SEISMIC ANALYSIS OF MULTISTOREYED BUILDINGS WITH AND WITHOUT FLOATING COLUMNS

A DISSERTATION

SUBMITTED IN THE PARTIAL FULFILLMENT OF REQUIREMENTS
FOR THE AWARD OF THE DEGREE
OF
MASTER OF TECHNOLOGY
IN
STRUCTURAL ENGINEERING

Submitted by:
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CANDIDATE'S DECLARATION

I, ARCHIT DWIVEDI , Roll No 2k16/ste/04 student of M.Tech. (STRUCTURAL ENGINEERING), hereby declare that the project Dissertation titled "SEISMIC ANALUSIS OF MULTISTOREYED BUIDING WITH FLOATING COLUMNS" which is submitted by me to the department of CIVIL ENGINEERING,DELHI TECHNOLOGICAL UNIVERSITY,DELHI in partial fulfillment of the requirement for the award of degree of Master Of Technology is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associate ship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled "Seismic Analysis of Multisotereyed buildings using floating columns " which is submitted by ARCHIT DWIVEDI, 2K16/STE/04 department of civil engineering(structural engineering), Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi
Date:

Mr. (Prof) NIRENDER DEV
SUPERVISOR

ACKNOWLEDGEMENT

It is a great pleasure to have the opportunity to extend my heartiest felt gratitude to everybody who helped me throughout the course of this Major project report.

It is distinct pleasure to express my deep sense of gratitude and indebtedness to my learned guide **Prof NIRENDER DEV** , in the Department of Civil Engineering, Delhi Technological University, for his invaluable guidance, encouragement and patient review. His continuous inspiration only has made me complete this major dissertation.

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CONTENTS

ABSTRACT

In present scenario buildings with floating column is a typical feature in the modern multistory construction in urban India. Such features are highly undesirable in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the floating columns.

The study is carried out on a building with floating columns. The plan layout of the building is shown in the figure. The building considered is a residential building having G+9. Height of each storey is kept same as other prevalent data.

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LIST OF SYMBOLS

P Axial force in member

Δ Global lateral deformation

δ Local deformation

L Length of member

P_d Design strength in axial compression

e Eccentricity

T Natural period of vibration

V Design shear force

P_z Design wind pressure

h Height of building

V_z Design wind velocity

V_b Basic wind speed

A Surface area of structural element or cladding

F Wind load

C_{pe} External pressure coefficient

C_{pi} Internal pressure coefficient

W Seismic weight of building

Z Zone factor

I Importance factor

R Response reduction factor

$\frac{s_a}{g}$ Average response acceleration coefficient

d Base dimension of building at plinth level

Q Design lateral force

CHAPTER 1

INTRODUCTION

1.1 Introduction

Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. 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.

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 storey wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path..

1.2 What is floating column

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.

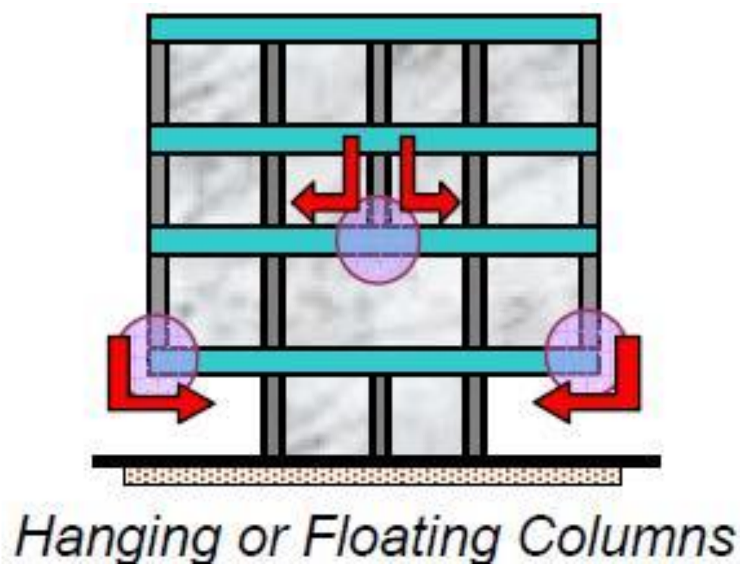

FIG 1.1

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. These open spaces may be required for assembly hall or parking purpose. 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.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first storey can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

Some pictures showing the buildings built with floating columns:

FIG 1.2
240 Park Avenue South in New York, United States

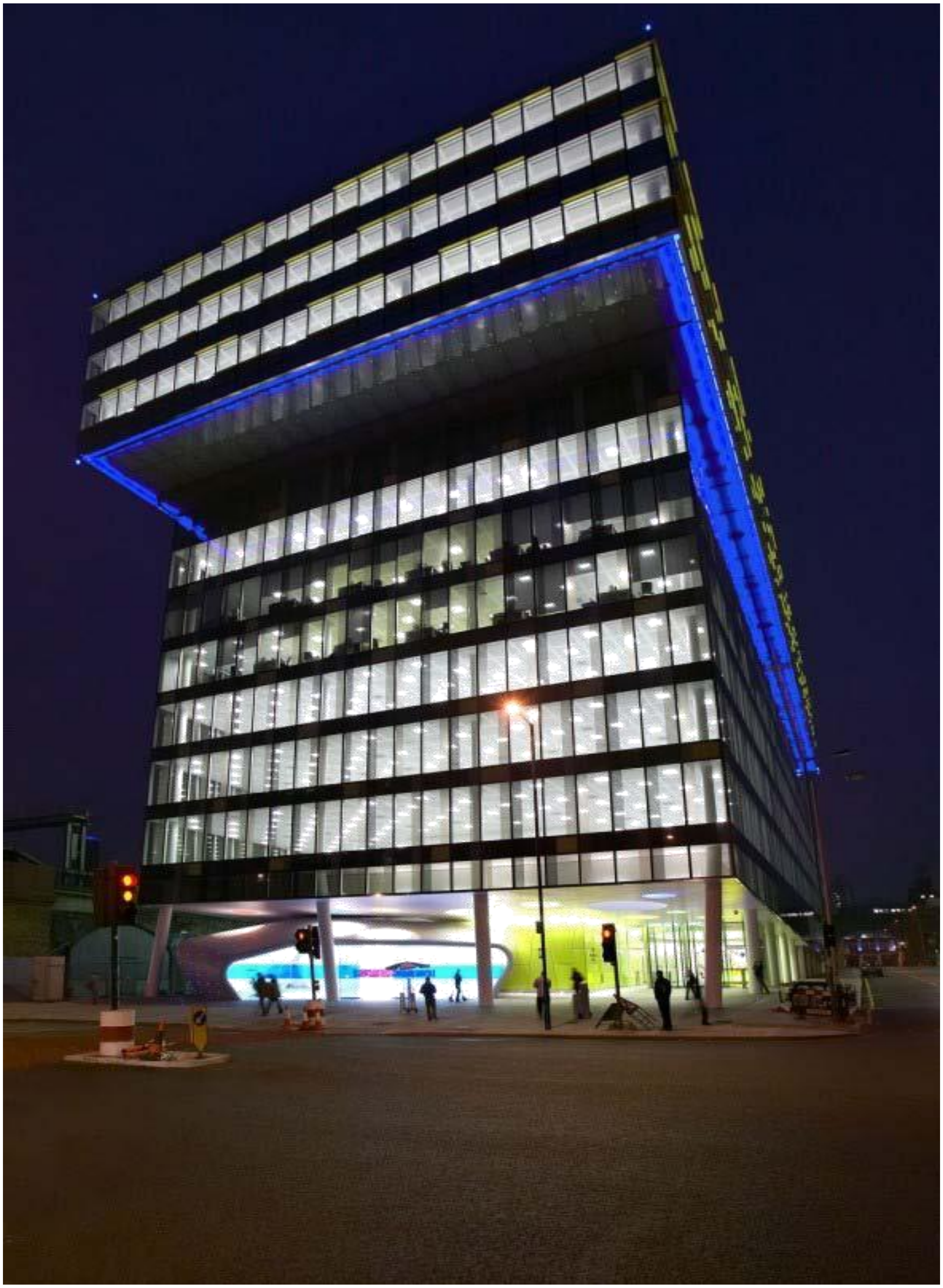

FIG 1.3
Palestra in London, United Kingdom

FIG 1.4
Chongqing Library in Chongqing, China

FIG 1.5
One-Housing-Group-by-Stock-Woolstencroft-in-London-United-Kingdom

1.3 Objective and scope of present work

The objective of the present work is –

- to study the behavior of multistory buildings with floating columns under earthquake excitations.
- Staad pro is used to analyse the effects of seismic analysis of the building with floating column.
- To investigate the base shear & storey displacements between floating columns located at different locations of a G+9 residential mutistorey building.

1.4 Research significance

In urban areas, multi storey buildings are constructed by providing floating columns at the ground floor for the various purposes which are stated above. These floating column buildings are designed for gravity loads and safe under gravity loads but these buildings are not designed for earthquake loads. So these buildings are unsafe in seismic prone areas. The project aims to create awareness about these issues in earthquake resistant design of multi-storeyed buildings

CHAPTER 2

REVIEW OF LITERATURES

- **ISHA ROHILLA et. al. [2015]**, discussed the critical position of floating column in vertically irregular buildings 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. The response of building such as storey drift, storey displacement and storey shear has been used to evaluate the results obtained using ETABS software. On the basis of analysis and results following conclusions have been made: 1. Floating columns should be avoided in high rise building in zone 5 because of its poor performance. 2. Storey displacement and storey drift increases due to presence of floating column. 3. Storey displacement increases with increase in load on floating column. 4. Storey shear decreases in presence of floating column because of reduction mass of column in structure. 5. Increase in size of beams and columns improve the performance of building with floating column by reducing the values of storey displacement and storey drift. Increasing dimensions of beams and columns of only one floor does not decreases storey displacement and storey drift in upper floors so dimensions should be increased in two consecutive floors for better performance of building.

- **KAVYA N et. al. [2015]**, studied the seismic behavior of the RC multistory buildings with and without floating column are considered. The analysis is carried out for the multi-storey buildings of G+3 situated at zone IV, using ETABS software. To determine seismic behavior of the Buildings with and without floating columns for zone IV the basic components like inter storey drift, lateral displacement, and fundamental time period this analysis has been carried using the software ETABS V 9.7.1. for the analysis purpose Equivalent static method, and Response spectrum methods are adopted. In this building model RC multi storied structures of 4 stories are considered with and without floating columns for the analysis. The typical height of the floors is considered as 3.6m and the height of the ground storey is taken as 4.8m. to avoid the tensional response under the pure lateral forces the buildings are kept symmetric in both the orthogonal directions in plan. On the basis of analysis following conclusions are drawn: 1. The natural time periods obtained from the empirical expressions do not agree with the analytical natural periods. Hence, the dynamic analysis is to be carried out before analyzing these type of structures. And also it can be concluded from the analysis that the natural time period depends on the building configuration. 2. Lateral displacement increases along the height of the building. There is more increase in the displacement for the floating column buildings compared with the regular building. 3. The inter storey drift also increases as the increase in the number of storeys. The storey drift is more for the floating column buildings because as the columns are removed the mass gets increased hence the drift. 4. As the mass and stiffness increases the base shear also increases. Therefore, the base shear is more for the floating column buildings compared to the conventional buildings. Hence, from the study it can be concluded that as far as possible, the floating columns are to be avoided especially, in the seismic prone areas.

