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SEISMIC ANALYSIS OF MULTISTORYED RCC AND COMPOSITE BUILDING SUBJECTED TO VERTICAL IRREGULARITY

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Abstract - *Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subjected to devasting earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. Structures experience lateral deflections under earthquake loads. Magnitude of these lateral deflections is related to many variables such as structural system, mass of the structure and mechanical properties of the structural materials. Reinforced concrete and steel construction is extensively preferred over the whole world. But the use of composite construction is of particular interest, due to its significant potential in improving the seismic performance of structure. Steel concrete composite construction is built in place of RCC structures to get maximum benefit of steel and concrete and to produce efficient and economic structure. Composite construction combines the better properties of both steel and concrete along with speedy construction, fire resistance, high durability and superior seismic performance characteristics. In this study comparison of composite and conventional RCC structure is carried out for G+16 RCC and composite structure. The building is situated in seismic zone V. Seismic design is followed by IS 1893-2002. Modeling and analysis has been carried in ETABS software. The results are obtained of various parameters such as base shear, storey displacement, storey drift.*

***Key Words*: RCC, composite columns, regular and vertical irregular buildings, ETABS, response spectrum analysis, base shear, storey displacement, storey drift**

1. INTRODUCTION

As we know earthquakes are the unpredictable natural disasters, from which it is very difficult for saving life and engineering properties against it. We want to identify the act of the building for seismic loads to overcome these issues by the various developmental analytical procedures, from which the structures can withstand for small earthquakes and enough warning has to be produced when subjected to strong earthquakes, this may save the possible number of lives. The performance of building during an earthquake depends upon several factors, such as stiffness, mass, geometry and regular configuration.

But in modern days, with more advancement in the rapid growth of urbanization and for aesthetic purpose buildings are constructed with irregular structural configurations. These building configurations provides to irregular distribution of strength, mass and stiffness from this it may lead to damage of the frame during earthquakes.

Irregular building configuration: The section-7 of IS-1893 (part-1) 2002 enlists the different irregularity in structural configuration system. The irregularities are categorized in to two types

(i) Plan/Horizontal irregularities
(ii) Vertical irregularities

The Vertical Irregularities are as follows,

1. Soft story (stiffness discontinuity): This type of story exists when a lateral-stiffness becomes less than 70% of its above story or less than 80% of its average stiffness.

2. Weak storey (strength discontinuity): This type of story exists when the strength becomes less than 80% of its above story.

3. Vertical Geometric Irregularities: The lateral-force-resisting systems in a horizontal dimension of any storey should be greater than 150% of its adjacent storey.

4. Mass Irregularity: The mass of any floor/story is greater than 200% of the effective mass of its adjacent story. (A lighter roof mass excepted).

5. In-plane Discontinuity: A lateral-load-resisting elements which is greater than a length of their elements.

1.1 Composite Column

A column is designed to combine two different materials to form a structural member. A composite column is a member which is mainly subjected to compression. Composite construction that seeks to co-action the capabilities of two materials i.e. concrete and steel.

This combination increases the stiffness and ultimate strength of columns which is very suitable for columns and other compressive members. The integral and interactive performance of concrete and structural steel elements make the composite column, these are very cost effective structural member in building. Composite columns have many merits over a conventional RCC and structural steel columns.

1.1.1 Merits of composite columns

- Protection against corrosion in case of concrete encased columns.
- Increased stiffness which influences to reduce slenderness of column.
- Higher stiffness results in less deflection, longer spans and less overall height.
- Encased columns are good fire resistance.
- There are some economic advantages compare to concrete and steel.

1.2 Objectives

- To evaluate the comparison of RC Column and composite encased I section column.
- To study the effect of vertical irregularities of building and performance of the structure.
- To understand the behavior of regular and vertical irregular framed structure on the basis of shear force, storey drift and storey displacement.
- To find the structural behavior of multi-storey building for different vertical irregularities of parameters like mass irregularity, stiffness irregularity and geometrical irregularity.
- To understand the performance of RCC and composite structure under seismic zone V.

1.3 Scope of the study

- A seismic analysis of multi-storied composite and RCC structure is carried-out for different parameters of vertical irregularities.
- The installation of composite column in a construction increases strength, fire resistance and resistance towards lateral forces.
- The scope of present project is explained in detail for all models to compare the analysis results including storey displacement, storey drift and base shear.

