Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Linear Analysis of Multistorey Irregular RCC Buildings with Different Sections of X-Bracing

Meghana B. M [1],
[1]PG Scholar,
Civil Engineering Department,
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Archana Sukumaran[2]
[2]Assistant Professor,
Civil Engineering Department,
Sree Buddha College of Engineering,
Alappuzha/Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Abstract: **The most suitable method for the improvement of reinforcement concrete structures against lateral loading is to provide steel bracing system. Braced frames are a very common form of construction, being economic to construct and simple to analyse. In the present study, G+14 storeyed RC irregular buildings is analyzed with X bracing for different IS steel sections such as rolled beam and channel sections with different depths. The building is situated in seismic zone III. Response spectrum analysis is carried out using ETABS 2015 software to investigate seismic performance of a multi storey steel frame building and to find the most effective IS section in resisting lateral loads.**

Keywords: Irregular buildings, IS steel sections of X bracing, Base shear, Maximum storey displacement, Response spectrum analysis

I. INTRODUCTION

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Use of steel bracing systems is one of such method which is highly efficient and economical. A bracing system improves the seismic performance of the frame by increasing its stiffness and capacity. Steel braced frames are efficient structural systems for buildings subjected to seismic or wind lateral loadings. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. The potential advantages of using steel bracing are their high strength, stiffness, economical, occupies less space and adds much less weight to the existing structure.

Steel bracings can be arranged like diagonal, cross bracing X, V, inverted V or Chevron. Rolled steel sections are often used for strut bracings in buildings and single angles for ties. The applications of braced frame includes structures like bridges, aircrafts, buildings, transmission towers. In this study, irregular high rise reinforced concrete buildings are analysed with different rolled steel sections of X bracing system.

II. OBJECTIVES

- To investigate seismic performance of multi-storey RC irregular buildings with X bracing system located in seismic zone III.
- To study the effect in base shear and storey drift with the variation of depth of rolled steel I sections of X bracing for all irregular buildings.
- To study the effect in base shear and storey drift with the variation of depth of rolled steel channel sections of X bracing for all irregular buildings.
- To find out which section is more effective in resisting lateral loads by comparing both IS sections.

III.SCOPE

The study is limited to:

- Irregular plans of C, plus, I and L shape buildings with uniform eccentricity.
- High rise RC buildings.
- X bracing system with different rolled steel I and channel sections.
- Linear Response- Spectrum analysis.

IV. LITERATURE REVIEW

This chapter gives a brief review of previous studies conducted on behaviour of RC buildings provided with steel bracings.

Nitin N. Shinde, R. M. Phuke (2015)[1] published a paper on "Analytical Study of Braced Unsymmetrical RCC Building". In this report two separate Unsymmetrical RCC framed buildings one braced and another unbraced subjected to lateral loads are analyzed. Different bracing sections along with different bracing systems are employed to study the seismic response of the building. The comparison is done between the braced and unbraced building on the basis of floor displacements, storey drifts, base shear, axial force and bending moments. It was observed that seismic performance of the braced building is improved as compared to unbraced building.

Dr. Ramesh B.R et.al (2015)[2] submitted a paper on "Study on Effective Bracing Systems for High Rise Steel Structures". This paper is about the efficiency of using different types of bracings and with different steel profiles for bracing members for multi-storey steel frames. Wind load and Earthquake loads are taken by bracings. The bracings are provided only on the peripheral columns. Maximum of 4 bracings are used in a storey for economic purposes. In this study, an attempt has been made to study the effects of various types of bracing systems, its position in the building and cost of the bracing system with respect to minimum drift index and inter storey drift.

Anitha, Divya (2015)[3] published a paper on "Seismic Effect of Different Types of Steel Bracings". In this study, a comparison of knee braced steel frame with other types of bracings had been done. Performance of each frame had been studied using non-linear static analysis and nonlinear time history analysis. In nonlinear static analysis performed, steel frame with double knee bracings shoed very good behaviour during a seismic activity. The ultimate load for double knee bracings is very much higher compared to without bracings. Double knee bracings showed more lateral stiffness compared to other type of bracings.

