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# Design of Steel Frame Industrial Building Compared With Reinforced Cement Concrete Industrial Building

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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 multistory 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 India cost of a project is generally restricted to direct initial cost without any comprehensive study like Life Cycle Cost (LCC) analysis. Life Cycle Cost assessment offers whole life costing (WLC) of a structure covering current construction cost as well as all future cost. This provides better & more realistic assessment of cost involved for having any structure. As a result, there has been an increasing global awareness about the durability aspect of building & a general trend for use of LCC as a measure for proper selection of best alternative.

This paper discusses LCC of RCC Industrial Building (G+2) compared with LCC OF Steel Industrial Building (G+2) with Hollow Columns & steel Deck & LCC of Steel Industrial Building with I-section columns & steel deck.

**INTRODUCTION -**

Composite construction practice is still in a very nascent stage in India so its effectiveness & applicability must be propagated for structures where fast track construction is of utmost importance promoting the cost effective composite construction. Construction is all the more necessary now in India, because of our Governments intention of improving the infrastructure & housing (both commercial & residential) facilities to attract foreign investment in the country to compete in the liberalized global economy.

Steel concrete composite construction combines the compressive strength of concrete with the tensile strength of steel to evolve an effective & economical structural systems. Over the years this specialized field of construction has become more & more popular in the Western World & has developed into a multifaceted design & construction

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technique. Steel concrete composite construction though not uncommon is not very popular in India.

In Steel concrete composite construction structural steel work is typically used with concrete. For example beams with concrete decks. Steel & concrete have almost the same thermal expansion apart from an ideal combination of strengths. Hence, these essentially different materials are completely compatible complementary to each other. Members made of structural steel & concrete used as composite structures so that they act together & concrete is subjected to compressive force & steel takes the tensile force.

Steel Hollow sections are the most versatile & efficient form of construction. It gives a building a better strength to weight ratio than those using comparable concrete. In construction this strength to weight ratio reduces material usage & allows for greater spans. The London Eye Building, Emirates Stadium & space frame structure of the world record breaking JCB Dieselmax. Also they are ideal for every day application such as vehicle trailers, fences & Handrails.

**APPLICATION IN ADVANCED COUNTRIES -**

Experiences from advanced countries suggest that, time required for composite construction is lesser than that of reinforced concrete construction. The basic advantages of steel concrete composite construction as are being fully utilized by the advanced countries may be summarized as follows -

1. Faster construction for maximum utilization of structural steel members & hence quick return of the invested capital.
1) Advantages based on LCC analysis instead of the invested capital.
2) Quality assurance of the steel material along with availability of the proper paint system suiting to different corrosive environment.
3) Ability to cover large column free area in building. This leads to more usable space.
4) Better seismic resistance i.e. best suited to resist repeated earthquake loadings, which require a high amount of ductility & hysteretic energy of the material/ structural frame.
5) Keeping span & loading unaltered, a lower structural steel section ( having lesser depth & weight) can be achieved in composite construction, compared to the section required for non – composite construction.
6) Reduced beam depth reduces the story height & consequently the cost of cladding in a building.
7) Reduced depth allows provisions of lower cost for fire proofing of beams exposed faces.
8) Cost of formwork is lower compared to RCC construction.
10) Easy structural repair/modification/ maintenance.
11) Structural steel component has considerable scrap value at the end of useful life.
12) Reduction in overall weight of structure & thereby reduction in foundation cost.
13) More use of material i.e. steel which is durable, fully recyclable on replacement & environment friendly.
14) Considerable flexibility in design, pre-fabrication & convenience in Construction scheduling in congested areas.

**USE OF EFFICIENT STRUCTURAL SECTIONS**

(G+2) Industrial Building (both RCC & Steel) is analyzed & design on STAAD-PRO Software by considering following loads.

Loads Considered –

Live load 8 KN/m2

Roof Live load 8 KN/m2

Earthquake & wind analysis is done for Amravati Region (Zone III) for both steel as well as RCC building.

(Insert Fig.1, Fig.2, Fig.3 here)

Keeping the loading conditions, span of beams same, applying Indian Code provisions for a (G+2) Industrial Building. It is observed that, by using Hollow sections as columns (as shown in Fig.2) the initial cost of steel –

concrete composite construction may be 42.72% higher than the corresponding RCC (as shown in Fig.1) structure. By using I-section as columns (as shown in Fig.3) the initial cost of steel – concrete composite construction may be 44.14% higher than the corresponding RCC structure.

(G+2) Industrial building comprise of Composite Deck slab which consists of steel decking as the permanent form work to support the underside of the concrete slab spanning between supporting beams. The steel decking by itself supports loads applied to it before the concrete has gained adequate strength. The steel decking also supports the loads during construction & acts as a working platform develops adequate composite action with concrete to support construction loads, stabilizes the beam against lateral buckling until concrete hardens acts as transverse reinforcement to composite beams, prevent serious cracking & finally most importantly, reduces the volume of concrete in tension zone.

**COMPREHENSIVE COST (LCC) ANALYSIS -**

Life Cycle Cost considers the total cost incurred by a structure through out its life instead of only the construction cost. A structure having lowest LCC will offer better solution to the Planners/Designers & decision makers. For a building structure the LCC heads includes direct cost, time cost, periodic maintenance cost, Regular maintenance cost, Replacement cost , End use value etc.

Even if the initial cost of Steel concrete composite construction is higher compared to RCC construction, its LCC is appreciably lower .Time as well as cost involved in a composite construction comes down particularly for using steel beams , columns, profiled decks. Also, life of structure needs to be considered. Since life of steel structure is much higher than that of RCC structure, it is essential to consider this aspect while calculating the cost of project.

