Cost Comparison of Modular Construction with Ordinary Site Construction

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Abstract

The advent of the 19th century brought about the industrial revolution in which the manufacturing process was streamlined. This novel process severely cut down the time taken for construction and reduced the inherent defects in the finished products. But, why hasn't this industrial revolution impacted the construction industry? In India, we still continue to construct buildings just like the pre-historic man did albeit with better materials and techniques. The underlying reason is the said "higher cost" of these factory made products over ordinary site erection. Modular construction (factory made products) has many advantageous such as speed of construction, higher factor of safety, higher design loads, reduction in labour required and no haphazard construction practices. We aim to offset these advantageous as costs and thus comment on the viability of modular construction in India.

Key Words

Cost Comparison, Modular Construction, Ordinary Site Construction.

Units

All units used in this paper are according to the MKS system

Introduction

The industrial age has ushered in the mass production of products with identical properties. Hence, the consumer is assured of a tested product without any blemish. If this technique can be applied to the construction industry, we can assure the consumer of products which are of assured standards. Modular Construction refers to making these factory made modules which can be assembled on site. Modular Construction is not a preferred construction technique in India because of its high initial manufacturing cost, transportation cost and a lack of knowledge about construction in steel. The aim of our study is to analyse a sample G+4 storey building and estimate the quantity of steel required. Using this, we aim to adequately estimate the cost of construction of the same structure using ordinary site construction and modular construction.

Study

To study the pros and cons of modular construction over conventional steel construction, we analysed a G+4 residential steel building consisting of two flats of 1-BHK and 2-BHK on each floor using structural analysis software, STAAD Pro, and made a cost analysis of the structure based on the duration of project, transportation for lead of 30Km, material and labour cost, cost of tools plants & contingencies. The structure was designed for wind load as per IS 875, seismic loads as per IS 1893-2002 for Mumbai, Maharashtra along with self-weight, dead load of RCC slab of 150mm thickness and a live load of about 10 KN/m. The various sections used for the structural members have been tabulated below.

Table 1: List of Structural Steel Sections used in design

Sr. no	Section	Area (cm2)	Iyy (cm4)	Izz (cm4)	J (cm4)	Material
1	ISHT100	25.3	486	177	6.371	STEEL
2	ISHB300	74.8	2.19E3	12.5E3	23.93	STEEL
3	ISWB600	170	4.7E 3	106E3	187.163	STEEL

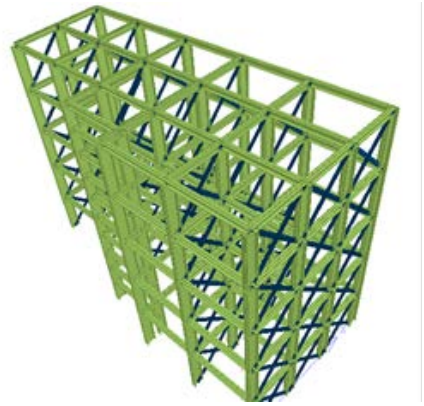
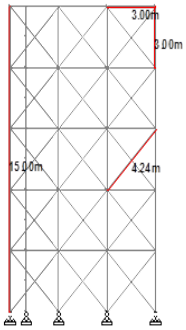


Fig 1: *3-D Rendered View of Structure*



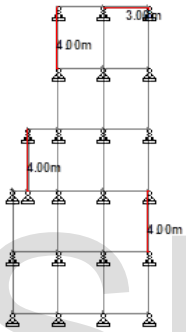


Fig2:StructuralDrawing(Elevation)
Fig 3: Structural Drawing (Plan)

The Structure was analysed for Limit State of Strength and Serviceability as per IS 800-2007.The structure was safe in the foresaid limit states the results of which have been summarized below.

Table 2: Deflection Summary

	Node	L/C	Horizontal	Vertical	Horizontal	Resultant
			X mm	Y mm	Z mm	mm
Max X	137	52 (1.0 DL + 0.8 LL + 0.8 WL(+X))	0.257	-0.912	0.095	0.952
Min X	138	56 (1.0 DL + 0.8 LL + 0.8 EL(-X))	-1.874	-0.791	0.604	2.122
Max Y	1	50 (1.0 DL + 1.0 LL)	0	0	0	0
Min Y	129	50 (1.0 DL + 1.0 LL)	-1.442	-2.59	0.395	2.99
Max Z	136	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	0.067	-0.813	14.349	14.372
Min Z	118	54 (1.0 DL + 0.8 LL + 0.8 EL(-Z))	0	-0.945	-7.878	7.935
Max rX	24	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	0	0	0	0
Min rX	16	54 (1.0 DL + 0.8 LL + 0.8 EL(-Z))	0	0	0	0
Max rY	138	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	-1.518	-0.709	10.267	10.402
Min rY	128	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	-0.669	-1.162	10.228	10.315
Max rZ	131	56 (1.0 DL + 0.8 LL + 0.8 EL(-X))	-1.825	-1.443	0.052	2.327
Min rZ	128	52 (1.0 DL + 0.8 LL + 0.8 WL(+X))	-0.32	-1.113	0.557	1.285
Max Rst	130	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	-1.496	-1.9	14.34	14.542

