Comparative Study of Reinforced Cement Concrete (RCC) and Steel Structure

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Abstract: ***In South Asian countries concrete is mostly used as construction material, especially for low rise structures. Still steel is not predominantly used in high rise structures. Besides, Reinforced Cement Concrete (RCC) and steel structures; composite structures can be built to get maximum benefit of the steel and concrete, as well to produce reliable and economic structures. In this paper comparative study of nine storey hospital RCC and steel building is carried out. For the modelling and analysis of RCC and steel structure ETABs software is used. Comparative study of different parameters like base shear, load carrying capacity, displacement, time period, axial force, and cost is carried out with RCC and steel structures. Final results illustrates that steel structures are more suitable for high rise structures, less time consuming and they are cost effective too.***

Keywords: Comparative Study, Displacement, Base Shear, Etabs Software

1. Introduction

Reinforced concrete structures are the commonly used structural materials which have been used frequently over a century and ago. In developing countries like Nepal and India use of RCC structures is high because of convenient economy for the low rise buildings. The high rise buildings RCC structures are no more economic because of their increased dead loads, greater stiffness, span size restrictions and difficulty in setting the formwork.

On the other hand where the structures are located in highly seismic prone zones, where forces carrying on the structures are directly proportional to the weight of the structures; then the use of steel structures makes the much more impact. The steel structures have got large strength/weight ratio and can undergo large plastic deformations before failure. Steel structures have higher rigidity, ductility, and are cost effective too due to which the use of steel structures is used for every types of structures like high rise building, bridges, tower, airport terminal, industrial plants, etc. Generally RCC structures are stronger in compression but due to higher strength/weight ratio of steel structures they are more susceptible to more buckling.

The composite construction practice in the South Asian countries is still in preliminary stage; if their effectiveness and applicability can be explained properly then only we can march ahead into composite construction. Steel concrete composite construction combines the tensile strength of steel and compressive strength of concrete which makes them more economical and effective structural system compare to other structural system.

2. Building Details

The building consists of nine storey including one basement floor. Columns are placed 5m center to center in both ways, while the typical floor height is 3.15m and the beam, column size are given below in the table.

Table 1: Building Description

Building Type	Hospital Building
Plan Dimension	36.27 x 21.70 (m)
Height of each Storey	3.15 m
Thickness of Slab	0.125 m
Thick of Brick Masonary Wall	0.23 m
Floor Finish	1 kN/m^2
Grade of Reinforced Steel	Fe 415, Fe 250
Grade of Concrete	M20
Seismic Zone	0.36
Soil Type	Medium
Importance Factor	1.5
Zone Factor	IV
Damping Ratio	5%

Table 2: Column and Beam Details

Type of Building	Column Size	Beam Size
RCC Building	600 mm	350 mm x 500 mm
Steel Building	2- ISMC 200 + 2 Plates of 16mm	ISMB 500

3. Analysis of RCC and Steel Building Configuration

The 3D analysis of building is carried out in ETABS software using Response Spectrum method. Various parameter of building like time period, deflection, storey drift, base shear etc. are studied. IS 875 (part 1 and 2) is used for dead load and live load calculations respectively.

