Comparison of Seismic Behavior of a Structure with Composite and Conventional Columns

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Abstract - ***An extensive study has been carried out on the behavior of composite column in a structure. In composite column construction steel and concrete are united in such a manner that the advantages of the materials are employed in a efficient manner. By bonding and friction between steel and composite material these materials will accept the external loading in composite columns. In this study comparison of composite and conventional structure is carried out. Just varying the design of column i.e., by using composite and conventional column and keeping all other structural members same for both the structures. Composite column design is carried out according to Euro code 4 and conventional column design is by IS 456-2000. The buildings are taken to be true to be placed in III seismic zone. Seismic design is followed by IS 1893-2002. There are many different types of composite column from those we have taken concrete encased composite column for our analysis. Concrete encasement would increase the load resistance of steel column.***

During seismic activity the response of structure is also influenced by the material property which depends on the materials and also its configuration in the structural system. The base of the structure is assumed to be fixed. The building height is 36.8m which comes under low rise building. Modeling and analysis has been carried in ETABS software. The results are obtained of various parameters such as base shear, storey overturning, storey drift etc.., thus by obtaining those results graphs have been plotted. And comparison of two different type of structure has been done. Thus, we found that low rise conventional building is more suitable than low rise composite building.

Key Words: *Composite columns, Seismic behavior, ETABS Software, roof displacement, Storey drift, Overturning moment etc.,*

1. INTRODUCTION

A column is designed to combine two different materials or two different grades of material to form a structural member. A composite column is a member which is mainly subjected to compression or to compression and bending.

Composite construction that seeks to co-action the capabilities of two materials i.e., concrete and light weight steel has been used in both buildings and bridges over a many spans. The buildings in India are constructed with RCC and the use of steel structures is generally restricted to industrial buildings and of late multi-storey buildings, which have acquired eminence by adopting composite structural elements. However, in recent times, the composite columns are gaining popularity for use in multi-storey buildings by excellence of their static and earthquake resistant properties. The earthquake resistance properties such as follows

1. Lower mass & high strength, rigidity and stiffness.
2. High toughness and ductility.
3. High energy dissipation ability.

A concrete-steel column is a compression column member. These columns are usually referred as load-carrying members in a composite framed structure.

1.1 History of Composite Columns

It is commonly divided into 4 periods

1. Earlier of the 20th century research has been started.
2. In 1930 a first highlight is applied.
3. Oblivion period.
4. Renewal of research and its application has started from 1950 till today.

The premature evolution of composite column was predicated on the dominancy for providing efficacious fire resistance for structural steel in buildings. Generally to wrap steel beams in concrete. The impuissant concrete resulted in very little vigor. Increment in vigor and stiffness due to wrapping of concrete is neglected! In past, albeit it was descried that bucking resistance for the columns was incremented.

By early 1960, research showed that concrete encasement or wrapping can increase the load resistance of steel columns. Substantial economy in construction could be gained by using a better quality of concrete and introducing the composite action in design of columns. Both steel section and concrete oppose the exterior loading by collaborating collectively through friction and chemical bond. And also by the use of mechanical shear connectors in some circumstances.

Albeit composite columns of steel & concrete were infrequently utilized from the terminus of World War II until the early 1970s, research had commenced a long time afore, at the commencement of the 20thcentury. Cumulating of these materials had shown interest, steel columns were customarily encased in concrete to bulwark them from fire, while concrete columns were coalesced with structural steel as reinforcement.

Now-a-days Euro code 4, the design method of Roik and team was considered developed in the 1970s. This was taken as a substructure for the proposed simplified design method.

1.2 Advantages of Composite Column

- Protection against corrosion in case of concrete encased columns.
- Even smaller dimension gives better strength.
- Fire proof.
- Increased buckling resistance
- Increased stiffness which influences to reduce slenderness of column.
- Economically advantageous over either pure reinforced concrete or structural steel.
- Concrete filled tubular columns formwork is not required.
- High rise building can be erected in an efficient manner.
- By changing steel depth, concrete vigor and reinforcement identical sections can be adopted with different loads and moment resistance. This in turn influence to keep outer dimension of column to be constant and simplifying the construction and architectural detailing.
- Higher stiffness results in less deflection, longer spans and less overall height.