- **SARITA SINGLA et. al. [2015]**, investigates the effects of the structural irregularity which is produced by the discontinuity of a column in a building subjected to seismic loads. In this paper static analysis and dynamic analysis using response spectrum method is done for a multi-storied building with and without floating columns. Different cases of the building are studied by varying the location of floating columns floor wise and within the floor. The structural response of the building models with respect to Fundamental time period, Spectral acceleration, Base shear, Storey drift and Storey displacements is investigated. The analysis is carried out using software STAAD Pro V8i software. A 12.5m x 24m multistoried building (G+6), with special moment resisting frame was selected for study. The building has a one brick thick exterior wall along the periphery and all the interior walls are half brick thick. It was considered to be located in Zone IV on Type II soil. In this study first a normal building (NB) without any floating columns is modeled. Then, two types of models, namely 1 and 2 are modeled. In model 1, the floating columns are located at ground floor and in model 2 they are located at first floor. For each model three different cases are studied by varying the location of floating columns. In all six cases have been studied namely-NB, 1A, 1B, 1C, 2A, 2B and 2C.

For the analysis purpose two models have been considered namely as:

MODEL 1 – Building in which floating columns are located at ground floor.

MODEL 2 – Building in which floating columns are located at first floor.

MODEL 1 – Following cases have been considered under this model based on the location of floating columns –

CASE 1A – Corner columns and alternate columns in exterior frame along the two long edges are floating columns.

CASE 1B – Corner columns and all the columns in the centre most frame along the short edge are floating columns.

CASE 1C – Alternate columns in exterior frame along the two long edges except the corner ones and those in the centre most frame along the short edge are floating columns.

MODEL 2 – Following cases have been considered under this model based on the location of floating columns –

CASE 2A – Corner columns and alternate columns in exterior frame along the two long edges are floating columns.

CASE 2B – Corner columns and all the columns in the centre most frame along the short edge are floating columns.

CASE 2C – Alternate columns in exterior frame along the two long edges except the corner ones and those in the centre most frame along the short edge are floating columns.

Following are some of the conclusions which are drawn on the basis of this study.

1. It was observed that in building with floating columns there is an increase in fundamental time period in both Xdirection as well as Z-direction as compared to building without floating columns (NB).

2. By introduction of floating columns in a building base shear and spectral acceleration decreases. Thus, it has this technical and functional advantage over conventional construction.

3. The storey displacements increase when floating columns are introduced in the building. The deflections were more in Model 1 as compared to Model 2, which proves that buildings with floating columns in ground floor are more vulnerable during earthquake. It was also observed that deflections increase marginally in that storey where floating columns are located.

A.P. MUNDADA et. al. [2014], studied the architectural drawing and the framing drawing of the building having floating columns. Existing residential building comprising of G+ 7 structures has been selected for carrying out the project work. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. The importance and effects due to line of action of force is also studied. In this paper we are dealing with the comparative study of seismic analysis of multi-storied building with and without floating columns. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure. Also they concluded that provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building.

KEERTHIGOWDA B. S et. al. [2014], examined the adverse effect of the floating columns in building. Models of the frame are developed for multi-storey RC buildings with and without floating columns to carry out comparative study of structural parameters such as natural period, base shear, and horizontal displacement under seismic excitation. Results obtained depicts that the alternative measure of providing lateral bracing to decrease the lateral deformation, should be taken. The RC building with floating column after providing lateral bracing is analyzed. A comparative study of the results obtained is carried out for three models. The building with floating columns after providing bracings showed improved seismic performance. The main purpose of present study was to assess seismic performance of the RC building with floating columns and seismic performance of RC building with floating columns after providing lateral bracings. For this purpose response spectrum analysis (RSA) is performed considering three models (without floating columns, with floating columns and floating columns with bracings). Through the parametric study of storey drift, storey shear, time period and displacement, it was found that the multi-storey buildings with floating columns performed poorly under seismic excitation. Thus to improve seismic performance of the multi-storey RC building, lateral bracings were provided. The bracings improved seismic performance of multi-storey building considerably as different parameters such as storey drift, storey shear, time period and displacement improved upto 10% to 30%.

PRATYUSH MALAVIYA et. al. [2014], studied the effect of floating columns on the cost analysis of a structure designed on STAAD Pro V8i. For this purpose a 2 storied15mt x 20mt regular structure is considered for the study. Modeling, analysis, estimation and design of the structure is done separately on the software. Analysis is performed on the zone II, zone III, zone IV and zone V. It is concluded that in the framed structure with no floating columns the nodal displacements is minimum with uniform distribution of stresses at all beams and columns. As a result it is most economical.

PRERNA NAUTIYAL et. al. [2014], investigated the effect of a floating column under earthquake excitation for various soil conditions and as there is no provision or magnification factor specified in I.S. Code, hence the determination of such factors for safe and economical design of a building having floating column. Linear Dynamic Analysis is done for 2D multi storey frame with and without floating column to achieve the above aim i.e. the responses (effect) and factors for safe and economical design of the structure under different earthquake excitation. For the analysis purpose two models have been considered namely as:

Model A: Four storied (G+3) special Moment Resisting Frame (Case 1).
Model B: Six storied (G+5) special Moment Resisting Frame (Case 2).

From the study it is concluded that the base shear demands for medium soil are found higher than that of the hard soil in both cases (i.e. G+3 and G+ 6 models). As the height of the building increases, variation in base shear from medium to hard soil condition decreases. For different soil conditions (medium to hard) the max moments vary from 22-26% for four storied building model and 16-26% for six storied building model. It has been found that max. variation in values of max. moments comes at the ground floor

(26%) for both the cases whereas the min. variation comes at the top floor (22% for case 1 and 16% for case 2). It can further been concluded that as the height of the building increases the variation of max. moments gets reduced for different soil conditions.

SABARI S et. al. [2014], highlighted the importance of explicitly recognizing the presence of the Floating Column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the Floating Columns. FEM analysis carried for 2D multi storey frames with and without floating column to study the responses of the structure under different earthquake excitation having different frequency content keeping the PGA and time duration factor constant. The time history of roof displacement, inter storey drift, base shear, column axial force are computed for both the frames with and without Floating Column. It is concluded that by increasing the column size the maximum displacement and inter storey drift values are reducing.

SREEKANTH GANDLA NANABALA et. al. [2014], studied the analysis of a G+5 storey normal building and a G+5 storey floating column building for external lateral forces. The analysis is done by the use of SAP 2000. They also studied the variation of the both structures by applying the intensities of the past earthquakes i.e., applying the ground motions to the both structures, from that displacement time history values are compared. This study is to find whether the structure is safe or unsafe with floating column when built in seismically active areas and also to find floating column building is economical or uneconomical. Based on the investigation following conclusions were drawn.

1. By the application of lateral loads in X and Y direction at each floor, the displacements of floating column building in X and Y directions are less than the normal building but displacement of floating column building in Z direction is large compared to that of a normal building. So the floating column building is unsafe for construction when compared to a normal building.

2. By the calculation of lateral stiffness at each floor for the buildings it is observed that

floating column building will suffer extreme soft storey effect where normal building is free from soft storey effect. So the floating column building is unsafe.

3. After the analysis of buildings, comparison of quantity of steel and concrete are calculated from which floating column building has 40% more rebar steel and 42% more concrete quantity than a normal building. So the floating column building is uneconomical to that of a normal building.

4. From the time history analysis it is noticed that the floating column building is having more displacements than a normal building. So floating column building is unsafe than a normal building.

The final conclusion is that do not prefer to construct floating column buildings. With increase in dimensions of all members also it is getting more displacements than a normal buildings and also the cost for construction also increased. So avoid constructing floating column buildings.

SRIKANTH.M.K et. al. [2014], studied the importance of explicitly recognizing the presence of the floating column in the analysis of building and also, along with floating column some complexities were considered for ten storey building at different alternative location and for lower and higher zones. Alternate measures, involving stiffness balance of that storey where floating column is provided and the storey above, are proposed to reduce the irregularity introduced by the floating columns. The high rise building is analyzed for earthquake force by considering two type of structural system. Frame with only floating column and floating column with complexities for reinforced concrete building. Analysis was carried out by using Extended Three Dimensional Analysis of Building Systems (ETABS) version 9.7.4 software. The entire work consists of four models (Model FC, Model FC+4, Model FC+HL, Model FC+4+HL). And these models were analysed for lower (II) and higher (V) seismic zones for medium soil condition. The results are tabulated for base shear, story drift and lateral displacements. The model having only floating column, the model having a floating column by increasing the height of the storey, the model having a floating column by heavy load on the slab where floating column is provided, and a last model in which floating column is provided by rising the storey height a heavy load on slab, these four models were analysed by changing the location of floating column firstly in the middle, outer and in edge of the frame of building. The models considered the present study are:

Model FC: Where only Floating Column is provided in a particular location, particular floor and in a particular zone.

Model FC+4: Where Floating Column is provided by rising the Story Height by 4 m in a particular location, particular floor and in a particular zone.

Model FC+HL: Where Floating Column is provided by applying Heavy Load on the slab, particular floor and in a particular zone. (Heavy load may be swimming pool, water tank or machinery room etc...)

Model FC+4+HL: Where Floating Column is provided by rising the Story Height by 4 m along with provision of Heavy Load in a particular location, particular floor and in a particular zone. Based on the study the conclusions are as follows:

1. The models FC+4, FC+HL, FC+4+HL are not preferred in higher zones because the more displacement value according to code. In lower zones all models were preferred but while designing special care should be taken.

2. The displacement of the building increases from lower zones to higher zones, because the magnitude of intensity will be more for higher zones, similarly for drift, because it is correlated with the displacement.

3. Storey shear will be more for lower floors, then the higher floors due to the reduction in weight when we go from bottom to top floors. And with this if we reduce the stiffness of upper floors automatically there will be a reduction in weight on those floors so in the top floors the storey shear will be less compared to bottom stories.

4. The response of the building which is having only floating column will be less when compared to other (FC+4, FC+HL, FC+4+HL) models of the study.

5. The maximum value of Displacement and Drift are more for the models FC+HL and FC+4+HL than the models FC and FC+4, due to increment in weight.

6. Whether the floating columns on ground floor or in eight floors the displacement values increases when a floating column is provided in edge and middle than the outer face of the frame.

7. The multi-storey building with complexities will undergo large displacement then the model having only floating column.

8. In all models the displacement values are less for lower zones and it goes on increases for higher zone.

9. There is a sudden change in storey shear in models FC+HL and FC+4+HL it is due to the heavy load on the slab, so there should not be any a sudden change in load in upper floors.

10.The drifts are deviated more in model FC+4+HL compared to other models, particularly in above and below where floating column, which is provided in zone II and V so this model either be redesigned by replacing the properties of the model.

T.RAJA SEKHAR et. al. [2014], developed FEM codes for 2D multi storey frames with and without floating column to study the responses of the structure at different earthquake conditions having different frequency by keeping the PGA and time duration factor constant. The behavior of building frame with and without floating column is studied under static load, free vibration and forced vibration condition. The results are plotted for both the frames with and without floating column by comparing each other time history of floor displacement, base shear. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure. It is concluded that with increase in ground floor column the maximum displacement is reducing and base shear varies with the column dimensions.

