=1746.56 X 10^6 x 2.1779 = 3803.89 X 106 mm^4
Kbeam= Ibeam/ Lbeam = (3803.89 x 106)/5000 = 760778
Kcolumn= Icolumn/ Lcolumn= (9109.40 x 106 x 106)/3000= 3036466.66
Kbeam /Kcolumn = (= 760778/3036466) = 0.25

Table.4.1: Sizes of Square column and beam for different stiffness ratios.

SL No	(KB/KC) Ratio	Column size	Beam size
1	0.25	575×575	**230×450**
2	1.00	409×409	
3	2.0	341×341	
4	3.0	310×310	
5	4.0	289×289	
6	5.0	273×273	

Table.4.2: Sizes of Rectangular column and beam for different stiffness ratios.

SL No	(KB/KC) Ratio	Column size	Beam size
1	0.25	230 × 787	**230×450**
2	1.0	230 × 496	
3	2.0	230 × 390	
4	3.0	230 × 345	
5	4.0	230 × 313	
6	5.0	230 × 290	

V. MODELLING

Table.5.1: Building properties considered for conventional structure.

Properties	Values
No. of stories	10
Plan dimension	35 × 50
Height of floor	3m

Size of columns	575 × 575
Size of beams	230 × 450
Slab thickness	150
Grade of concrete	25
Grade of steel	Fe500
Wind Speed	33 m/sec
Seismic zone	2 & 5
Soil type	medium
Importance factor	1.2
Reduction factor	5 (IS 1893 2016) page-20
Bracing	ISLB250
Live load	2.0 kN/m^2
Floor finish/SDL	2.0 kN/m^2
Method of Analysis	Response spectrum method

Load Combination

1) 1.5[DL+LL]

2) 1.5[DL+SPECX]

3) 1.5[DL+SPECX]

4) 1.5[DL+LL-SPECX]

5) 1.5[DL+LL-SPECY]

6) 0.9[DL] +1.5[SPECX]

7) 0.9[DL] +1.5[SPECY]

8) 1.5[DL+WX]

9) 1.5[DL-WY]

10) 1.5[DL-WX]

11) 1.5[DL-WY]

12) 1.5[DL+EQX]

13) 1.5[DL+EQY]

14) 1.5[DL-EQX]

15) 1.5[DL-EQY]

16) 0.9[DL] + 1.5 [EQX]

17) 0.9[DL] + 1.5[EQY]

18) 0.9[DL] - 1.5 [EQX]

19) 0.9[DL] - 1.5 [EQY]

The 10-storey building is having 35m x 50m plan dimension and 30m total height of building. The storey height is 3m. The typical plan and elevation are shown in figure.

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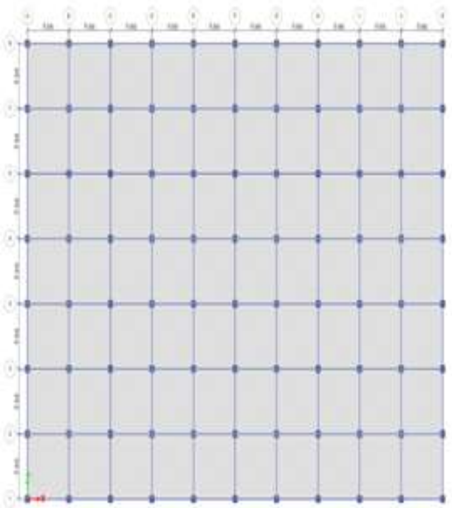

Fig.5.1: Plan view of bare frame Structure.

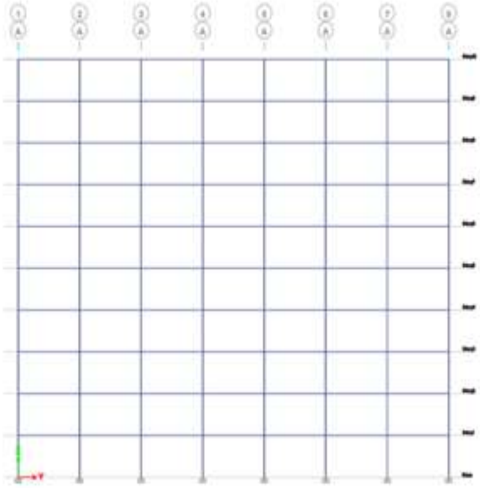

Fig.5.2: Elevation view of bare frame Structure.

