Behaviour of a Floating Column in a Building

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Abstract— Floating column has now become a trend in building provision to obtain big quantities of spaces for adequate construction usage. But taking into consideration the stability of the construction is one of the typical measures to consider in the design of the construction. Suitable design for smooth loading flow requires adequate care and abilities to provide floating column. In multi-story buildings, providing a floating column is ignored if it is situated in regions susceptible to earthquake. This research paper introduces RCC framed construction on the first floor with floating column that is analysed and intended under the standard condition of loading. STAAD Pro is a structural instrument that can assist identify the structural modifications that may occur while the column is floating. This software deals with all kinds of loading, including wind loading and earthquake loading, on the structure. STAAD Pro is widely used for structural design by civil engineers and is now leading structural design software. Many design companies conduct all design kinds on this building-related software. This study therefore deals with the assessment and design of the framed structure with floating column in the ground floor of the construction, the floating behaviour. This study article introduces a building's floating column behaviour, load distribution, and structural continuity. It has been noted that floating columns do not take the same load as those columns attached to the base. This research will also mention pros and cons of using a floating column in a framework.

Keywords: STAAD Pro, Floating Column, RCC Framed Construction

I. General Introduction

This research paper uses STAAD Pro to present the study conducted on floating columns to verify their behaviour with other structure members. Floating column has now become a trend in the provision of building to acquire big spaces for proper building use. But considering the building's stability is one of the typical measures to be considered in the building design. Appropriate design for smooth load flow needs appropriate attention and ability to provide floating column. Providing a floating column in multi-story structures is ignored if it is located in areas prone to earthquake. When large spaces such as parking fields, shopping complex etc. are needed, a method is followed to meet this requirement by offering Floating column. Floating column is the column type that does not go down to the base. In "column-beam" practice, the load transferred from beams is transferred to column, but in this case the load is transferred to adjacent beam as there is no continuity. Then these beams transfer load to the primary columns that can transfer load to the base. Nowadays, this method has become unique in getting the region fully utilized. Floating columns are mostly provided where parking is needed in the ground floor or sometimes in locations where there is no obstacle owing to column presence. This study is performed to check floating column behaviour in a multi-storey construction and to verify the impacts of floating columns in neighbouring columns to analyse them. Some special measures are taken to design this column that are described obviously in this study.

To be familiar with the behaviour of a floating column in a framework, analysing and design must be well versed. So, they can check their neighbouring column capabilities and potential. Because of the existence of a large number of columns, floating columns are mostly used in commercial buildings not to have congested region. Sometimes, when there is less surface area to place columns, these columns are separated from the base. If the floating column is provided, the cross section of the columns to be designed must be increased. The Indian seismic code IS 1893:2002 provides some suggestions for the provision of floating columns in structures resistant to earthquake. The floating columns are supplied to neighbouring columns on the grounds of strength, so that loads can usually be transferred. The beam supporting the floating column is referred to as the beam of transfer. This beam serves as the basis for that column, so it requires a great deal of strengthening. Chances of collapse is more when floating column is provided.

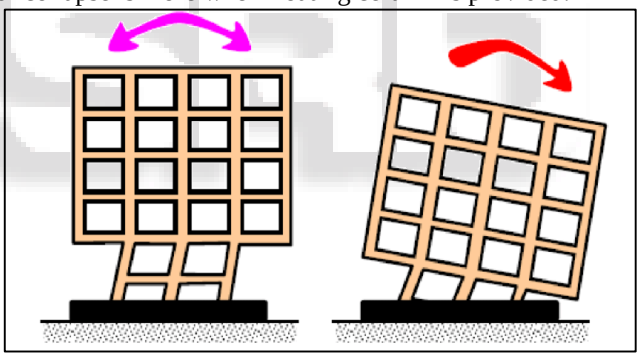

Fig. 1: Tilt of building due to floating column.

II. Objective of the Research

This research paper presents the behaviour of floating column and the main objectives considered are given below:

- The design and Analysis results of Floating Column.
- Contribution of floating column in a building with soft storey.
- Cross section and volume of concrete result given by STAAD Pro for a definite shape for column to resist given loading.
- To check axial forces coming from top floors and the torsional effect generated.
- Deflection taking place in structural elements due to given loading.
- To assign a suitable cross section which will resist load as well as fulfill some design requirements such as economy and serviceability.
- To check the safety measures of floating columns as it is used in conference halls, lobbies and commercial

buildings. Floating column is nowadays the basic feature for architectural purpose, to get look better and where ever there is need of to take structure outwards in orientation.

