

# The Economic, Social, and Environmental Benefits of Monolithic Form Work Systems in Construction

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**Abstract**— In recent times, nations have acknowledged the threat of greenhouse gases and its effect on the environment. Global warming became a major concern that caused the United Nations to hold yearly conferences urging countries from all over the globe to reduce their greenhouse gas emissions [1]. Because construction accounts for half of the nonrenewable resources consumed by humans, making it one of the least sustainable industries, engineers are urged to address the environmental impact of construction and work on finding other methods and materials that lessen the negative effect of construction and make it more ecofriendly [2]. With all the recent sustainable technologies emerging, such as Green Concrete, Self-Consolidating Concrete, and Green Construction, the industry still has a major negative effect on the planet. One of the Key factors that determine the success of the project is the formwork system used. Formwork plays an essential role in the speed, cost, quality and safety of the project. Monolithic form work systems is a technology that allows the structure to be casted at one go, saving time, reducing labor, and therefore decreasing the overall cost of the project. This paper discusses the benefits of Monolithic Formwork Systems and illustrates the savings in time, cost and labor.

## I. INTRODUCTION

Fresh concrete is initially in plastic state and needs a mold so it could take its required shape before it sets. These molds, which are called formwork, are temporary support that stays in place until the concrete sets and is able to carry its own weight. Types of formwork vary based on its need and materials available, yet the most used system is the conventional formwork system. It is typically fabricated on site from timber and used for columns, core walls, and slabs separately. Timber can cause safety issues when reused because it loses its structural properties over time. Many of the accidents on site are cause by misuse of timber formwork and scaffolding [3]. On the other hand, monolithic formwork systems using Aluminum panels allows the structural system (columns, shear walls, and slabs) to be poured in one go. Aluminum formwork systems are made strong and can be reused up to 250 times. Formwork systems are divided into either horizontal formwork or vertical formwork. Horizontal systems are used for casting slabs and roofs, while the vertical systems are used for columns, shear walls, and core walls. Aluminum formwork systems are designed to carry high pressure from load bearing walls while the conventional systems that use timber have a hard time bearing the pressure from the fresh concrete in walls. Monolithic formwork systems have been used vastly in the construction of residential units and high rise buildings where repetition of typical floors is present [3].

## II. COST COMPARISON

Based on several research and extensive analysis, Aluminum formwork has proven to be cost effective. Jignesh Chotaliya and Hiren Rathod [3] compared the cost between aluminum and conventional formwork on actual projects in India and found out that aluminum formwork gives an average of 15% saving. Professor Ramesh and Ramling [4] have also stated in their research on aluminum formworks that if Mivan technology which is an aluminum formwork system is used in the project, it increases the quality and speed of construction and reduces the overall cost since some construction activities are eliminated completely while some are reduced to certain extent. Aluminum formwork system provide a very smooth finish eliminating the need for plastering after deshuttering which is a very costly and time consuming activity. Aluminum formwork systems do not require skilled labors because of the simplicity of assembling the system, therefore reducing the cost on skilled labors and carpenters. The system reduces the floor cycle to 4 days resulting in huge savings in the overhead expenses of the project.

Professor Patil and post graduate student Ganar [5] have done a numerical comparison between mivan and conventional formwork system. The building used for comparison consists of 12 floors having an area of 860.77 m<sup>2</sup>. The comparison included the cost of foundation and G+12 floors to come up with the total cost of the building, and then compared the duration required for each system. The results are presented in the figures below.

TABLE I. Numerical comparison (Mivan Vs Conventional).

