Influence of Bracings on the Seismic Behavior of RC Framed Irregular Structures

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Abstract - *In general, earthquake is the main cause of damage of structures. During earthquake many buildings collapse mainly due to the presence of irregularity in the building. The irregularities in the buildings are commonly due to architectural, functional and economic concept. To strengthen the structure the bracings are provided which resists the lateral forces. Hence it is necessary to analyze the response of irregular structure subjected to seismic forces. In present work the G+9 storey RC framed structure is analyzed by response spectrum and time history method. The five structural configurations are used for this study as Regular, IRR1, IRR2, IRR3 and IRR4. The models are analyzed for response of irregular structure compared to regular structure subjected to seismic loads. The RC framed models are analyzed for structure with and without bracings. The X bracing, V bracing and K bracings are used in this study. The analysis of RC framed structure with and without bracing is carried out using ETABS software. The main parameters considered in this paper to compare the seismic performance of the structure by response spectrum method are modal period, storey shear, displacement and drift. The parameters considered in the time history method are base shear, joint displacement and column force. From the analysis, use of X bracing to all models is found more effective compared to V bracing and K bracing.*

Key Words: Seismic performance of irregular structures, Response spectrum method, time history method, bracing.

1. INTRODUCTION

We know that compared to all natural or manmade disasters the earthquake are the most dangerous and life harming phenomenon ever. Recent earthquakes showed that many RC framed structures have been collapsed, which focuses on the requirement to concentrate on the seismic resistance of structures. The main reason of the structural damage is irregularity in building. A building which is not regular in geometry, symmetry or mass is called as irregular building. The irregularities in the buildings are commonly due to architectural, functional and economic concept. In these days construction of irregular building became a new challenge to an engineer which has higher seismic risk compared with regular buildings. In most cases irregularities are categorized as horizontal and vertical.

A Bracing element is necessary to minimize the lateral deflection of structure caused due to earthquakes. The braced frames are used to resist lateral forces formed due to the earthquake and wind force. In this the frames are designed such that it works in tension as well as compression forces. These frames are composed of steel and concrete members.

2. MODELLING

In the present study, an attempt is made to quantify the influence of irregularity on the seismic behavior of RC framed structures and its possible strengthening using different types of bracing. For this purpose reinforced concrete frame building of G+9 storey is considered. The four different irregular structures with three different types of bracings are modelled and analyzed using ETABS software. The method used for analysis is time history and response spectrum method. Structural data assumed during analysis is as follow Table.1. Structural details of the model

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Number of storey	10
Storey height	3.5m
Number of Bays	6 bays in both directions
Spacing of Bays	5m in both direction
Beam Size	230x500 mm
Column size	500x750 mm
Bracing size	350x350 mm
Grade of Materials	M25 and Fe 500
Slab Thickness	150mm
Live load for floor	4 kN/m^2
Live load for roof	1.5 kN/m^2
Floor Finish	1.5 kN/m^2
Seismic Zone and Soil Type	Zone II and Medium Type soil
Response Reduction Factor	3

The bare frame models considered are described as following

1. Regular: Building model considered is symmetrical and regular in both the axis.
2. IRR1: Building model is in L shape configuration
3. IRR2: Building model is in T shape configuration
4. IRR3: Building model is in setback configuration. Setback provided is different for each storey.
5. IRR4: Building model is soft storey. Soft storey is provided at the bottom 1st storey.