2. METHOD OF ANALYSIS

The seismic analysis of all the building frames are carried out according to IS 1893:2002 (Part 1) by response spectrum method.

2.1.1 Response Spectrum Analysis

In this method, peak response of a structure during an earthquake is obtained directly from the earthquake response spectrum. This method gives an approximate peak response, which is quite accurate for structural design. In RSM multiple modes of response of a building to an earthquake is taken into account.

3. MODELING AND ANALYSIS USING ETABS

3.1 Description of the model:

In our present study four different configurations have been chosen in which one is rectangular and remaining three are of vertical irregularities. The floor to floor height, column size, beam size, slab thickness, floor finish loads, live loads and Response-spectra data remains same for all the models.

The models consists of G+16 stories of Rectangular, mass irregularity, stiffness irregularity and geometrical irregularities are considered. For all models composite structure column of size 300x700mm (ISMB 250) and composite beam ISMB 250 without shear connector is provided and all other parameters are kept constant. The Response Spectrum analysis is made for all the buildings using a ETABS version 15.

3.2 Materials property and geometry of the model:

- Layout of plan : 8 bays x 8 bays
- Plan dimension : 40 m x 40 m
- Spacing in x direction : 5 m
- Spacing in Y direction : 5 m
- Height of each storey : 3.3 m
- Number of storey : G+16
- Grade of concrete : M40
- Grade of reinforced steel : Fe 500
- Size of beam : 300 x 600 mm
- Size of column : 300x 700 mm
- Slab thickness : 150 mm
- Floor finish : 1 KN/m^2
- Live load : 3 KN/m^2 (FLOOR)
- Live load : 1.5 KN/m^2 (ROOF)
- Total height of building :52.8 m
- Density of concrete :25 KN/m^3
- Composite column :300 x 700 mm (With ISMB 250)
- Composite beam :ISMB 250 (Without shear connector)

Seismic parameters considered

- Seismic zone : V
- Zone factor : (0.36)
- Soil type : III
- Importance factor : 1
- Response reduction factor : 5
- Damping ratio : 5%
- Time period :Program calculated

- Earthquake load :X and Y direction
- Diaphragm :Rigid

3.3 Modeling of structure:

3.3.1 Regular structure:

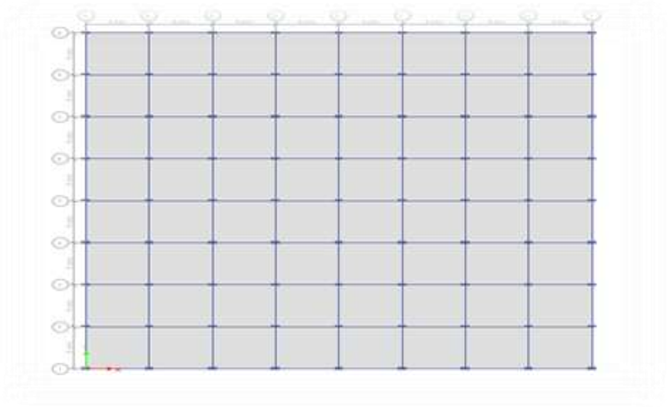

Fig 1. Plan of a regular structure

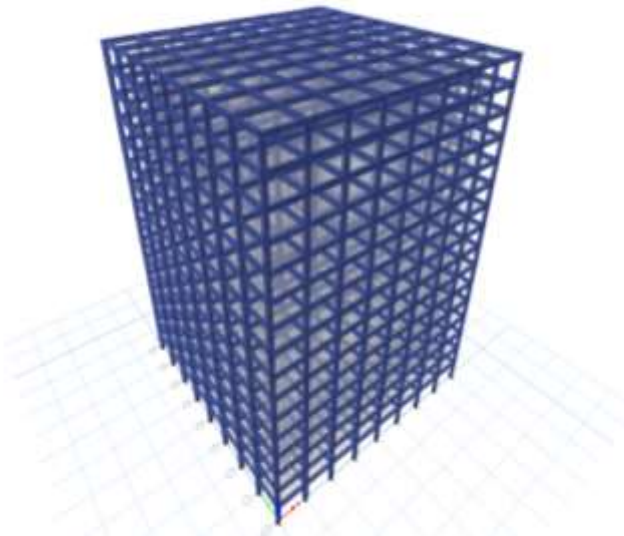

Fig 2. 3D View of regular structure

3.3.2 Mass irregular structure:

The structure is modeled as same as that of regular structure except the loading due to swimming pool is provided on the terrace floor.

