# DESIGN OF G+15 MULTISTOREY BUILDING STIFFENED WITH BRACING

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**Abstract-** *This Paper work focuses on comparison of seismic analysis of G+15 building stiffened with bracings. The performance of the building is analyzed in Zone II, Zone III, Zone IV, Zone V. The study includes understanding the main consideration factor that leads the structure to perform poorly during earthquake in order to achieve their appropriate behavior under future earthquakes. Earthquake is the natural calamity, it produce strong ground motions which affect the structure. Small or weak motions that can or cannot be felt by the humans. Provision of shear walls and bracings are installed to enhance the lateral stiffness, ductility, minimum lateral displacements and safety of the structure. Storey drift and lateral displacements are the critical issues in seismic design of buildings. Due to Industrial revolution, availability of jobs and facilities, population from rural area is migrating towards cities. Because of this metro cities are very thickly populated. Availability of land goes on decreasing and land cost also increases. To overcome this problem the use of multistoried buildings is must. But such provisions increases self weight and live load along with earthquake forces. With increase in height stress, strain, deformation and displacement in the structure increase which ultimately increases the cost of construction due to increased cross-sections of the elements. Multi-storey buildings are designed to carry gravity loads as well as earthquake loads and their combinations. I.S. codes providing these loading combinations for which structure need to be analyze and design. The analysis is aimed at finding the internal forces in component of structures and to find displacements developed in the structure leading to the development of strains. Structure must be safe from both strength viewpoint and serviceability as well. While vertical forces are most significant, the primary problem for most structures is force in the horizontal or lateral direction, which tends to subject buildings to large horizontal distortion. Therefore, most buildings are designed with lateral-force-resisting systems to resist the effects of earthquake forces. Bare frames are found to be more flexible and have large section requirement to with stand forces induced. The same can be minimizing by making structure more rigid. In this volume, use of bracing to increase the stiffness of structure has been resorted to on the basis of previous work done on.The crosstype, diagonal- type concrete bracing separately. The cross- type, diagonal- type of bracing system has been used. A number of structures with same height and width with and without braces have been analyzed. The responses of braced frames of different configurations have been compared with each other and the same also have been compared with unbraced frame. For all type of structures which are serving more economy for particular type, it was found that the lateral displacements are well within the acceptable limit as per IS 1893:2002.*

***Keywords-* *Bracing, Multistorey Building, STAAD PRO, I.S CODES, Response Spectrum Method, G+15***

## I. INTRODUCTION

### 1.1 General Introduction:

Lateral forces on buildings such as wind, earthquake and blast forces can be produced critical stresses in the buildings that it cause excessive lateral sway of the buildings and undesirable stresses and vibrations in the buildings. Design and structural evaluation of the building systems subjected to lateral loads form the important task of the present generation and the designers are faced with problems of providing adequate strength and stability of buildings against lateral loads. Different lateral loads resisting systems are used in high-rise building as the lateral loads due to earthquakes are a matter of concern. Steel plate shear walls system and steel bracings system are used in steel structures buildings and their effect shows unequal variations and behaviour against seismic loads. Recently, laminated composite plate shear walls are used as a lateral loads resisting system where the laminated composite plates are used as infill plate in shear walls. The laminated composite plates are created by constructing plates of two or more thin bonded layers of materials and it can be either cross-ply laminates or angle-ply laminates.

Importance of Multistoried Building The tallness of a building is relative and cannot be defined in absolute terms either in relation to height or the number of stories. But, from a structural engineer's point of view the tall building or multi-storied building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design. Tall structures have fascinated mankind from the beginning of civilization. The Egyptian Pyramids, one among the seven wonders of world, constructed in 2600 B.C. are among such ancient tall structures. Such structures were constructed for defense and to show pride of the population in their civilization.

The development of the high-rise building has followed the growth of the city closely. The process of urbanization that started with the age of industrialization is still in progress in developing countries like India. Industrialization causes migration of people to urban centers where job opportunities are significant. The land available for buildings to accommodate this migration is becoming scarce, resulting in rapid increase in the cost of land. Thus, developers have looked to the sky to make their profits. The result is multistoried buildings, as they provide a large floor area in a relatively small area of land in urban centers.

