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ANALYSIS OF EARTHQUAKE LOADS ON G+7 STOREYED BUILDING WITH CONCETRIC BRACING SYSTEM AND ECCENTRIC BRACING SYSTEM USING RESIST SOFTWARE

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ABSTRACT
The proposed project is to analyze the performance of G + 7 multi storied building for lateral forces, (seismic/wind). Work was carried out considering seismic zones (II, III, IV and V) and hard, medium, soft type of soils. The parameters which are proposed to be observed for the effect of lateral forces are: length of bracing, size of the bracing system, floor width support of the bracing system, drift, base moment and base shear. The work was carried out with the help of Resist software which is developed by NICEEE, Govt. of India, which can be used only for research work. Results showed that the usage of concentric bracing system is more safe and economical than the eccentric bracing system.

KEYWORDS: Concentric bracing, eccentric bracing, base shear, base moment.

INTRODUCTION
Bracings are steel elements which are used for resisting lateral forces, (seismic and wind forces); Bracings are so designed that they will have the strength and stiffness to resist lateral forces. Bracings are most efficient to help in withstanding of structure. Lateral loads caused due to wind and seismic forces act normal to the width i.e., thickness of the wall. Bracings resists maximum amount of lateral shear caused in buildings through flexural deformation only but not through shear deformation.

When moment resisting frames (MRFs) cannot be economically designed sufficiently stiff for resisting wind forces, concentrically braced frames (CBFs) are generally employed. In some instances in order to accommodate architectural requirements for openings, braces are offset from the column or do not intersect at the floor beams resulting in an eccentrically connected bracing. This is the prototype for seismic resistant EBFs. Several alternative bracing arrangements for such framing configurations can be devised

LITERATURE REVIEW
G.Brandonisio et al [2012] made some modifications to the design procedure in modern European seismic code, for improving the ductile cross concentric bracing frame. The codal procedure was used to obtain ductile and dissipative ultimate behaviour by improved yield of diagonal members. Modifications are made to the design provisions with major aim of control of over strength requirements to the non dissipative members of braced frames, for reducing the associated structural weight. Analysis was made using non linear finite element analysis with reference to three, six and nine storey buildings for obtaining different structural solutions of design. The modified approach appeared more flexible for design of ductile consideration of concentric bracing than European code of practice. It was also observed that the safety factor values in European code are over strength and are larger than the elastic solutions which showed a high potential of performance of modified approach.

Habib saeed Monir et al [2013] studied diagonal bracing of structures using modified friction damper. The dynamic behaviour of friction damper was demonstrated. The analysis was made using SAP 2000 for all the experimental study. The damper was installed in a single degree steel frame and tested with help of shaking table under several earthquake excitations. Numerical assessments of the study are of model single degree freedom frame in SAP 2000. Using modified friction damper not only provided additional stiffener but it also made effective dissipative device with good energy dissipating capabilities. Modified friction damper used reduced the displacements and drift of the story also. Using El Centro and Kobe earthquake the excitation obtained was reduced by 22%, 25%, 26% when compared with time displacement approach.

Massood Mofid et al [2000] presented a disposable knee bracing behavior for structural framing systems. The model of disposable knee bracing model of bracing with the proper optimization of diagonal bracing and easy to use and can be determined using non linear analysis also. Two frames of different length to height ratios are considered for analysis of framing system with varying tangential ratios. Non linear behavior of the considered bracing was also considered with lateral load increasing gradually, on to the three plastic joints created on the respective knee element. This will make effect on the change of stiffness of structure and also in displacement also. Bilinear model considered was successfully estimated towards it real behavior. The limitations of the considered bracing are that effect on the general behavior of the structure when ground motion occurs. If diagonal knee bracing designed properly it can work for severe earthquake also and for saving entire structure. If knee element would be parallel to the frame diagonal direction then diagonal element passes through beam column interaction.

