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Comparative Study on Seismic Behaviour of Rc and Composite Structure for Different Types of Irregularities

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Abstract

When compared to composite structures for high rise construction, RC structures have increased seismic weights. The structural design influences how multi-storey buildings react to earthquakes. In the case of vertical constructions, composite structures provide a distinctive option of ergonomic member and material design. In the majority of developing nations, reinforced concrete structures are the preferred construction technique. A combined structural property of concrete and steel is achieved by using composite structures. In the current work, ETABS is used to model and analyse the comparison of RC and composite structures with CFT columns for different kinds of irregularities, such as vertical geometric irregularity, mass irregularity, and stiffness irregularity, in accordance with IS codes. When RC constructions are compared to composite structures, it has been found that storey displacements and drifts are considerably fewer in RC structures. The base shear for the composite structure is lower than that of the RC structure due to the composite structure's lighter weight.

Keywords: *RC Structure, Composite Structure, CFT column, Irregularities.*

1.0 Introduction

In India, low-rise structures make up the majority of the building design. As a result, reinforced concrete members are frequently employed for these structures because they are quite practical and cost-effective to build. But because land is limited and urban population growth is exponential, there is a demand for vertical building growth in major areas. In order to accommodate this demand, numerous medium to high rise structures are being built. It has been shown that using composite members rather of reinforced concrete ones for creating these high-rise structures is more efficient and cost-effective. However, because to higher dead loads, span constraints, decreased stiffness, and a structure that is extremely prone to dangers, conventional reinforced concrete construction cannot be employed in medium and high-rise buildings. With India's rapid expansion, there is a pressing need to research the building industry further and discover new, better ways to employ steel as a construction material wherever it is cost-effective to do so. Although they require more steel, steel concrete composite frames are a cost-effective way to address issues with medium to high-rise building constructions. Although they require more steel, steel concrete composite frames are a cost-effective way to address issues with medium to high-rise building constructions.

Naresh Kumar Reddy Lomada, Guvvala Bhagyamma[1] discussed the response of a typical G+12 framed multi-storey building with two alternative column schemes for seismic zone 3 using ETABS for parameters such as base shear, storey over turning moment, storey drift and roof displacement resulting in the reduction of storey over turning moment and base shear.

Mohammed Akif Uddin, M. A. Azeem[2] concluded that the RC

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structure has high stiffness value, storey displacement and drifts.

N.G. Agrawal, S. D. Agrawal, P. N. Patil[3] discussed the effect of flat slab buildings with and without shear wall for high rise building with different types of shear wall positions for parameters like time period, storey displacement and drifts.

1.1 Objectives

- To model the RC and Composite structure for various irregularities like mass, stiffness and vertical geometric irregularities using ETABS software.
- To study the seismic behaviour of RC and composite structures for different irregularities.
- To compare the seismic response of composite and RC structures in terms of storey displacement, drift and shear.

1.2 Methodology

A detailed literature review to understand the seismic evaluation of behaviour of RC frame and composite structure with different types of irregularities and application of equivalent static method and response spectrum method.

- A detailed literature review is carried out to understand the seismic behaviour of RC and composite structures by using different types of irregularities.
- Modelling of different irregular RC and composite structures by using ETABS software.
- The analysis of linear static and linear dynamic methods for the analysis of RC and composite structures by using ETABS.
- Extraction of seismic responses such as storey displacement, storey drift and storey shear and arriving at conclusion.

2.0 Overview of Structural Models

2.1 Structural Model

ETABS software is used in this study to analyse the linear static or equivalent static method and the linear dynamic or response spectrum method. As per IS 1893-2016, the modelling considers a wide range irregularities such as mass irregularity, stiffness irregularity, and vertical geometric irregularity.

