iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 9 **Issue:** VIII **Month of publication:** August 2021

**DOI:** https://doi.org/10.22214/ijraset.2021.37530

# Seismic Analysis of L-Shape Multi-Storey RCC Building with X-Bracing in Different Effective Location and Pattern

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***Abstract: In this day and age of urbanization, there is a strong need for a large-scale high-rise apartment building in every city but high-rise construction systems are extremely difficult to construct in any seismic region due to the intense and disruptive nature of seismic forces. Seismic forces have the highest risk of causing the most harm to high-rise buildings. To meet this need, the Civil Engineering industry is constantly developing new groundbreaking techniques. To solve this problem RCC or steel bracings are provided in high-rise buildings which help to the low down the effect of seismic and wind forces. The main objective of this paper is to locate an effective position and pattern of the RCC X-bracing system in the L- shape multi-storey building which is subjected to seismic forces. According to a previous reference paper, X-bracing produces better results than other bracing systems. Analysis the seven types of frame models are taken – (1) Normal L-shape building without bracing, (2) X-bracing are provided at the face of L-shape building, (3) X-bracing are provided alternative pattern at the face of L-shape building from bottom to top floor, (4) X- bracing are provided zig-zag pattern at the face of L-shape building, (5) X-bracing are provided at the corner of L-shape building, (6) X-bracing are provided alternative pattern at the corner of L-shape building from bottom to the top floor, (7) X-bracing are provided zig-zag pattern at the corner of L-shape building. Developed and evaluated by response spectrum analysis method (Linear dynamic analysis) as per IS 1893-2000 using STAAD PRO V8i. In the present work G+12 storey, the L-shape frame structure is analyzed by using X-bracing. It is analyzed and the results of the Following Parameters are taken - (1) Peak storey shear, (2) Base shear, (3) Nodal displacement, (4) Maximum bending moment, (5) Total quantity of steel in the whole structure, (6) Total volume of concrete in the whole structure are evaluated and compared.***
***Keywords: RCC Bracing, Seismic Behavior, Seismic Analysis, Peak Storey Shear, Base shear, Nodal Displacements, Maximum Bending Moment, The Total Quantity of Steel, The Total Volume of Concrete***

## I. INTRODUCTION

The structural collapse starts at weak points during an earthquake, and its deficiency is caused by structural geometry, mass discontinuity, and stiffness. These types of discontinuity structures are known as irregular structures. In high-rise buildings, irregularity is a major cause of structural errors during earthquakes. As a result, any type of irregularity has a major effect on the seismic efficiency of high-rise building constructions. However, much of the urban modern infrastructure is funded by haphazard constructions. The aim of high-rise buildings is often to safely or carefully pass the primary gravity load. The dead and live loads are both typical gravity loads. Furthermore, the structure should be able to withstand lateral loads induced by an earthquake, wind in the seismic zone, loads causing sway moment and trigger high stresses, all of which decrease the structure's stability. The greater the emphasis placed on making a structure secure against lateral load in high-rise buildings constructed of RCC frames. Wind, earthquakes, and other natural disasters create these loads. Different types of steel or RCC bracing systems are available to withstand lateral load acting on the building. RCC bracing has potential advantages over other bracing forms, such as increased stiffness and stability. In columns, the bending moment of the braced frame can also be controlled. These are inexpensive and simple to erect, with the feature flexibility to generate stiffness and strength. The main purpose of this paper analysis of L-shape multi-storey RCC building is to provide X-bracing in different effective location and pattern. The key reason for selecting the L-shape building is that it has a higher displacement value than other shapes of buildings but this shape of the building will be constructed to fulfill the demands of any seismic zone site construction such as elevation of building and shape of the plot. X-bracing systems are used because they have more reliable outcomes as compared to other bracing systems.

### A. *Earthquake*

Earthquakes are a natural disaster that is harmful to both living and non-living objects, such as human, animal, and building or other structures. They are a devastating phenomenon that occurs all the time. Significant earthquakes are triggered by the sudden release of a large amount of strain energy by fault movement, which causes seismic waves to travel in all directions within the earth layer as the ground shakes. These seismic waves will carry various levels of a lot of energy emit within some limited region of the rocks of the earth, The different amplitudes, and arrive at various instants of time to the surface. This form of energy is the only kind that can be stored in sufficient quantity on the Earth to produce major disturbances. According to the intensity of ground shaking and magnitude during the earthquake disaster, earthquakes can be categorized as mild, moderate, major, or powerful based on their scale and frequency. The magnitude (M) parameter is used to determine the size of an earthquake reported on a seismogram. The severity of ground shaking can vary depending on where it occurs, even though the amplitude is the same. On the MMI scale, this is calculated (Modified Mercalli Intensity). When an earthquake occurs, different buildings on the same site perform differently. This difference in amounts is influenced by a variety of factors, including spontaneous variations in material strength, the amount of mass and stiffness of structural and non-structural members, levels of workmanship, site conditions, the severity and distribution of live load at the time of the earthquake, and the reaction of the soil underneath the buildings. As a result, there is an immediate need to evaluate the seismic vulnerability of buildings in India's urban areas, which is an important component of a robust earthquake disaster risk management strategy. Innovative preservative ideas are being established in India and other countries around the world. A multi-storey building that is built to withstand lateral loads acting on the structure.

### B. *Irregular Building*

Irregular construction accounts for a significant portion of the new metropolitan infrastructure. Its irregularity is caused by structural geometry, mass irregularity, and stiffness irregularity. These types of discontinuity structures are known as irregular structures. In high-rise buildings, irregularity is a major cause of structural errors during earthquakes. Irregular buildings are located in seismically active areas, making the job of structural engineer more difficult.

Types of the irregular building following are:-

*1)* Structural geometrical irregularity,

*a)* Plan irregular ( such as architectural plan irregularity – L-shape, U-shape, I-shape building, etc. ),

*b)* Vertically irregular- Vertical irregular building refers to vertical discontinuities in the distribution of mass, stiffness, and strength in a structure. (In the case of a set-back building, the vertical distribution of mass and stiffness changes abruptly.)

*2)* Mass irregular – The seismic weight of unequally distributed in every storey of any building are called mass irregular building (such as a set-back irregular building ).

*3)* Stiffness irregular- The lateral stiffness of unequally distributed in every storey of any building is called stiffness irregular building ( such as soft storey building ).

### C. *STAAD PRO V8i software:*

Structural analysis and architecture are difficult tasks in the civil engineering culture. Any 3-dimensional analysis takes time and is difficult to complete. It will be simpler for you if you understand what Staad pro software is and what its past is.

1) *What is Staad Pro Software?* It's a program for structural analysis and design. In 1997, Research Engineers International in Yorba Linda, California, created this software. They later sold it to Bentley Systems in 2005, and Bentley Systems is now selling and promoting it worldwide through local distributors.
2) *What is Staad Pro Used for?* Staad Pro is now a consumer version that is commonly used for Structural Analysis and Design products all over the world. This curriculum supports the majority of steel, concrete, and timber building codes of practice. This software can be used to design and analyze any structure. This software can perform a variety of analyses, including conventional 1st order static analysis, p-delta analysis, pushover analysis, buckling analysis, and geometric non-linear analysis. This software can perform a variety of complex analyses, including modal extraction, time history, and response spectrum analysis. During large-scale structure monitoring, it has made all of the above a lot simpler and less time-consuming. It has been a part of integrated structural analysis and design strategies in recent years. It is important to note that it uses an open API called Open STAAD to enter and drive the program through a Visual Basic macro framework. Another approach is to provide Open STAAD functionality in applications that have their programmable macro systems. STAAD Pro also includes some applications that are connected directly, such as RAM connection and STAAD Foundation, to enable

Engineers to work with applications that handle design post-processing that is not handled by STAAD Pro. The research schema of the CIM steel integration Ideals, version 2 commonly known as CIS/2 and used by a few modeling and analysis applications is the other form of integration endorsed by the STAAD Pro. Staad Pro is a 3D visualization and design program used by the Civil Engineering community all over the world.

*a) The advantages of using STAAD Pro*

- STAAD Pro provides precise results when measuring Shear Force and Bending Moment.
- STAAD Pro eliminates the need for manual calculations, saving time and increasing performance.
- Engineers may use STAAD Pro to improve the structure, section, and dimensions.
- STAAD Pro allows you to build the structure more quickly.
- STAAD Pro can be used to measure a variety of loads, including live loads, dead loads, wind loads, snow loads, area loads, and floor loads.
- STAAD Pro is a sophisticated and feature-rich structural design program with an open architecture called OpenSTAAD.
- Designs that use Indian, the US, British, Euro, Canadian, Japanese, and nuclear codes are featured in STAAD Pro.

*b) Limitations or Disadvantages of Staad Pro Software*

- It produces uneconomical results for multi-storey buildings.
- Modeling limitations. Curvy boundaries, parabolic beams, and other complex shapes can't be effectively modeled or analyzed.
- Complex structure analysis can be time-consuming. Requires the right skills.
- It is not possible to detail reports properly.
- This product is not suitable for brick masonry work.

