Effects of Different Types of Bracings on RCC Building Under Earthquake Loads

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ABSTRACT

Earthquake is a natural disaster that society has been aware of for a long time. In the past, experts have explored many methods to protect buildings. Multistorey reinforced concrete buildings are subjected to excessive deformation due to lateral loads, which needs the implementation of unique methods to limit this deformation. One of the lateral loads opposing frameworks in multistorey structures is the steel bracing. By increasing the structure's rigidity and stability, the steel bracing system improves the structure's resistance to lateral loads. Steel bracing is affordable, easy to install, takes up less space, and may be designed to fulfil the necessary strength and stiffness requirements. In the current work, the seismic analysis of a multistorey reinforced concrete building with various forms of bracing, including diagonal, V, chevron, and X bracing, is investigated. The bracing is provided for middle bays of peripheral columns of building model. For this analysis of work G+10 building is analysed for seismic zone III and IV in accordance with IS 1893:2016 using ETABs software. Story Displacement and Story drift were compared using graphs for bare frame and different types of bracing. It has been found that for X bracing decreased the deflection significantly and increases structural rigidity of the frame.

Keywords:- Steel Bracing, ETABs, Seismic Analysis etc.

1. INTRODUCTION

India is now a fast-developing nation, and as a result, there is a desire for more infrastructure amenities to keep up with population expansion. Population growth has led to an increase in the need for housing land, which is growing daily. The only way to meet the demand for land for homes and other commercial structures is through vertical development in the form of multistorey building.

As these multistorey buildings are so prone to additional lateral loads from earthquakes and winds, this form of development necessitates safety. In general, as the elevation of structure increases, its reaction to lateral stresses increases. These lateral forces could result in the structure experiencing critical stresses, unfavorable vibrations, or excessive lateral sway. Therefore, it is crucial that the structure has enough strength to withstand vertical loads in addition to having enough stiffness to resist lateral stresses [3].

One of the most effective ways to protect reinforced concrete multistorey buildings against horizontal stresses like seismic and wind forces is to install steel bracing systems. Different types of bracings are X bracing, V bracing, chevron bracing and diagonal bracing. Bracing members experience tension and compression; as a result, they are designed to withstand these forces[1]. The addition of steel bracing to RC multistorey buildings increases their stiffness and strength and decreases deformation. Bracings increase a structure's stiffness while minimising story displacements, story drifts, etc.

The frame's beams and columns support vertical loads, while the bracing system supports lateral stresses. The primary goal of this research is to withstand the earthquake forces by designing stable seismic resisting R.C. structures. The different types of bracing are used to study the seismic behavior of G+10 RC structure with and without Bracings under earthquake loads using ETABs software.

1.1 Related work

Shachindra Kumar Chadhar and Dr. Abhay Sharma (2015): They used StaadproV8i software and the linear static method to analyse a G+15 story building in accordance with IS 1893:2000. For the building, V-type and inverted V-type bracing were utilised. They came to the conclusion that the building's seismic performance is significantly impacted by the way the bracing systems are arranged. When compared to V type bracing, the inverted V bracing system greatly reduces the bending moment and shear forces [1].

Adithya M. and Dr. Ramesh B.R. (2015): In order to identify the most effective bracing system, the researcher in this work introduced numerous forms of bracing systems, including X bracing, V bracing, and Inverted V bracing Systems in steel structures. These systems were then analysed using time history analysis using ETAB software. After comparing a number of seismic factors, the researcher came to the conclusion that in comparison to concentric X bracing and eccentric V bracing systems, the lateral story displacements are significantly reduced by the employment of single diagonal bracings structured as a diamond shape in the third and fourth bay [2].

1.2 Objectives

The main objectives of this project are:

- To investigate how a bracing system effects a G+10 RCC building during an earthquake.
- To compare how lateral loads affect braced and unbraced buildings in seismic zone III and IV.
- To study how structure respond in terms of story displacement and story drift.
- To find best bracing system to effectively resist earthquake loads.