CHAPTER 3

METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge.

3.1 Load Considered

Dead loads

A load fixed in magnitude and in position is called a dead load.The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights.

For floors; unit weight of reinforces cement concrete= 25 kN/m^3

Unit weight of steel is = 78.5 kN/m^3

Imposed loads

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

For residential buildings i.e. hostels

Hostels, hotels, boarding houses, lodging houses, dormitories, residential clubs:

Living rooms, bed rooms and dormitories = 4.0 kN/m^3 (IS: 875, Part 2- 1987)

Wind loads

The force on a structure arising from the impact of wind on it. As the height of building increases effect of wind increases. The wind normally blows horizontal to the ground at high wind speeds.

3.2 Design of Wind Pressure

The design wind pressure at any height above ground level shall be calculated by the following relationship between wind pressure and wind speed:-

P_Z=.6 V_Z^2

Where P_Z is design wind pressure in N/m^2 at height z and Vz is design wind velocity in m/s at height z,

Design Wind Speed (V_z)

The basic wind speed (V_z) for any site shall be calculated from and shall be modified to include the following effects to get design wind velocity at any height for the given structure:

a) Risk level;

b) Terrain roughness, height and size of structure; and

c) Local topography.

It can be mathematically expressed as follows:

V_Z= V_bxk_1xk_2xk_3

Where $V_b$is basic wind speed

k_1 is Probability factor (risk coefficient)

k_2 is terrain, height and structure size factor

k_3 is topography factor

Note: design wind speed up to 10m height from mean ground level shall be considered constant (IS: 875, Part 3- 1987)

Calculation of Wind Load:-

F = $\left(C_{pe} - C_{pi}\right) AP_z$

Where

C_{pe} = external pressure coefficient,

C_{pi} = internal pressure coefficient,

A = surface area of structural element or cladding unit, and

P_z = design wind pressure

Positive wind load indicates the force acting towards the structural element and negative away from it.

Seismic loads

When earthquakes occur, a buildings undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. Since earthquake motions vary with time and inertia forces vary with time and direction, seismic loads are not constant in terms of time and space. In designing buildings, the maximum story shear force is considered to be the most influential, therefore in this chapter seismic loads are the static loads to give the maximum story shear force for each story, i.e. equivalent static seismic loads. Time histories of earthquake motions are also used to analyze high-rise buildings, and their elements and contents for seismic design. The earthquake motions for dynamic design are called design earthquake motions

List of Indian Standards on Earthquake Engineering:-

1. IS 1893 (Part I), 2002: Indian Standard Criteria for Earthquake Resistant Design of Structures

2. IS 4326, 1993: Indian Standard Code of Practice for Earthquake Resistant Design & Construction of Buildings.

3. IS 13827, 1993: Indian Standard Guidelines for improving Earthquake Resistance of Earthen Buildings

4. IS 13828, 1993: Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings

5. IS 13920, 1993 Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

6. IS13935, 1993: Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings

3.3 A Review of Analysis (IS 1893 (Part I), 2002):-

Equivalent Static Analysis

Response Spectrum Analysis

Time History Analysis

Equivalent Static Analysis – An Overview

The equivalent static method is the simplest method of analysis. Here, force depend upon the fundamental period of structures defined by IS Code 1893:2002 with some changes. First, design base shear of complete building is calculated, and then distributed along the height of the building, based on formulae provided in code. Also, it is suitable to apply only on buildings with regular distribution of mass and stiffness.

Following are the major steps in determining the seismic forces:-

3.3.1 Determination of Base shear

The total design lateral force or design base shear along any principal direction is determined by the expression:-

V = AW

Where,

A = design horizontal seismic coefficient for a structure

W = seismic weight of building

The design horizontal seismic coefficient for a structure A is given by:-

A = (ZISa)/ 2Rg

Z is the zone factor in Table 2 of IS 1893:2002 (part 1).

I is the importance factor

R is the response reduction factor; Sa/g is the average response acceleration coefficient for rock and soil sites as given in figure 2 of IS 1893:2002 (part 1). The values are given for 5% damping of the structure.

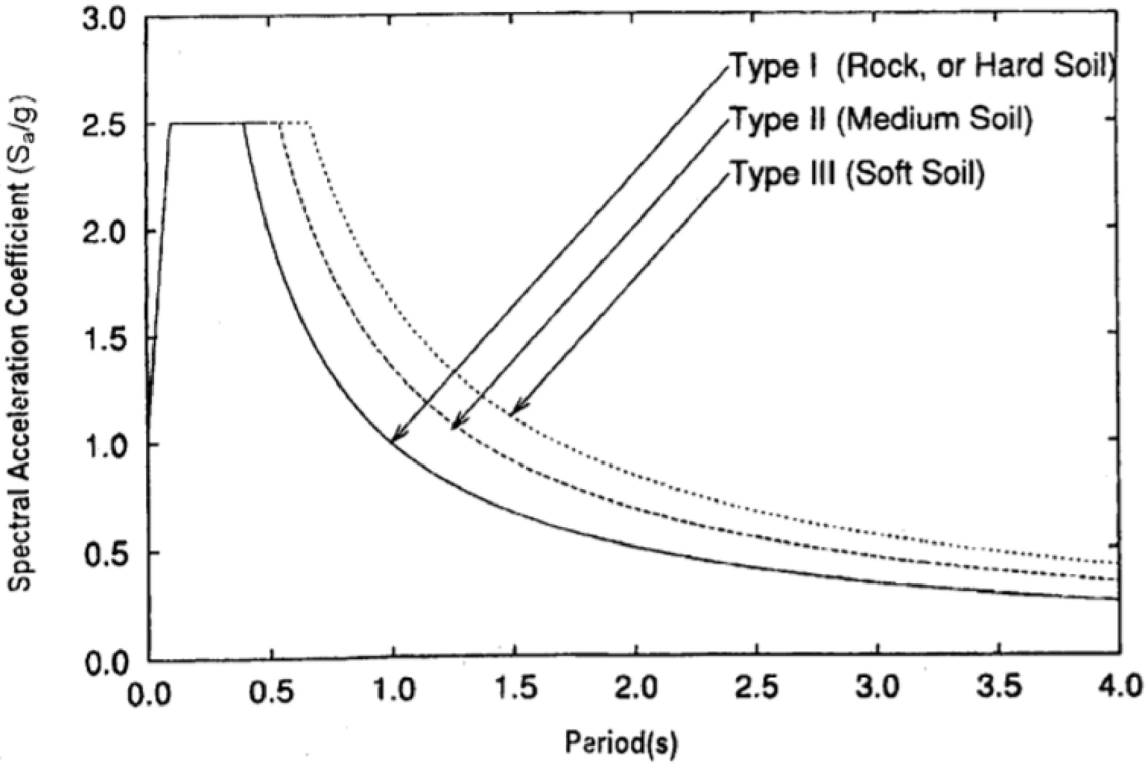

Fig. 3.1 Spectral Acceleration Coefficient Vs. Period

For rocky, or hard soil sites

$$\frac{s_a}{g} = \left\{ \begin{array}{l} 1+15T; 0.00 \le T \le 0.10 \\ 2.50; 0.10 \le T \le 0.40 \\ 1.00/T; 0.40 \le T \le 4.00 \end{array} \right\}$$

For medium soil sites

$$\frac{s_a}{g} = \left\{ \begin{array}{ll} 1+15T; & 0.00 \le T \le 0.10 \\ 2.50; & 0.10 \le T \le 0.55 \\ 1.36/T; & 0.55 \le T \le 4.00 \end{array} \right\}$$

For soft soil sites

$$\frac{s_a}{g} = \begin{Bmatrix} 1+15T; & 0.00 \le T \le 0.10 \\ 2.50; & 0.10 \le T \le 0.67 \\ 1.67/T; & 0.67 \le T \le 4.00 \end{Bmatrix}$$

T is the fundamental natural period for buildings calculated as per clause 7.6 of IS 1893:2002 (part1).

Ta = $0.075h^{0.75}$ for moment resisting frame without brick infill walls

Ta = $0.085h^{0.75}$ for resisting steel frame building without brick infill walls

Ta = $0.09h/\sqrt{d}$ for all other buildings including moment resisting RC frames

h is the height of the building in m and d is the base dimension of building at plinth level in m.

3.3.2 Lateral distribution of base shear

The total design base shear has to be distributed along the height of the building. The base shear at any story level depends on the mass and deformed shape of the building. Earthquake forces tend to deflect the building in different shapes, the natural mode shape which in turn depends upon the degree of freedom of the building. A lumped mass model is idealized at each floor, which in turn converts a multi storied building with infinite degree of freedom to a single degree of freedom in lateral displacement, resulting in degrees of freedom being equal to the number of floors.

The magnitude of lateral force at floor (node) depends upon:-

- Mass of that floor
- Distribution of stiffness over the height of the structure
- Nodal displacement in given mode

Distribution of base shear along the height is done according to this equation:-

$$Q_i = V_B \times \frac{W_i\, h_i^2}{\sum_{j=1}^{n} W_j\, h_j^2}$$

Where,

Q_i = Design lateral force at floor i,

W_i = Seismic weight of floor i

h_i = Height of floor *i* measured from base and

N = Number of storeys in the building at which the masses are located.

3.4 Load calculations

Loads and Load combinations are given as per Indian standards. (IS 875:1984, IS 1893:2002 and IS 800:2007*)*

Seismic Loading

Seismic load is given as per IS 1893- 2002. Following assumptions are used for the calculation.

Zone factor – 0.24

Soil type – Hard Soil

Importance Factor – 1.0

Response reduction – 3.00

Damping Ratio - 0.05

Dead loads

For floors; unit weight of reinforces cement concrete= 25 kN/m^3

Unit weight of steel = 78.5 KN/m^3

Assume depth of slab= 125 mm

Wall Self Weight = 2.00 KN/m^2

Floor Load

Slab Dead Weight + Floor Finish = 4 KN/m^2

Total Dead Floor Weight = 4 KN/m^2

Imposed loads

For residential buildings i.e. hostels

Hostels, hotels, boarding houses, lodging houses, dormitories, residential clubs:

Living rooms, bed rooms and dormitories = 4.0 kN/m^2 (IS: 875, Part 2- 1987)

3.4.1 Load combinations

1) 1.5 (DL+ IL)
2) 1.2 (DL+ IL $\pm$ EL)
3) 0.9 DL$\pm$ 1.5 EL

CHAPTER 4

ANALYSIS OF MODELS

4.1 General

The building used for this study was designed to the standards presented by the IS 800: 2007 and IS 1893 (Part 1): 2002

A multi-story steel building is analysed in STAAD Pro.

The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes. The minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads and other external loads, the structure would be required to bear.

