SEISMIC ANALYSIS OF A RC MULTI STOREY BUILDING WITH AND WITHOUT FLOATING COLUMNS

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Abstract - *The columns which are supported solely on the beam instead of rigid foundation are called as floating columns. Many of the structures in India are constructed with floating columns. This is primarily being adopted to provide accommodations for parking or reception lobbies in the first story. The earthquake force generated at different floor level of the building must to be carried out to the foundation by the shortest possible way which may not be the case when floating columns are provided. Providing floating columns may please some of the functional requirements but structural behaviour changes abruptly due provisions of floating columns. The flexural and shear demand of the beams which supports floating columns are greatly higher than surrounding beams, this indicates the stiffness irregularities at a particular joint. Columns are main lateral load resisting elements in moment resisting frame and play a vital role in seismic performance of building. The stiffness of the storey below the floating column is usually lesser than the storey above. In this thesis, the seismic performances of building with and without floating columns are presented in relation to various parameters such as storey displacement, storey drift, base shear, time period, bending moment and shear force. The building having no floating columns, floating column at the corners, at the longer spans and at the shorter spans are considered for the study at two floors in zone III and V. The building is modeled using finite element software ETABS. Time history analysis is performed on the various buildings and their seismic performance is calculated using ETABS software. The main aim is to evaluate the seismic response of building with floating columns and compare it with the regular building.*

Key Words: **ETABS, Floating Column, RCC, Seismic Forces, Storey displacement, etc**

1. INTRODUCTION

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 ends (due to architectural design or site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. These are buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation with discontinuities in the load transfer path. The beams in turn transfer the load to other columns below it. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few stores wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity.

1.1 SEISMIC RESPONSE

There can be substantial variation when an earthquake occurs in the stages of performances by buildings situated on the same site. The inconsistency may be due to several of factors such as, differences in workmanship levels, structures condition at that zone, and material strength of the buildings, the amount and live loading distribution on the structure during the time of earthquake, the impact of mass and stiffness of structural and non-structural components, and the soil types underneath the buildings, and moderately differences in the ground motion character transmitted to the structures.

1.2 FLOATING COLUMN

Column is a vertical member starting from foundation level and transfers the load to the ground. The term floating column is also a vertical element which (due to the architectural design or site situation) at its lower level (termination level) rests on a beam which may be either horizontal or inclined. The beams inturn transfers load to other columns below it.

2. ANALYSIS

Earlier researchers have carried out their analysis with floating columns being provided at the outer side of the building at different floors in different seismic zones (Zone II, III, IV, V). So after going through some of these journals and thesis I have decided to do my thesis on internal floating columns at different positions of the building in different seismic zones.

2.1 EQUIVALENT STATIC ANALYSIS

This method defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when ground moves. The response is read from a design response, given the natural frequency of building. The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of structure, many codes apply modification factors that reduce the design forces (example force reduction factors).

2.2 TIME HISTORY ANALYSIS

A linear time history analysis overcomes all the disadvantages of modal response spectrum analysis, provided non-linear behaviour is not involved. This method requires greater computational efforts for calculating the response at discrete time. One interesting advantage of such procedure is that the relative signs of response qualities are preserved in the response histories. This is important when interaction effects are considered in design among stress resultants. The below figure 2.1 represents the El-Centro time history analysis data.

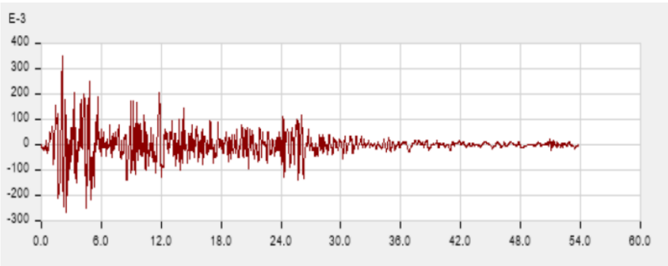

Fig. 2.1 El-Centro Time history analysis data from ETABS

3. MODELING OF RC STRUCTURAL SYSTEM

Modelling of G+9 storey building is considered for the analysis in ETABS software. A building is considered where the floating columns are positioned at interior corners, on both of the longer spans alternatively and on both of the shorter spans alternatively at Ground floor and on the first floor respectively.