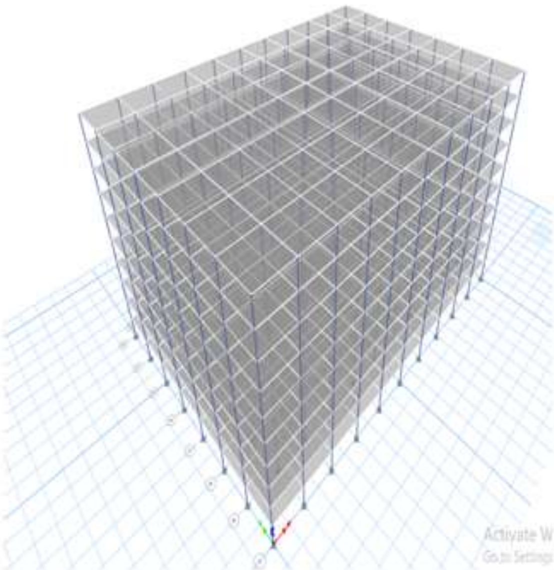

Fig.5.3: 3D view of bare frame Structure.

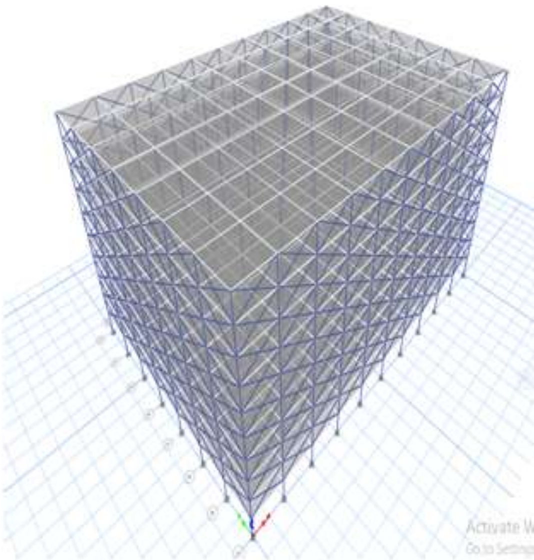

Fig.5.4: 3D view of bare frame Structure with bracings at outer Periphery.

IV. RESULTS AND CONCLUSION

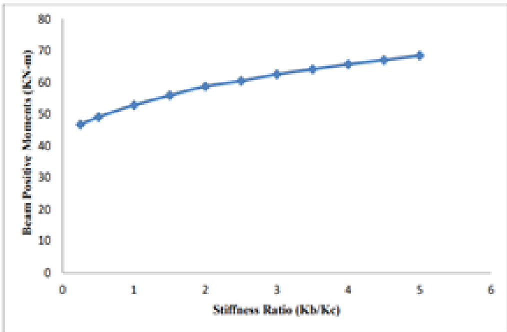

Fig.6.1: Variation of beam positive bending moments for different stiffness ratio of square columns for a 10-storey building in zone-earthquake region of bare frames structure. (Beams=B36 & B42)

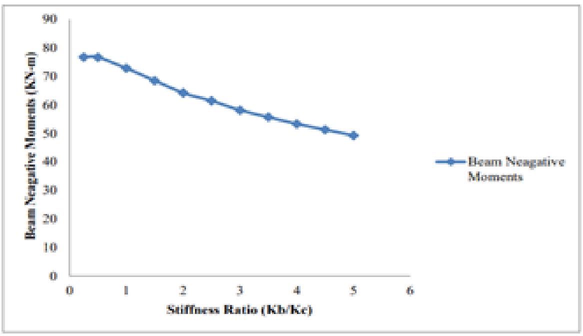

Fig.6.2: Variation of beam negative bending moments for different stiffness ratio of square columns for a 10-storey building in zone-2 earthquake region of bare frames structure. (Beams=B36 & B42)

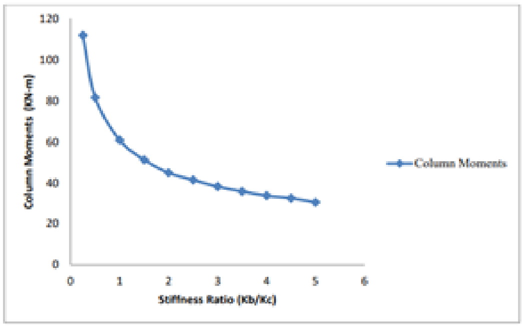

Fig.6.3: Variation of column moment for different stiffness ratio of square columns for a 10-storey building in zone-2 earthquake region of bare frame structure.(Columns=C19,C23 &C67)