The 3D view of all models are shown below

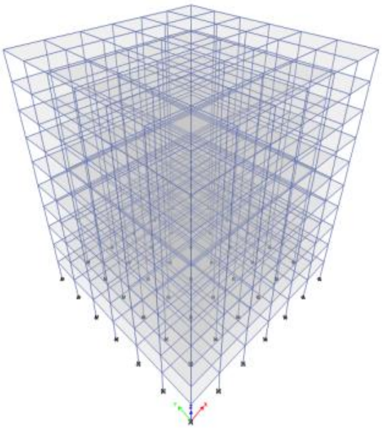


Fig.1. Regular model

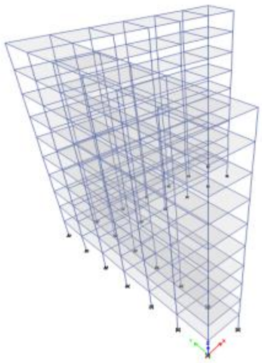


Fig.2. IRR1 model

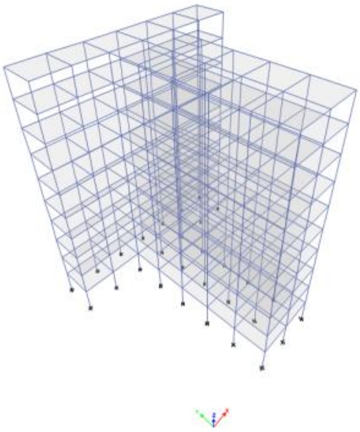


Fig.3. IRR2 model

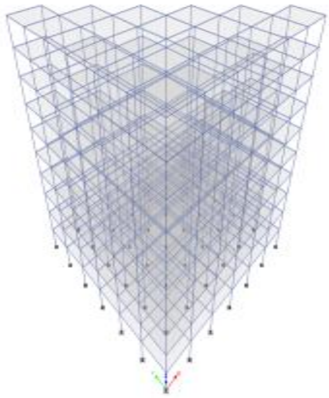


Fig.4. IRR3 model

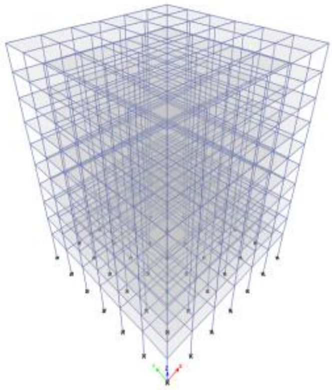
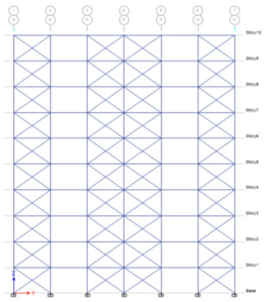
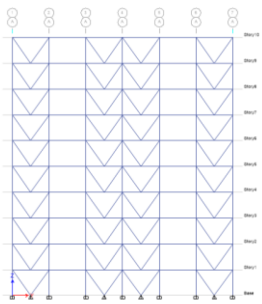


Fig.5. IRR4 model

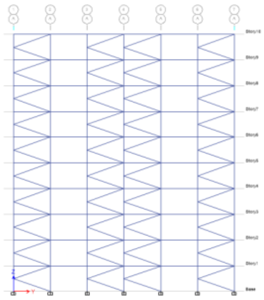
The analysis is carried out for the bare frame as well as for the braced frames by considering X, V and K type bracing for the same model configuration described above. The regular building elevation views with different types of bracings are shown below.



a)



b)



c)
Fig.6. Regular model with a) X bracing, b) V bracing c) K bracing

Similarly, this bracing pattern is followed by other irregular models, such as IRR1, IRR2, IRR3 and IRR4. The bracings are provided considering the irregularity of the structure such as

- For IRR2 (L shape) and IRR3 (T shape) structure the bracings are provided mainly at the re-entraint corners.
- For IRR3 (Setback building)) structure bracings are provided at the setback area.
- For IRR4 structure bracings are provided at weak storey i.e. at the bottom storey and at the corners of the structure.
- Economy of the structure is also considered while providing bracings.

3. RESULTS AND DISCUSSIONS

The bare frame models of 5 different configurations such as Regular, IRR1, IRR2, IRR3 and IRR4 are analyzed. Later X, V and K bracings are applied to strengthen the structures. The results are compared for structures with and without bracings for all models. The results are basically compared to find which type of bracing will be more effective for different irregular structures.

A. *Response Spectrum Analysis*

The results of analysis compared include modal periods, storey shear, displacement and storey drift in x direction and y direction.

i. *Modal periods*

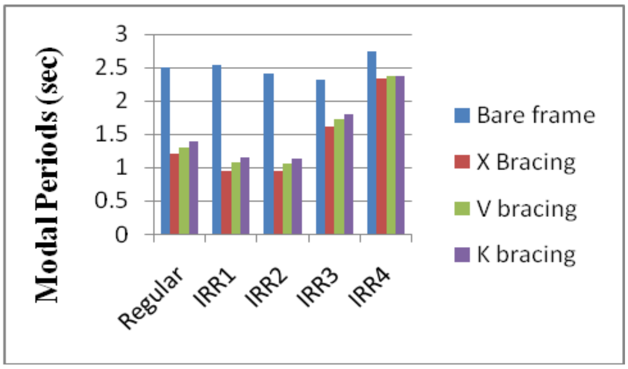


Fig.7. Result comparison of Modal periods

From above figure it is observed that, in bare frame models longest time is found at IRR4 model. It takes 2.737 sec while the Regular model does 2.49 sec. In case of models with bracings the X bracing is showing least time compared to other bracings. It can be conclude that application of bracings to the structure decreases with the time of mode shapes.

ii. *Storey Shear*

The storey shear is a function of mass and stiffness of the structure. The base shear is compared for regular and irregular structures with and without bracings in x and y directions as shown in Fig.8 and Fig.9 respectively.