### *D. Bracing*

A bracing element is a concrete or steel member used on any kind of massive structure to reduce lateral deflection caused by earthquakes and wind forces. The braced frames are used to withstand lateral forces caused by earthquakes and wind. To aid in the distribution of load effects and to provide restraint to the structure's tension and compression members. In this, the frames are designed such that it works in tension as well as compression forces. The lateral loads minimize stability of structure by producing sway moment and induce stresses too high. So, in such cases, stiffness is a more important factor than strength to resist lateral loads. To improve the seismic performance of building structures there are various ways of bracing systems. The different typically bracing systems configurations used are:-

*1)* Diagonal bracing
*2)* Cross bracing
*3)* V- bracing
*4)* K-bracing
*5)* Chevron bracing

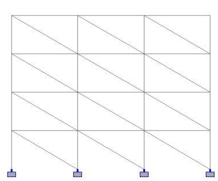

Fig1.1 – Diagonal Bracing system

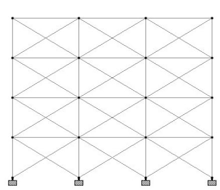

Fig1.2 – Cross Bracing system ( X-Bracing )

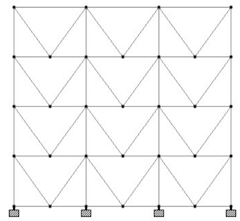

Fig1.3 – V-Bracing system

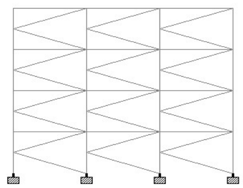

Fig1.4 – K-Bracing system

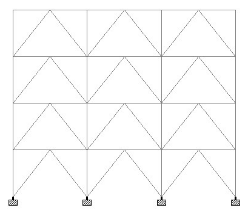

Fig1.5 – Chevron Bracing system

*E. Analysis Objectives*

1) During an earthquake, the base shear at the bottom of the building should be increased.
2) During an earthquake, to minimize nodal displacement.
3) To determine the seismic response of all models using STAAD.PROV8i software's response spectrum analysis.
4) To determine the effects of the presence of a bracing device on different parameters of an RC building during seismic events.
5) In higher earthquake zones, to assess which structure is better than another.
6) In higher earthquake zones, to decide the effective position and pattern of the x-bracing system is superior to another.

*F. Scope Of The Work*

1) With the help of this study analyze the different shapes of high-rise buildings.
2) Apply different design parameters and various zone or city located buildings.
3) This study helps to economical and stiffness study of seismic zone building.
4) The help of this analysis saves more money and time-consuming.

*G. Need of Present study*

In this day and age of urbanization, there is a strong need for a large-scale high-rise apartment building in every city but high-rise construction systems are extremely difficult to construct in any seismic region due to the intense and disruptive nature of seismic forces. Seismic forces have the highest risk of causing the most harm to high-rise buildings. To meet this need, the Civil Engineering industry is constantly developing new groundbreaking techniques. To solve this problem RCC or steel bracings are provided in high-rise buildings which help to the low down the effect of seismic and wind forces. The main objective of this paper is to locate an effective position and pattern of the RCC X-bracing system in the L- shape multi-storey building which is subjected to seismic forces.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
*Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com*

According to previous research papers are show L-shape buildings are more deflective in the seismic zone as compare to other shapes of buildings such as U-shape, Plus shape, I- shape, square shape, rectangular shape. For any Requirement of construction of L-shaped building of site condition such as architectural plan and size or shape of the plot. The main aim of this study reduces the deflection of L-shaped buildings by the use of X-bracing systems which are provided different effective locations and patterns to make 7 above-listed models prepare then after comparing with model1. To determine which effective location and pattern of the x-bracing system in L-shape building is superior in higher earthquake zones as well as make structure economical.

## II. METHODOLOGY

The methodology is the strategy of project work step to step. Before starting this project Identification of problems, Literature survey, Use STAAD PRO V8i software some models are created, assign properties of the structure, Applied seismic definition IS 1893, Load applied according to IS 875 (Dead load and live load), Applied response spectrum load, Applied material IS 456, Design parameter, Print analysis, Run the analysis. After these steps go to the output file and compare their results.

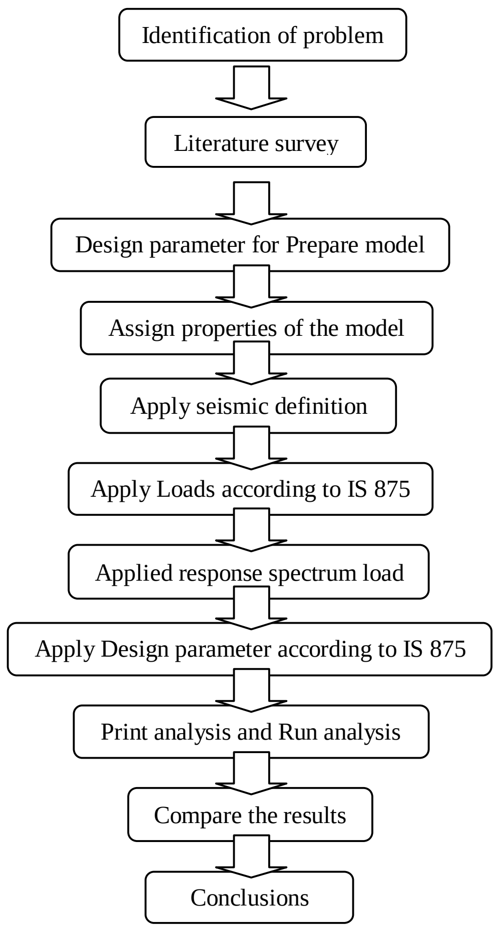


Fig 2 - Flow chart of Methodology

### *A. Modelling*

In this project analysis of the seven types of frame models are taken - (1) Normal L-shape building without bracing, (2) X- bracing are provided at the face of L-shape building, (3) X-bracing are provided alternative pattern at the face of L-shape building from bottom to the top floor, (4) X- bracing are provided zig-zag pattern at the face of L-shape building, (5) X-bracing are provided at the corner of L-shape building, (6) X-bracing provided alternative pattern at the corner of L-shape building from bottom to the top floor, (7) X-bracing provided zig-zag pattern at the corner of L-shape building. Developed and evaluated by response spectrum analysis method ( Linear dynamic analysis) as per IS 1893-2000 using STAAD PRO V8i. In the present work G+12 storey, the L-shape frame structure is analyzed by using X-bracing. Following Parameters are taken for results are- (1) Peak storey shear, (2) Base shear, (3) Nodal displacement, (4) Maximum bending moment, (5) Total quantity of steel in the whole structure, (6) Total volume of concrete in the whole structure.

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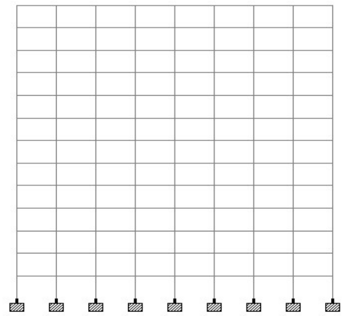

Fig2.1(a) – Front view of Model 1 (Normal Building)

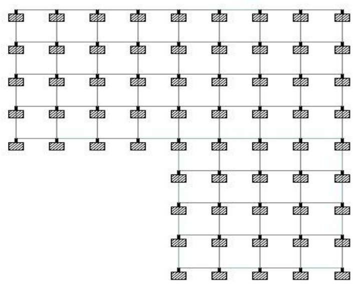

Fig2.1(b) – Top view of Model 1 (Normal Building)

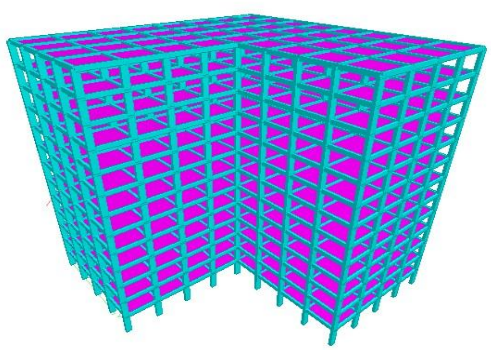

Fig 2.1(c) – 3D view of Model 1 (Normal Building)

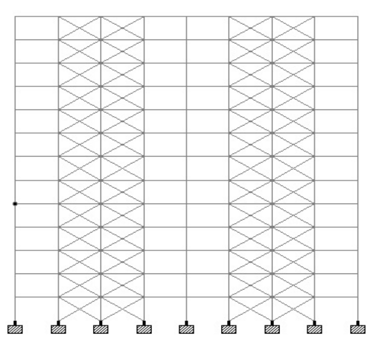

Fig2.2(a) – Front view of Model 2 (X-Bracing at the face)

