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Behaviour of Concrete Encased Columns in Irregular Buildings under Seismic Conditions

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***Abstract**: Concrete encased columns have various use in high rise structure owing to high ductility and stiffness. This type of structural members can overcome high loading conditions and different patterns of seismic loading. In this study, detailed analysis of multi-storey G+20 high rise building having various irregularities with Concrete encased columns is being carried out using ETABS 2015 to understand the behaviour of structure subjected to earthquake and to check effective use of Concrete encased columns against RC columns to overcome the structural irregularity of building mostly the Mass Irregularity and Stiffness Irregularity.*

***Keywords–**Base Shear, Concrete encased column, Irregularity, Seismic performance.*

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I. Introduction

A Concrete encased column is a column composed of structural steel built up section, encased in concrete with steel reinforcement and lateral ties. In this type of column, the steel section (i.e. I section considered in this study) support the initial loading of the structure, including the weight of entire structure during construction. Concrete is later encased around the steel section. In case of severe flexural overload, concrete encasement of column cracks leading to reduction of stiffness. But steel core of the column provides enough shear capacity and ductile resistance to successive cycles of overloads. The combined use of Steel and Concrete in composite member would be favourable for strength of entire structure. Structural irregularities are important factors which reduces the seismic performance of the structures.

According to research papers, Regular structures proved to be more stable in seismic conditions rather irregular structures in the same seismic zone [9]. Irregularity in horizontal direction affects the least as compared to the vertical irregularity of the building seeing the CM (Center of Mass) and CV (Centre of Strength) as if the distance between these two causing torsional and drifting of the entire structure [14]. Irregularity in vertical direction is can be reduced by changing the section properties of the structure holding the irregularity in the respective direction. But these modifications are limited subjected to code provisions [11]. Concrete encased columns proved to be economical and with high ductility. Also the irregularity of building may surely affect the stability of building in the seismic zone [12].

The irregularities in buildings can be vulnerable for the structures and it is important to have simpler and regular shapes of frames as well as uniform distribution of load around the building. But in unavoidable cases, these irregularities needs to be solved by making changes in section properties of structural members. The use of Concrete encased columns helps in reducing the sizes of the structures thereby maintaining the same strength as that of RC columns used to overcome the irregularity. Also the required levels of rotation capacity of the structure can be attained by using slender steel section in Concrete encased columns. In this study, detailed analysis of multi-storey G + 20 high rise building having Mass and Stiffness irregularities with Concrete encased columns is being carried out using Etabs 2015 to understand the behaviour of structure subjected to earthquake and to check effective use of Concrete encased columns against RC columns to overcome irregularities.

II. Structural Modelling and Analysis

Considering one plan of the building, irregularities namely Mass and Stiffness is induced in the same plan to check the effect of the Concrete encased column (CEC) on the irregularity and its respective response in terms of lateral displacement, storey drift, base shear and time period. Following is the architectural plan of the considered building for analysis. The overall area of the plan is 38.18m X 28.99m. These irregularities are being induced in the same plan. For Mass irregularity, the depth of the beam is increased 1.5 times the actual and the thickness of the slab too, in order to increase the dead load of the 20th story only. The response of RC column and CE column is checked.

Table 1: Member Sizes

Member	Storey	Building with RC columns	Building with Concrete encased columns (CEC)
Primary Beams	1-19thStorey	230mm X 450mm 230mm X 600mm	230mm X 450mm 230mm X 600mm
	20thStorey	230mm X 675mm 230mm X 900mm	230mm X 675mm 230mm X 900mm
Secondary Beams	1-19thStorey	230mm X 350mm	230mm X 350mm
	20thStorey	230mm X 525mm	230mm X 525mm
Slab	1-19thStorey	110mm thick	110mm thick
	20thStorey	165mm thick	165mm thick
Column	Ground to 20th	RCC – 450mm X 950mm	400mm X 600mm with ISHB 450 embedded I Section

For Concrete encased columns - Dimension of 400x600mm with ISHB450 Embedded I Section used throughout the structure. The structural member sizes are selected such that they are safe for all load combinations. It is found that RCC building requires heavy sections as compare to building with Concrete encased columns.

The stiffness irregularity also comprises the same dimension of members but the length of the column of soft storey is assumed as 4m as that leads to stiffness irregularity in the structure.

The beam sizes remains the same for all stories, whereas the column for RCC structure is 400x900mm and that of Concrete encased column structure having dimension of 400x500mm with ISHB400 embedded I section.