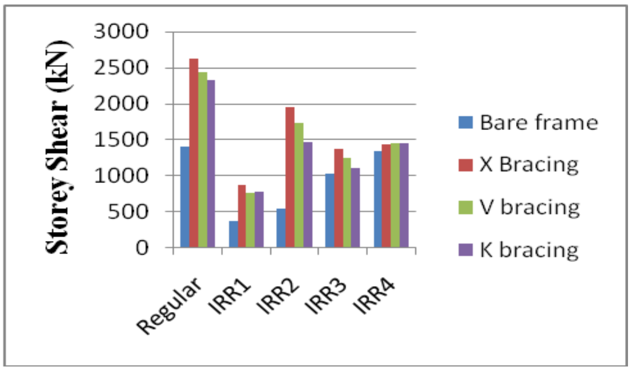


Fig.8. Comparison of storey shear in x direction

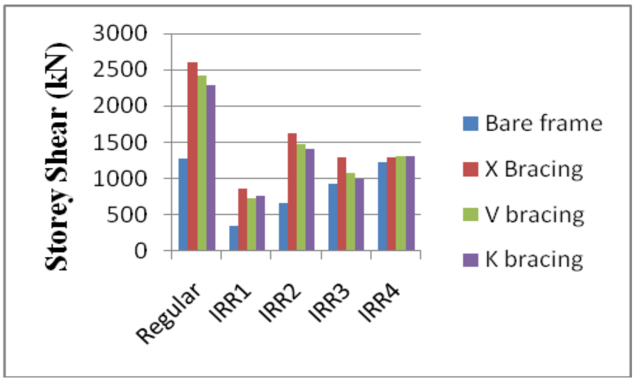


Fig.9. Comparison of storey shear in y direction

Above figures shows that Regular model has the higher storey shear because of its higher mass whereas IRR1 has the least storey shear compared to other structures, because of higher time period and lesser seismic weight. The X bracing has lesser displacement in both directions compared to other bracing systems.

iii. Displacement

Storey displacement is the lateral movement of the structure caused by lateral forces. The deflected shape of the structure is most important and most clearly visible point of comparison for any structure.

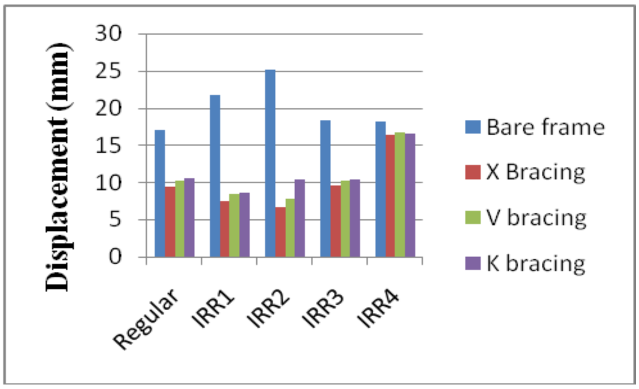


Fig.10. Comparison of displacement in x direction

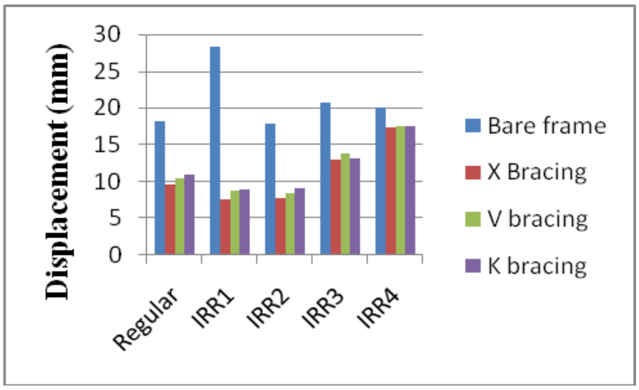


Fig.11. Comparison of displacement in y direction

Fig.10 and Fig.11 present that the IRR2 model has 46.78% more displacement in x direction and IRR1 model has 55.5% more displacement in y direction compared to Regular model. In bracing systems X bracing has least displacement in x as well as in y direction.

iv. Storey drift

In this study, storey drifts are expressed as a percentage of storey height. Damage to non-structural components of buildings depends on drift. The following figures illustrate the storey drift in x and y direction respectively.