There are several other applications of composite construction including multi-storey car parks, industrial and residential buildings, apartments, metro station buildings, etc

1.3 Aim of the study

The objective is8to the study the behavior of steel concrete composite column in a multi stored structure by giving some importance to structural response in seismic areas.

The main aim of the study is to compare the seismic behavior of two types of multi stored framed structure consisting of:
1. Steel beam, RC Slab & RC Column.
2. Steel beam, RC Slab & Concrete encased steel (CES) Composite column.

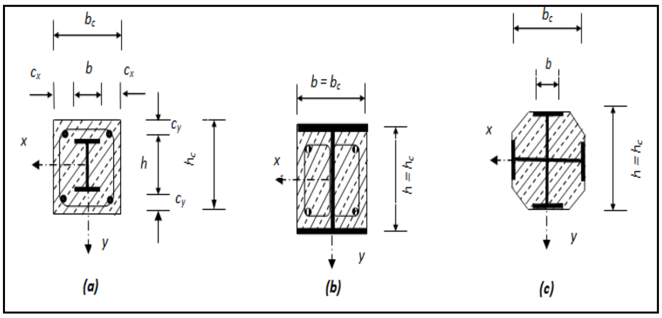

Fig-1:Cross-sections of fully and partially concrete encased columns

2. BUILDING DESCRIPTION

One of the prime objectives of this project is to study the behavior of composite and conventional structure in a particular seismic zone. Investigation is carried out to assess the performance of the framed structure with two alternative column schemes, RCC and Encased. The structures are modeled and analyzed using ETABS software package as per IS 1893: 2002.

Table-1: Common Specifications for RCC and Encased Structures

Seismic zone	III
Zone factor	0.24
Importance factor	1
Response spectra as per IS 1893:2002 (part 1)	3
Damping ratio	5%
Type of soil	Rock or hard soil
Number of storey's	G+10
Base dimension of the building	17.2m x 21.35m
Total height of the building	36.8m
Typical storey height	3.2m
Plinth height	1.5m
Number of Bays along X-direction	3
Number of Bays along Y-direction	10
Live load	2kN/m

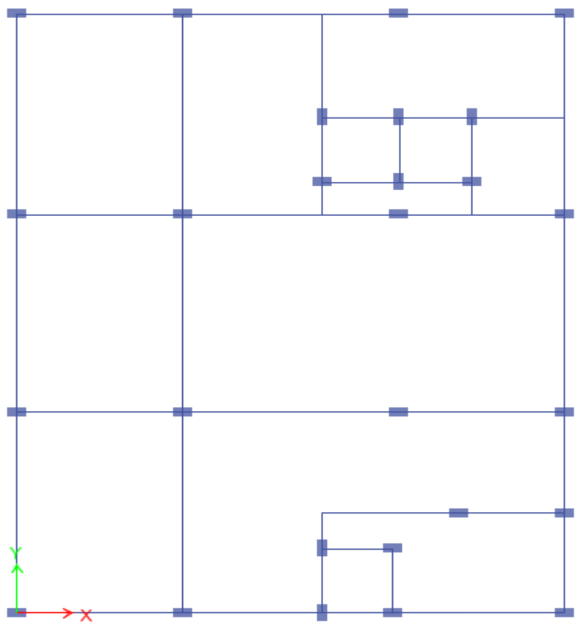

Fig -2: Plan of the Building (17.2m X 21.35m)

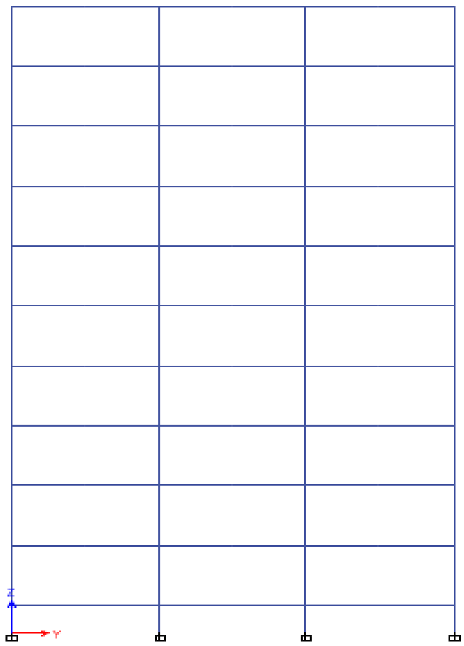

Fig -3: Elevation of the building

Fig 2 shows the plan of the building which is having base dimension of the building as 17.2m x 21.35m

A portion of structure's elevation view with the assignment of beams and conventional columns is as shown in figure 4 below.