2.2 Description of Models

- M1 - Regular RC framed building without irregularity.
- M2 - Regular composite building without irregularity.
- M3 - RC framed building with vertical geometric irregularity-1.
- M4 - Composite building with vertical geometric irregularity 1.
- M5 - RC framed building with vertical geometric irregularity 2.
- M6 - Composite building with vertical geometric irregularity 2.
- M7 - RC framed building with vertical geometric irregularity 3.
- M8 - Composite building with vertical geometric irregularity 3.
- M9 - RC framed building with vertical geometric irregularity 4.
- M10 - Composite building with vertical geometric irregularity 4.
- M11 - RC framed building with stiffness irregularity 1.
- M12 - Composite building with stiffness irregularity 1.
- M13 - RC framed building with stiffness irregularity 2.
- M14 - Composite building with stiffness irregularity 2.
- M15 - RC framed building with stiffness irregularity 3.
- M16 - Composite building with stiffness irregularity 3.
- M17 - RC framed building with mass irregularity 1.
- M18 - Composite building with mass irregularity 1.
- M19 - RC framed building with mass irregularity 2.
- M20 - Composite building with mass irregularity 2.

Table 1: Description of RC frame building

Terms	Data
No. of storeys	15
Number of bays in X-direction	5
Number of bays in Y-direction	6
Spacing in X-direction (m)	6
Spacing in Y-direction (m)	4
Dimension of Beam (mm)	400*600
Dimension of Column (mm)	600*900
Thickness of Slab (mm)	150
Grade of concrete	M30
Grade of steel	Fe500
Live load, LL (kN/m^2)	2
Floor finish, FF (kN/m^2)	1
Wall load, WL (kN/m)	12

Table 2: Description of Composite frame building

Terms	Data
No. of storeys	15
Number of bays in X-direction	5
Number of bays in Y-direction	6
Spacing in X-direction (m)	6
Spacing in Y-direction (m)	4
Dimension of Beam (mm)	ISMB 300
Dimension of column	350x350
Thickness of Slab (mm)	150
Grade of concrete	M20
Grade of steel	Fe500
LL (kN/m^2)	2
FF (kN/m^2)	1
WL (kN/m)	12

Table 3: Earthquake Parameters

Seismic Zone	III
Seismic zone factor	0.16
Importance factor	1.2
Soil type	Medium
Response reduction factor	5
Seismic Zone	III

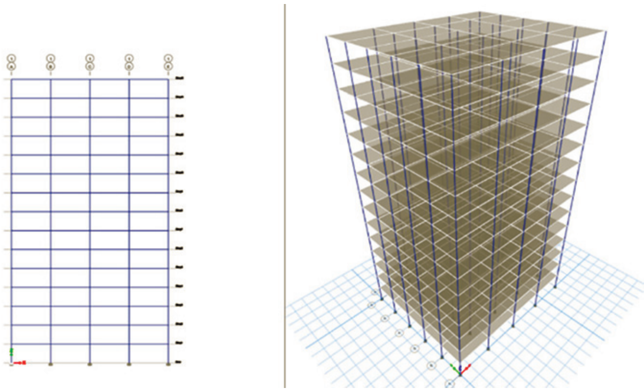

Figure 1: Views of the regular model in elevation and 3D for both composite and RC buildings

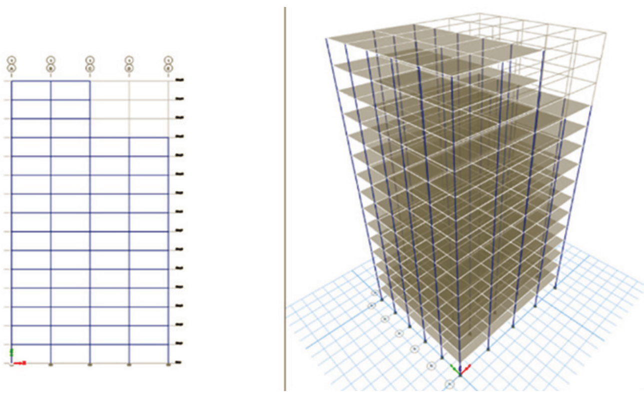

Figure 2: Views of the Vertical Geometric Irregular-1 Model in elevation and 3D for both composite and RC buildings

