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Seismic Behaviour of Steel Staggered Truss in Building

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***Abstract:** In this study staggered-truss system (STS) is studied for structural steel framing for the multi-story and high-rise buildings. The staggered-truss systems (STS) consists of a series of story-high trusses spanning the total width between two rows of external columns and arranged in a staggered pattern on adjacent column lines. The system is known to be appropriate for use in residential buildings such as apartments, dormitory and hotels. The columns are located only on the external faces of the building. The large clear span and open areas can be created. The interaction of the floors, trusses, and columns makes the structure perform as a single unit, there by taking maximum advantage of the strength and rigidity of all the components simultaneously. Each component performs its particular function, totally dependent upon the others for its performance. These column free areas can be utilized for ballrooms, concourses and other large areas. The one added benefit of the staggered-truss framing system is that it is highly efficient for resistance to the lateral loading caused by wind and earthquake. The stiffness of the STS provides the desired drift control for wind and earthquake loadings. The staggered-truss framing system is one of the quickest available methods to use during winter construction. The floor system not only carries the direct vertical loads. In addition, It has to act as a diaphragm to transfer the horizontal shear forces between stories through truss diagonals. Because of this double use concept this system results in a lighter structure and provides more column-free space than a conventional beam-column framed structure.*
***Keywords:** Staggered Truss System (STS), Seismic Behaviour, Storey Displacement, Storey Drift, Storey Shear, Response Spectrum Analysis.*

I. INTRODUCTION

The staggered-truss framing system, originally developed at MIT in USA, has been used as the major structural system for certain buildings for some time. The steel staggered truss system is efficient for mid-rise apartments, hotels, motels, dormitories, hospitals, and other structures for which a low floor-to-floor height is desirable. The story trusses arrenged in a vertically staggered pattern at alternate column lines.

It can be used to provide large column-free areas for room layouts as shown in Fig. 1.1The staggered-truss framing system is one of the only framing systems that can be used to allow column-free areas. This system is normally economical. The one added benefit of the staggered-truss framing system is that it is highly efficient for resistance to the lateral loading caused by wind and earthquake.

The stiffness of the STS system provides the desired drift control for wind and earthquake loadings. The system can provide a significant amount of energy absorption capacity and ductile deformation capability for high-seismic applications. When conditions are proper, it can yield great economy and maximum architectural and planning flexibility. It also commonly offers the most cost-efficient possibilities, given the project scheduling considerations. The staggered-truss framing system is one of the quickest available methods to use during winter construction. Erection and enclosure of the buildings are not affected by prolonged sub-freezing weather.

The Steel framing, consist of spandrel beams and precast floors, are projected to be erected at the rate of one floor every five days. Once two floors are erected, window installation can start and stay right behind the steel and floor erection. There is no time is lost in waiting for other trades such as bricklayers to start work. The vertical loads concentrated at a few columns normally exceed, it uplift forces generated by the lateral loads and, as a result, uplift anchors are often not required. The reduced number of columns also results in less foundation formwork, less concrete, and reduced construction time. When used, precast plank is lighter then cast-in-place concrete, the building is lighter, the seismic forces are smaller, and the foundations are reduced. The fire resistance of the system is also good.

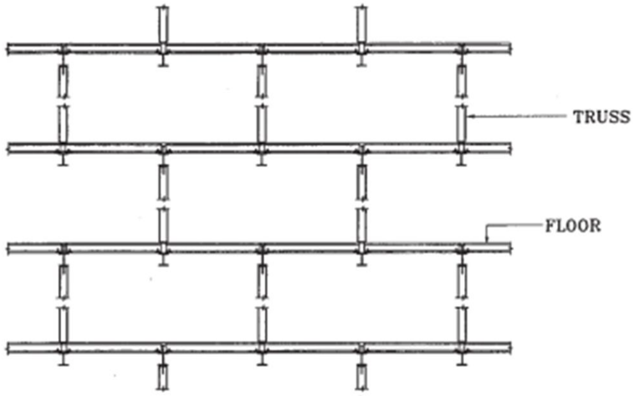

Fig.1.1: Staggered-truss system-vertical stacking arrangement.

