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# Seismic Performance of Composite Frame and RCC-Moment Resistant Frame for G+9 Storey Buildings

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**Abstract**

Composite structure is a structure made with steel and concrete where hot rolled steel sections are used as structural members to take tensile force whereas concrete take compressive load in structure. Now-a-days construction has gained wide acceptance worldwide as an alternative to pure steel and pure concrete construction. There is a great potential for increasing the volume of steel in construction,especially in the current development needs Nepal and not using steel as an alternative construction material.So, it is better to use best character of both steel and concrete in the structure which is known as composite structure.This research has been carried out to study the behaviour of composite structure in commercial buildings. Two different type irregular building with varying floor height of G+9 storey building are taken to the analysis and by using the linear time history analysis and Etabs v16 comparision is done on same plinth area of RCC model and composite model and results obtained are discussed.The comparision is based on the different parameter like Time period ,Base shear and Top displacement where as the three different input excitation are taken i.e Loma-Priata Earthquake,Kobe Earthquake and Northridge Earthquake.

**Keywords**

Seismic Behavior Composite structure, Composite column, Comparison parameter

## 1. Introduction

The entire territory of Nepal lies in high seismic hazard zone. Seismicity of Nepal is related to the movement of tectonic plates along the Himalayas that has caused several active faults. A total of 92 active faults have been mapped throughout the country by the Seismic Hazard Mapping and Risk Assessment for Nepal carried out as part of the Building Code Development Project – 1992-1994 (MHPP, 2994). Earthquakes of various magnitudes occur almost every year and have caused heavy losses of lives.

The composite members are used in construction from the necessity of protecting the steel member from fire and corrosion. Composite construction of steel concrete structure first appear in United states in 1894 but the design guide line were established in 1930. The composite structures are generally defined as the structures with members having composite cross-sections. In such cross-sections, more than one material (generally reinforced concrete and steel sections) are bound to act together to get optimum benefit and capacity utilization of each material[1]. The steel reinforcing bars are generally considered as a component of traditional RC construction, while the steel sections are hot-rolled or built-up sections welded, riveted or bolted with steel plates.

For many years composite construction has been widely applied in many types of structures Originated from the steel construction, the most popular type of composite construction is the composite floor beam, in which the concrete slab on top of a steel beam is used as part of the beam section to reduce the steel usage (Peng, 2014).Similarly, full or partial encasement in concrete is an economical method for steel columns, since the casing makes the columns much stronger resulting in improved overall structural performance of the building.Since composite systems are comprised of steel as well as concrete components,it is natural analytical methods for composite structures draw upon techniques used for reinforced concrete and/or steel systems.

The advantages and design methodology of composite column which have been proposed/used in all over the world. Further, Introduce to steel-concrete composite members and construction; to explain the composite action of the two different materials and to show how the structural members are used, particularly in building construction should be known to every people to take the better advantage of such structure.

The necessity of the study in the field of composite structure is that most of the structure in Nepal is built with RCC structure and RCC itself occupies large space in case of highrise building and most of the building are of 3-3.5m floor height.No any research has been carried out in field of composite structure with the unsymmetrical floor plan and varying floor height since we have to vary the floor height in order to provide false ceiling and AC cooling pipe(duct). Faster construction,ability to cover large column free area in the building,to provide the longer span in buildings and better seismic resistance are the advantageous properties of composite structure.To make our structure more safe,serviceable and economical we should adopt different construction technique. Steel concrete composite structure may be one construction technique due to its various advantage in which we should broaden our research level in this sector.

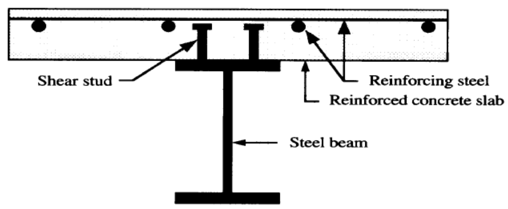


**Figure 1:** Steel Beam interactive with and support the Rcc slab

**Component of Composite Structure**

**a) Composite beam:**

Composite beam itself are of two type i)fully incased steel in rcc beam and ii)steel beam with a Rcc slab.In conventional composite construction, concrete slabs rest over steel beams and are supported by them (figure 1 above).Under load these two components act independently and a relative slip occurs at the interface if there is no connection between them. With the help of a deliberate and appropriate connection provided between them can be eliminated which is also known as the shear connecto[2].

