A Comparison between RCC and Steel Structure

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***Abstract*—Design of structural members with maximum efficiency & minimum cost is always a challenge to the Architects & Engineers. The most important & frequently encountered combination of construction materials is that of steel & concrete with application in multi-storey building. Acceptance of steel – concrete composite construction is dependent on availability of cost effective design. Use of Hollow, I- section help to promote composite construction. In this paper, we compare a G+4 building made of RCC and steel simultaneously. The building is built in an earthquake zone where the effects of earthquake is studied on the building with the help of STAAAD.PRO**

Index Terms—Earthquake zone, RCC building, Steel building.

I. Introduction

1) RCC Structures:

RCC means Reinforced Cement Concrete, i.e., cement concrete reinforced with steel bars, steel plates, steel mesh etc to increase the tension withstanding capacity of the structure. Cement Concrete can take up immense compression but weak in tension whereas steel is good in withstanding both tension and compression.

(a) Advantages

- Materials used in RCC construction are easily available.
- It is durable and long lasting.
- It is fire resisting and not attacked by termites.

(b) Disadvantages:

- Scrap value of reinforced members is almost nil.
- Constant checking is required.
- Skilled labour is engaged in the work.

2) Steel Structures:

Steel structure is a metal structure which is made of structural steel components connect with each other to carry loads and provide full rigidity. Because of the high strength grade of steel, this structure is reliable and requires fewer raw materials than other types of structure like concrete structure and timber structure.

Structural Steel is steel construction material which fabricated with a specific shape and chemical composition to suit a project's applicable specifications. Common shapes include the I-beam, HSS, Channels, Angles and Plate.

Fig. 1. Steel structures

(a) Advantages

- High Strength – This means that the weight of structure that made of steel will be small.
- Uniformity – Properties of steel do not change as opposed to concrete.
- Elasticity – Steel follows Hooke's law very accurately.

(b) Disadvantages

- Maintenance cost – steel structures are susceptible to corrosion whenever exposed to air water and humidity. They must be painted periodically.
- Steel has very small resistance against fire as compared to concrete.
- Fireproofing cost- Steel is incombustible material however its strength is reduced tremendously at high temperatures due to common fires.

3) Earthquake Zones:

Earthquake - prone areas of the country have been identified on the basis of scientific inputs relating to seismicity, earthquakes occurred in the past and tectonic setup of the region. Based on these inputs, Bureau of Indian Standards [IS 1893 (Part I):2002], has grouped the country into four seismic zones, viz. Zone II, III, IV and V. Of these, Zone V is seismically the most active region, while zone II is the least. Broadly, Zone - V comprises entire north-eastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands. Zone - IV covers remaining parts of Jammu and Kashmir and Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan. Zone – III comprises Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Bihar, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka. Zone - II covers remaining parts of country.

We took the RCC and steel structure in Zone II (Bhopal) and then simultaneous results were calculated using the STAAD.Pro Software.

II. Experimentation

*(A) Assumptions in Design***:**

- Using partial safety factor for loads in accordance with clause 36.4 of IS-456-2000 as $\Upsilon t = 1.5$
- Partial safety factor for material in accordance with clause 36.4.2 is IS-456-2000 is taken as 1.5 for concrete and 1.15 for steel.

- Using partial safety factors in accordance with clause 36.4 of IS-456-2000 combination of load.
  D.L+L.L. =1.5
  D.L+L.L+W.L =1.2
- M20grade is used in designing unless specified.
- Tor steel Fe 415 is used for the main reinforcement.
- Tor steel Fe 415 and steel is used for the distribution reinforcement.
- Mild steel Fe 230 is used for shear reinforcement.

(B) Density of materials used:

- Plain concrete= 24.0KN/m^3
- Reinforced= 25.0KN/m^3
- Flooring material (C.M.)= 20.0KN/m^3
- Brick masonry= 19.0KN/m^3
- Fly ash= 5.0KN/m^3

(C) Live Loads:

In accordance with IS: 875 (part II) 1987

- Live load on slabs = 20.0KN/m^2
- Live load on passage = 4.0KN/m^2
- Live load on stairs = 4.0KN/m^2

(D) Building Design:

A design of R.C building of G+4 storey frame work is taken up. The building in plan (50'X80') consists of columns built monolithically forming a network. The size of building is 50'X80'. It is a residential complex. The dimensions taken up are the same for both the RCC and Steel structure. The building is subjected to both the vertical loads as well as horizontal loads. The vertical load consists of dead load of structural components such as beams, columns, slabs etc and live loads. The horizontal load consists of the wind forces thus building is designed for dead load, live load and floor load as per IS 875. The building is designed as two dimensional vertical frames and analyzed for the maximum and minimum bending moments and shear forces by trial and error methods as per IS456-2000.