2. METHODOLOGY AND MODELLING

2.1 Methodology

The following methodology is used to accomplish the stated objectives:

1) Using the ETABs 2017 software to model the selected building.
2) Modelling building with different types of bracings placed at middle bays of peripheral columns.
3) Application of all seismic characteristics and loading requirements in accordance with IS 1893:2016 code.
4) After analysing all the models under seismic loads, we compared results and found the most suitable bracing system.

2.2 Modelling and analysis OF G+10 story building

The different types of bracing are used to study the seismic behavior of G+10 floors building with and without Bracings under earthquake loads using ETABs software. For seismic analysis response spectrum method is used as per IS 1893:2016.

The structural data for building is as follows:

- Plan dimension = 20m X 20m
- Number of stories = 11
- Height of building = 33 m
- Height of each story = 3 m
- Type of building = Residential
- Structure = OMRF
- Soil type = Medium
- Beam Size = 300 X 500 mm
- Column size = 600 X 600 mm
- Slab thickness = 150 mm
- Internal wall thickness = 115 mm
- External wall thickness = 230 mm
- Live load = 3 kN/m^2
- Floor finish = 2 kN/m^2
- Unit weight of brick = 20 kN/m^3

- Unit weight of concrete = 25 kN/m^3
- Grade of concrete = M30
- Grade of steel = Fe 500
- Seismic zone, (Z) = III and IV
- Importance factor, (I) = 1
- Response reduction factor, (R) = 5

Different types of models used for analysis are:

1) Model-1: RC Frame without Bracings model.
2) Model-2: RC Frame with X Bracings placed in the center.
3) Model-3: RC Frame with V Bracings placed at the center.
4) Model-4: RC Frame with Chevron Bracings placed at the center.
5) Model-5: RC Frame with Diagonal Bracings placed at the center.

