



# Response Simulation of G+16 Commercial Building with Different Types of Bracing Systems Using ETABS

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

Multi-storey structures are affected mainly by tremor compel in the seismic inclined zone. The real issue in the plan of the multi storey structure is the buildings mostly have enough horizontal solidness and oppose sidelong powers to control the lateral float of the structure, assigning respective loadings, analyzing the behaviour of the structure, and predicting the responses of each structural component due to external loads. Our project "Response simulation of G+16 commercial building with different types of bracings like single diagonal, V bracing, inverted V bracing, X bracing and K bracing using ETABS software" is one of the attempts made to analyze and design a commercial building using ETABS. Steel bracings are economical with easy erection, occupy less space and have the flexibility to design to meet the required strength parameter and stiffness. In the model, the author considers the building models with different bracing systems based on the journals the authors investigated. Therefore, the project concentrated some design factors like storey displacement drift and storey stiffness.

**Keywords:** Commercial building; bracing systems; ETABS

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## 1. INTRODUCTION

Structures are considered to give the specific performance of various activities connected with residential. Offices, educational field, health cares unit, sports and recreation transportations, storage bins, electric generation etc. Every one of the structures ought to maintain increasing heights by having satisfactory quality and further more strength confining them is happening by satisfactory materials. Quality of the structure relies upon attributes of the materials with which it is developed and stiffness relies on the cross sectional and geometrical property of the structure. Tall buildings or multi storied buildings characterized as ideals of its height (in excess of 30m). It is highly influenced by horizontal forces because of wind or seismic tremor or both to a factor of safety that they assume a critical path in the basic plan, Auxiliary studies manages the tools of recovery of load connected onto the frame work into near by component, utilizing different mathematical operations and articulated methods by manually or software applications [1,2].

Probably, reason for the high rise building is to transfer primary gravity loads safely to the components on small area. The commonly considered gravity loads are dead load and live load. Additionally the structure also should withstand the lateral loads caused by earthquake and wind depending on terrain category and zone. Lateral loads produce sway moment and then reduce the stability of structure and inducing high stresses to the structure. In such cases stiffness also plays more important role than stiffness to resist lateral loads on buildings [3,4].

The different types of bracing configuration used are, cross bracings(X), V bracing, diagonal bracing, K bracing and inverted V bracing. Each bracing configuration possess its own merits and demerits compared to each other.

### 1.1 ETABS

ETABS offers the widest application of analysis and design tools available for the structural engineering works on building structures.

The following lists indicates a portion of the types of systems and analyses that ETABS can handle easily:

- Multi-storey residential, commercial and health care buildings and facilities.

- Parking lots or garages with linear and circular ramps.
- Staggered truss buildings.
- Buildings with concrete, steel, composite framing.
- Static and dynamic analysis of moment frames and shear walls.
- Explicit design and analysis of frames and shell elements of irregular shapes.
- Buildings based on multiple rectangular and/or cylindrical grid systems.
- Flat and ribbed slab buildings.
- Vertical loads are transferred automatically to frames.
- P-Delta analysis with static or dynamic analysis.
- Construction sequence loading analysis.

### 1.2 BRACINGS

- Bracing system enhances stiffness and capacity of structure and upgrades seismic performance of the frame.
- Braces support the resistance towards lateral loads with bracing action.
- The braces simulate force with the associated beams and columns, so that all work together as one truss member.
- These are of less weight compared to the concrete material.
- Steel bracing systems provide openings and easy to erect.
- In this thesis steel bracing o ISMB350 is used.

### 1.3 Objective

- a) Analysing 16 storey building using ETABS software without bracings and with bracings of different configurations.
- b) Comparing the response of different braced and unbraced building subjected to gravity and lateral loads.
- c) Identifying the suitable bracing system to resist the lateral loads effectively.
- d) In this thesis, X, K, diagonal, V, Inverted V bracing systems are used.

## 2. MODELLING

### 2.1 Description of the Building

In this thesis, 16 storey commercial building with 7 floors of parking space and remaining floors for office purposes. The following is the description

of the building,

- Type of the frame : Special moment resisting frame
- Number of stories : 16
- Seismic zone : 2
- Importance factor : 1.5
- Response reduction factor : 5
- Slab thickness : 150mm
- Live load : 5.0kN/m<sup>2</sup>
- Height of each floor : 3.2m
- M40 grade of concrete is used.
- Fe500 steel is used
- ISMB 350 section is used for steel bracing.

## 2.2 Modelling of Structure

A sixteen storey building with parking lot upto 7 stories and commercial space for 9 stories is analysed without bracing systems and with X-type bracing, V, Inverted V bracing system and diagonal bracing and their comparison of storey displacements, storey drifts and storey stiffness results.