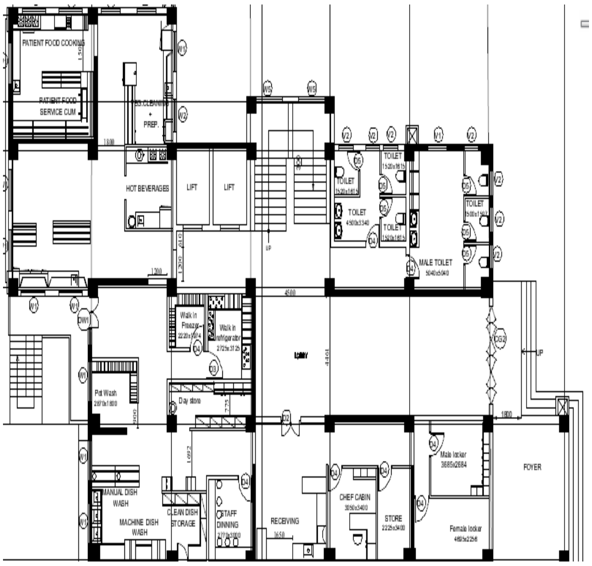


Figure 1: Plan of Building

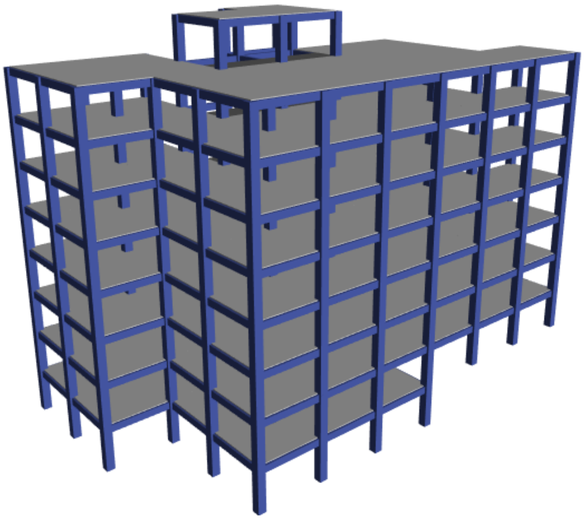


Figure 2: 3D Modelled View in Etabs

4. Load Combinations

The different load taken in analysis are Dead Load (DL), Imposed Loads (IL), Earthquake Load along X and Y axis in positive and negative direction. The load intensities on both the buildings were kept almost similar for the comparison purpose. As per IS 1893(1):2002 clause no 6.3.1.2, the following load combinations have been taken into account:

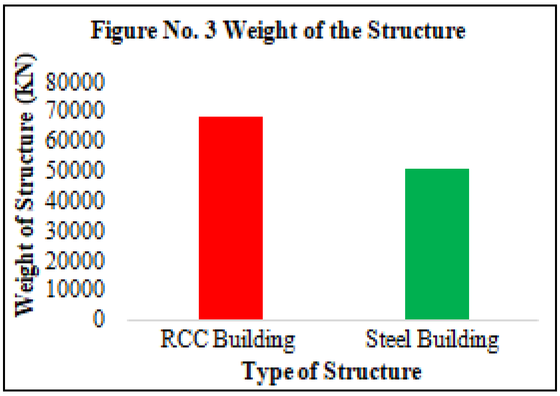
1.5 (DL+LL)   0.9DL±1.5EQ
1.5 (DL±EQ)   1.2(DL+LL±EQ)

5. Findings

a) Weight of the Structure

RCC Building	68335.4 KN
Steel Building	51,085.6 KN

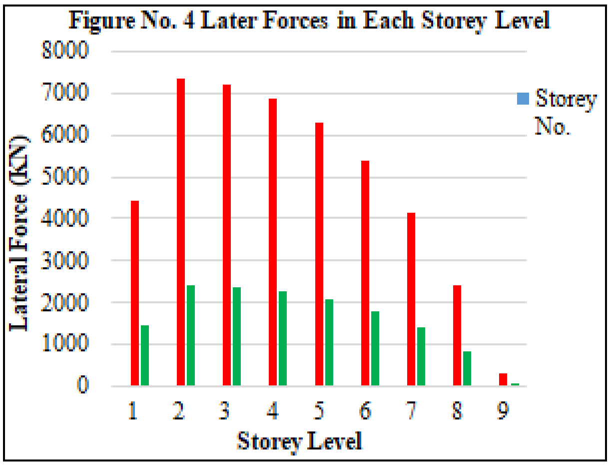
Weight of steel structure is lesser than that of the RCC structure which helps to reduce the cost of the foundation; which is represented in the below graph too.



b) Lateral Forces

Storey No.	RCC (KN)	Steel (KN)
1	4424.78	1426.99
2	7370.70	2431.47
3	7214.84	2384.99
4	6881.77	2280.42
5	6304.62	2094.51
6	5415.64	1804.04
7	4146.74	1385.76
8	2429.64	816.43
9	297.1	67.42

Below graph illustrates that the lateral forces acting on the RCC structures are much more than steel. Hence, the steel structures are less susceptible against the seismic action. The shear force on the main beam in higher in the base stories and decreases as the stories number increases. Similarly, the lateral forces increases as the height of the building increases, besides these there are other parameters which also affects the lateral forces.



c) Base Shear

Direction	RCC (KN)	Steel (KN)
Base Shear in X-Direction	7227.58	2695.87
Base Shear in y-Direction	7227.49	2439.13

Base shear of RCC structures is more because of the weight of the RCC frame than that of the steel frames. Hence, greater the weight of the structure, higher the stiffness greater will be the base shear.

