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RESEARCH ARTICLE

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COMPARATIVE STUDY OF SYMMETRIC STRUCTURE WITH FLOATING AND NON-FLOATING COLUMN UNDER SEISMIC CONDITION

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ABSTRACT

In present scenario buildings with floating column is a typical feature in the modern multi-storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. These floating columns are introduced to the building so that the structure serve for both commercial and residential purpose and the floating columns start from the floor levels where the building would serve as residential building.

In this paper, studied the effect of floating columns of an RC frame structure for G+10 storey at different seismic zones in India and also studied the effect of position of floating column at different locations in the considered plan.

INTRODUCTION

The buildings can be broadly categorized as regular and irregular buildings. In the present day scenario irregular buildings are given more preference due to a variety of reasons. The aesthetic , considerations, space availability and user requirement are the most important reasons for preference of irregular buildings. An irregular building can be defined as a building that lacks symmetry and has discontinuity in geometry, mass or load resisting elements. The presence of structural irregularities has an adverse effect on the seismic response of the structure. The structural irregularities can be broadly categorized as horizontal and vertical irregularity, and different types of irregularities have different types of effects on the structure.

Many urban multi-storey buildings in India today have open storeys at lower levels which are an unavoidable feature. This is primarily being adopted to accommodate to have a commercial complex. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

FLOATING COLUMNS

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it such columns are called floating columns. The general floating column structure is shown below in Fig. 1

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

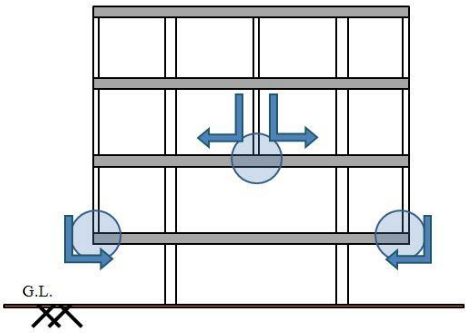


Fig 1. Floating column

A. Scope Of The Work

- Studied the behaviour of structure for R.C. frame only.
- Linear elastic analysis was done using STAADPro V8i.
- For the purpose of Comparison of drifts & quantity of steel, building type, floor system, floor area, bay size, column height, beam and column sizes were assumed as constant.
- Designs are carried out using IS: 456:2000 and IS: 1893:2002.

I. LITERATURE

Maison & Ventura[2], (1991), Members of ASCE computed dynamic properties and response behaviours OF THIRTEEN-STOREY BUILDING and this result are compared to the true values as determined from the recorded motions in the building during two actual earthquakes and shown that state-of-practice design type analytical models can predict the actual dynamic properties.

Arlekar, Jain & Murty[3], (1997) said that such features were highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes. They highlighted the importance of explicitly recognizing the presence of the open first storey in the analysis of the building, involving stiffness balance of the open first storey and the storey above, were proposed to reduce the irregularities introduced by the open first storey.

Rohilla1 & Gupta[4],(2015): In this paper, the critical position of floating column in vertically irregular buildings has been discussed for G+5 and G+7 RC buildings for zone II and zone V. Also the effect of size of beams and columns carrying the load of floating column has been assessed. Also for each model 2 cases of irregularities have been taken. Each model consists of two bays at the spacing of 5 m each and 1 bay at 6m spacing in X direction. However in Y- direction each bay is at spacing of 5m. The importance factor and response reduction factor have been used as 1 and 5 respectively in the analysis. Earthquake has been considered in X direction only.

Nakul & Riyaz[5], (2015):The paper presents comparative study of floating and non-floating columns with and without seismic behaviour. This work includes the analysis and design of the floating column and non floating column structures by using software in comparison of result with STAAD-Pro v8i Software. The effect of earthquake forces on various building models for various parameters is proposed to be carried out with the help of response spectrum analysis. Cost evaluation of both the models. The idea is to reach a definite conclusion regarding the superiority of the two structures over one another.

Shiwli & Gargi Danda[6], (2015) have preformed the computer analysis of an existing different levels of RC frame Building to study the influence of various dynamic properties .The paper presents the floating column analysis on multi-storeyed building and analysed by STAAD PRO V8i. Here G+3, G+5 and G+10 structures are analysed and compared with parameters shear force and bending moment.

II. METHODOLOGY

A. Basic Model Specification

- Building Type RC frames with and without floating columns also floating columns at different positions. Floor area 12 m x 12 m Storey Height 3m No. of Stories G+10 excluding beam and column dimensions.

- Comparison of displacements of structure with and without floating columns were done by doing analysis in STAAD PRO.