**b)Composite Column:**

A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled hollow section of hot-rolled steel. It is generally used as a load-bearing member in a composite framed structure.there are three type of composite column: i) fully incased steel column ii) Partial incased steel column and iii) concrete filled tubular section. In case of fully incased steel column supplementary reinforcement are provided to prevents excessive spalling of concrete both under normal load and fire conditions

## 2. Methodology

The conceptual framework followed to accomplish this work can be described as follows :Finite element analysis methods is used for predicting the stress, strain, and displacement fields in complex structural geometries like composite structure. Automated mesh generation, mesh refinement, and automated adaptive re meshing have resulted in major improvements in the efficiencies of model development and analysis and in the accuracies of the numerical solution.since the principle objective of this study is to make the comparision both on RCC structure and Composite structure on the basis of parameter like base shear,top displacement and time period.The unsymmetrical building plan was created on AUTO CAD v17 and modeling was done FEM software(Etabs v2016)

## 3. Structural Detail and Material Properties

All commercial buildings with irregular plan dimension and varying floor height are consider for the analysis.Building with the floor height of 3m,3.5m and 4m are considered.so, all together 6 model for Rcc and 6 models for composite buildings are created with Plan dimension of 319.34 sqm and 219.35 sqm. The comparative study is carried out on the same building plan.All building material and structural properties are shown in Table 1 and Table 2.

**Table 1:** Material Properties

| | |
|---|---|
| Grade of concrete | M25 |
| Elastic modulus | 25000 MPa |
| Concrete weight | 2500 Kg/m³ |
| Poisson's ratio | 0.2 |
| Reinforcement bar | HYSD500 TMT |
| Unit weight of Rebar | 7850Kg/m³ |
| Poisson's ratio | 0.3 |

**Table 2:** Structure data for building model

| | |
|---|---|
| Plan dimension | Model 1: 319.34 sqm<br>Model 2: 219.35 sqm |
| Total height of building | 28.5m,33m,37.5m |
| Height of each storey | 3m ,3.5m and 4m |
| Number of storey | G+9 |
| Span(Bay)width | 4.5m and 3.5 m |
| Size of Column(RCC) | 450mmx450mm |
| Size of Beam(RCC) | 300mmx500mm |
| Size of Slab(RCC) | 125mm |
| Size of Column(composite) | 350mmx350mm (ISHB 250 internal core) |
| Size of Beam(composite) | ISHB 300 |
| Size of Slab(RCC) | 125mm |

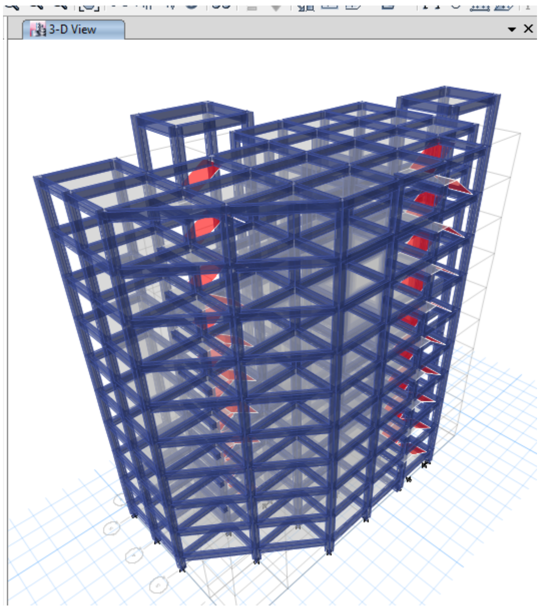

**Figure 2:** 3D modeling of model 2

All the live load in building are assign as per the Is 875:Part II (Table 3)

**Table 3:** Live Load on Building

| | |
|---|---|
| Floor Finish load | 1 KN/m2 |
| Roof live load | 1.5 KN/m2 |
| Live Load | 3 KN/m2 |

## 4. Modelling and Analysis

3D building models are analyzed using linear time history analysis where three different type of ground motion are taken as input excitation for the building i.e Kobe earthquake(1995), loma-prieta Earthquake(1989), Northridge Earthquake(1994) etc. The buildings models are analyzed by using Etabs V16 software. In composite beam structure the beams are modeled as steel beam element and columns are modeled as composite column element with concrete encased steel section. In RCC structure the beam and column are modeled as RCC beam and column element. The dead load and live load are considered as per IS-875 (part 1 & 2)[3]. For earthquake loading IS: 1893 (Part1):2002 is used and for RCC design IS 456:2000[4] is considered whereas IS 11384:1985[3] and IS:800:2007[5] is used for the design of composite structures and steel structure. Different parameters such Time Period,Top Displacement and Base Shear are studied for the models. Seismic codes are unique to a particular region of country. The results of model are obtained and discussed.