Height of swimming pool considered – 1.8 m

Loading due to swimming pool – 18 KN /m^2

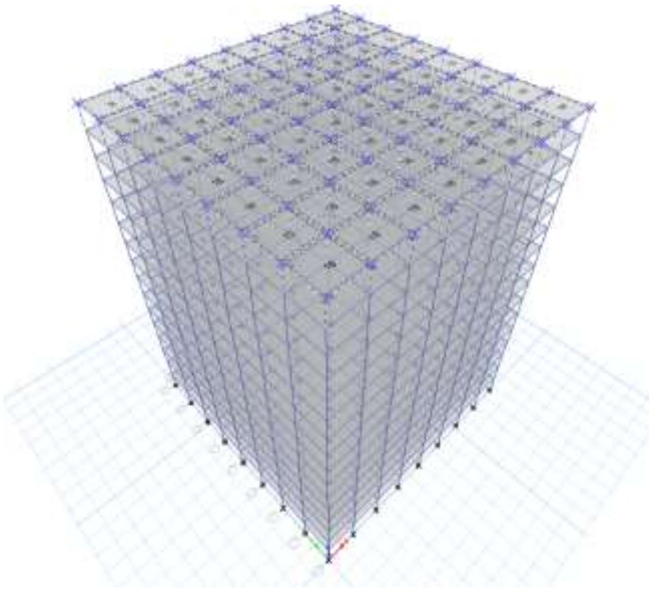

Fig 3. Mass irregular structure with swimming pool on terrace floor

3.3.3 Stiffness irregular structure:

In this irregularity, the changes made with respect to regular building are, the base story is made as soft story by increasing the height of it from the following equation,

Stiffness of each column – $12EI/L^3$

Therefore,

Stiffness of other floor/Stiffness of ground floor

$(3.3/4.5)^3 = 0.39 < 0.7$

Hence as per IS 1893 Part-1 the structure is irregular

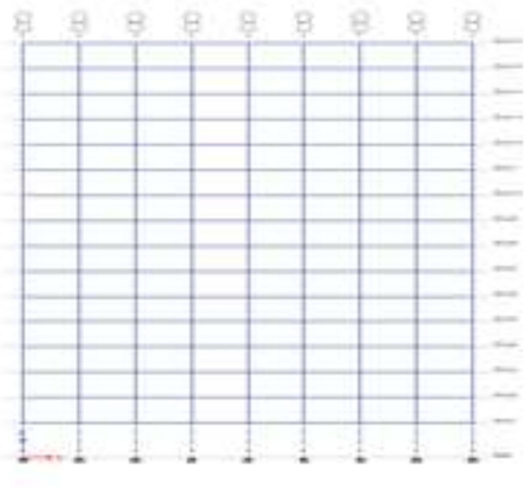

Fig 4 Stiffness irregular structure

3.3.4 Vertically Geometric irregular:

The structure is 16 storyed with steps in 4th, 8'th, 12'th and 16th floor. The setback is along Y direction.