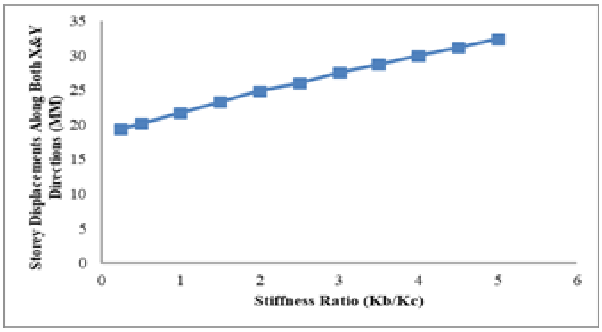

Fig.6.4: Variation of storey displacement of square columns along both x & y directions, for 10 storey building in zone-2 earthquake region for bare-frame structure.

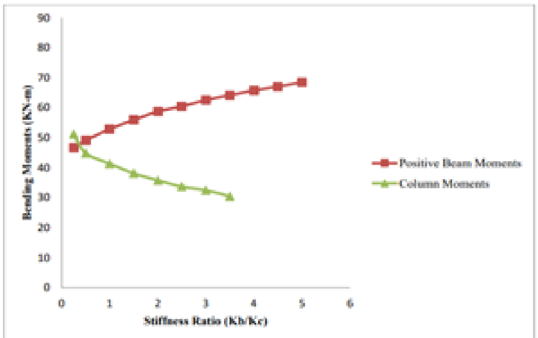

Fig.6.5: Variation of column and beam bending moments for different stiffness ratio of square columns for a 10-storey building in zone-2 earthquake region of bare frames structure. Here the optimumstiffness ratio is 0.5.

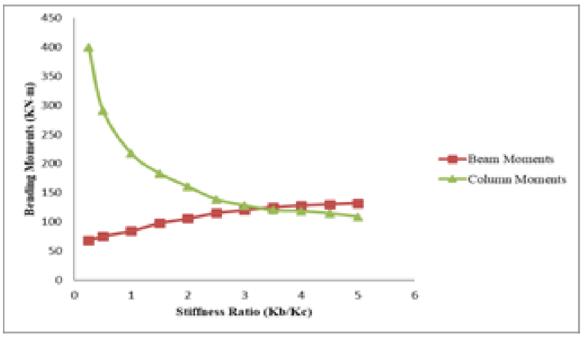

Fig.6.6: Variation of column and beam bending moments for different stiffness ratio of square columns for a 10-storey building in zone-5 earthquake region of bare frames structure. Here the optimumstiffness ratio is 3.25.

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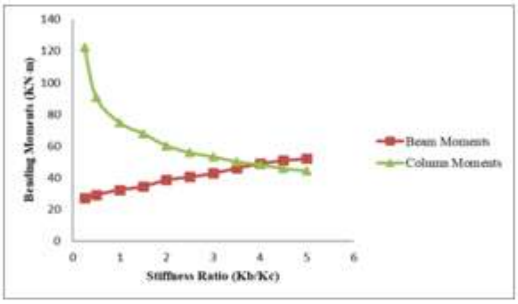

Fig.6.7: Variation of column and beam bending moments for different stiffness ratio of square columns for a 10-storey building in zone-2 earthquake region of bare-frame structure with bracings outer periphery. Here the optimum stiffness ratio is 4.

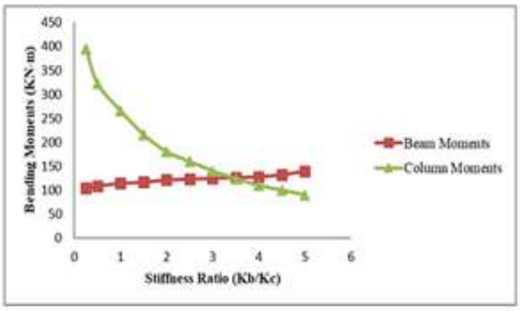

Fig.6.8: Variation of column and beam bending moments for different stiffness ratio of square columns for a 10-storey building in zone-5 earthquake region of bare-frame structure with bracings outer periphery. Here the optimumstiffness ratio is 3.5.

