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Comparison of seismic behaviour of atypical Multi-storey structure with composite Columns and steel columns

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Abstract
In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfilment of this purpose a large number of medium to high rise buildings are coming up these days. For these high rise buildings it has been found out that use of composite members in construction is more effective and economic than using reinforced concrete members. The popularity of steel-concrete composite construction in cities can be owed to its advantage over the conventional reinforced concrete construction. Reinforced concretes frames are used in low rise buildings because loading is nominal. But in medium and high rise buildings, the conventional reinforced concrete construction cannot be adopted as there is increased dead load along with span restrictions, less stiffness and framework which is quite vulnerable to hazards. In construction industry in India use of steel is very less as compared to other developing nations like China, Brazil etc. Seeing the development in India, there is a dire need to explore more in the field of construction and devise new improved techniques to use Steel as a construction material wherever it is economical to use it. Steel concrete composite frames use more steel and prove to be an economic approach to solving the problems faced in medium to high rise building structures.

I. Introduction

Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. The construction industry has discovered, invented and developed a number of technologies, systems and products, one of them being the concept of Pre-Engineered Buildings (PEBs). As opposed to being on-site fabricated, PEBs are delivered as a complete finished product to the site from a single supplier with a basic structural steel framework with attached factory finished cladding and roofing components. The structure is erected on the site by bolting the various building components together as per specifications. PEBs are developed using potential design software. But sometimes for small sheds PEB may prove costly also. Comparative study includes deflections, bending moments in x & y direction, axial force & shear force in columns & beams, size and material consumption of members in composite with respect to steel sections. Composite construction combines the better properties of the both i.e. concrete in compression and steel in tension, they have almost the same thermal expansion and results in speedy construction.

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis employs the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures. After analyzing the structure, a structural engineer should assign proper structural sections so that the structure can sustain existing loads along with wind and seismic loads. Structural members are beams, columns, sub beams, footings and other necessary sections that is required for an industrial building.

Formulation of Present Work

Analysing and design of composite structures is done through modelling in Etabs. First simple G+5 storey model prepared with steel columns and beams

Model I – Building With Steel Column & Beams (G+5 Storey)