– Last but not the least objective of this research is to know the designing procedure of Floating column.

III. MOTIVATION OF THE PRESENT RESEARCH

Structural Engineers are continuing to modify structures to make the best possible use of the framework. So, they keep altering the structural components for adequate loading pattern and knowing how they can reduce the quantity of building material required to create financial structure.

To get fresh characteristics and create excellent modifications, designs are best produced in their look and complicated in their structure. Changes are produced from moment to time if design is discovered to be good and all design rules are followed and practically applicable. Furthermore, scientists continue to change in order to obtain fresh outcomes and compare them with current ones. If the design is discovered to be appropriate and is carried out in accordance with design norms. It is placed under the expert method, which then goes into detail to understand the procedures and if it is discovered to label. Then they offer their application permission. By making some revolutionary modifications, various IIT's are attempting to bring this field on a different level. Some procedures are under way that include replacing building material with waste products in order to preserve ecological equilibrium.

Being interested in design, I chose this as my subject of studies so that I can make excellent use of design and understand the process of design in detail. Not only did this study increase my understanding of the field of design, but it also caused me to know some software that I use to verify the outcomes in this study. After all, I discovered this one of the trending topics that many IIT's and overseas are doing research on.

IV. OVERVIEW OF THE METHODOLOGY

The design work of the has been completed by using STAAD Pro V8i and AutoCAD, and with the help of following IS Codes: -

– IS-875: (Part 1) Recommended code for provision of "Dead Load" for buildings and constructions.
– IS-875: (Part 2) Structural imposed loading design code.
– IS-456 Recommended code for design of concrete structures.
– IS-1893 Seismic design code to consider lateral loading on structures by earthquake.
– IS-13920 Recommended code by BIS for ductile consideration by seismic strengthened reinforced constructions.
– IS: 4326-1993, "Earthquake Resistant Building Design– Code of Practice (Second Revision)."

A. Introduction to STAAD Pro

In 1997, an organization known as Research Engineers International created the very best sophisticated civil engineering software known as STAAD pro at Yorba Linda California, USA. In 2005, Bentley Systems bought Research Engineers International. STAAD Pro is now regarded as Bentley Systems ' product.

STAAD pro has now become the embedded civil engineering design instrument as it provides us the cost-effective design and helps us solve complicated issues. Nowadays, every structural engineer has understanding of this software despite working on other techniques for purpose design. When regarded for any sort of structure, this software demonstrates its cosmopolitan nature. It is very essential to understand this software, its interface and its contribution to design in order to achieve better results. If an Engineer wishes to achieve economic results in a specified interval of time for its design, then there is only one option to go through this sophisticated software of engineering.

B. Why STAAD Pro

– STAAD software. Pro comprises of a graphical user interface (GUI) that makes it very easy to model any construction setup for analysis and design purposes.
– This user interface makes it easy to display charts and diagrams graphically after assessment and design.
– STAAD assessment and motor design: deals with the calculation of concrete, steel, aluminium and timber-related design outcomes
– This software is an object model with a full component. STAAD Pro can use any third-party software. The STAAD Pro user interface is the industry standard. Complex models are simple to create.
– STAAD Pro supports multi-material design codes including timber, steel, concrete and aluminum.

V. STRUCTURAL MODELING AND DESIGN

One of the most damaging events in nature is a severe earthquake. It is quite difficult to predict and prevent an earthquake precisely, but its proper design can decrease the damage to a structure. Therefore, to protect constructions from any disaster, the seismic analysis and layout is prudent. The severity of the damage depends on mixing several factors such as the magnitude of the earthquake, proximity to the epicenter, and local geological conditions that affect the seismic wave's propagation. The lateral forces induced by the earthquake cause the maximum problem of the constructions.

Therefore, earthquake-resistant design focuses mainly on reducing the seismic risk associated with man-made building to socio-economically acceptable concentrations. It seeks to forecast the prospective impact of an earthquake on civil infrastructure and to guarantee that structural design and construction comply with design codes to preserve a decent level of efficiency with a certain accepted level of harm during an earthquake exposure.

