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Comparative Study of Structure Using Composite Members And Conventional Members

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ABSTRACT
There are different methods of construction for building structure. The most popular conventional structures used are reinforced cement concrete structures, pure steel structures and Timber Structures. In the modern age the rapid growth in population and continuous influx of people from rural to metros; buildings are constructed on a large scale and with great Architectural requirement.
In this paper a new type of structure is introduced which involves use of composite members. To reduce the construction time, material quantity and cost the composite members are used. The composite members here mean use of steel sections as structural steel along with timber. Here by using composite members for miscellaneous Architectural building, lot of saving has been done in material, construction time and cost. It saves approximately 20-25% cost of structure if conventional type is used. Composite members used are Structural steel and solid timber compare to conventional steel or RCC members.
Keywords **-** Conventional type frame structure, composite member frame structure, Light frame structure, timber steel composite, Cost Analysis

I. INTRODUCTION

The most important and most frequently encountered combination of construction materials is that of steel and concrete, with applications in multi-storey commercial buildings and factories, as well as in bridges. These materials can be used in mixed structural systems in composite structures where members consisting of steel and concrete act together compositely. Here, in this paper use steel and timber hybrid structure is focused. In conventional practice RCC / structural steel members are used in building structures. But due to Architectural requirement cladding is used in some cases to give aesthetic looks. This increases cost of structure. Hence, if we use composite material then, it saves a lot of material, time and ultimately costing. Benefits of using steel in timber include increase in tensile capacity, seismic performance, and cost savings.

These essentially different materials are completely compatible and complementary to each other. Steel and timber materials are used to form composite members which increase the serviceability of structure during earthquake and wind prone areas. Steel has more thermal expansion than the wood. This forms ideal combination of strength with the timber efficient in compression and the steel in tension. By using steels connections will allow timber buildings to survive and remain serviceable after earthquakes, reducing death tolls as well as repair and business interruption costs.

The extent to which the components of a building structure should embody all the steel construction, be constructed entirely in reinforced concrete, in timber construction, or be of composite construction depends on circumstances. However engineers are increasingly designing composite and mixed building systems of structural steel and reinforced concrete or structural steel and timber to produce more efficient structures when compared to designs using either material alone. Timber and steel composite members mainly use for light frame structures.

II. OBJECTIVE OF THE STUDY

The light frame structures (Timber Structures) are more susceptible to damage due to earthquake and heavy wind. Due to this fact the modern techniques of construction involves use of moment resisting frames. The use of composite members suggested in this report may prove to be seismic and wind resistant over conventional technique used for such type of buildings.

The main objective of the present paper is to capture the modified performance of the building using composite member against regular members and its cost comparison with conventional steel/ timber building structure. For this one miscellaneous light frame building structure located near Pune is considered. It is observed that the structure with purely steel structure may have more efficient than timber structure, only when the overall form of

building is regular and it is possible to use bracing at least along the longer direction without hampering the aesthetics of building. In India mostly buildings are irregular in shapes due to which aesthetic requirements of building cannot be fulfilled by only steel construction. Hence, a comparative study of Structural Steel and composite member construction is carried out in this report.

III. CHOICE OF MATERIALS

1. Structural Materials

Nowadays basic framing materials for the building construction are steel, concrete and wood. Availability of material, cost, adequate knowledge of design and construction, maintenance and modification are some of influencing factors in selecting the material of construction. Here, we are considering steel and timber material due to aesthetic requirement of structure. Both the materials have their own advantages and limitations. Combining steel and wood will increase the seismic performance of the structure. Wood has a high strength to weight ratio therefore wood buildings tend to be lighter than other building types [8]. Table below shows a comparison of strength/density ratios for some structural materials. For pure wood this ratio is significantly higher than other building materials [4].