Krishnaraj R. Chavan et al. (2014)[4] studied on "The Seismic Response of RC Building with Different Arrangement of Steel Bracing Systems." In this study, the seismic analysis of reinforced concrete buildings with different types of bracing (Diagonal, V type, inverted V type, X type) is studied. The bracing is provided for peripheral columns. A G+6 storey building is situated at seismic zone III are analyzed by equivalent static analysis as per IS 1893:2002 using STAAD Pro V8i software. It is found that the X type of steel bracing significantly contributes to the structural stiffness and reduces the maximum interstorey drift of R.C.C building than other bracing system.

Till now, all of the studies are carried out on different types of bracings in regular RC and steel buildings. So aim of this study is to investigate on the effect of different rolled steel sections of X bracings in an irregular RC building frame.

V. METHODOLOGY

The response spectrum method is employed.

A. Modelling of Building

Here the study is carried out for the behaviour of G+14 storied RCC buildings with irregular plans of I, L, C and Plus shapes with X bracing system. Properties are defined for the frame structure. Three varying depths of both I and channel sections are used as bracing sections for each model. The general software ETABS has been used for the modelling. ETABS is an engineering software product that caters to multi-story building analysis and design.

B. Building Plan and Dimensions

For the present study, G+14 storied irregular RC buildings located in seismic zone III is used. Floor height is provided as 3.4m. Fixed supports are provided for all the supports. The details and dimensions of the buildings are given in Table I.

TABLE I
DIMENSIONAL DETAILS OF THE BUILDING

Type of structure	All general RC frame
Thickness of slab	160mm
Dimension of beam	300mm × 400mm
Dimension of column	300mm × 450mm
Grade of concrete	M25
Grade of steel	Fe415
Type of bracing used	X bracing
Steel sections of bracing	Rolled Steel Beams ISHB 200, ISHB 250, ISHB 300
	Rolled Steel Channels ISMC 200, ISMC 250, ISMC 300

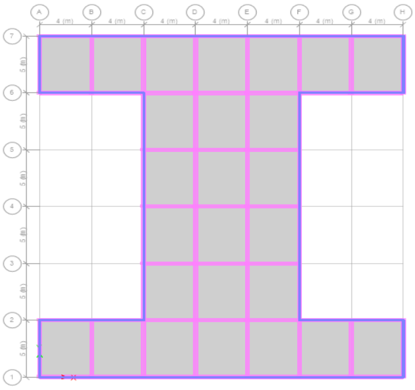

Fig.1 Plan of I shape building

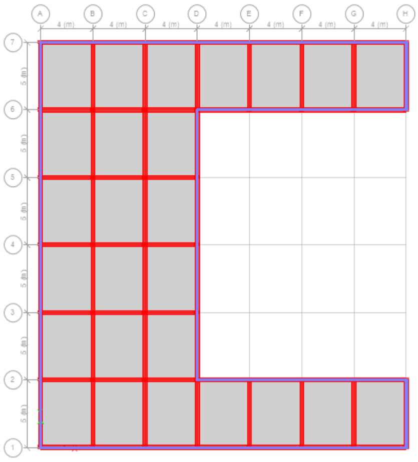

Fig.2 Plan of C shape building

Fig.3 Plan of L shape building

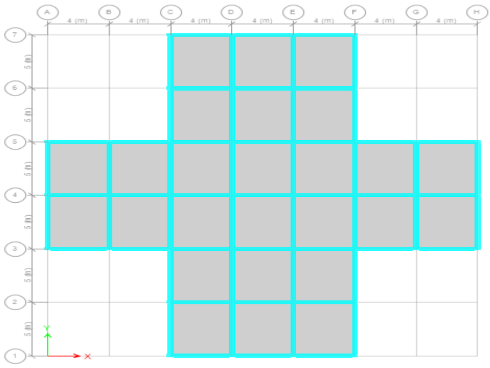

Fig.4 Plan of PLUS shape building

C. Load Formulation

For given structure, loading is applied which includes dead load, live load, earthquake load and floor finish and are according to IS 875 part I, part II and IS 1893:2002

- Live Load

Floor load:

Live Load Intensity specified (Commercial building) = 4kN/m^2

Live Load at roof level =1.5 kN/m^2

TABLE II

EARTHQUAKE LOAD DATA

Earthquake zone	III
Damping ratio	5%
Importance factor, I	1
Type of soil	Medium soil (Type II)
Response reduction factor, R	5
Zone Factor ,Z	0.16