A.Ghobarah et al [2001] made analysis of a three storey office building for different ground motions for knowing the effect of eccentric steel bracing system for reinforced concrete frame. The effectiveness of the distributing the steel bracing over the height of the RC frame on the seismic performance of the building was studied. The link behavior was also modeled using tri linear moment and shear force representations. Performance of the building was also evaluated in terms of story drifts and damage identifying conditions of forces. The analysis performed on the considered eccentric bracing system shown that link deformation angle was an important parameter for stability condition. For limiting the deformation storey drift of the building should not exceed the link length to story height ratio. The distribution of eccentric bracing system on the building height was found significant effect on the development of plastic mechanism under the effect of lateral seismic load conditions. Buildings for eccentric bracing condition of rehabilitation should be of uniform distribution of story drift.

A.R.Rahai et al [2008] analyzed two existing concrete structures a three story and nine story buildings strengthen against seismic loadings by both conventional concentric steel and latter composite bracing systems. The behaviours of the structures was studied using push over analysis and the results were compared for the considered bracing systems. Stability of the composite bracing members under cyclic loading and two existing concrete structures with clear weak points against seismic loading are found and studied. With usage of push over diagrams initial stiffness and the capacity of different models where observed with X-bracing system, produced suitable rigidity and ductility for the structures. Load displacement curves showed that models strengthened with the encased bracing system effect the displacement with exceeded limits of the targeted safety conditions. Over strength factors of various models showed the structures strengthened by encased bracing system with maximum safety factor.

AIM & OBJECTIVE

The present paper details the usage of concentric bracing system and eccentric bracing system for a G + 7 multi storied building. This project is proposed for detail analysis of the considered system's under consideration of code provisions of IS: 1893 (Part I): 2002. The zones considered are Zones II, III, IV, V and soil classifications considered are hard, medium and soft soil conditions. A detail statements regarding the effect of earthquake parameters like base shear, base moment and drift are considered for analysis. The design parameters like size of the bracing system with change of zone and soil conditions are considered for examination. The objective of the project is to understand the behavior of the bracing systems on multi storied systems using resist software prepared exemption ally for research and educational purpose by NICEE, with IIT Kanpur. The effect of bracing systems considering the considerations of IS: 1893 (Part I): 2002, helps the designers to study the project and to understand the safety considerations of the structural design. This proposed work helps in preparation of a model for developing the relations of base shear, base moment and design parameters of the bracing systems developed by the software. This project identifies the optimum usage of bracing system with concentric and eccentric bracing systems.

BUILDING INFORMATION FOR ANALYSIS:

Number of storeys = 8
Length in X direction = 15.0 m
Length in Y direction = 15.0 m
Inter-storey height = 3.5 m
Floor Weight type: Heavy, Dead load: 6.50kPa, Live load: Office (3.00kPa)

Interior wall Weight type: Heavy, Dead load: 4.75kPa
External wall Weight type: Heavy, Dead load: 3.50kPa
Roof Weight type: Heavy, Height: 1.5m, dead load: 7.71kPa (over floor area), Live load: 0.25kPa (over floor area)
Structure in X direction: Steel Cross Braced Frame, Steel Eccentric K Braced Frame.
Structure in Y direction: Steel Cross Braced Frame, Steel Eccentric K Braced Frame.

Table 1: Seismic information as per IS : 1893 (Part 1) : 2002.

Zone	Zone factor	Intensity	Soil	Importance factor
II	0.10	Low	H/M/S	1.0
III	0.16	Moderate	H/M/S	1.0
IV	0.24	Severe	H/M/S	1.0
V	0.36	Very severe	H/M/S	1.0

RESULTS

The tabular forms listed below present the results of the effect of earthquake in different zones of India with change of zoning conditions and also soil conditions with response value of 5. Tabular forms, graphs show the change of drift of building with each storey and also change of base shear with effect of earthquake.

Tab 1: Details of results obtained for concentric bracing in hard soil:

ZONE	FQ	B.S	B.M
II	0.65	907	20342
III	0.65	1459	32711
IV	0.65	2202	49380
V	0.65	3325	74524

Tab.2.Details of results obtained for concentric bracing in medium soil:

ZONE	FQ	B.S	B.M
II	0.65	1237	27740
III	0.65	1987	44565
IV	0.65	3014	67568
V	0.65	4552	102002

Tab3.Details of results obtained for concentric bracing in soft soil:

ZONE	FQ	B.S	B.M
II	0.65	1483	33256
III	0.65	2388	53550
IV	0.65	3611	80928
V	0.65	5497	123132

Tab.4.Details of results obtained for eccentric bracing in hard soil:

ZONE	FQ	B.S	B.M
II	0.65	727	16299
III	0.65	1167	26174
IV	0.65	1765	39578
V	0.65	2663	59682

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Tab.5.Details of results obtained for eccentric bracing in medium soil:

ZONE	FQ	B.S	B.M
II	0.65	988	22167
III	0.65	1593	35729
IV	0.65	2408	53970
V	0.65	3649	81767

Tab.6.Details of results obtained for eccentric bracing in soft soil:

ZONE	FQ	B.S	B.M
II	0.65	1187	26610
III	0.65	1907	42767
IV	0.65	2900	64978
V	0.65	4394	98426

Tab.7.Details of seismic drift for zone II using concentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.002	0.002	0.002
7.0	0.003	0.004	0.004
10.5	0.006	0.007	0.007
14.0	0.008	0.009	0.009
17.5	0.010	0.012	0.012
21.0	0.013	0.015	0.015
24.5	0.015	0.017	0.018
28.75	0.017	0.020	0.021

Tab.8.Details of seismic drift for zone III using concentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.002	0.002	0.002
7.0	0.004	0.005	0.005
10.5	0.007	0.009	0.009
14.0	0.010	0.012	0.012
17.5	0.013	0.016	0.016
21.0	0.016	0.020	0.020
24.5	0.019	0.023	0.023
28.75	0.022	0.027	0.026

Tab.9.Details of seismic drift for zone IV using concentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.002	0.003	0.003
7.0	0.005	0.006	0.006
10.5	0.009	0.010	0.010
14.0	0.012	0.014	0.015
17.5	0.016	0.018	0.019
21.0	0.019	0.022	0.024
24.5	0.023	0.025	0.028
28.75	0.026	0.029	0.032

Tab.10.Details of seismic drift for zone V using concentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.003	0.004	0.003
7.0	0.007	0.008	0.007
10.5	0.011	0.012	0.012
14.0	0.015	0.017	0.016
17.5	0.020	0.023	0.021
21.0	0.024	0.028	0.026
24.5	0.028	0.032	0.031
28.75	0.032	0.037	0.035

Tab.11.Details of seismic drift for zone II using eccentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.005	0.006	0.007
7.0	0.011	0.013	0.014
10.5	0.017	0.021	0.022
14.0	0.024	0.029	0.031
17.5	0.030	0.037	0.040
21.0	0.037	0.046	0.049
24.5	0.044	0.054	0.057
28.75	0.051	0.062	0.066

Tab.12.Details of seismic drift for zone III using eccentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.006	0.003	0.003
7.0	0.014	0.007	0.007
10.5	0.022	0.010	0.011
14.0	0.031	0.014	0.015
17.5	0.039	0.018	0.019
21.0	0.048	0.021	0.023
24.5	0.056	0.024	0.027
28.75	0.065	0.027	0.030

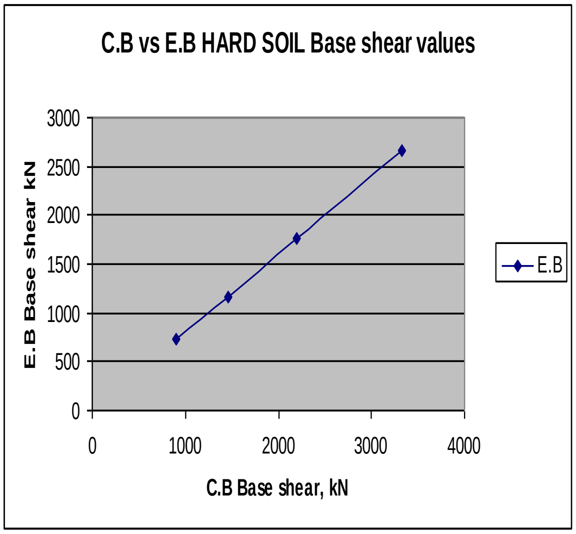
Tab.13.Details of seismic drift for zone IV using eccentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.003	0.003	0.003
7.0	0.006	0.007	0.007
10.5	0.009	0.011	0.011
14.0	0.013	0.015	0.015
17.5	0.016	0.019	0.019
21.0	0.019	0.023	0.022
24.5	0.022	0.026	0.025
28.75	0.024	0.029	0.028

