SEISMIC ANALYSIS OF R.C. DUAL FRAME SYSTEMS WITH AND WITHOUT FLOATING COLUMNS

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Abstract - *In present scenario structures with and without floating columns is a typical feature in the modern multi-storey construction in the urban areas. The aim of the project is to investigate the effect of a floating column under earthquake excitation for medium soil conditions and under zones V. hence, the determination of such factors for safe and economical design of a building having a floating column and also not having a floating column. Sometimes, to meet the requirements these type of aspects cannot be avoided though these are not found to be safe. Hence, an attempt is taken to study the behavior of the structures during the seismic activity. The current study of finite modelling is to analyze the structure with floating columns and without floating columns, Horizontal / Vertical Irregularities considered i.e. regular and I shaped are taken, also for the same models when shear wall is created, the models are considered to bare moment resisting frames without brick infills. To study the behavior of each individual models when columns become floating under loadings. And for the same models, M25 grade concrete thick shear walls are created and then analyzed. The analysis is done in Linear or Equivalent static method, Response Spectrum method, Comparison is done for both methods. The models are analyzed by using E-Tabs 2015 software. Maximum storey displacement, inter storey drift and each storey shear is taken with in-built plot graphs.*

Key Words: Floating Column, Dual system, Equivalent static method [EQSM], Response Spectrum Method [RSM], Storey Displacement, Inter Storey Drift, Base Shear.

1. INTRODUCTION

This document is template. We ask that authors follow some simple guidelines. In essence, we ask you to make your paper look exactly like this document. In urban areas many multi-storey building or high rise structures in India today have an uncovered story is unavoidable element. This is essentially being received to give housing to auto parks or gathering or building outlines (architectural designs in the base story or alternate storey's. Due to increase in the amount of tall storey's in modern localities and their pressing concern is on the appearance of the structure which is supposed to be tall and slender. Along with these choices the structure should be taken care of performance wise. Since the structure being tall and slender are subjected to earthquake and wind loads. The conduct of a structure amid seismic movement depends fundamentally on its general shape, size, geometry and load burdens, notwithstanding how the quake strengths are conveyed to ground. It is important for these structures to resist lateral forces along the vertical forces.

Dual systems have been recognized to resist lateral loads effectively. Since it's a mix of two load resisting frameworks. Combination of moment resisting frames along with shear walls and flat slabs with shear wall is used. Shear walls are vertical most usually utilized structures which act like vertical cantilevers to oppose the parallel loads successfully, such a component when joined gives a good execution. Structures with vertical difficulties (like the lodging structures with a couple story's more extensive than the rest) cause a sudden hop in tremor powers at the level of discontinuity. Structures that have less walls or columns in a specific storey or with curiously tall storey tend to harm or collapse which is started in the story.

1.1 Dual Systems

A blend of Shear Walls or Moment Resisting Frames or Braced Frames to resist total lateral forces in proportion to their relative rigidities considering the interaction of the dual system at all levels. Be that as it may, the moment resisting frames shall be capable of resisting not less than 25% of the relevant aggregate seismic horizontal forces, notwithstanding when wind or some other lateral forces represents the design.

1.2 Shear Wall

A wall intended to resist the lateral forces or horizontal forces to the plane of the wall. At the end of the day, it is a wall in a building intended to design for lateral forces in its own particular plane. On the off chance that the building frame is appropriately associated with the shear walls, the float of the building and the forces in the members from the frame decrease. Sometimes, it can be mentioned as a vertical diaphragm or a main wall.

1.3 Floating column

A column should be a vertical member beginning from base level and exchanging the load to the ground. The term floating column is likewise a vertical component which (because of site circumstance or architectural configuration) at its lower level or end level lays on a pillar (it might be cantilever beam or continuous beam) which is an even part.

2. THEORY AND FORMULATION USED FOR ANALYSIS OF MODELS

2.1 Finite Element Method

The Finite Element Method (FEM), in some cases likewise called as Finite element analysis (FEA), is a computational system which is utilized to get the solution of different boundary value problems in engineering issues. Boundary value problems are here and there likewise alluded to as field problems. It can be said to be a numerical issue wherein one or more dependent variables must fulfil a differential equation everywhere inside the area of autonomous variables furthermore fulfil certain particular conditions at the limit of those spaces. The field value issue in FEM commonly has field as a domain of interest which frequently speak to a physical structure.