Material	Density kg/m^3	Strength, MPa	Strength/Density 10^{-3} MPa·m^3/kg
Structural steel	7800	400–1000	50–130
Aluminium	2700	100–300	40–110
Concrete, compression	2300	30–120	13–50
Clear softwood, tension	400–600	40–200	100–300
Clear softwood, compression	400–600	30–90	70–150
Structural timber, tension	400–600	15–40	30–80
Glass fibre in epoxi, typical value, tension			500
Carbon fibre in epoxi, typical value, tension			1000

Table 1: Strength/density ratios structural materials

2. Advantages of composite members

The advantages of using steel timber composite members may be emulated as: -

a. Considerable flexibility to structure when there is sudden increase of load by dissipating energy.
b. Ease of fabrication with skilled technique facilitates faster erection of structure.
c. Enables easy construction schedule in congested sites.
d. Light weight of material eases the transport at remote located sites.
e. Satisfies requirement of long span construction, a modern trend in architectural design.
f. Permits easy structural repair and modification for antique structure.
g. Ideal material in earthquake prone/ heavy wind prone locations due to high strength, stiffness and ductility.
h. Properly designed composite steel and wood members prevent the tensile failure mode of wood members and have significant ductility.
i. The size of the members can be made smaller thus increasing strength to weight ratios.

IV. TYPES OF COMPOSITE SECTIONS

A composite column is defined as a compression member which may either be a concrete encased section or a concrete filled hollow section or a steel sandwich between timber sections:-

1. Steel - Concrete Composite

According to the shape of the cross-section, there are mainly three different types of steel concrete composite members as:-

a. Concrete-encased sections (as shown a, b and c below)
b. Concrete-filled hollow sections (as shown f, g and i below)
c. Partly concreted-encased sections (as shown d and e below).

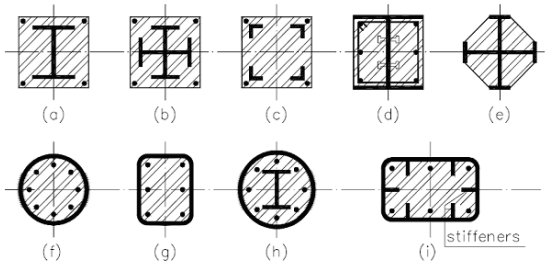

Fig.1:- Typical cross-sections of steel -concrete composite

2. Steel - Timber Composite

Steel – Timber composites frequently called as flitch type me

mbers. The cross sections are as shown in figure below. In these types of sections, mainly steel plates pressed between different timber sections and connected through nuts, bolts or pins. Typical cross section is as below from betterheader [13]:-

Fig. 2:- Typical cross-sections of steel timber composite

V. BASIC CONCEPTS IN ANALYSIS AND DESIGN OF COMPOSITE STRUCTURE

1. Case Study: Miscellaneous light Frame Arch. Structure

Here, for comparative study the following light frame miscellaneous structure is considered. This structure is situated near Pune. Below picture shows the Architectural concept required.

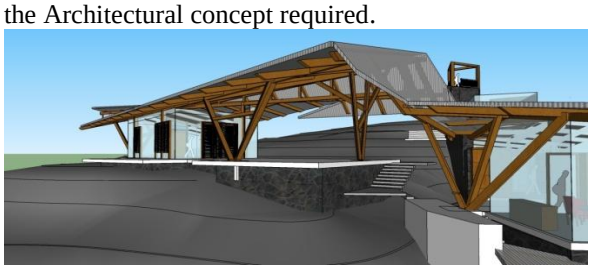

Fig.3:- Architectural Concept of Building-3D view

2. Structural Concept with Conventional Approach

STAAD Pro software is used to create model of the structure and design by conventional approach. The whole structure is divided into three different parts mainly for analysis and design purpose.

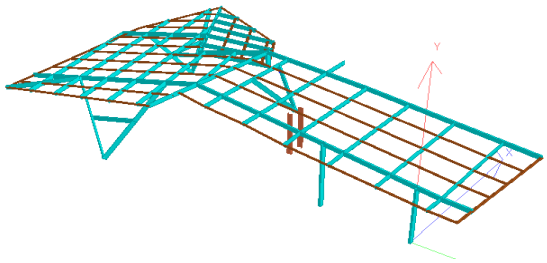

Fig.4:- Structural model for conventional approach

By conventional method Structural steel members are used and timber is used as cladding to fulfill the Architectural requirement.