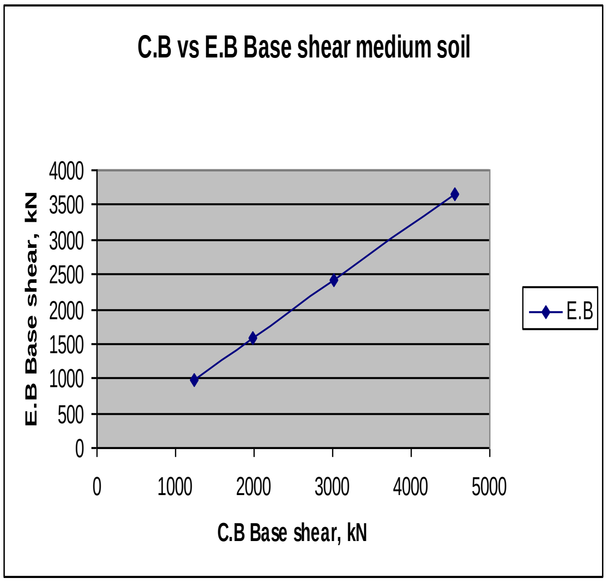
Tab.14.Details of seismic drift for zone V using eccentric bracing:

Height	Hard soil	Medium soil	Soft soil
0	0.000	0.000	0.000
3.5	0.003	0.004	0.003
7.0	0.007	0.007	0.007
10.5	0.011	0.011	0.011
14.0	0.015	0.016	0.015
17.5	0.019	0.020	0.020
21.0	0.023	0.024	0.024
24.5	0.026	0.027	0.027
28.75	0.029	0.030	0.030

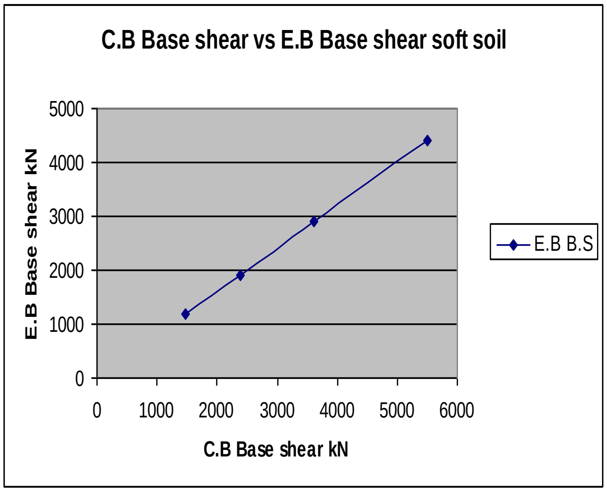
Comparision of concentric base shear and eccentric shear :
a) hard soil