2.2 FEM in E-tabs Software

- The element library incorporates all types of elements like 1D, 2D, 3D elements, plate and shell elements. Geometrical properties and material properties may be given with nodal points.
- Different types of loads like point load, UDL, uniformly varying load, internal and external pressures, centrifugal forces, moving loads, temperature stresses are handled.
- Boundary conditions can be imposed. And limitations of degree of freedom can be handled.
- Software has included all method of analysis like Linear, Dynamic and Non-linear analysis.
- All Codal provisions are incorporated.
- Finally, discretised output is given with required data with diagram, chart and tables.

2.3 Linear Analysis of Equivalent Static Method (Seismic Coefficient Method) [EQSM]

Seismic analysis of most structures is still completed on the presumption that the horizontal or lateral forces is equal to the dynamic loading. It represents the building dynamics in an appropriate manner. This method requires less exertion in light of the fact that, with the exception of the natural fundamental time period, the periods and shapes of higher natural modes of vibration are not required. The base shear which is the total lateral forces on the structure is ascertained on the premise of the structure's mass, its basic time period of vibration, and comparing shape.

2.4 Response Spectrum Analysis or modal method (mode superposition method) [RSM]

The technique is pertinent to those structures where modes other than the fundamental or essentially influence the response of the structure. Generally, the method is applicable to investigation of the dynamic reaction of structures, which are as-symmetrical or have areas of discontinuity or irregularity, in their linear kind of behaviour. Dynamic load dependably changes with time. Dynamic load contains live load, wind load, quake load and so forth.

This technique gives an approximate peak response, however this is very exact for structural configuration applications. In this approach, the numerous modes of response of a building to a seismic tremor are considered. For every mode, a response is perused from the design spectrum, taking into account the modal frequency and the modal mass. The response of various modes are joined to give an evaluation of total response of the structure utilizing modal combination methods, for example, absolute sum (ABS) technique, Square root of sum of squares (SRSS) and complete quadratic combinations (CQC).

- Absolute sum method (ABS): the peak responses of all the modes are added algebraically, assuming that all modal peaks occur at same time. The maximum response is given as

$$r_{max} = \sum_{i=1}^{n} |r_i|$$

- Square root of sum of squares (SRSS): in this method, combining maximum modal responses is fundamentally sound where the modal frequencies are well separated. The maximum response is obtained by square root of sum of square of response in each mode of vibration is expressed as

$$r_{max} = \sqrt{\sum_{i=1}^{n} r_i^2}$$

- Complete Quadratic Combination (CQC): the maximum response from all the modes is calculated as

$$r_{max} = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} r_i \alpha_{ij} r_j}$$

Where ri and rj are maximum responses in the ith and jth modes, respectively and αij is the correlation coefficient.

2.5 Maximum Storey Displacement

As per clause 20.5 of IS 456: 2000 the structure under wind load action the lateral sway at the top should not exceed H/500, where H is the total height of the building.

2.6 Inter Storey Drift

As per clause no. 7.11.1 of IS 1893 (Part 1):2002, the storey drift in any storey due to specified design lateral force with partial load factor of 1.0, shall not exceed 0.004 times the storey height.

2.7 Base Shear

The sum of the horizontal forces acting at the different levels of a building because of a base movement. It is equivalent to the shear acting at the most minimal story of the building.

3. ANALYSIS OF MODELS

3.1 Generation of Response Spectrum

It is a plot of the maximum value of a quantity i.e. acceleration defining the movement of the mass of a single degree of freedom i.e. single mass system subjected to a base motion, with respect to the natural period of the system.

The response spectrum graph is plotted for following condition. For medium soil condition, Zone factor, Z is 0.36 importance factor, I is 1 and response reduction factor, R is 5 and results obtained are further infused into E-tabs software for final analysis of models.