Table 3: Reaction Summary

	Node	L/C	Horizontal	Vertical	Horizontal
			Fx kN	Fy kN	Fz kN
Max Fx	31	56 (1.0 DL + 0.8 LL + 0.8 EL(-X))	45.518	1027.815	3.333
Min Fx	30	52 (1.0 DL + 0.8 LL + 0.8 WL(+X))	-39.574	634.9	0.037
Max Fy	31	56 (1.0 DL + 0.8 LL + 0.8 EL(-X))	45.518	1027.815	3.333
Min Fy	46	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	-0.064	278.805	-10.884
Max Fz	46	54 (1.0 DL + 0.8 LL + 0.8 EL(-Z))	-0.064	362.048	9.627
Min Fz	26	51 (1.0 DL + 0.8 LL + 0.8 WL(+Z))	3.133	500.95	-19.237
Max Mx	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127
Min Mx	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127
Max My	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127
Min My	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127
Max Mz	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127
Min Mz	1	50 (1.0 DL + 1.0 LL)	24.8	394.495	-2.127

Table 4: Failed Members Table

There is no data of this type

The max deflection from Table 2 is 14.372mm which is much less than the deflection of height/300=15000/300=50mm permissible by the Code. Hence the structure is safe for limit state for strength and serviceability.

The Structure is also safe in the limit state of collapse as there are no failed members.

One of the noting parameter in this analysis was the quantity of steel required. We have estimated the quantity of steel required for modular construction to be the same with no deviations from the structure and sections used in ordinary site construction. Hence, the quantity of structural steel used in both forms of construction were same.

Further, an approximate cost analysis of the modular steel construction over conventional steel construction was performed which gave the following results-

Table 5: Cost Comparison of Modular Construction with Ordinary Site Construction

Sr. No.	**Item**	**Modular Construction**	**Ordinary Site Construction**
1	Material Cost	Rs 6,254,089.51	Rs 6,254,089.51
2	Tools and Plants	Rs 625,408.95	Rs 156,352.24
3	Contingencies	Rs 312,704.48	Rs 312,704.48
4	Transportation	Rs 8,976.20	Rs 6,732.15
5	Labour Cost	Rs 20,800.00	Rs 342,000.00
Total Cost		Rs 7,221,979.13	Rs 7,071,878.37
Cost of Construction per sqmt		**Rs 9,027.47**	**Rs 8,839.85**

Conclusion

From the results, we can see the myth of modular construction being much costlier than ordinary site construction is false. The many advantageous and safety of modular construction offset the slight increase in its cost over ordinary site construction. These advantages include:

1. As these products/ modules are developed in a controlled factory setup by skilled labour, they require a lower factor of safety and can sustain higher design loads.
2. The time required for construction is also drastically reduced as finished products are obtained from the factory, which only have to be placed on site. Hence, the need for temporary sheds for labour and the labour cost is significantly reduced. The speedy construction means return of investment is faster, this is especially advantageous to Hotel chains using modular construction.
3. Modular Structures are portable structures. Modular construction can be used as temporary structures which can be dismantled easily. This is especially advantageous during natural calamities or other such emergencies.
4. The speedy construction and removing major construction work from on-site to off-site increases the overall safety and security as traffic interruptions, site interruptions and other such hazards are avoided.
5. The material wastage is lesser in modular construction as the modules are manufactured in controlled factory environments. A certain quality of work is assured.
6. In a country like India the cost of materials is much more than the labour cost therefore modular construction practice may be a little costlier. However in the future years when the labour cost will exceed the material cost the Modular Construction technique will prove fruitful in lowering the construction cost.
7. Modules can be manufactured according to any design and hence, there are countless design options available to the consumer

All these major advantageous of modular construction offset the slightly higher cost of construction of modular construction of **Rs 9,027.47 per sqmt** over ordinary site construction of **Rs 8,839.85 per sqmt.**

References:

[1] Construction Rates quoted by Khozema Umrethwala from S.K contractors, Mazgaon,Mumbai
[2] Standards, Bureau Of Indian. *IS 800* (2007): n. pag. Web.
[3] Standards, Bureau Of Indian. *IS 1893-1 (2002): Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings* (n.d.): n. pag. Web.
[4] Standards, Bureau Of Indian. *IS 875-3 (1987): Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 3: Wind Loads* (1987): n. pag. Web.