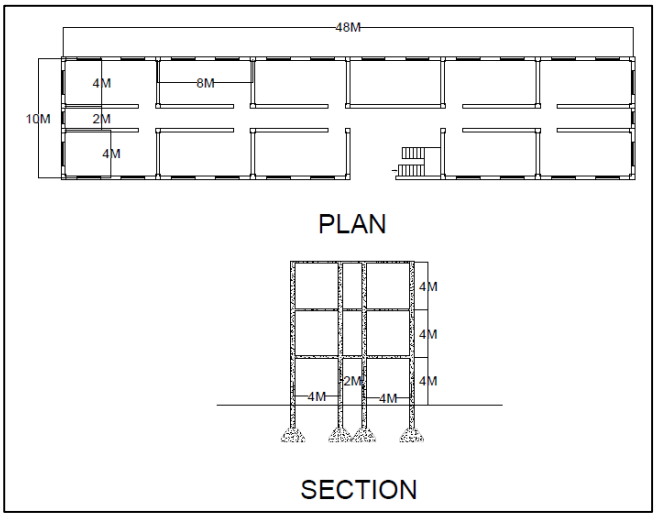

Fig. 2: Plan and sectional Elevation of Building.

The plan of a building is considered to be symmetrical. A G+2 Building with some floating column at ground floor is being modelled in STAAD Pro to check the results about the behaviour of those columns in structure and their contribution in stability of structure.

A. *Modelling of Structure*

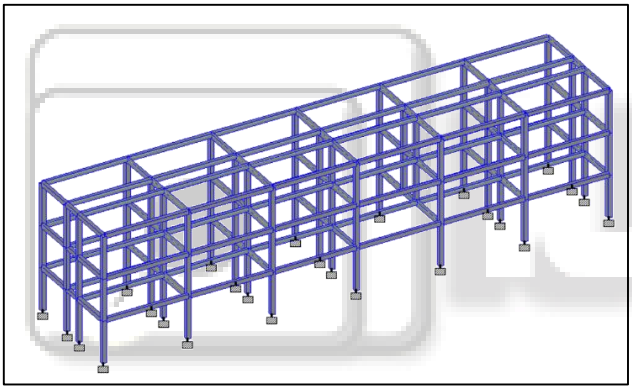

Fig. 3: Solid section of beams and columns.

Model creation is the primary step in the process of obtaining outcomes on a construction. Modelling means producing members like beams, columns, slabs and so on. Modelling needs to be precise and dimensions need to be precise. If produced, a structure model provides us a clear concept of the entire structure skeleton. With the help of model of a structure we can find the locations of critical loading and we can find the type of structure.

A structural engineer can create adjustments without losing funds and manpower with the assistance of model. Beams and columns are positioned so that adequate and systematic loading flow will occur and the building's functionality will not be disturbed.

The above figure gives the full description of the model taken to complete this research. A building's model comprises of three floors with a symmetrical design. The number of bays in the direction of X is six while the number of bays in the direction of Z is three. Bays in the direction of X have the same spacing as bays in the direction of Z.

Rendered view provides a thorough perspective of the supplied strong segments. It gives the clear image of the real project and we can find the exact locations of each and every member being modelled.

VI. Analysis Results

A. *Bending Moment Diagram*

The primary parameter for deciding the quantity of reinforcement supplied in a beam is bending moment. In fact, bending moment is a parameter that indicates the quantity of bending that can occur and the amount of reinforcement required to counter this deformation. Knowing the ultimate bending moment in a specific segment decides the primary strengthening. The force multiplied by perpendicular distance at a specific point or section is analytically bending moment at a point.

It is discovered from fig 4 that beams resist the moment that has to be transferred to the column, so that these beams need to be designed with heavy oversight and keen interest, so that the structure will not fail and the design output is economical. From the diagram above it is evident that in the frame composed of floating columns, the Bending Moment Diagram is distinct. By offering a floating column, the magnitude and direction of the bending moment are altered. Additional reinforcement is given in neighbouring beams as the primary reinforcement to withstand this extra moment owing to the lack of columns.