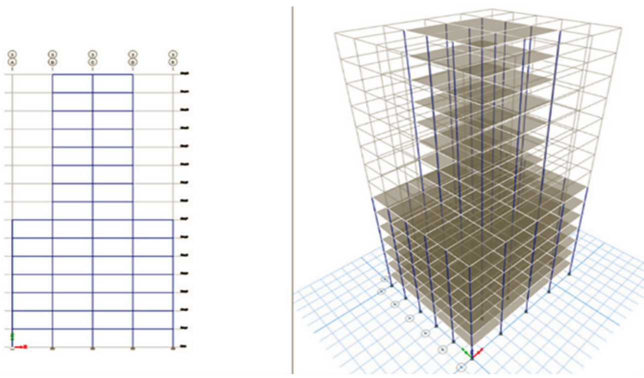

Figure 3: Views of the Vertical Geometric Irregular-2 Model in elevation and 3D for both composite and RC buildings

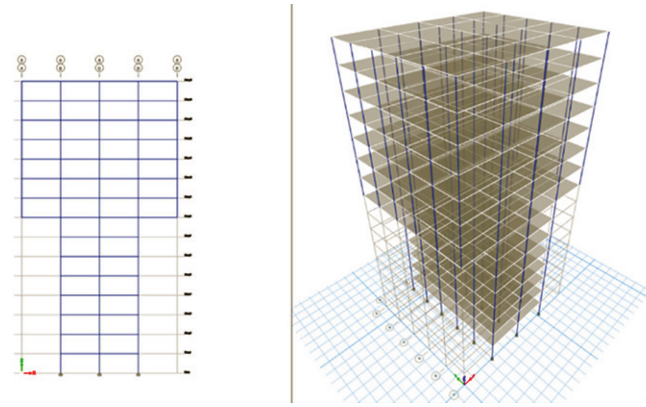

Figure 4: Views of the Vertical Geometric Irregular-3 Model in elevation and 3D for both composite and RC buildings

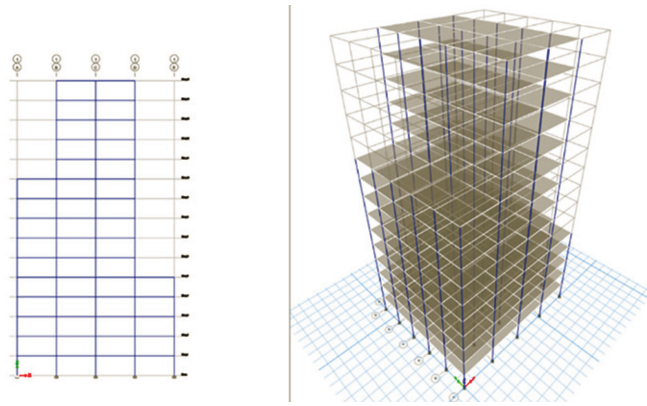

Figure 5: Views of the Vertical Geometric Irregular-4 Model in elevation and 3D for both composite and RC buildings

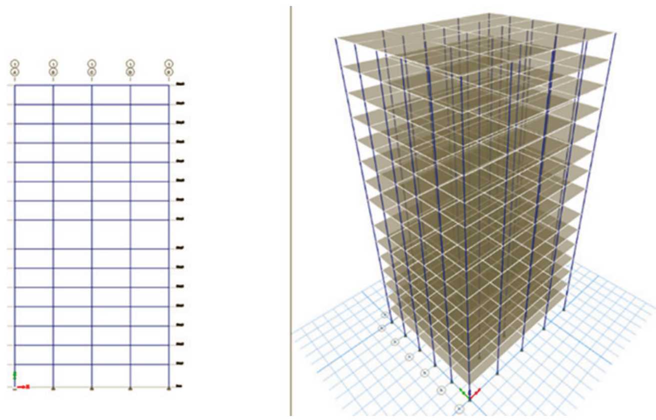

Figure 6: Views of the Stiffness Irregular-1 Model in elevation and 3D for both composite and RC buildings