II. METHODOLOGY

A. *Selection of Earthquake Zone*

For seismic analysis zone III selected.Because Pune lies very close to the seismically active zone around koyna dam, about 100km south of the city. This zone is classified as moderate damage risk zone. The IS code design zone factor of 0.16 for zone III. The importance factor and response reduction factor is 1.2 and 5 respectively for building.

B. *No. of Storey*

8 Storey building have been use in this study.

C. *Role of ETABs*

Extended Three-Dimensional Analysis of Building System (ETABs) is a kind of software generally used for structural analysis of multi-storey building or other structure. ETABs features are contain powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated used in common data base.

D. *Response Spectrum Method*

Response spectrum analysis is method to estimate the structural response to short, non deterministic, transient, dynamic event. This concept provides a conceptual basis for using response spectra based on single mass system for analyzing multi stoery buildings. We can use response spectra of single degree of freedom for computing the deflected shape, storey acceleration, forces and moment. We can use response spectra of single degree of freedom for computing the deflected shape, storey acceleration, forces and moment.

III. MATERIAL DESCRIPTION

A staggered-truss frame is designed with concrete framing members and concrete floors. The beams and columns are designed as per IS code. Early buildings were designed with chords made of wide-flange sections and diagonal and vertical members made of channels. The channels were placed toe-to-toe to the floor.The properties of concrete members result from both its chemical composition and its method of manufacture. Standard properties of concrete and steel are given in Table 2.1

Sr. No	Property	Value
1	Density of Concrete	2400 Kg/m^3
2	Density of steel	7850 Kg/m^3
3	Yield Strength	250 N/mm^2
4	Young's Modulus	$2.1x10^5$
5	Poisson's ratio	0.3

Table 2.1: Material Properties

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IV. MODELLING AND DESIGN OF STRUCTURE

Following structure is studied for the analysis.

A. MODEL I: Structure without Steel Staggered Truss (STS)

In this type of structure, the structure is created normal frame i.e without using steel staggered truss system (STS).The G +7 storey building is created for analysis

Table 4.1: Properties of Model I Structure

Sr.no.	Description	Values
1	Dimension	24 X 21m
2	Number of storey	8
3	Height of each storey	3 m
4	Type of floor	concrete
5	column	650 x 650 mm
6	beam	300 x 600 mm
7	Thickness of floor	0.15 m

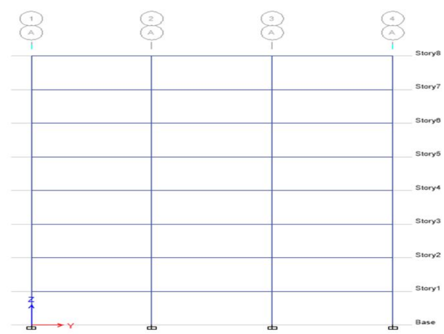

Fig.4.1: Elevation of Model I

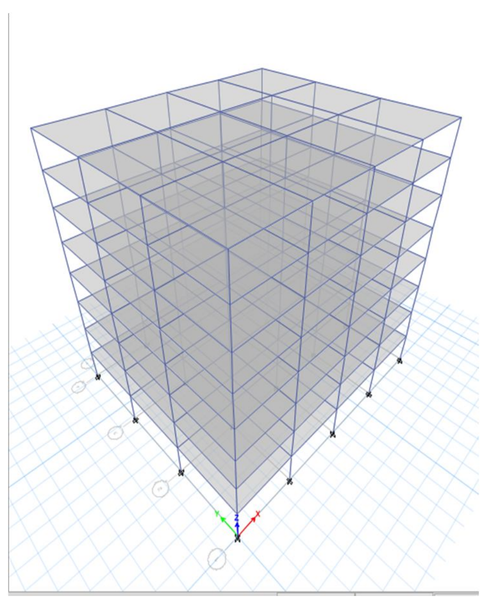

Fig.4.2: 3D View of Model I

B. MODEL II: Structure with Steel Staggered Truss (STS)

In this type of structure, the structure is created using steel staggered truss system (STS). The G +7 storey building is created. In this model steel staggered truss are placed alternatively on the floor.