Parameters considered for analysis of G+20 Building are:

- Frame type=Special moment resisting frame
- Type of building = Residential
- Floor to floor height = 3.0 m
- Ground Floor height = 4.0m (for stiffness irregularity)
- Grade of concrete = M40
- Grade of steel = Fe415
- Grade of structural steel = Fe410
- Thickness of internal and external walls = 150mm
- Slab thickness = 110 mm
- Shear wall thickness = 250 mm
- Slab thickness for Mass Irregularity = 165 mm
- Terrain category = III
- Dynamic analysis method = Response spectrum analysis [as per Clause 7.7.5 of IS 1893 (Part 1) – 2016]

By using above data, the analysis of G+20 building with RC and Concrete encased column (CEC) was carried out. Also following are the loading conditions considered for the structure:

A. Dead Load Conditions.
This includes the self-weight of all structural members along with partition walls. These calculations are considered as per IS 875 (Part – 1) 1987.

B. Live Load Conditions

- Live load conditions are considered according to IS 875 (Part 2) – 1987.
- Live load on passage/staircase = 3 kN/m^2
- Live load on roof = 1.5 kN/m^2
- Live load on other rooms = 2 kN/m^2

C. Seismic Load Parameters
Seismic load parameters are considered according to IS 1893 (Part I) – 2016. All models are analysed by Response spectrum method of Dynamic analysis.

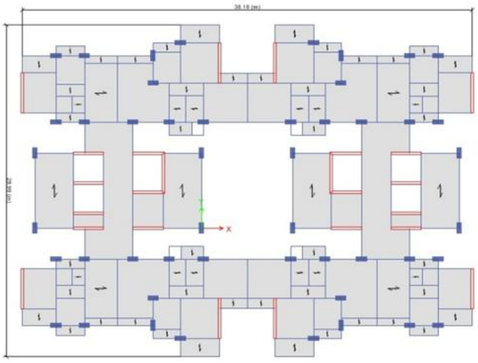
- Zone - III
- Soil type - Medium soil [Clause 6.4.2, IS 1893 (Part 1) – 2016]
- Importance factor - 1.2 [Clause 7.2.3, Table 8, IS 1893 (Part – 1) – 2016]
- Seismic zone factor - 0.16 [Clause 6.4.2, Table 3, IS 1893(Part 1) – 2016]

- Damping ratio - 5 %

D. Wind Load Parameters

Following wind load parameters are considered for analysis of models. Wind load parameters are considered as per IS 875 (Part 3) – 2015.

- Basic wind speed = 44 m/s
- Terrain category = III
- Probability Factor k_1 = 1
- Topography Factor k_3 = 1
- Importance Factor k_4 = 1
- Terrain roughness factor k_2 = Changes as per height [Clause 6.4, IS 1893 (Part 1) – 2016]



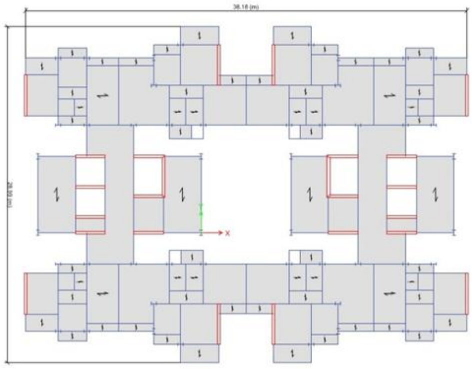


Figure 1- : Plan View of RC Building (M_1-RCC)
Figure 2- : Plan View of CEC Building (M_2-CEC)

Following above figures shows the plan view of RCC and Concrete encased column (CEC). Same plan are considered for both irregularities.

Model M1 – MRCC is Mass Irregularity in RCC Building where Model M2 – MCEC is Mass Irregularity in CEC Building. Model M3 – MRCC is Stiffness Irregularity in RCC Building where Model M4 – MCEC is Stiffness Irregularity in CEC Building.

III. Results & Discussions

Following are the results of models with RCC and Concrete encased columns (CEC) of Mass & Stiffness irregularities in the form of base shear, maximum lateral displacement and time period. Results obtained in present study are discussed. Also, results obtained for both building models are compared.

3.1 Base Shear

Following graph shows the pattern of Base Shear of RCC as well as Concrete encased columns (CEC) building models of Mass & Stiffness irregularity for X & Y - Direction. This base shear for Mass irregularity is observed to be reduced by 10%& for Stiffness irregularity it is observed as12%.

Maximum Lateral Displacement

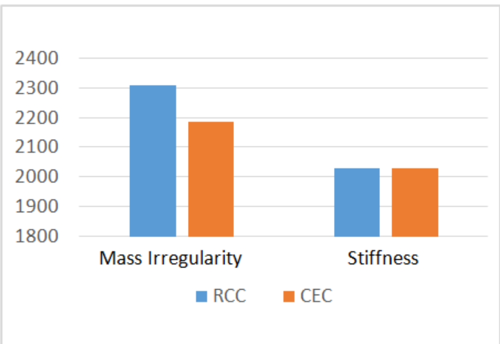


Figure 3- : Base Shear in X – Direction

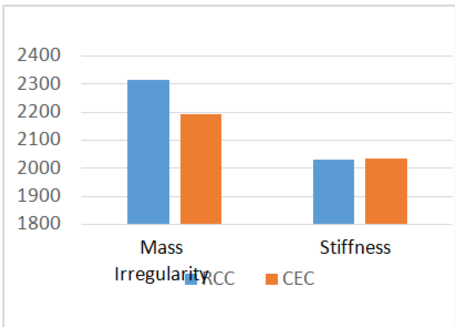


Figure 4- : Base Shear in Y - Direction

The maximum displacement can be seen on the top story of both the models. This displacement varies due to the use of Concrete encased columns (CEC) but this variation is slight as 0.04% - 0.05% can be seen between these models which is acceptable for the stability. Following graph shows the displacements for models in each irregularity for X & Y – Direction.

