Impact Factor (SJIF): 5.301

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 6, Issue 9, September-2019

Dynamic Analysis of Steel Building using different types of Bracing Systems

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***Abstract*— Structures that are located in seismic areas have higher risk of structured damage and causes severe loss of property as well as life. The bracing system is one of the most efficient systems used to effectively control the lateral displacement due to seismic load, so that, during lateral load due to earthquake the risk of structural and non-structural damage can be reduced to a greater extent. The study is carried out by providing bracing system at different locations in the building in order to suggest the best suitable location of bracing considering seismic parameters. For bracing X, V & Diagonal-type bracing systems are used and loads are considered as per IS: 1893(Part1)-2016. The modeling and analysis is performed using finite element based software ETABS.**

KEYWORDS: Bracing system; Response spectra; Lateral displacement; Storey Drift: Time period: ETABS.

I. INTRODUCTION

A. General

The disastrous effect of past earthquakes on humans, animals and properties have taken a step ahead to think and take into account lateral load resisting systems and to adopt this system for effective and efficient mitigation of earthquake forces. Structures which are located in high seismic areas have greater amount of risk which may cause severe damage. While designing the structures the provisions are used as per given in the code so as to prevent the damage of the structure during the high earthquakes. Most of the structures lack in lateral strength and also ductility even if they are designed as per code criteria. Seismic strengthening mainly depends upon the financial status and life safety.

In general, earthquake ground motion can occur anywhere in the world and the risk associated with the buildings, especially under severe earthquake forces needs to be given special attention. While adopting bracing structural system in building design the location of bracing should be at effective position to make the building stiffer.

B. Concept of Bracing

Steel bracing system is one of the best methods for resisting earthquakes to a greater extent. Steel bracing system is most commonly used because it is most economical and efficient. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. Various researchers have found that lot of techniques such as infill walls, providing walls to existing columns, encasing columns, and adding steel bracing will improve the strength and even the ductility of existing buildings. A bracing system improves the seismic performance of the building by increasing its lateral stiffness and capacity to resist loads. Through the addition of the bracing system, load can be transferred out of the frame and into the braces, avoiding the weak columns while increasing strength. Therefore, the use of steel bracing systems for retrofitting reinforced concrete frames with inadequate lateral resistance is attractive.

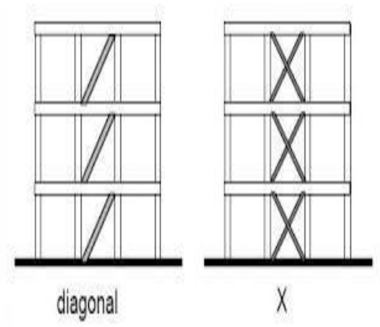

Figure 1: Bracing system (a) Diagonal type (b) X-Type

The concentric bracings increase the lateral stiffness of the edge, along these lines expanding the regular recurrence and furthermore typically diminishing the horizontal drift. Eccentric Bracings decrease the lateral stiffness of the framework and enhance the vitality dissemination limit

II. LITERATURE REVIEW

A. General

Literature survey was conducted on the works carried out by earlier researchers whose efforts has been devoted to study seismic behavior of various type of braced and non-braced frames. The summary and gap of literature are discussed below.

B. Summary of Literature review

Based on study, following broad conclusions could be drawn:

1. In strengthening weak column and structural members, bracing system is one of the best approach.
2. Bracing improves the strength and stiffness of building better than Shear wall for high raised buildings
3. Bracing regulates story drift and provides lateral resistance to the building.
4. X type of Bracing system found to be more effective than the Shear wall and other type of bracing systems.
5. Use of bracing system is found more beneficial in high raised steel building than Conventional RC building.

C. Gap in Literature Review

In previous studies as studied in literature review research is carried out only on seismic behavior of different bracing systems throughout the building. Also, all studies are carried out using either linear dynamic analysis or Non-linear static analysis. But there is lack of research of a braced building with bracing provided at different location in order to suggest the best position..

III. OBJECTIVES AND SCOPE

A. Objectives

The main objective of this research is to present the comparative study of steel building with and without steel bracing having different arrangements of steel bracing systems, at different location and to suggest the best optimized location and type of braced system for high rised building under seismic action..

