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Design and Analysis of Different Shapes of 50 Storeys High Rise Building under Different Loading Condition

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ABSTRACT

As we are moving towards the modern world, we are facing many problems and increasing population is one of the biggest problems and to provide land is another challenge because of the limited natural land. So, to resolve this problem we have to drop the plan of horizontal building design instead of we have to built the high-rise building. I am going to design the 50 storey's high rise building of different shapes for which I have selected the shape, they are Rectangular, Square, Triangular, Circular, Elliptical .and for designing I am designing these all shape of building for constant Area, Column size, Beam Size, Slab thickness. After the designing work completion, the different loads were applied on the Structure; the loads are Seismic Load, Wind Load, Live Load, Dead Load. The main purpose of this work is to determine the most stable and workable shape of the high rise building in most critical seismic zone i.e., zone v and under the most critical wind zone i.e. zone v. and to check the stress of the building of different shapes.

KEYWORDS: *High rise building, Seismic load, Wind load, ZoneV, critical, shapes*

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I. INTRODUCTION

STAAD Pro. V8i is a structural analysis and design computer program originally developed by research engineers at Yorba Linda, CA in year 1997. In late 2005, Research Engineers International was bought by Bentley Systems. STAAD Pro. Is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes.

STAAD Pro. V8i is a comprehensive and integrated finite element analysis and design offering program. It is capable of analyzing any structure exposed to static loading, a dynamic response, wind, earthquake and moving loads. STAAD-PRO was born giant. It is the most popular software used now a day's, basically it is performing design works. There are four steps using STAAD-PRO to reach the goal.

- Prepare the input file.
- Analyze the input file.
- Watch the results and verify them.
- Send the analysis result to steel design or concrete design engines for designing purpose.

1. Prepare the input file-

- First of all we described the structure. In description part we include geometry, the materials, cross sections, the support conditions.

2. Analyze the input file-

- We should sure that we are using STAAD-PRO syntax. Else it will error.
- We should sure that all that we are inputting that will generate a stable structure .Else it will show error.
- At last we should verify our output data to make sure that the input data was given correctly.

3. Watch the results and verify them.

- Reading the result take place in POST PROCESSING Mode.
- First we choose the output file that we want to analyze (like various loads or load combination). Then it will show the results.

4. **Send the analysis result to steel design or concrete design engines for designing purpose.**

- If someone wants to do design after analysis then he can ask STAAD-PRO to take the analysis results to be designed as design
- The data like Fy main, Fc will assign to the view
- Then adding design beam and design column.
- Running the analysis it will show the full design structure.

Our project involves analysis and design of High rise building using a very popular designing software STAAD Pro. We have chosen STAAD Pro because of its following advantages:

- easy to use interface,
- conformation with the Indian Standard Codes,
- versatile nature of solving any type of problem,
- Accuracy of the solution.

II. LITRATURE REVIEW:

1. 3-D Analysis Of Building Frame Using STAAD-PROAshis Debashis Behera 2021 The deflection and shear bending is more in wind load combination compare to seismic.
2. Seismic Behavior of L-Shape RC Building and Effect of Shearwall Sushant G. Kute 2019 In a building with the shear wall, The maximum displacement is observed in the lower part of the corner columns and in a building having bare frame it is observed in upper part of the corner columns.
3. Seismic Analysis of Various Shapes of Building.