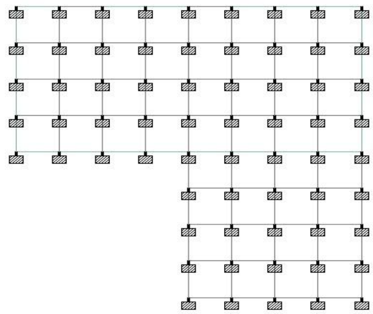

Fig 2.2(b) – Top view of Model 2 (X-Bracing at the face)

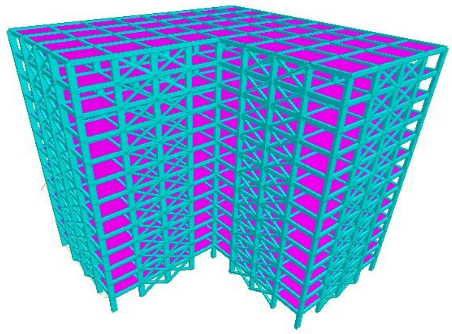

Fig 2.2(c) – 3D view of Model 2 (X-Bracing at the face)

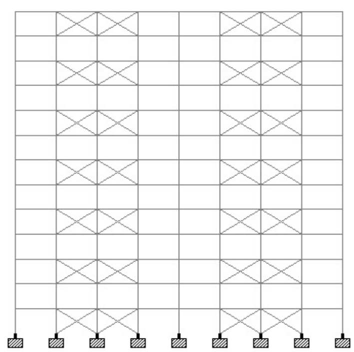

Fig 2.3(a) – Front view of Model 3 (X-Bracing alternative pattern at the face)

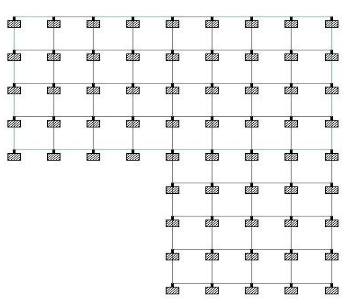

Fig 2.3(b) – Top view of Model 3 (X-Bracing alternative pattern at the face)

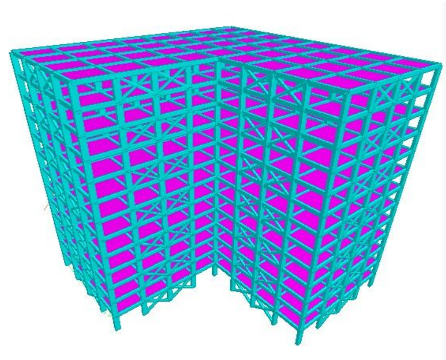

Fig 2.3(c) – 3D view of Model 3 (X-Bracing alternative pattern at the face)

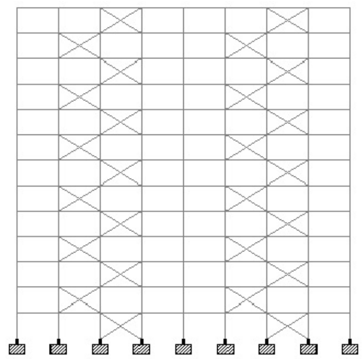

Fig 2.4(a) – Front view of Model 4 (X-Bracing zig-zag pattern at the face)

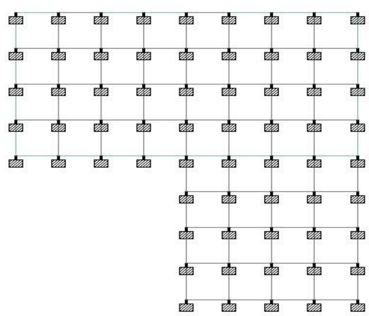

Fig 2.4(b) – Top view of Model 4 (X-Bracing zig-zag pattern at the face)

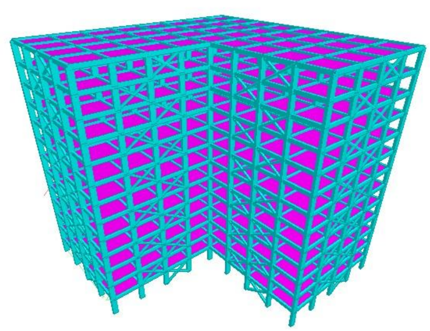

Fig 2.4(c) – 3D view of Model 4 (X-Bracing zig-zag pattern at the face)

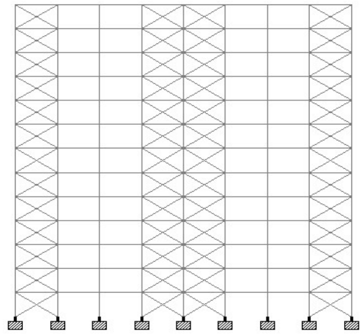

Fig 2.5(a) – Front view of Model 5 (X-Bracing at the corner)

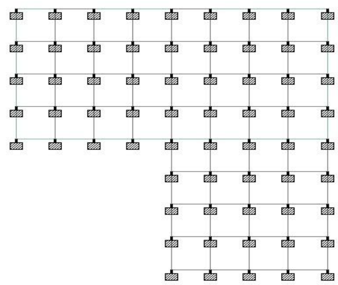

Fig 2.5(b) – Top view of Model 5 (X-Bracing at the corner)

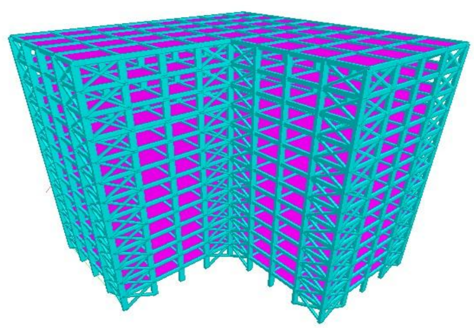

Fig 2.5(c) – 3D view of Model 5 (X-Bracing at the corner)

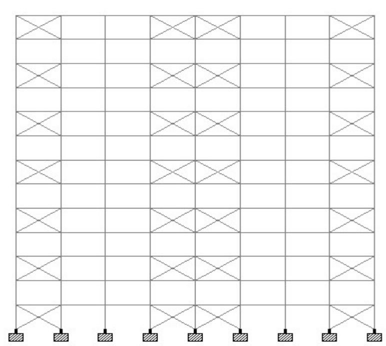

Fig 2.6(a) – Front view of Model 6 (X-Bracing alternative pattern at the corner)

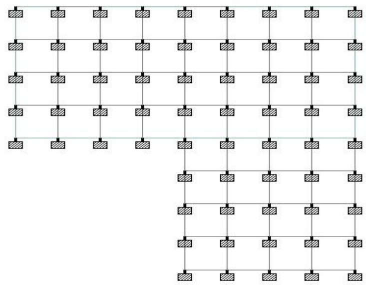

Fig 2.6(b) – Top view of Model 6 (X-Bracing alternative pattern at the corner)

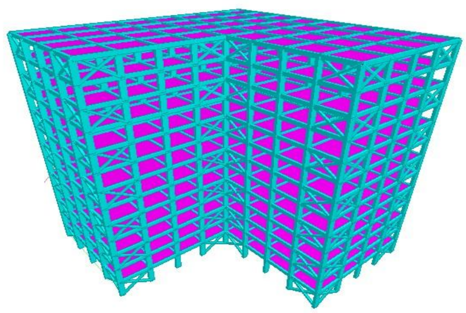

Fig 2.6(c) – 3D view of Model 6 (X-Bracing alternative pattern at the corner)

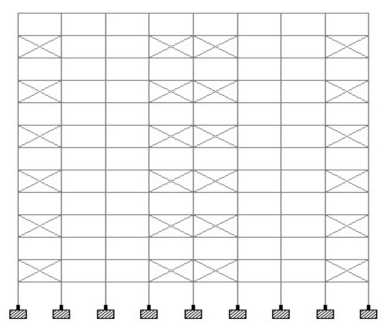

Fig 2.7(a) – Front view of Model 6 (X-Bracing zig-zag pattern at the corner)

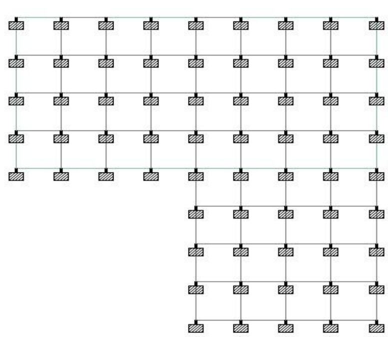

Fig 2.7(b) – Top view of Model 6 (X-Bracing zig-zag pattern at the corner)

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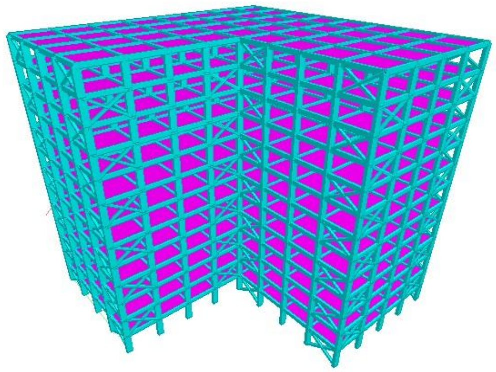

Fig 2.7(c) – 3D view of Model 7 (X-Bracing zig-zag pattern at the corner)

*B. Data for the Analysis*

Assumed following data- (1) Number of storey, (2) Types of building, (3) Storey height, (4) Beam size, (5) Column size, (6) Bracing size, (7) Thickness of slab.