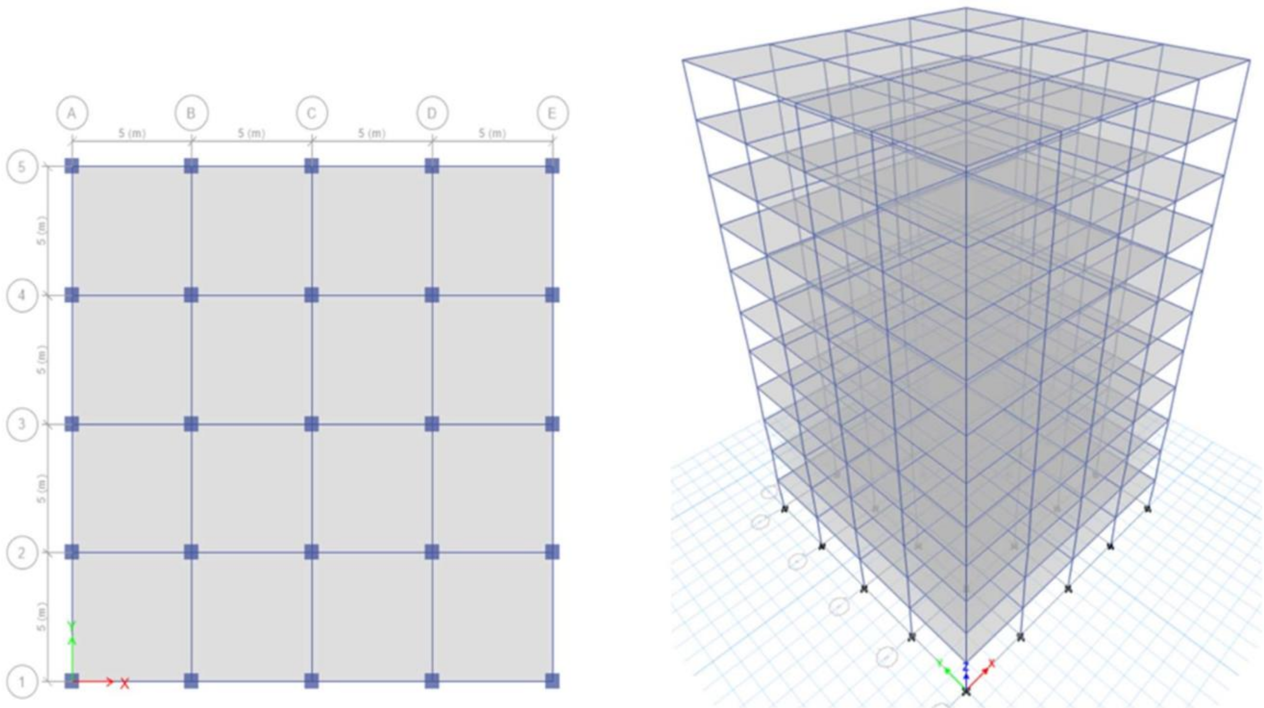

Fig -1: Typical floor plan and 3d view of structure

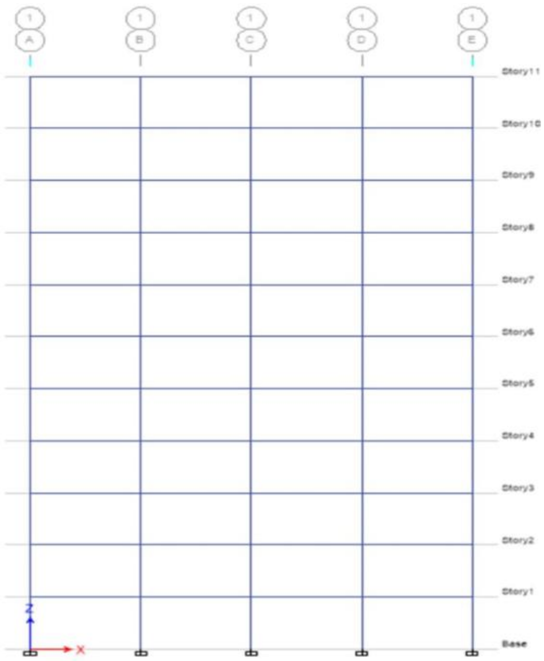

Fig -2: Elevation of without braced model

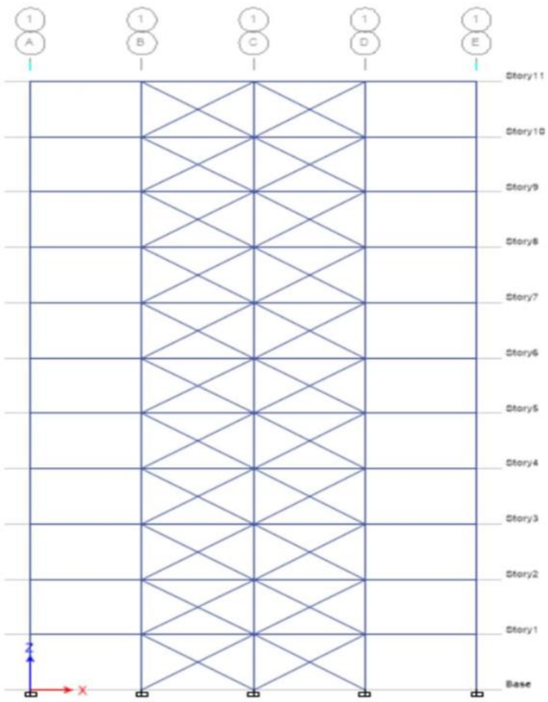

Fig -3: Elevation of X braced model

ISSN: 2456-236X
Vol. **08** Special Issue **01 | 2023**

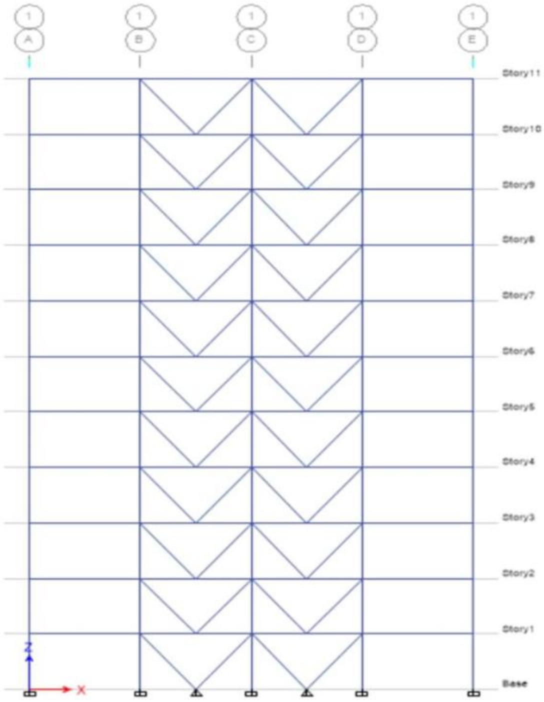

Fig -4: Elevation of V braced model

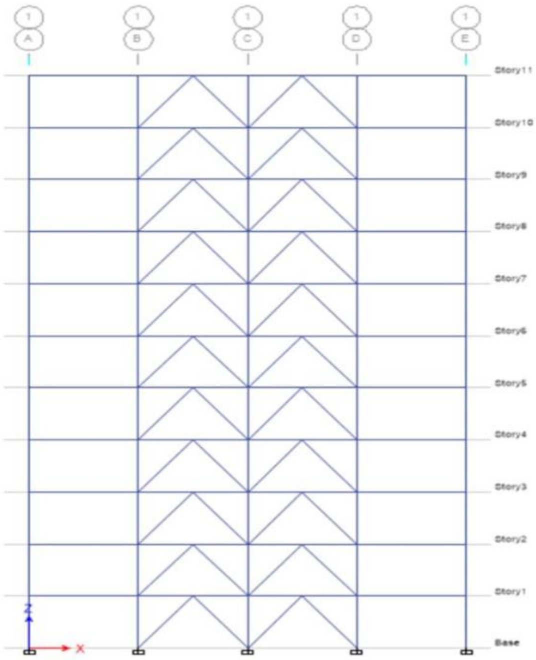