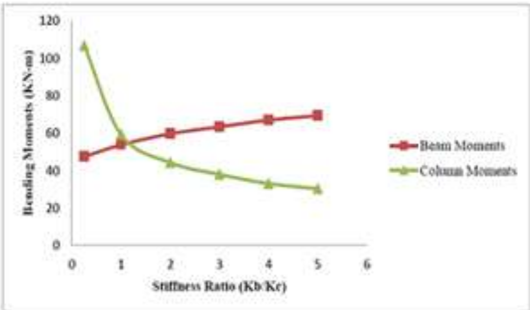

Fig.6.9: Variation of column and beam bending moments for different stiffness ratio of rectangular columns for a 10-storey building in zone-2 earthquake region of bare frames structure. Here the optimumstiffness ratio is 1.25.

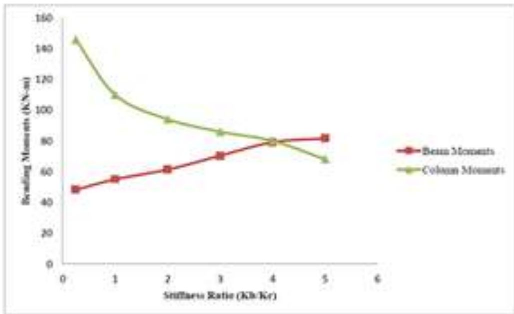

Fig.6.10: Variation of column and beam bending moments for different stiffness ratio of rectangular columns for a 10-storey building in zone-5 earthquake region of bare frames structure.Here the optimumstiffness ratio is 4.

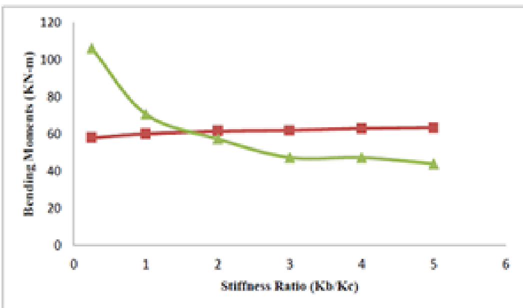

Fig.6.11: Variation of column and beam bending moments for different stiffness ratio of rectangular columns for a 10-storey building in zone-2 earthquake region of bare frames structure with bracings. Here the optimumstiffness ratio is 2

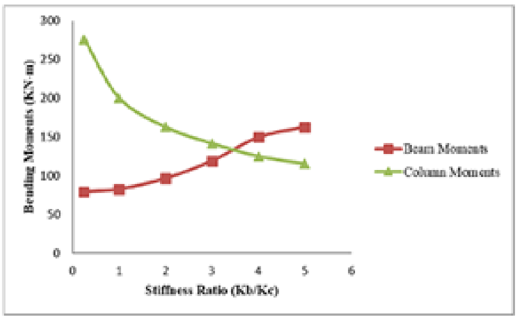

Fig.6.12: Variation of column and beam bending moments for different stiffness ratio of rectangular columns for a 10-storey building in zone-5 earthquake region of bare frames structure with bracings. Here the optimumstiffness ratio is 3.5.

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Table.6.1: Optimum Stiffness ratio

SQUARE COLUMNS	ZONES	RANGE		AVG		AVG
BARE FRAME STRUCTURE	ZONE-Ⅱ	0.5	3.75	1.875		
	ZONE-V	3.25				
BARE FRAME STRUCTURE WITH BRACINGS	ZONE-Ⅱ	4	7.5	3.75		
	ZONE-V	3.5				
RECTANGULAR COLUMNS					11	2.75
BARE FRAME STRUCTURE	ZONE-Ⅱ	1.25	5.25	2.625		
	ZONE-V	4				
BARE FRAME STRUCTURE WITH BRACINGS	ZONE-Ⅱ	2	5.5	2.75		
	ZONE-V	3.5				

Here the optimum stiffness ratio ranges between 0.25 – 2.75
0.25 + 2.75 = 3 /2 = 1.5
So 1.5 stiffness ratio is considered as optimum stiffness ratio for analyzing the results
And to plot the graphs that satisfies the strong column and weak beam.

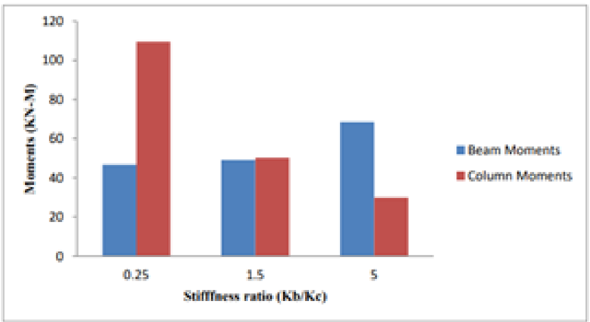

Fig.6.13: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a square columns of a 10-storey building at Zone-□ earthquake region of a bare frame structure.