According IS 456 data- (1) M30, (2) Fe 415.

According to IS 875 data- (1) Dead load of the slab, (2) Dead load of the beam, (3) Dead load of the column, (4) Dead load of bracing, (5) Live load.

According to IS 1893 data- (1) Seismic zone, (2) Response reduction factor, (3) Importance factor, (4) Damping ratio, (5) Soil type.

Table No 1: Data for the analysis

| S.No. | Type | Specification |
|---|---|---|
| 1. | Number of storey | G+12 |
| 2. | Types of building | Commercial building |
| 3. | Storey Height | 3.20 meters |
| 4. | Center to center distance of each column with each other | 5.00 meters |
| 5. | Total height of the building | 41.60 meters |
| 6. | Length of building | 40.00 meters |
| 7. | Width of building | 40.00 meters |
| 8. | Grade of concrete | M30 |
| 9. | Grade of steel | Fe 415 |
| 10. | Beam size | 0.5mX0.3m |
| 11. | Column size | 0.80mX0.30m |
| 12. | Bracing size | 0.30mX0.30m |
| 13. | Thickness of slab | 0.125m |
| 14. | Unit weight of reinforced concrete | 25 KN/m3 |
| 15. | A dead load of slab | 5.125 KN/m2 |
| 16. | A dead load of the beam | 3.75 KN/m2 |
| 17. | A dead load of the column | 6 KN/m2 |
| 18. | A dead load of bracing | 2.25 KN/m2 |
| 19. | Live load | 3 KN/m2 |
| 20. | Seismic zone (z) | 4 |
| 21. | Response reduction factor | 5 |
| 22. | Importance Factore (I) | 1 |
| 23. | Damping ratio | 0.05 |
| 24. | Soil type | Medium |

### *C. Load Calculation*

*1) Dead Load*

Dead load of slab = Unit volume of slab X Unit weight of concrete
= 1 x 1 x 0.125 x 25 = 3.125 KN/m2
Floor finish load = 1 KN/m2 (As per IS 875 part-1)
Total dead load of slab = Dead load of slab + Floor finish load
= 3.125 KN/m2 + 1 KN/m2
= 5.125 KN/m2
Dead load of beam = Unit volume of beam X Unit weight of concrete
= 0.60 x 0.30 x 1 x 25 = 4.5 KN/m
Dead load of column = Unit volume of column X Unit weight of concrete
= 0.80 x 0.40 x 1 x 25 = 8 KN/m
Dead load of bracing = Unit volume of bracing X Unit weight of concrete
= 0.30 x 0.30 x 1 x25 = 2.25 KN/m

*2)* Live load = 3KN/m2 (As per IS 875 part-2)

### *D. Dead Load*

Deal loads are loads that are relatively constant over time, such as the weight of all permanent elements of a structure, such as walls, beams, columns, flooring material, and so on. Equipment and fittings are permanently installed and are an integral part of the structure. For calculation of dead load structure's dimension multiplied with a unit weight of material like concrete. Simple concrete and bolstered concrete constructed of sand and gravel or beaten natural stone aggregate have unit weights of 24 and 25 KN/m3, respectively.

### *E. Live Loads*

Live loads, also referred to as forced loads, are normally transient, variable, and dynamic. Vehicle traffic, occupants, furniture, and other equipment are all examples of these types of loads. All the loads that are temporarily loaded on the building, such as humans, furniture, and machines, are referred to as live loads on floors and roofs. The number of live loads changes regularly. Implied loads are also known as live loads. The weight of movable partitions, dispersed and concentrated loads, load due to having an impact on and vibration, and dust loads are all examples of imposed loads. Wind, volcanic activity, precipitation, and loads applied due to temperature variations to which the form may be subjected, creep and shrinkage of the structure, and differential settlements to which the structure will also be subjected are not considered imposed loads.

### *F. Seismic Load: Seismic*

Loading is a fundamental term of earthquake engineering that refers to the application of a structure's agitation caused by an earthquake. It occurs when a structure's touch surfaces come into contact with the earth, surrounding objects, or tsunami gravity waves. Seismic analysis is a crucial method in earthquake engineering since it allows engineers to discern the structural response to a variety of seismic excitations in a less complicated manner. In the past, structures were only built to withstand gravity loads; however, seismic analysis is the most recent development. It is a sector of structural evaluation and a sector of the structural graph where the earthquake is prevalent. There are one-of-a-kind methods of earthquake analysis. Some of them used in the task is-

*1) Equivalent Static Analysis:* The elastic format method is unquestionably an equivalent static analysis technique. It is, however, easier to observe than the multimodel answer process, with the absolute simplifying assumptions probably being more compatible with previous absolute assumptions absolute elsewhere in the format procedure. The measures in the analogous static analysis procedure are as follows:

*a)* Calculate the build's first mode response length based on the response spectra graph.

*b)* Using the specific format response spectra, determine if the overall build's lateral base shear is stable, and the degree of post-elastic (ductility) response is maintained.

*c)* Share out the base shear among many lumped mass levels using an overturned triangular shear allocation of 90% of the base shear regularly, with 10% of the base shear forced at the top point to allow for superior mode effects.

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2) *Response Spectrum Analysis:* This approach takes into account more than one mode of the answer of a building that is to be occupied. Many building codes require this, except for extremely simple or extremely complicated structures. The structural response can also be described as a multi-mode mixture. These modes for certain structures can be determined using computer analysis. A response is extracted from the planning spectrum for each mode, analogous to the modal frequency and modal mass, and then mixed to estimate the structure's overall response. This calculates the sum of forces in all directions and then observes the effects on the structure.
3) *Time History Analysis:* The step-by-step answer in the time domain of the multi-degree-of-freedom equations of motion that characterize the true response of a building is what time-history assessment strategies are all about. It's the most advanced analytic technique available to a structural engineer. Its response is a direct result of the earthquake floor movement, which was chosen as an enter parameter for a specific structure.

### G. Dynamic Analysis

In contrast to the structure's normal frequency, a dynamic load shifts rapidly over time. The natural frequency produced during an earthquake is extremely high, and the nature of the event is unpredictable and impossible to predict. The period time in dynamic loading is uncertain and the time period for which earthquakes may occur in nature cannot be determined so overcome this structure should be such a design that it can easily absorb all the lateral loads that they may affect the structure at the time of the earthquake. Furthermore, for the same loading amplitudes, the dynamic response is typically much higher than static displacements, particularly at resonant conditions. The displacements in actual physical systems are numerous. As a consequence, the most important aspect of structural analysis is to construct a computer model; there is a variety of software that can be used to conduct analysis and produce reliable results. The software used in this analysis is STAAD pro V8i for modeling and evaluating the building using different parameters. Finding results is made easier by using software, and all parameters such as peak storey shear, base shear, nodal displacement, maximum bending moment, the total quantity of steel in the entire structure, and total volume of concrete in the entire structure can be concluded. There are many dynamic analysis methods available; however, in this project, the response spectrum analysis approach is used.

### H. Parameter Consideration

Following are the design parameter on structure:-

1) Seven types of models are used-
a) Normal L-shape building without bracing,
b) X- bracing provided at the face of L-shape building,
c) X-bracing provided an alternative pattern at the face of L-shape building,
d) X- bracing provided zig-zag pattern at the face of L-shape building,
e) X-bracing provided at the corner of L-shape building,
f) X-bracing provided an alternative pattern at the corner of the L-shape building,
g) X-bracing provided a zig-zag pattern at the corner of the L-shape building.
2) Assume beam, column, sizes, and slab thickness.
3) Assign material properties according to IS 456.
4) Assign seismic definition according to IS 1893-2000.
5) Assign dead load and live load according to IS 875.
6) Assign Response spectrum load (Dynamic analysis).

## III.RESULT AND DISCUSSION

This paper compares results of L-shape building without X-bracing and L-shape building with X-bracing models at the different effective location in the seismic zone- 4 condition. In this project analysis of seven types of frame models are taken - (1) Normal L-shape building without X-bracing, (2) X-bracing are provided at the face of L-shape building, (3) X-bracing are provided alternative pattern at the face of L-shape building from bottom to the top floor, (4) X- bracing are provided zig-zag pattern at the face of L-shape building, (5) X-bracing are provided at the corner of L-shape building, (6) X-bracing are provided alternative pattern at the corner of L-shape building from bottom to top floor, (7) X-bracing are provided zig-zag pattern at the corner of L-shape building. Developed and evaluated by response spectrum analysis method (Linear dynamic analysis) as per IS 1893-2000 using STAAD PRO V8i.