The structure considered here is a regular building with plan dimension of 32m x 24m with a bay length of 4m on both sides. In the present study, a G+9 storeys RC structure with and without floating column are considered. The floating columns are proposed at different positions in the building.

3.1 TYPES OF MODELS FOR ANALYSIS

In the present work seven models were considered and analysed they are viz.,

NFC- Building without floating columns

FCC GL- Building with floating columns at the interior corner in the ground floor

FCLSA GL- Building with floating columns alternatively on the longer spans in the ground floor

FCSSA GL- Building with floating columns alternatively on the shorter spans in the ground floor

FCC 1F- Building with floating columns at the interior corner in the first floor

FCLSA 1F- Building with floating columns alternatively on the longer spans in the first floor

FCSSA 1F- Building with floating columns alternatively on the shorter spans in the first floor

3.2 MODELING

Figure 3.1 indicates the plan of the symmetrical structure. The figure 3.2 shows the elevation of the model without floating column. From fig 3.3 to 3.8 floating columns shows the choosen different positions. All these models were analysed for two different seismic zones (Zone III and V).

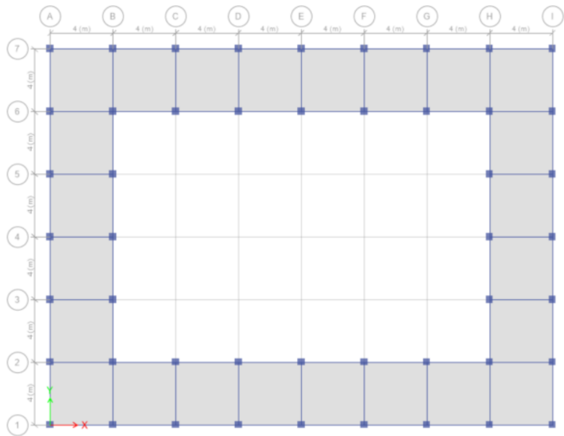

Fig. 3.1 Plan of the buildings

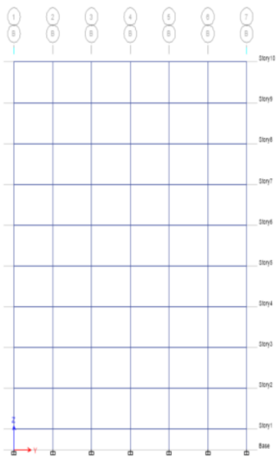

Fig. 3.2 Elevation of NFC

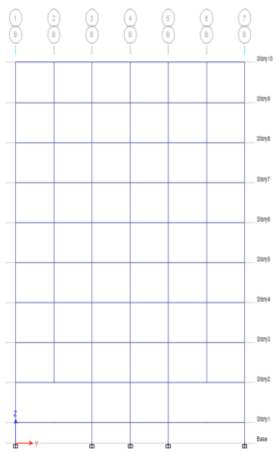

Fig. 3.3 Elevation of FCC GL

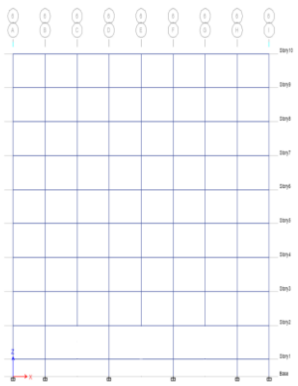
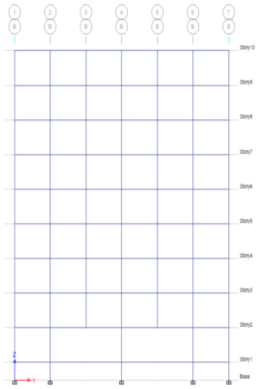

Fig. 3.4 Elevation of FCLSA GL **Fig. 3.5** Elevation of FCSSA GL

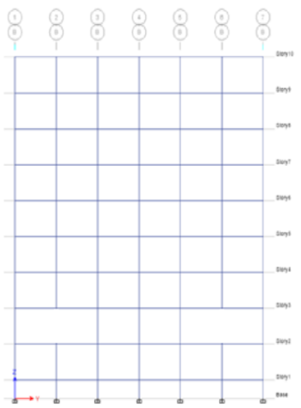
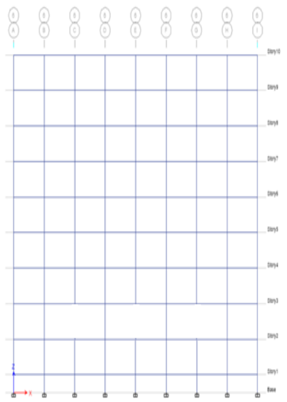

