



A COMPARATIVE LIFE CYCLE COST ANALYSIS OF PLASTIC & STEEL FORMWORKS

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Abstract: Formwork is probably the most important component of a construction project, but is often neglected and least cost method is adopted as regards it planning, designing, usage, handling, storage, maintenance etc. This is majorly because formwork is a temporary structure and the client pays the contractor only for the permanent works. This is especially true for the small and medium-scale projects. Contractors of small and medium scale projects still resort to the traditional timber and plywood formwork which has a long list of drawbacks and technical limitations.

So, this study focuses on pointing out the importance of formwork in the construction projects and the need for engineered formwork. Further the study lists down the various types of formwork systems existing in the market today along with their different properties, usability, benefits and limitations. Finally, a Life Cycle Analysis comparison of Plastic formwork with the steel (metal) formwork is done to show their relative suitability.

This will be helpful for the contractors to choose appropriate formwork for their construction project on both technical as well as commercial grounds.

Keywords: *Formwork, Plastic Formwork, Steel Formwork, Life Cycle Cost, Construction.*

I. INTRODUCTION

Indian construction industry has started using some of the world class technologies. Several formwork systems are in use at different places in the world; eventually the systems which are reasonably economical and easy for operation with skilled labour are more useful in India.

1. Formwork system has significant role in the construction process, making the right decision by choosing the appropriate formwork system could lead to response to sustainable construction. Different systems have their own advantages but one needs to choose a formwork which best supports individual project requirement. Formwork is defined as temporary structures to support the concrete until it supports itself. It moulds the concrete to different types of formworks used in construction, generally differing according to the building requirements. Formworks are generally made by wood, steel, Aluminium or prefabricated forms into which the concrete is poured [1]. The formwork used to cast the structural elements such as, columns, beams, slabs and shear walls also used for smaller parts of building such as stairs, etc. Selection of formwork in high-rise building is dependent upon the main factors such as cost, time and quality. [2]. In the conventional type of formwork, the timber planks were supported on timber columns. Now a days technology has developed gradually, people used plywood sheet instead of timber planks and steel props with jacks are used to support [3]. Then people invented small units of formwork and connect the repeating units in the construction. In the recent times, the quest for raising the efficiency, sustainability and cost effectiveness of the formwork has led to the development of system formwork. Initially Mild Steel was used and it was very heavy [4]. With further advancement in the research in order to reduce weight of formwork system, the material of formwork has changed to Aluminium, plastic, etc. and the results found are very promising.

II. LITERATURE REVIEW

Various literature have been referred to for the purpose of this research and have been explained herewith.

[1] Presented a comprehensive review of various formwork systems in concrete construction, including their raw materials, flexibility, fabrication methods, applications in concrete structures and environmental impacts. The advantages and current limitations of different formwork systems are compared and discussed, and finally recommendations are given.

[2] The Sustainable Building Technical Manual is a comprehensive compilation of experiences of private practitioners and local government experts about information on sustainable buildings.

[3] Is a book on Construction Project Management with an emphasis on Project Costs. Chapter 3 from this book discusses about green design & its impacts on Construction Economics.

[4] RDSO, published a report on the state-of-the-art of Modern Formwork Systems in India. This report enlists the basic fundamental information as well as the future trends in the formwork industry.

[5] As per Varghese, although modern formwork systems paved their entry into the market in the late 1990s, their growth and penetration has been at a very slow pace. A change is always a struggle. Mindset of influential decision makers, inadequate/inappropriate quality codes, cost factors everything plays a role in the growth.

[6] Discussed the various methodologies on Life Cycle Costing with special emphasis on Green Buildings, and also presented a method to build a sustainable decision matrix based on value-chain.

[7] The entry of several scaffolding and formwork multinationals into Indian market in the recent past has revolutionized the way we used to construct few years ago. Few Indian manufacturers have also introduced innovative products and systems which are affordable and one stop solution provider for all construction related problems. But it is vital to select the appropriate and right formwork solutions and their service provider. These days, most of them are offering best of their services and cost-effective scaffolding and formwork solutions.

[8] Is a book dedicated to Concrete Form Systems. It includes comprehensive information on the types, design, requirements and selection criteria for various formwork systems.

[9] This paper proposes a modified table formwork system (MTFS) that can improve construction productivity, reduce labour requirements, accelerate construction schedules, and significantly reduce construction costs. A case study was performed to verify the validity of the MTFS.