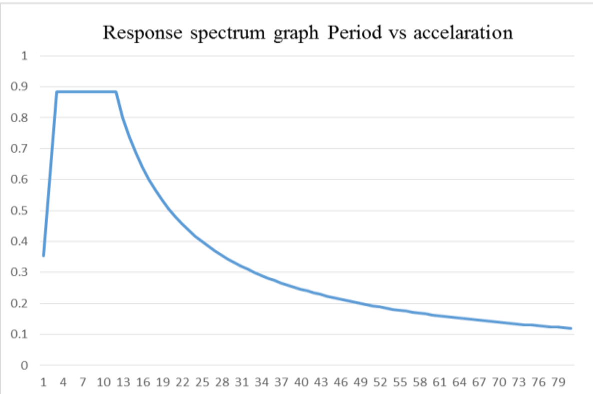

Fig -1: Response Spectrum Graph

3.2 Model description

The aim of this study is to find the response of Maximum story displacement, inter storey drift and base shear for horizontal and vertical irregularities at zone V, when soil is in medium condition and support is fixed, by using Equivalent static method and Response spectrum method and comparison is done for both results.

Table -1: Structural parameters and description of loads are listed below

Structural parameters for models		
1	No. of Bays	6 bays
2	Spacing of each bays	3 m
3	No. of Storey's	10 Storey's [G+9]
4	Support condition at bottom	Fixed
5	Total height of building model	31 m
6	Bottom Storey height	4 m
7	Typical Storey height	3 m
8	Size of Column	450 x 450 mm
9	Size of Beam	230 x 450 mm and 450 x 600mm
10	Shear Wall thickness	230mm
11	Depth of Slab	125 mm
12	Clear Cover of Beam	30 mm
13	Clear Cover of Column	40 mm
14	Live Load	a) On Floor = 4.0 KN/m^2 b) On Roof= 2.0 KN/m^2
15	Floor Finish	a) On Floor = 1.5 KN/m^2 b) On Top Roof = 2.0 KN/m^2
16	Type of Structure	Multi storey rigid jointed plane frame infill panels
17	Seismic Zone Factor	V [0.36]
18	Type of Soil	II [Medium soil]
19	Importance Factor	1.0
20	Response Reduction Factor	Special RC Moment Resisting Frame [SMRF] = 5.0
21	Damping Ratio	5 %

Mainly Regular (Square shaped) and Irregular (I shaped) RC building models are considered.

Regular RC Building model (Square shape)

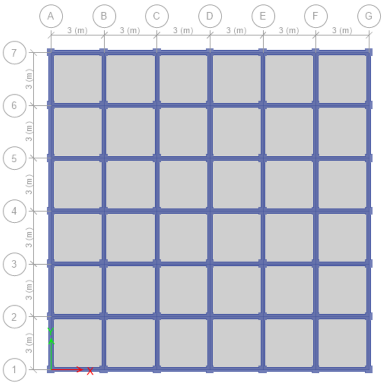

Fig -2: Regular RC building frame without infills

Irregular RC Building model (I-shaped)

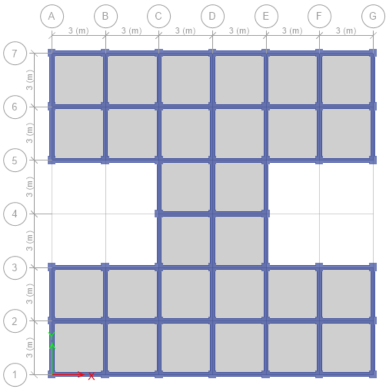

Fig -3: Irregular RC building frame [I-shaped] without infills

In the above two, 16 vertical irregularity models are created with and without shear walls and studied further detail model title detail explanation is given below.