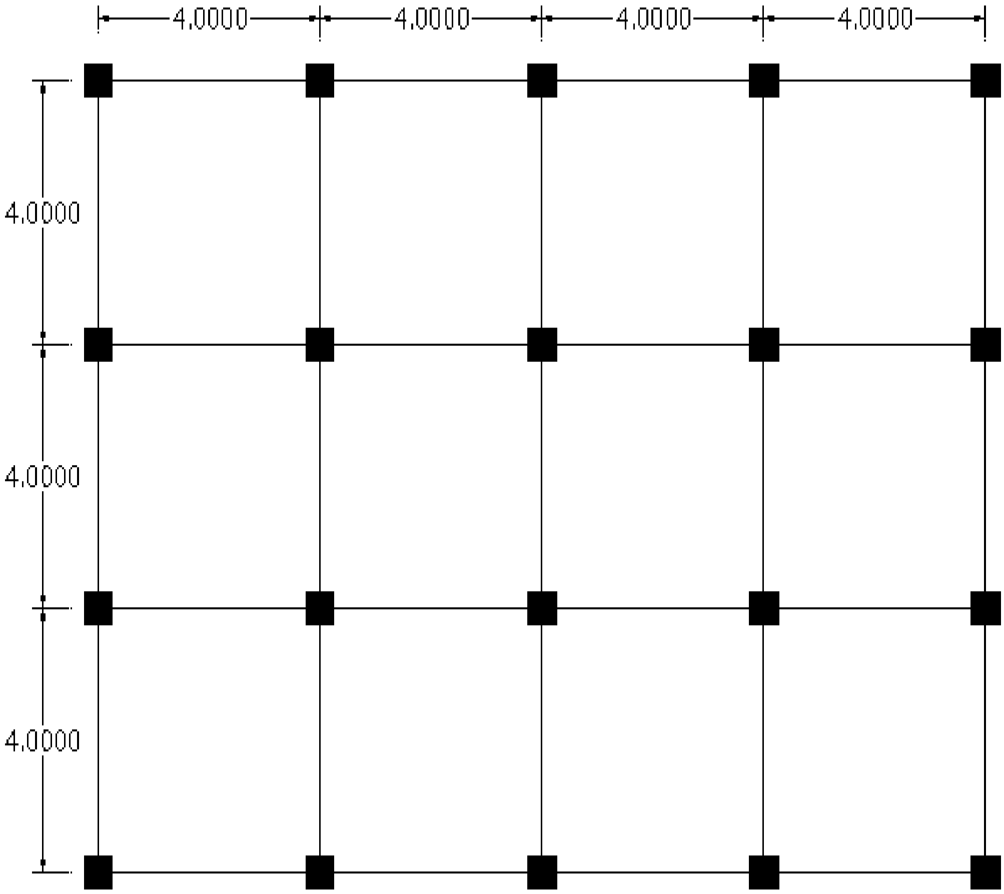


Fig :3. 1 Plan of building

A building model is prepared in Etabs where plan dimensions are 16 m X 12 m . Total height of building is 20.7 m It is a 5 storey building having height of each floor 3.2 m .Consider ISMB 350 as beam ans ISMB 500 as column. Using M-25 grade of concrete and Fe-500 Steel for RC structure.

Table 3.1 : Model I Details

Plane dimensions	16x12 m
Total height of building	20.7 m
Height of storey	3.2m
Height of parapet	1m
Depth of foundation	1.5m
Size of beams	ISMB 350
size of columns	ISMB 500
Thickness of slab	125 mm
Thickness of walls	230 mm
Seismic zone	III
Soil condition	Hard
Response reduction factor	5
Importance factor	1
Floor finishes	1.0kN/m^2
Live load on floors	4 kN/m^2
Grade of Concrete of RC Slab	M25
Grade of Steel of RC Slab	Fe500
Density of Concrete	25 kN/m^3
Density of brick masonry	20 kN/m^3

Live load taken as per Is 456 about 4 kN/m2. Floor finish taken as 1.0 kN/m2.

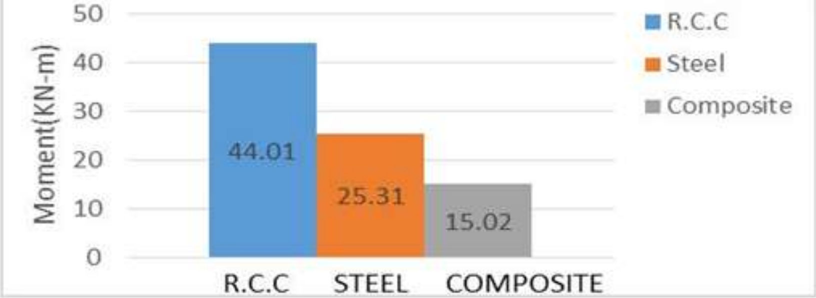
II. Conclusion & Suggested Further Work

The advantage of superior performance of composite columns under gravity loads have been brought out in several studies. However, the lateral load resistance of composite columns especially against seismic loads has not been investigated so extensively. The present study makes an attempt to bring out the advantages of composite columns against conventional Steel columns in multi-storey structures. For this purpose, a typical (G+5) framed multi-storey building with two alternative column schemes vis a vis. Steel and Concrete Filled Steel Tube (CFST) located in seismically active moderate zones III is taken up for evaluation and equivalent static lateral load analysis is carried out using Etabs software. Following are the conclusions of analysis and design of three models based on steel beam column beam and composite sections.

