Design of a RCC Structure Supported on a Single Column

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Abstract-In this project, an RCC structure supported on a single column is designed and analysed. In this work, structural modelling, stress, bending moment, shear force, and displacement design concerns for a structure are presented. The structure is STAAD Pro analysed. Designing an RCC structure supported by a single column using STAAD Pro entails a number of steps, including geometric modelling, providing material and section properties, fixing supports and boundary conditions, providing loads and load combinations, special commands, analysis specification, and Design Command.
In static analysis, the impact of plan geometry is significant. The highest possible values for stresses, bending moments, shear forces, and displacements are shown. Self-weight, floor load, wind load, and earth quake load were the loads taken into account in the current analysis. In both instances, the floor load was applied perpendicular to the RCC structure. Comparisons between RCC single columns and RCC multi columns are made.

1. INTRODUCTION

A single column can support a structure better than numerous columns can, from an architectural standpoint. As they need less land for foundation installation and offer more space for parking, they conserve ground space. They are also distinctive. RCC or steel can both be used to construct single columns. In India today, RCC constructions are more prevalent. In a variety of different structures, reinforced concrete is frequently employed as a structural material. When economically planned and performed, it can compete with steel. In comparison to steel, it is more fire resistant and has a comparatively high compressive strength. Its maintenance costs are modest and it has a long service life. Any necessary shape can be cast out of it.

In reinforced concrete, reinforcement with higher tensile strength and ductility is added to compensate for the concrete's comparatively low tensile strength and ductility. Software called STAAD Pro is used to model and analyse structures that are supported by a single column. Originally created by Research Engineers International in Yorba Linda, STAAD Pro is a computer program for structural analysis and design.

SINGLE COLUMN BUILDING

Utilising the STAAD Pro program, single column structures are modelled. The building is planned to be 24.5 metres tall. On one column, the structure is supported. It has seven stories. Each story is 3 m tall. At 3.5 metres above the ground, the first storey begins. The building is kept 3.5 metres above the ground by a single column. Each floor is 12 m in width and breadth. From the base up to a height of 24.5 m above the ground, a column is offered in the centre of the construction.

EXAMPLES OF SINGLE COLUMN BUILDING

Astra house building
Hamburg , Germany

L&T Headquarters building
Manapakkam ,Chennai

Fig 1 Single column buildings

OBJECTIVE OF THE STUDY

1. To investigate how RCC single column buildings and RCC framed buildings perform in terms of lateral displacement.
2. To investigate the behaviour of earth quakes on RCC framed buildings and RCC single column buildings.
3. RCC framed buildings and RCC single column buildings were studied for their maximum stress, bending moments, and shear force.

2. LITERATURE REVIEW

G.Pradeep, Dr.H.Sudarsana Rao, Dr.Vaishali . G. Ghorpade (2018) [1]
When compared to a column in a multi-column building, deflections for a single column in a single column building are fewer. Support reactions for a column in a multi-column building are significantly lower than those for a single column in a single column building. In comparison to multi column structures, single column structures are 27.260% more expensive. When planning and developing, the most efficient use of space is taken into account to guarantee optimal serviceability.

Ankur Pandey, Vaibhav Singh, Gaurav Awasthi. (2018) [2]
Under static loading conditions, RCC columns perform satisfactorily. Maximum stress is created by a large floor effect at the floor's connection with a single column. Node displacement also increases as the size of the cantilever floor increases. A large cantilever span is supported by inclined steel strut members, which control deflection by making the cantilever propped. In comparison to RCC structures, composite material structures have reduced dead weight.

Ambati Venu Babu et.al. (2016) [3]
When a single column construction is subjected to symmetrical and eccentric loading conditions, it is crucial, according to analysis of a triangular-shaped building in which the mono column is located at the edges of the triangle rather than at its centre. Because a single column supports the entire structure, all other elements will behave as cantilevers. To convert two-thirds of the length as simply supported by providing two ring beams and inclined beams to reduce the cantilever span for the structural beams.