Fig -5: Elevation of chevron braced model

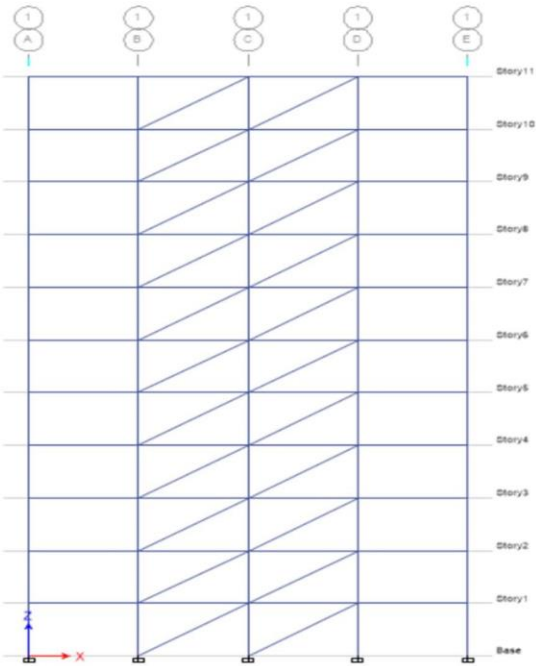

Fig -6: Elevation of diagonal braced model

3. RESULTS AND DISCUSSIONS

3.1 Comparison of seismic performance of Models with Different types of Bracing system in seismic zone III and IV (taken x-directional results of all response spectrum cases)

a) Story Displacement:

The variation in story displacement for different types of braced buildings is shown in the following graphs.