Regular model with shear wall

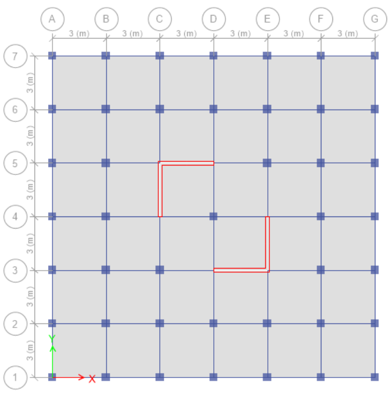

Fig -4: Regular RC building frame with dual systems without infills

Irregular model with shear wall

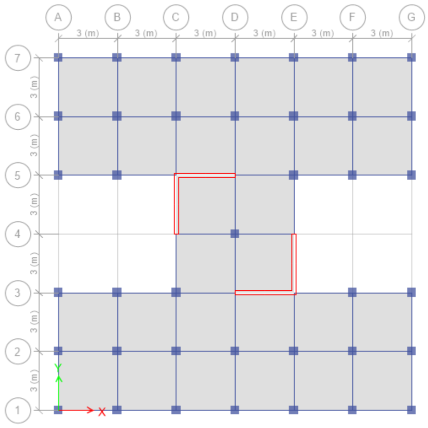

Fig -5: Irregular RC building frame with dual systems without infills

Model 1: Regular RC Building without floating column. [M-1]
Model 2: Regular RC Building with alternate floating column on peripheral at ground floor only. [M-2]
Model 3: Regular RC Building with alternative floating column on peripheral at alternate floors. [M-3]
Model 4: Regular RC Building with alternate floating column at x-axis at ground floor only. [M-4]
Model 5: Irregular RC Building without floating column. [M-5]
Model 6: Irregular RC Building with alternate floating column on peripheral at ground floor only. [M-6]
Model 7: Irregular RC Building with alternative floating column on peripheral at alternate floors. [M-7]
Model 8: Irregular RC Building with alternate floating column at x-axis at ground floor only. [M-8]
Model 9: Regular RC Building without floating column. (With dual system). [M-9]
Model 10: Regular RC Building with alternate floating column on peripheral at ground floor only. (With dual system). [M-10]
Model 11: Regular RC Building with alternative floating column on peripheral at alternate floors. (With dual system). [M-11]
Model 12: Regular RC Building with alternate floating column at x-axis at ground floor only. (With dual system). [M-12]
Model 13: Irregular RC Building without floating column (with dual system). [M-13]
Model 14: Irregular RC Building with alternate floating column on peripheral at ground floor only (with dual system). [M-14]
Model 15: Irregular RC Building with alternative floating column on peripheral at alternate floors. (With dual system). [M-15]
Model 16: Irregular RC Building with alternate floating column at x-axis at ground floor only. (With dual system). [M-16]