B. Material Properties

The material used for analysis is Reinforced concrete with M-20 grade concrete and Fe-415 grade reinforcing steel.

The Stress-Strain relationship used is as per IS 456:2000. The basic material properties used are as follows:

- Modulus of Elasticity of steel, Es = 200000MPa
- Ultimate strain in bending, $\sum_{cu}$ =0.0035
- Characteristic strength of concrete, f_{ck} = 20MPa
- Yield stress for steel, f_y = 415 MPa

C. Modelling Of Structure

A regular RC frame structure is chosen with and without floating columns, the plans of the buildings with different positions of floating columns were shown in tabular forum and the structure was modelled for G+10 storeys. The overall plan dimension of RC frame structures 12 m x 12m. All the considered frames are assumed to be fixed at ground level and storey heights are taken as 3m. All the members of the structure are assumed to be homogeneous isotropic and having elastic modulus same in compression as well as in tension. Constant beam and columns sizes were taken at all floors levels for each considered frame.

D. Loads Considered

- Dead Load (as per IS 875 part I)
- Live Load (as per IS 875 part I)
- Seismic Load (as per IS 1893 part I)

COMBINATIONS CONSIDERED AS PER IS 1893 (Part I) Clause 6.3.1.2

- 1.5 (D.L. + I.L.)
- 1.2 (D.L. + I.L. + E.L.)
- 1.5 (D.L. + E.L.)
- 0.9 D.L. + 1.5 E.L.

E. Building Nomenclature

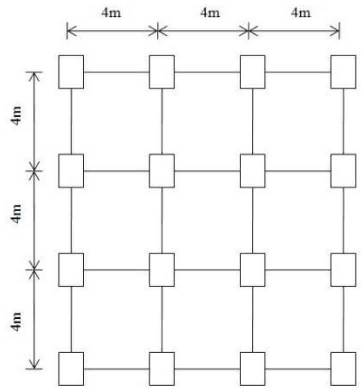


Fig : 2. Plan showing the considered RC frame building without floating column REGULAR FRAME (RF).

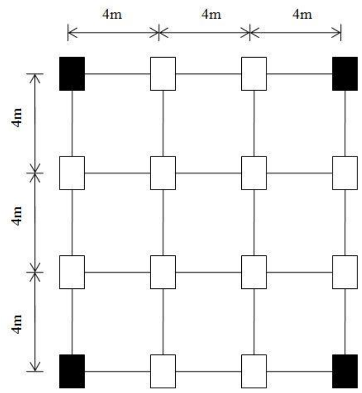
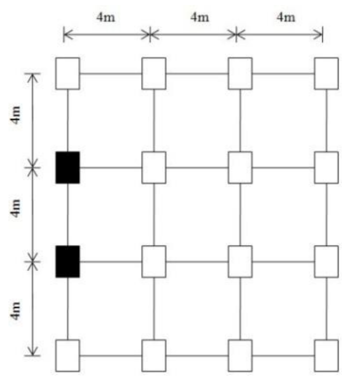


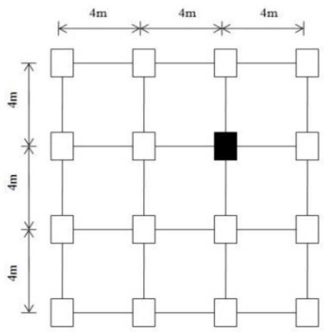
Fig : 3. Plan showing the considered RC frame building with floating column FRAME WITH FLOATING COLUMNS -I(FWFC - I)



Columns from foundation level

Floating Column at ground level

Fig : 4 Plan showing the considered RC frame building with floating column FRAME WITH FLOATING COLUMNS -II (FWFC - II)



Columns from foundation level

Floating Column from foundation level

Fig : 5. Plan showing the considered RC frame building with floating column FRAME WITH FLOATING COLUMNS -III (FWFC - III)

III. RESULTS

A. General

Failure of structure starts at point of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of the structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures. In this study, a similar R.C space frame with and without floating columns has been analysed and also different positions of floating columns were considered for G+10 storey for different seismic zones in India (II,III,IV,V) using STAADPro . Variations in percentage of displacements, drifts and quantities of steel of these structures were discussed below:

i. Frame without Floating Column (RF)

A frame of G+10 without floating columns has been considered which is shown in Fig.2 and graph is plotted for Displacements Vs Height at different seismic zones in Fig .6