In the present work G+12 storey, the L-shape frame structure is analyzed by using X-bracing. It is analyzed and results of Peak storey shear, Base shear, Nodal displacements, Maximum bending moment, Total quantity of steel, Total volume of concrete are evaluated and compared.

1) *Peak storey shear in KN:* According to the Base storey to the 13th storey all models peak storey shear values are calculated and compared to model 1. When increases every floor peak storey shear value as well as increase stiffness of building. Increased height of the building reduces peak storey shear value.

Table No 2: Peak storey shear value

| Storey | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| Base | 3262.00 | 2644.51 | 3192.05 | 3815.26 | 3625.97 | 2897.78 | 3624.17 |
| 1 | 3262.00 | 2644.51 | 3192.05 | 3815.26 | 3625.97 | 2897.78 | 3624.17 |
| 2 | 3239.29 | 2627.25 | 3171.06 | 3788.47 | 3603.40 | 2880.09 | 3596.89 |
| 3 | 3175.30 | 2579.49 | 3107.19 | 3715.38 | 3541.06 | 2823.99 | 3530.32 |
| 4 | 3065.67 | 2497.66 | 3002.48 | 3591.60 | 3433.19 | 2732.64 | 3411.82 |
| 5 | 2910.39 | 2380.87 | 2851.77 | 3416.46 | 3277.40 | 2599.31 | 3247.84 |
| 6 | 2711.08 | 2229.28 | 2660.94 | 3190.78 | 3073.00 | 2429.98 | 3032.48 |
| 7 | 2470.35 | 2043.81 | 2427.70 | 2916.44 | 2820.57 | 2221.13 | 2773.41 |
| 8 | 2191.49 | 1826.02 | 2158.60 | 2596.24 | 2521.77 | 1979.15 | 2468.15 |
| 9 | 1878.44 | 1578.07 | 1853.64 | 2233.76 | 2179.24 | 1703.13 | 2124.52 |
| 10 | 1535.67 | 1302.71 | 1519.53 | 1833.36 | 1796.49 | 1399.35 | 1743.18 |
| 11 | 1168.08 | 1003.23 | 1158.48 | 1400.00 | 1377.80 | 1069.38 | 1331.53 |
| 12 | 780.95 | 683.42 | 776.88 | 939.25 | 928.07 | 718.90 | 893.14 |
| 13 | 379.65 | 347.50 | 378.89 | 457.01 | 452.67 | 351.69 | 434.00 |

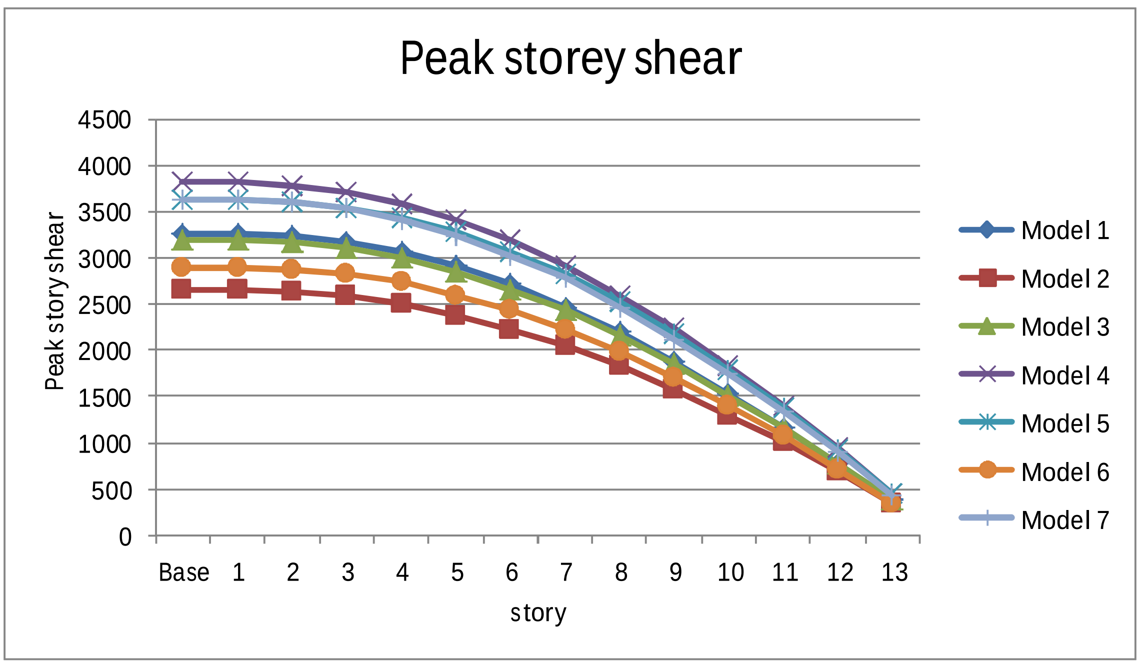


Fig. 3.1. Peak storey shear.

Evaluate the above-listed results and plot graph (Between storey and peak storey shear value) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 peak storey shear value at base storey respectively 3262.00 KN, 2644.51 KN, 3192.05 KN, 3815.26 KN, 3625.97 KN, 2897.78 KN, 3624.17 KN compare to all value and concluded maximum peak storey shear at the base of model 4 is 3815.26 KN.

2) *Base Shear:* According to model 1 to model 7 base shear values are calculated and compared to model 1. When increases base shear value as well as increase stiffness of building. Increased height of the building as well as reduces base shear value. Listed below base shear of all models:-

Table No 3: Base shear

| Model | Base shear in KN |
|---|---|
| Model 1 | 3262.00 KN |
| Model 2 | 2644.51 KN |
| Model 3 | 3192.05 KN |
| Model 4 | 3815.26 KN |
| Model 5 | 3625.97 KN |
| Model 6 | 2897.78 KN |
| Model 7 | 3624.17 KN |

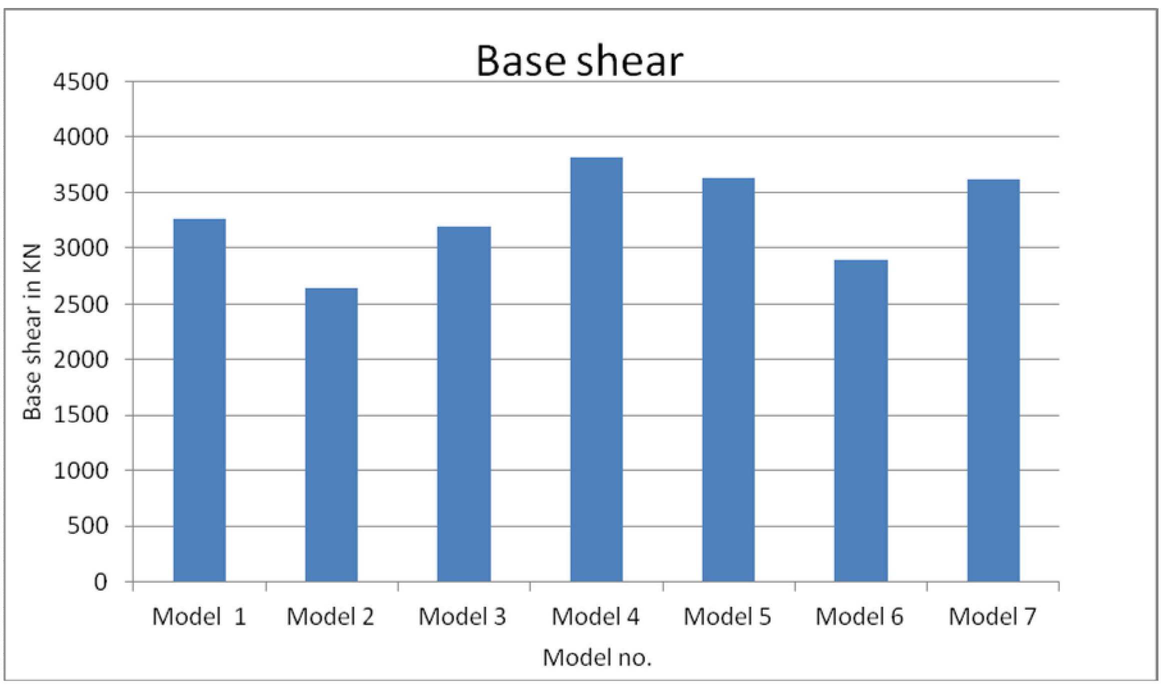


Fig. 3.2. Base shear

Evaluate the above-listed results and plot chart (Between model no. and base shear value) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 base shear value respectively 3262.00 KN, 2644.51 KN, 3192.05 KN, 3815.26 KN, 3625.97 KN, 2897.78 KN, 3624.17 KN compare to all value and concluded maximum base shear at model4 is 3815.26 KN.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
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3) *Nodal Displacement (mm) in X-Direction:* According to Node no. 10 to 18 nodal displacement of model 1 to model 7 values are calculated and compared to Model 1. When increases nodal displacement value as well as reduces the stiffness of building.