- Load Combinations

The following Load combinations have been considered for the analysis

1. DL
2. DL+LL
3. 1.5(DL+LL)
4. 1.2(DL+LL+ EQX)
5. 1.2(DL+LL+ EQY)
6. 1.2(DL+LL - EQX)
7. 1.2(DL+LL - EQY)
8. 1.5(DL+EQX)
9. 1.5(DL+EQY)
10. 1.5(DL- EQX)
11. 1.5(DL- EQY)
12. 0.9DL+1.5EQX
13. 0.9DL+1.5EQY
14. 0.9DL - 1.5EQX
15. 0.9DL - 1.5EQY

D. Analysis Results

The three dimensional reinforced concrete structures were analyzed by Response Spectrum to evaluate dynamic results in form of storey shear, storey drifts in X and Y directions. It is a linear dynamic statistical analysis method to indicate the likely maximum seismic response of an elastic structure. A plot of the peak acceleration for the mixed vertical oscillators.

1) Maximum storey drift in X direction:

TABLE III

MAXIMUM STOREY DRIFT IN X DIRECTION FOR DIFFERENT I AND CHANNEL SECTIONS OF X BRACING

Sections of X bracing	Shape of Plan of Buildings			
	I	L	C	PLUS
ISHB 200	0.001701	0.002164	0.001957	0.001697
ISHB 250	0.00154	0.001949	0.001775	0.001566
ISHB 300	0.001407	0.001762	0.001608	0.001283
ISMC 200	0.001955	0.002491	0.002226	0.001361
ISMC 250	0.001752	0.002246	0.002023	0.001249
ISMC 300	0.001672	0.002156	0.001918	0.001174

2) Maximum storey drift in Y direction:

TABLE IV

MAXIMUM STOREY DRIFT IN Y DIRECTION FOR DIFFERENT I AND CHANNEL SECTIONS OF X BRACING

Sections of X bracing	Shape of Plan of Buildings			
	I	L	C	PLUS
ISHB200	0.001597	0.002003	0.001534	0.001637
ISHB 250	0.001421	0.001855	0.001307	0.001471
ISHB 300	0.001384	0.001638	0.001298	0.001209
ISMC 200	0.001581	0.002429	0.001368	0.001353
ISMC250	0.001463	0.002155	0.001256	0.001211
ISMC300	0.001361	0.002025	0.001203	0.001158

It is found that as the size of the both sections increases, the value of maximum storey drift decreases for all irregular buildings. In beam sections of X bracing, ISHB 300 has minimum value of storey drift and in channel sections, ISMC 300 has the minimum value in both X and Y directions.

3) Base Shear:

TABLE V
BASE SHEAR FOR DIFFERENT I AND CHANNEL SECTIONS OF X BRACING

Sections of X bracing	Shape of Plan of Buildings			
	I	L	C	PLUS
ISHB 200	19048	12214	19991	14273
ISHB 250	20597	13374	21530	15535
ISHB 300	22219	14580	23067	16971
ISMC200	16877	10857	18009	8678.43
ISMC250	18497	11867	19539	9454.42
ISMC300	19354	12257	20242	14520

It is found that as the size of the both sections increases, the value of base shear also increases for all irregular buildings. In beam sections of X bracing, ISHB 200 has minimum value of base shear and in channel sections, ISMC 200 has the minimum value.

VI. RESULTS AND DISCUSSIONS

After analysing the models various results are obtained. The results of base shear and storey drift in X and Y directions are represented graphically. The performance of ISHB and ISMC sections are compared to find which section of X bracing is more effective in resisting lateral loads.

A. *Maximum Storey Drift in X Direction*

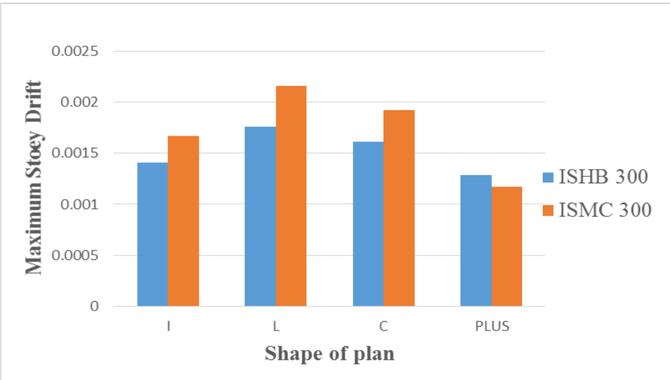

Fig.5 Comparison of Storey Drift in X Direction among I and Channel Sections of X Bracing in Irregular Buildings

From the graph, it is found that in X direction, ISHB 300 has minimum value of storey drift for I, L, C shape buildings and for plus shape building, ISMC 300 has the minimum value.