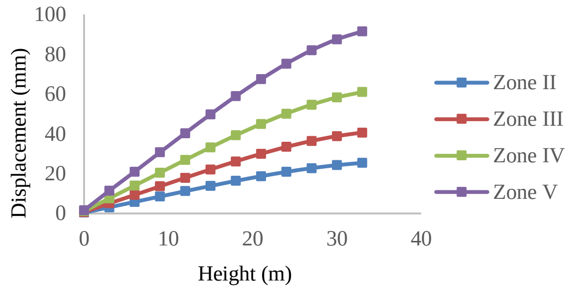


Fig :6 Height vs Displacement for Regular Frame (RF)

Quantity of Steel for Regular frame under different seismic zones are plotted in column chart in Fig .7

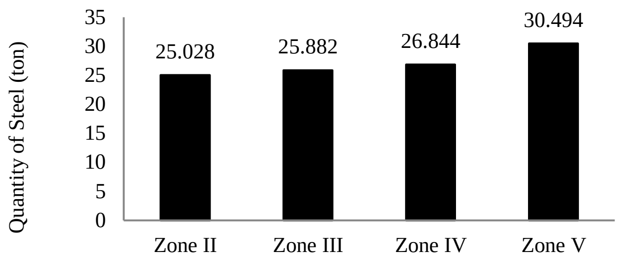


Fig 7 Quantity of Steel (ton) for Regular Frame

TABLE I: DRIFT FOR THE REGULAR FRAME AT DIFFERENT SEISMIC ZONES.

FRAME TYPE	SEISMIC ZONE	DRIFT (mm)
RF	II	2.286
	III	3.657
	IV	5.485
	V	8.228

ii. Frame with Floating Column - I (FWFC –I)

A frame of G+10 with floating columns has been considered which is shown in Fig. 3 and graph is plotted for Displacements Vs Height at different seismic zones in Fig .8

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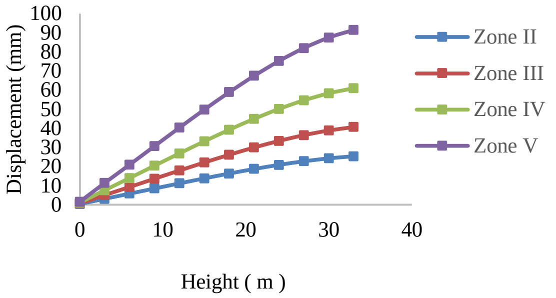

Fig: 8 Height vs Displacement for Frame With Floating Column - I (FWFC -I)

Quantity of Steel for Frame with Floating Column - I (FWFC - I) under different seismic zones are plotted in column chart in Fig .9

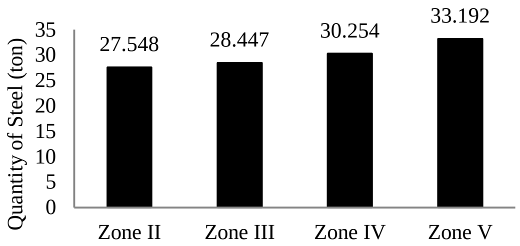

Fig: 9 Quantity of Steel (ton) for Frame with Floating Column - I (FWFC -I)

TABLE II: DRIFT FOR THE FRAME WITH FLOATING COLUMN - I AT DIFFERENT SEISMIC ZONES.

FRAME TYPE	SEISMIC ZONE	DRIFT (mm)	PERCENT VARIATION OF DRIFT with RF
FWFC-I	II	2.738	19.772%
	III	4.380	19.770%
	IV	6.570	19.781%
	V	9.855	19.773%

iii. *Frame With Floating Column - II (FWFC –II)*

A frame of G+10 with floating columns has been considered which is shown in Fig. 4 and graph is plotted for Displacements Vs Height at different seismic zones in Fig .10

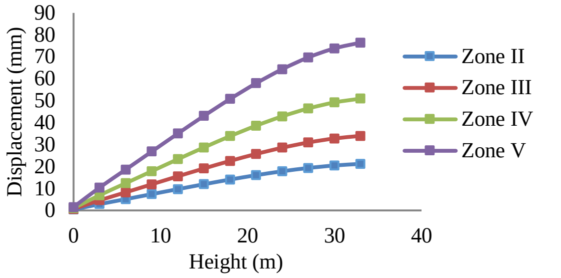

Fig :10 Height vs Displacement for Frame With Floating Column - II (FWFC -II)

Quantity of Steel for Frame with Floating Column - II (FWFC - II) under different seismic zones are plotted in column chart in Fig .11

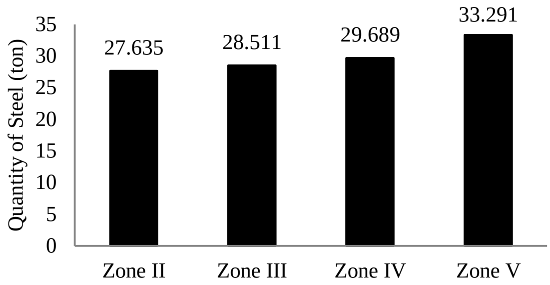

Fig: 11 Quantity of Steel (ton) for Frame with Floating Column - I I (FWFC -II)

TABLE III: DRIFT FOR THE FRAME WITH FLOATING COLUMN - II AT DIFFERENT SEISMIC ZONES.