Nowadays, the Earthquake disaster has become a great concern. Many damages have been caused due to earthquake in both Asia & other continent. It is very tremendous as it is unforeseeable in nature. So it is very necessary to keep in mind the hazards due to seismic effects and should adopt the necessary assumptions before design. Because structures are susceptible to severe damages due to earthquake. Different countries have a variety of provisions of providing such system with a view to dissipating the energy of earthquake. Shear wall and steel bracing systems are most effective means to adopt to add more stiffness in frames. At present, in many high rise building constructions, shear wall has been provided as lift core in case of core type shear wall or constructed as load bearing walls. Besides, the steel bracing systems are allocated in that portion of a structure where more rigidity is required. For different cases, distinct kinds of bracing systems are assumed. Though, bracings have less stiffness comparing with shear wall, there is a significant concern that is the selfweight of bracings are to a small extent comparing with concrete shear wall.

A steel frame can be strengthened in various types to resist lateral forces. These systems are moment resisting beam-column connections, braced frames with moment-resisting connections, braced frames with pin jointed connections and braced frames with both pin-jointed and moment-resisting connections. In steel buildings the most widely used method of constructing lateral load resisting system is braced frames. Hence, the main concern is to select the appropriate bracing model and to decide the suitable connection type. Bracing systems are used in structures in order to resist lateral forces. Diagonal structural members are inserted into the rectangular areas so that triangulation is formed. These systems help the structure to reduce the bending of columns and beams and the stiffness of the system is increased.

**1.1.1 Steel Bracing systems:**

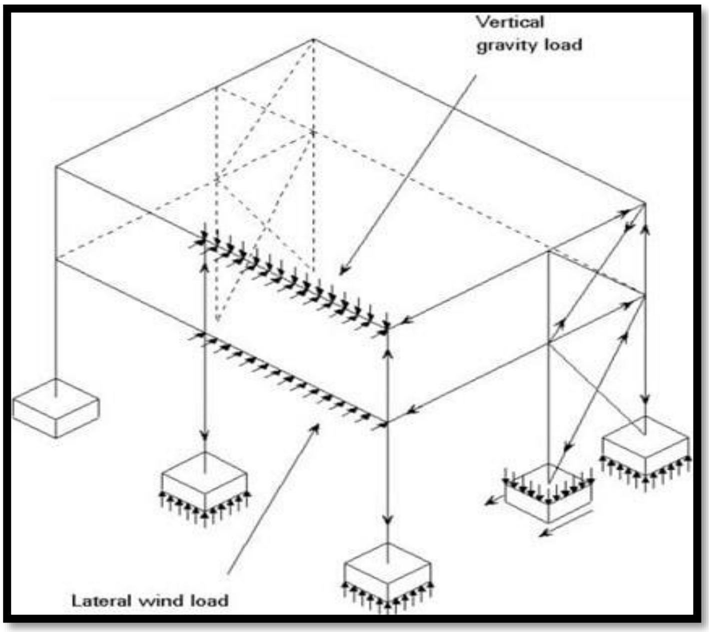
A bracing system is a secondary but essential part of a bridge structure. A bracing system serves to stabilize the main girders during construction, to contribute to the distribution of load effects and to provide restraint to compression flanges or chords where they would otherwise be free to buckle laterally.
There are different types of bracing systems commonly used in multi-storey steel structures between orthogonally arranged beams and columns to transfer horizontal forces imposed on the structure.

**Types of Bracing Systems Used in Multi-Storey Steel Structures-**
There are two major bracing systems:

- Vertical bracing system
- Horizontal bracing system

**Vertical Bracing System for Multi-Storey Steel Structures-**
Vertical bracing as shown in Figure-2 are diagonal bracings installed between two lines of columns. Not only does it transfer horizontal loads to the foundations (create load path for horizontal forces) but also it withstands overall sway of the structure.

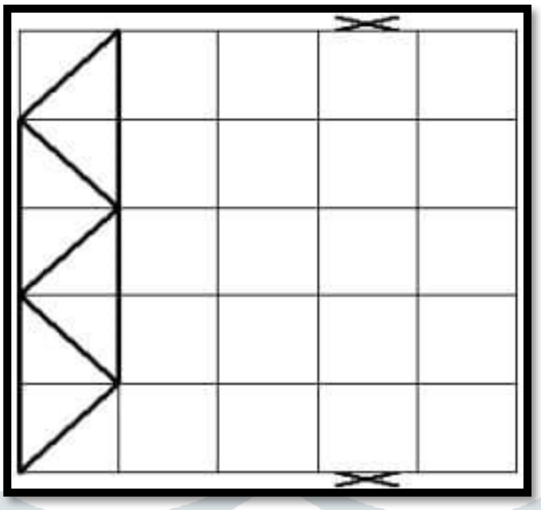
Configurations of vertical bracings include cross diagonals (cross bracing) and single diagonal. In the former case, bracings are slender and withstand tension forces only, so they will not resist compression forces.