1. Displacement for composite structure has increased by 48% and for steel structure by 49% compared to that of Reinforced concrete structure.
2. Drift of all structures is within permissible limit.
3. Column forces in steel structure have reduced by 48% and in composite structure by 50% compared to that of R.C.C structure
4. Beam moments in composite structures have reduced considerably compared to that of R.C and steel structures.
5. Composite structures are more economical compared to that of R.C structures.
6. Also time required for construction of composite structures is less compared to that of R.C structures as no formwork is required.
7. In RCC and composite structures, storey displacement and storey drift values are within permissible limit.
8. Storey displacement is reduced up to 20% and 18% in CFST columns encased with I section in X and Y directions respectively. And CFRP wrapping on CFST columns reduced the displacement up to 18% and 17% in X and Y directions respectively.
9. It is clear that the maximum storey displacement and storey drift in a CFST columns with encased I section, by response spectrum analysis, compared to an R.C.C. structure in both longitudinal and transverse directions are less which is due to the higher stiffness of members in a composite structure compared to an RCC structure. So CFST columns encased with steel I section performs well under earthquake forces.
10. Base shear values are 28% and 27% more for CFST columns encased with steel I section compared to RCC columns in transverse and longitudinal directions respectively. This may be due to increase in weight of Composite columns.
11. CFRP Wrapping reduces storey displacement, and storey drift up to 8% and 5% respectively compared to unwrapped CFST columns. So CFRP wrapping improves overall performance of composite columns by providing additional confinement to the concrete without increasing the original column size. CFRP wrapping on CFST column is effective in multi-storied structure.
12. CFRP wrapping is more effective in circular composite columns compared to rectangular columns due to variation in lateral confining
13. Pressure distribution for rectangular columns. Also more numbers of CFRP layers are not performing well due to delamination failure of CFRP sheets.
14. Structural frames with CFST columns have good performance due to near field earthquakes, they bear higher base shear in comparison to equivalent ordinary RC frames which can be collapse due to earthquake, but because of their high shear capacity they remain safe during the earthquake.

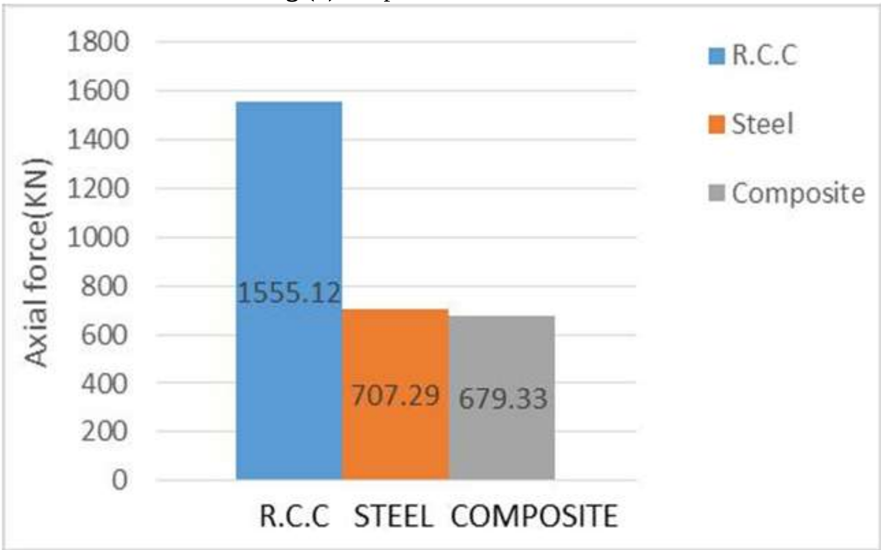
By doing the proper analysis of frame ie model of a G + 5 building in E tab following graphs are prepared on the basis of the stresses given by the software, which are useful in doing comparison of the various material parameters,

Fig. Graph for Beam Moments



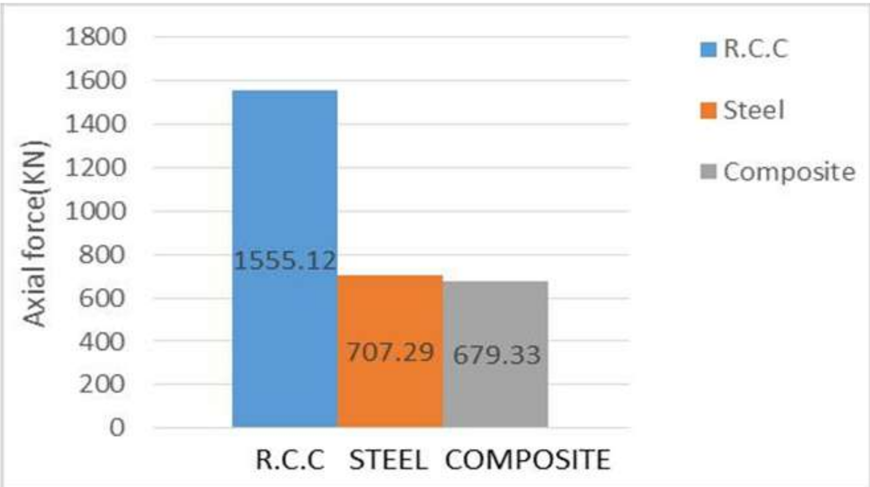
The above graph shows the moments induced in the beam after applying the load in respective members. On this on X axis material heads like RCC steel are shown and on Y axis moments induced in the respective heads are shown.