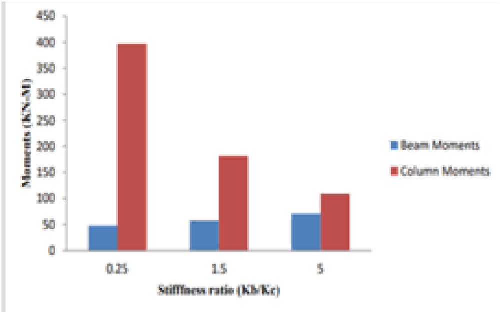

Fig.6.14: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a square columns of a10-storey building at Zone-□ earthquake region of a bare frame structure.

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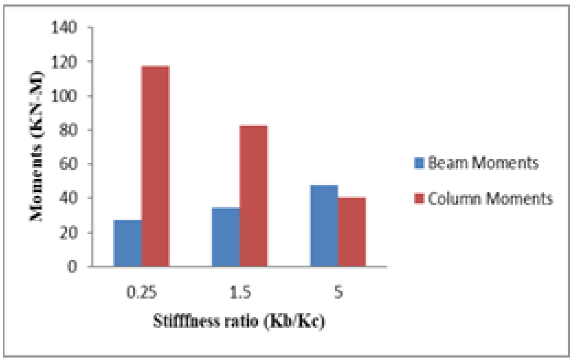

Fig.6.15: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a squarecolumns of a 10-storey building at Zone-□ earthquake region of a bare frame structure with bracings.

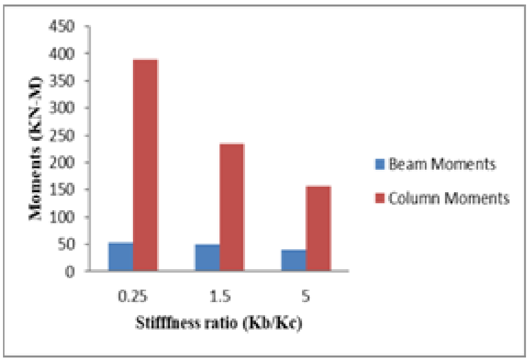

Fig.6.16 From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 and satisfies the strong column and weak beam for a square columns of a 10-storey building at Zone-□ earthquake region of a bare frame structure with bracings.

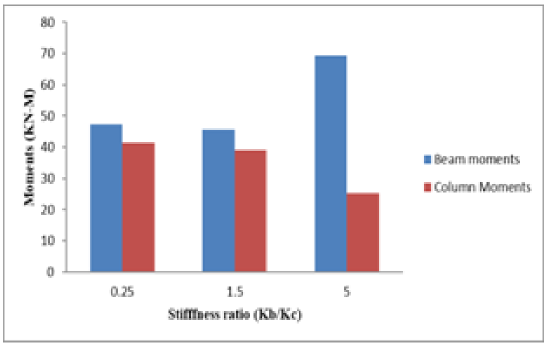

Fig.6.17: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a rectangular columns of a 10-storey building in Zone-□ earthquake region of a bare frame structure.

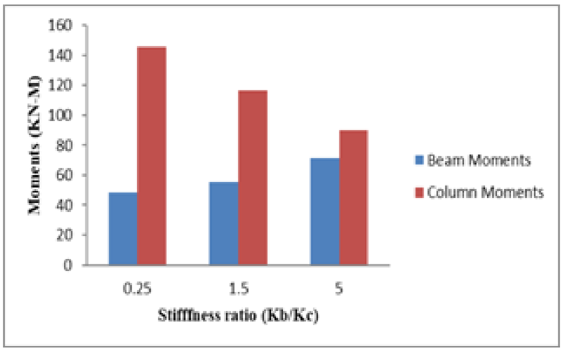

Fig.6.18: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a rectangular columns of a 10-storey building at Zone-□ earthquake region of a bare frame structure.

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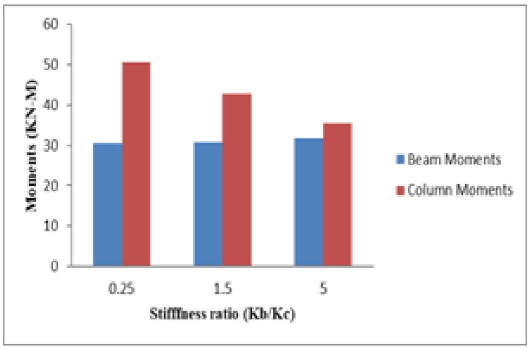

Fig.6.19: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a rectangular columns of a 10-storey building at Zone-Ⅱ earthquake region of a bare frame structure with bracings at outer periphery.