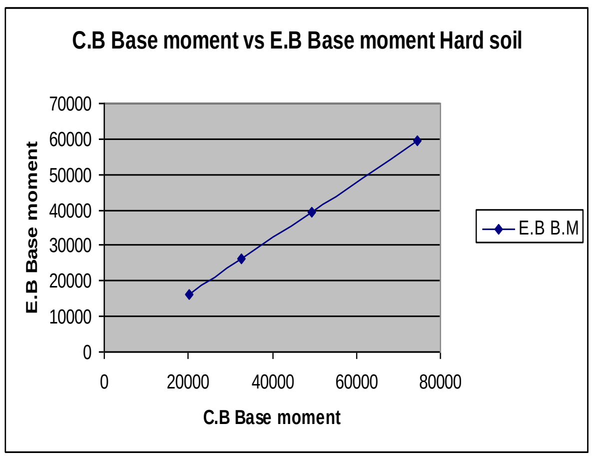
b) Medium soil



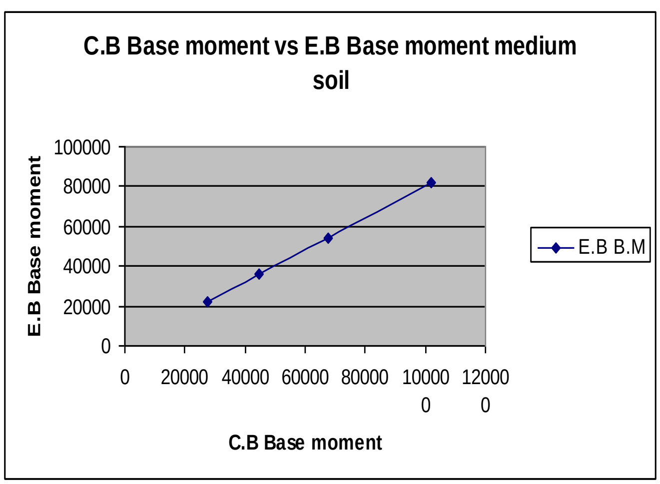
c) Soft soil



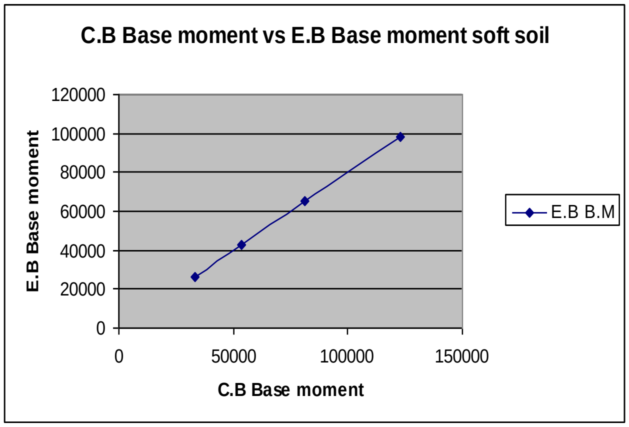
Comparison of base moment values of concentric bracing and eccentric bracing:
a) Hard soil



b) Medium soil



c) Soft soil



DISCUSSION

Percentage of base shear reduction:

A) Hard soil:

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone II in utilization of EBS than CBS is 19.8%.

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone III in utilization of EBS than CBS is 20.01%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone IV in utilization of EBS than CBS is 19.84%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone V in utilization of EBS than CBS is 19.90%.

B) Medium soil:

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone II in utilization of EBS than CBS is 20.04%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone III in utilization of EBS than CBS is 19.82%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone IV in utilization of EBS than CBS is 20.10%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone V in utilization of EBS than CBS is 19.83%.

C) **Soft soil:**

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone II in utilization of EBS than CBS is 19.95%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone III in utilization of EBS than CBS is 20.14%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone IV in utilization of EBS than CBS is 19.68%

The percentage of reduction of base shear for the considered (15x15)m area and G + 8 building for zone V in utilization of EBS than CBS is 20.07%.

The response values for concentric bracing considered is 4 and for eccentric bracing is 5 where seismic coefficient is calculated for different soil conditions and for zone conditions are per IS :1893(PART I) : 2002, clause 6.4. Highest seismic coefficient was observed in concentric bracing soft soil zone V condition of 0.112 which enhances the seismic weight of the building which is directly proportional to the lateral force condition.

The fundamental frequency for concentric bracing system and eccentric bracing system is 0.65sec which is constant with respect to height and width of the considered building.

Column length of the building is kept constant, equal to the floor level of the building hence the change is made in depth and width of the columns. The peak column size observed is for eccentric bracing system of zone v soft soil condition of (400 x 400)mm which is 60% high in dimension when compared to the least dimensions of the column in concentric bracing system size of (314 x 307)mm. When compared to column sizes of concentric sizes to eccentric sizes the size of columns is high in ratio than concentric bracing, where economical aspect failure will occur when compared with material cost consumption of the building size.

In dimensions of the bracing systems of both the methods there is nearly equivalence in the dimensions of the bracing systems in similar zones and soil conditions of the building. The highest dimensions obtained are (0.28 x 0.28 x 0.0168)m of depth, width, thickness respectively for concentric bracing soft soil zone v and eccentric bracing soft soil zone v for considered conditions.

For concentric bracing and eccentric bracing systems for zones V, IV, III,II and for hard soil, medium soil, soft soil the percentage of drift and seismic force in safe condition are derived, the results generated are made as per safe condition stated by result should be less than 100%.