**(Figure 1: Vertical Diagonal Bracing Provided Between Two Lines of Columns)**

Therefore, tensile diagonals provide necessary lateral stability in addition to the floor beams that act as a part of bracing system. Figure-2 shows the placement of cross bracings between two lines of columns.

**Horizontal Bracing System for Multi-Storey Steel Structures-**



**(Figure 2: Horizontal Bracing Placement)**

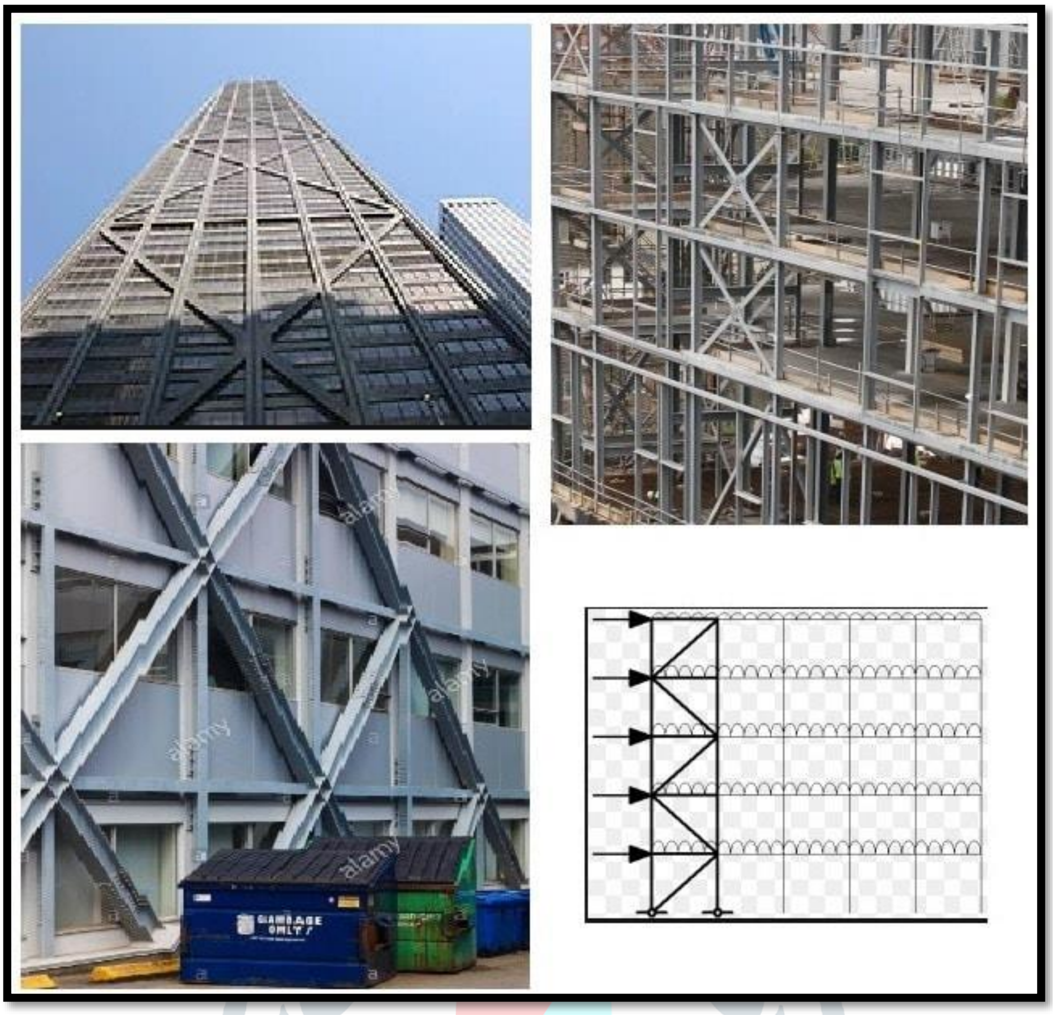
Horizontal bracing systems purpose is the transfer of horizontal loads from columns at the perimeter of the structure to the planes of vertical bracing.

