COMPARATIVE ANALYSIS OF MULTISTORIED RCC AND COMPOSITE BUILDING DUE TO MASS IRREGULARITY

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Abstract -*Steel-Concrete Composite construction is built in place of R.C.C. structures to get maximum benefit from steel and concrete and to produce efficient and economic structures. Composite construction is increasing rapidly so that proper earthquake design should be needed to reduce damages during earthquake. Earthquake damage in irregular configuration of buildings is because of not taking proper design consideration regarding irregularity factor. In this report, Irregularity is considered in the form of Mass in G+9 multistoried R.C.C. and Composite building and compared both R.C.C. and Composite structures. Equivalent static and Response spectrum methods are used to analyze the building as per IS 1893(Part 1):2002 using SAP 2000 software. Mass irregularity at upper or middle floor should be considered. The study shows that Composite structures having mass irregularity will better perform than R.C.C. structures.*

Key Words: Composite, Mass irregularity, Equivalent static method, Response spectrum method, SAP 2000.

1. INTRODUCTION

In India most of the building systems were low rise buildings. Now a days due to greater migration towards cities increases population in most of the major cities. In order fulfill the requirement of this increased population in the limited land the height of building becomes medium to high-rise. Along with this there is necessity for efficient and economical construction of buildings. The best way to produce efficient and economical design of building system is composite steel-concrete construction. Composite steel concrete design and construction has wide range of scope as well as necessity in present construction world.

The performance of building during an earthquake depends upon several factors, stiffness, ductility, lateral strength and Simple and regular configuration. Buildings having uniformly distributed mass, stiffness and simple and regular configuration cause less damage compared to buildings having irregular configuration. . Vertical Mass irregularity is an important factor which is to be considered while designing multistoried building. This article work focuses on study of multistoried R.C.C. & Composite building due to Mass irregular buildings in *SAP 2000* software. The analysis between R.C.C and composite building involves parametric study of displacement, base shear, storey drift, lateral force. Linear static and dynamic analysis is carried out in order to know the seismic performance of R.C.C and Composite structure

2. OBJECTIVE

1) Modeling of multistoried R.C.C. and Steel-Concrete Composite 3-dimensional building considering mass irregularity at different stories.
2) To study various components of composite elements.
3) To analyze multistoried R.C.C. and Steel-concrete composite building by linear static and linear dynamic analysis as per IS 1893(Part 1): 2002 code.
4) Comparative study of structural parameters like base shear, storey drift, displacement of both R.C.C. and Steel-concrete Composite building.
5) To study the performance of structures having Mass irregularity.

3. MASS IRREGULARITY IN STRUCTURES

The irregularity in the structures is due to uneven distribution of mass, strength or stiffness or due to their structural form. The Analysis and design becomes complicated when these structures are constructed in high seismic zones. Most of the structures having irregular configuration which collapses is due to lack of proper seismic design. Hence seismic performance of irregular structures becomes very much important. Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 % of that of its adjacent storey's.. This article is having vertical irregularity in structures i.e. Mass irregularity should be considered. If the mass irregularity should be present at the top or bottom of the storey, there is increase in the average peak drift demand compared to regular structures. If the mass irregularity should be present at the middle of the structures there is lesser demand of drift corresponding to regular structures.

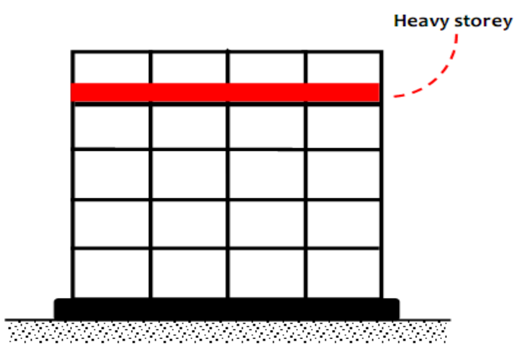

Figure 1: Mass irregularity in structure

With increase in the mass in one storey, there is increase in the inertia forces generated in that storey. If the percentage difference is small of changes in mass in comparison to the total mass of the building, the effect of mass irregularity is small on the mode shapes in regular buildings. The difference becomes pronounced if the difference is large; the difference in response is explicit during non-linear response of such buildings under strong earthquake shaking.

4. BUILDING DESCRIPTION

The main intention of modeling the following structures is to study the mass irregularity in R.C.C. structures in comparison with Composite structures.