The highest frame line self weight is for eccentric bracing soft soil zone v condition and for concentric bracing soft soil zone v condition of 547kN and 539kN respectively. The change pattern of slenderness ratio to self weight of the bracing system can be observed through graph where low slenderness ratio was observed of eccentric bracing soft soil zone V and high slenderness ratio was observed for concentric bracing hard soil zone II condition.

The analysis of the considered G + 8 building was made by use of Resist software designed for research purpose by Govt. Of India and was supplied by NPEEE program.

By use of this software a detail study in safety of the buildings can be done for earthquake resisting systems like shear walls, moment resisting frames, bracing systems. This work was made by the use of steel cross braced frames of concentric bracing type and eccentric bracing type. For both concentric bracing system and eccentric bracing system, floor width was kept constant at 2.0m.

Analysis of the building was made subject to earthquake forces as per IS :1893 (PART :1):2002, for zones II, III, IV, V and for soil conditions of hard soil, medium soil, soft soil. This considered G + 7 multi storied building analysis was done in consideration of concentric bracing system and eccentric bracing system.

CONCLUSION

For study and analysis in concentric bracing system bay length of concentric bracing is kept at 7m of constant value and floor width of 2.0m as constant value. By increase of severity of earthquake forces from zone II to Zone V for all soil conditions of hard, medium, soft by changing the depth and width of bracing system the safe condition of the building was observed in the considered software.

In consideration of eccentric bracing system of building, bay length of 6m and floor width of 2.0m was kept constant and analysis of building was similar as concentric bracing for eccentric bracing for all zones of II to V with soil conditions hard, medium and soft soil. In comparison of zone II for concentric bracing and eccentric bracing the depth to width have a change of increase of dimensions from 170 x 170 (mm) to 200 x 200 (mm) depth to width was observed as safe for all soils.

In comparison of zone III of concentric bracing system, eccentric bracing system there is no change in dimension of bracing systems for safe conditions when subjected to earthquake zone intensities.

For zones IV and zones V there is a change in dimensions of bracing systems in hard soil and medium soil of (210 x 210)mm and (230 x 230)mm to (200 x 200)mm and (250 x 250)mm for zone IV and zone V to hard soil respectively. And for medium soil of zone IV is 230 x 230 mm to 220 x 220 mm for medium soils and for zone V (250 x 250) mm and 260 x 260mm for concentric bracing and eccentric bracing respectively. But similar in soft soil conditions of (240 x 240) mm for zone IV in soft soil and (280 x 280) mm for zone V in soft soil conditions.

Hence in dimensions of bracings the similarity lies in zone III and for all zones in soft soil conditions of use of concentric bracing and eccentric bracing system.

When compared to base shear the change of base shear from use of concentric bracing and eccentric bracing is in form of reduction of 19% to 20% and hence the use of eccentric bracing is safe as the effect of base shear is nearly 19% to 20% less when compared to concentric bracing to eccentric bracing systems.

Use of concentric bracing system can increase ductility and also permits to buckle elastically in compression zone. Drift observed in all the case is less by providing bracing systems but this drift when needed can also be minimized by increasing horizontal stiffness. Flexural actions in beams and columns of the considered building are negligible, using the retrofitting technique of concentric bracing and eccentric bracing. If slip occurs at worst condition of application of seismic load, flexural action in structural members can be observed.

When compared with bracing size of the building with concentric and eccentric the drift is minimized in concentric bracing system for all the zones are soil conditions. From the performance of concentric bracing and eccentric bracing system from the project, it can be concluded that the use of bracing systems can be effectively used in moderate conditions of earthquake as the moments observed in zone V are much high than the remaining regions.

Response reduction value of R = 4, for concentric bracing and R = 5 for eccentric bracing of Indian standard considered are much higher than the response values of AISC provisions. From the results there is a need to study the ductility performance of the bracing systems of the building, the dimensions of the braces generated in resist software.

Lateral displacement of the structures can be greatly reduced when compared with structures which are not made with earthquake resisting systems. Eccentric bracing system provides a unique combination of increasing ductility, stiffness and strength making the structures safer for lateral loads.

Hence the use of EBS is more economical and safe than concentric bracing system, the statement was made in consideration of the length of the bracing system, dimensions of the bracing system, base moment, base shear, drift parameters for the floors calculated with use of RESIST software and stated.

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