   Roshan Bandhekar 2019 Maximum deflection is observed in L-shape of Building as compared to Rectangle shape of the Building. Helps in building parameters.
4. Seismic Analysis of High-Rise Buildings (G+30) by Using ETABS G. Lalith Kumar 2019 It is found that the lateral displacements or drifts are more in zone 5 when compared to the zones 4, 3 & 2.
5. Seismic Analysis of Vertically Irregular RC framed Structure using X-Bracing and Bundle Tube in Various Zones using STAAD Pro Software Sagar Belgaonkar2019 The base shear is maximum in zone IV and displacement is maximum in zone IV Idea of use of STAAD PRO.
6. Analysis of different shape of building with same area Khan Md. Muhateshem Azhar2 2018 Base reaction is less in triangular shape buildings.
7. Reducing the Impact of Wind Load with Shape of High Rise Buildings Nasra Mohammed Nasser Al-Azri, Himanshu Gaur & Sachin Kuckian 2018 The circular shape building is more effective and less affected by wind load because of smooth surface that create a less friction.
8. Study on seismic analysis of high-rise building by using software Bhalchandra P. Alone2017 Duetounsymmetrical of building geometry modes are not resisting 90 % as its satisfying in X direction.
9. Analysis of Wind Response on Different Shapes of High Rise Mivan Wall Buildings by Using Gust Factor Method Hemanth Kumar 2017 C-shape, L -shape, T-shape building models have more displacement in comparison with H-shape models.
10. Seismic analysis of residential building with short column effect Sristi Gupta 2016 It has been concluded that a short column is safe under normal loading (d.l. and l.l). Idea of dead load and live load combination.
11. Impact of building shape on indoor building performance combined with cost of structure Mamdooh Alwetaishi & Ahmed Elamary 2016 Structure cost of circular shape is the lowest while the expenditure of pentagon and triangular shape was increased by 3% and 12%, respectively. Idea of different shape of building.
12. Effects of shape on the wind-instigate response of high rise buildings Sayali Gawali 2015 The gust factor method uses the statistical concepts of a stationary time series to calculate the response of structure to a gusty wind. Hence it is important for the estimation of wind loads on the flexible structures.
13. Analysis of wind & earthquake load for Different shapes of high rise building Anupam Rajmani 2015 For 15 storied building the most stable structure is circular shape and triangular shape.
14. Seismic Analysis of High-Rise Building By Response Spectrum Method Sweta Swagatika Dash 2015 Time Period in case of Shear Wall C is the highest, hence is the most stiff and better option for strengthening the structure.
15. Seismic analysis and design of hospital building by equivalent static analysis Mohammad Naser 2015 The building was designed without earthquake loads as per IS456:2000. Then building is designed considering the earthquake loads as per IS1893: 2002. Idea of seismic analysis.

16. Design and analysis of skywalk in aluminium Atle Aasgaard 2012 The STAAD PRO V8i analysis shows that the skywalk has sufficient capacity in the ultimate limit state.
17. Analysis of the building shape erected in Krakow and its impact on construction costs Krzysztof Zima & Edyta Plebankiewicz 2012 Constructing buildings simpler in shape to decrease the costs of construction.
18. The relationship between the shape of a building and its energy performance Diana Kalibatiene , Josifas Parasonis & Andrius Keizikas 2011 It has been found that the geometric efficiency of a building depends both on its size and proportions. Gives idea of ratio of bulding.
19. Shape effects on the wind-induced response of High-rise buildings Ryan Merrick and Girma Bitsuamlak 2009 Elliptical, triangular and rectangular shaped buildings were identified as being more susceptible to high torsion loading.
20. Computer aided analysis and design of multi-storeyed buildings Bedabrata Bhattacharjee & A.S.V. Nagender 2007 STAAD PRO has the capability to calculate the reinforcement needed for any concrete section. Idea of using STAAD PRO.

III. EXPERIMENTAL PROGRAM:

1. The main objective of this work is to contribute to the development of the design guidance for high rise buildings in relation to different shapes of building to control wind excitation and earthquake load as a reference for architects, engineers, developers, and students.
2. To understand which shaped buildings out of five taken in the consideration is most stable.
3. To check which shaped building is feasible to be constructed in seismic zone IV.
4. To design and analysis the 50 storeys high rise building as per to the IS code.
5. Analyze the building as per code IS 1893-2002 part I criteria for earthquake resistant structure.
6. Analyze the building as per code IS 875 (Part 3)-1987 criteria for earthquake resistant structure.
7. To give the comparative data which helps in the selection of the shape of the building.

To detect most desirable and undesirable shape of the building.