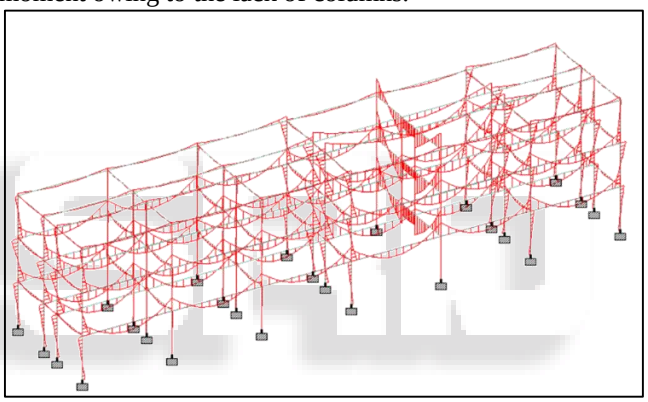

Fig. 4: Bending Moment Diagram in the frame where floating column is different.

B. *Deflection Observation*

Deflection is the main concern to control for the successful design process. Deflection occurs due to loading coming on the structure. It is utmost responsibility for a structural Engineer to control deflection as much as possible by keeping in mind the IS code recommendations. According to IS 456: 2000 the allowable deflection of a member can be calculated by L/250 (mm). The deflection diagram of whole structure is shown below:

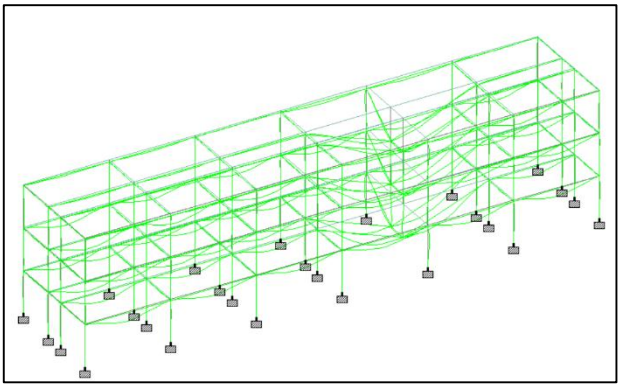

Fig. 5: Deflection Diagram of whole framed structure.

It is found in the above diagram that deflection is maximum where floating column is located. These columns are deleted so as to get large area near stair cases to avoid congestion. Columns exist as barrier in some cases, so it becomes necessary to remove those barriers. But removing columns or any other member will have impact on nearby structure. To check their stability and to maintain structural continuity some parameters are adjusted which include cross section and reinforcement or the orientation of the members.

C. Axial Force Details

Axial force is the power transmitted axially by columns. This force is the mixture of all forces including live load, dead load, earthquake load, ground finish load, etc. from a ground to move straight through beams to columns. This force is also made up of dead members, including beams and pillars. Using columns and eventually underground strata, this axial force is then transmitted to the base. To finish the network between floors with beams and then move the load to columns, the axial force transfer requires column. But in the event of this study columns are overlooked or removed in order to provide maximum space near the staircase for roominess.

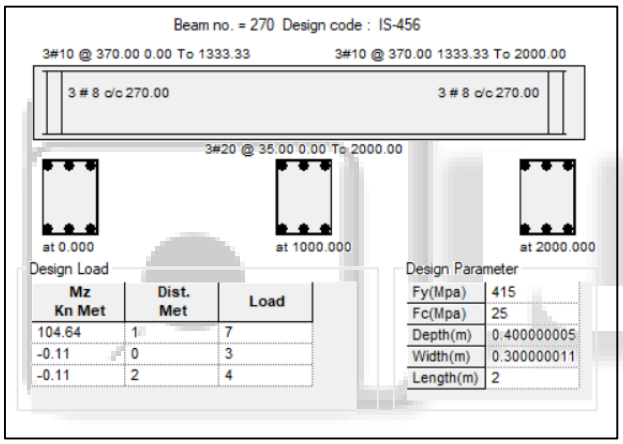

Fig 6: Reinforcement detailing of the beam below floating column.

VII. DESIGN RESULT

The column design outcome will offer the reinforcement information given in the column. The structure of the column is made up of primary bars and reinforcement of the tie. You can decide the design by understanding the details of the reinforcement if it is secure or not. If the message that "section is not sufficient" is presented, this implies that the section in the column fails for the given section. STAAD Pro selects the ultimate load case for cross section design automatically. The cross section can only be changed by Structural Engineer if section fails. We can also alter the characteristics of the material and the grades of steel and concrete. These parameters also play a significant role in altering member power.

