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Seismic Response of Multi-Storey Building Equipped with Steel Bracing

Rahul D. Sapkale

Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur, India

***Abstract*— *Steel bracing has proven to be one of the most effective systems in resisting lateral loads. Although its use to upgrade the lateral load capacity of existing Reinforced Concrete (RC) frames has been the subject of numerous studies, guidelines for its use in newly constructed RC frames still need to be developed. In this paper the study reveals that seismic performance of moment resisting RC frames with different patterns of bracing system. The three different types of bracings were used i.e. X - bracing system, V - bracing system and Inverted V - bracing system. This arrangement helped in reducing the structural response (i.e. displacement, interstorey drift, Shear Forces & Bending Moments) of the designed building structure. An (G+6) storey building was modelled and designed as per the code provisions of IS-1893:2002. And linear analysis is been carried out in the global X direction. The analysis was conducted with a view of accessing the seismic elastic performance of the building structure.*

Keywords*— *Braced frame, Linear analysis, Storey Displacement, Storey Drift, Unbraced Frame.

I. INTRODUCTION

Braced steel frames are commonly used to resist lateral loads. Their design guidelines are readily available [1]. The use of bracing to upgrade the seismic capacity of existing RC frames has been the subject of several research investigations over the past three decades. Two bracing systems are typically considered: external bracing and internal bracing. In order to strengthen concrete structures against lateral and seismic loading, the designers generally tend to lighten the total weight of structures, as well as strengthening them with shear walls, steel or concrete jackets or fibre reinforced polymer layers, external pre-stressing, and other popular means of bracings. The logical arrangement of steel bracings in plan and levels has a great influence on the response and on the lat lateral displacement of structures. In the case of braces with high slenderness ratios and while they are in tension, the system may experience excessive horizontal or vertical deformations before failure of the joints. On the other hand if the bracing members are in compression, lateral deflection may easily occur; and regarding the possibility of occurrence of plastic deformations, the structures' hysteresis curves become unstable. Bracings with medium slenderness ratios have a brittle behaviour, and thus, when in compression, would not provide enough stiffness to contribute against lateral loads [2].

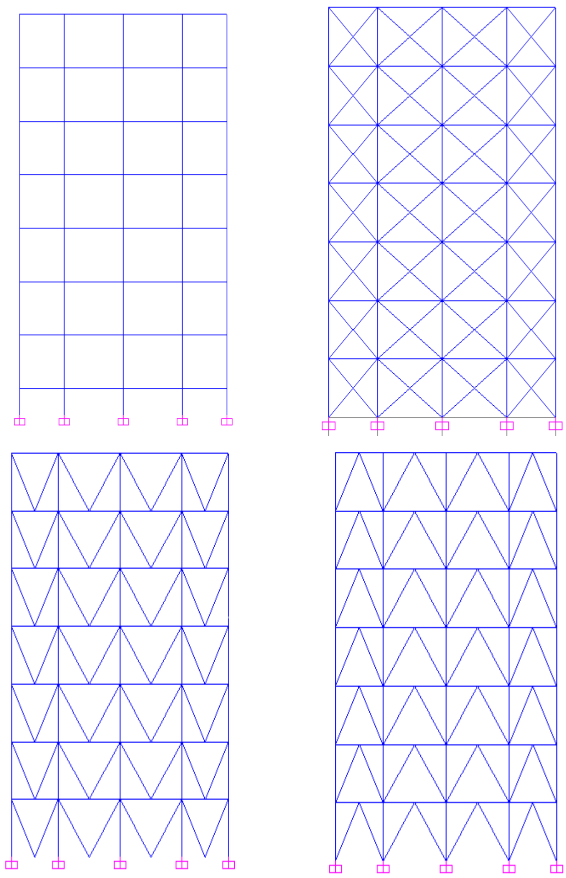

Fig. 1:- Unbraced and different types of Braced Model

The aim of this research is to evaluate the performance and strengthening of RC frame structures with bracing members. At first, different type of bracing members is studied by considering a variety of models having different geometrical properties and characteristics. In the second stage, two RC frame structures unbraced and braced are designed and analysised. Then using the results obtained from analysis suitable frame with less displacement, Drift, etc. result is selected for the structure.

II. DESCRIPTION OF BRACING SYSTEM

Braced frames are a very common form of construction, being economic to construct and simple to analyse. Economy comes from the inexpensive, nominally pinned connections between beams and columns. Bracing, which provides stability and resists lateral loads, may be from diagonal steel members or, from a concrete 'core'. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. A Braced Frame is a structural system which is designed primarily to resist wind and earthquake forces. Members in a braced frame are designed to work in tension and compression, similar to a truss. Braced frames are almost always composed of steel members. Following fig. 2 show the different types of bracing system use to braced the structure.