Width of top storey :25 m

Width of bottom storey :40 m

As per IS 1893 (PART 1): 2002

Vertical geometric irregularity when $L_2 > 1.5\ L_1$

Where L_1 – Width of top storey

L_2 – Width of ground storey

Vertically irregular 40 > 37.5

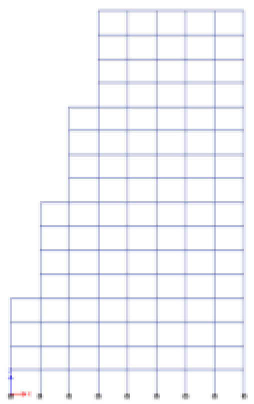

Fig 5. Vertical geometric irregular structure

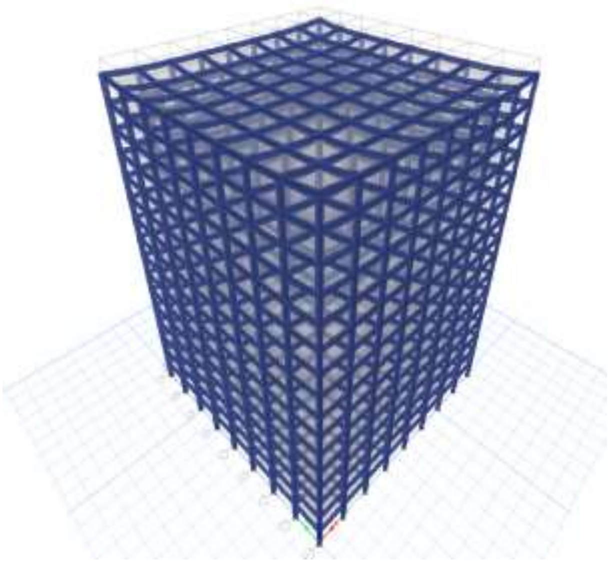

Fig 6. Analysis of a structure

4. RESULTS AND DISCUSSION

This chapter represent the results and discussion of dynamic analysis of regular and vertical irregular building of both conventional RCC and composite structure. After analysis of the structure situated in seismic zone V using ETABS, the results are compared in terms of response parameter such as base shear, storey drift and storey displacement.

4.1 Base shear:

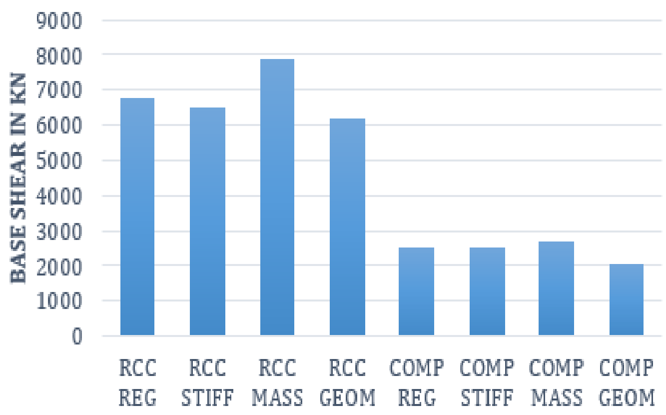

Fig 6. Base shear along X – direction

Base shear is more incase of mass irregular structure both in conventional RCC and composite structure and also conventional RCC structure have more base shear compared to composite structure.

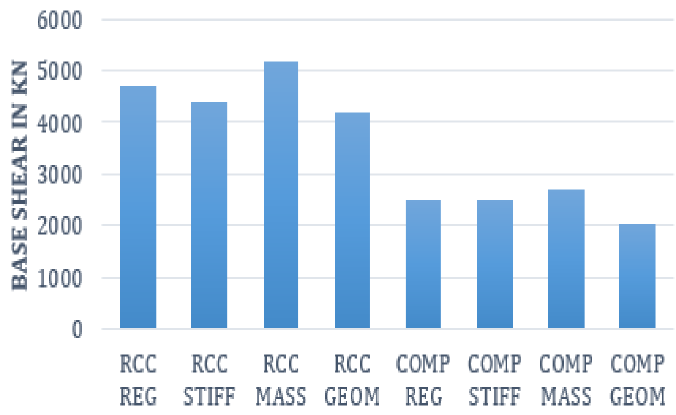

Fig 7. Base shear along Y – direction

Composite structure will experience less base shear since dead weight of composite structure is less compared to RCC structure. storey shear is different in Y direction since moment of inertia of column section is different in both the direction.

4.2 Displacement

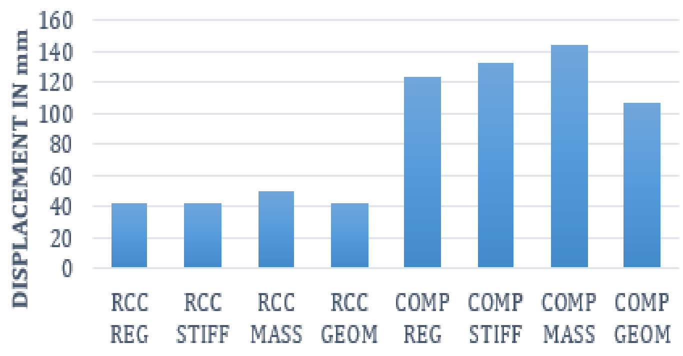

Fig 8. Storey displacement along X – direction

Storey displacement is maximum for composite building as compared to conventional RCC building. Mass irregular structure have more displacement compare to other irregular structure. As the vertical irregularities increases storey displacement also increases.