4.2 Steel Frames

The frame used for this study is a 10 (G+9) storey, steel structures. The typical floor height is 3 m with a total 30 m of the building. In plan, the sides span 24 meter by 20 meter divided into 4 meter square bays as shown in figure 4.1

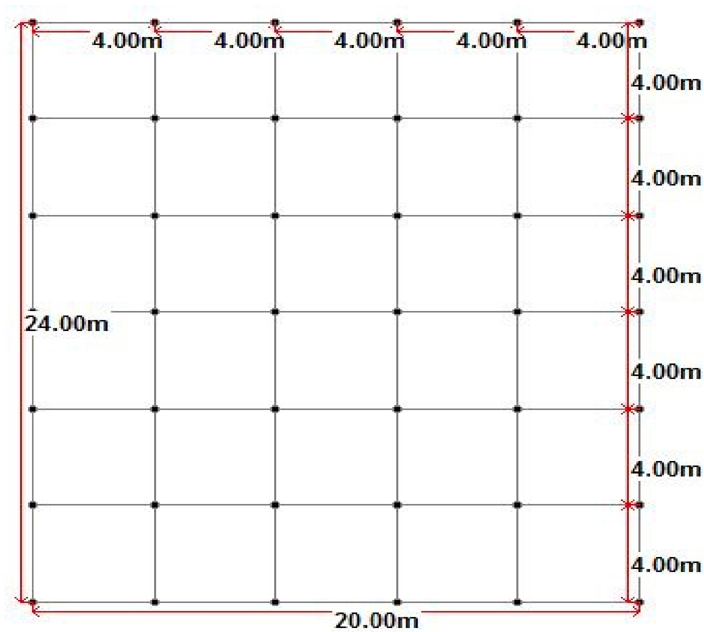

Fig 4.1

Following models are considered for analysis:

- Rectangular Building without any floating column
- Rectangular Building with floating column at ground floor
- Rectangular Building with floating column at third floor
- Rectangular Building with floating column at fifth floor

MODEL 1 - Rectangular Building without any floating column

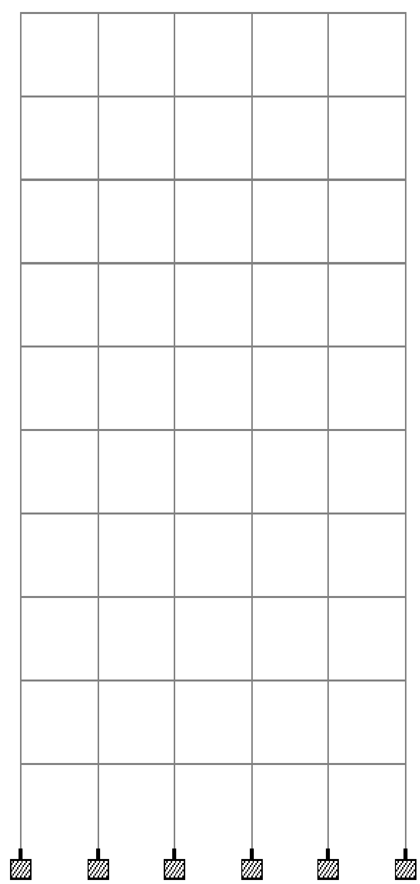

FIG 4.2

Elevation of building without floating columns

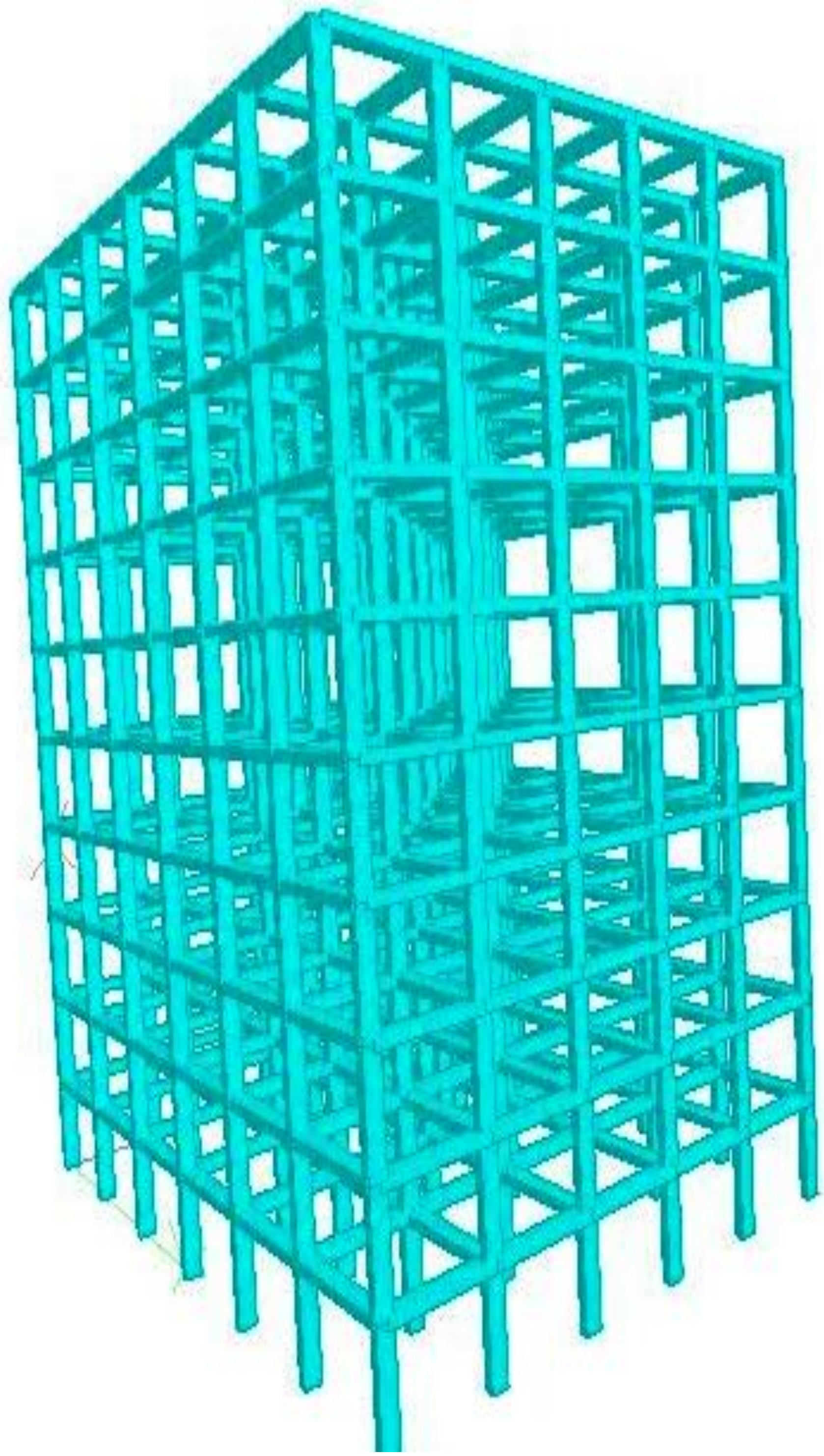

FIG 4.3
3d view of the model without floating column

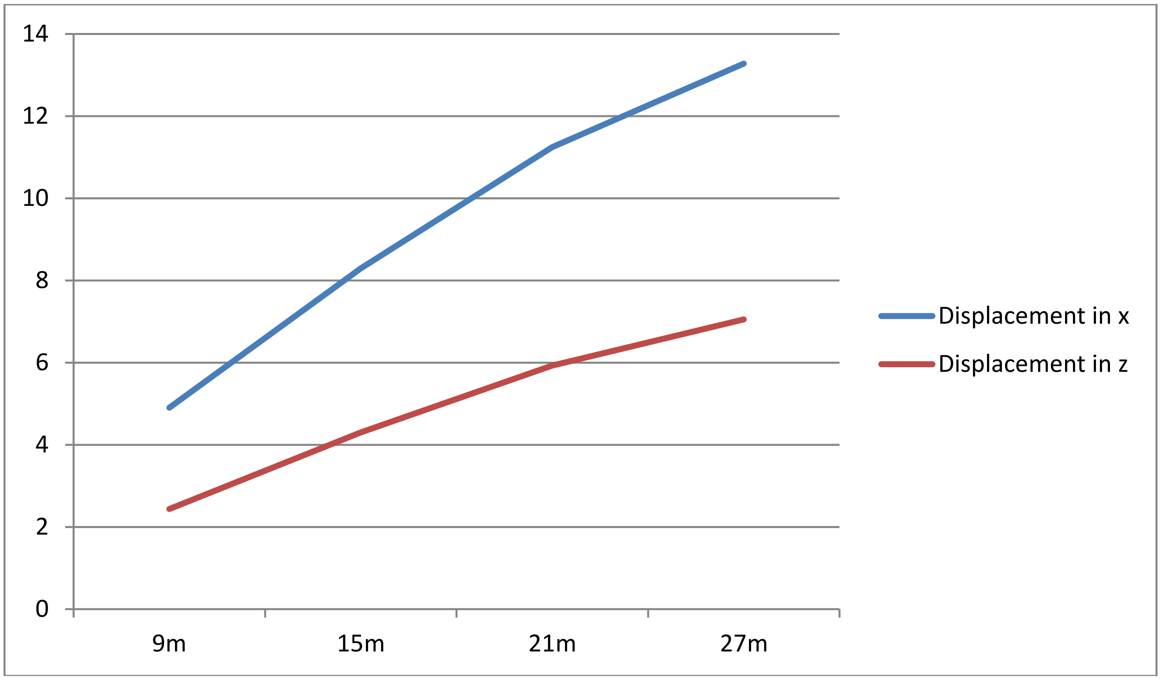

FIG 4.4

Displacements in x and z directions

It is observed from fig. 4.4 that as the height of building increases displacement is increasing from bottom to the top floor.