4. Results and Discussions

4.1 Storey displacement

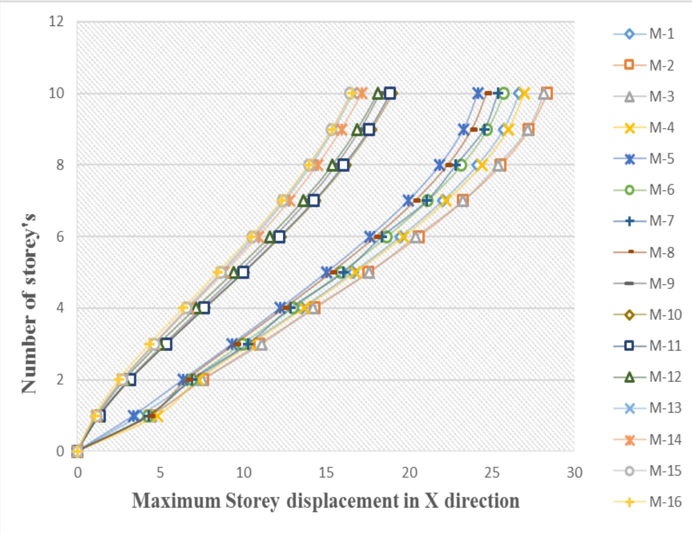

Chart 1: Storey displacement in X direction - EQSM

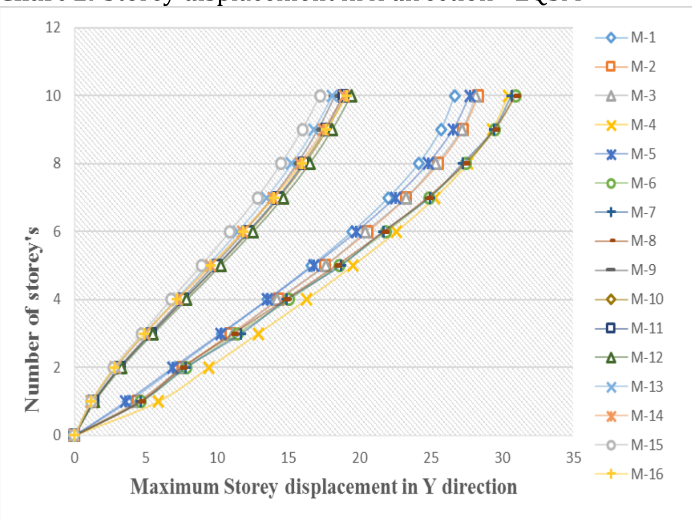

Chart 2: Storey displacement in Y direction – EQSM

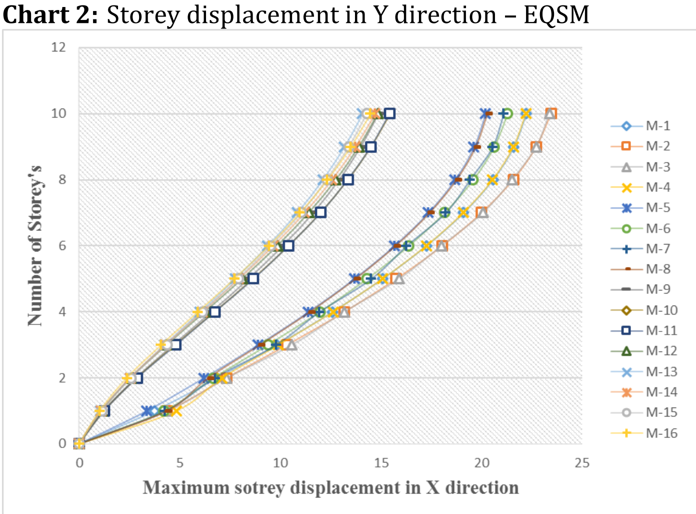

Chart 3: Storey displacement in X direction – RSM

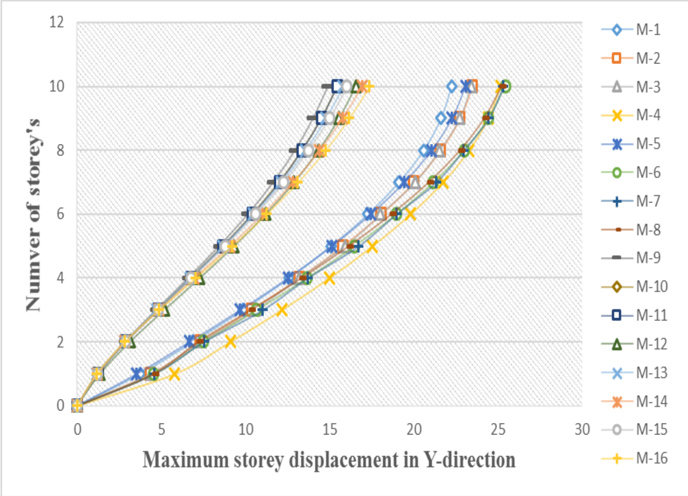

Chart 4: Storey displacement in Y direction - RSM

4.2 Inter Storey Drift