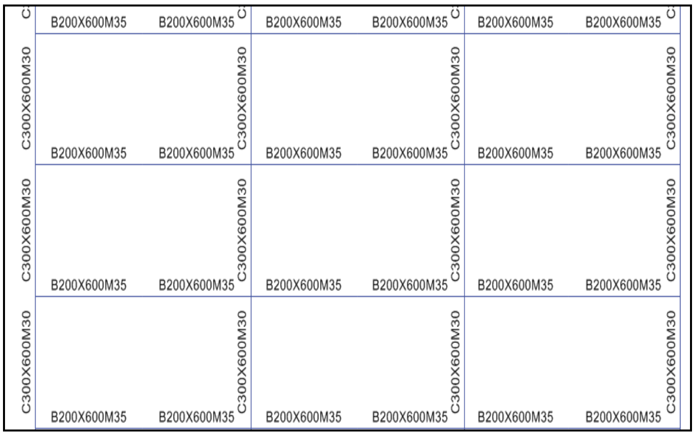

Fig -4: Section properties assigned to structure

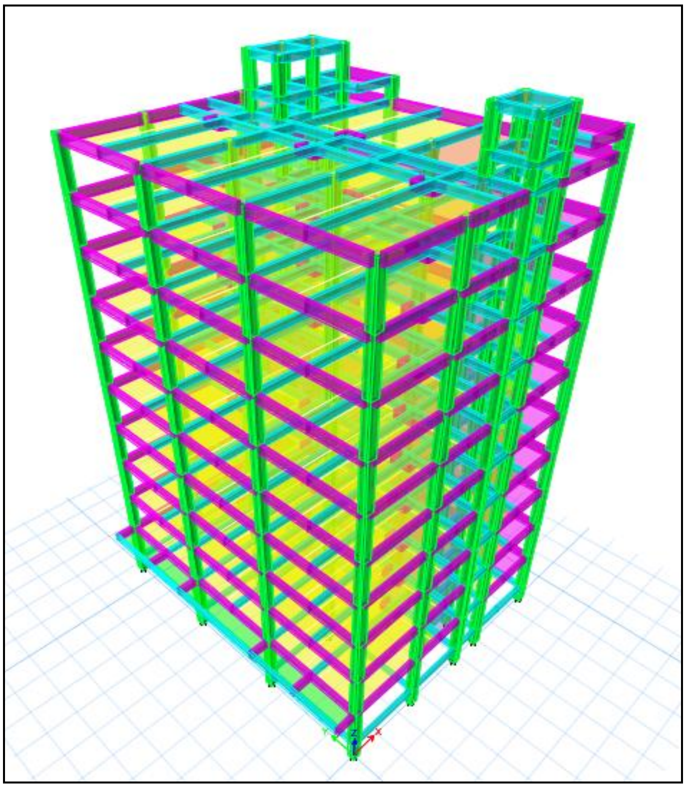

Fig -5: Isometric view of structure

3. RESULTS AND DISCUSSION

After analysis of the conventional and composite column structures located in seismic zone III conforming to IS 1893:2002 by using ETABS, the results are extracted and compared in terms of critical earthquake response parameters such as base shear, maximum storey drifts, roof displacements and storey overturning moments. Comparative results are listed in tables and graphs below.

Table- 2: Comparison of composite and conventional (RC) building for base shear

STOREY LEVEL	BASE SHEAR (kN)		% increase of base shear
	COMPOSITE	CONVENTIONAL	
LMR TOP	281.616	0	100
LMR BOTTOM	776.5786	0	100
TERRACE	2566.665	349.305	86.39
8F	4777.847	737.262	84.56
7F	6755.505	1047.6	84.49
6F	8499.639	1288.98	84.83
5F	10010.25	1470.04	85.31
4F	11287.33	1599.46	85.82
3F	12330.9	1685.87	86.32
2F	13140.93	1737.93	86.77
FF	13717.45	1764	87.14
GROUND FLOOR	14100.11	1774.75	87.41
PLINTH	14128.06	1774.98	87.43