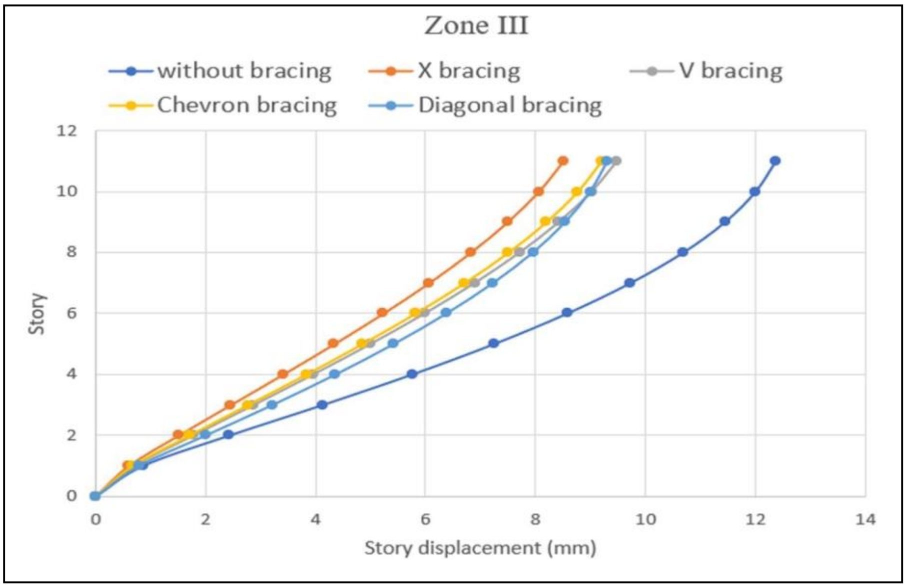

Fig -7: Comparison of story displacement of different types of bracing models in seismic zone III

International Journal of Interdisciplinary Innovative Research &Development (IJIIRD)
ISSN: 2456-236X
Vol. **08** Special Issue **01 | 2023**

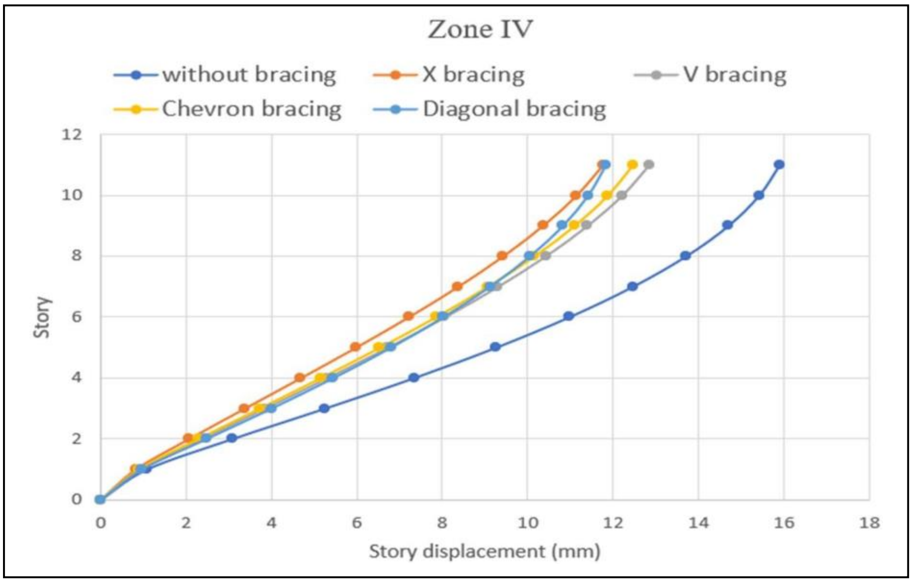

Fig -8: Comparison of story displacement of different types of bracing models in seismic zone IV

b) Story Drift:

The variation in story drift for different types of braced buildings is shown in the following graphs.