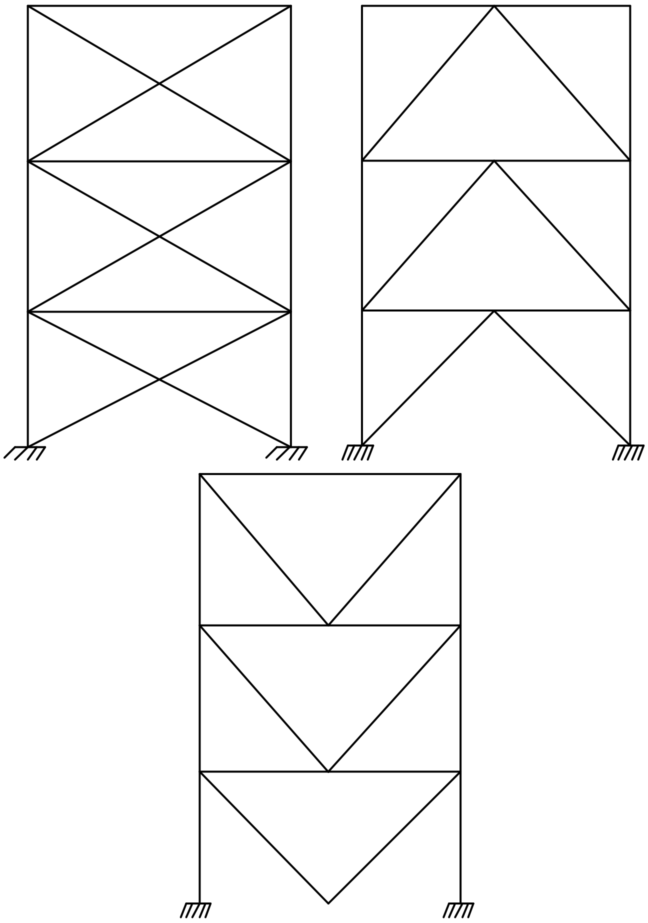

Fig. 2:-Different types of bracing

III. LINEAR ANALYSIS

Once the structural model has been selected, it is possible to perform analysis to determine the seismically induce forces in the structure. There are different methods of analysis which provide different degree of accuracy. The analysis process can be categorized on the basis of three factors

a) Type of external load applied
b) Behaviour of structure/structural element
c) Type of structural model selected

The analysis can be further classified as under linear static analysis, linear dynamic analysis

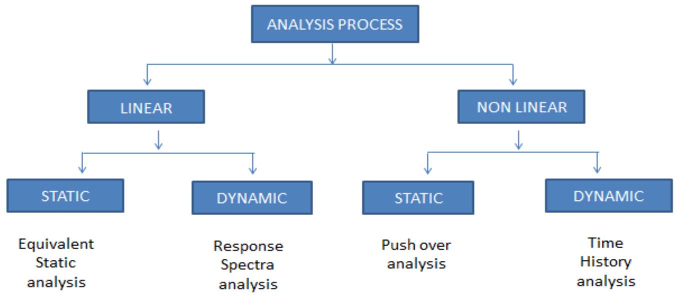

Fig.3: Different Types of Analysis

3.1 Linear Analysis:

Linear static analysis or equivalent static analysis can only used for regular structure with limited height. Linear dynamic analysis method can be performed in two way either by mode superposition method or response spectrum and elastic time history method. This analysis will produce the effect of higher mode of vibration and the actual distribution of forces in elastic range in better way. They represent an improvement over linear static analysis. The significant difference between linear static and dynamic analysis is the level of force and their distribution along theheightof structure.

a) Linear equivalent static analysis
b) Linear dynamic analysis

3.1.1 Linear equivalent static analysis:

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design b response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building code by applying factor to account for higher building with some higher modes, and for low levels of twisting. To account for effect due to "yielding "of the structure, many codes apply modification factors that reduce the design forces (force reduction factor)

3.1.2 Linear Dynamic analysis:

This approach permits multiple mode of response of building to be taken in to account (in the frequency domain). This is required in many building codes for all except for every simple or very complex structure. The response of structure can be defined as a combination of many special shapes (mode) that in vibrating string correspond to the "harmonic". Computer analysis can be used to determine these modes of structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i e X, Y & Z and then see the effect on the building. Combination methods include the following

- Absolute – peak values are added together
- Square root of the sum of the squares (SRSS)
- Complete quadratic combination (CQC)-a method that is an improvement on SRSS for closely spaced mode.