Fig. 3.6 Elevation of FCC 1F **Fig. 3.7** Elevation of FCLSA 1F

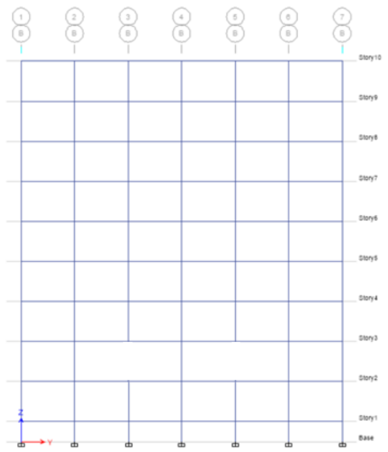

Fig. 3.8 Elevation of FCSSA 1F

The above models were analysed in ETABS software and results were extracted and graphs were plotted in Microsoft EXCEL.

4. RESULTS

This chapter describes the results and discussion of the models analyzed in ETABS by non-linear time history analysis.

4.1 STOREY DISPLACEMENT

Storey displacement is the lateral movement of the structure caused by lateral force. The deflected shape of a structure is most important and clearly a visible point of comparison for any structure. No other parameter of comparison can give a better idea of behaviour of the structure than comparison of storey displacement.

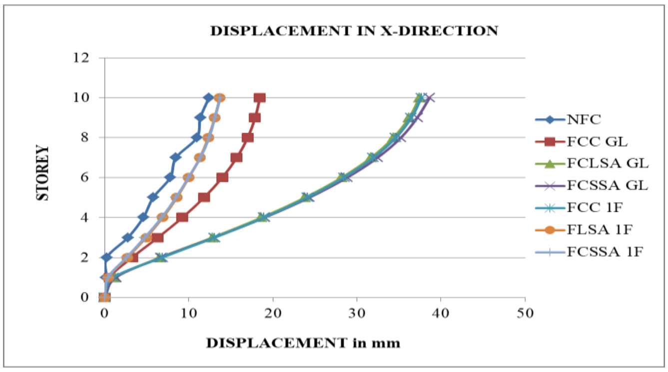

Fig. 4.1 Variation of storey displacement in X- direction in Zone 3

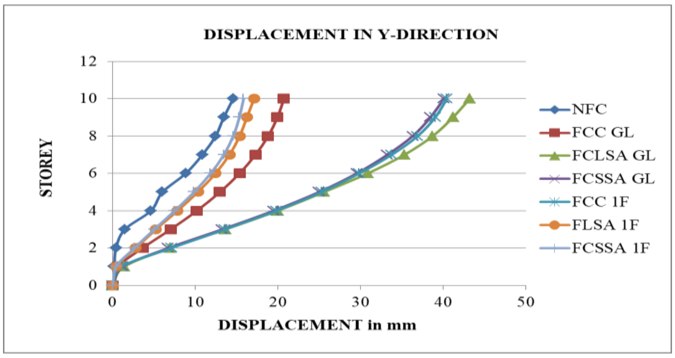

Fig. 4.2 Variation of storey displacement in Y- direction in Zone 3

The above graphs show that, the buildings with floating columns provided at longer and shorter spans on the interior side of the building exhibit higher displacement when its on the ground floor.

The buildings with floating columns provided at interior corner of the building exhibit higher displacement when its on the 1st floor.

4.2 BASE SHEAR

Shear induced at the base of building during earthquake is called base shear which depends on the seismic mass and stiffness of building. The results of variation in Base Shear due to the effect of floating columns for different cases are tabulated below

It is observed that due to the introduction of floating columns in the building the value of base shear decreases due to increase of natural period of vibration of structure.