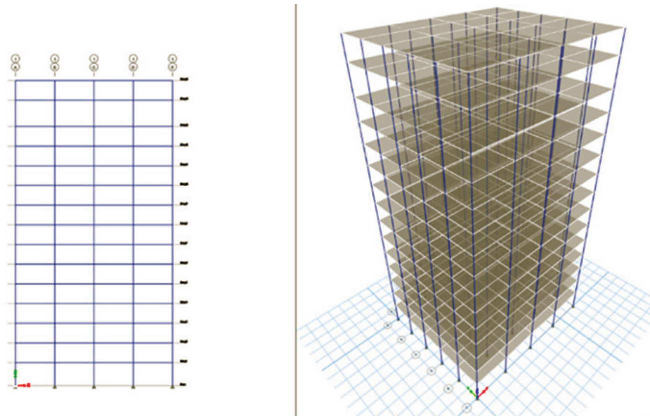

Figure 7: Views of the Stiffness Irregular-2 Model in elevation and 3D for both composite and RC buildings

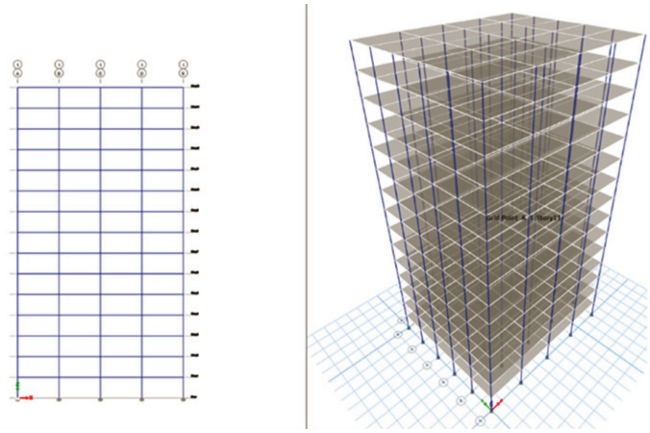

Figure 8: Views of the Stiffness Irregular-3 Model in elevation and 3D for both composite and RC buildings

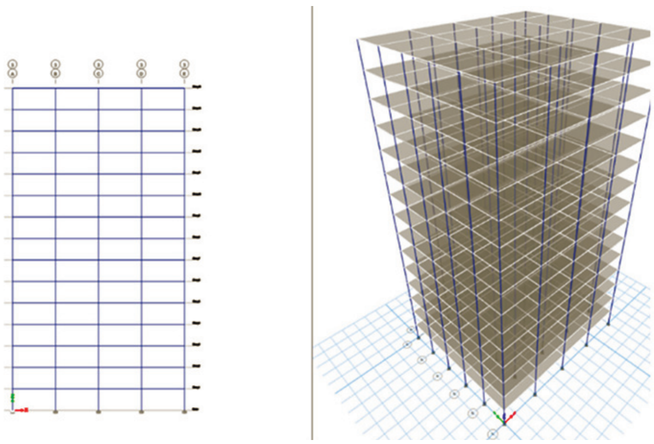

Figure 9: Views of the Mass Irregular-1 Model in elevation and 3D for both composite and RC buildings