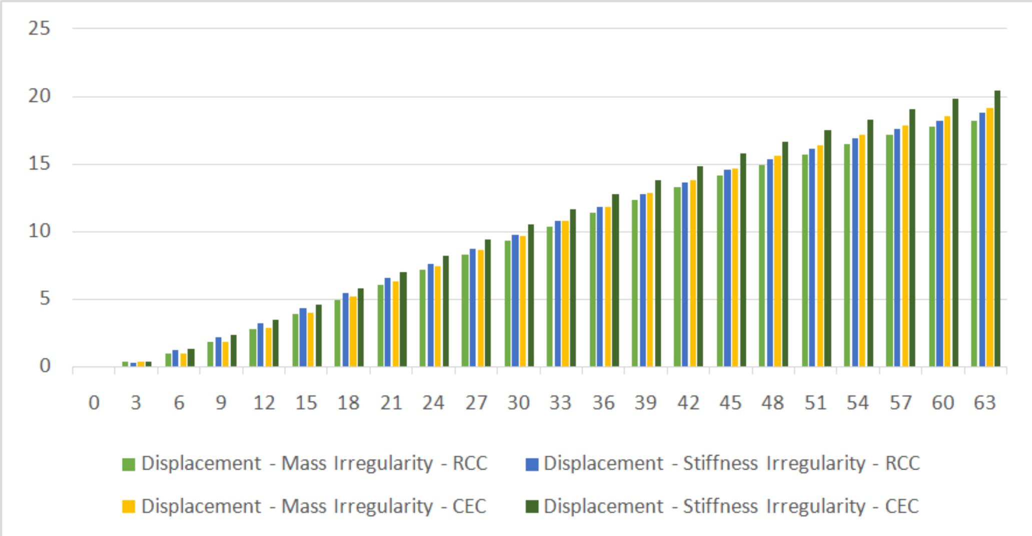


Figure 5- : Story Displacement in X - Direction
Figure 6- : Story Displacement in Y - Direction

3.2 Time Period

The time period obtained from the models is being compared and it is seen that the response remains the same as that of RC column models for the Concrete encased column modified mode.

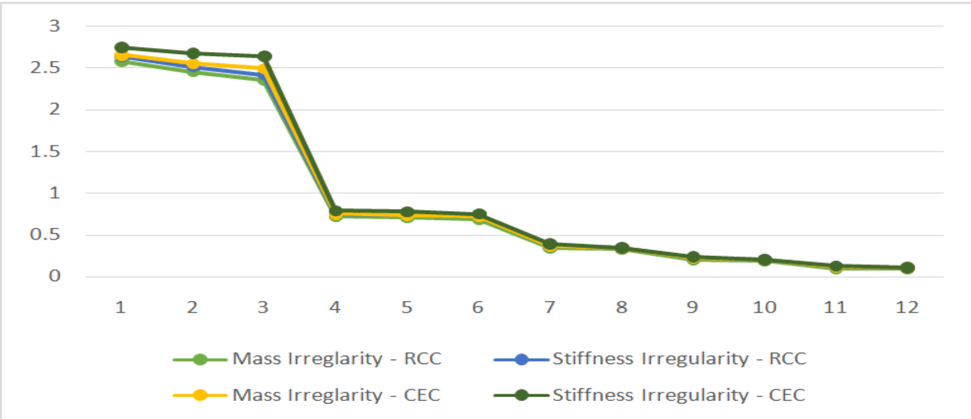


Figure 7- : Time Period of All Models

IV. Conclusions

1. From the present study, it can be seen that base shear is reduced by 10-14% by using Concrete encased columns. Due to which 43% area reduction in Mass irregularity & 51% area reduction in Stiffness irregularity can been seen.
2. Also it is observed that some of the responses of story displacement obtained due to this type of column are slightly more than that of conventional RC columns, still these are within permissible limits. This is because of ductility of the Concrete encased columns.
3. The time period obtained those of Concrete encased columns is more as compared to conventional RC columns because of increase in ductility of structure.

Therefore, from the results obtained, it can be concluded that Concrete encased columns are more suitable for Stiffness irregularity building due to its high stiffness property which enables the structure to resist it in a better manner.

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