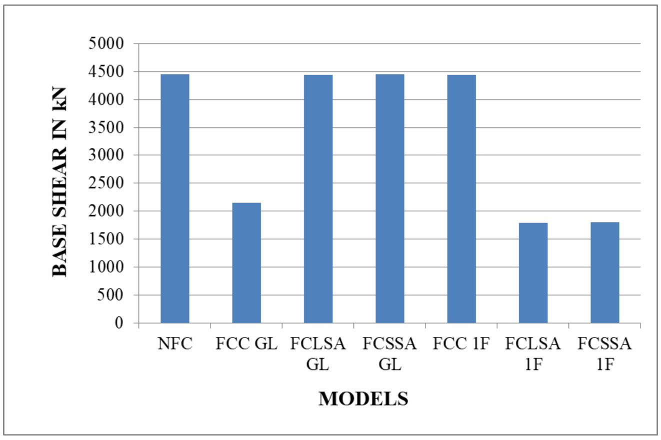

Fig. 4.3 Variation in base shear in Zone 3

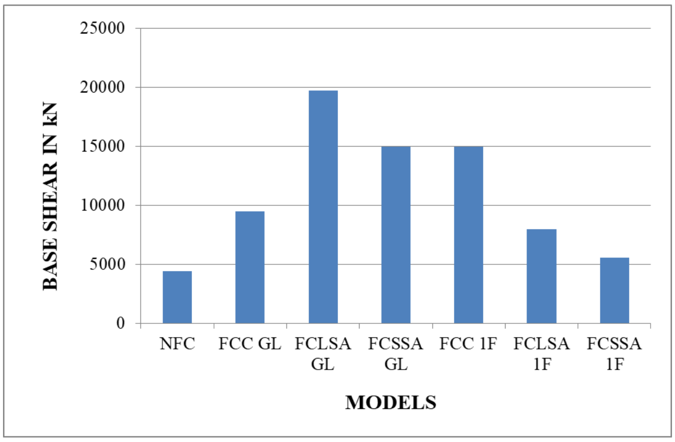

Fig. 4.4 Variation in base shear in Zone 5

Variations in the base shear were shown in the fig. 4.3 and 4.4 for all the models in Zone III and V.

It is observed that model FCSSA GL has the maximum base shear value and FCLSA 1F has the minimum base shear value in Zone III due to the positioning of the floating columns in those models.

It is observed that model FCLSA GL has the maximum base shear value and FCSSA 1F has the minimum base shear value in Zone V due to the positioning of the floating columns in those models.

4.3 STOREY DRIFT

Storey drift is the drift of one level of a multi-storey building relative to the level below. Inter storey drift is the difference between the roof and floor displacements of any given story as the building sways during the earthquake, normalized by the story height.

As per IS: 1893 (Part 1) 2002, the storey drift for RC building is limited to 0.004 times the storey height or h/ 250.