The increased height of the building as well as increases nodal displacement value. Listed below nodal displacement value of all models:-

Table No 4: Nodal displacement value in X-direction

| Node No. | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| 10 | 3.246 | 1.579 | 2.655 | 2.252 | 1.873 | 1.482 | 3.113 |
| 11 | 3.260 | 1.597 | 2.707 | 2.219 | 1.861 | 1.554 | 3.066 |
| 12 | 3.269 | 1.635 | 2.584 | 2.177 | 1.841 | 1.782 | 2.780 |
| 13 | 3.274 | 1.694 | 2.212 | 2.089 | 1.832 | 1.884 | 2.646 |
| 14 | 3.276 | 1.606 | 1.922 | 2.375 | 1.836 | 1.912 | 2.610 |
| 15 | 3.274 | 1.697 | 2.222 | 2.744 | 1.850 | 1.880 | 2.655 |
| 16 | 3.269 | 1.642 | 2.604 | 2.522 | 1.879 | 1.772 | 2.799 |
| 17 | 3.258 | 1.609 | 2.743 | 2.406 | 1.922 | 1.533 | 3.099 |
| 18 | 3.243 | 1.597 | 2.719 | 2.359 | 1.886 | 1.433 | 3.168 |

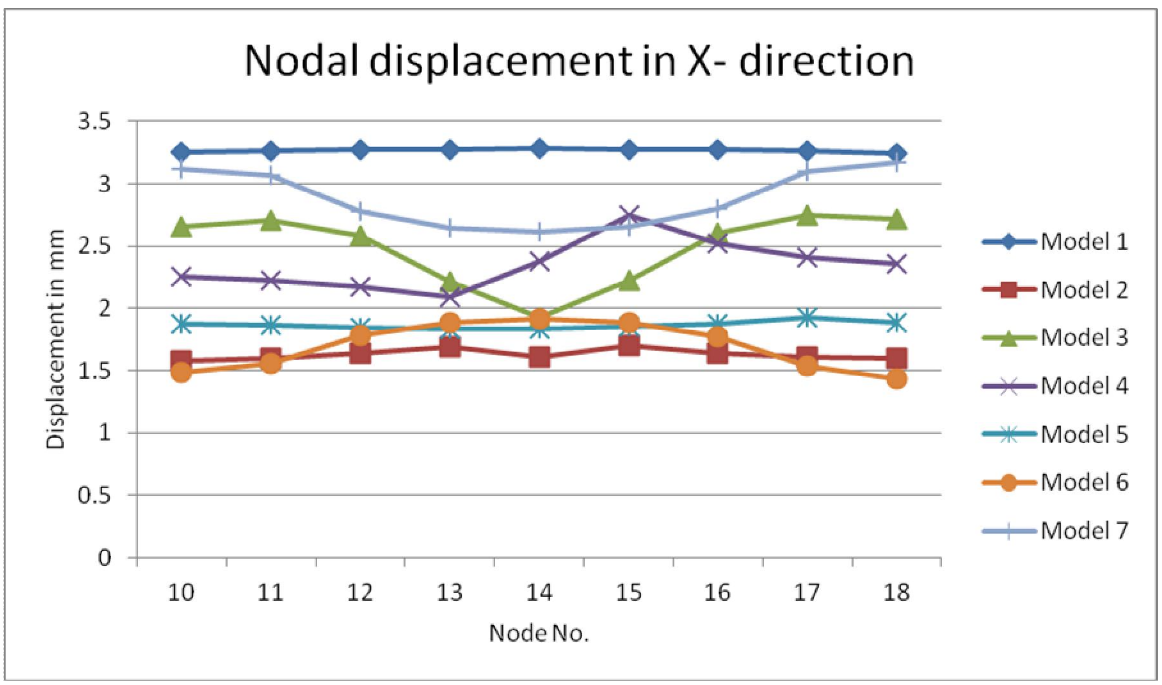


Fig. 3.3. Nodal displacement in X- direction

Evaluate the above-listed results and plot graph (Between node no. and displacement value) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 average nodal displacement value respectively 3.263mm, 1.628mm, 2.485mm, 2.349mm, 1.864mm, 1.692mm, 2.881mm compare to all value and concluded minimum nodal displacement value at model 2 is 1.628mm.

4) *Maximum bending moment (KN-m) in the column:* According to column no. 105 to 112 maximum bending moment of model 1 to model 7 values are calculated and compared to model 1. When increases maximum bending moment value at column as well as reduces the stiffness of building. Listed below maximum bending moment value of all models:-

Table No 5: Maximum bending moment in Column

| Column No. | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 |
|---|---|---|---|---|---|---|---|
| 105 | 344.748 | 173.725 | 235.465 | 244.965 | 203.963 | 99.869 | 408.263 |
| 106 | 373.210 | 189.087 | 273.316 | 254.941 | 218.717 | 127.371 | 417.126 |
| 107 | 374.848 | 199.383 | 247.476 | 246.642 | 218.879 | 179.700 | 358.121 |
| 108 | 375.817 | 207.504 | 160.967 | 220.708 | 213.912 | 200.755 | 327.986 |
| 109 | 376.087 | 188.742 | 94.176 | 282.407 | 214.107 | 206.904 | 320.156 |
| 110 | 375.768 | 207.997 | 162.749 | 265.812 | 218.846 | 199.881 | 329.608 |
| 111 | 374.719 | 200.595 | 251.219 | 220.759 | 225.241 | 177.538 | 361.653 |
| 112 | 372.939 | 191.010 | 280.196 | 294.230 | 229.264 | 123.067 | 423.720 |

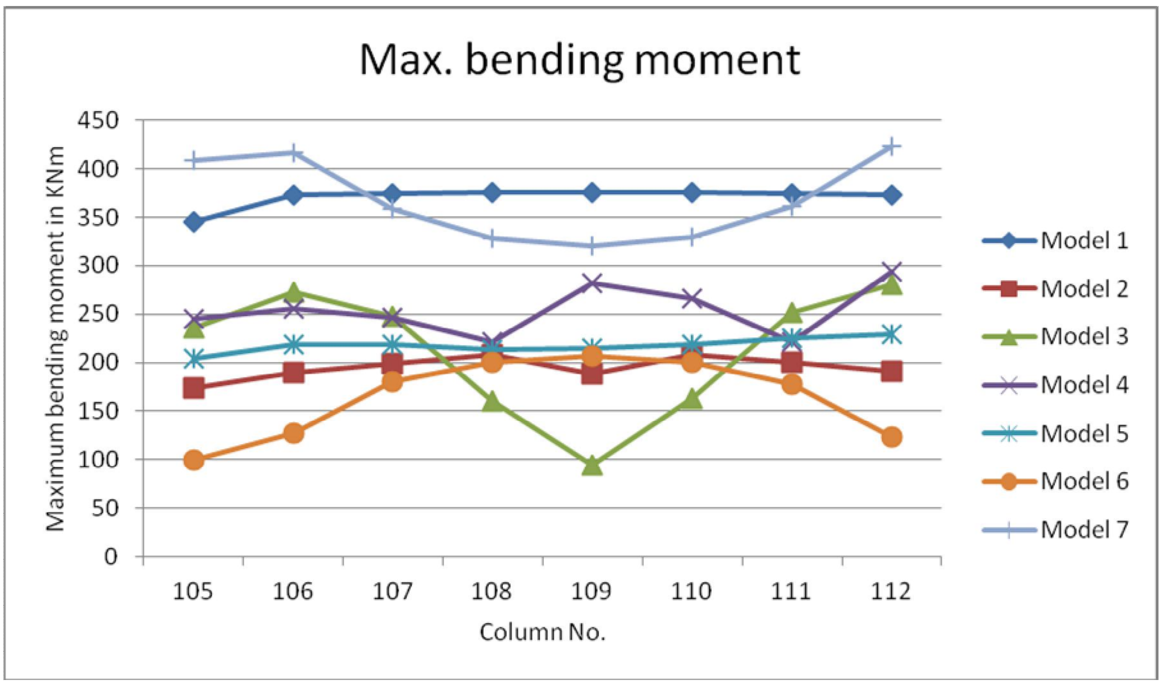


Fig. 3.4. Max. bending moment in Column

Evaluate the above-listed results and plot graph (Between column no. and maximum bending moment value) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 average maximum bending moment value respectively 371.017 KN-m, 194.755 KN-m, 213.195 KN-m, 253.808 KN-m, 217.866 KN-m, 164.385 KN-m, 268.329 KN-m compare to all value and concluded optimum maximum bending moment value at model 6 is 164.385 KN-m.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
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5) *Quantity of steel in whole structure (Kg):* According to model 1 to model 7 total quantity of steel is calculated and compared to model 1. When increases total quantity of steel in whole structure as well as the increasing cost of construction which is uneconomical but reduce the total quantity of steel in whole structure as well as reduce the cost of construction which is economical. Also, take care to increase the stiffness of the building as well as reduce the total quantity of steel. Listed below the total quantity of steel in all models:-

