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COMPARATIVE ANALYSIS OF R.C.C. AND COMPOSITE STRUCTURES WITH DIFFERENT VERTICAL IRREGULARITIES

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ABSTRACT

Overall development of the country is based on the infrastructural development. Hence for the construction, nowadays RC structures are being replaced with steel-concrete composite structure due to their structural efficiency which also include cost and time efficiency. During an earthquake, damage occurs due to the discontinuities in the structure. Discontinuities are caused by the presence of irregularities in the structure. Irregular structures are highly vulnerable to seismic forces. Hence structures with different irregularities must be analysed for their performance under seismic force. In this paper, different vertical irregularities such as stiffness, mass and geometric irregularities are analysed for both RC and composite structure.10 storey RC and steel-concrete composite structure are modelled and analysed using response spectrum method in ETABS 2015. On comparison, steel-concrete composite structures with different vertical irregularities perform better than irregular RC structures.

Keywords: RC structure; Composite structure; seismic analysis; response spectrum method; vertical irregularity.

I. INTRODUCTION

Seismic forces vandalize the high-rise structures particularly structures with irregularities suffer more damage during an earthquake. Structures with irregularities are built for the need of aesthetic or architectural demand and space requirem-ent. Irregularities present in the structure are the points of weakness due to which failure occurs. Hence performance of irregular structures must be evaluated [Baldev & Panchal, 2013].

Steel-concrete composite structures are highly efficient than conventional RCC structures from cost and performance aspects [Deepa and Thenmozhi, 2014] Thus composite structures must be analysed with irregularities and must be compared to RCC structures for performance. This paper deals with 10 storey RCC and composite structures with different vertical irregularities and are analysed using response spectrum method. Different vertical irregularities considered are stiffness, mass and geometric irregularities. The comparison of the structures involves the parametric study of storey displacement, storey drift and storey shear. The results are com-pared and effects of different vertical irregularities over the RCC and composite structures are observed.

II. MODELLING AND ANALYSIS

10 storey structures with different irregularities (stiffness, mass and geometry) are modelled for analysis. In order to examine the effect of irregularities at different levels of a structure, individual models with irregularities positioned at lower, middle and top portion are modelled for analysis i.e., irregularities are placed at 2^{nd}, 5^{th} and 9^{th} floor of the structure. Each model carries an irregularity placed at a level of a structure. As per code, irregularities are not positioned at roof level [Bhavin et al.,2016].

Table 1 shows the details required for modelling and analysis of both RCC and steel-concrete structures. The structures are modelled and analysed using Etabs 2015 and usual modelling procedure is carried out. Figure 1 shows the modelled plan view of the 10 storey structure. For seismic analysis response spectrum method is used [Bureau of Indian Standards:IS-875., 1987].

Table 1: Parameters for modelling

DESCRIPTION	DATA
Area	1200mm x 2400mm
Ht. of each storey	3m
RC Beam size	350mm x 400mm
RC Column size	400mm x 400mm
Composite beam size	ISWB 300
Composite column size	ISHB 350-2
Slab thickness	150mm
Thickness of wall	230mm
Dead load (wall)	15.732 kN/m
Dead load (parapet)	3.96 kN/m
Floor finish	5.75 kN/m
Live load	3 kN/m^2
Live load (roof)	1.5 kN/m^2
Density of concrete	2 kN/m^2
Grade of concrete	M30
Grade of steel	Fe 415
Seismic zone	3 (moderate)
Type of soil	Medium soil
zone factor	0.16
Damping ratio	5%
Importance factor	1

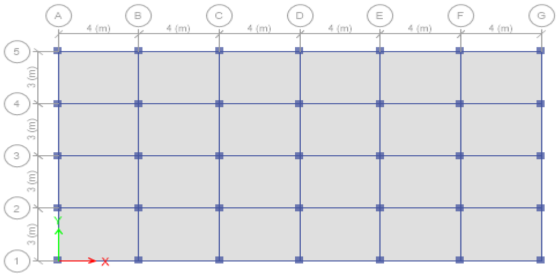

Fig. 1. Plan of the 10 storey structure

Stiffness irregularity: To impart stiffness irregularrity in the model, a storey with height of 4.5 m is placed as shown in figure 2. Hence as per IS 1893 part 1 the structure is stiffness irregular. Similarly, other stiffness irregular structures having irregularity at different floor levels (2nd, 5th and 9th floors) were modelled and analyzed. Stiffness irregular models are made for both RCC and composite structures [Ni and Kyaw, 2015].

