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ANALYSIS OF G+15 RCC AND COMPOSITE STRUCTURE HAVING A SOFT STOREY AT GROUND LEVEL BY RESPONSE SPECTRUM AND EQUIVALENT STATIC METHODS USING ETABS 2013

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ABSTRACT

Comparing to RCC structures, steel concrete composite system are being more popular due to the various advantages they offer. Both speed and economy can be achieved in case of composite systems. An attempt was made in this work to evaluate and compare the seismic ***performance of G+ 15 storey's made of RCC and*** *composite structures ETABS 2013 software was used for the purpose. Both steel and concrete composite structures and RCC structures were having soft storey at ground level, structures were located in the region of earthquake zone III on a medium soil. Equivalent static and response spectrum method is used for analysis. Storey drift, self weight, bending moment and shear force, are considered as parameters. When compared composite structures shows better performance than RCC.*

Key words: Composite steel-concrete systems, Soft storey, Equivalent static method, Response spectrum method, Base shear.

1. INTRODUCTION

Composite members are made up of two different materials such as steel and concrete which are used for beams and columns. The steel and concrete structures have wide applications in multistory commercial buildings and factories as well as in case of bridges. Steel and concrete have almost the same thermal expansion, concrete is efficient in taking compression loads and steel is subjected to tensile loads. Composite structures are becoming popular and preferred choice of structural Engineers as disadvantages of using purely steel or purely concrete structures can be minimized. In composite construction initial construction loads will be carried out by steel frame sections including the self weight during construction and then concrete is cast around the section or concrete is poured inside the tubular section.

In this work, an attempt was made to compare the study of seismic performance of RCC and composite structures with soft storey at ground floor with different height using ETABS 2013. Storey drift, self weight, bending moment and shear force in columns are considered as parameters.

1.1 Components of composite structures

Composite slab

A composite slab in which steel sheets are connected to the composite beam with the help of shear connectors, initially steel sheets act as permanent shuttering and also act as bottom reinforcement for steel deck slab and later it is combined with hardened concrete.

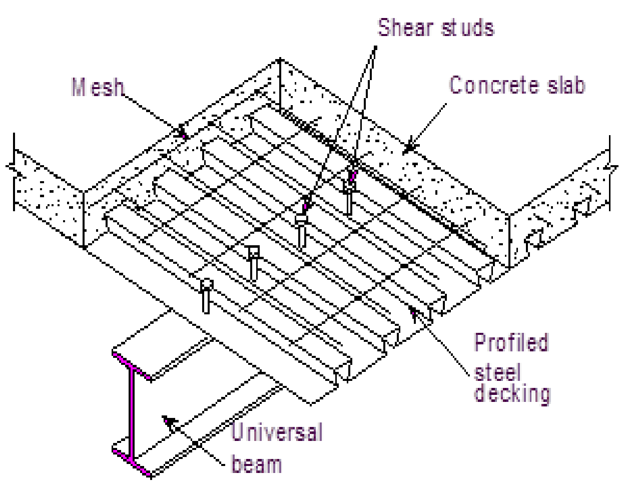

Fig 1: Composite Beam and Slab

Shear connectors

Shear connectors (studs) are used to connect the concrete and structural steel and they give the sufficient strength and stiffness to the composite member.

Fig 2: Installation of Shear Studs

Composite beam

A composite beam is a steel beam or partially encased beam which is mainly subjected to bending and it supports the composite deck slab.

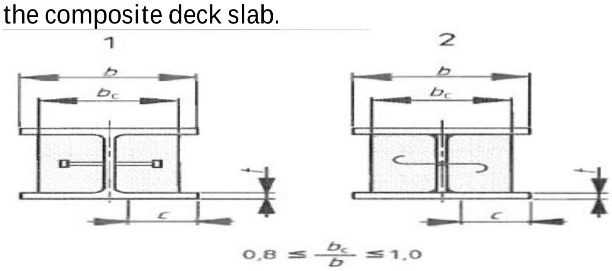

Fig 3: composite beam

Composite column

Composite columns are a composite compression members or bending and compression members with steel encased sections partially or fully and concrete filled tubes.