B. Scope

Braced frames are known to be efficient structural systems for building under high lateral loads such as seismic or wind loading.

IV. METHODOLOGY

In high raised buildings, lateral load due to earthquake are often resisted by a system of coupled shear walls. To make the building structure more ductile and to provide sufficient stiffness bracing system is used.

In this study, the analysis of G+29 storey steel building with bracing structural system subjected to seismic forces is proposed to be carried out. For the analysis, steel bracing are proposed to be used in the form of X-type, V-type and Diagonal-type bracing system. The Position of bracing in a building is changed and the behavior is checked. The modeling and analysis of steel building is done by using ETABS software. ETABS is simple, user friendly and completely incorporated research software used for design and analysis of mainly RCC building.

MODELING AND ANALYSIS

For resisting the earthquake forces steel bracing is one of the best method. For tall structure bracing system is used to stabilize the structure the following research is to study the seismic response of G+29 steel building with different steel bracings placed at various locations. The seismic analysis method used for the study is **Response Spectrum Method** i.e. **Linear Dynamic Analysis**. The modeling and analysis is done by using ETABS software.

Type of Building	=	Steel
No. of story	=	G+29
Plan area	=	16m*16m
Height of building	=	90m
Height of floor	=	3m
Type of building	=	Residential
Seismic zone	=	IV
Importance factor	=	1.2
Response reduction factor	=	4
Type of soil soil	=	Medium
Grade of steel	=	Fe415
Column 2-400/40	=	ISWB600-
Slab thickness	=	120mm
Live load	=	$3kN/m^2$
Beam and ISLB150	=	ISWB300
Steel Bracing	=	ISA110*110 *10
Bracing types Diagonal types	=	X, V and

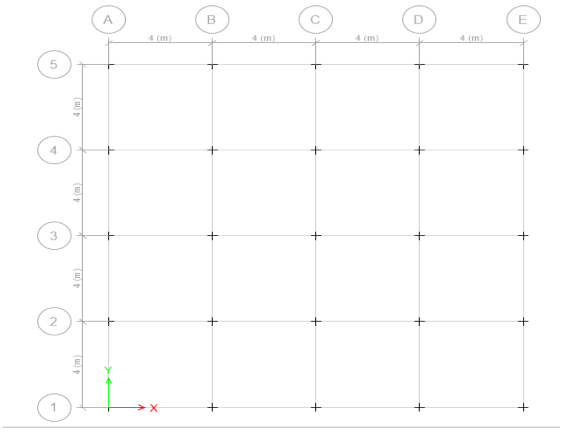

Figure 2: Plan of Building

Figure 3: Elevation of Building without bracing system

1) Criteria for selection of suitable steel bracing section

In order to select the suitable section for the bracing various steps were followed in sequential manner listed below,

1) The slenderness ratio of column and bracing was calculated for 1m member.

Size of Steel column – ISWB600-2-400/40

Size of steel bracing (Steel angle section) - 110x110x10mm

Slenderness ratio,

$$\lambda = \frac{l}{rmin}$$

Where,

K = Stiffness factor

r_{min} = Minimum radius of gyration

λ = *Slenderness Ratio*

For building column, $\lambda = \frac{1000}{97.5} = 10.25$

For steel bracing, $\lambda = \frac{1X1000}{21.4}$

$= 46.72$

2) Stiffness of steel column and bracing calculated for 1m member

For steel column $= K = \frac{AE}{L}$

$$K = \frac{264.86\ X\ 10^2 X\ 2\ X\ 10^5}{1000}$$

$= 5.29X\ 10^6$ N/mm

For steel bracing $= K = \frac{AE\,(\cos\theta)^2}{L}$

$$= \frac{21.06\ X\ 10^2 X\ 2\ X\ 10^5 X\ (\cos 36.86)^2}{1000}$$

$= 0.269\ X\ 10^6$ N/mm

The effective slenderness ratio of brace should be kept relatively low to avoid buckling, so that the brace are effective in compression as well as tension. The maximum slenderness ratio allowed for steel bracing in earthquake and wind is 350 as per clause of IS 800-2007.