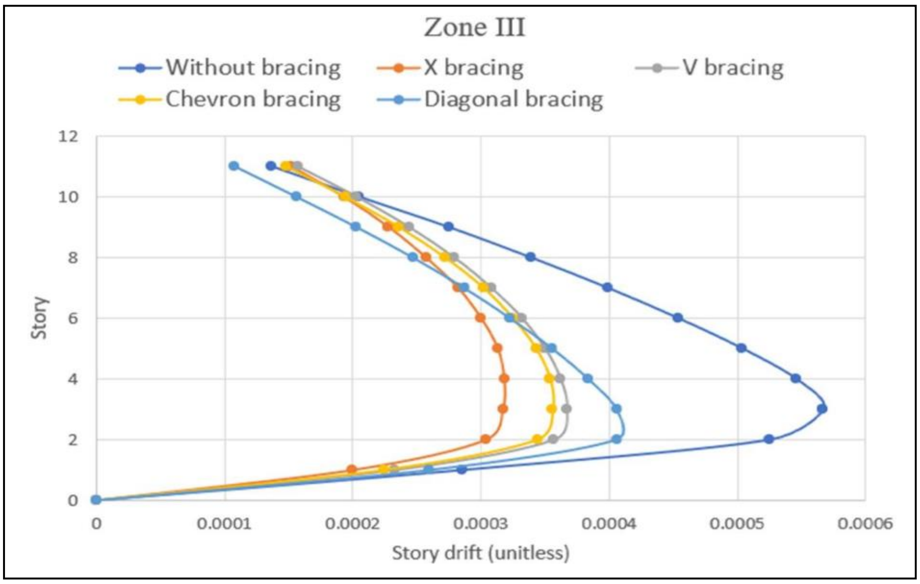

Fig -9: Comparison of story drift of different types of bracing models in seismic zone III

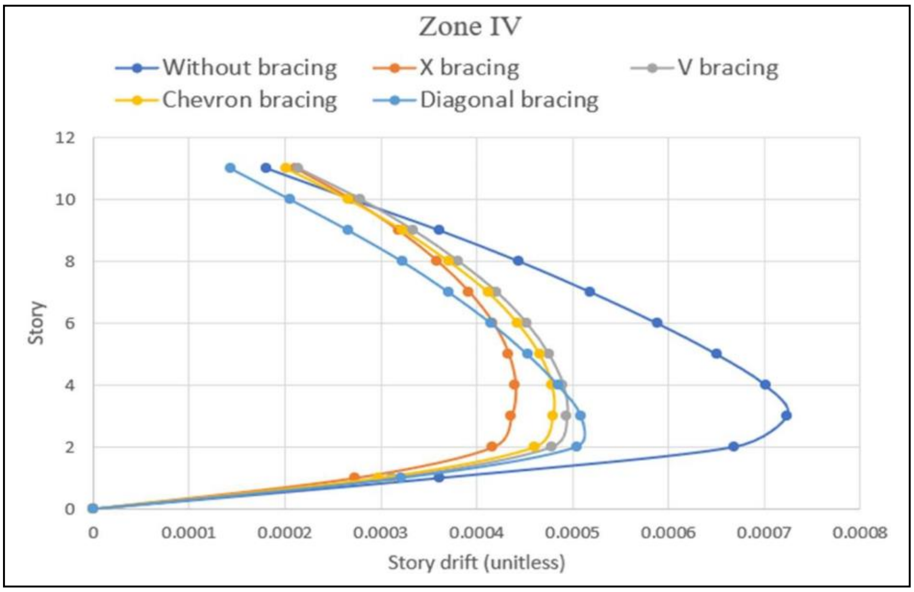

Fig -10: Comparison of story drift of different types of bracing models in seismic zone IV

3.2 Discussions:

1. In seismic zone III, maximum story displacement of a regular building is reduced by 31.3%, 23.39%, 25.74%, and 24.77% by using X bracing, V bracing, chevron bracing and diagonal bracings respectively.
2. In seismic zone IV, maximum story displacement of a regular building is reduced by 26.04%, 19.28%, 21.73%, and 25.61% by using X bracing, V bracing, chevron bracing and diagonal bracings respectively.
3. In seismic zone III, maximum story drift observed between 2nd to 4th story of a regular building is reduced by 42.65%, 33.65%, 35.62%, and 26.91% by using X bracing, V bracing, chevron bracing and diagonal bracings respectively.
4. In seismic zone IV, maximum story drift observed between 2nd to 4th story of a regular building is reduced by 38.19%, 30.10%, 32.12%, and 28.35% by using X bracing, V bracing, chevron bracing and diagonal bracings respectively
   Note: The story drift is dimensionless element = Actual Drift (Δ1- Δ2)/ Story height

4. CONCLUSIONS

From the above study it is concluded that:

- One of the helpful ideas that can be used to reinforce or retrofit existing structures is steel bracing. Strengthening existing structures is preferable than replacing them from a financial perspective and for immediate housing needs.
- In seismic zones III and IV, the X type of steel bracing is proven to be more effective than the other bracing kinds, such as V bracing, diagonal bracing chevron bracing.
- The lateral drift and story displacement is greatly decreased by adding bracing to the building structure, which shows that the building's stiffness has increased.
- The margin of safety against collapse increased after employing the bracing component as a resistive member.

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