Table 4.2: Properties of model II structure

Sr.no.	Description	Values
1	Dimension	24 X 21m
2	Number of storey	8
3	Height of each storey	3 m
4	Type of floor	concrete
5	Column	650 x 650 mm
6	Beam	300 x 600 mm
7	Chords	ISLB200
8	Thickness of floor	0.15 m

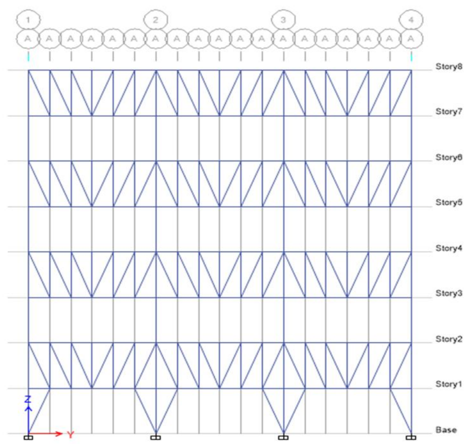

Fig. 4.3: Elevation of Model II

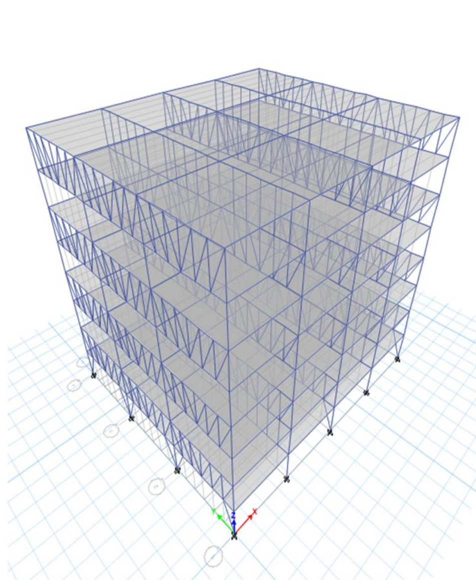

Fig. 4.4: 3D View of Model II

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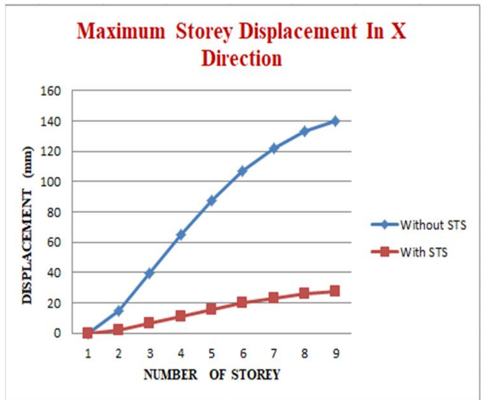
V. RESULT AND DISCUSSIONS

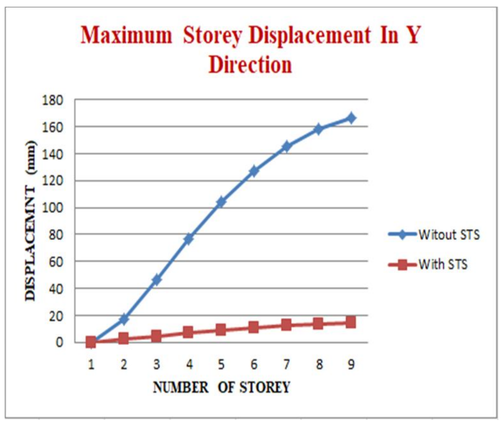
In this study two models of eight storey one model of normal frame and one model of steel staggered truss system has been designed and their seismic performances has evaluated by response spectrum analysis.

A. Storey Displacement

In case of storey displacement in both X direction & Y direction without steel staggered truss building shows maximum displacement. And the minimum storey displacement occurred in with steel staggered building.