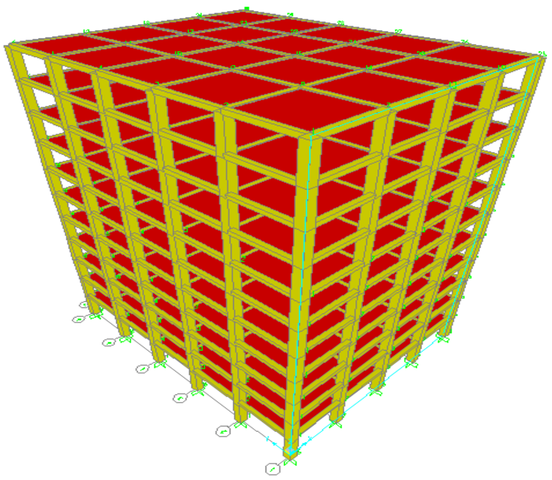

Figure 2: 3-D Elevation of the building

The structures considered here is a commercial complex building having G+9 storey model located in seismic zone III and wind velocity 39 m/s.. The plan dimension of the building is 24m X 30m. Height of the storey is kept as 3.5 m. Depth of foundation is kept as 3.5 m including 1 m plinth height. Parapet Height is given as 1m. The study is carried out on R.C.C and Composite structures with one of the important consideration of Mass irregularity in the form of swimming pool at 9th floor. The 3-D elevation of the building is shown in the figure.1.

Table 1: Building Data

Details	R.C.C.	Composite
Plan dimension	24m X 30m	24m X 30m
Total Height of the building	38.5m	38.5m
Height of each storey	3.5m	3.5m
Depth of foundation	2.5m	2.5m
Plinth Height	1m	1m
Height of parapet	1m	1m
Thickness slab	0.125m	0.125m
Thickness Exterior wall	0.230m	0.230m
Thickness of Interior wall	0.115m	0.115m
Seismic zone	Zone III	Zone III
Soil Condition	Medium Soil	Medium Soil
Wind Speed	39 m/s	39 m/s
Importance factor	1.5	1.5
Zone factor	0.16	0.16
Response reduction factor	5	5
Floor Finish	1.875 kN/m^2	1.875 kN/m^2
Live Load	4 kN/m^2	4 kN/m^2
Roof Live	2 kN/m^2	2 kN/m^2
Staircase load	3kN/ m^2	3kN/ m^2
Swimming pool load	18KN/m^2	18KN/m^2
Grade of concrete	M 25	M25
Grade of concrete in composite column	--	M30
Grade of reinforcing steel	Fe 415	Fe 415
Grade of structural steel	---	Fe 500
Density of concrete	25 kN/m^3	25 kN/m^3
Density of brick masonry	20 kN/m^3	20 kN/m^3
Damping ratio	5%	3%

Table 2: Beam and Column size used in R.C.C. and Composite structures

Type of Building	Beam Size	Column Size
R.C.C. Structure	450 mm X 450 mm	850 mm X 850 mm
Composite structure	500mm X 500mm of ISMB 250	Composite column of size 500mm X 500 mm with ISHB 250

5. PROCEDURE OF MODELING & ANALYSIS

The above details are used to model R.C.C. and Composite structure using SAP 2000. Using grid lines option model can be generated. Material are assigned using define menu. In Section properties option frame sections are defined as beam and column. Slab is assigned as slab section. In composite modeling column can be generated by using section designer. The materials assigned are as per codal requirement. The modulus of elasticity is 25 KN/mm². Poisson's ratio is taken as 0.2. The base joint of all columns are restrained against translation and rotation about all the three global axes. The fixed support is assigned. After creating model we have to assign various loads (Dead load, Live load, roof live, Earthquake load etc.). Mass irregularity should be considered in the form of swimming pool taking into consideration that it should be assigned at 9th floor.

In this article an attempt has been made to compare R.C.C. and Composite structure. In this study results are obtained from both Equivalent static and Response spectrum method of analysis in order to compare R.C.C and Composite structures. Joint displacement, base shear, storey drift, self-weight, shears force in columns, time periods are taken up to discuss on R.C.C and Composite structures.