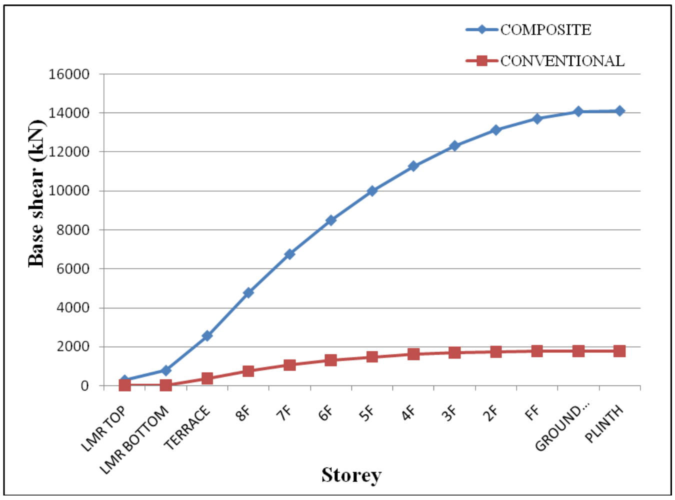

Chart- 1: Comparison of composite and conventional (RC) building for base shear.

Base shear for composite building is observed to be 8 times higher than that of conventional building. Maximum base shear is observed in case of composite structures. From this it is noticed that conventional structure is safer.

Table- 3: Comparison of composite and conventional (RC) building for overturning moment

STOREY LEVEL	STOREY OVERTURNING MOMENT (MN-m)along X direction		% increase
	COMPOSITE	CONVENTIONAL	
LMR TOP	0	0	0
LMR BOTTOM	0.5913	0	100
TERRACE	1.5232	0	100
8F	9.7366	1.1177	88.52
7F	25.0257	3.4770	86.10
6F	46.6433	6.8293	85.35
5F	73.8422	10.9540	85.16
4F	105.875	15.6582	85.21
3F	141.994	20.7764	85.36
2F	181.453	26.1712	85.57
FF	223.504	31.7326	85.80
GROUND FLOOR	267.4	37.3784	86.02
PLINTH	312.52	43.0576	86.22
BASE	333.713	45.7200	86.29

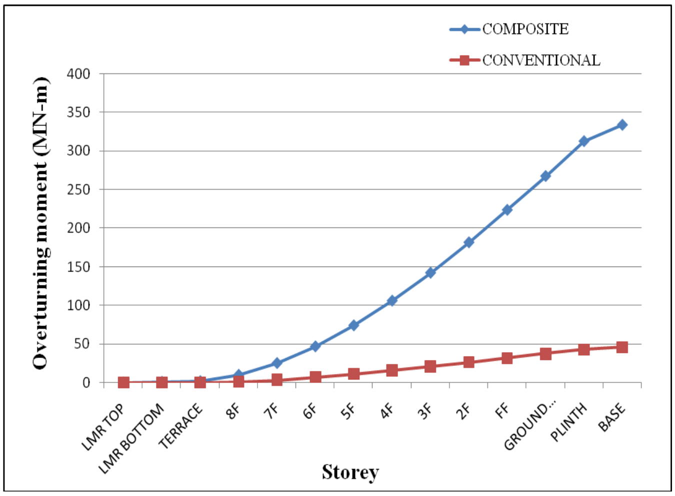

Chart- 2: Comparison of composite and conventional (RC) building for overturning moment

When compared with composite building conventional building have very low overturning moment nearly 8 to 9 times difference is observed. Overturning moment is maximum at the base of the building. A very drastic change is observed in the structures when compared.

Table- 4: Comparison of composite and conventional (RC) building for storey drift.

STOREY LEVEL	STOREY DRIFT along X direction		% increase
	COMPOSITE	CONVENTIONAL	
LMR TOP	0.00398	0.00052	86.93
LMR BOTTOM	0.00406	0.000551	86.42
TERRACE	0.005007	0.00081	83.82
8F	0.007158	0.001231	83.80
7F	0.00927	0.001614	82.58
6F	0.01114	0.001916	82.80
5F	0.01272	0.002136	83.20
4F	0.01399	0.002282	83.68
3F	0.01493	0.002362	84.17
2F	0.015547	0.002377	84.71
FF	0.01530	0.002301	84.96
GROUND FLOOR	0.01301	0.001959	84.94
PLINTH	0.005069	0.000762	84.96
BASE	0	0	0