The Footing used is Isolated (Spread) Footing. Isolated footings are commonly used for shallow foundations in order to carry and spread concentrated loads, caused for example by columns or pillars. Isolated footings can consist either of reinforced or non-reinforced material. For the non-reinforced footing however, the height of the footing has to be bigger in order to provide the necessary spreading of load. The Software STAAD Foundations is used to calculate the dimensions and the positioning of the footing columns so as to properly dissipate the load of the structure to the soil underneath.

The Building is made 50ft x 80ft on the STAAD software and all the respective loads are put in the software. When all the loads are put in, the foundation is applied to the structure which is fixed footing in our case.

Seismic Load is then applied to the structure. The building is considered to be in Bhopal which is in Zone II which has a Zone factor value = 0.1

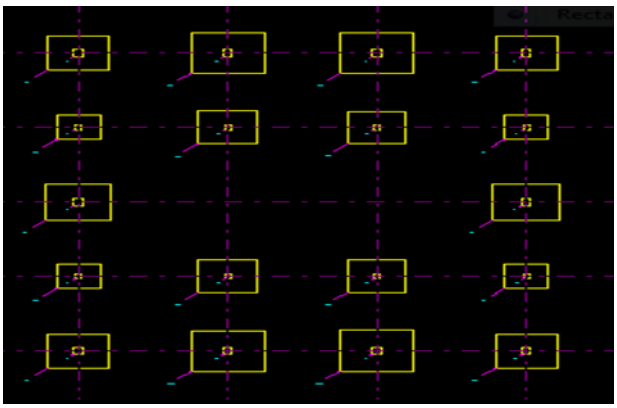


Fig. 2. Isolated Footing

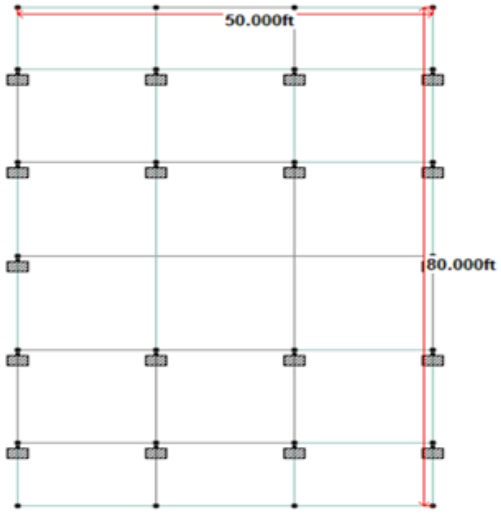


Fig. 3. Building Plan

TABLE I
DATA FOR ANALYSIS OF R.C.C. STRUCTURE

Plan dimension	15.24mX24.39m
Total height of building.	15 m
Height of each storey	3 m
Height of parapet	1.0m
Depth of foundation	3.65m
Size of beams 4.5m span	457x203 mm
Size of beams 3.0m span	457x203 mm
Size of beams 15.2m span	609x304 mm
Size of columns (3m)	203x304 mm
Thickness of slab	160mm
Thickness of internal & external walls	230mm
Seismic zone	II
Wind speed	4 m/s
Soil condition	hard soil
Zone factor	0.1
Floor finish	4.0 kN/m2
Live load at all floors	4.0 kN/m2
Grade of concrete	M25
Grade of reinforcing steel	Fe415
Density of concrete	25 kN/m 3
Density of brick	20 kN/m 3