3. RESULTS & DISCUSSIONS

3.1 Joint Displacement

Table 3: Joint Displacement in X-direction

Storey No	R.C.C.		Composite	
	EQ-X (mm)	RS-X (mm)	EQ-X (mm)	RS-X (mm)
Storey 11	116.3	91.3	90.0	73.6
Storey 10	111.3	87.7	87.7	71.9
Storey 9	104.1	82.6	82.3	68.1
Storey 8	94.6	76.0	75.1	63.0
Storey 7	83.3	68.0	66.8	57.1
Storey 6	70.7	58.9	57.6	50.4
Storey 5	57.1	48.8	47.8	43.0
Storey 4	43.0	37.7	37.7	34.8
Storey 3	28.9	26.1	27.3	26.0
Storey 2	15.7	14.5	16.9	16.5
Storey 1	5.0	4.7	6.8	6.8
Base	0.0	0.0	0.0	0.0

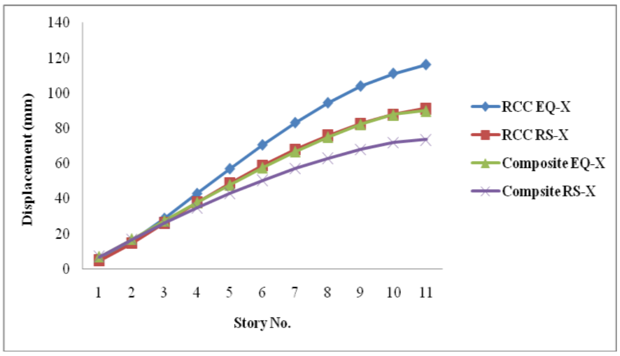

Figure 3: Joint Displacement in X-direction

Table 4: Joint Displacement in Y-direction

Storey No	R.C.C.		Composite	
	EQ-Y (mm)	RS-Y (mm)	EQ-Y (mm)	RS-Y (mm)
Storey 11	125.8	99.0	66.2	54.2
Storey 10	120.5	95.2	64.6	53.1
Storey 9	112.8	89.8	60.7	50.3
Storey 8	102.6	82.6	55.4	46.6
Storey 7	90.4	74.0	49.4	42.3
Storey 6	76.7	64.2	42.6	37.4
Storey 5	62.0	53.2	35.5	31.9
Storey 4	46.8	41.2	28.0	25.9
Storey 3	31.5	28.5	20.3	19.4
Storey 2	17.2	15.9	12.6	12.4
Storey 1	5.4	5.1	5.2	5.2
Base	0.0	0.0	0.0	0.0

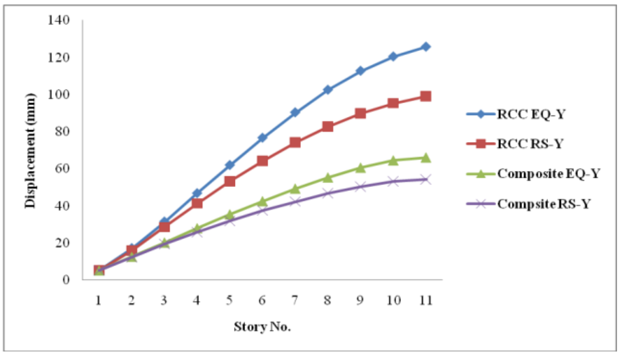

Figure 4: Joint Displacement in Y-direction

The above Tables and Figures show values of joint displacements for structures having mass irregularity at 9th floor. Composite structures represent lower values of displacement than R.C.C structures. Joint displacement in X-direction in composite structures is reduced by 18.36% and 14.3% after analyzing by both Equivalent static and Response spectrum analysis respectively. Similarly in Y-direction it reduced by 16.52% and 12.58% respectively.

3.2 Storey Drift

Table 5: Storey Drift in X-direction

Storey No	R.C.C.		Composite	
	EQ-X (mm)	RS-X (mm)	EQ-X (mm)	RS-X (mm)
Storey 11	4.9	3.5	2.4	1.7
Storey 10	7.2	5.1	5.4	3.8
Storey 9	9.5	6.6	7.2	5.1
Storey 8	11.3	8.0	8.3	5.9
Storey 7	12.6	9.1	9.2	6.7
Storey 6	13.6	10.1	9.8	7.4
Storey 5	14.1	11.1	10.2	8.1
Storey 4	14.1	11.7	10.4	8.8
Storey 3	13.2	11.6	10.4	9.5
Storey 2	10.7	9.9	10.0	9.7
Storey 1	5.0	4.7	6.8	6.8
Base	0.0	0.0	0.0	0.0