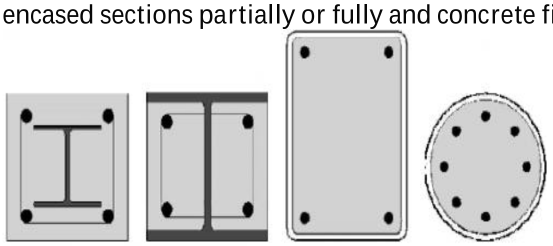

Fig 4: Composite Column

Plastic resistance of a composite column of a cross section will be determined by following equation

For concrete encased and partially concrete encased sections

$P_{PC} = A_a{*}f_{yd} + 0.85A_c{*}f_{cd} + A_s{*}f_{sd}$ Eq-1

For concrete filled sections

$P_{PC} = A_a{*}f_{yd} + Ac{*}f_{cd} + A_s{*}f_{sd}$ Eq-2

A_a – cross sectional area of structural steel

A_c – cross sectional area of concrete

A_s – cross sectional area of reinforcing steel

f_{yd} – design value of yield strength of structural steel

f_{cd} – design value of yield strength of cylindrical compressive strength of concrete

f_{sd} – design value of yield strength of reinforcing steel

1.2 Behavior of Soft Storey

Due to the presence of soft storey in the buildings large stress concentration will be developed at the joints which lead to formation of plastic hinges these plastic hinges will leads to collapse of structure. It may be soft storey at ground storey level or may be upper storey level the frame structures will undergo large sway mechanism. This sway will leads to formation of plastic hinges at top and bottom ends of the columns therefore these columns will subjected to large deformation.

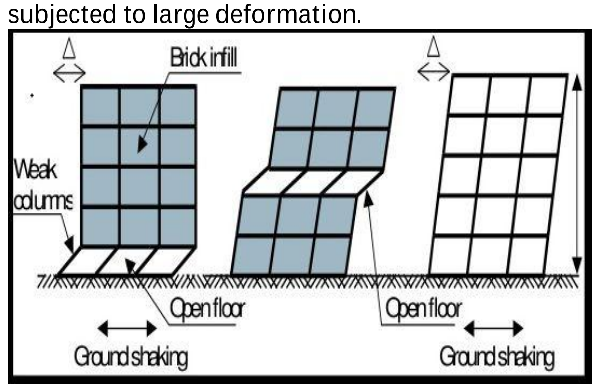

Fig 5: Behavior of Soft Storey

2. MODELING AND BUILDING DATA

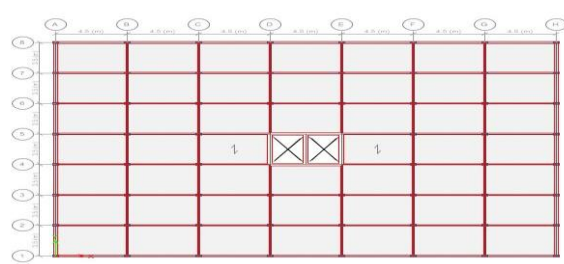

Fig 6: Building Plan

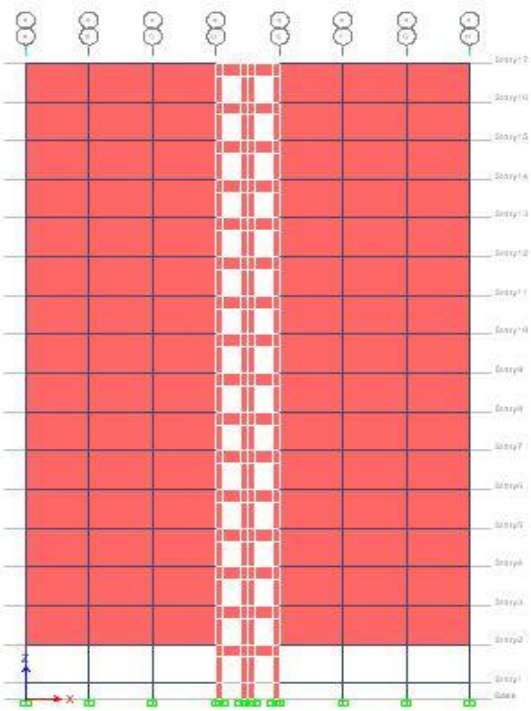

Fig 7: Building Elevation

Table 1: Building Data

Plan dimension	31.5m x 24.5m
No of storey's	G+15
RCC and composite model	51.2m, ground storey height 4m
Typical storey height	3m
Depth of foundation	1.2m
Thickness of concrete (lift) wall	300mm
Thickness of external wall	230mm
Thickness of internal wall	150mm
Height of parapet wall	1m
Thickness of parapet wall	150mm
Thickness of slab	150mm
Floor finish	1kN/m²
Live load on floors	4kN/m²
Live load on roof	1.5kN/m²
Density of concrete	25kN/m³
Density of brick	20kN/m³
Grade of concrete(f_{ck})	M30
Grade of steel(f_y)	Fe 415