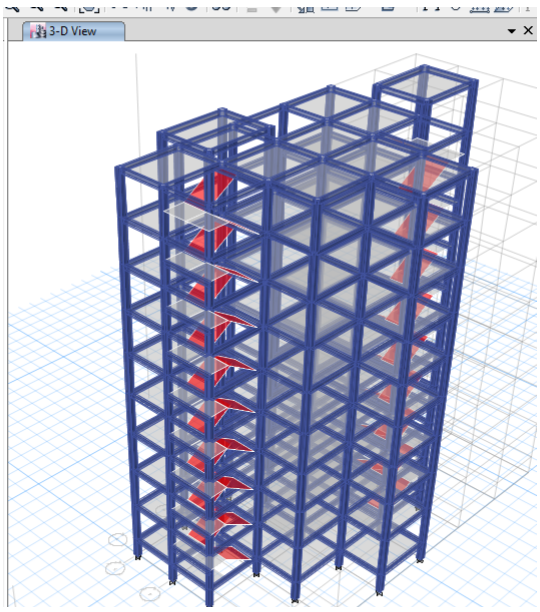

**Figure 3:** 3D modeling of model 1

## 5. Result and Discussion

Analysis of all type buildings is done and the results are as follows:

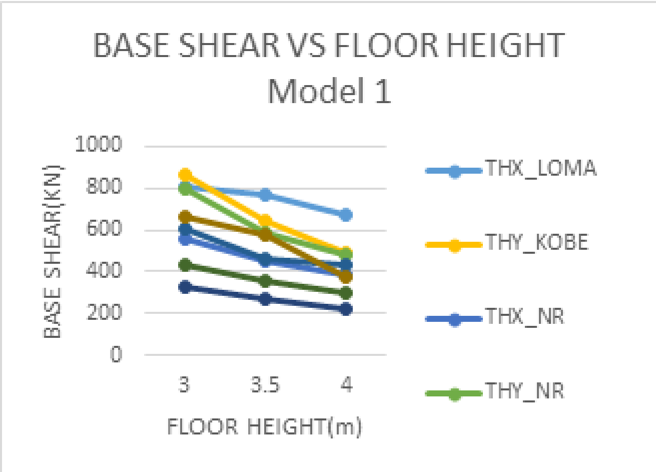


**Figure 4:** Comparision Based on Base shear vs Floor Height of model 1

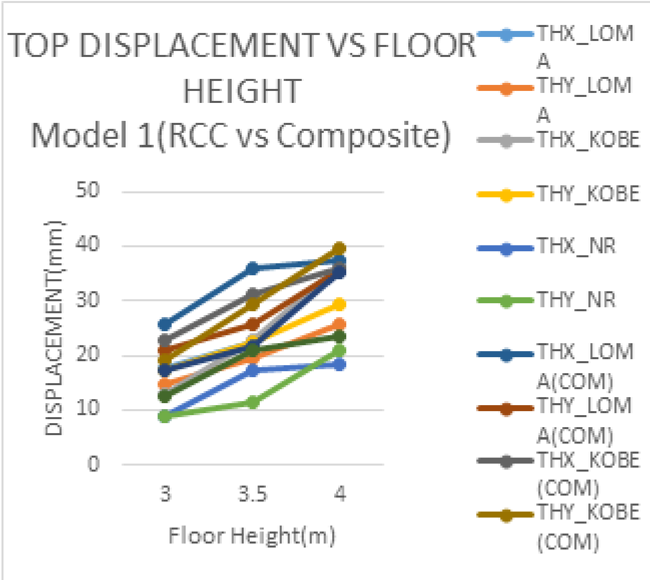


**Figure 6:** Comparision based on Top displacement of model 1

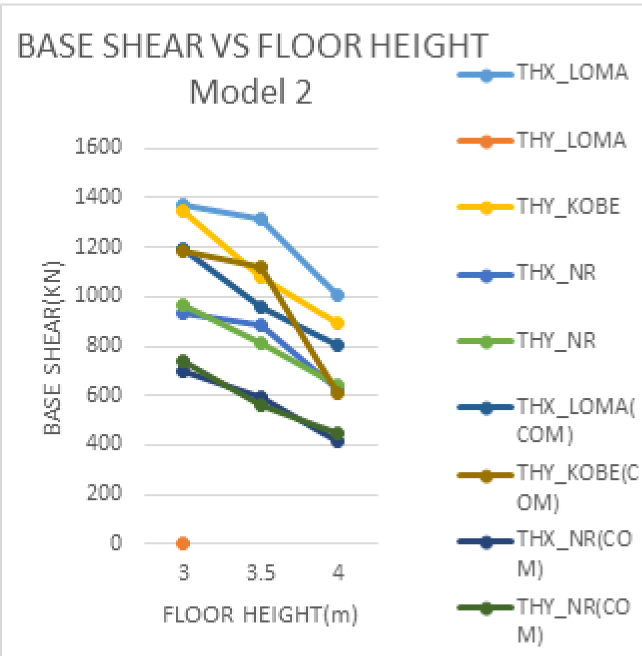


**Figure 5:** Comparision based on base shear vs floor height of model 2

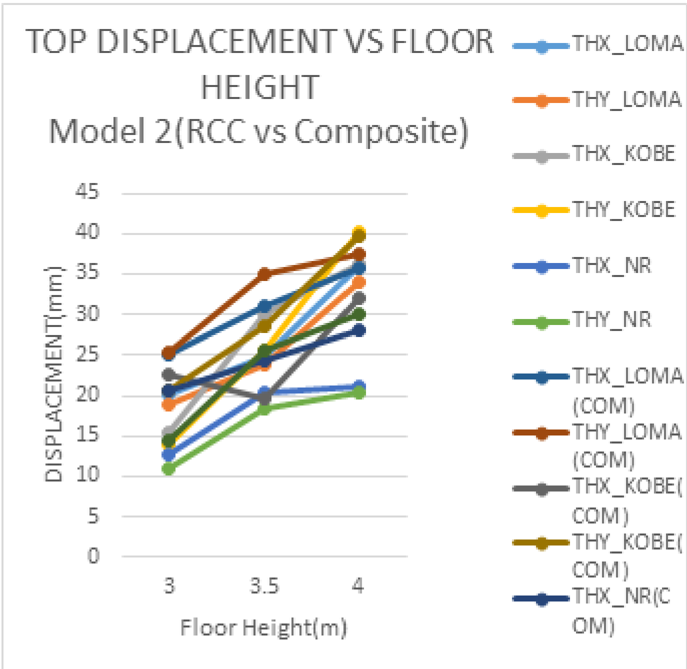


**Figure 7:** Comparision based on Top displacement of model 2

From the above Figures (Fig 4 & Fig 5) it has been shown that base shear of composite structure decreases itself with respect to corresponding floor height of same building and also decrease with respect to the Rcc building which can also be verified with the help of response spectrum curve of IS:1893:2002.

The above Figures (Fig 6 & Fig 7) shows that Top displacement of composite structure are more than the RCC structure in every earthquake with in the permissible limit.

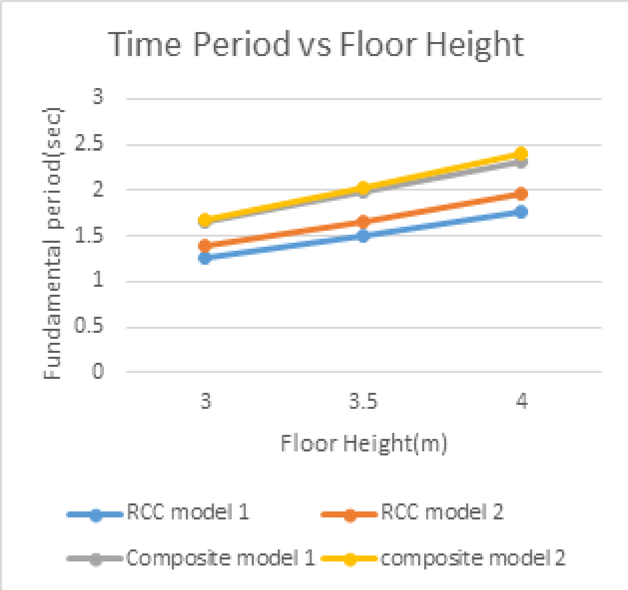


**Figure 8:** Comparision based on the time period

The above figures shows that fundamental time period of composite building are more than the Rcc building in both model[6].

## 6. Conclusion and Recommendation

Analysis and design of two irregular and different floor height building has been done and comparison between them results following conclusions:

- In case of composite structure,base shear is reduced due lighter section used in composite structure.Thus, it reduce self weight and correspond seismic weight of building.
- It is seen that top displacement and Fundamental time period of composite structure is more due to use of more ductile material like steel in beam and composite column which is the best suited with respect to the lateral forces because of its flexibility characteristics. Implementation of above results in context of Nepal for construction of G+9 storey buildings(like: Hospitals,commercial Buildings and other institutional buildings helps for better performance regarding to circulation are providing false ceiling and AC duct pipe.

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