B. *Maximum Storey Drift in Y Direction*

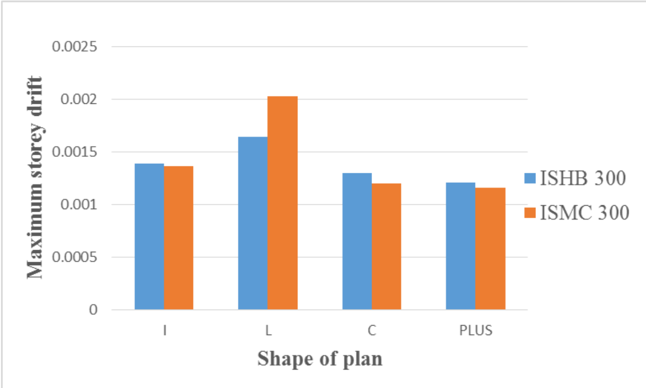

Fig.6 Comparison of Storey Drift in X Direction among I and Channel Sections of X Bracing in Irregular Buildings

From graph, it is found that in Y direction, ISHB 300 has minimum value of storey drift in L shape building. But in I, C, plus shape buildings, there is only a little variation in storey drift value between ISHB 300 and ISMC 300 and the minimum value is for ISMC 300.

C. *Base Shear*

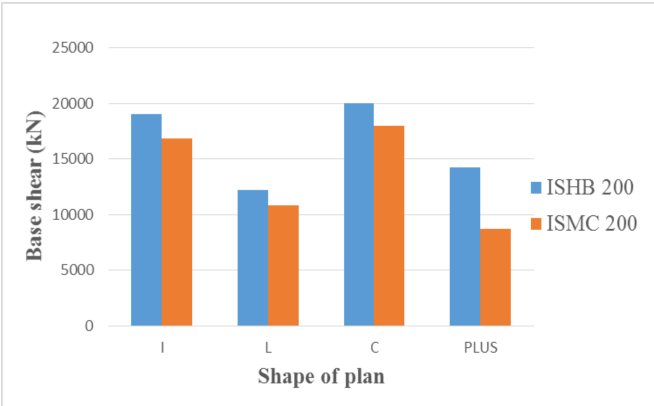

Fig.7 Comparison of Base Shear among I and Channel Sections of X Bracing in Irregular Buildings

From the graph, it is seen that, ISMC 200 has minimum base shear for I, L, C, plus shape buildings and maximum for ISHB 200 in all irregular shape of buildings. Thus ISMC 200 is better in terms of base shear.

VII. CONCLUSIONS

- As size of section increases, maximum storey drift decreases for both ISHB and ISMC sections for all irregular plan of buildings.
- The value of base shear increases for both ISMC and ISHB sections with increase in size of section for all irregular buildings.
- In beam sections of X bracing, ISHB 300 and in channel sections, ISMC 300 has the minimum value of storey drift in both X and Y directions.
- In beam sections of X bracing, ISHB 200 and in channel sections, ISMC 200 has the minimum value of base shear.
- In X direction, ISHB 300 has minimum value of storey drift for I, L, C shape buildings and ISMC 300 has the

minimum value for plus shape building (percentage reduction for I shape is

- In Y direction, ISHB 300 has minimum value of storey drift in L shape building. But in I, C, plus shape buildings, ISMC 300 has the minimum value.
- In base shear point of view, ISMC 200 has minimum base shear for I, L, C, plus shape buildings.

ACKNOWLEDGEMENT

I am thankful to my guide, Asst. Professor, Archana Sukumaran in Civil Engineering Department for her constant encouragement and able guidance. Also I thank my parents, friends etc. for their continuous support in making this work complete.

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