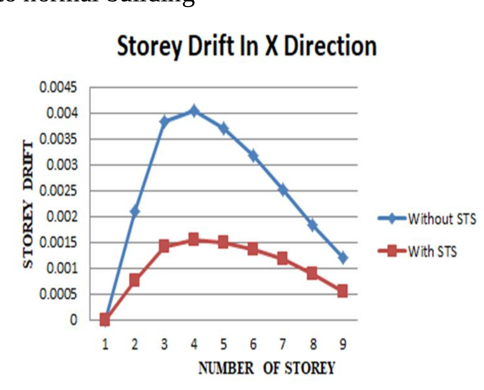
Graph 5.1: Maximum Displacement In X Direction



Graph 5.2: Maximum Displacement in Y Direction

B. Storey Drift

The distribution of storey drift ratio over building height become non uniform over building height increases. The storey drift ratio is higher in normal building than steel staggered truss system building for all lateral load cases. The storey drift ratio for steel staggered truss system is lower compared to normal building



Graph 5.3: Storey Drift In X Direction

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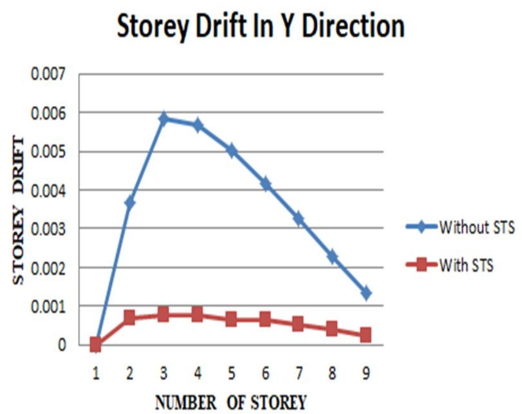
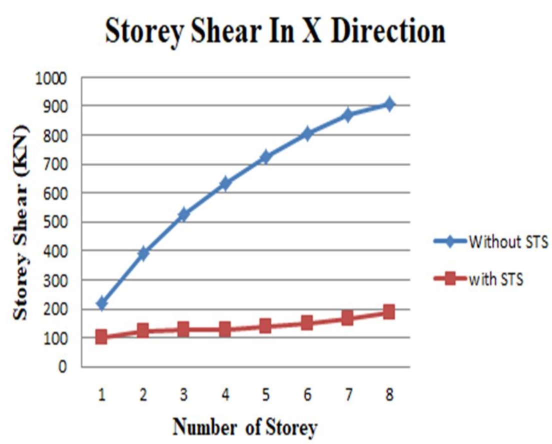


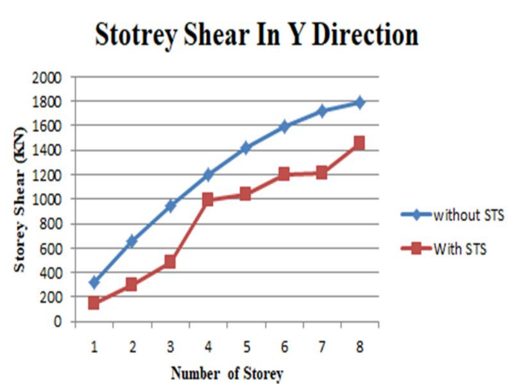
Graph 5.4: Storey Drift in Y Direction

C. *Storey Shear*

The storey shear in the models shows an increasing manner in the values according to the height of building. The storey shear in X direction for steel staggered truss system has the least value and the model with normal frame has the highest value of storey shear. The graphical representation of storey shears of two models in X and Y direction are shown in Figure5.5and Figure 5.6 respectively. While comparing the two models it could be concluded that the normal framed structure has the highest value of storey shear.



Graph 5.5: Storey Shear In X Direction



Graph 5.6: Storey Shear in Y Direction

VI. CONCLUSION

In this paper, an attempt is made to assess the seismic behaviour of steel staggered truss (STS) in the building. The seismic analysis of steel staggered truss system(STS) has been completed and form the result it is clear that steel staggered truss model building have maximum strength than the without steel staggered truss building. This structure has minimum value of storey displacement in both X and Y direction. The maximum value of storey displacement observed in without steel staggered truss building (STS). The storey drift ratio is less in the STS than the normal building. The Stiffer the frame storey drift ratio is less. The storey shear of the structure with normal frame has been seen as decreasing as the height of the building increases.

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