Model 2: Square Building with floating column at first floor

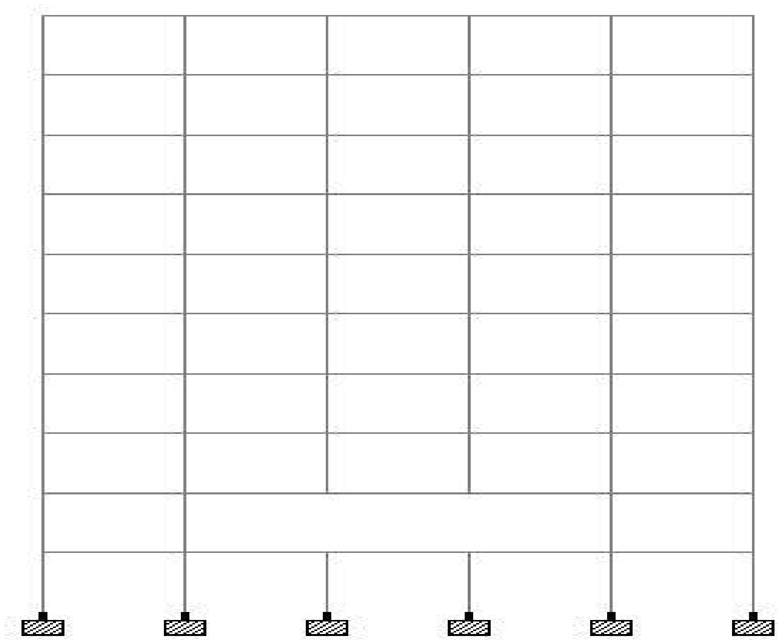

FIG 4.5

Elevation of building with floating column at first floor

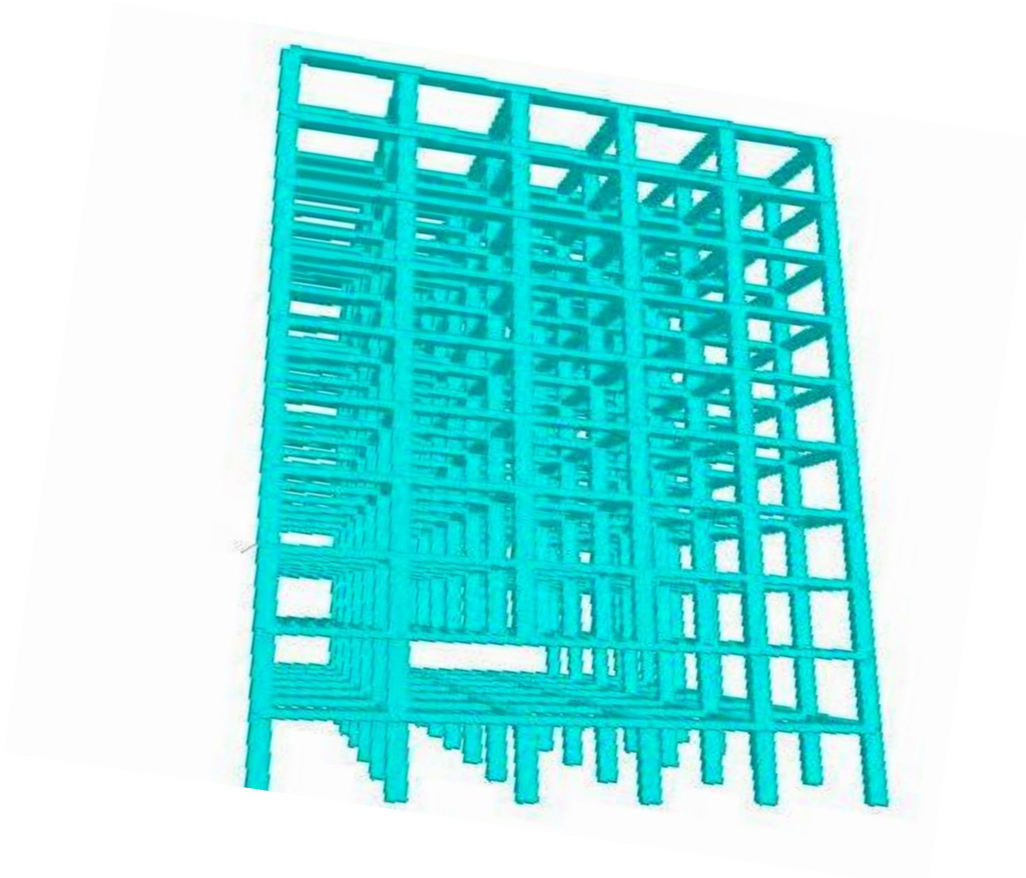

FIG 4.6

3d view of building having floating column at first floor

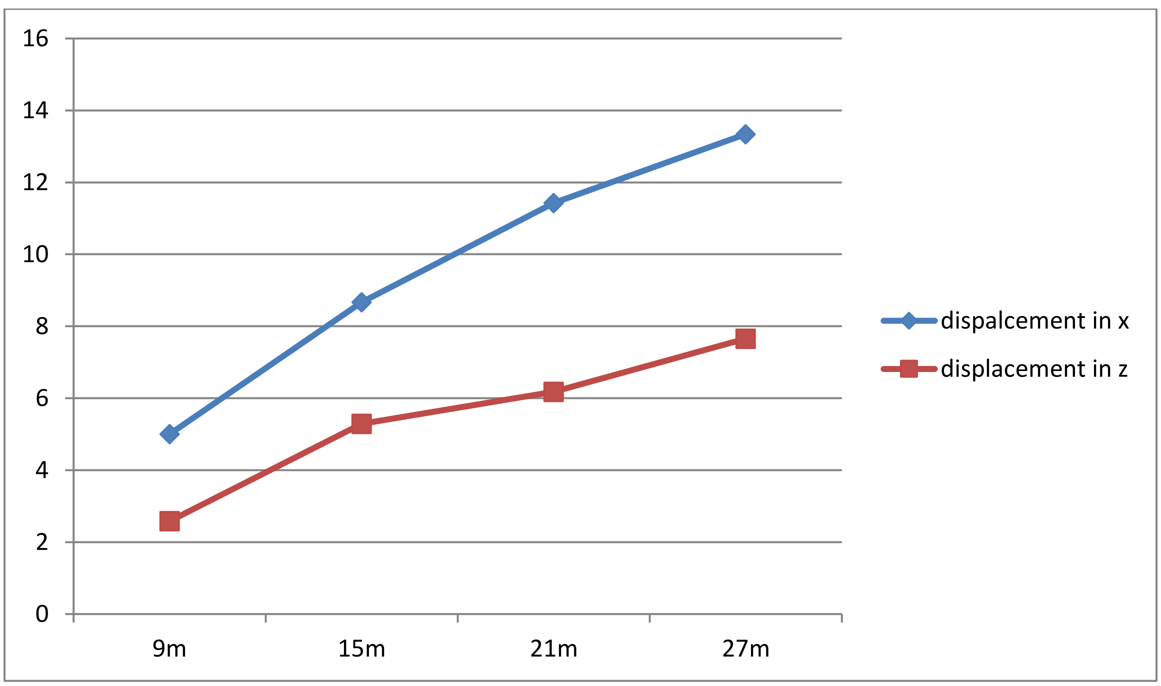

FIG 4.7

Displacement in x and z directions

Model 3: Square Building with floating column at third floor

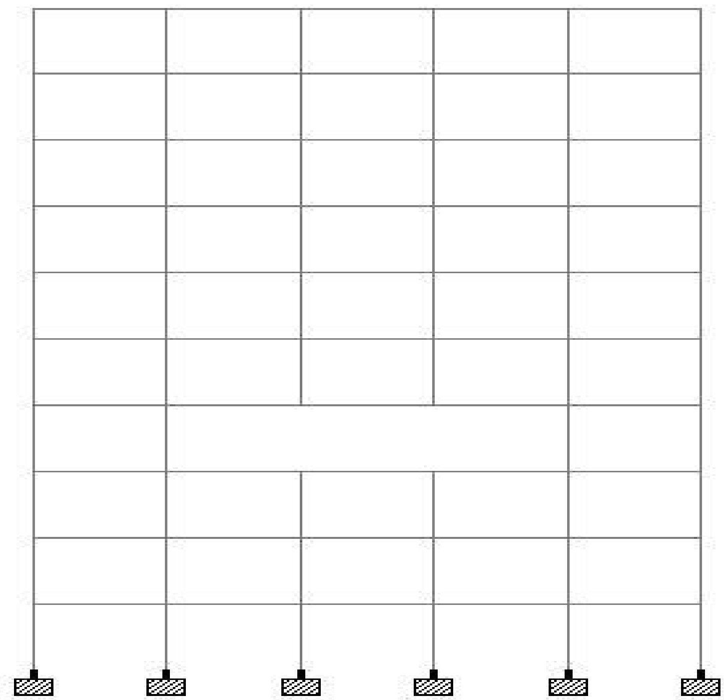

FIG 4.8

Elevation of building with floating column at third floor

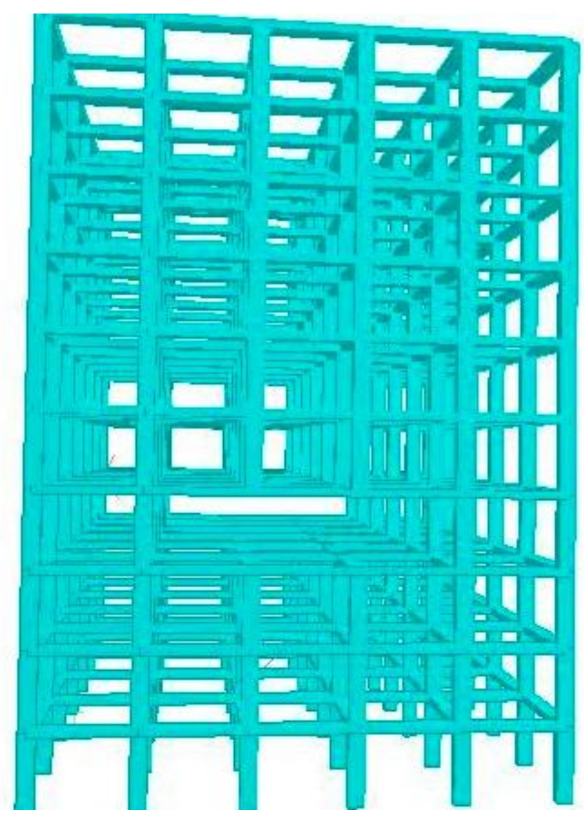

FIG 4.9

3d model of building with floating column at 3rd floor

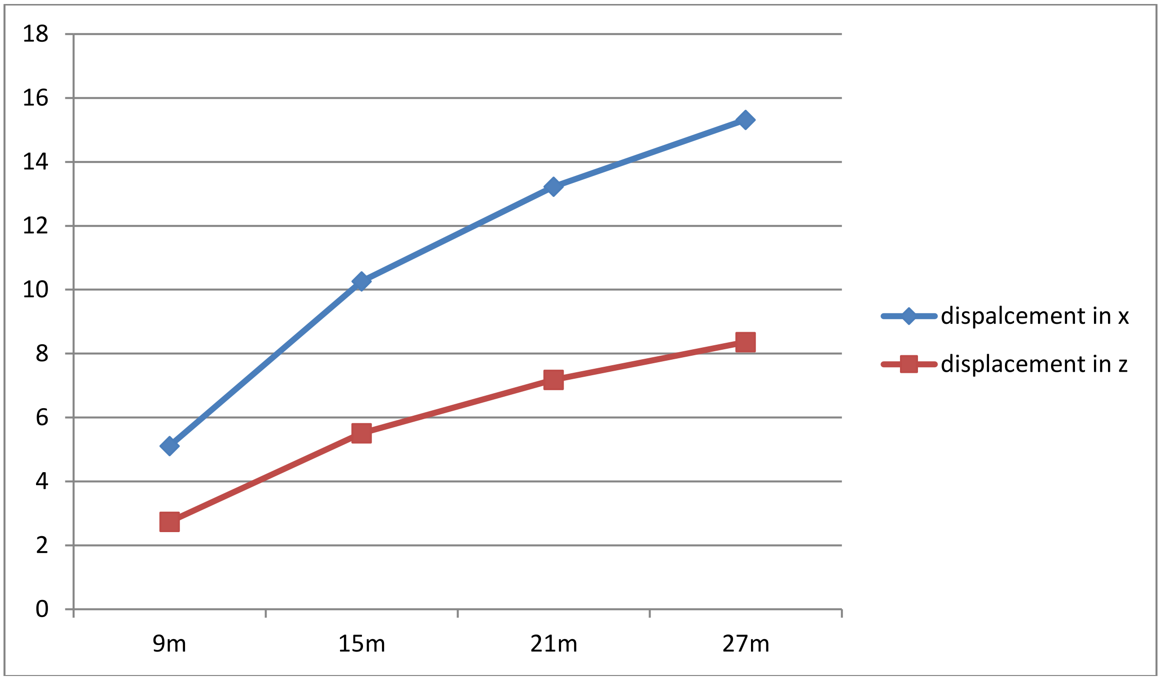

FIG 4.10
Displacements in x and z direction

Model 4 : Square Building with floating column at fifth floor

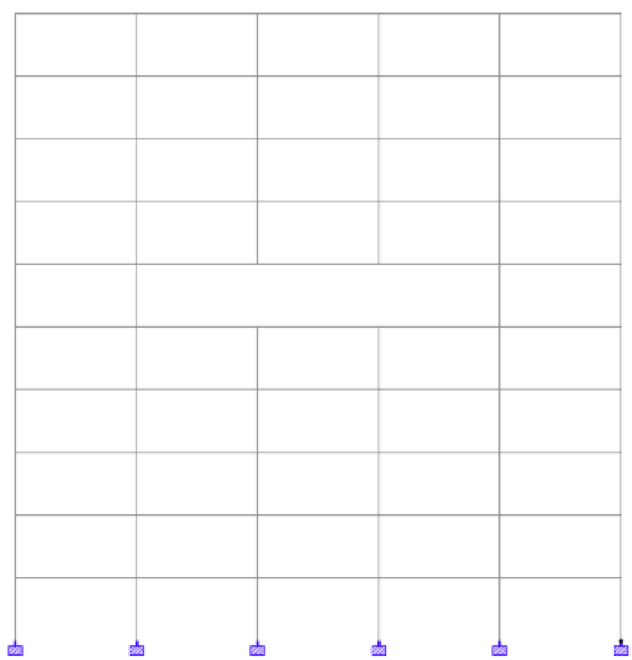

FIG 4.11