From the above calculation it is concluded that,

- The slenderness ratio is more for steel brace section as compared to steel column section. As a result, when structure is subjected to lateral loading the steel bracing would fail early as compared to the steel columns.
- The stiffness for steel column is more than steel bracing which thus give better resistance to failure as compared to steel bracing:

From the above results, size of steel bracing is taken as 110x110x10mm.

The various models are prepared using ETABS software and their elevations and 3-D view are shown as below:

Model 1: X-type Bracing Model

Model 1.1: Peripheral Bracing Model

Model 1.2: Alternate bay braced Model

Model 1.3: Central Braced Model

Model 1.4: Zigzag braced Model

Model 2: V-type Bracing Model

Model 2.1: Peripheral Bracing Model

Model 2.2: Alternate bay braced Model

Model 2.3: Central Braced Model

Model 2.4: Zigzag braced Model

Model 3: Diagonal type Bracing Model

Model 3.1: Peripheral Bracing Model

Model 3.2: Alternate bay braced Model

Model 3.3: Central Braced Model

Model 3.4: Zigzag braced Model

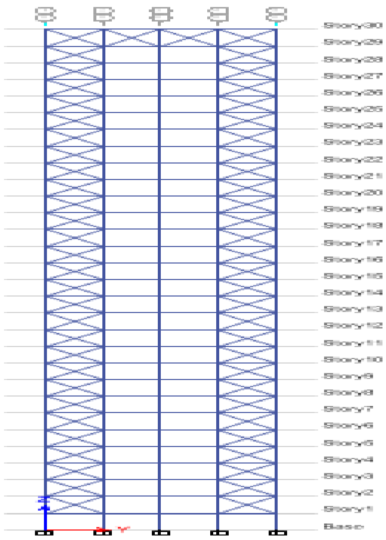

Figure 4: Elevation for Model 1.1

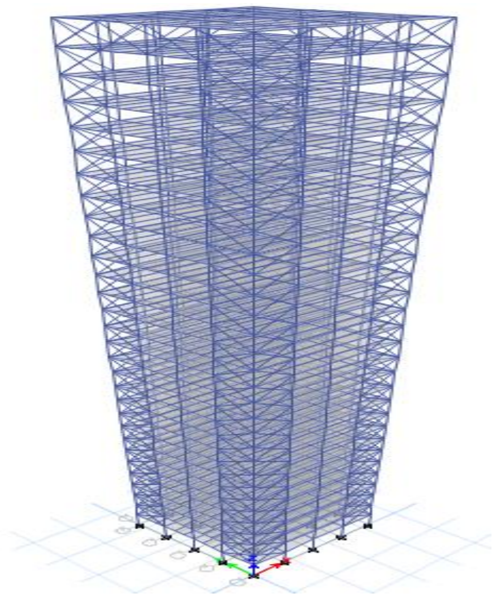

Figure 5: 3-D view for Model 1.1

V. RESULT AND DISCUSSION

Displacement for various models

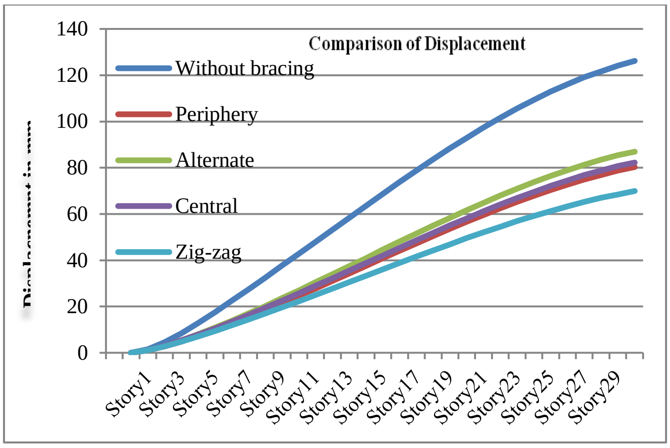

Figure 6: Displacement for without and with bracing system at different position for X-type bracing.