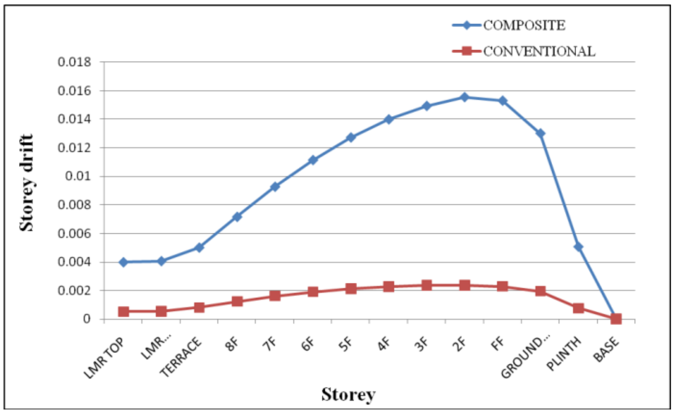

Chart -3: Comparison of composite and conventional (RC) building for storey drift

Storey drift along both X and Y direction is maximum in 2Floor in composite building. In conventional building considerable difference is observed between the floors. More drift is observed in X direction when compared along Y direction.

Table- 5: Comparison of composite and conventional (RC) building for roof displacement.

STOREY LEVEL	DISPLACEMENT (mm) along X direction		% increase
	COMPOSITE	CONVENTIONAL	
LMR TOP	394.6	62.7	84.11
LMR BOTTOM	386.4	61.7	84.03
TERRACE	384.7	61.8	83.93
8F	368.7	59.2	83.94
7F	345.8	55.3	84.00
6F	316.1	50.1	84.15
5F	280.5	44	84.31
4F	239.8	37.1	84.52
3F	195	29.8	84.71
2F	147.2	22.3	84.85
FF	97.7	14.7	84.95
GROUND FLOOR	48.7	7.3	85.01
PLINTH	7.6	1.1	85.52
BASE	0	0	0

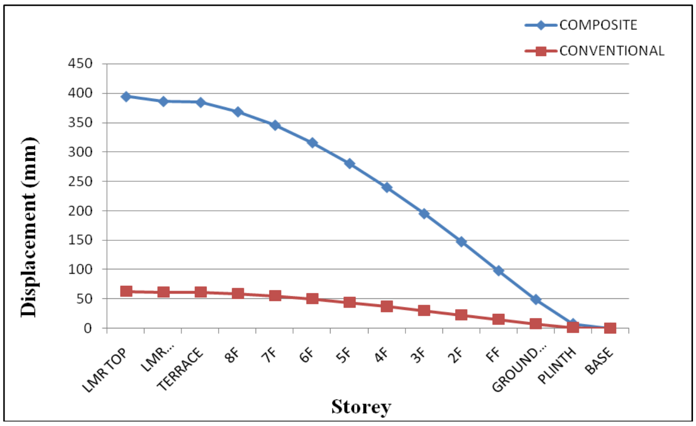

Chart -4: Comparison of composite and conventional (RC) building for roof displacement

Comparatively, the conventional building has less roof displacements for the same floor locations of the composite building, though the displacement patterns are same for both the buildings.

4. CONCLUSIONS

Analytical study has been conducted to understand the behavior of concrete encased columns in a structure. ETABS software is used to carry out the analysis. Comparison of conventional and composite design has done. And the following conclusion has been drawn from it.

- Both the composite and conventional buildings/structures which are comparatively studied, behave identically for the parameters considered, but more difference in their magnitudes.
- It is observed that the base shear is about 80% difference in composite columns structure when compared to the structure with RC columns. Hence, conventional building can be considered superior than the composite building in terms of base shear.
- From the comparative study made for a typical low rise building with a height of 36.8 m, the base shear is more in composite structure and so it is more vulnerable to earthquake than the RC building.
- Storey drifts and overturning moments are also higher that is 80% and 85% in the case of composite building.
- The storey drift is maximum at second floor which may cause more damage to the floors above it, particularly in case of composite structure. But in conventional building, not much drift are observed in between successive floors, which makes it relatively safe.
- These results and comparative study observations lead to a conclusion that for low rise buildings composite column design is not suitable.

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