Material take-off provides material assessment that involves concrete volume and steel weight. Reinforcing bar weight is calculated individually by bar diameter. The concrete quantity comprises of the complete amount of concrete used for casting beams and columns. STAAD Pro does not estimate other materials as they are not modelled in STAAD Pro, their loading is implemented by manual calculation and then implemented in STAAD Pro at a specific location. STAAD Pro does not model the brick walls. Loads are applied straight to beams instead of brick walls. The primary wall load is introduced to internal columns while inside beams are applied as partition wall load. Wall load is calculated by multiplying wall thickness to brick unit weight to receive UDL load. Reinforcing steel in plates is not included in the reported quantity.

TOTAL VOLUME OF CONCRETE = 146.8 m^3

BAR DIA (mm)	WEIGHT(N)
8	32522
10	17084
12	40097
16	19545
20	22650
25	5821
*** TOTAL= 137718 ***	

Table 8.1: Reinforcing data.

Here total weight of steel needed for construction is 137718 N and volume of concrete is 146.8m^3.

VIII. CONCLUSIONS

This Research led me lot of knowledge about the behaviour and interrelationship of floating column with nearby members. This project helped me to deeply analyse structure with floating column.

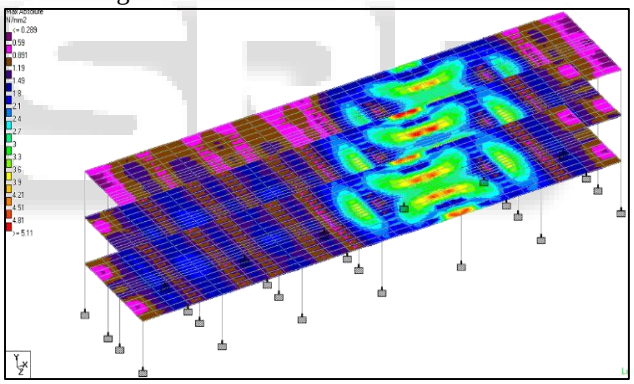

Fig. 7: Stress diagram of slab showing increase in stress (Red colour) at the location of floating column.

The main observations which I came to know while going through this research are pointed below:

1) The total variation in percentage of steel in the structure can be minimized by providing floating columns.
2) The percentage of steel in case of beams get increased whereas in case of columns no increment takes place in case of reinforcing bars.
3) In analysis process if grade of concrete increases the area of reinforcement decreases.
4) The reinforcement percentage in edge and interior columns are more compare to exterior columns. The percentage reinforcement in external beams are more compared to internal beams.

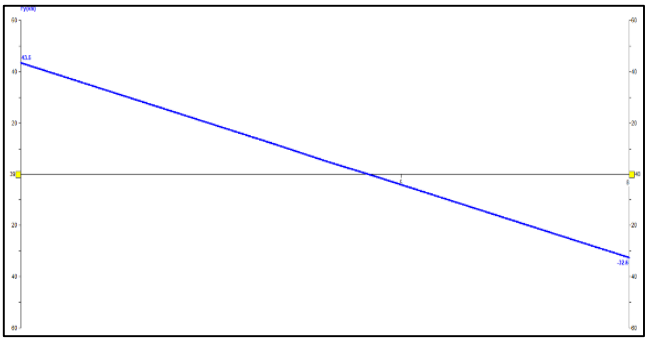

Fig. 8: Increase in shear force at beam surrounding floating columns.

5) In case of beams, the reinforcement percentage in bottom middle portion is same in all cases.
6) The base shear increases as the seismic Zone increase. The displacement of structures increased as the seismic zone increase.
7) The moments in building increases gradually according to seismic zones, but in some cases certain variation in values has been noticed.
8) If there is a smaller number of floating columns in structure then it has not huge impact on the building in case building is not more than three storeys.
9) Floating column must be ignored in case of earthquake resistant building.
10) For open spaces and parking lots curved roof must be preferred instead of floating columns as they directly transfer loads to columns and there is generation of compressive forces only.
11) Floating columns are suitable if columns are nearer to each other so that they can distribute loads normally and will not have much impact on adjacent beams.

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