Table No 6: Quantity of Steel in the whole structure

| S. No. | Model No. | Total Quantity of steel in Kg |
|---|---|---|
| 1. | Model 1 | 1524904 Kg |
| 2. | Model 2 | 1611015 Kg |
| 3. | Model 3 | 1634804 Kg |
| 4. | Model 4 | 1561642 Kg |
| 5. | Model 5 | 1618652 Kg |
| 6. | Model 6 | 1669135 Kg |
| 7. | Model 7 | 1559031 Kg |

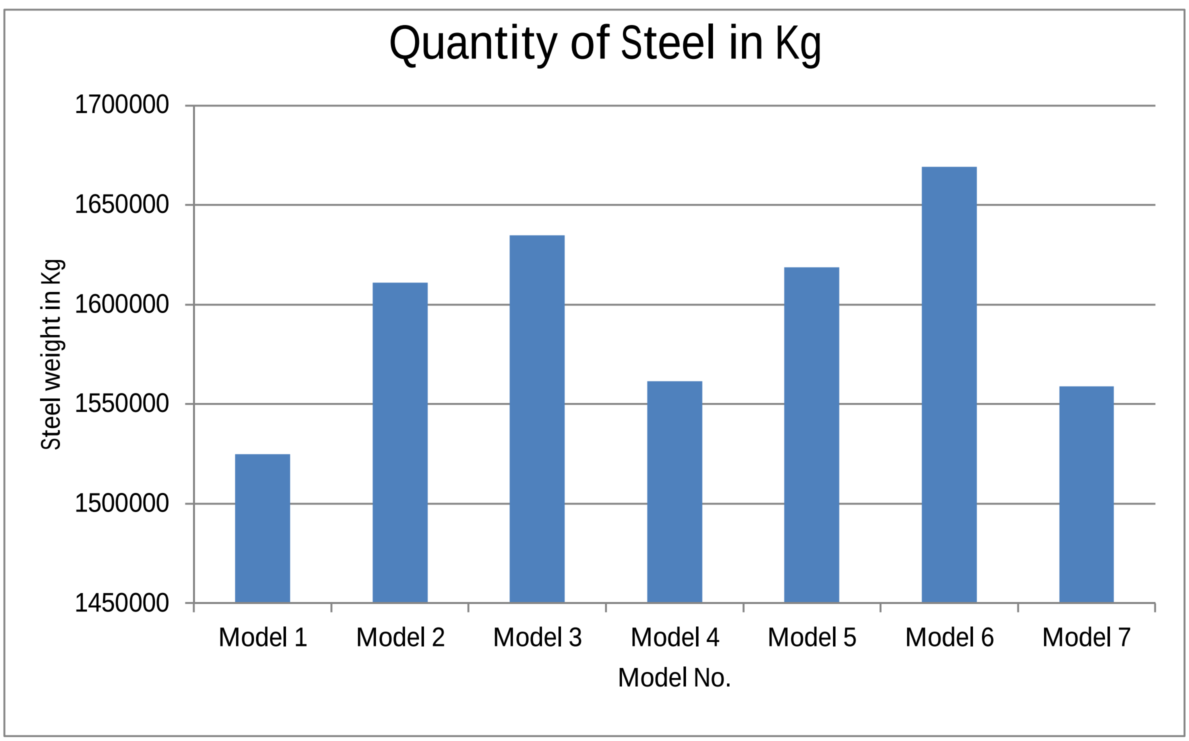


Fig. 3.5. Quantity of Steel in the whole structure

Evaluate the above-listed results and plot chart (Between model no. and weight of steel) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 quantity of steel respectively 1524904 Kg, 1611015 Kg, 1634804 Kg, 1561642 Kg, 1618652 Kg, 1669135 Kg, 1559031 Kg compared to all value and concluded minimum total quantity of steel model 6 is 1524904 Kg.

6) *Volume of concrete in whole structure (cu.m.):* According to model 1 to model 7 total volumes of concrete are calculated and compared to model 1. When increases volume of concrete in whole structure as well as increasing cost of construction which is uneconomical but reduce the volume of concrete in whole structure as well as reduce the cost of construction which is economical. Also, take care to increase the stiffness of the building as well as reduce the volume of concrete. Listed below the volume of concrete all models:-

Table No 7: Total volume of concrete in the whole structure

| S.No. | Model No. | The total volume of concrete |
|---|---|---|
| 1. | Model 1 | 2165.5 cu.m. |
| 2. | Model 2 | 2335.3 cu.m. |
| 3. | Model 3 | 2257.3 cu.m. |
| 4. | Model 4 | 2250.9 cu.m. |
| 5. | Model 5 | 2338.3 cu.m. |
| 6. | Model 6 | 2258.3 cu.m. |
| 7. | Model 7 | 2255.0 cu.m. |

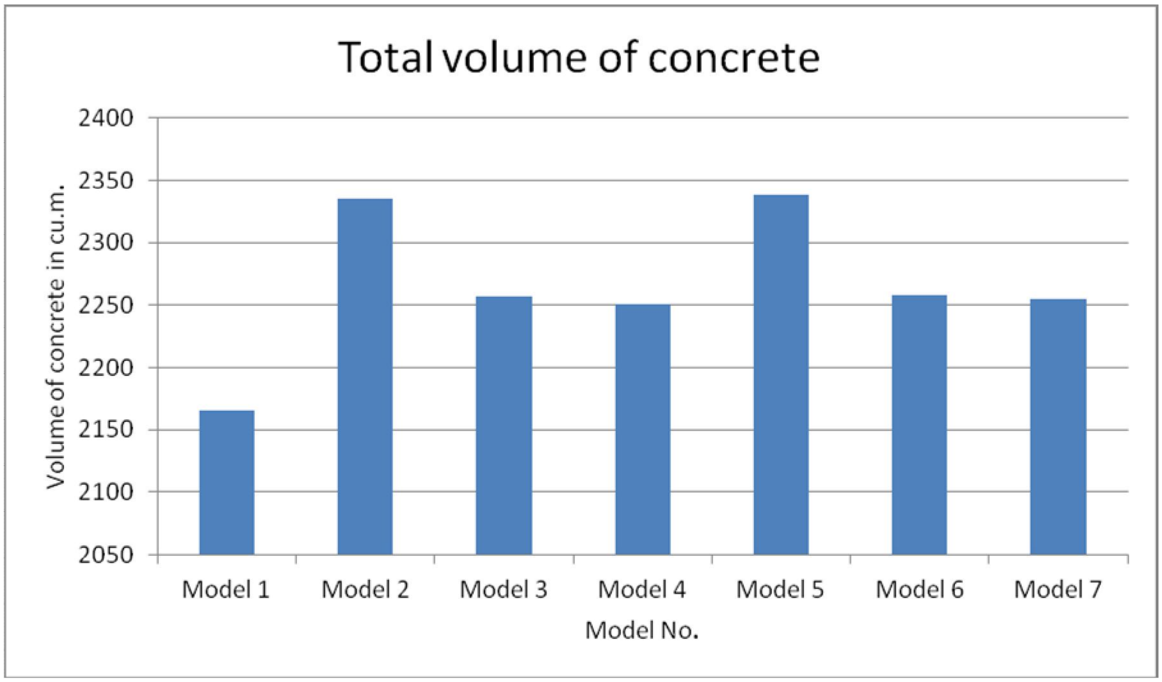


Fig. 3.6 – Total volume of concrete in the whole structure

Evaluate the above-listed results and plot chart (Between model no. and total volume of concrete) according to model 1, model 2, model 3, model 4, model 5, model 6, model 7 total volume of concrete respectively 2165.5 cum, 2335.3 cum, 2257.3 cum, 2250.9 cum, 2338.3 cum, 2258.3 cum, 2255.0 cum compared to all value and concluded minimum total volume of concrete model 1 is 2165.50 cum.

7) *Economical analysis:* According to model 1 to model 7 total quantity of steel is calculated and compared to model 1. When increases total quantity of steel and total volume of concrete in whole structure as well as the increasing cost of construction which is uneconomical but reduce the total quantity of steel and total volume of concrete in the whole structure as well as reduce the cost of construction which is economical. Also, take care to increase the stiffness of the building as the optimum quantity of steel and volume of concrete. Evaluate the above-listed values total quantity of steel and total quantity of concrete in all models. Model 4 values total quantity of steel and total quantity of concrete are high as compared to model 1 and model 7 but values of the total quantity of steel and total quantity of concrete are low as compare model 2,3,5,6 or model 4 is economical and stiffness is high as compare to other models.