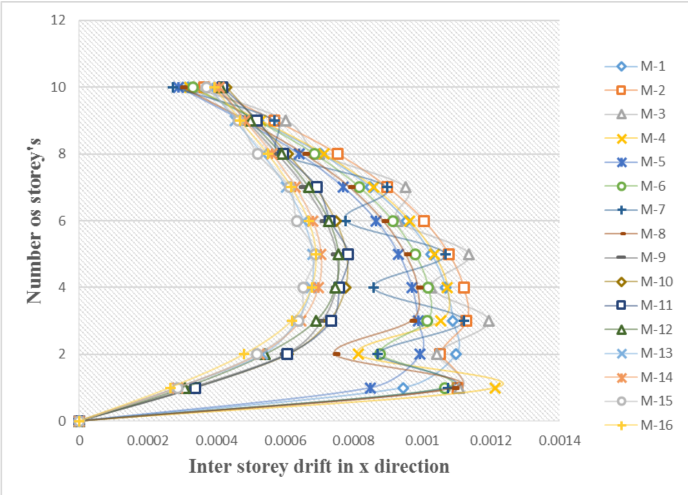

Chart 5: Inter Storey drift in X direction - EQSM

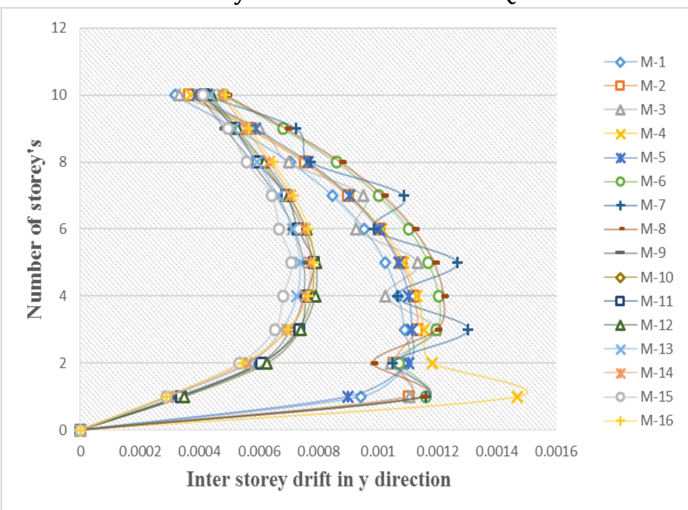

Chart 6: Inter Storey drift in Y direction - EQSM

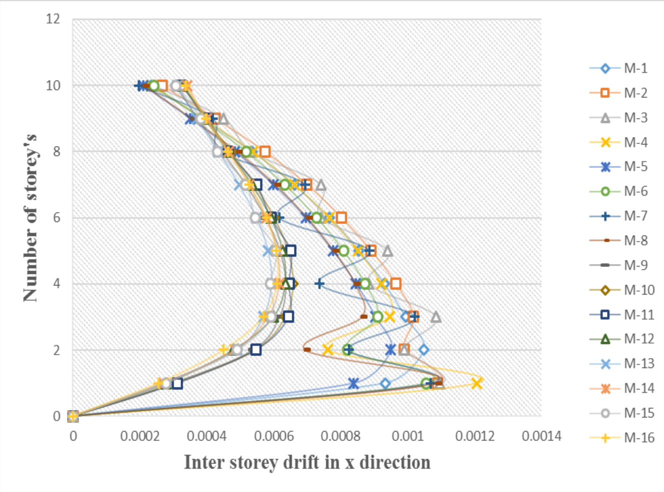

Chart 7: Inter Storey drift in X direction - RSM

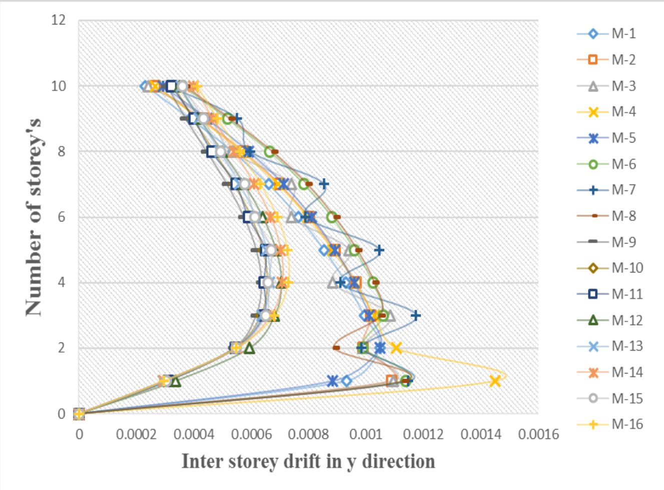

Chart 8: Storey displacement in Y direction – RSM

4.3 Storey Shear

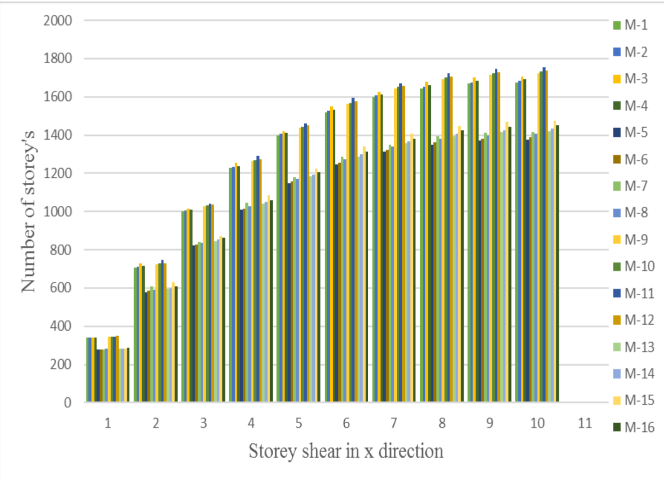

Chart 9: Storey Shear in X direction - EQSM