[10] The modern formwork systems are a far cry from the bespoke timber formwork that used to be the staple of the construction industry earlier. Intense competition has meant that suppliers are always on their toes and coming out with product innovations to garner their share of the market.

From the literature review conducted herein, it was found that previous researchers have conducted extensive studies on formwork in construction, but lacks a method to do direct comparison of Life Cycle Costs of Formwork. The conclusions of the literature review study have been summarized as below:

1. Many studies have been conducted on the topic of Formwork addressing the elements like types, applications, need, purpose, functional and codal requirements etc.
2. There is also a good amount of research conducted on the topic of Life Cycle costs.
3. There is very limited work done on direct comparative assessment of life-cycle costs of two different types of formworks.

Hence, this work focusses on the comparative life-cycle cost analysis of Plastic and Steel Formworks..

III. METHODOLOGY

The present study is divided into the following stages:

Step#1: Introduction to various formwork systems available in India.

Step#2: The need for Engineered Formwork systems is emphasized.

Step#3: Life Cycle Cost as a decision-making tool is introduced.

Step#4: Life Cycle Cost Analysis is done on common one-to-one grounds for both Plastic & Steel Formwork.

Step#5: Comparison of LCC Analyses as done in Step#4 above is done and the inferences are drawn therefrom.

Formwork types in use:

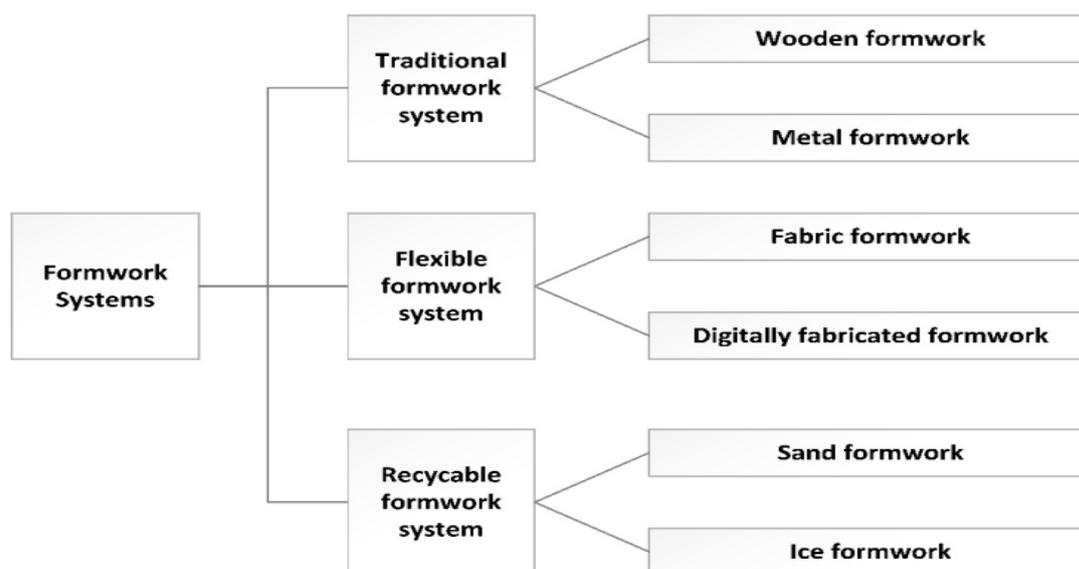


Fig. 1 Different Formwork Systems in use

Until recent years, the formwork industry had long been reliant on traditional formwork methods for concreting. Since, these traditional systems pose a long list of drawbacks, the need for Engineered Formwork Systems optimized for the modern age construction was felt, leading to advancements in the formwork industry as a result of extensive research & development and commercial production of advanced systems.

Fig. 1 above shows graphically the list of traditional as well as modern formwork systems in use today.

Life Cycle Cost:

The Life Cycle Costing method is commonly used to compare TWO similar and competitive products on the basis of their total costs of ownership. This is most commonly done to investigate the suitability of alternative designs on same parameters and helps in decision making while choosing between alternatives.