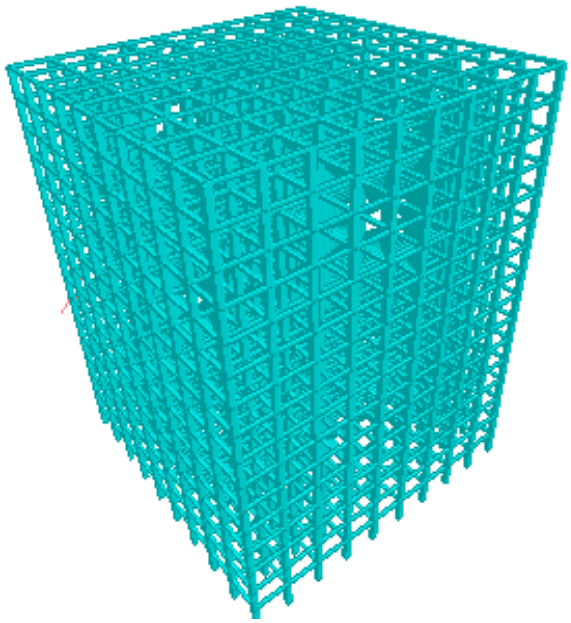

Fig. No. 3.1 Square Shape Building

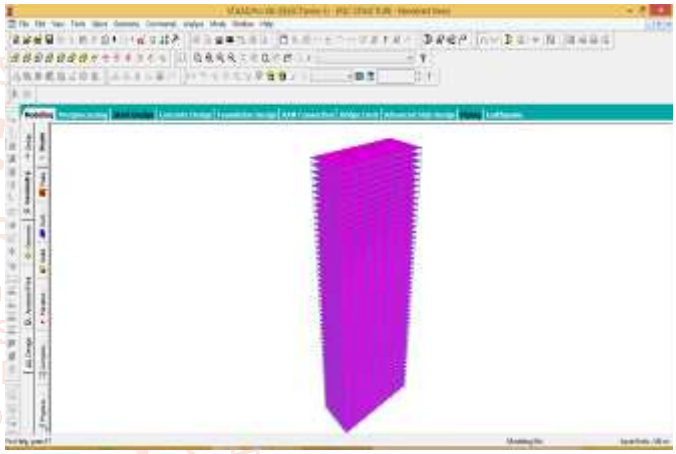

Fig. 3.2 model of rectangular building

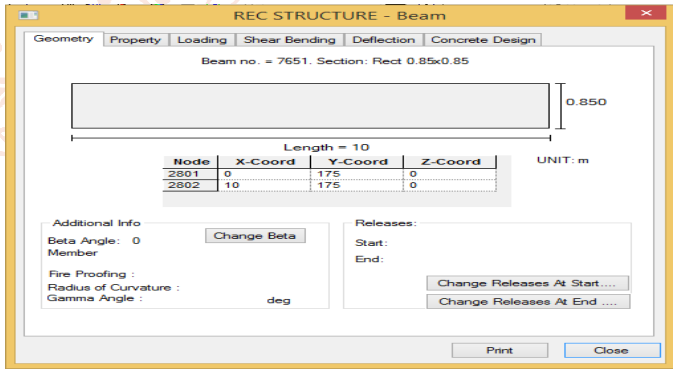

Fig.3.3 Geometry of beam

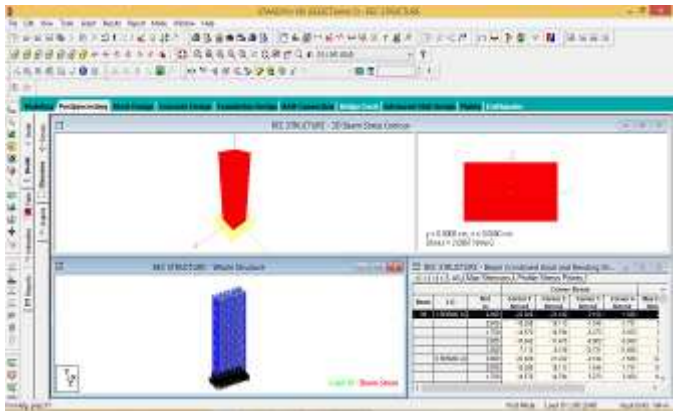

Fig. 3.4 Stress on the structure

IV. METHODOLOGY:

A tall building, whose shape is unsuitable, often requires a great deal of steel or a special damping mechanism to reduce its dynamic displacement within the limits of the criterion level for the design wind speed. Understandably, an appropriate choice of building shape and architectural modifications are also extremely important and effective design approaches to reduce wind induced motion by altering the flow pattern around the building and to see the seismic load effect on the building of different shapes, hence for this research work four shaped buildings are generally studied namely circular, rectangular, square and triangle as shown in figure.