Madireddy Satyanarayana (2016) [4]
A multi-story building resting on a single column was examined and developed using various code requirements. AutoCAD 2010 is used to create a layout plan for the proposed building. The building was planned in accordance with Indian standard code requirements and has a ground floor plus five stories. Using the Limit State Method, building frames are manually evaluated to provide structural details for critical and typical R.C.C. members.

3. MODELING METHODOLODY OF SINGLE COLUMN BUILDING

3.1 PROBLEM STATEMENT

A Model of G+7 storied is created, investigation and configuration is done by utilizing STAAD-Pro programming. Building design measure is 12m X12m. The building is arranged in seismic zone III. Following particulars are given to the structure:
All columns = 0.6mx0.6m
Single column = 3mx3m
All Beams = 0.4mX0.4m
Slab = 0.12m
Physical parameters of Building:
Length = 4 bays @3.0m =12m
Width = 4 bays @3.0m =12m
Height of Building = 3.5+3X7 =24.5m
Live load on the floor = 3kN/m2
Grade of concrete and steel used:
Used M30 concrete and Fe 550 steel

ELEVATION
The elevation of the building consists of Ground storey=3.5m
Height of each storey=3m(From 1st floor to 7th floor)
The elevation of the single and multi column building are generated using the STAAD pro software, where the dimensions of single and multi column building are same.
The only difference is the number of columns.

The elevation view of the single column building and the multi column building are shown in figure 2.

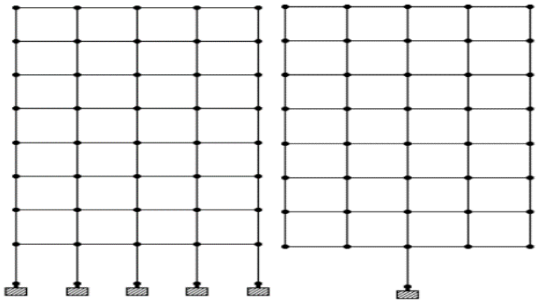

Fig 2 Elevation view of single and multi column building.

3.2 MODELING IN STAAD Pro:

The following details the entire process of analysis and design:
1. Inputting the job Information:
Following STAAD Pro opening, the project information is first entered. Numerous pieces of information are entered, including the project's name, the client's name, the project's start date, the

engineer's name, and many others.

2. Generating the 3d model geometry:

In STAAD, a structural data can be created using one of two approaches. a. Using the command file, commonly known as "The STAAD editor method". b. Using the GUI, or graphical user interface. Since STAAD's GUI tool is more user-friendly and sophisticated, we used it for all of our programming. In STAAD, the Snap Node/Beam dialogue box that occurs when we pick the grid creates the model of the framed structure. The nodes and beams are then built. This command will place Beams and Nodes at the appropriate distances based on our needs.

3. Assigning the material:

As we will allocate the appropriate material to the beams and columns once they have been built. Since our design is made of concrete, the beams and columns are made of concrete as well.

4. Specifying member properties:

The dimensions (width and depth of the cross-section) of the beams and columns are their characteristics. So we entered the various qualities (such as circular, rectangular, and square) and assigned these properties to the designated members with the use of this command.

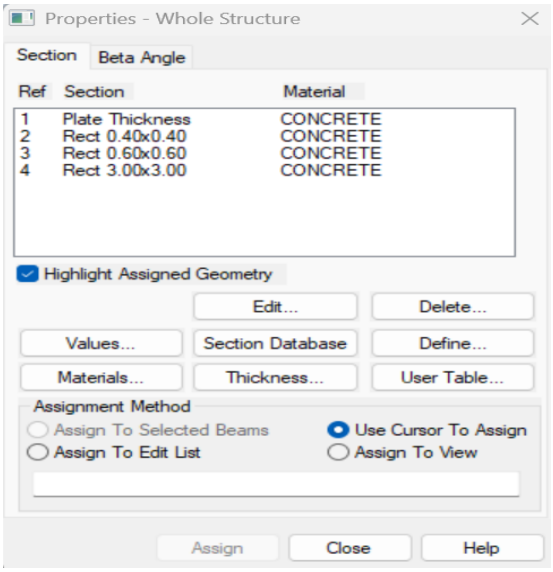

Fig 3 Generation of member property

The size of the beam is 0.4mx0.4m, size of the column is 0.6mx0.6m, slab thickness is 120mm for both single and multi column buildings. In single column building the centre column size is 3mx3m.