While calculating Lcc, Initial cost of building is calculated taking into consideration superstructure of building only i.e. only beams, columns, slab in case of RCC building & only beams, columns & steel deck in case of steel building.

LCC, Steel concrete composite (by using Hollow section as columns) option has lower cost 46.21% compared to RCC option. LCC of Steel concrete composite (by using I-section as columns) option has lower cost for about 44.67% compared to RCC option. Summary table with study period of 80 yrs.& discount rate 12% for steel option ( for Hollow as well as I- section).

(Insert Table 1 here).

**CONCLUSION -**

1. Steel concrete composite construction is efficient & LCC is lesser in almost all the cases (both Hollow & I-section) compared with RCC provided proper cost benefit analysis is done.
2. Use of profiled decking, reduce construction time. However, effect of early completion of work & longer life of structure need to be considered in the calculation. Even if the initial cost of Steel concrete composite construction is higher than RCC construction its LCC is lower.
3. While analyzing Steel concrete composite Industrial building (in both case Hollow & I-section)on STAAD-PRO wind governs.

**Table 1**

| Item | RCC option (Lacs) | Steel with Hollow column (Lacs) | Steel with I-section as column (Lacs) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **1.Initial cost** Total Bldg.Cost | 58.4 | 136.68 | 132.28 |
| Interest during construction on average investment * | 3.88 | 5.78 | 5.59 |
| Differential early rentals for steel option. * | --- | -14.76 | -14.76 |
| | 62.28 | 127.7 | 123.11 |
| **2. Future Cost** a) Routine Inspection & Regular maintenance cost | 3.89 | 3.93 | 3.93 |
| b) Periodic Maintenance cost | -- | 5.9 | 5.9 |
| c)Replacement Cost | 62.28 | -- | -- |
| d)Rental & Dismantle cost | 47.2 | --- | --- |
| e)Scrap value | 2.92 | -55.01 | -53.17 |
| **Total** | **178.57** | **82.52** | **79.77** |
| **LCC** | | **46.21 % Less** | **44.67% Less** |

* shows it is assumed that, completion period for RCC building is 11 months whereas for steel building is 7 months.

-ve sign indicates that, there is gain in cost (in case of steel building) whereas +ve sign indicates ,there is loss in cost.

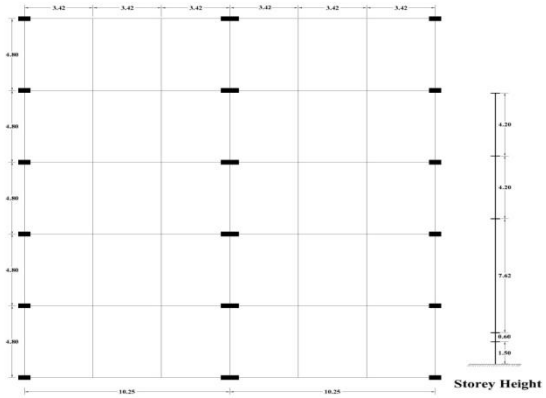



Fig. 1

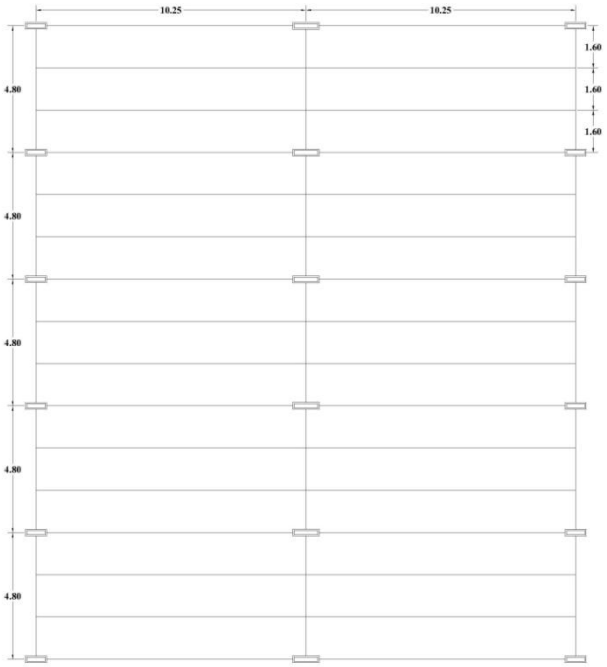
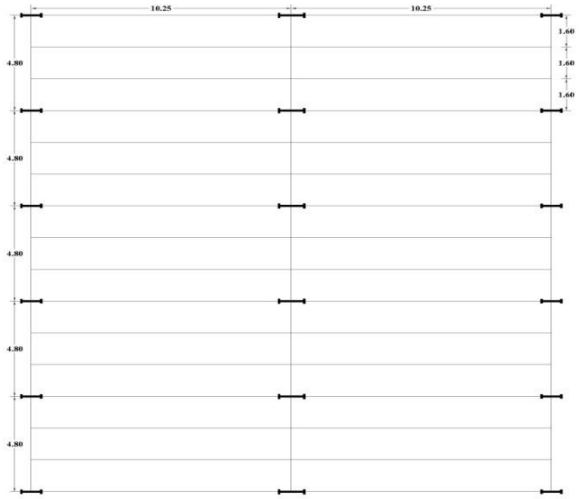



Fig. 2




**Plan of steel Industrial Building**
**(By using I - section as coloumn)**

Fig. 3

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