- Type of Structure = Multi-storey fixed joined plane frame structure.
- Shape of Structure = Rectangular, Square, Circular, Triangular, Elliptical.
- Number of storey = 50 storey (G+49).
- Floor height = 3.5m.
- Total height of structure = 50*3.5 = 175m.
- Grade of concrete = M35.
- Grade of steel = Fe500.
- Size of all columns = 1m*1m.
- Size of all beam = 0.85m*0.85m.
- Size of all circular beam and columns D= 1m.
- Depth of all slab = 0.4m
- Clear cover of beam and column= 0.035m.
- Dead load on the floor = 2kN\m^2.
- Dead Load on the roof = 2kN\m^2.
- Live load on the floor = 1.75kN\m^2 .
- Live load on the roof = 1.75kN\m^2 .
- Specific weight of infill = 19.2kN\m^2.
- Type of soil = Medium soil.
- Wind zone = VI
- Wind exposure factor = 0.8
- Seismic Zone = V
- Seismic Zone Factor = 0.36

LOAD COSIDERATION

1. Seismic load (+X ,-X ,+Z, and –Z Direction)
2. Wind load (+X ,-X ,+Z, and –Z Direction)
3. Live load
4. Dead load

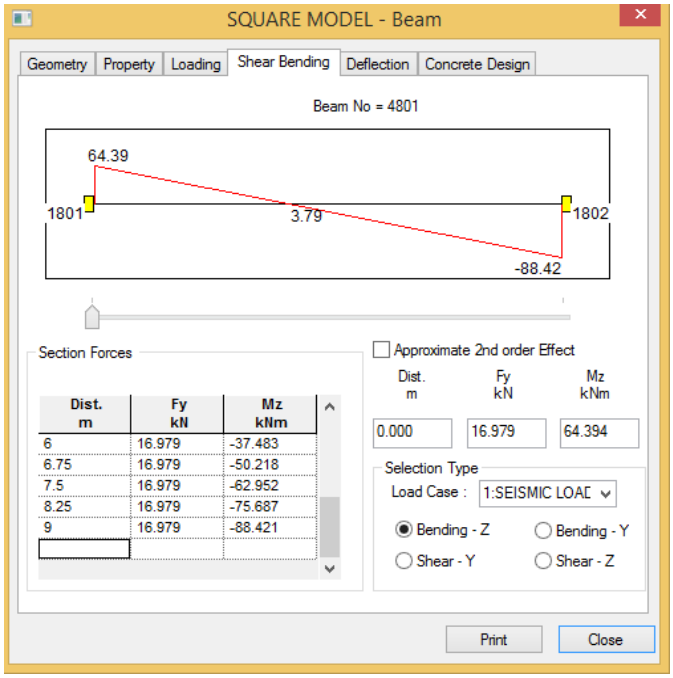

Fig. 4.1 Shear bending of beam

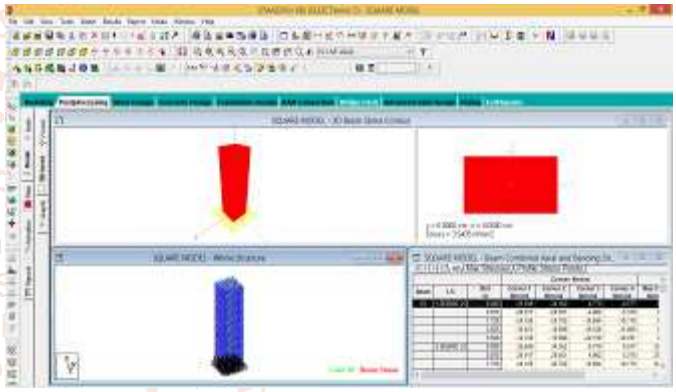

Fig. 4.2 Stress on the structure

V. RESULT AND DISCUSSION

After designing the 50 storey high rise building of different shapes and applying the different loads and after doing comparative analysis of the above design, the following result obtain.

1. The Shear Force (Fy) on the beam of different shapes of building is maximum for the Triangular shape building.i.e.25.058 kN, and minimum for the elliptical shape building. i.e.4.838kN.
2. The Shear Force (Fy) on the Column of different shapes of building is maximum for the Rectangular shape building. i.e.88.301kN, and minimum for the elliptical shape of building.i.e.25.498kN.
3. The Bending Moment (kNm) on the beam of different shapes of building is maximum for the Triangular shape building.i.e.116.840kNm, and minimum for the elliptical shape building. i.e.13.939kNm.
4. The Bending Moment (kNm) on the Column of different shapes of building is maximum for the

Rectangular shape building.i.e.149.656kNm, and minimum for the elliptical shape building. i.e.37.083 kNm.