5. Specifying material constants:

We already know the constants for concrete because we assigned the concrete material, so we don't need to use this command separately. Alternately, we can use this command if we need to update the constants.

6. Specifying member offset:

The STAAD takes the beams and columns centre to centre by default in the design of the model after assigning characteristics. If we want the beams to span the columns end to end, we must use the Beam offset command.

7. Printing member information:

If we want a report that includes details about every member, such as their start and end joint numbers and length, we can use this command by selecting Commands Pre-Analysis Print Member information from the top menu bar.

8. Specifying Supports:

As we did with the fixed supports, the supports are first made, and they are then allocated to all of the lower nodes of the structure where the foundation would be designed.

9. Specifying Loads:

The steps involved are as follows: a. To begin with, create all of the load cases. b. Finally, putting them in their appropriate members and nodes.

All different kinds of loads can be generated by the STAAD programme and assigned to the structure. It offers the capacity to apply a dead load on the structure as well. Prior to generating specific load instances (such as seismic or wind loads), some definitions of loads are first defined in accordance with IS standards.

Load Combinations. With the help of the auto load combinations command, the load combinations have been constructed. We can generate loads in accordance with the Indian code, which we can subsequently add. These combinations can be used without having to assign them to members. Since the structure is now carrying all of the weights, we will advance.

10. Specifying the analysis type:

e need to specify the analysis command, which must be of the linear static type, before we can analyse the loads. We'll add this command by picking statics check.

DEAD LOAD

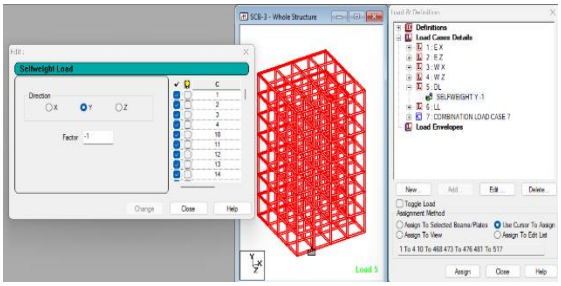

Fig 4 Generating Dead load

LIVE LOAD

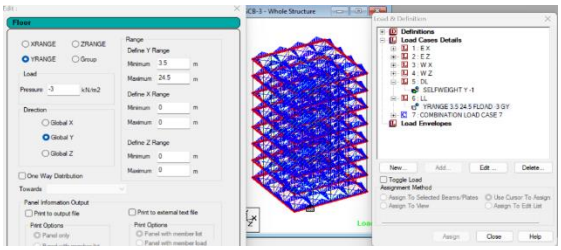

Fig 5 Generating Live load

WIND LOAD:

According to IS 875, the software itself generated the wind load figures. According to ASCE-7 (which establishes a set of minimum standards for the structural resistance of a structure), intensity is generated in accordance with structure classification category-IV, Wind speed of 50 m/sec, and Building wall to generate wind load on windward side.

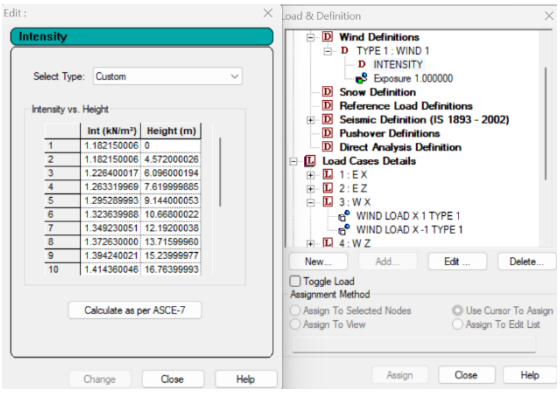

Fig 6: Creation of wind intensity

SEISMIC LOAD:

According to IS 1893-2002, the seismic load values were determined. STAAD Pro has a seismic load generator that fits to the above IS code.