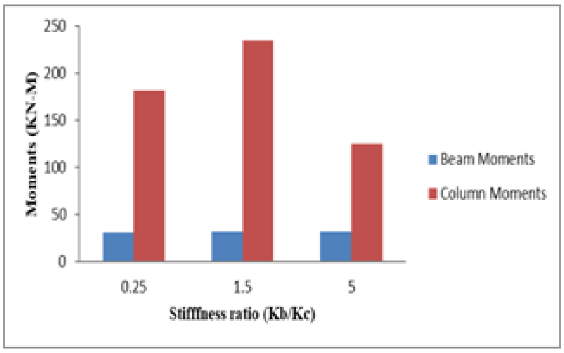

Fig.6.20: From the above graph we can observe that stiffness ratio of 0.25, 1.5 and at 5 the beam moments and column moments are optimum at 1.5 stiffness ratio and satisfies the strong column and weak beam for a rectangular columns of a 10-storey building at Zone-Ⅱ earthquake region of a bare frame structure with bracings at outer periphery.

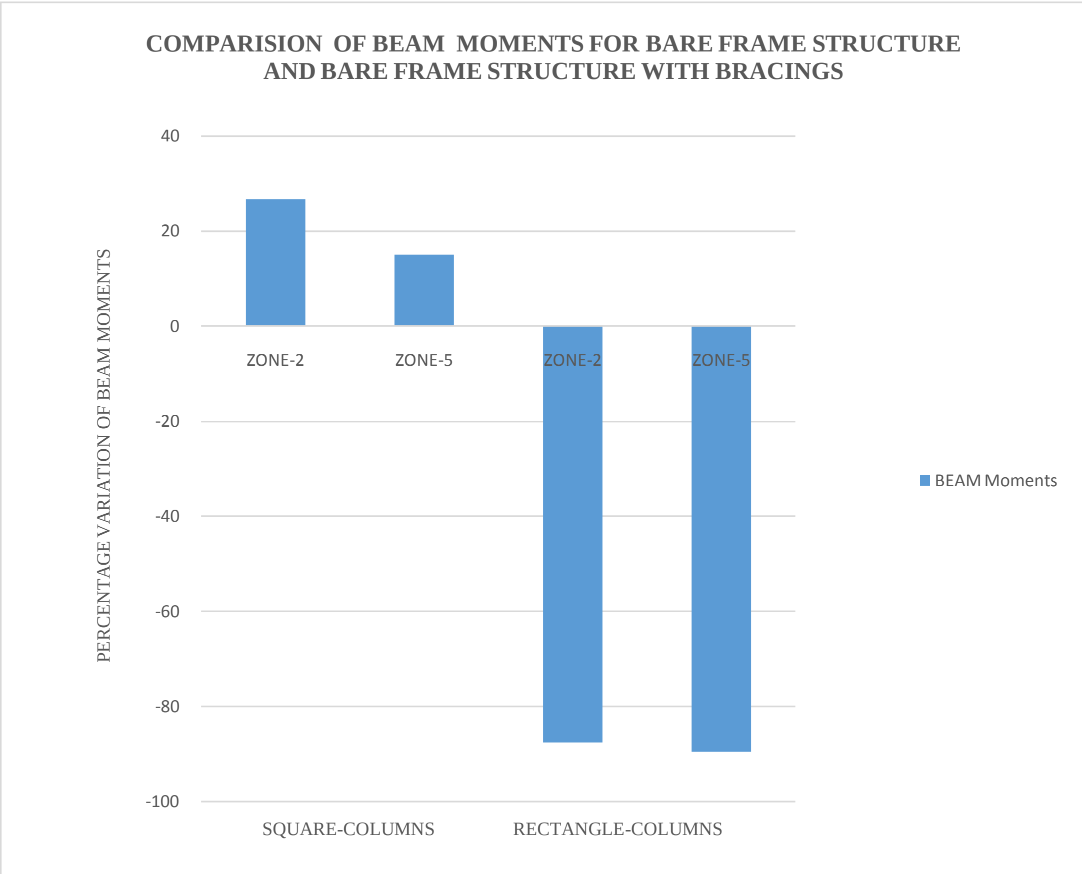

Fig6.21: Comparison of beam moments between square columns and rectangular column of a bare frame structure and bare frame structure with bracings at outer periphery.