## IV. CONCLUSION

After analysis of different types of models are response spectrum analysis method (Linear dynamic analysis) as per STAAD PRO V8i software and after obtain various values form of result. In these results, values are compared by using tables and graphs plotted. Following Parameters are taken for results are- of (1) peak storey shear, (2) base shear, (3) Nodal displacement, (4) maximum bending moment, (5) Total quantity of steel in the whole structure, (6) Total volume of concrete in the whole structure, maximum are evaluated and compared. After all, these studies' following conclusions are found which are presented below the description.

1) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 peak storey shear value at base storey respectively 3262.00 KN, 2644.51 KN, 3192.05 KN, 3815.26 KN, 3625.97 KN, 2897.78 KN, 3624.17 KN compare to all value and concluded maximum peak storey at the base of model 4 is 3815.26 KN (increase 16.96% as compare to model 1).
2) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 base shear value respectively 3262.00 KN, 2644.51 KN, 3192.05 KN, 3815.26 KN, 3625.97 KN, 2897.78 KN, 3624.17 KN compare to all value and concluded maximum base shear at model 4 is 3815.26 KN (increase 16.96% as compare to model 1).
3) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 average nodal displacement value respectively 3.263mm, 1.628mm, 2.485mm, 2.349mm, 1.864mm, 1.692mm, 2.881mm compare to all value and concluded minimum nodal displacement value at model 2 is 1.628mm but effective results of model 4 (2.349mm reduce nodal displacement 28.02% as compare to model 1) because its peak storey shear value (increase 16.96% as compare to model 1) and base shear value (increase 16.96% as compare to model 1) is high as compare to other models also economical.
4) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 average maximum bending moment value respectively 371.017 KN-m, 194.755 KN-m, 213.195 KN-m, 253.808 KN-m, 217.866 KN-m, 164.385 KN-m, 268.329 KN-m compare to all value and concluded the minimum value of maximum bending moment at model 6 is 164.385 KN-m but effective results of model 4 (253.808 KN-m reduce maximum bending moment 31.60 % as compare to model 1) because its peak storey shear value (increase 16.96% as compare to model 1) and base shear value (increase 16.96% as compare to model 1) is high as compare to other models also economical.
5) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 quantity of steel respectively 1524904 Kg, 1611015 Kg, 1634804 Kg, 1561642 Kg, 1618652 Kg, 1669135 Kg, 1559031 Kg compare to all value and concluded minimum total quantity of steel model 6 is 1524904 Kg but effective results of model 4 (Its quantity of steel increase as compare to model 1, model 7 respectively 2.04%, 0.16% and its quantity of steel reduced as compare to model 2, model 3, model 5, model 6 respectively 3.06%, 4.47%, 3.52%, 6.44% ) because its peak storey shear value (increase 16.96% as compare to model 1) and base shear value ( increase 16.96% as compare to model 1) is high as compare to other models also economical.
6) According to model 1, model 2, model 3, model 4, model 5, model 6, model 7 total volume of concrete respectively 2165.5 cum, 2335.3 cum, 2257.3 cum, 2250.9 cum, 2338.3 cum, 2258.3 cum, 2255.0 cum compare to all value and concluded minimum total volume of concrete model 1 is 2165.50 cum but effective results of model4 (Its volume of concrete increase as compare to model 1 3.94% and its volume of concrete reduced as compare to model 2, model 3, model 4, model 5, model 6 respectively 3.61%, 0.28%, 3.73%, 0.32%, 0.18%) because its peak storey shear value (increase 16.96% as compare to model 1) and base shear value (increase 16.96% as compare to model 1) is high as compare to other models also economical.
7) In this study found model 4 is stiffness higher than other models also economical.
8) With help of all these data buildings can be analyzed and designed considering all possible factors which may cause harm to human life as well as to building or structure that is planned to be built, so using STAAD.Pro V8i software can save money an

## V. ACKNOWLEDGMENT

At the very outset, I would like to express my deep sense of gratitude and indebtedness to my project guide, Mr. ASWIN C. P, Assistant Professor, Department of Civil Engineering for his valuable suggestions from the beginning of my studies and project to the completion of this thesis. Without his consistent encouragement and help, this work would never have been completed. It was an honour for me to work under his exemplary supervision. I would like to extend my gratitude to the Head of the department Mr. G.P. KHARE, for their kind suggestions and constant inspiration that enabled me to present this work in the current form. I would like to thank you for your continuous encouragement kind support and valuable guidance. We acknowledge with a sense of obligation and gratitude to Mr. M.R. KHAN, principal, for infusing me his interminable enthusiasm into all of us and installing a spirit of dynamism in us. Lastly, but not least, we owe gratitude to all staff members and I feel immensely moved in expressing my indebtedness to my revered parents whose sacrifice, guidance, and blessing helped to complete my project. At last but not least gratitude goes to all of my friends who directly or indirectly helped me to complete this project report. Any omission in this brief acknowledgment does not mean a lack of gratitude.

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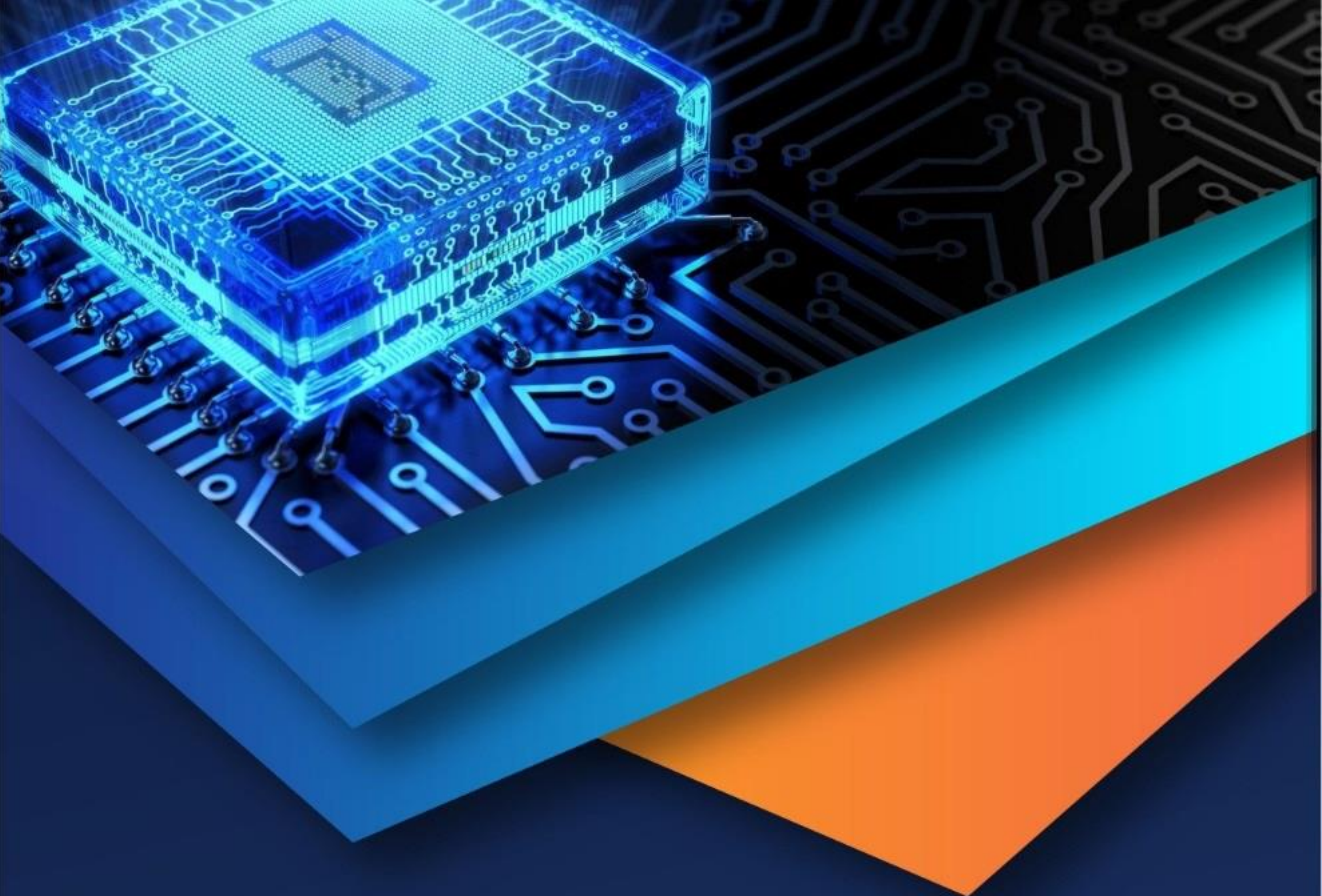


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