Elevation of building having floating column at 5^{th} floor

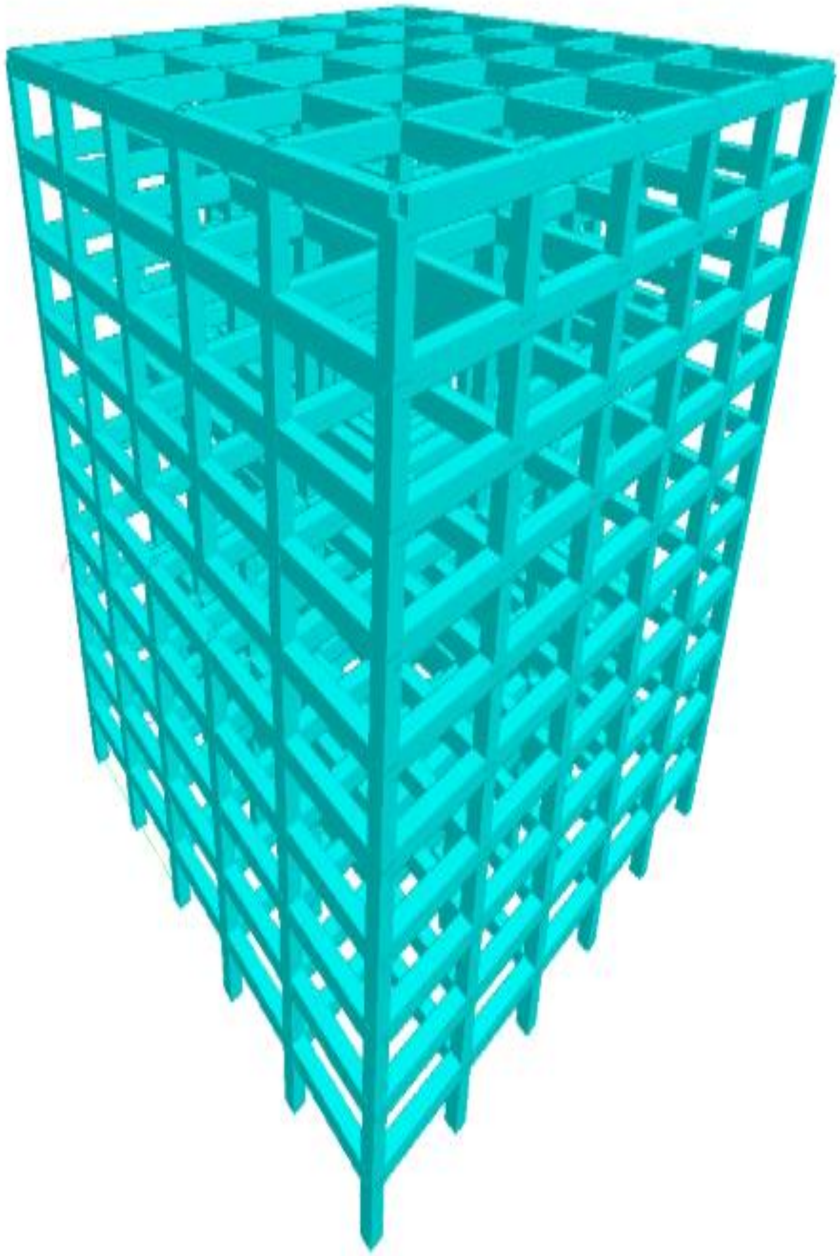

FIG 4.12
3d view of building with floating column at 5th floor

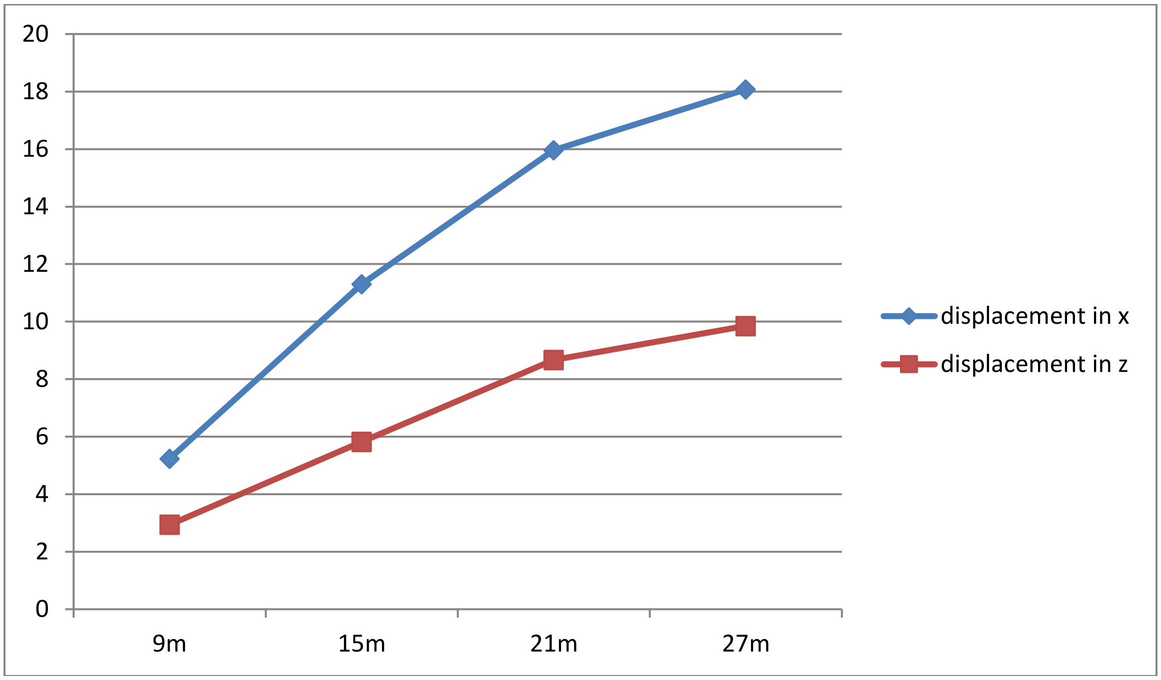

FIG 4.13

Displacements in x and z directions

CHAPTER 5

Results and Discussions

The results of the comparative analysis between a building without floating column and with floating column will be carried on the basis of base shear and storey displacements.

1) **Base shear:**

S.No	SEISMIC WEIGHT	BASE SHEAR	TIME PERIOD
MODEL 1	**52959.43**	**2206.64**	**0.96**
MODEL 2	**52590.00**	**2205.50**	**0.96**
MODEL 3	**52844.92**	**2201.87**	**0.96**
MODEL 4	**52755.85**	**2198.16**	**0.96**

TABLE 5.1

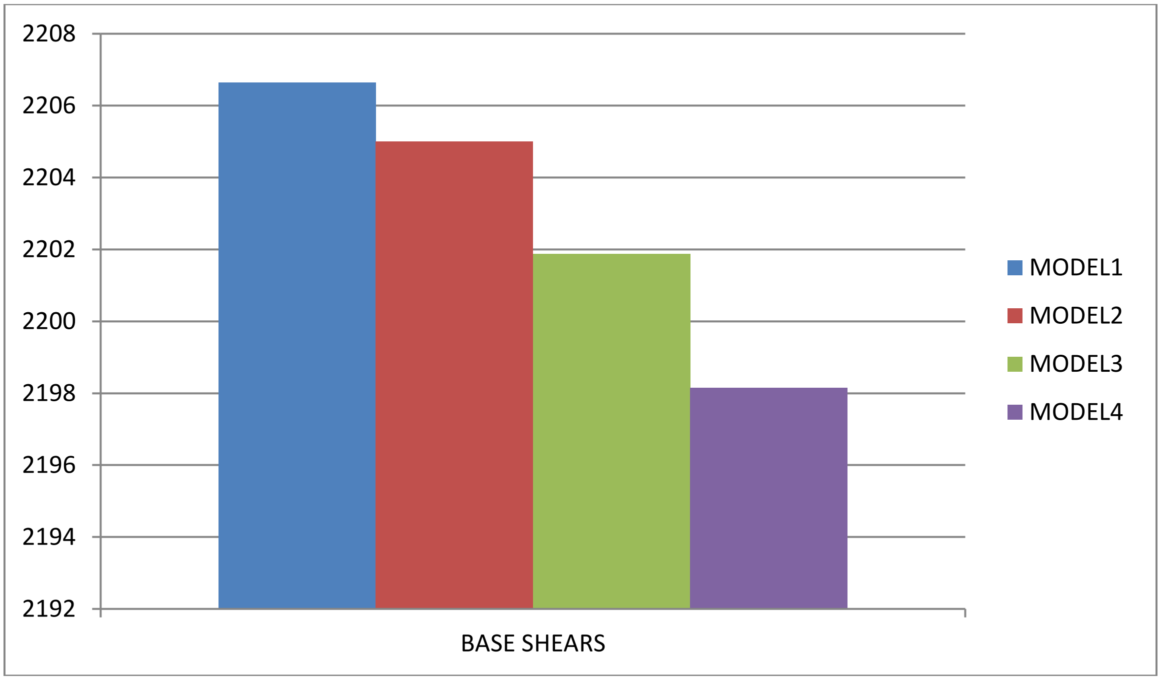

FIG 5.1

VARIATION OF BASE SHEAR

2) Displacements at different heights

a) In x-directions(in mm)