FRAME TYPE	SEISMIC ZONE	DRIFT (mm)	PERCENT VARIATION OF DRIFT with RF
FWFC-II	II	2.474	8.223%
	III	3.959	8.258%
	IV	5.939	8.277%
	V	8.908	8.263%

iv. *Frame With Floating Column - III (FWFC – III)*

A frame of G+10 with floating columns has been considered which is shown in Fig. 5 and graph is plotted for Displacements Vs Height at different seismic zones in Fig .12

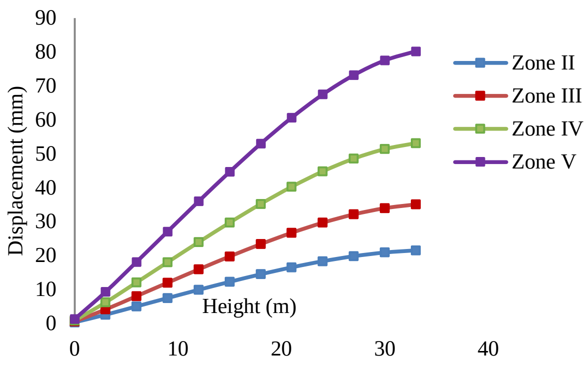

Fig : 12 Height vs Displacement for Frame With Floating Column - III (FWFC -III)

Quantity of Steel for Frame with Floating Column - II (FWFC - II) under different seismic zones are plotted in column chart in Fig .13

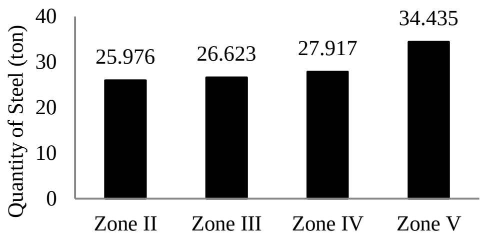

Fig : 13 Quantity of Steel (ton) for Frame with Floating Column - III (FWFC -III)

TABLE IV: DRIFT FOR THE FRAME WITH FLOATING COLUMN - III AT DIFFERENT SEISMIC ZONES.

FRAME TYPE	SEISMIC ZONE	DRIFT (mm)	PERCENT VARIATION OF DRIFT with RF
FWFC-III	II	2.590	13.298%
	III	4.048	10.691%
	IV	6.071	10.683%
	V	9.054	10.038%

IV. CONCLUSIONS

From the overall comparison and study the structure which is to selected according to the safety and economy in variant zones are as follows.

i. Seismic Zone - II

The resultant economic structure with is FWFC - II when compared to RF which gives less drift. The next preference was given to FWFC - III later FWFC -I as it distributes more drift. But when it comes for the quantity of the steel FWFC - III consumes less rather than FWFC - I, FWFC - III.

ii. Seismic Zone - III: The resultant economic structure with is FWFC - II when compared to RF which gives less drift. The next preference was given to FWFC - III later FWFC -I as it distributes more drift. But when it comes for the quantity of the steel FWFC - III consumes less rather than FWFC - I, FWFC - II.

iii. Seismic Zone - IV: The resultant economic structure with is FWFC - II when compared to RF which gives less drift. The next preference was given to FWFC - III later FWFC -I as it distributes more drift. But when it comes for the quantity of the steel FWFC - III consumes less rather than FWFC - II, FWFC - I.

iv. Seismic Zone - V: The resultant economic structure with is FWFC - II when compared to RF which gives less drift. The next preference was given to FWFC - III later FWFC -I as it distributes more drift. But when it comes for the quantity of the steel FWFC - I consumes less rather than FWFC - II, FWFC - III.

The conclusion is that there is a gradual increase in the drift and the order of different cases in ascending order is RF, FWFC - II,FWFC - III,FWFC - I with respect to seismic zones. There was no change in the order in all zones even though the structural alignment changes. But when coming to the quantity of steel there is a change in the order of cases in different seismic zones. So, for a safe and economic work the structure has to be selected on the basis of purpose which is to be used and construction materials.

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