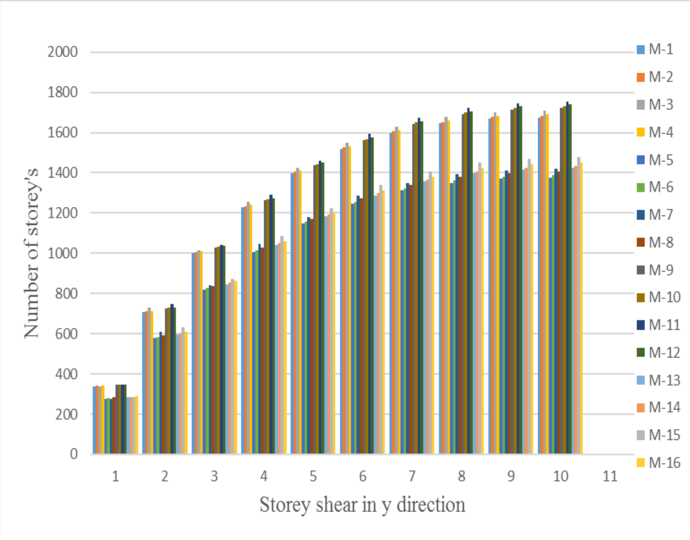

Chart 10: Storey Shear in Y direction - EQSM

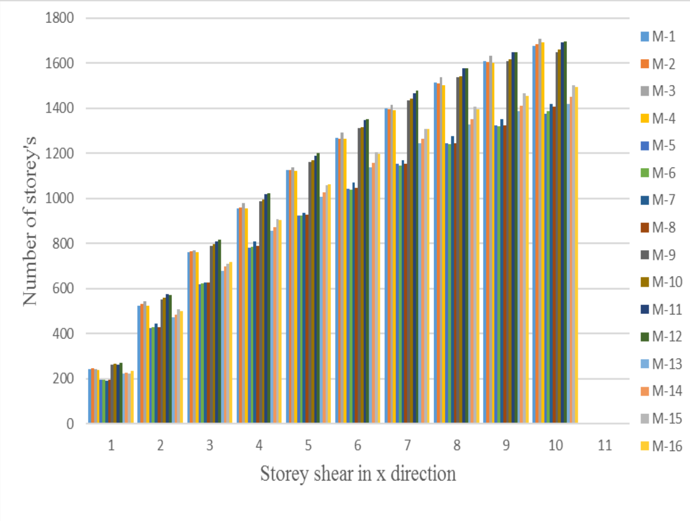

Chart 11: Storey Shear in X direction - RSM

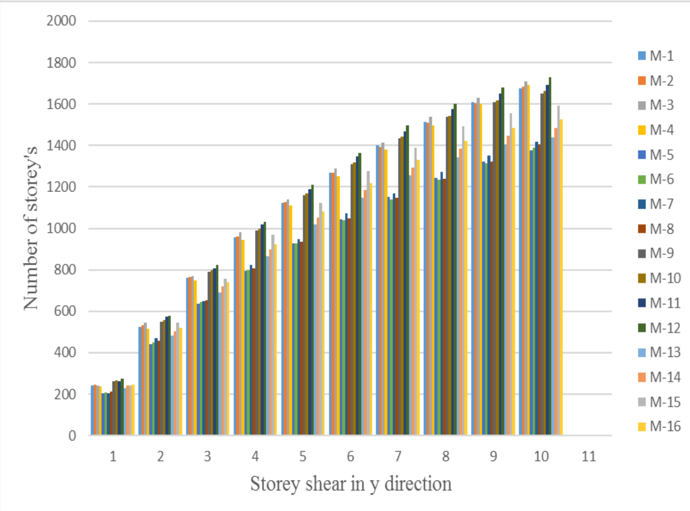

Chart 12: Storey Shear in Y direction – RSM

4.4 Discussions

Storey Displacement

EQSM: Maximum Storey displacement is observed for model [M-2] along X direction whereas, along Y direction it is observed for Model [M-6].