S.No	9m	15m	21m	27m
Model 1	4.9035	8.2946	11.2413	13.2791
Model 2	5.0020	8.6681	11.4293	13.3431
Model 3	5.1114	10.2266	13.2287	15.3226
Model 4	5.2360	11.3086	15.9596	18.0762

TABLE 5.2

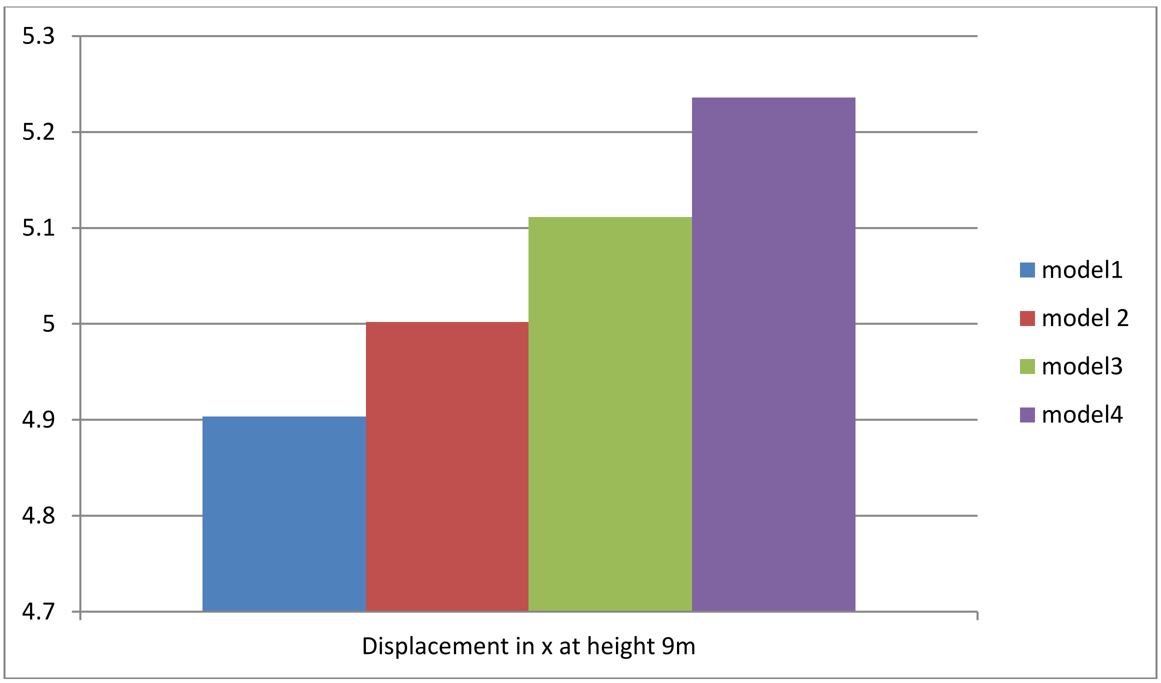

FIG 5.2
Variation of displacement at height 9 metres

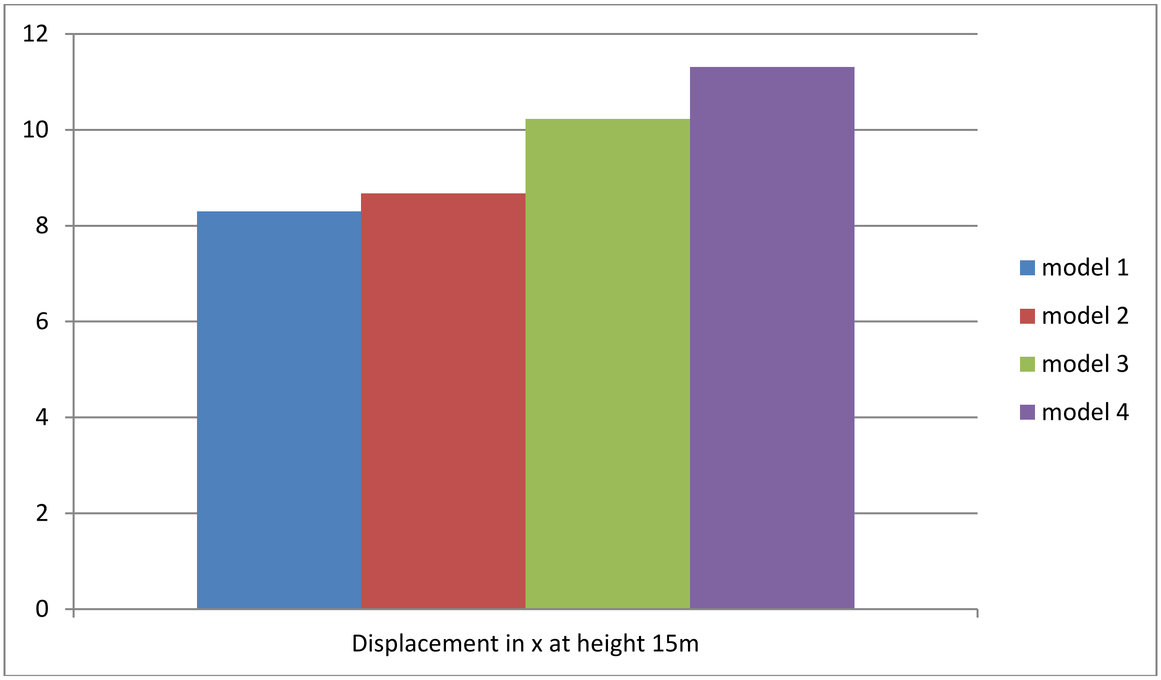

FIG 5.3

Variation of displacement at height 15 metres

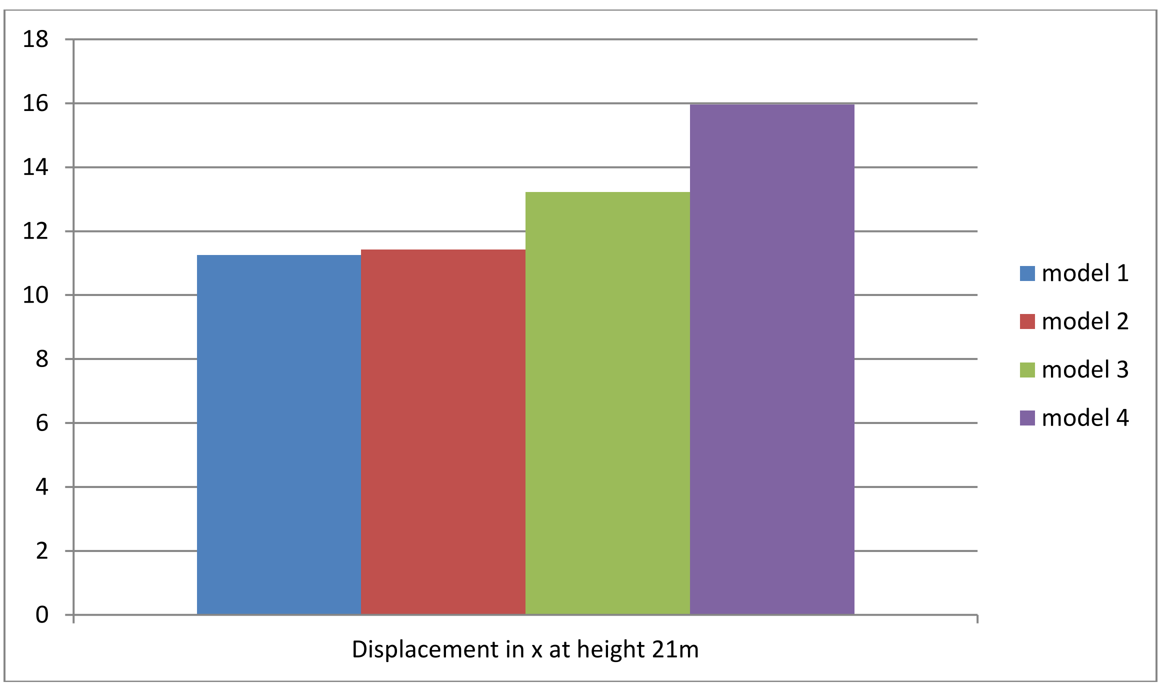

FIG 5.4

Variation of displacement at height 21metres

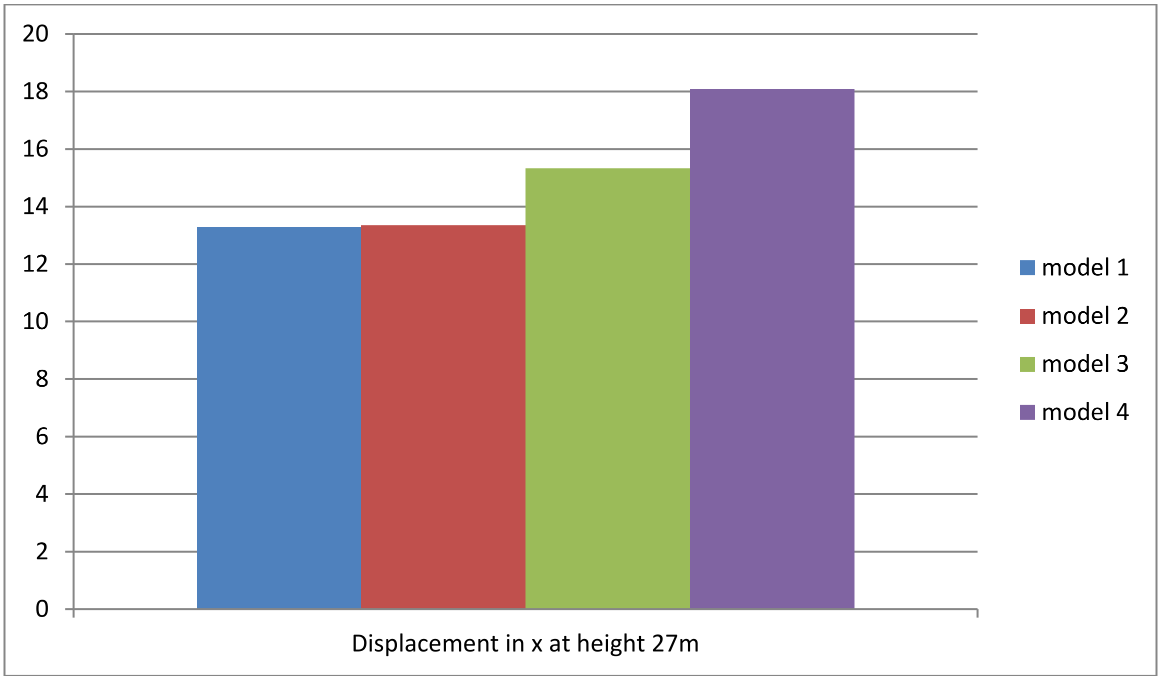

FIG 5.5
Variation of displacement at height 27 metres

b) In z-directions(in mm) :

S.No	9m	15m	21m	27m
Model 1	2.4376	4.3017	5.9274	7.0523
Model 2	2.5844	5.2896	6.1786	7.6567
Model 3	2.7399	5.5090	7.1862	8.3620
Model 4	2.9386	5.8180	8.6700	9.8753