5. The Displacement (mm) on the Beam of different shapes of building is maximum for the Triangular shape building.i.e.711.662 mm, and minimum for the elliptical shape building. i.e. 231.377 mm.
6. The Displacement (mm) on the Column of different shapes of building is maximum for the Triangular shape building.i.e.705.039 mm, and minimum for the elliptical shape building. i.e. 226.707 mm.
7. The Stress (N/mm) on different shapes of building is maximum for the Triangular shape building.i.e.39.5231N/ mm, and minimum for the elliptical shape building. i.e. 0.0034N/mm.
8. The most safe shape of 50 storey high rise building in seismic zone v and in wind zone v is Elliptical shape.
9. The most unstable shape of 50 storey high rise building in seismic zone v and in wind zone v is Triangular Shape.

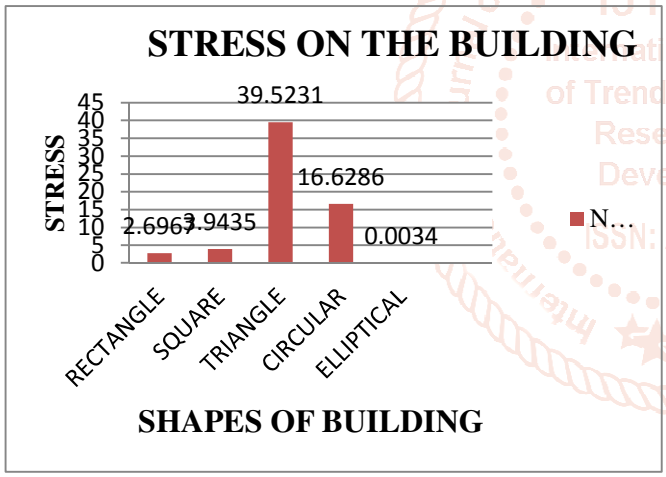

Fig.5.1 Stress on the building

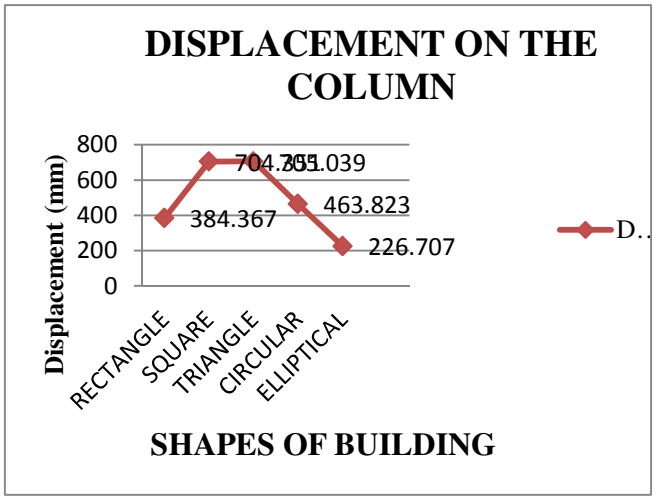

Fig.5.2 Displacement on the Column of the building.

VI. CONCLUSION:

In my work first I have selected the different shapes of the building by reviewing the research papers, journal. After that I have selected five shapes (Rectangular, Square, Triangular, Circular, Elliptical) as the shape of the building. Then I consider the property of the building in which the floor area of all shapes of building is constant, the size of column and beam is constant, the thickness of the slab is constant, the grade of the concrete is constant, the grade of steel is also constant. After that I made the model of the building of all shape with the help of STAAD Pro. Software. And then all the loads were applied on the model of the building, the loads are, Seismic load (zone v), Wind load (zone v), Live load, Dead load. And then I perform the analysis of structure in the software, and the outcome result are,

1. The most safe shape of 50 storey high rise building in seismic zone v and in wind zone v is Elliptical shape.
2. The most unstable shape of 50 storey high rise building in seismic zone v and in wind zone v is Triangular Shape.

VII. SCOPE FOR FURTHER STUDY:

This work will help in the shape selection of high rise building in most critical area. Mostly in critical seismic and wind zone.

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