Table 2: Section Dimensions for RCC and Composite Models

Sections	storey levels	Model With Soft Storey Height 4m	Composite Model With Soft Storey Height 4m
Beams	1 to 2	230mm X 400mm	350mm X 750mm
	3 to12	230mm X 400mm	300mm X 600mm
	13 to17	230mm X 300mm	230mm X 400mm
Columns	1 to12	ISHB 200-1	600mm X 600mm ISHB 400-1
	13 to 17	ISHB 200-1	400mm X 400mm ISHB 300-1

2.1 Analysis of Building

Equivalent static and response spectrum method are used for the analysis of RCC and composite structures with soft storey. In equivalent static analysis single mode of vibrations are considered. Base shear can be determined by multiplying total seismic weight of building to coefficient of acceleration spectrum value. In response spectrum method, dynamic characteristics are considered for analysis. In this method multiple modes of vibrations are considered where base shear of each mode can be calculated separately. It can be calculated by determining the modal mass and modal mass participation factor for each mode.

EQX- Equivalent static in X direction
EQY- Equivalent static in Y direction
SPX- Response spectrum in X direction
SPY- Response spectrum in Y direction

2.2 Results and Discussion

1. Storey Drift

Table 3: Storey Drift (in mm) for Equivalent Static and Response Spectrum Methods

Models	RCC		COMPOSITE	
Storey No	EQX	SPX	EQX	SPX
Story17	0.1	0.0413 5	0.03135	0.0229
Story16	0.1	0.0413 7	0.03138	0.02291
Story15	0.1	0.0413 9	0.0314	0.02293
Story14	0.1	0.0414	0.03142	0.02294
Story13	0.1	0.0414 2	0.03144	0.02296
Story12	0.1	0.0414 3	0.03145	0.02297
Story11	0.1	0.0414 4	0.03145	0.02298
Story10	0.1	0.0414 5	0.03145	0.02298
Story9	0.1	0.0414 6	0.03144	0.02299
Story8	0.1	0.0414 6	0.03143	0.02299
Story7	0.1	0.0414 5	0.0314	0.02298
Story6	0.1	0.0414 3	0.03136	0.02297
Story5	0.1	0.0413 1	0.03123	0.02286
Story4	0.1	0.0397 9	0.02986	0.02149
Story3	0.1	0.1	0.1	0.1
Story2	1	1	0.9	0.9
Story1	0.2	0.2	0.2	0.2

Storey drift is reduced by 10% in composite models compared to RCC in soft storey level. In other storey's using equivalent static case, storey drift is reduces by 70% and the same reduces by 50% using response spectrum case.

2. Self Weight

Table 4: Self Weight (in kN) For RCC and Composite Models

Models	Self Weight (in KN)
RCC	208524.3
Composite	188811.1

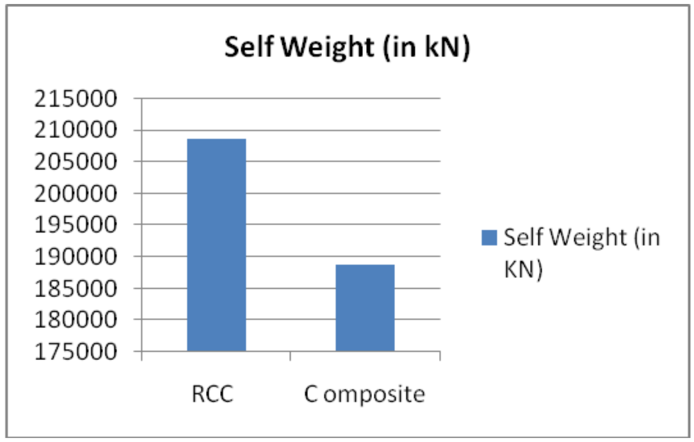

Chart 1: Self Weight For RCC and Composite Models
Self weight is reduced by 10% in composites compared to RCC.