RSM: Maximum Storey displacement is observed for model [M-2] along X direction whereas, along Y direction it is observed for Model [M-6].

The observed values are less for RSM compare to EQSM.

Inter Storey Drift

EQSM: Maximum Inter Storey Drift is observed for model [M-4] along X and Y direction at storey level 1

Minimum Inter Storey Drift is observed in model [M-16] along X direction and for models [M-14, M-15, M-16] along Y direction at storey level 1

RSM: Maximum Inter Storey Drift is observed for model [M-4] along X and Y direction at storey level 1.

Minimum Inter Storey Drift is observed in model [M-5] along X direction and for models [M-1] along Y direction at storey level 10

Storey Shear

EQSM: Maximum Storey shear is observed for model [M-11] along X and Y direction at storey level 1

Minimum Storey shear is observed in model [M-5] along X and Y direction at storey level 10

RSM: Maximum Storey shear is observed for model [M-12] along X and Y direction at storey level 1

Minimum Storey shear is observed in model [M-8] along X direction and model [M-7] along Y direction at storey level 10

5 CONCLUSIONS

In this work, the behavior of buildings with and without Floating columns are analyzed. The seismic parameters such as storey displacement, storey shear and inter storey drift and comparison of above models are studied. From the results, it is observed that lateral displacement increases with respect to height of building. The lowest displacement are observed in irregular building with floating column provided with shear walls. Hence, not vulnerable. Inter storey drift is maximum observed for regular building with alternate floating column provided in Ground floor along X direction. Maximum storey shear is observed for regular model with alternative floating column on peripheral at alternate floors with shear wall and minimum storey shear is observed for irregular model with alternate floating column at x-axis at ground floor only without shear wall. Finally, concluded that the results obtained are within the permissible limits as per IS 456:2000 and IS 1893 (Part 1):2002

REFERENCES

[1] Pankaj Agarwal, Manish Shrikhande (2006), "Earthquake Resistant Design of Strucutres", PHI private limited, New Delhi.

[2] S.K. Duggal (2007), "Earthquake Resistant Design of Strucutres", Oxford university press, YMCA library building Jai singh road, New Delhi.

[3] Paz Mario (2010), "Structural dynamics", CBS publishers.

[4] S.S.Bhavikatti, (2005) "Finite Element Analysis", New age International (P) Ltd, Publishers, New Delhi.

[5] Handbook for the Seismic Evaluation of Existing Buildings - Google Books_files.html.

[6] Federal Emergency Management Agency (FEMA) 310, (1998) "Handbook for the seismic evaluation of building.

[7] FEMA 178 (1992), "NEHRP handbook of the seismic evaluation of existing building.

[8] FEMA 451 (2006), NEHRP recommended provisions: for seismic regulations for new buildings and other structures and accompanying commentary and maps, Washington, D.C., USA.

[9] Krishnamoorthy CS, Finite element analysis, TMH Publications, 1987.

[10] Draft Handbook on seismic retrofit of buildings, central public works department and Indian building congress, IIT- Madras, (April 2007).

[11] V.Sigmund and I. Guljas M.Hadzima-Nyarko, "Base shear redistribution between the r/c dual system structural components", the 14th World conference on earthquake engineering, October 12-17, 2008, Beijing, China.

[12] http://www.comp-engineering.com/products/ETABS/general_characteristic.html.

[13] IS 1893, Criteria for Earthquake Resistant Design of Structures-Part 1, General Provision and Buildings (fifth revision); Bureau of Indian Standards, New Delhi, 2002.

[14] Bureau of Indian Standard, IS-456 (2000), "Plain and reinforced concrete code of practice".

[15] IS: 1893-2002, "General Construction in concrete- code of practice", Bureau of Indian Standards, New Delhi, India.