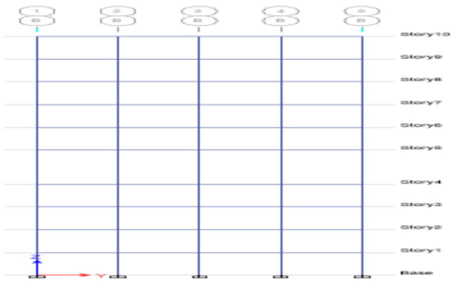

Fig. 2. Structure with stiffness irregularity

Mass irregularity: For mass irregularity, the structure is modelled with swimming pool load. Mass irregular models are made for both RCC and composite structures.

Height of swimming pool considered = 1.5 m

Loading due to swimming pool = 20 kN/m^2

The loading is greater than 200% when compared to other floor, which is an irregularity according to the code. Similarly, other mass irregular structures having irregularity at different floors were modelled and analysed. Figure 3 explains the loading of swimming pool of 20kN at a floor level.

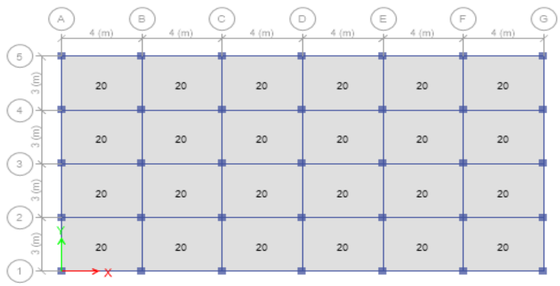

Fig. 3: Loading of swimming pool

Geometric irregularity: The structure is 10 storied with setbacks at 2nd, 5th and 9th floor as shown in figure 4. The setback is along Y direction. Geometric irregular models are made for both RCC and composite structures.

Width of top storey = 3 m

Width of ground storey = 12 m

Hence it is a geometric irregular structure.

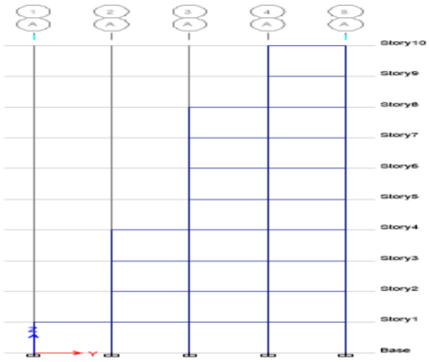

Fig. 4: Structure with setback (10 storey)

III. RESULTS

Response Spectrum analysis was performed on various irregular buildings using Etabs. Maximum deformations due to irregularity are considered and compared with composite structures and are plotted in figure 5, 6 and 7. (a), (b), (c) shows the joint displacement, storey drift and storey shear for different types of irregularities respectively.

Results for Stiffness irregular structures (ST):

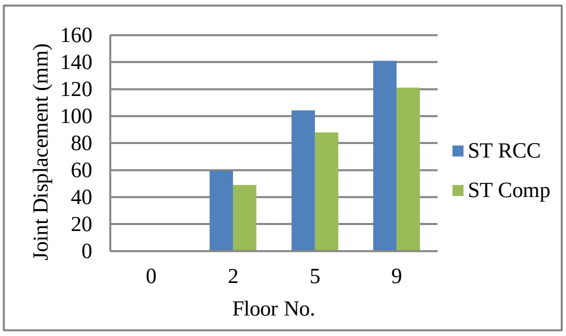

Fig.5 (a)

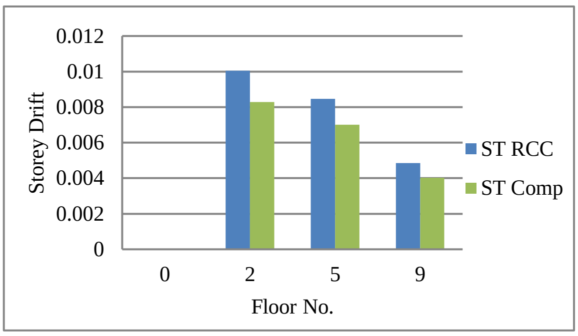

Fig.5 (b)

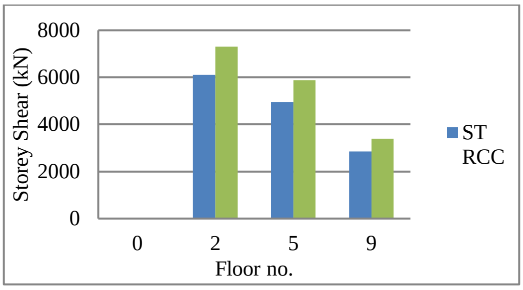

Fig.5(c)

Fig. 5 (a) (b) (c) Comparison of stiffness irregular RCC and composite structures

Results for Mass irregular structures:

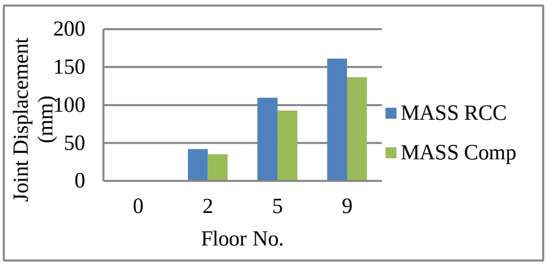

Fig.6(a)

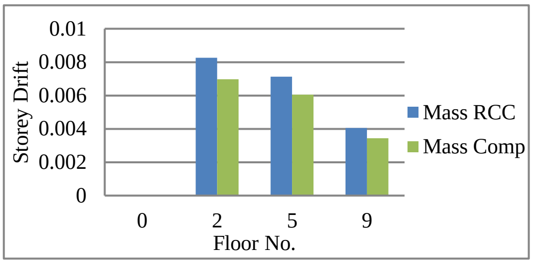

Fig.6 (b)

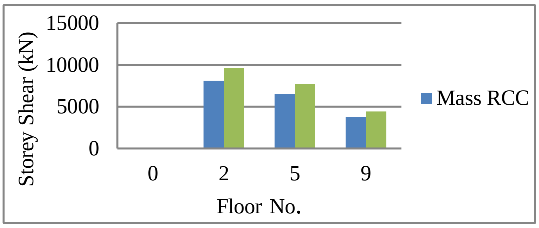

Fig.6 (c)

Fig. 6 (a) (b) (c). Comparison of mass irregular RCC and composite structures

Results for geometric irregular structures (SB):

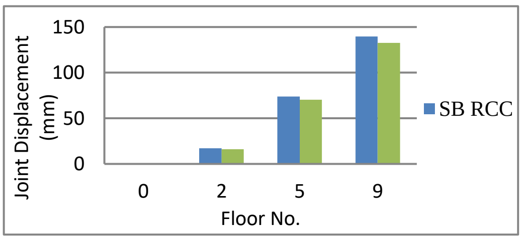

Fig.7 (a)

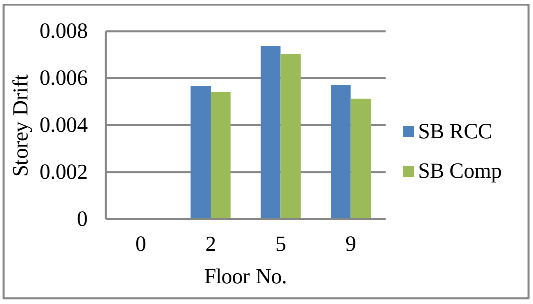

Fig.7 (b)

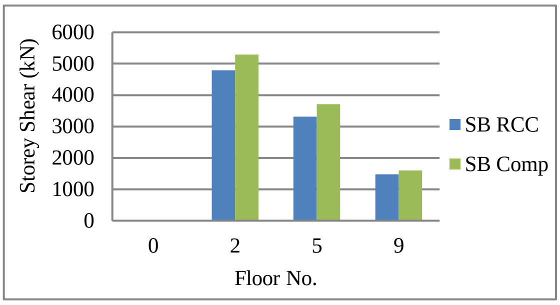

Fig.7(c)

Fig. 7 (a) (b) (c) Comparison of geometric irregular RCC and composite structures

IV. DISSCUSSION

1) When the stiffness irregularity is at the top floor level (9th floor) maximum joint displace-ment occurs and displacement of RCC structure is 1.16 times greater than composite structure.

2) Storey drift due to stiffness irregularity is higher when it is at lower level and composite structure performs well. It is 1.21times lesser than the RCC structure.

3) Irregularity due to extra mass caused by the swimming pool causes higher joint displacement at top stories.

4) When mass irregularity is imparted joint displacement for RCC structure is 1.18 times hig-her than the composite structure.

5) Due to setback in geometric irregular struc-tures, overall mass and stiffness of the structure is reduced. Hence geometric irregularity cause less deformation than other irregularities.

6) Though they cause less deformation, there is a sudden increase of displacement between the floors which has setbacks which is highly vulne-rable.

7) Composite structure performs well with irregu-larities than irregular RC structures, but storey shear for composite structure is always found to be higher than the RC structure. It is 1.18 times greater than RCC structure.

8) Irregular structures are always vulnerable to seismic forces but irregularity in the structure is unavoidable.

9) So intense care must be taken in the design and construction of irregularity.
10) Composite structure has overall better performance when irregularities are imparted in them.
11) Steel-concrete composite structures are economical, time efficient and they perform well under seismic forces than RCC structures.

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