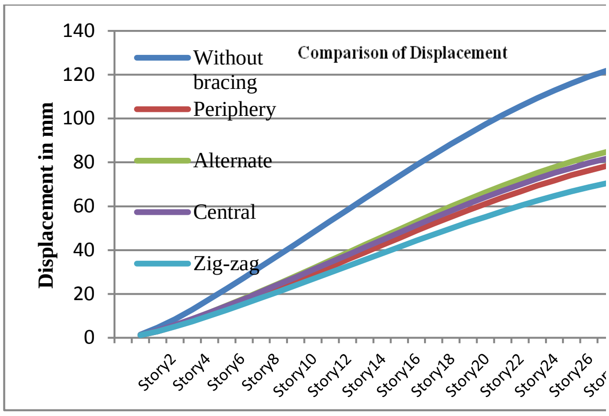

Figure 7: Displacement for without and with bracing system at different position for V-type bracing.

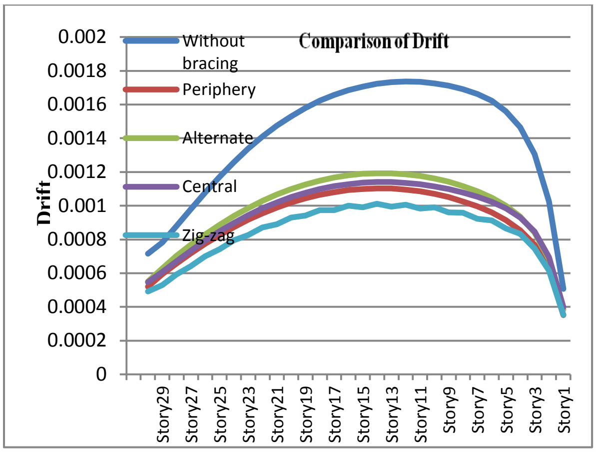

Figure 10: Drift (m) for models without and with bracing system at different position for V-type bracing..

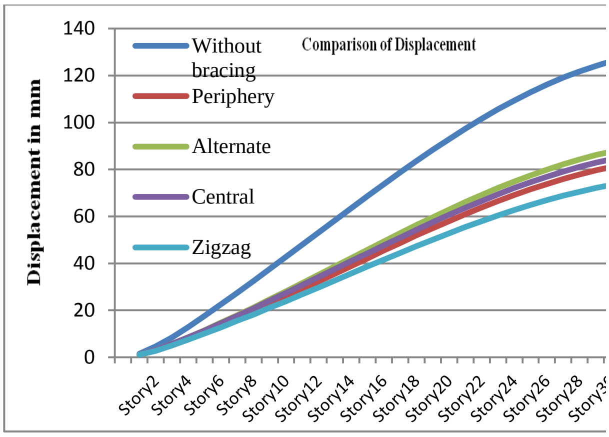

Figure 8: Displacement for without and with bracing system at different position for Diagonal-type bracing.

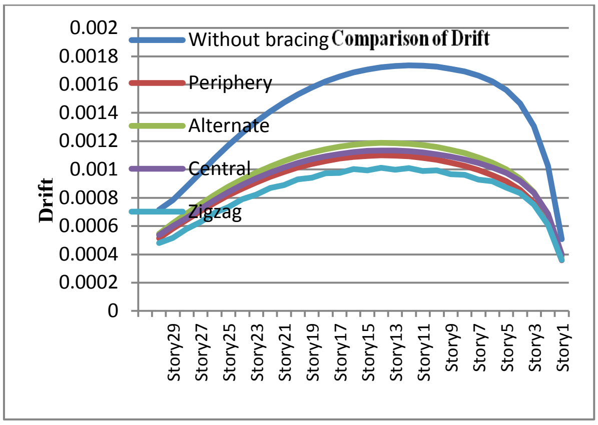

Figure 11: Drift (m) for models without and with bracing system at different position for Diagonal-type bracing.