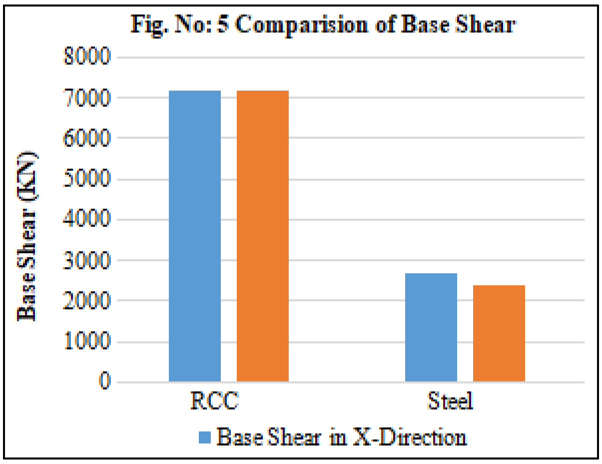


Fig. No: 5 Comparision of Base Shear

d) Storey Displacement

Storey No	RCC (mm)	Steel (mm)
1	8.19	4.8
2	22.53	12.2
3	37.99	18.5
4	53.11	26.5
5	67.15	33.2
6	79.38	37.2
7	89.03	42.8
8	95.61	44.9
9	89.06	47.54

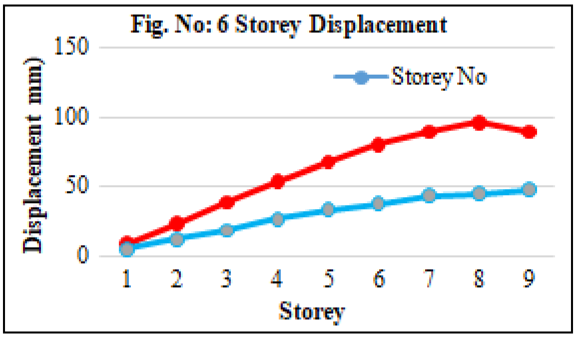


Fig. No: 6 Storey Displacement

From the above line diagram storey vs displacement is observed and it is seen that the displacement of the RCC structure is higher than the steel structure. The displacement of both the buildings is within the permissible limits too.

e) Time Period

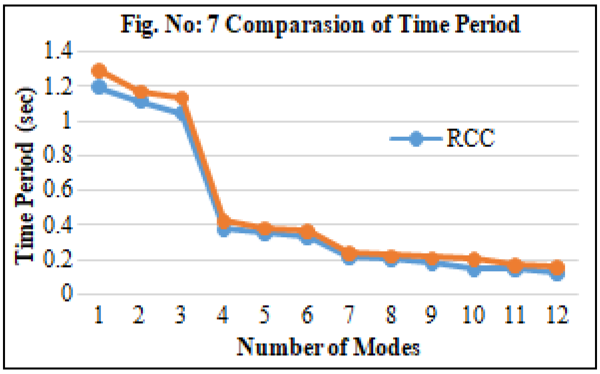


Fig. No: 7 Comparasion of Time Period

From the above line chart, time period of resistance against the seismic action of steel building is found to be slightly higher than the RCC building, when the height of building increases the performance of steel building increase too.

f) Axial Forces on Column

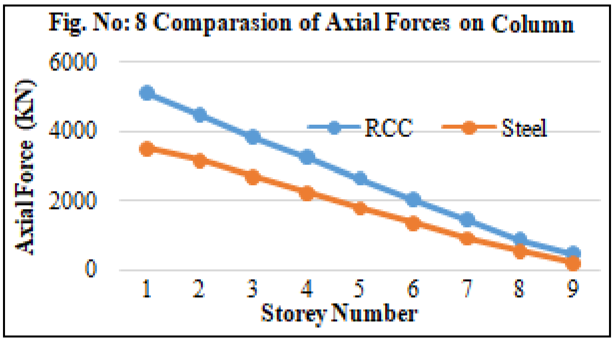


Fig. No: 8 Comparasion of Axial Forces on Column

In the above figure the maximum axial forces in each storey column is illustrated; which shows that the axial forces are greater at the base of the structure and decrease as the height of structures increases. The higher axial force at the base level is due to higher stiffener members and all the loads of member coming on it.

g) Cost

Cost is an important factor for comparison of steel and RCC buildings. Nowadays, the clients always seek for the cheaper option neglecting the time consuming and costly structures. Cost of steel beams, columns is lesser than the RCC beams and columns because they don't require any formwork. Reaction and axial forces on the column are lesser in steel columns ultimately, reducing the cost of columns, foundation and the whole steel structures.

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