From the above graph we can observe that on comparison between the square columns and rectangular columns of a bare frame structures and bare frame structures with bracings at outer periphery region**,** Results in increase in beam moments up to 26% in Zone-Ⅱ earthquake region

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and 15% in Zone-Ⅴ earthquake region in square columns structures with bracings at outer periphery when compare to with bare frame structures and decrease in beam moments up to 87% in Zone-Ⅱ earthquake region and 89% in Zone-Ⅴ earthquake region in rectangular columns structures with bracings at outer periphery region when compare to with bare frame structures.

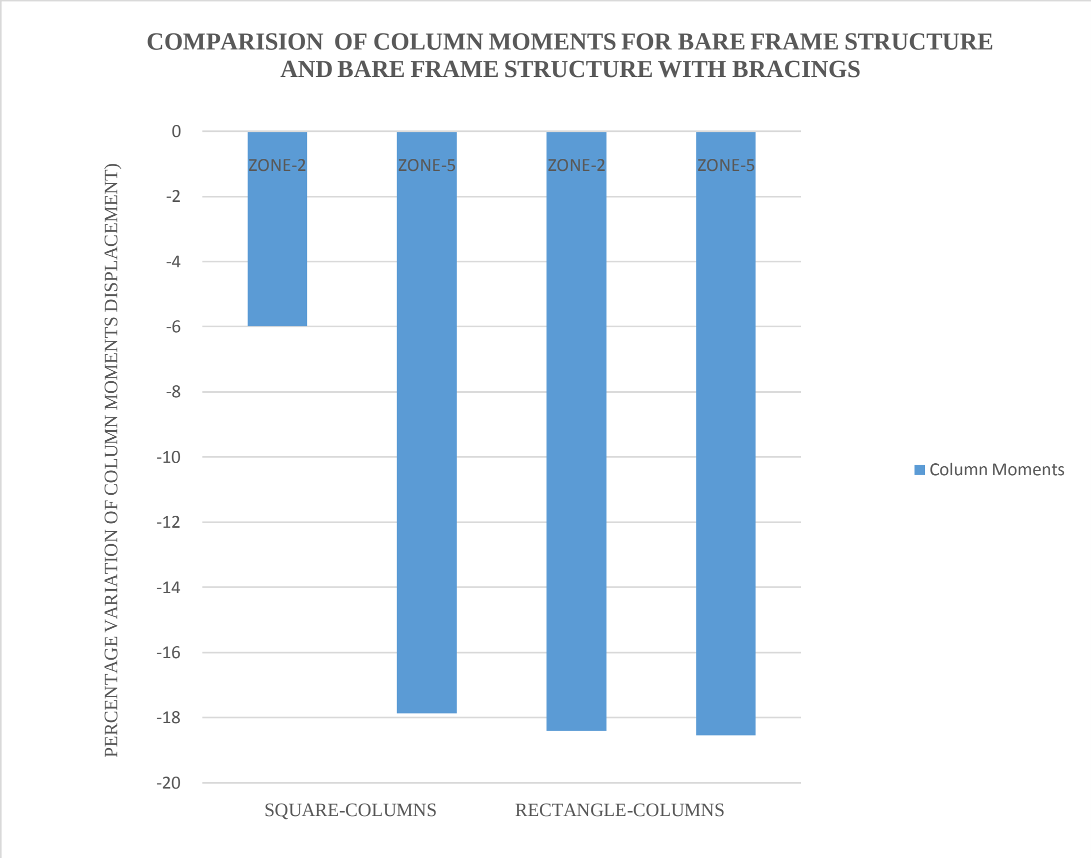

Fig6.22: Comparison of column moments between square columns and rectangular column of a bare frame structure and bare frame structure with bracings at outer periphery**.**

From the above graph we can observe that on comparison between square columns and rectangular column of a bare frame structure and bare frame structure with bracings at outer periphery, Results in decrease in column moments up to 6% in Zone-Ⅱ earthquake region and 18% in Zone-Ⅴ earthquake region in square columns structures with bracings at outer periphery region when compare to with bare frame structures and decrease in column moments up to 18% in Zone-Ⅱ earthquake region and 19% in Zone-Ⅴ earthquake region in rectangular columns structures with bracings at outer periphery region when compare to with bare frame structures.