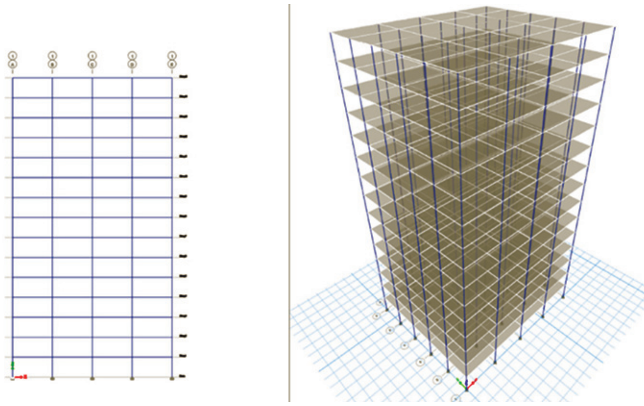

Figure 10: Views of the Mass Irregular-2 Model in elevation and 3D for both composite and RC buildings

3.0 Results and Discussions

3.1 Storey Displacement

For the stated G+15 building in seismic zone III, the storey displacement values were calculated using the equivalent static method and the response spectrum method, respectively. Storey displacement values were computed along the X and Y axes.

It is clear from the data that storey displacement is under discussion. The vertical geometric irregular model-2 has the greatest storey displacement for both the static approach and the response spectrum method, whereas the mass irregular model-2 exhibits the least storey displacement. The vertical geometric irregular-1 model has a 57% storey displacement when compared to other models. Composite models display the greatest storey displacement in comparison to RC models as well.

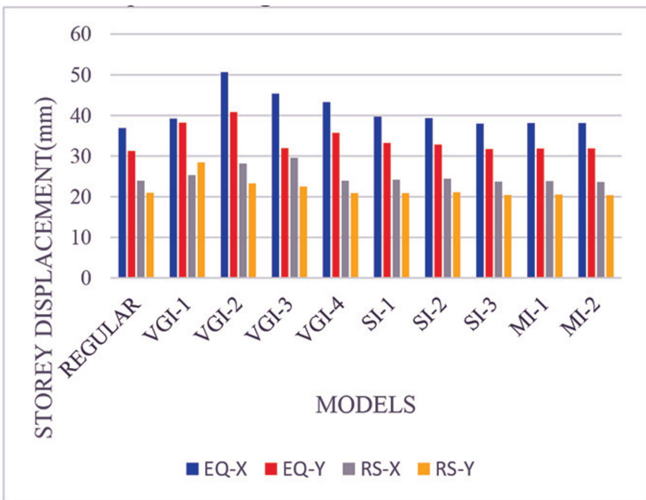

Figure 11: Variation in the storey displacement for composite models

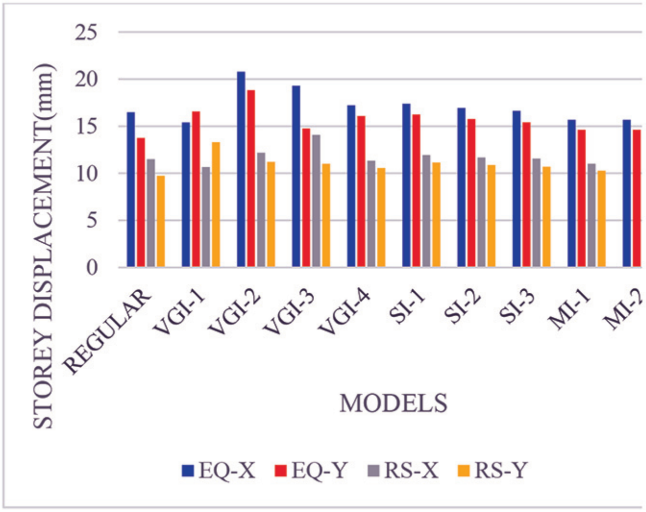

Figure 12: Variation in the storey displacement for RC models

3.2 Base Shear

The maximal lateral force brought on by an earthquake's ground motion at a structure's base is estimated as base shear. Here base shear values are obtained for G+15 RC and composite structures from equivalent static method and response spectrum method.