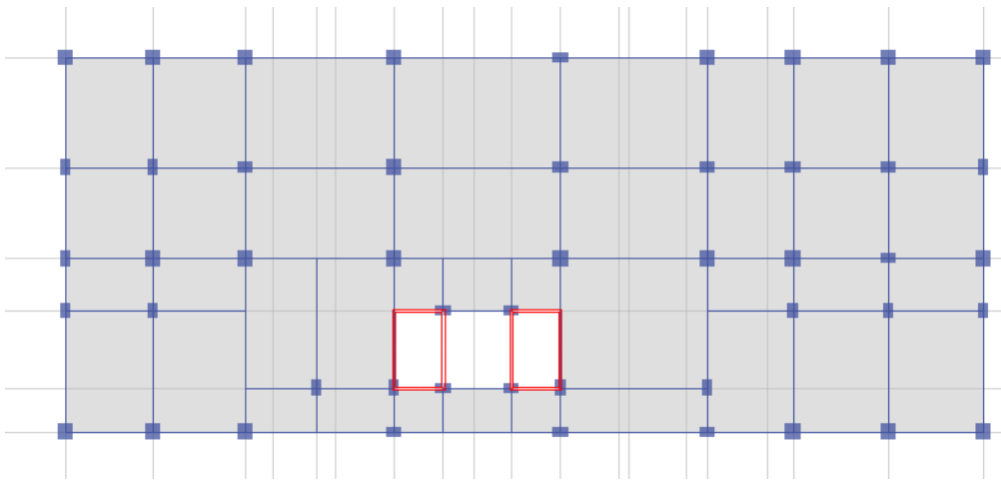


Fig. 1. Plan view of the building

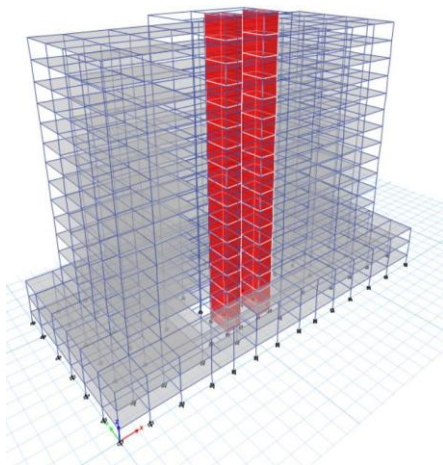


Fig. 2. Bare frame

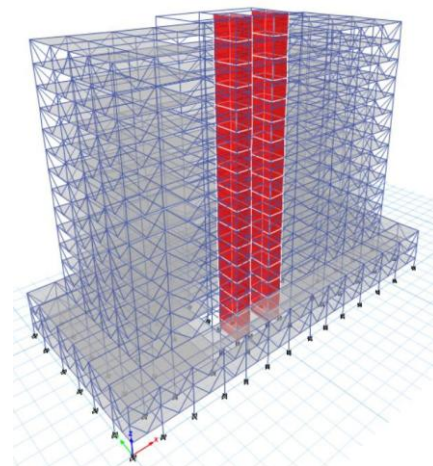


Fig. 3. V bracings

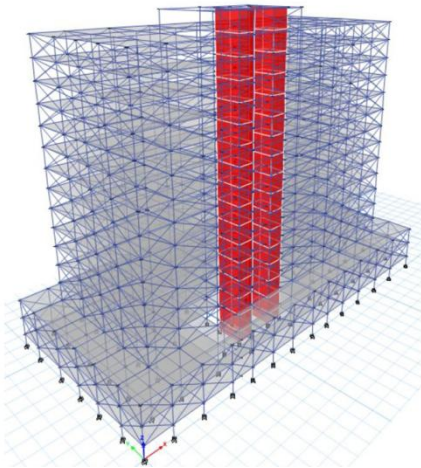


Fig. 4. X bracings

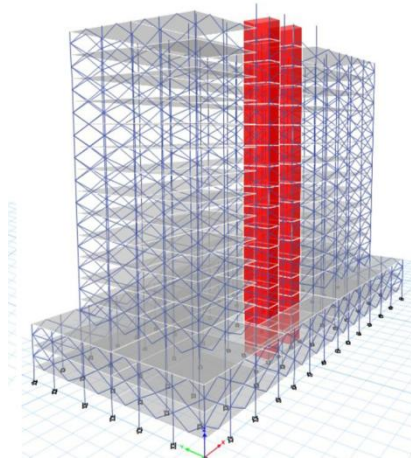


Fig. 5. K bracings

### 3. LOADING CASES

The kinds of loads that impose on buildings and other structures can be classified broadly as vertical, horizontal and longitudinal loads. The vertical load consists of dead, live, and impact loads. Horizontal loads consist of wind and seismic load. In this case of outrigger structure, all the aforementioned load have been taken into consideration. The anticipated types of loads imposing on the structure are dead, live, wind, and seismic loads. Based upon these loads, load combinations have been generated with the model created in ETABS.