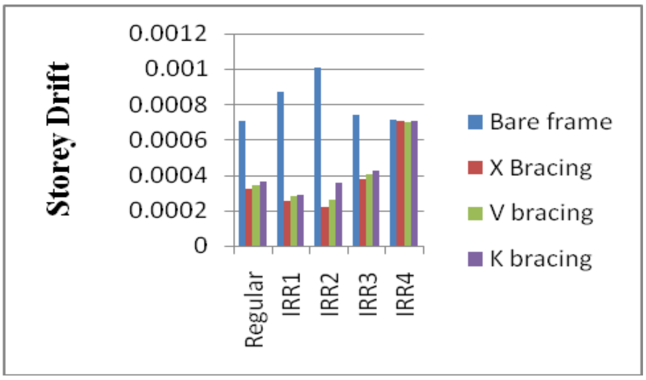


Fig.12. Comparison of storey drift in x direction

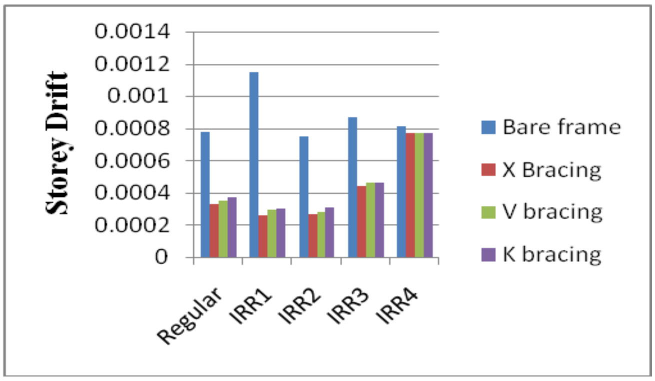


Fig.13. Comparison of storey drift in y direction

From the above Fig.12 it is observed that IRR2 has 57.14% more storey drift compared to Regular model and Fig.13 present that IRR1 has storey drift 2 times compared to Regular model. The models with X bracing have less drift compared to other bracings.

B. Time history analysis

The parameters considered for the comparison of results in time history analysis include base shear, joint displacement and column force.

1) Base shear

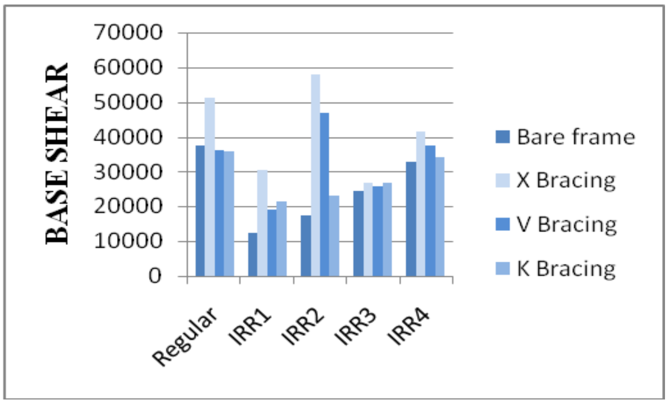


Fig.14. Comparison of base shear

From Fig.14 it is observed that base shear is higher for regular structure compared to irregular structure. It can be observed that in case of irregular structures IRR4 model has higher base shear. The IRR1 model has 67.2% less base shear, IRR2 has 53.37% lesser base shear, IRR3 has 35% less and IRR4 has 12.4% lesser baser shear compared to Regular model. The X bracing models have 50% higher base shear compared to bare frame models.

2) *Joint displacement*

For all models one common joint is selected to represent the displacement and for this Joint displacement is taken for column 7 of 10th storey.