	Mivan Formwork System		Conventional Formwork System	
	Rupees	Rupees	Pounds	Pounds
Cost of Foundation	5,000,000	5,000,000	60,000	60,000
G+12	42,250,000	48,250,000	575,327	503,784
Total Cost	<b>47,250,000</b>	<b>53,250,000</b>	<b>635,327</b>	<b>563,784</b>

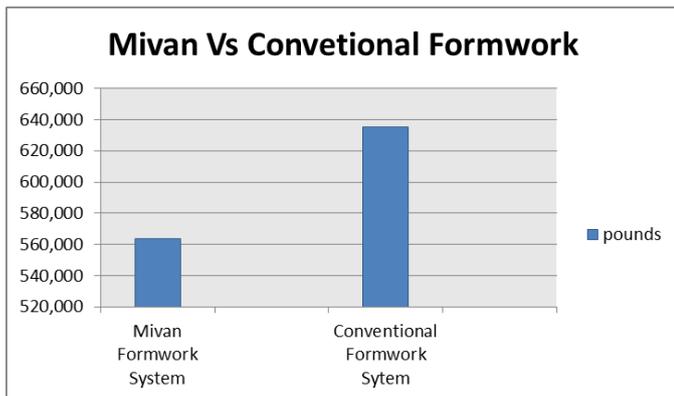


Fig. 1. Graphical comparison (Mivan Vs Conventional).

The results illustrated on the table above indicate that Mivan formwork system is around 71K pounds cheaper than the conventional formwork system majorly because of the durability of aluminum panels and the high wastage of timber in the conventional system. In typical floors where the structure is identical, Mivan formwork has a vast advantage in both cost and time over the conventional formwork system. The figure below illustrates the duration comparison between the two systems on the same building.

### III. DURATION COMPARISON

TABLE II. Duration comparison (Mivan Vs Conventional).

	Mivan Formwork System	Conventional Formwork System
	Days	Days
Excavation	38	37
RCC Work	400	348
Brick Work	N/A	150
Internal Plaster	N/A	135
Ceiling POP	N/A	120
External Plaster	N/A	90
Total	438	880

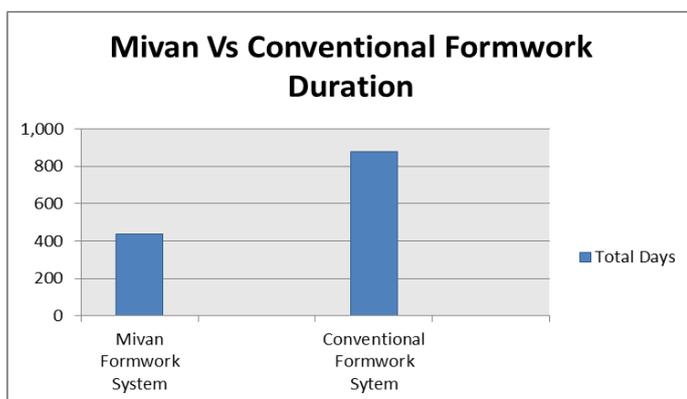


Fig. 2. Graphical duration comparison (Mivan Vs Conventional).

Mivan formwork system saves up to 50% of the duration needed for the conventional system and that is because it does not require skilled labors to erect it. The maximum weight for an aluminum panel does not exceed 25 Kg which means it can be carried easily by a single worker. Because of its simplicity and light weight, aluminum systems can go as fast as 4 days

for a slab to slab cycle [5]. Mivan formwork produces a very smooth finish eliminating the need for plastering and ceiling works. The system also saves the time needed for brickwork because RCC walls are casted instead. One of Aluminum formwork advantages is that it does not require crane for shifting and assembly, allowing the crane to be used for other activities that would have needed to be delayed if the conventional formwork system was used, such as:

- 1) Shifting of reinforcing steel rebars into assembly point
- 2) Removing debris from site
- 3) Loading and Unloading materials from trucks into site storage area

In projects where the number of cranes is limited, aluminum formwork systems can prevent many possible delays due to bad management of the crane. In addition to that, any failure or malfunction in the crane will not delay the progression of work on site reducing the risks of delay on the project.