The horizontal forces on perimeter columns are generated because of wind force pressure on the cladding of the structure.

There are two major types of horizontal bracing systems which are used in the multistory braced steel structure namely: diaphragms and discrete triangulated bracing.

Regarding diaphragms, there are various types of floor systems that some of them provide perfect horizontal diaphragm such as composite floors whereas others such as precast concrete slabs need specific measures to satisfactory serve their purpose.

For example, steel work and precast concrete slab should be joint together properly to avoid relative movements.As far as discrete triangulated bracing is concerned, this type of bracing is considered when floor system cannot be used as a horizontal bracing system.It is a horizontal system of triangulated steel bracing placed in each orthogonal direction. The horizontal bracing are placed between supports which commonly are locations of vertical bracings.Regarding bracing at roof level, wind girder is used to resist horizontal forces at the top of the columns.



**(Figure 3: Types of Bracing Systems in Multistory Steel Structures)**

**1.2 Objectives:**

- The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes.

- The present study is an effort towards analysis of the structure during the earthquake. G+15 stories residential building is considered. To analyze a multistoreyed RC framed building considering different earthquake intensities II, III, IV and V by response spectra method and find the base shear value for different structures.

## II. LITERATURE REVIEW

**Zandi (2013)** discussed on comparison between thin steel plate shear walls with dual system of steel moment frame and cross bracing or chevron with a design method based on performance levels. The study focused and discuss on the dual system comprising with thin steel plate shear wall and bracings. In addition, it is based on steel moment resisting frames and approach on performance based design has been arrogated in this research.

**Parasiya et al (2013)** has showed a review on comparative analysis of brace frame with conventional lateral load resisting frame in rc structure using software. It has been represented that the parameters of bracings, locations & stiffness of bracings have notable effect on the performance of a building.

**Kevadkar & Kodag (2013)**discussed on lateral load analysis of rc buildings. An illustration of non-identical buildings including bare frame, frame with shear wall & frame with steel bracings is the main key point of the exploration.

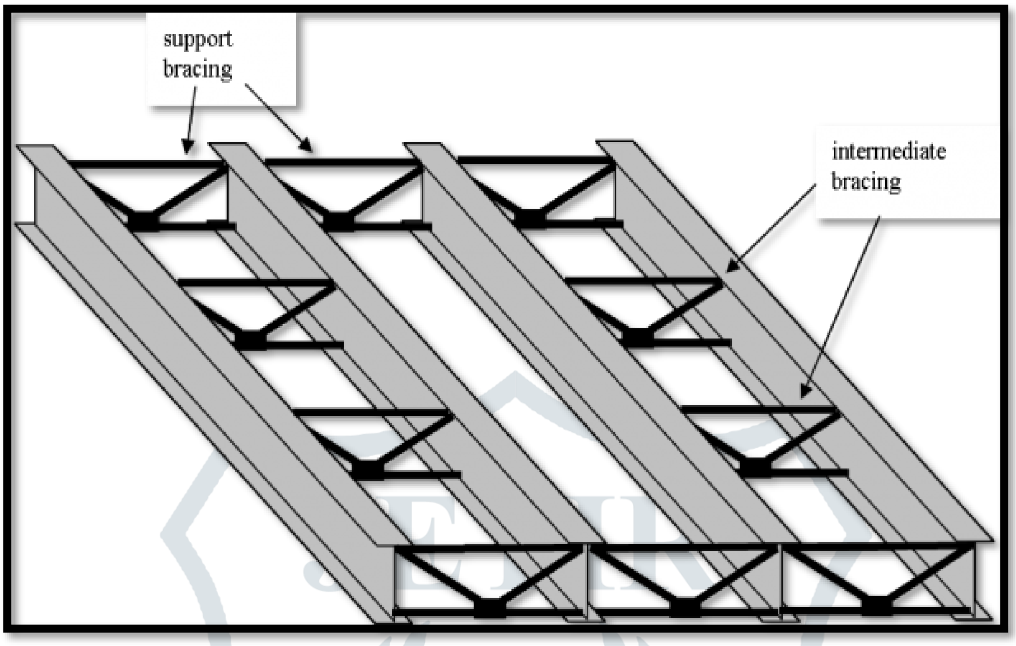
**Kumar.n et al (2014)** has presented a review of shear wall systems. The main focused of this research has been found that the behaviour and resistance of miscellaneous type shear wall against cyclic loads. The output of this analysis shows the suitability of inner shear walls comparing with outer shear walls.