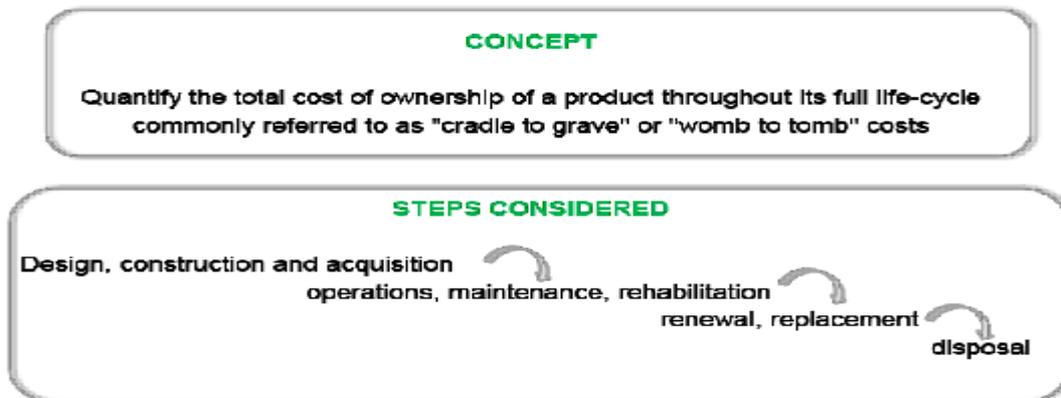
Life-cycle cost analysis (LCCA)

Fig. 2 Life Cycle Cost

1.1.1 Phases of LCCA Analysis:

The entire process of Life Cycle Costing is done through THREE major phases:

- A. **Production Cost:** These are the costs of production of a component or Product including the material, labour and transportation costs
- B. **Service Life Costs:** The costs incurred during the functional use of the product including maintenance and repair costs come under this category.
- C. **End of Life Costs:** The costs of dismantle and disposal of the product at the end of its serviceable life, when it becomes functionally un-usable are called End of Life Costs.

Case Study I:

Konark Paradise

Format: G+6 including Compound Wall Construction

Formwork: Plastic Formwork



Fig. 3 Plastic FW: KONARK PARADISE.

Case Study II:

Maitri Homes, Nashik

Format: G+12 Towers

Formwork: Steel Formwork



Fig. 4 Steel FW, Maitri Homes
ANALYSIS, RESULTS AND DISCUSSIONS

For the purpose of uniformity, same size is considered for both Plastic & Steel Panels

Panel Size: 1.5 ft X 8 ft (0.460 M X 2.40 M)

Plastic Formwork

I.] Production Costs:

Table 1 Plastic FW: Production Costs

SR. NO.	ITEM	SIZE (mm x mm)	QTY.	UNIT	RATE (RS.)	AMOUNT (RS.)
1	PANEL (INCL. CHECKNUT & TIE ROD)	2400 X 460	1.104	SQ.M	6000	6624
COST (RS./ SQ.M)						6000

II.] Service Life Costs:

Table 2 Plastic FW: Service Life Costs

Sr. No.	Cost Centre	Cost per event (Rs.)	No. of Repetitions	Total Cost (Rs.)
1	Maintenance	0	100	00
Total Service Life Cost (Rs.)				00
Total Service Life Cost (Rs./ SQ.M)				00

III.] End of Service Life Costs: There are NO end of service life costs involved.

IV.] Life Cycle Costs: Life Cycle Cost is the sum of Production Cost, Service Life Cost & End of Service Life costs.

Table 3 Plastic FW: Life Cycle Costs

Sr. No.	Cost Type	Cost (Rs.)
1.	Production Cost	6,000
2.	Service Life Cost	00
3.	End of Service Life Cost	00
Total Cost (Rs./ SQ.M)		6,000

Steel Formwork

A panel of shuttering is made up of Mild Steel components. Various parts used in a panel are MS Sheet, MS Angles connected with rivets or are welded. The specifications are as follows:

Mild Steel Sheet – 14 SWG @ 15.70 Kg/ Sq.M

MS Angle – ISA 35 X 35 X 3 @ 1.6 Kg/ m

I.] Production costs:

Table 4 Steel FW: Production Costs

Sr. No.	Item	Size X mm X mm	(mm)	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
1	MS Sheet	2400 X 460 X 2		17.33	KG	58	1005
2	MS Angle (3 MM)	7590 X 35 X 35		12.14	KG	54	656
3	Anti-Rust+Paint	--		1	L.S	300	300
4	Labour	--		1	L.S	500	500
5	Transportation	--		1	L.S	50	50
Total Cost of ONE Panel					Rs.		2511
Cost of ONE Panel					Rs./SQ.M		2275