3.3 Storey Drift

Storey drift is the noticeable variation between an upper storey displacement and a lower storey displacement. Equivalent static method and response spectrum approach were used to evaluate the storey drift values for the given G+15 building in seismic zone III. The values of storey drift are calculated along the X and Y axes.

Storey drift is described as the difference between two successive storey displacements divided by the structure's

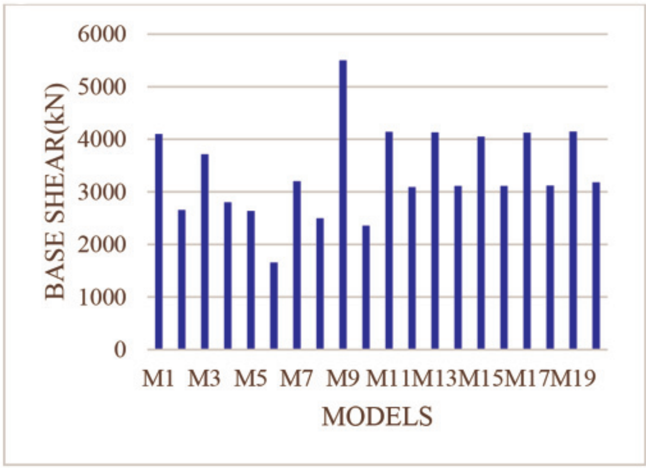

Figure 13: Plot of Models verses Base shear

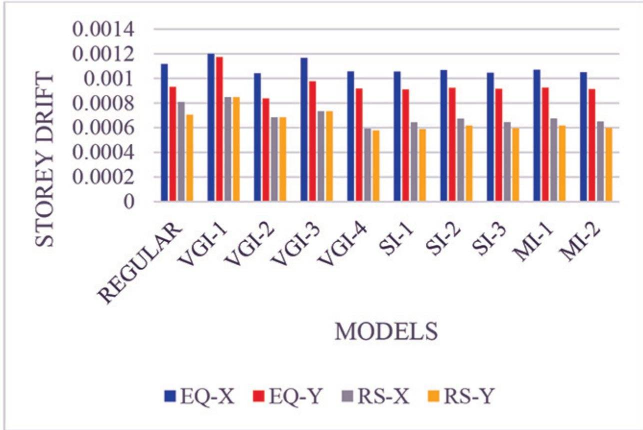

Figure 14: Variation in the storey drift for composite models

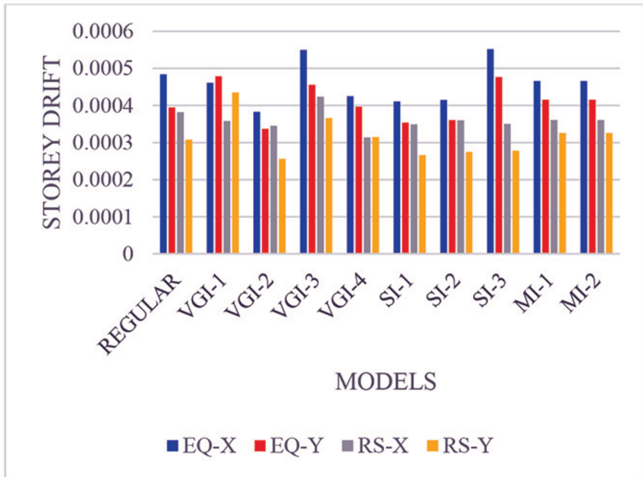

Figure 15: Variation in the storey drift for RC models

elevation. According to IS 1893-2016, a storey drift of no more than 0.004h is allowed. For both the static technique and the response spectrum method, the vertical geometric irregular model-1(composite) and vertical geometric irregular model-3(RCC) show most, while the vertical irregular model-2 (RCC and composite) shows least. Vertical geometric irregular model-2(RCC) displays 58% storey drift in contrast to other models. Additionally, composite models exhibit the most storey drift as compared to RC models.