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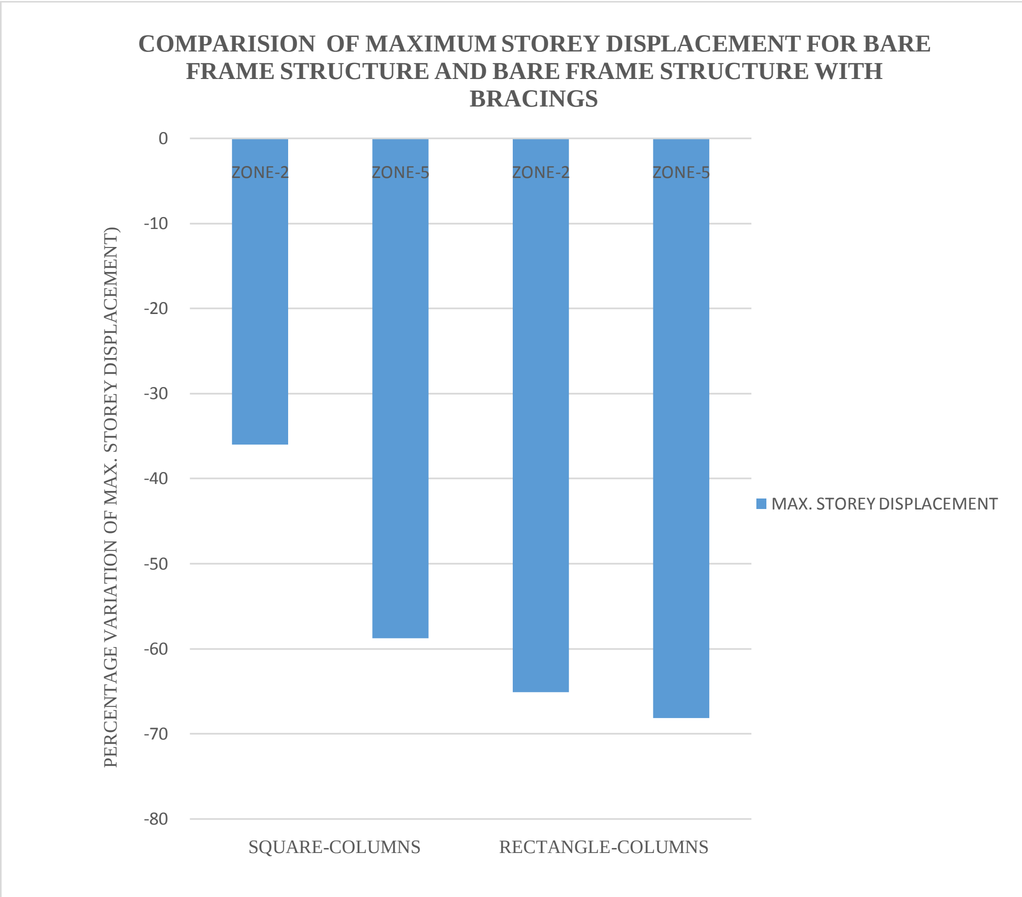

Fig6.23: Comparison of storey displacement between square columns andrectangular column of a bare frame structure and bare frame structure with bracings at outer periphery.

From the above graph we can observe that on comparison between square columns and rectangular column of a bare frame structure and bare frame structure with bracing at outer periphery, Results in decrease in maximum story displacement up to 36% in Zone-Ⅱ earthquake region and 58% in Zone-Ⅴ earthquake region in square columns structures with bracings at outer periphery when compare to with bare frame structures and decrease in maximum story displacement up to 65% in Zone-Ⅱ earthquake region and 68% in Zone-Ⅴ earthquake region in rectangular columns structures with bracings at outer periphery when compare to bare frame structures.

V. CONCLUSIONS

1) Column moments decreases with increases in stiffness ratio.
2) Stiffness ratio less than 2.5 satisfies strong columns and weak beams which are effective for against the earthquake.
3) Square columns and rectangular columns effectively resists against the earthquake.
4) The displacements increases as the height of stories increases and the maximum displacement is observed in the top storey.
5) When bracings are used in structure, displacement are found to be decrease when compared to displacement of bare frame.
6) Position of bracings is important in controlling the moments at both in beams and columns. The best position of bracing is at outer periphery.
7) Obtained optimum stiffness ratio range (0.5-3.5) can optimize the moments of columns and beams economically.
8) The Positive Beam moments increases with increase in Stiffness ratio (Kb/Kc).

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