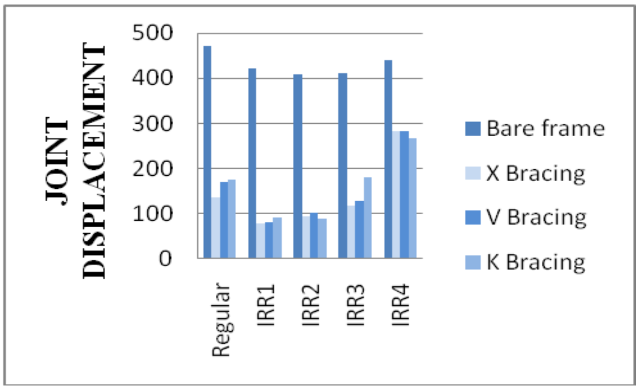


Fig.15. Comparison of joint displacement

From Fig.15 it is observed that the Regular model has more displacement compared to other models. The models with X bracing have least displacement except in IRR4 model. The IRR4 model with K bracing is showing least displacement.

3) *Column Force*

Column selected for comparison of column force is column 7 of first storey.

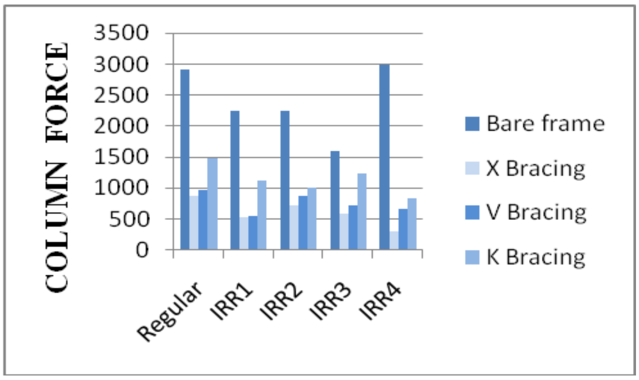


Fig.16. Comparison of column force

From Fig.16 it is observed that IRR4 model has higher column force compared to other models. In case of bracings X bracing has lesser column force while compared to other type of bracings.

4. CONCLUSION

The response spectrum and time history analysis of G+9 storey building for regular and irregular configuration with and without bracings concludes the following.

1. Structural irregularities affect the performance of the building.
2. Mode shape of IRR4 (soft storey) model takes more time than regular model.
3. Base shear of irregular configured structure is less compared with the regular building. Base shear is also affected by the seismic weight of the structure which is seen in IRR1 (T shape) model. The IRR1 model has the least base shear compared to other models.
4. Displacement and storey drift increases as the amount of irregularity present in the building increases.
5. Introduction of irregularities alters the force distribution in columns.
6. Addition of bracings to the bare frame models shows reduction in time period, displacement and storey drift.
7. Base shear of all bare frame models increased with the application of bracings to the structures.
8. Use of X bracing to all models is found more effective compared to V bracing and K bracing.

REFERENCES

1. Jagadeesh B N, Mahesh Kumar C L, Dr. Prakash M R, Venkatasubbaiah, "Seismic response of steel structure with concentric bracing system" International journal of processes in engineering, management, science and humanities, ISSN(print):2395-7786,(online):2395-7794, Volume-1, Issue-2,2015.

2. Hossein Naseri, Mohammad Moavi, "Seismic performance evaluation of plan irregular steel structures with buckling restrained brace and eccentrically braced frames under near fault earthquake" International journal of biology, pharmacy and allied sciences: IJBPAS, December 2015.4(12),Special Issue:1239-1246, ISSN:2277-4998.

3. Arun kumar, Ajay S C, Khushpreet Singh, Aditya Tiwari, "Invetigation of seismic performance on existing buildings, a case study" Journal of mechanical and civil engineering IOSR, e-ISSN: 2278-1684, p-ISSN: 2320-334X, 2014.

4. Thi ThiHein Lwin, Kyaw Lin Htat, "Study on effect of high rise steel building with different masses"

International journal of science, engineering and technology research (IJSETR), Volume4, issue7, July 2015.

5. Bhavya B S, Jisha P, "Seismic evaluation of rc unsymmetrical building with floating columns and soft storey considering different configuration" International journal of innovative research in science, engineering and technology, volume 5, Issue 8, august 2016.

6. S. Varadharajan, V. K. Sehgal and B. Saini, "Review of structural irregularities in buildings" Journal of structural engineering, Volume 39, no.5, pp. 393-418, no.39-51, January 2013.

7. IS 1893 (part 1)-2002, "Criteria for earthquake resistant design of structures"- part 1 general provision and buildings', 5th revision, 2002, bureau of Indian standards, New Delhi, India.

8. S. Varadharajan, V.K.Sehal and B.Saini, "Review of different structural irregularities in buildings", Journal of structural engineering, vol. 39, No. 5, Dec 2012-Jan 2013, pp.393-418, No 39-51.