Fig (a) Graph for Column Forces



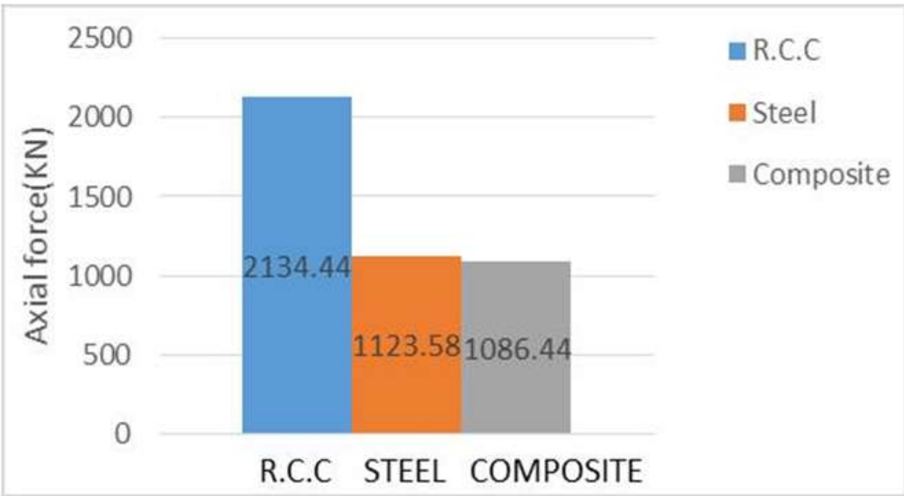
The above graph shows the moments induced in the column after applying the load in respective members. On this on X axis material heads like RCC steel are shown and on Y axis moments induced in the respective heads are shown.

Fig (b) Graph for Column Forces



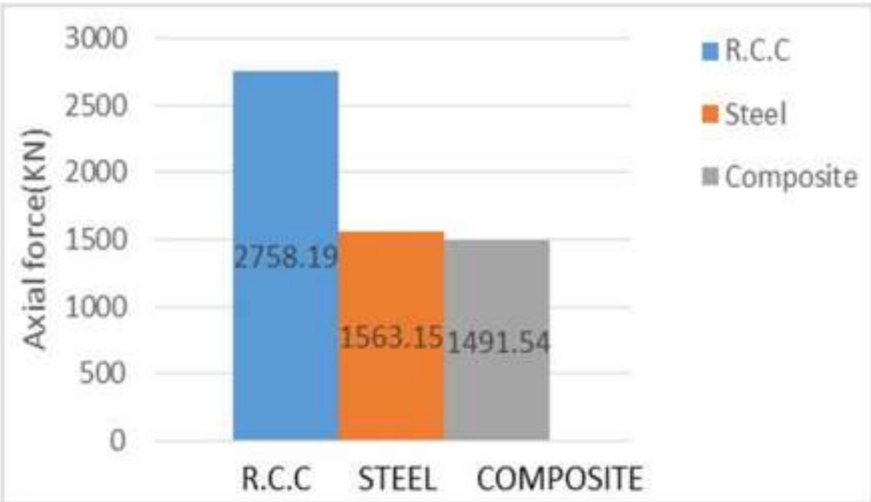
The above graph shows the moments induced in the column after applying the load in respective members. On this on X axis material heads like RCC steel are shown and on Y axis moments induced in the respective heads are shown.

Fig (c) Graph for Column Forces



Above graph shows the moments induced in the column after applying the load in respective members.On this on X axis material heads like RCC steel are shown and on Y axis moments induced in the respective heads are shown.

Fig (d) Graph for Column Forces



Above graph shows the moments induced in the column after applying the load in respective members. On this on X axis material heads like RCC steel are shown and on Y axis moments induced in the respective heads are shown.

Suggested further work

Analytical study has to be been conducted to understand the behavior of concrete encased columns in a structure. For that ETABS software is to be used to carry out the analysis. Comparison of conventional and composite design has done.

An extensive study has to be 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.

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