Drift for various models

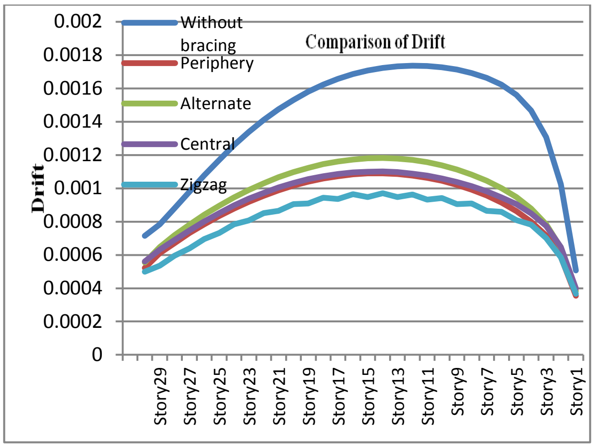

Figure 9: Drift (m) for models without and with bracing system at different position for X-type bracing..

Time period for various models

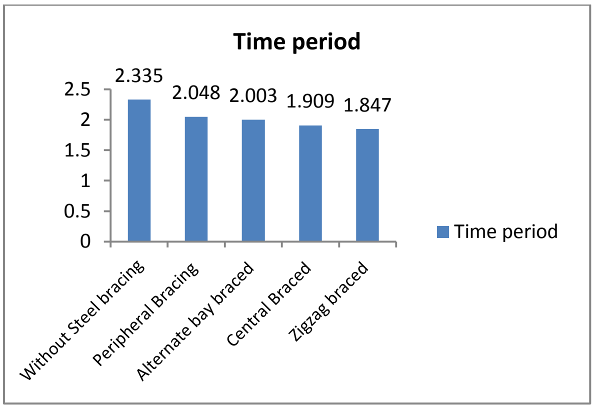

Figure 12: Time period for models without and with X-braced system at different position.

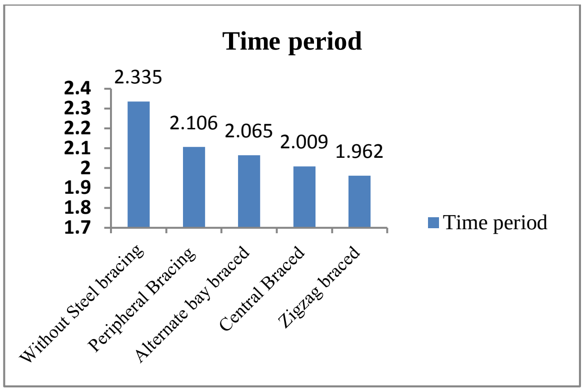

Figure 13: Time period for models without and with V-braced system at different position.

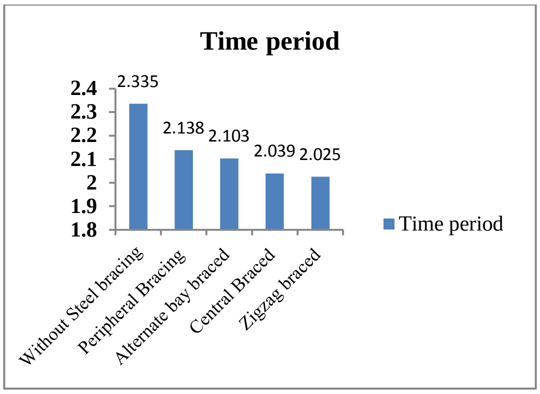

Figure 14: Time period for models without and with Diagonal-braced system at different position.

VI. CONCLUSIONS

1. The Zigzag X-type braced model building shows maximum of 44.53% reduction in lateral displacement than conventional building without bracing system and other braced models.
2. The Zigzag X-type braced model building shows maximum of 44.10% reduction in drift than conventional building without bracing system.
3. The time period of Zigzag X-type bracing system is less i.e. 1.847sec as compared to the other bracing systems which indicate that X-Zigzag system gives maximum stiffness as compared to other systems.
4. Zigzag X-type braced Model building is more effective in case of earthquakes.
5. From this study, it can be concluded that Zigzag X type bracing is best amongst all the discussed types of bracings.

Future scope:

1. Study of building having different unsymmetrical plan can be studied with different position of bracing.
2. Study of seismic behavior of steel building with different location of bracing system can be studied by comparing linear and non-linear analysis methods.

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