3. Bending Moments

Table 5: Bending Moment (in kN – m) for Corner Column

Models	Bending moment in X direction	bending moment in Y direction
RCC	95.6772	10.3626
Composite	84.2998	39.7226

Bending moment in X direction in composites is reduced by 11% compared to RCC, but in Y direction it is increased by 70%.

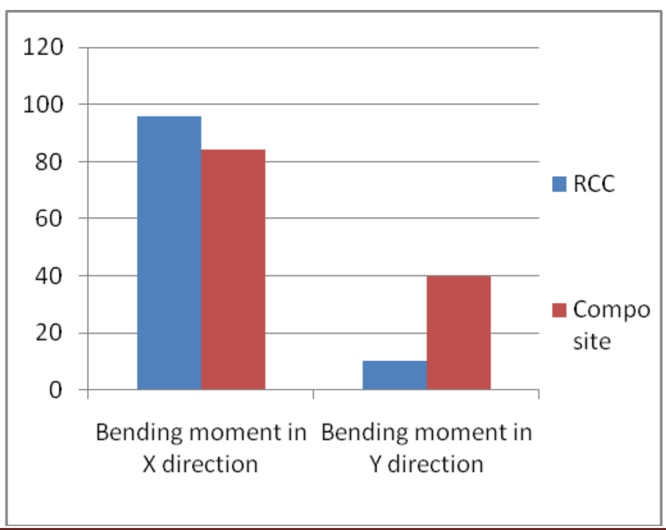

Chart 2: Bending Moment for Corner Column

4. Shear Force

Table6: shear force (in kN) for corner column

Models	Shear Force in X direction	shear force in Y direction
RCC	38.5561	4.4534
Composite	32.6495	15.2413

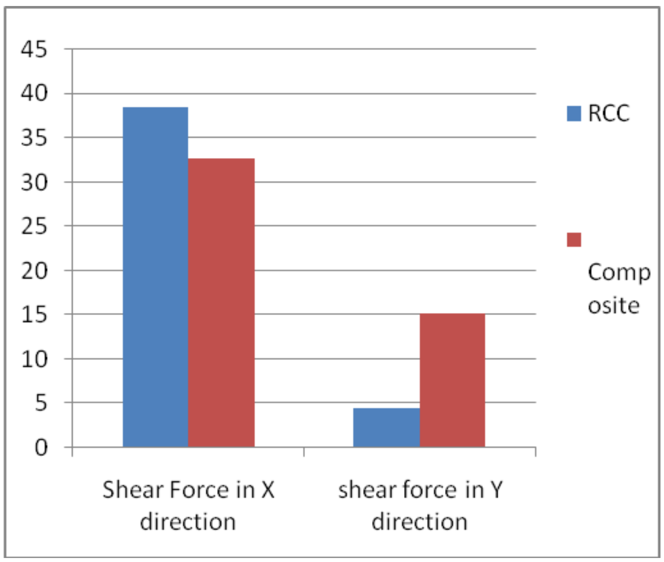

Chart 3: shear force for Corner Column

Shear force in X direction in composites is reduced by 16% compared with RCC, but in Y direction increases by 65%.

3. CONCLUSION

Two structures G+15, one made of composite steel concrete material and other one is made up of RCC, situated in the earth quake zone III, having a medium soil were investigated analytically for their performance using ETABS software. Following are the broad conclusions

- Storey drift reduces in composite structures as compared to RCC, because composite structures have higher stiffness than that of RCC. In both RCC and composite structures, storey drift is within permissible limit, i.e., 0.004 times the height of storey.
- Storey drift is different in both X and Y direction because of the difference in moment of inertia in the column sections.
- It is possible to control the drift in soft storey by providing 1) Shear walls 2) Bracings 3) Stiffer column 4) Lateral load resisting system.
- The beams and columns in the soft storey are designed 2.5 times of obtained bending moments and shear forces. And shear walls are designed by a factor of 1.5 times the storey shear.
- Self weight of composite structures reduces as compared to RCC which in turn reduces the foundation cost. Due to the reduction of self weight of composite structures, it induces fewer amounts of lateral forces.
- Bending moments and shear forces in columns for composite structures are less as compared with RCC structures in X direction, but in Y direction RCC have more bending moments.
- Composite structures are being more ductile, resist lateral load better than RCC structures.

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