**Gowardhan et al (2015)** reviewed on comparative seismic analysis of steel frame with and without bracing by using software. This research has depended upon the affectivity of steel bracings in steel structures. A comparison has been deliberated between structure with and without steel bracings resistant to seismic effects. It has been found that seismic bracings increase the stiffness against lateral loadings and it might be a good practice to use bracings as retrofitting scheme.

## III. PROPOSED METHODOLOGY

### 3.1 MATERIAL AND THEIR PROPERTIES

A braced frame is a structural system commonly used in structures subject to lateral loads such as wind and seismic pressure. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression.




**(Figure 4: Bracing Made Up Steel)**

### 3.2 METHODOLOGY

Loads on Buildings There are different types of loads are acting on the building but basically there are two types of loads, which a structure must support.
1. Gravity load: These act vertically downward and can be further divided into 'Dead Load' and 'Live Load'. Dead load consists of the weight of the structure itself including the frame, walls, plaster, flooring, waterproofing, fixed furniture etc. Live load constitutes the transient loads such as the weight of people, movable furniture, furnishings, domestic equipment etc.

2. Lateral loads: These act horizontally on the building. The most common lateral loads are wind load and earthquake load. These are occasional loads and may act in any direction.

### 3.3 BRACINGS:

Bracing is a highly efficient and economical method to laterally stiffen the frame structures against wind loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and diagonal bracing members that are connected so that total set of members forms a vertical cantilever truss to resist the horizontal forces. Bracing is efficient because the diagonals work in axial stress.

Type of bracing -
A) Diagonal bracing
B) Cross bracing
C) Zip type of bracing
D) K type of bracing
E) V Type of bracing

### 3.4 METHOD OF EARTHQUAKE ANALYSIS

Earthquake analysis of building is required to know how the building is going to behave at the time of earthquake. This can be done either by dynamic or simple equivalent static analysis. Static analysis does not give us clear idea of how the structure is going to behave during earthquake but gives approximate forces and displacements. Dynamic analysis gives somewhat accurate results. This method requires large amount of computational work. Moreover, to carry out this analysis ground motion data is required.

### 3.5 ANALYSIS TECHNIQUES USED ON STAAD PRO

A. Max deflection Max deflection can also be called the Top deflection of the structure. It is the maximum extent to which the structure displaces in X & Z direction under earthquake loads in both perpendicular directions.
B. Story drift Story displacement is the absolute value of displacement of the storey under action of the lateral forces
C. Story shear The design seismic force to be applied at each floor level is called storey shear.
D. Maximum Axial force The Axial Force is generally defined as the Force acting along the axis of a member. The maximum axial force is mostly experienced.

### 3.6 BUILDING MODELLING

In this paper I have used is a G+15 storey building with same floor plan with 4 bays having same lengths of 4 m along the longitudinal and the transverse direction as shown in figure. This building is designed as per the Indian Code of Practice for Seismic Resistant. Design of buildings story heights of buildings are assumed to be constant including the ground story. The buildings are modelled using software "STAAD-PRO V8i 3.1 Dimensions.