3.4 Storey Shear

Storey shear refers to the lateral force that a storey experiences as a result of events like seismic shocks. It is calculated for each storey and rises from lowest at the top to highest at the bottom of the building. The equivalent static approach and the response spectrum method respectively, have been used to compute the storey shear values for the stated G+15 building in seismic zone III. Storey shear values are computed along the X and Y axes.

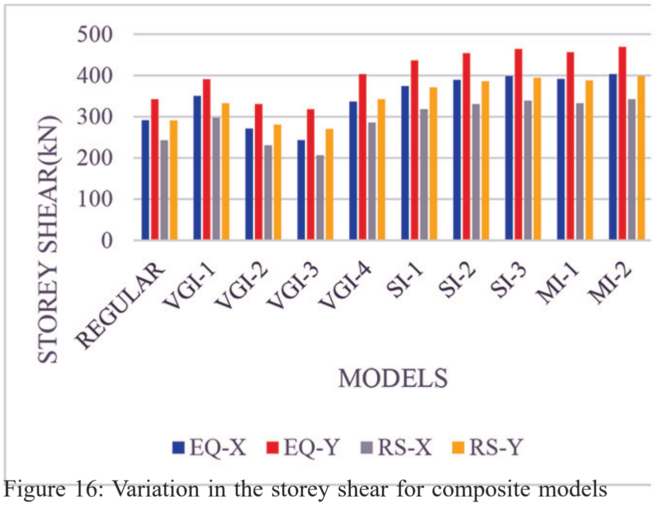

Figure 16: Variation in the storey shear for composite models

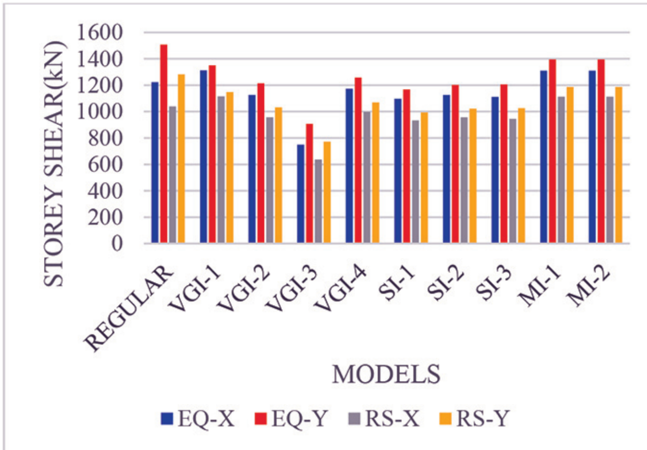

Figure 17: Variation in the storey shear for RC models

According to IS 1893-2016, storey shear is the total of the design lateral forces at all levels above the storey under consideration. For both the static technique and the response spectrum method, the stiffness irregular model-3 (composite) and the vertical geometric irregular-1 exhibit the greatest and the vertical geometric irregular model-3 (RCC and composite) the least. When compared to RC models, composite models show the least storey shear.

4.0 Conclusions

The specific study is concerned with the remarkable outcomes of the present study is carried out. From the present study it is observed that composite structure is more economical than RC structure due to the reduction in the weight of the structure thus reducing the cost of construction.

- The RC structure exhibits minimum storey displacement when compared to composite structure.
- It was observed that vertical geometric irregular model-1(composite) exhibits 57% storey displacement when compared to other models.
- In comparison with RC structures, the composite structure exhibits the most storey drift, but only to the extent permitted by codal requirements.
- It was observed that vertical geometric irregular model-2 (composite) exhibits 58% storey drift when compared to other models.
- Since the dead weight of the RC structure is more than composite structure, composite structure exhibits less storey shear when compared to RC structure.
- It was observed that composite model without irregularity exhibits 76% less storey shear when compared to other models.
- The base shear exhibited by RC structure is more than that of composite structure.

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