### IV. ENVIRONMENTAL BENEFITS

In construction sites, the majority of timber waste is generated from conventional formwork. Most of the timber brought into the site will eventually be discarded after a few uses, increasing the overall wastage of the project. On average, a typical project would require a new set of timber formwork every 8-10 floor cycles [6]. Because of the new regulation in some countries to reduce project wastage, conventional formwork system should be replaced with a more eco-friendly alternative, Aluminum formwork system is a perfect alternative for mass projects and high rise buildings with large number of identical floors. As obvious as the name is, Aluminum formwork system is made up from aluminum sheets. Those aluminum sheets / panels are very light weight and have an outstanding stiffness to weight ratio resulting in minimum deflection when concrete is loaded [7]. Aluminum panels are manufactured to suit the specific requirement of each project and can be reused up to 250 times making 25 times more reusable than timber formwork. Aluminum has a higher salvage value than timber, up to 50% of original price, which encourages contractors to sell wastage to aluminum recycling factories and therefore reducing the waste sent to landfills. Aluminum is more durable at different weather conditions such as rain, sun, and wind when compared to wood. Recycled aluminum requires as little as 5% of the energy used to produce it from raw materials. It is also very much cheaper than producing new aluminum even after considering the cost of collection, separation and recycling [8].

### V. SOCIAL BENEFITS

For an idea or product to be sustainable, it has to satisfy the three pillars of sustainability, which are:

- 1) Economical: In which the product should be profitable
- 2) Environmental: In which the product should have minimal impact on the environment
- 3) Social: In which the product has the approval and support of its employees, stakeholder, and community.

Aluminum formwork system has various social benefits because of its fast construction cycle. As mentioned previously in this paper, it reduces construction time to half what a conventional system requires [5]. This decreases the overall project duration and in turn reduces the inconvenience of neighbors and community around the site. Neighbors around the project will only have to deal with the project noise, dust, and road diversions half as much as they would have had to deal with if the conventional system is used.

Aluminum panels are clearly labeled and are easily identified on site therefore requiring no skilled labor to assemble them [9]. Because of its simplicity, labors tend to prefer working with aluminum formwork system over the conventional system and therefore increasing their productivity and satisfaction which is an important social benefit of the system. Unskilled labors cut cost on the project and allow the utilization of skilled labors on other tasks and projects.

#### VI. ADVANTAGES

- 1) High formwork quality ensuring consistency in dimensions.
- 2) Low carbon emissions due to the reuse of aluminum panels up to 250 times.
- 3) Provides a monolithic structure with zero cracks.
- 4) Minimizes the number of joints and therefore lowering the possibility of leaks and increases durability.
- 5) Eliminates the use of plywood for construction.
- 6) Improves site safety and cleanliness by reducing construction waste.
- 7) Allows deshuttering of slabs without moving props.
- 8) Overhead savings due to fast construction.
- 9) Higher scrap value, up to 50% of original price.
- 10) Minimizes the need for masonry work.
- 11) Reduces the need for skilled labors at the project.
- 12) Produces a structure with higher seismic resistance.
- 13) Uniform quality throughout the project
- 14) Can be used to cast columns, beam, slabs, shear walls, stairs etc.

#### VII. DISADVANTAGES

- 1) Requires extensive early planning.
- 2) Requires a long procurement process because panels are custom made for each project.

- 3) Only cost effective on large projects with high number of repetition.
- 4) High heat of hydration resulting from shear walls.
- 5) Produces RCC structures making it very hard to modify later on when compared to brick walls.

#### VIII. CONCLUSION

In a world where more than a million different species have become extinct because of global warming, we are obliged to find solutions to lessen the production of greenhouse gasses. Because methods of construction have a major effect on the planet, engineers are continuously trying to be more sustainable. Aluminum formwork construction is one of the newly invented techniques that have proven to be more sustainable by lowering the total cost and duration of the project, decreasing carbon emissions by using recyclable aluminum panels, and producing an easy to assemble system that does not require any skills. If used on mass projects and tall towers, aluminum formwork system will provide a high quality product in a short duration and at a reasonable cost.

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