The analytical results are used to design the steel members by using STAAD Pro Software. The members are designed with reference to IS 800.

3. Structural Concept with composite member Approach

By composite member approach Structural steel / pure timber members are replaced by composite flitch type members composed of steel as shown in fig. 2. SCIA and REVIT software is used for modeling and analysis of structure.

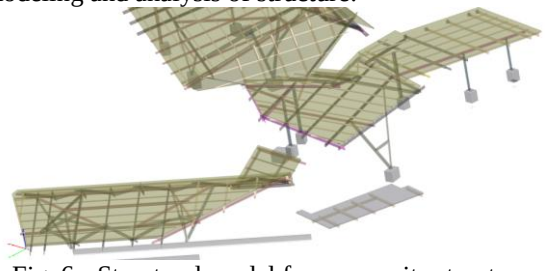

Fig. 6:- Structural model for composite structure approach

The analytical results are used to design the composite members by using excel spreadsheets. The composite members are designed with reference to EN1995-1-1:2004 [1] [2] [3].

VI. RESULTS AND COMPARISON

Quantities for Structure_By Conventional Approach

Steel quantities

Component	Length (m)	Weight (kg)	Weight (MT)	Cost
Column	38.70	4547.2	4.55	INR 545,666
Beam	94.94	9910.8	9.91	INR 1,189,299
Rafter	61.57	2411.7	2.41	INR 289,408
Purlin	107.44	956.1	0.96	INR 114,730
Deck Steel			6.30	INR 756,000
Connections	15%		3.62	INR 434,266
Total			**27.74**	**INR 3,329,369**

Timber quantities

Component	Length (m)	c/s area (m2)	Volume (m3)	Cost
Column	38.70	0.020	0.77	INR 87,075
Beam	94.94	0.020	1.90	INR 213,615
Rafter	61.57	0.020	1.23	INR 138,533
Purlin	0	0.020	0.00	INR -
Deck Steel			0.00	INR -
Connections			0.00	INR -
Total			**3.90**	**INR 439,223**
			Total Cost =	**INR 3,768,592**

Quantities for Structure_By composite Approach

Steel quantities

Component	Length (m)	Weight (kg)	Weight (MT)	Cost
Column	47.00	78.5	3.69	INR 442,740
Beam	103.4	62.8	6.49	INR 779,222
Rafter	61.57	39.3	2.42	INR 289,995
Purlin	107.44		0.00	INR -
Deck Steel			4.20	INR 504,000
Connections	15%		2.52	INR 302,394
Total			**19.32**	**INR 2,318,351**

Timber quantities

Component	Length (m)	c/s area (m2)	Volume (m3)	Cost
Column	47.00	0.020	0.94	INR 105,750
Beam	103.4	0.020	2.07	INR 232,650
Rafter	72.2	0.020	1.44	INR 162,450
Purlin	190	0.008	1.52	INR 171,000
Deck Steel			0.00	INR -
Connections			0.00	INR -
Total			**5.97**	**INR 671,850**
			Total Cost =	**INR 2,990,201**

The above values are calculated for partial area of the structure i.e. deck area.

This shows the total cost saving using composite material compared to conventional method lies between 20%- 25%.

Figure captions appear below the figure, are flush left, and are in lower case letters. When referring to a figure in the body of the text, the abbreviation "Fig." is used. Figures should be numbered in the order they appear in the text.

Table captions appear centered above the table in upper and lower case letters. When referring to a table in the text, no abbreviation is used and "Table" is capitalized.

VII. CONCLUSION

The comparison of Analysis and design results of building using composite members and steel members shows that:-

a. Overall of costing of structure by using composite member is reduced by 20% to 25% than that of steel / timber members.
b. Cross-section dimension of composite members are lesser than that of pure timber members by 5% to 15%.
c. Good fire resistance and corrosion protection are achieved due to use of flitch type sections than that of purely steel / timber members.

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