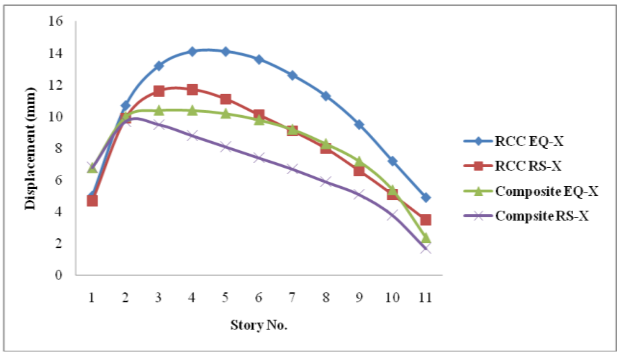

Figure 5: Storey Drift in X-direction

Table 6: Storey drift in Y-direction

Storey No	R.C.C.		Composite	
	EQ-Y (mm)	RS-Y (mm)	EQ-Y (mm)	RS-Y (mm)
Storey 11	5.2	3.7	1.6	1.2
Storey 10	7.7	5.5	3.9	2.8
Storey 9	10.2	7.2	5.2	3.7
Storey 8	12.2	8.6	6.1	4.3
Storey 7	13.7	9.8	6.7	4.9
Storey 6	14.7	11.0	7.2	5.5
Storey 5	15.3	12.0	7.5	6.0
Storey 4	15.3	12.7	7.6	6.5
Storey 3	14.4	12.6	7.7	7.0
Storey 2	11.7	10.8	7.5	7.2
Storey 1	5.4	5.1	5.2	5.2
Base	0.0	0.0	0.0	0.0

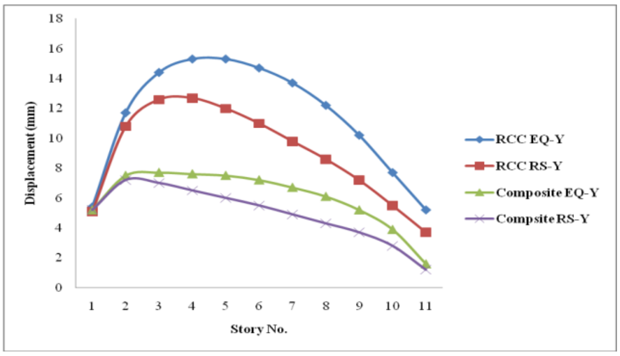

Figure 6: Storey drift in Y-direction

In the above Tables and Figures drift values are presented storey wise in X-direction and in Y-direction. Storey drift which is defines as displacement of any storey relative adjacent storey. Composite Structures having mass irregularity at 9th floor show storey drift reduction of 22.55% and 19.37% from R.C.C structures in X-direction and 21% and 18.6% in Y-direction i.e. Composite structures having lower values of storey drift compared to R.C.C. structures.

3.4 Base Shear

Table 7: Base Shear in X-direction & Y-direction

Type of Structure	Base shear in X-direction (KN)	Base shear in Y-direction (KN)
R.C.C.	5954.02	6657.33
Composite	4880.42	5453.35

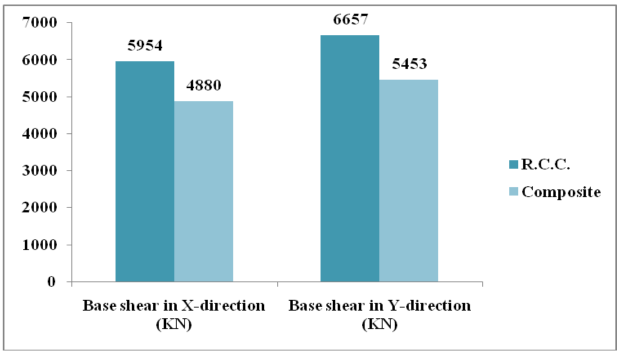

Figure 7: Base Shear in X-direction & Y-direction

Table 5 and Figure 5 shows Design base shear Values in X-direction & Y-direction. Design base shear obtained for composite structures having mass irregularity at 9th floor is decreased by 18% in X-direction and Y-direction.

3.5 Self-Weight

Table 8: Self-weight of the structure

Type of Structure	Self-weight (KN)
R.C.C.	145044.44
Composite	121585.90

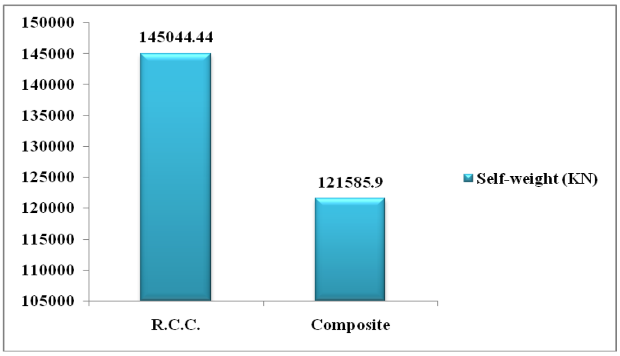

Figure 8: Self-Weight of the structure

Table 5 and Figure 5 represent self weight of structures. Composite Structures having mass irregularity at 9th floor is decreased by 16%.