IV. PROPERTIES OF BRACING MEMBER

1). Section = ISMC 75
2). Weight per Metre = 6.8 kg
3). Sectional area = 8067 cm^2
4). Depth of section 75 mm
5). Width of Flange = 40 mm
6). Thickness of flange = 7.3 mm
7). Thickness of web = 4.4 mm
8). Maximum Size of flange Rivet = 12 mm

V. DESCRIPTION OF THE INVESTIGATED STRUCTURES

Considering residential building for 14m x 11m plan building with 3x3m, 4x3m, and 4x4m grid having rectangular columns and beams. The entire rectangular columns are oriented such that longer side parallel to the global 'Y' direction and shorter side parallel to 'X' direction. The height of the column in global 'Z' direction is considered 3m for each floor. The size of Column and Beam are selected to satisfy codal provision in shape and Column and Beam are shown in Table no. 4.1. Building consists of 230mm Brick Masonry in external side and 115mm Thick Masonry in inner side and 230mm Thick Masonry for Top Parapet Wall.

Investigated structure is constructed of RCC frame with M20 grade of concrete and Fe415 grade of steel with fixed support condition at the foundation level. RCC frame Structure modelled and designed as per the code provisions of IS-1893:2002, IS-456:2000 and IS-13920:2002

The data assumed for the problem to be analysing in SAP 2000 are as follows:

1). Building = (G+6) Storey
2). Slab thickness = 100 mm
3). Live Load = 3 KN/m^2
4). Floor Finish = 1 KN/m^2
5). Software Used = SAP 2000
6). Method of Analysis = linear Analysis

Table .1: Properties of Sections

Columns	Size (mm)	Beams	Size (mm)
C1	230 X 500	B1	230 X 300
C2	230 X 450	B2	230 X 400
C3	230 X 400	------	------

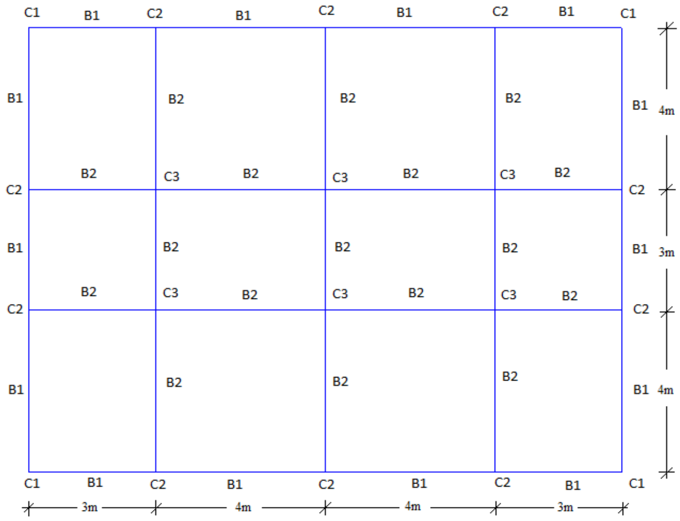

Fig. 4:- Plan of building

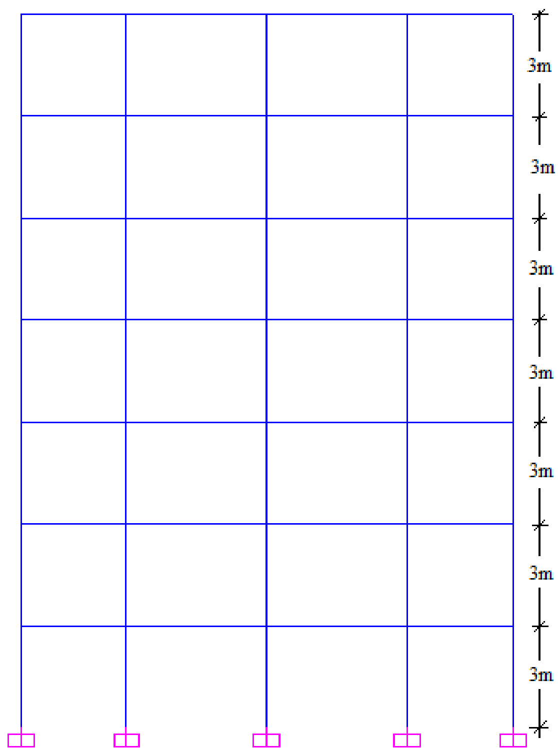

Fig. 5:-Elevation of building

VI. RESULTS AND DISCUSSION

As the analytical study is based on the reduction of the seismic energy through the structural RC Frames, unbraced frame system is used to correlates the values with the bracing system, were found out using SAP 2000.

Following figure no. 6 to 10 are showing the displacement and Drift comparison of unbraced and different braced system for linear analysis with help of graph. On X-axis in the graph indicates the displacement, Drift, Shear Force & Bending Moment in millimeters respectively while Y-axis indicates the floor level of the structure. To differient the bracing system from each other different colour of line with marking over it is be used.