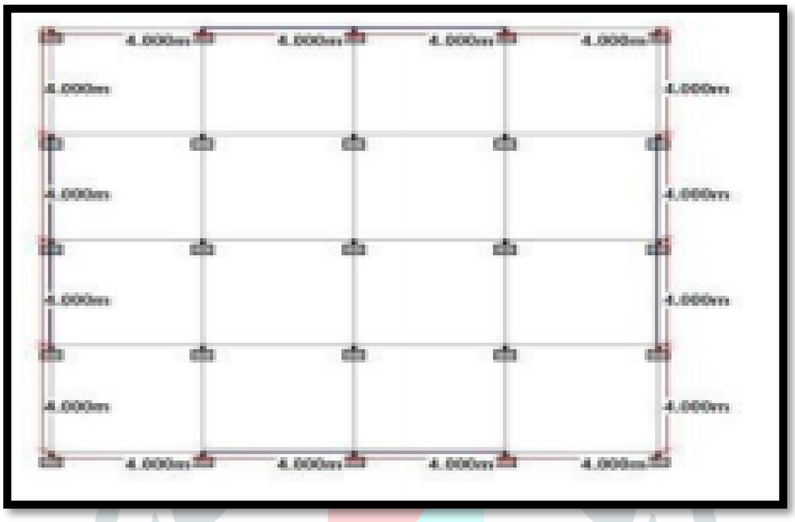


**Figure-5: Plan of the Structure (Top view)**

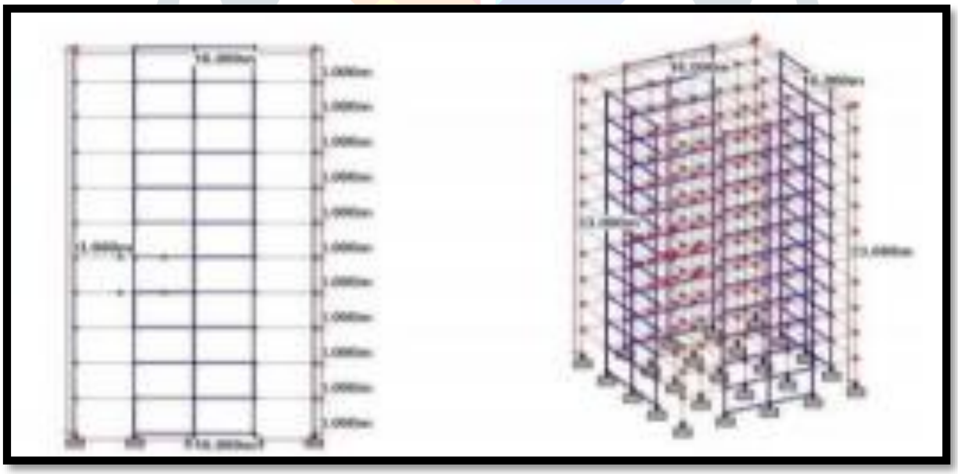


**Figure-6: Dimensions (side view,isometric view)**

Input Data
- Type of structure: multi-storey fixed jointed plane frame.
- Number of stories 16 (G+15).
- Floor height 3 m.
- Seismic zone III (IS 1893 (part 1):2002).
- Materials Concrete (M 35) and Reinforcement (Fe415).
- Bay sizes in the X-direction: 4m, 4m, 4m & 4m - 4 bays.
- Bay sizes in the Z-direction: 4m, 4m, 4m &4m4bays.
- Column 300 x 400 mm (for all columns).
- Beam 300 x 300 mm (for all beams).
- Type of soil medium soil.
- Response spectra as per IS 1893.

### 3.7 ANALYSIS

Analysis of building is one using STAAD Pro.The models were prepared in the STADD Pro. Software by using different types of RC shear wall viz. Parallel Shear wall and Cornered shear wall and these are located at different location such as along periphery and at corner. And also, analysis is done by modelling structure with Diagonal and Cross type Bracings.
A. Base Structure (without seismic restraints)

A base structure is modelled only with the use of columns and beams, and no additional seismic restraints are used. This the plain or base structure that will be further used for comparison with other models with additional seismic restraints. The following structure is a G+15 story building designed on staad pro having no seismic restraints.