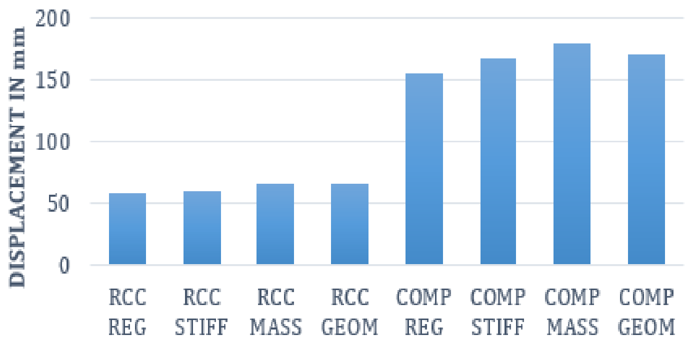

Fig 9. Storey displacement along Y– direction

Storey displacement is maximum for composite building as compared to conventional RCC building along Y-direction. After regular structure stiffness irregular structure undergone less displacement compare to mass and geometric irregular structure.

4.3 Drift

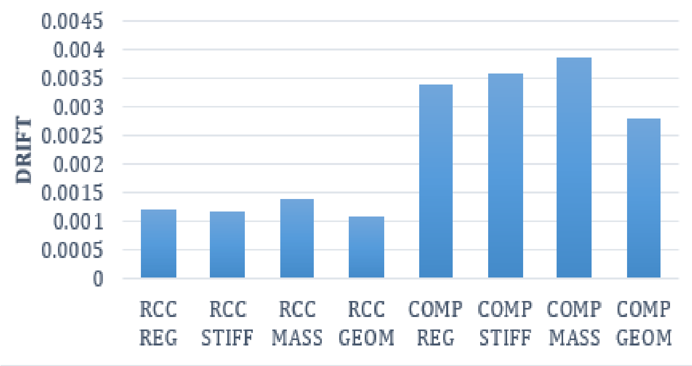

Fig 9. Storey drift along X– direction

On the basis of storey drift conventional RCC building is performed well compared to composite building and also vertical irregular building have more inter storey drift compare to regular structure.

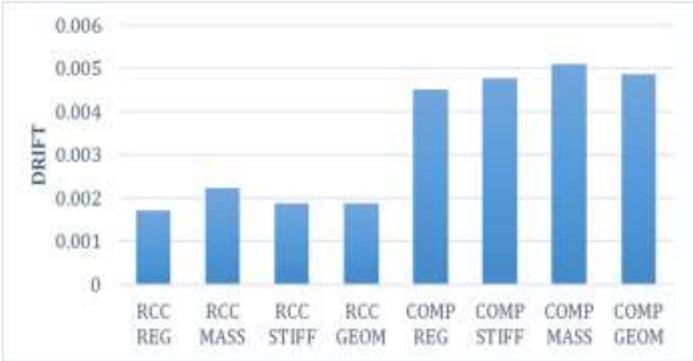

Fig 10. Storey drift along Y – direction

Storey drift is maximum along Y-direction compare to X-direction. Regular structure undergo less storey drift compare to other vertical irregular structure.

5. CONCLUSION

- According to the result of RSM, the storey shear was found to be more in conventional RCC building compare to composite building because weight of RCC building is more than the composite building.
- Storey shear was found to be more in mass irregular building than the regular building frames both in conventional RCC and composite building.
- Storey shear in case of stiffness irregular building is less compare to regular building
- Geometric irregular building has low base shear compared to regular building because setback is provided along Y direction and also dead weight of the building is low compare to regular structure both in conventional RCC and composite building.
- Storey displacement is maximum for composite building as compared to RCC building both in X and Y direction. RCC building has the lowest storey displacement because of its high stiffness.
- Vertical irregular building have more displacement than the regular building.
- Storey drift in response spectrum analysis along X and Y direction is more for composite structure as compared to RCC structure.
- The difference in storey drift along X and Y direction are depend upon the moment of inertia of column section.

- From overall result it can be concluded that maximum storey drift and storey displacement will increases as the vertical irregularities increases in all the models respectively both in conventional RCC and composite structure.

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