TABLE 5.3

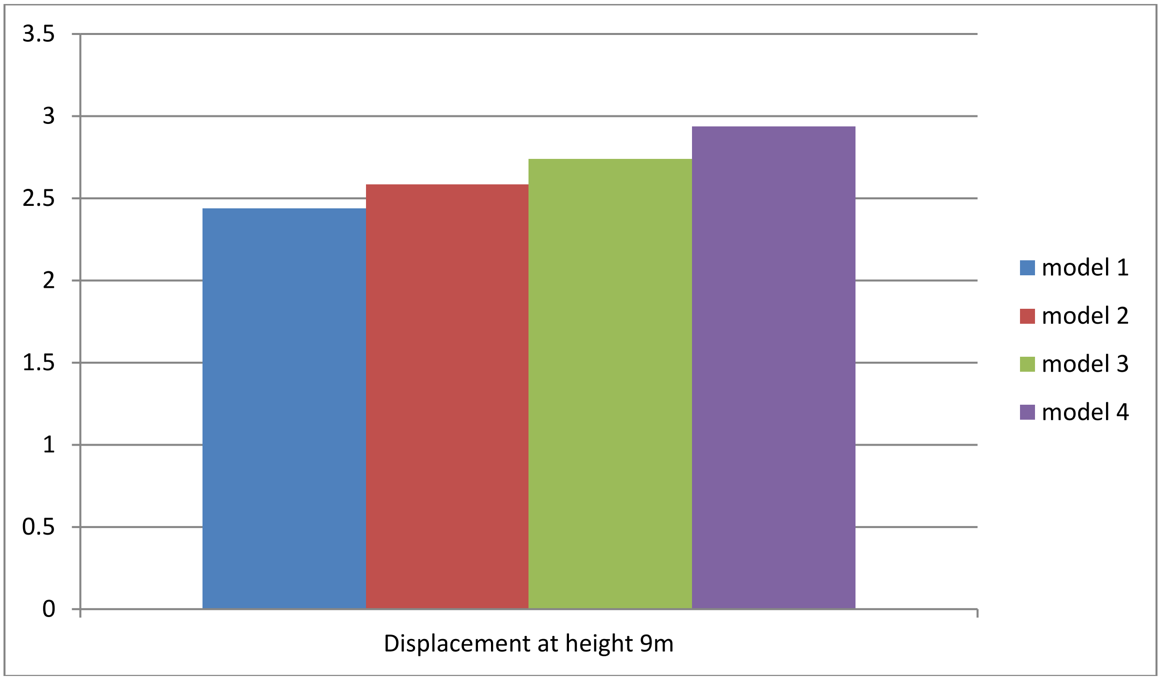

FIG 5.6
Variation of displacement at height 9 metres

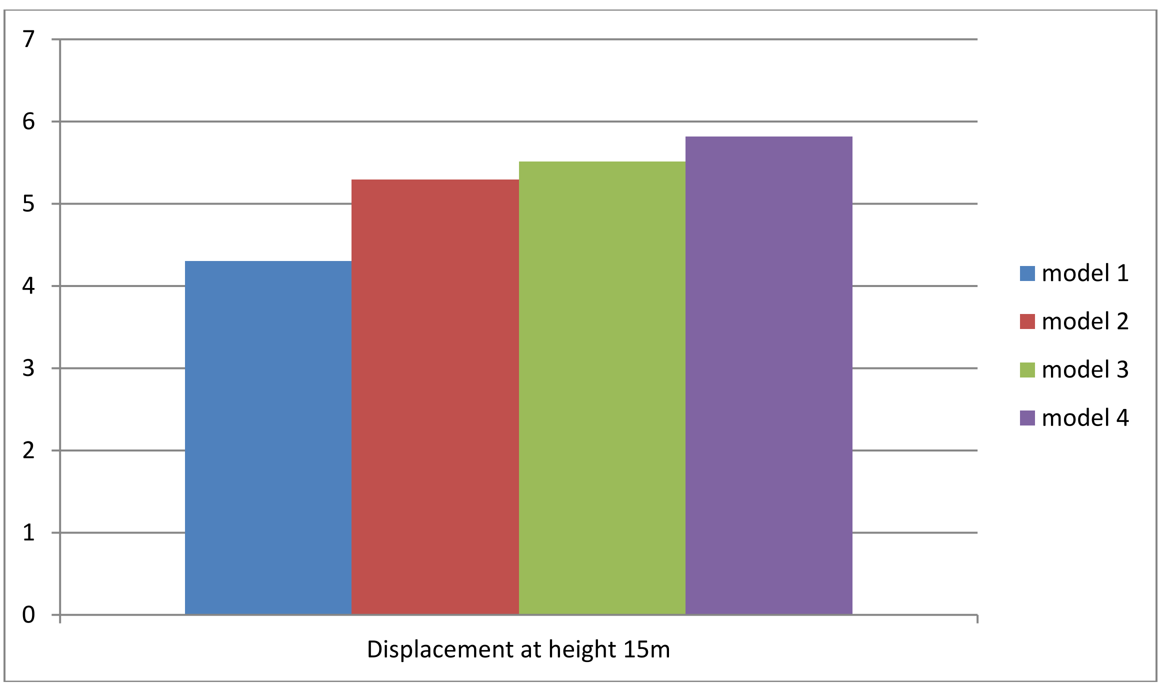

FIG 5.7
Variation of displacement at height 15 metres

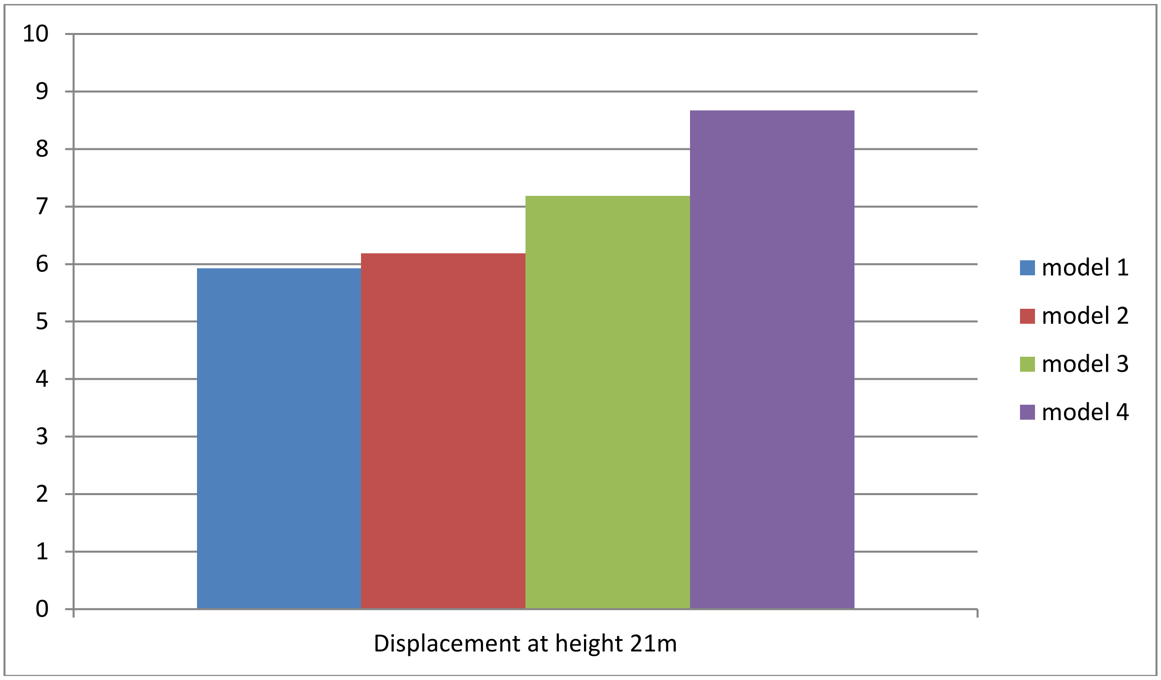

FIG 5.8
Variation of displacement at height 21 metres

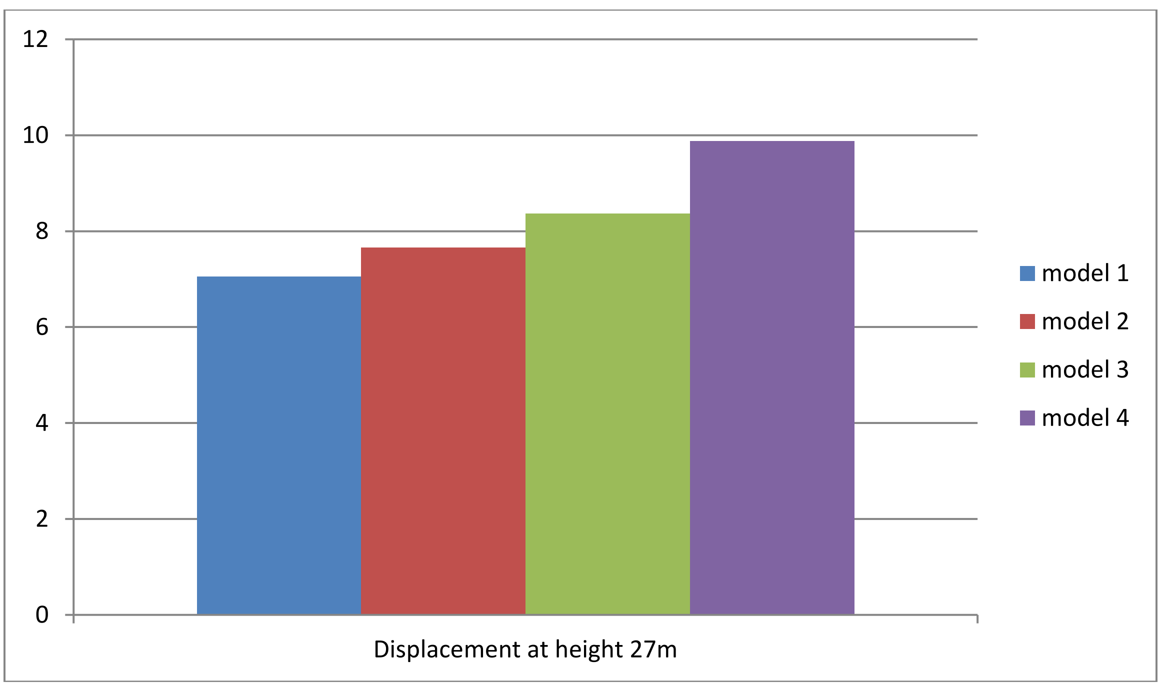

FIG 5.9
Variation of displacement at height 27 metres

CHAPTER 6

CONCLUSIONS

This paper has presented a general review of structural systems for tall buildings.Unlike the height-based classifications in the past, a system-based broad classification has been proposed. Various structural systems within each category of the new classification have been described with emphasis on innovation

On the basis of present study the following conclusions can be drawn:

- It was observed that that building with floating column has less base shear as compared to a building without floating column
- It was also observed that as floating column shifts from bottom storeys towards top storeys value of base shear decreases.
- It was also observed that building with floating column has more displacement as compared to a building without floating column.
- It was also observed that shifting of floating column from bottom to top storeys increases the values of displacements.
- It was observed that building with floating column has more storey drift than that compared with a building without floating column.
- It was also observed that shifting of floating column from bottom to top storeys increases the values of storey drifts.

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