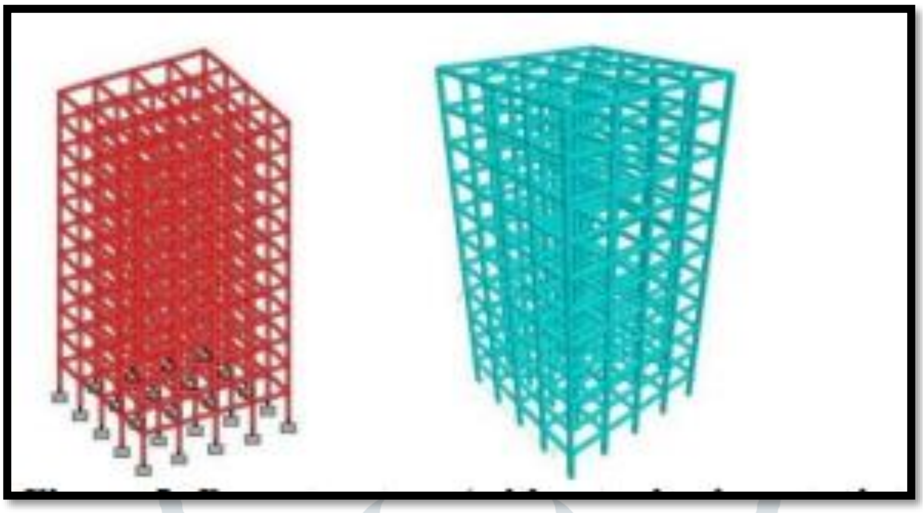
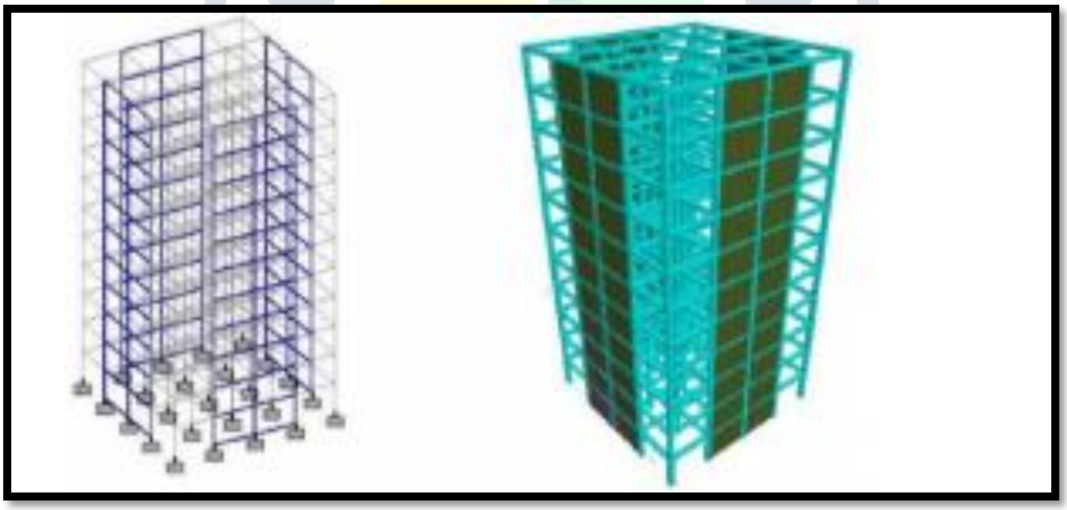


**Figure-7: Base structure (without seismic restraints)**

**B. Parallel Shear Walls**

Model is prepared using staad pro software where the highrise structure is embedded & supported with shear wall on all four sides. The plan dimensions the shear wall is given as (8m x 0.200m) from the base to the roof i.e. 33 m. As the Shear walls are in parallel direction with respect to the two directions of earthquake EQX &EQZ, it is names as Parallel Shear walls.



**(Figure-8: Parallel Shear Walls)**

**C. Bracings-Diagonal**

Model is prepared using staad pro software where the highrise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x10. The bracings are connected diagonally throughout the framework from one column beam joint to another.

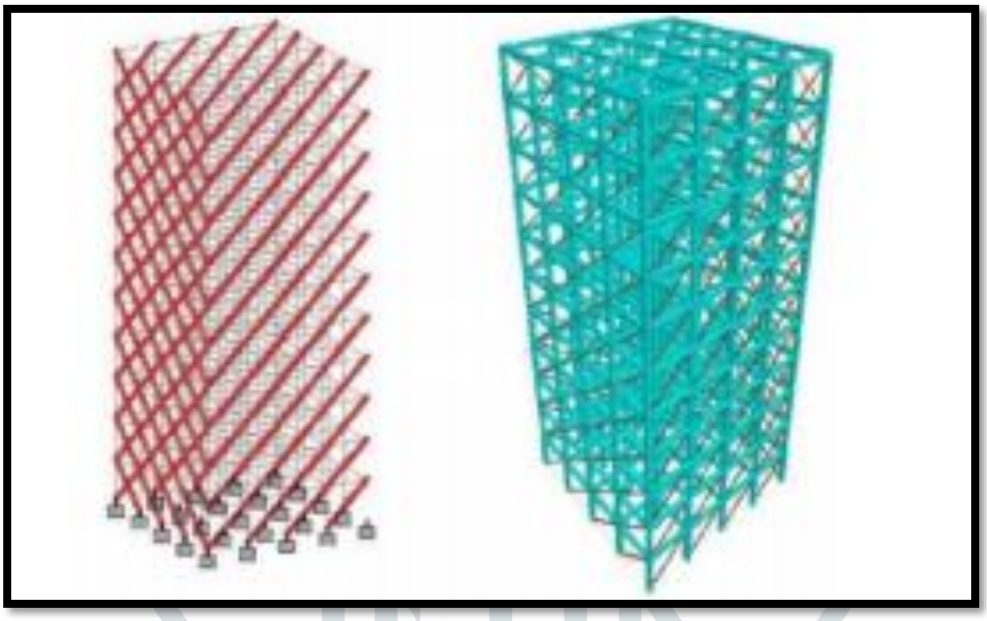


**Figure-9: Bracings-Diagonal**

**D. Bracing- Crossed**

Model is prepared using staad pro software where the highrise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x10. The bracings are connected diagonally throughout the framework from one column beam joint to another.