II.] Service Life Costs:

Table 5 Steel FW: Service Life Costs

Sr. No.	Cost Centre	Cost per event (Rs.)	No. of Repetitions	Total Cost (Rs.)
1	Oiling	50	40	2000
2	Repairs	200	2	400
Total Service Life Cost (Rs.)				2400
Total Service Life Cost (Rs./ SQ.M)				2174

III.] End of Service Life Costs:

Table 6 Steel FW: Life Cycle Cost

Sr. No	Cost Type	Cost (Rs.)
1	Production Cost	2275
2	Service Life Cost	2174
3	End of Service Life Cost	0
Total Cost (Rs./ SQ.M)		4448

Parametric Cost Comparison: Once individual costs are derived at different life cycle stages, a comparison can be made on various parameters which will help in finally arriving at the Life Cycle Costs as shown below.

Table 5.7 Parametric Cost Comparison

Sr. No.	Parameter	Unit	Plastic	Steel
1	Material	--	PP	Mild Steel
2	Size of Panel	mm X mm	2400 X 460	2400 X 460
3	Weight of Panel	Kg	13.8	22
4	Number of repetitions	No.	90-100	40-50
5	Productivity	SQ.M/ Man-Day	50	20 - 25
6	Labour Rate	Rs./ Day		
A	Skilled Labour		900	900

B	Unskilled Labour		600	600
7	Cost	Rs./ SQ.M		
A	Production Cost		6000	2275
B	Service Life Cost		0	2174
C	End of Service Life Costs		0	0
8	Salvage Value	%	25	50

Life Cycle Cost Analysis

This is the final step of the entire process wherein we calculate the Life Cycle Costs and based on our analysis compare the two most popular formwork systems existing in the construction industry for small and medium sized projects in India.

The Formula for LCCA is as follows:

$$LCCA = (\text{Initial Production} + \text{Service Life} + \text{End of Service Life}) \text{ Cost} - \text{Salvage Value}$$

On the basis of the above formula, we hence calculate the LCC of both plastic and steel formwork. The results are presented in the table below:

Table 5.8 Life Cycle Cost Analysis

Sr. No.	Cost type	Unit	Plastic	Steel
1	Production Cost	Rs./ SQ.M	6000	2275
2	Service Life Cost	Rs./ SQ.M	0	2174
3	End of Service Life Cost	Rs./ SQ.M	0	0
4	Salvage Value	%	25	50
		Rs./ SQ.M	1500	1137
5	Life Cycle Cost	Rs./ SQ.M	4500	3311

Results & Discussion

- A.] From the above Life Cycle Analysis, we can see that the Life Cycle Cost of Plastic Formwork is 1.35 times that of Steel Form.
- B.] Although initially very expensive, plastic formwork proves to be economical in the long run due to the high number of repetitions 90 – 100 as compared to Steel where only 40 – 50 repetitions are possible.
- C.] Steel formworks generally are costly although cheaper initially than Plastic formwork as well as not environmentally friendly.

Conclusion

Formwork is probably the most important component of a construction project. Since it is a temporary structure and client pays only for the permanent structure, hence generally formwork is often neglected and paid the least attention as regards its planning, designing, maintenance and handling is concerned. Different types of formwork systems are existing in the market today. The

traditional formwork material of Timber and Plywood is inferior in many aspects and hence there is the need for engineered formwork systems. Among modern formwork systems, a parametric Life Cycle Cost Analysis was made in the present study. A Life cycle Cost Analysis (LCCA) of Steel and Plastic Formwork reveals that Plastic Formwork is almost 35% expensive than Steel Formwork. Although, due to the high number of repetitions possible with Plastic formwork, it ultimately proves far superior than the Steel formwork.

Future Work

Further Research Work can expand the present study to accommodate the following:

1. Entire list of Steel & Plastic Formwork Items can be included for the purpose of deriving LCC.
2. Comparative LCCA Analysis and the resulting Costs could be found on per Sq.Ft. of Built-up Area.
3. Comparative LCCA studies can be done for Mivan & Plastic Formworks.
4. A Ready Reckoner Template can be prepared to readily derive the ultimate Life cycle Costs for various Formwork Systems.

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