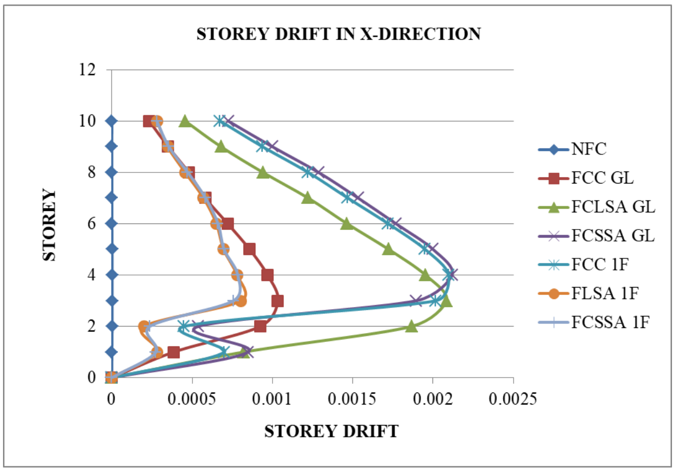

Fig. 4.5 Variation of storey drift in X- direction in Zone 3

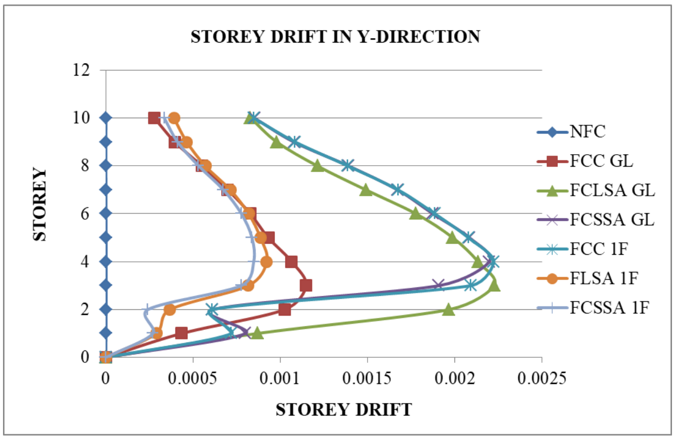

Fig. 4.6 Variation of storey drift in Y- direction in Zone 3

It is also observed that model FCSSA GL exhibit the maximum drift along X direction and model FCLSA GL experience the maximum drift along Y direction in Zone III.

It's mainly observed that models with floating columns at the longer span and shorter span at ground level in both the zones exhibit maximum drift compared to other models.

Values of drift are much less when floating columns are not provided. This difference can be seen in all the models with floating columns when it's compared with without floating column models on both the zones.

4.4 TIME PERIOD

Fundamental time period is the time taken by the building to undergo a cycle of to and fro movement. The fundamental time period determined for building with and without floating columns of different cases is presented. The variation of time period due to the effect of floating columns is also shown in Fig. 4.7.

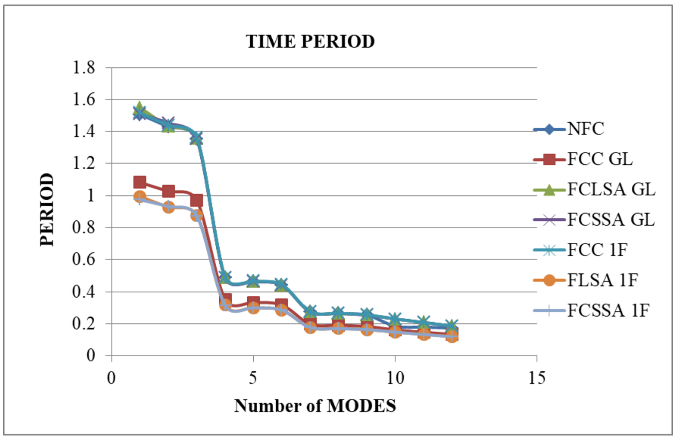

Fig. 4.7 Time period values of different models

The time period values of different models decreases slightly at the beginning from mode 1 to 3 and suddenly decreases at mode 5 and later it follows with a gradual decrease till mode 12.

The introduction of floating columns in the RC building mostly increases the time period due to decrease in the stiffness of structure. The columns act as springs in the building with having some stiffness value.

The storey having floating columns in it has lesser columns and therefore lesser stiffness resulting in the decrease of overall stiffness of the building.

3. CONCLUSIONS

The study presented in the paper compares the difference between conventional structure and structures with floating column. The following conclusions were obtained based on the investigation.

1. In the present thesis, the buildings with floating columns provided at longer and shorter spans on the interior side of the building exhibit higher displacement when it's on the ground floor. The buildings with floating columns provided at interior corner of the building exhibit higher displacement when it's on the 1st floor. The buildings with floating columns provided at longer and shorter spans on the interior side at ground floor and interior corner at 1st floor on Zone V fails by crossing the maximum storey displacement limit of the building.

2. It is observed that floating columns provided at the interior corners in the ground floor and floating columns positioned alternatively on the longer spans and shorter spans in the 1st floor shows reduced base shear when compared with building without floating column. It is observed that floating columns provided alternatively on the longer spans and shorter spans in the ground floor and floating columns positioned at the interior corners in the 1st floor shows increased base shear when compared with building without floating column. Thus, it has its technical and functional benefit over conventional structure.

3. It has been found that by incorporating floating columns there is about 5-8% increase in fundamental time period as compared to building without floating columns. The introduction of floating columns in the RC building increases the time period due to decrease in the stiffness of structure. The columns act as springs in the building with having some stiffness value. The storey having floating columns in it has lesser columns and therefore lesser stiffness resulting in the decrease of overall stiffness of the building.

4. Therefore, floating columns should be avoided as far as possible in seismic regions like zone III and V. If they are unavoidable, then the structure should be strengthened by adopting some remedial features

5. The final conclusion is not to introduce floating column in buildings unless there is a proper purpose and functional requirement for those. If they are to be introduced then appropriate care should be taken while designing the structure.

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