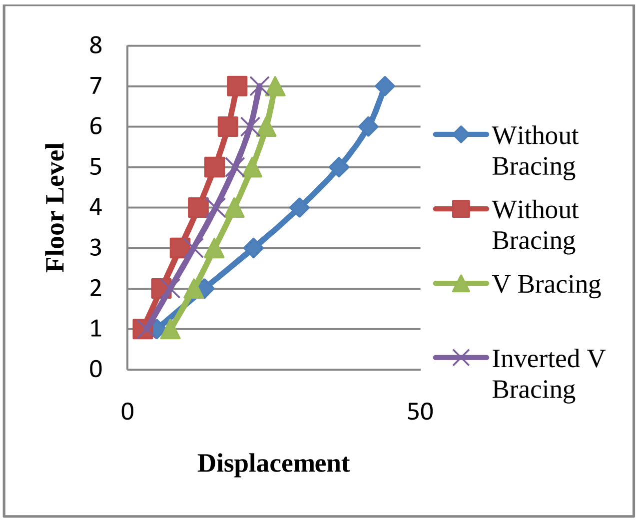

Fig. 6: Displacement Graph

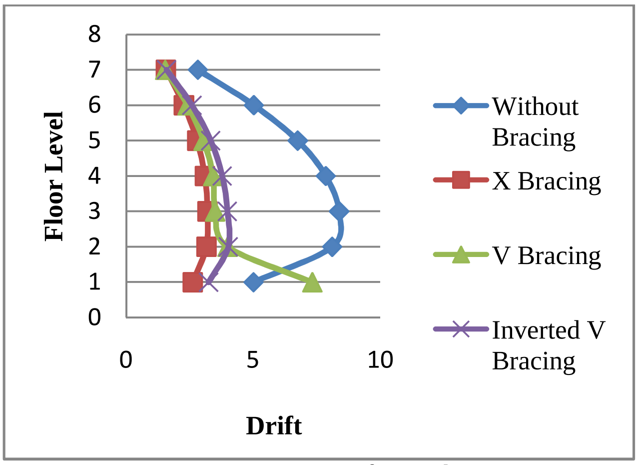

Fig. 6: Drift Graph

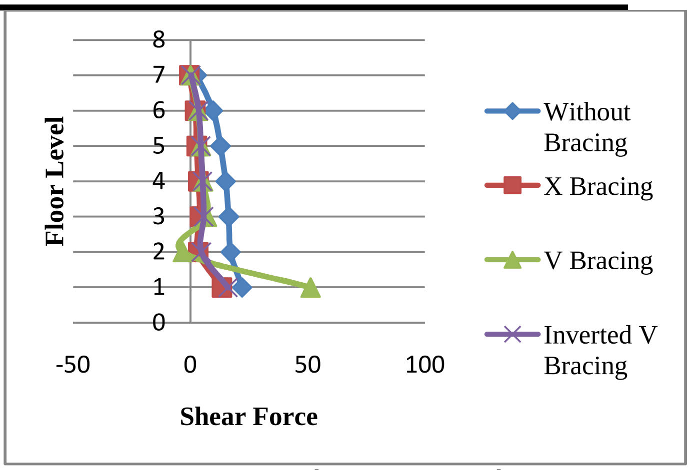

Fig. 7: Shear Force Graph

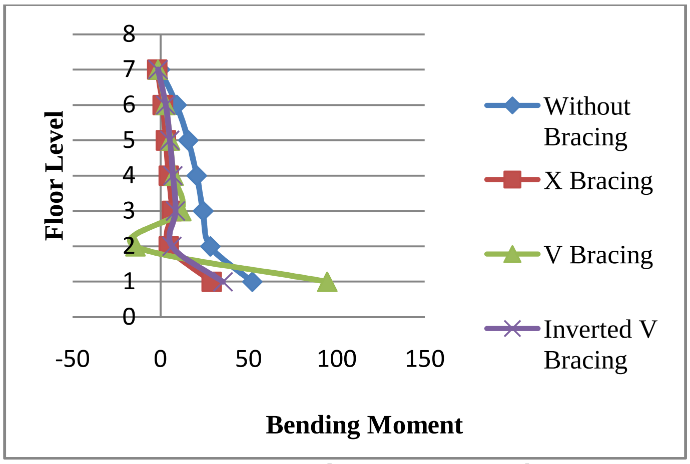

Fig. 10: Bending Moment Graph

VII. CONCLUSION

Two frames unbraced and a different braced frame with steel bracing, were designed and analysed using SAP 2000 software to see the behaviour of frames. The conclusions drawn based on the analysis is that a braced RC frame minimizes the displacement, drift, Forces & Moments of the structure during the seismic activity as compare to that of without braced frame. Comparing results of three types of bracing system i.e. X bracing system, V bracing system and Inverted V bracing system with unbraced frame in all type X bracing system show more promising result it reduces displacement and drift of storey more than any of bracing system.

VIII. ACKNOWLEDGEMENT

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