#### 3.1 Dead Loads

Dead loads are vertical loads that are permanent and stationary during the lifespan of structure. Dead load is majorly because of self-weight of structural elements, fixed partition walls, fixed equipment and weight of various materials. It mostly comprises the weight of roofs, beams, walls and column etc. which otherwise are the permanent components of the structure. In this particular project the estimated dead loads are mentioned below.

Self-weight of members

1. Floor and finishing loads=1.5kN/m<sup>2</sup>
2. Wall load used according to codes

#### 3.2 Live Loads

The next loads taken for design of structure are live loads are imposed loads. Live loads are both movable and moving loads except occurrence of acceleration or impact. These

loads are presumed to be formed by the purposeful use and occupancy of the building incorporating weight of portable furniture and partitions. Live loads keep on altering at certain time periods. All these loads are to be presumed by the structural designer since it is one of the crucial loads in the design. Since the project is according to Indian standards, the least values of live loads as given in IS 875 (Part 2): [5] 1987. 1. Live load on floors/slabs =4 kN/m<sup>2</sup>

#### 3.3 Earthquake Load

Further earthquake forces are engendered by inertial virtue of buildings as they respond dynamically to ground motion. This natural dynamic response keeps earthquake loads pointed distinctly from other variant building loads. Seismic loads upon the structure are computed specified in the design memorandum and conforming to the terms of IS 1893-2002(Part1) [6]. The analysis is executed by Static analysis method in ETABS 2015. The structure is analyzed with other loads with seismic combination in both transverse and longitudinal directions and also in the opposite sense by reversing the sign in the load combination. Based on the Indian code of practice for earthquake loads, the seismic parameters looked into the analysis process areas follows.

##### 3.3.1 Seismic zone

Seismic zone is a certain zone where in the rate of seismic function prevails quite consistent. This means that seismic activity is immensely

peculiar, or that it is accutely common. The main zones in India are four and they are called Zone II, III, IV and V.

### 3.3.2 Seismic zone factor (Z)

This parameter obtains the spectrum design dependent on discerned superlative seismic threat constituted by maximum considered earthquake (MCE) in zones where structures are present. Effective peak ground acceleration is of a standard reasonable estimate wherein the basic zone factors are included.

### 3.3.3 Response reduction factor(R)

This factor by which the actual base shear force, that will be generated if the structure is to stay elastic during its response to the Design Basis – Earthquake (DBE) shaking should be contained to obtain design lateral force.

### 3.3.4 Importancefactor(I)

This factories used to achieve the design seismic force which is dependent on functional use of structure, constituted by dangerous repercussions of its failure, its post-earthquake function, historic and economic importance.

### 3.3.5 Structural response factor (Sa/g)

This parameter denotes the acceleration response spectrum of structure exposed to earthquake ground vibrations, even dependent on natural period of vibration and damping.

Damping (%) Results of internalized friction and imperfections in material elasticity, sliding and slipping in decreasing the amplitude of vibration is further more characterized as damping percentage

### 3.3.6 Natural period (T)

Natural period of structure is defined as time period of undamped free vibration.

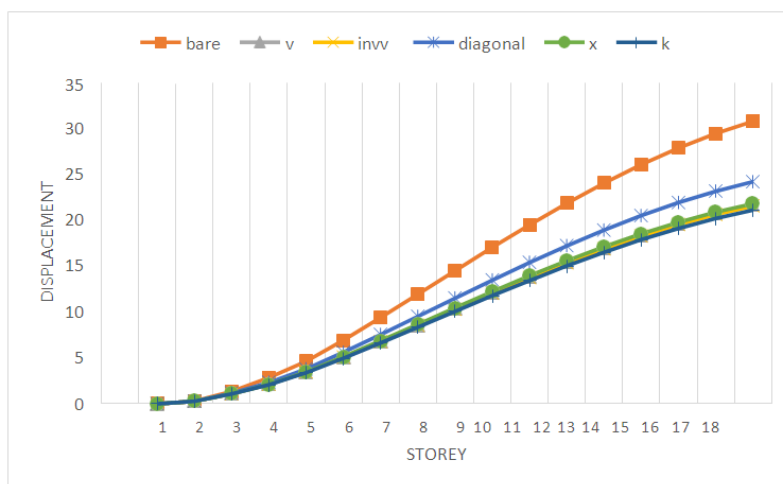
## 3.4 Wind Load

The anticipated wind loads acting on the proposed building are discussed further in this section. Wind loads constitute dynamic and static components. Loads given in code are the corresponding static wind loads; under the static deformation of structure is equivalent to the sum of dynamic and static deformations introduced by wind. The final wind load over the principle load bearing system of the structure is equivalent to vector total of all wind loads exploiting on all surfaces of the structure. Calculations for wind loads for the project was done in precedence with clauses of are 875:1987(Part3).