3.6 Shear Force

Table 9: Shear force in X-direction & Y-direction for corner column

Analysis Method	R.C.C.	Composite
EQ-X	171.149	136.207
RS-X	172.492	136.866
EQ-Y	187.389	150.61
RS-Y	189.165	151.247

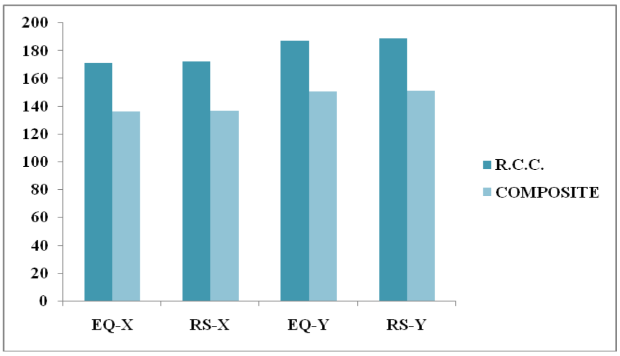

Figure 9: Shear Force in X-direction & Y-direction

From Table 9 & Figure 9 it is clear that Shear force in corner column for composite structures having mass irregularity at single floor in comparison with R.C.C structures reduces by 20% in both X-direction & Y-direction.

3.7 Time period

Table 10: Time period for R.C.C. & Composite structure

R.C.C.	Composite
2.342	2.120
2.306	2.111
2.117	1.933
0.693	0.672
0.684	0.671
0.634	0.618
0.351	0.378
0.348	0.377
0.325	0.351
0.214	0.258
0.212	0.256
0.199	0.239

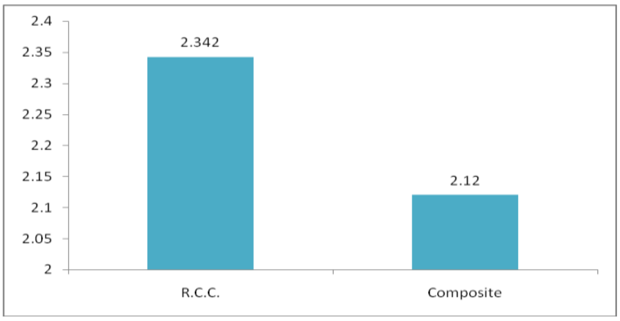

Table 10: Time period for Composite structure

Natural period for Composite structures having mass irregularity are lower than R.C.C. structures by 4.2%. Natural period values are presented in Table 10 & graphically shown in Figure 10.

4. CONCLUSION

In this study Mass irregularity is an important factor to be considered along with other relevant details in both Composite and R.C.C. buildings in order to compare them. Composite structures are typical to produce efficient and economical construction in case of regular structures. Here, a thought has been extended to irregularity in buildings to compare Composite with R.C.C. structures. Joint displacement, base shear, storey drift, shears force, self-weight and time period will help to decide which structure is efficient. Based on analysis and study on previous chapters will draw some conclusions which are presented below.

- The joint displacement values are less in composite structures compared to R.C.C. structures for both Equivalent static and response spectrum method which is because of high stiffness of composite sections. Response Spectrum method gives accurate values than Equivalent static method. The storey displacement values are within permissible limits as per codal provisions.

- Composite structures shows reduction of storey drift values of approximately 18% and 16% in X-direction and Y-direction from R.C.C. structures. In Equivalent static and Response spectrum method, Response spectrum gives better values than Equivalent static method.
- Design base shear values are reduced by 18% for composite structures. Because weight of Composite structures also less compared to R.C.C. structures.
- The dead weight of the composite structures is less compared to R.C.C. structures by 18%, hence earthquake forces also reduced by 18%.
- Shear force in Composite structures is reduced by 20%. Shear force obtained from Response spectrum method is nearly same as Equivalent static method.
- As it is already mentioned displacement values are less for composite structures so that time period required is also less for composite structures.
- From all the data obtained it is observed that results obtained for Equivalent static method for R.C.C and composite structures are quite high than Response spectrum method. Hence response spectrum gives better results than Equivalent static method.

The data mentioned above is clearly said that composite section is always a better choice against R.C.C. Composite Structure provides efficient and better option than R.C.C. structures.

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