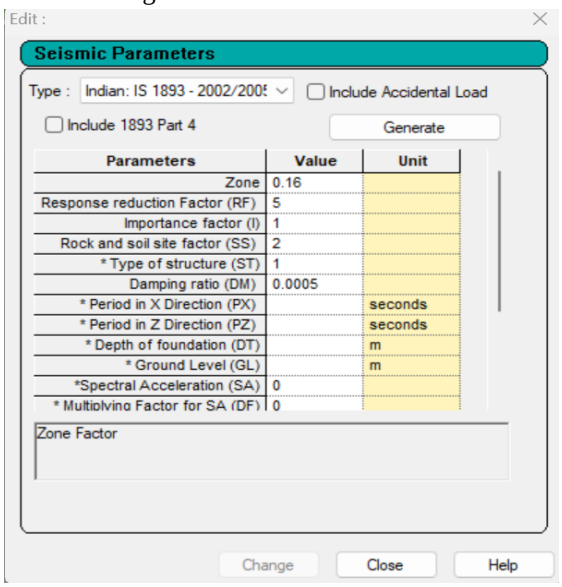

Fig 7: Seismic load definition

LOAD COMBINATION:

The load combination of self weight, wind load and seismic load is generated with the coefficient of 1.2.

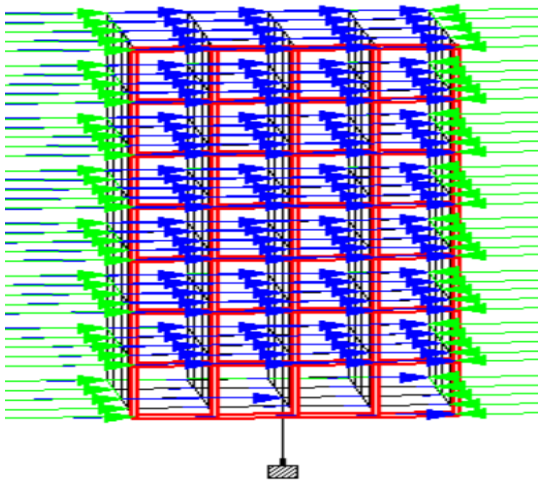

Fig 8: Load combination

4. RESULTS OF SINGLE AND MULTI COLUMN BUILDING

4.1 Shear Force and Bending Moment Diagram

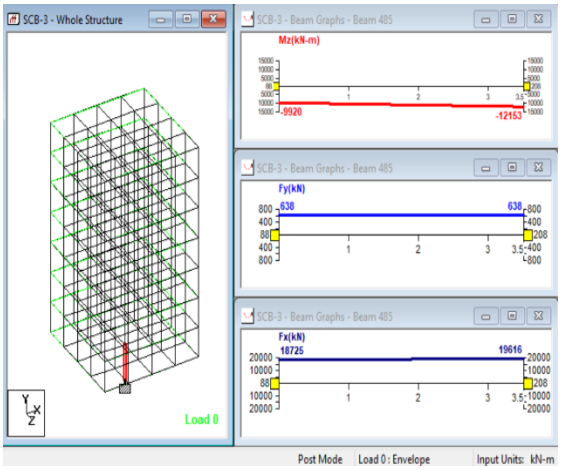

Fig 9: For Single Column Building

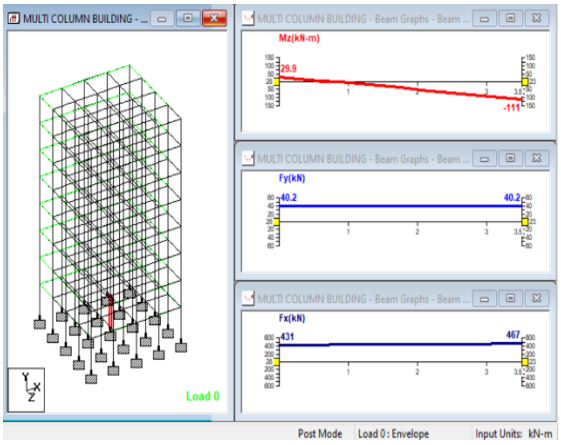

Fig 10: For Multi Column Building

4.2 STRESS COMPARISON

Load combination = 1.2DL+1.2EL+1.2WL

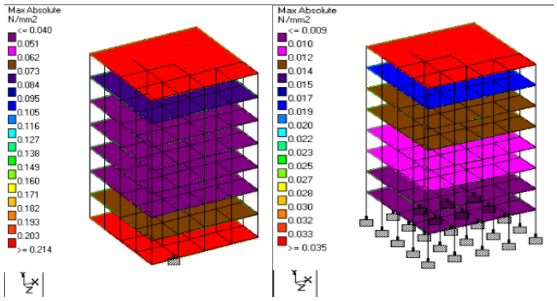

Fig 11: Stress Comparison

The Single column Building has the minimum stress of 0.04N/mm^2 and maximum stress of 0.214N/mm^2.

The Multi column Building has the minimum stress of 0.009N/mm^2 and maximum stress of 0.035N/mm^2.

4.3 DEFLECTION

The deflection for the single column building is 0.424mm.

The deflection for the multi column building is 1.430mm.

While comparing the single column building and the multi column building,

The deflection of the single column building is lesser compared to that of the multi-column building.

4.4 SUPPORT REACTIONS

The maximum value of support reactions developed for the critical load combination which may possible to act on the single column building. They are as listed below:

Max FX= 638.215kN

Max FY=19600kN

Max FZ= 531.846kN

Max MX=10100kN-m

Max MY=0kN-m

Max MZ=12200kN-m

The maximum value of support reactions developed for the critical load combination which may possible to act on the multi column building. They are as listed below:

Max FX= 41.897kN

Max FY=1370kN

Max FZ= 33.992kN

Max MX=93.408kN-m

Max MY=0.248kN-m

Max MZ=113.434kN-m

4.5 DISPLACEMENTS

The maximum value of Displacements for the critical load combination which may possible to occur in the single column building. They are as listed below:

Maximum Displacement in X direction = 15.069 mm

Maximum Displacement in Y direction =44.527mm

Maximum Displacement in Z direction = 12.518 mm

The maximum value of Displacements for the critical load combination which may possible to occur in the multi column building. They are as listed below:

Maximum Displacement in X direction = 16.570 mm

Maximum Displacement in Y direction =2.269 mm

Maximum Displacement in Z direction = 13.808 mm

4.6 FORCES

The maximum value of external forces for the critical load combination which may possible to act on the single column building. They are as listed below:

Maximum value of force FX = 19600kN

Maximum value of force FY = 785.744kN

Maximum value of force FZ = 654.786kN

Maximum value of Moment MX = 15.832kN-m

Maximum value of Moment MY = 10100kN-m

Maximum value of Moment MZ = 12200kN-m

The maximum value of external forces for the critical load combination which may possible to act on the multi column building. They are as listed below:

Maximum value of force FX = 1370kN

Maximum value of force FY = 58.955kN

Maximum value of force FZ = 37.402kN

Maximum value of Moment MX = 0.775kN-m

Maximum value of Moment MY = 93.408kN-m

Maximum value of Moment MZ = 113.434kN-m

5. CONCLUSION

The analysis above led to the following findings:

All loads, including earthquake and wind loads, have been successfully designed to tolerate single column structures.

The analysis of the bending moment, shear force, deflections, end moments, and foundation responses are determined using this software.

The shear force and bending moment values for a single column in a single column building are significantly larger than the values for a column in a multi-column building.

In a single column building, a single column has less deflection than a column in a multi-column building.

Support reactions for a column in a multi-column building are significantly lower than those for a single column in a single column building.
STAAD Pro can be used to get details about every single member.
Even though it is slightly more expensive than multi-column structures, single column structures offer a superior architectural view and more open ground space.
When planning and developing, the most efficient use of space is taken into account to guarantee optimal serviceability.

REFERENCE

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