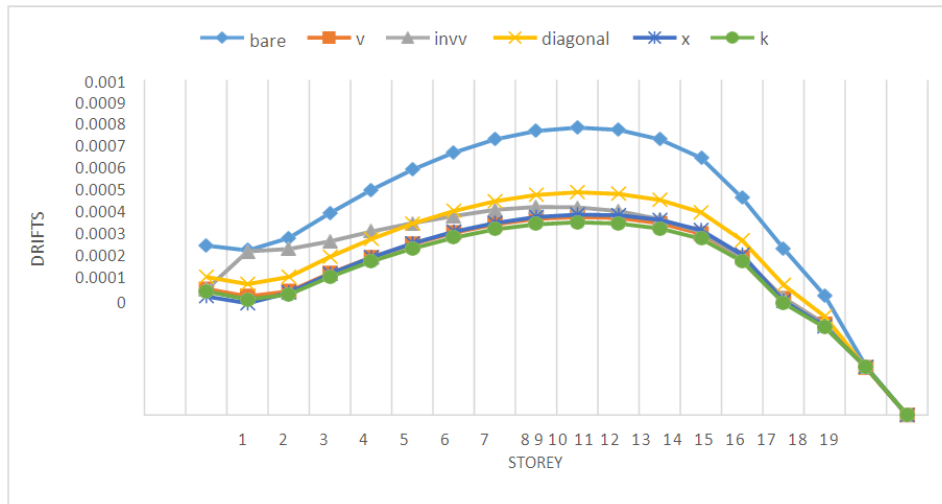
## 4. RESULTS AND DISCUSSION

### 4.1 Storey Displacement

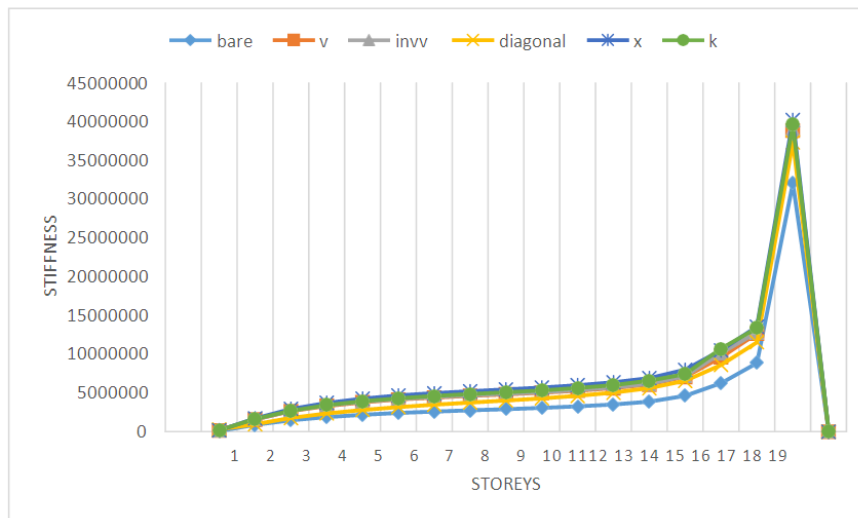
Storey displacement is displacement with respect to base of the structure. It is total displacement of ith storey and maximum permissible limit prescribed in IS codes for buildings is  $H/500$  where H is the building height.



Graph 1. Displacement variation for different types of bracings in Zone2



**Graph 2. Drift variation for different types of bracings in Zone2**



**Graph 3. Stiffness variation for different types of bracings in Zone2**

## 4.2 Storey Drift

Storey drift is a useful engineering lateral load response measurement and indicates structural performance, especially for high-rise buildings. Drift is defined as relative lateral displacement. Storey drift is the ratio of relative displacement difference with the storey height. Storey drift is the relative displacement between adjacent two stories of a building during earthquake.

## 4.3 Storey Stiffness

Stiffness of the building is more having the lesser in deflection. The following graph shows graphical representation of buildings with different bracings

## 5. CONCLUSIONS

1. Strength of the building will increase on adding of the bracings, more in X bracing compared to others. Stiffness will be less so that behave flexibly so that safe condition achieved.
2. All the storey displacement values are in limitations as per IS codes, for the different bracing conditions.
3. Storey drift of K bracing is 32% less than compared to bare frame system.
4. The performance of K-bracing and inverted V bracing is better than other specified bracing systems.



## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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