TABLE II
DATA FOR ANALYSIS OF STEEL STRUCTURE

Plan dimension	15.24mX24.39m
Total height of building.	15 m
Height of each storey	3 m
Height of parapet	1.0m
Depth of foundation	3.65m
Size of beams 4.5m span	IW 350x300
Size of beams 3.0m span	IW 400x300
Size of beams 15.2m span	IW 400x300
Size of columns (3m)	IW 350x300
Thickness of slab	160mm
Thickness of internal & external walls	230mm
Seismic zone	II
Wind speed	4 m/s
Soil condition	hard soil
Zone factor	0.1
Floor finish	4.0 kN/m2
Live load at all floors	4.0 kN/m2
Grade of steel	Fe415
Density of steel	7850 kg/m 3

TABLE III
COMPARISON OF RCC STRUCTURE AND STEEL STRUCTURE

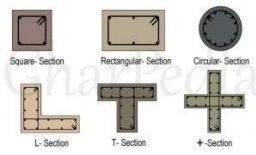
RCC Structure	**Steel Structure**
Construction is simple.	Construction is cumbersome.
The cross Section areas of structural elements are large.	The Cross Section areas of structural elements are small.
RCC structure has less tensile strength than Steel Structure.	Steel structure has more tensile strength than RCC structure.
Reinforced concrete framed structure is less resistant to Earthquake and Wind.	Steel framed structure is more resistant to Earthquake and Wind.
Speed of construction is less	Speed of construction is more.
Reinforced concrete framed structure is less prone to corrosion	Steel framed structure is prone to corrosion
Cost of repair is more and repairs are cumbersome.	Cost of repair is less and repairs are comparatively easy.
Reinforced concrete framed structure is fire resistant.	Steel framed structure is not fire resistant.
Quality control is difficult.	Better quality control.
Skilled as well as non-skilled workers are needed for its construction.	Only Skilled worker are needed for its construction.
Economical where formwork and labour are easily available.	Costly form of construction.
It is brittle as compared to steel structure. Hence, failure is sudden and hazardous.	It is ductile. Hence, failure is not sudden.
Reinforced concrete framed structure is more labour intensive. In reinforced concrete framed structure, the cross section of elements are square, rectangle, circular, L shaped, T shaped etc. 	Steel framed structure is less labour intensive and much work can be done in workshop. In steel framed structure, the Cross section of elements is I shaped, L shaped, C shaped, T shaped etc. 

TABLE IV
COST COMPARISON

	RCC Structure	Steel Structure
Quantity of materials required	138.7 m^3 of concrete + 22.97 tonne of steel	210.25 tonne of steel
Weight of structure	30294 KN	24414.4 KN
Cost per unit	Rs. 49000 per tonne of steel	Rs. 49000 per tonne of steel
	Rs. 4100 per m^3 of concrete	
Total Cost of Structure	Rs. 16942000.00	Rs. 10302250.00

III. CONCLUSION

The cost comparison of G+4 Building reveals that RCC structure is more costly, reduction in direct costs of steel structure resulting from speedy erection will make Steel structure economically viable. Further, under earthquake considerations because of the inherent ductility characteristics, Steel structure will perform better than a conventional R.C.C. and Steel structure, because of

- Weight of Steel structure is quite low as compared to RCC structure which helps in reducing the foundation cost.
- Steel structures are more economical than that of R.C.C. structure in the long run.
- Speedy construction facilitates quicker return on the invested capital & benefit in terms of rent.
- Steel Structure is more cost effective than RCC Structure.
- Steel structure is also portable.
- Steel structure is recyclable as well.

REFERENCES

[1] W. Morgan (1995). "Reinforced Concrete". The Elements of Structure".
[2] J. Qiu, "Emerging Corrosion Control Technologies for Repair and Rehabilitation of Concrete Structures", pp. 1.
[3] "2006 alert for defective cement". Archived from the original on October 29, 2006.
[4] Handbook on code of practice for Design Loads for Building Structures (IS:456-2007), Bureau of Indian Standards, New Delhi, 2007.
[5] J. M. Franssen, V. Kodur and R. Zaharia, "Designing Steel Structures for Fire Safety," May 6, 2009, CRC Press.
[6] B. S. Taranath, "Reinforced Concrete Design of Tall Buildings," December 14, 2009, CRC Press.
[7] S. H. Mahure, "Comparison of RCC and Steel Structures," *International Journal for Scientific Research & Development*, vol. 4, no. 5, pp. 554-558, 2016.
[8] Handbook on Code of practice for Design Loads for Building Structures Bureau of Indian Standards, New Delhi, 2007