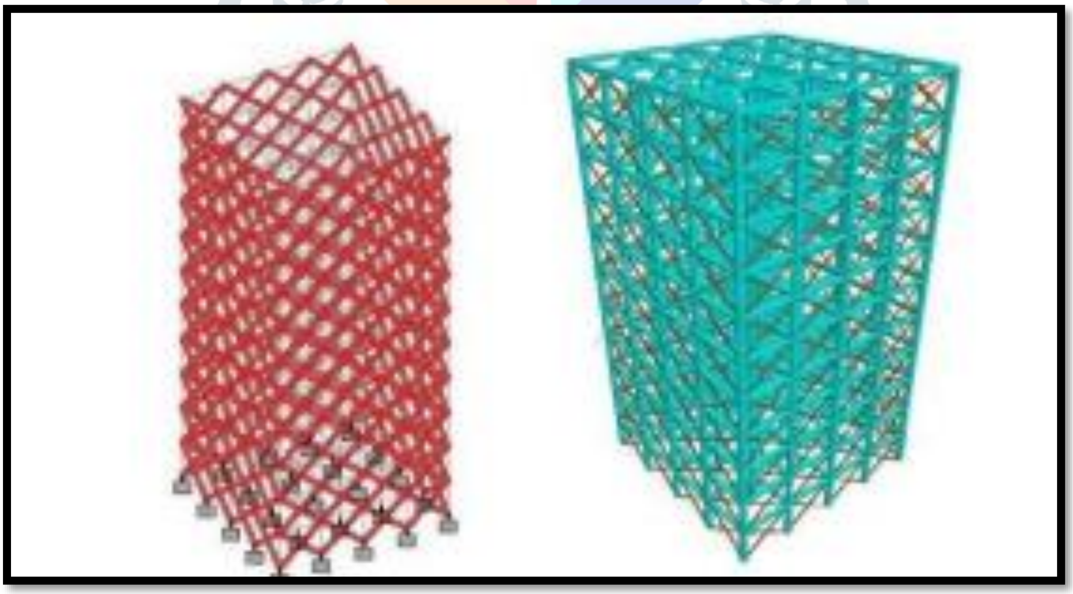


**Figure-10: Bracings- Crossed**

## CONCLUSION

1. Four RC framed models have been observed and analyzed by introducing various earthquake resisting members, like: Parallel shear walls, Corner Shear walls, Diagonal Bracings & Cross Bracings. 2. It is observed from the above analysis that the displacement observed in the models, which are without shear walls & bracings is more as compared to the models having shear walls and bracings at different locations.

3. It has been observed that the Max deflection is significantly reduced after providing the shear walls or bracings in the RC frame in X-direction as well as in Zdirection.

4. It is also been observed that Story shear effectively decreased by introducing Shear Walls and Bracings at different locations.
5. The best location of shear wall in multi-storey building is parallel shear walls. And the best type of bracings that can be used is cross bracing.
6. The lateral deflection of column for building with cross bracing is reduced maximum as compared to all models.
7. The least story shear is found in the model with cross bracing. The shear force is maximum at the ground level & the bending moment is maximum at roof level.
8. By providing shear walls and bracings to the high-rise structure, seismic behavior will be affected to a great extent and also the stiffness and the strength of the buildings is increased.
9. Finally, it is concluded that, optimization using cross bracings is the best procedure, in present work mode for maximum earthquake resistance.

## FUTURE SCOPE

- By using bracings in the structures, the displacement of the structure greatly reduced can be changed or altered. Hence the further study can be done by examining the behavior of the storey building due to wind load forces and Time history analysis.
- We can also study on the behavior of Bending Moment, shear Force etc.
- We can study other types of bracings in different Zones for the different soil type conditions.
- We can study for the different sections in steel structures and compare with and without bracings.

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