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REVIEW ARTICLE

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A STATE OF ART REVIEW ON ALUMINIUM FORMWORK SYSTEMS

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ABSTRACT

A comparatively a new technology in India, aluminium formwork, saves time and cost. It also improves the quality of construction. Aluminium Formwork is successfully used in first world countries such Japan, America etc. For repetition of building layouts and for above-the-plinth work, Aluminium Formwork system is very cost effective. It is used to design any component of building such as bay windows, stairs, balconies and special architectural features. This system is unique as all the components in a building, including slabs, floors, walls, columns, beams, staircases, balconies and window hood, are concrete and there is no need for masonary. This strengthens the structure and the durability of the structure increases. It also gives form finish, eliminates the need for external and internal plaster and the walls can be directly painted with a minimal skim coat, all these ultimately resulting in cost saving.

Keywords: Aluminium formwork, cost optimization

I. INTRODUCTION

India is the developing country and the construction projects and industries play a vital role in the economy of country. Time and cost are the two important parameters in any construction activity and they are used for planning of project. This has increased the importance of time and cost optimization in construction projects. Hence it is necessary to estimate the cost and time of each activity in order to determine the total duration and total cost of the entire project. Optimization is a systematic effort made to improve profit margins and obtain the best results under given circumstances or situations. "Cost Optimization can be defined as the achievement of real and permanent optimization in the unit cost of services provided without damaging their suitability for the in planned use". Although various techniques and softwares are available for this optimization, still many construction projects do not achieve their cost and time objectives. Optimizing performance by different techniques adopted at one stage of the construction process may not be beneficial if the methods used are not to up the efficient level. Hence it is required to follow and implement the techniques in every stage of the construction process with the analyses of the information available. The methodology used in a construction activity also plays a vital role in the successful completion of a project. Formwork system is one of the main processes involved in construction. Also, as the cost optimization is applicable to various construction aspects, we will just consider the optimization of cost of formwork and its various aspects and comparing conventional and modern techniques of formwork. Mivan formwork system

(aluminium) is the most advanced formwork system. It is fast, simple and adaptable. It produces total quality work which requires minimum maintenance and when durability is the prime consideration. It is a totally pre-engineered system where in the complete methodology is planned to the finest details. In this system the walls, columns and slab are casted in one continuous pour on concrete. Early removal of forms can be achieved by the air curing/ curing compounds. These forms are made strong and sturdy, fabricated with accuracy and easy to handle. The components are made out of aluminium and hence are very light weight. They afford large number of repetitions (around 250). The re-propping is simple hence short cycle time can be achieved.

II. TYPES OF FORMWORK

1. Conventional formwork: Conventional formwork is highly used type of formwork for the construction of 2 or 3 storey buildings. This type of formwork mainly consist of bamboo, plywood, carpentry and masonry. As mentioned above this is not suitable for high rise building. Conventional formwork is mainly advantageous because of its less weigh, low cost factor, less experience factor and it is disadvantageous because of its poor surface finish, skilled labour requirement, time consumption, and high number of labour requirement.

2. Modern Formwork: This type is one step advanced than the conventional type. The same technique is used in the both the types and the only difference is the materials used for the formworks. In modern conventional formwork more advanced materials are used and they can be reused many times. The differences in both the types are that aluminium props and various types of jacks (U jacks, T jacks) are used as supports in the formwork instead of timber supports and ply wood sheets are used instead of timber planks on slab decks, beams and columns. Some of the advantages of this type are low initial cost, low skilled labor requirement, can be used in small places and when there is a lot of deviation in the structure while poor finish of the concrete surface, high labor requirement and the higher floor cycle are the disadvantages. This type is much more advanced. There are other forms of semi system formwork such as table forms, flying form etc. DOCA is the most famous brand for this type of formwork and some people know about this type only as “DOCA formwork”.

III. ALUMINIUM FORMWORK

Aluminum formwork is also known as MIVAN technology. MIVAN system is formwork construction, cast-in-situ concrete wall and floor slabs cast monolithic provides the structural system in one continuous pour. Large room sized forms for walls and floors slabs are erected at site. These forms are made strong and durable, fabricated with accuracy and easy to handle. They can be used repeatedly for many number of times (around 250). The concrete is produced in RMC batching plants under strict quality control and conveyed to the site with transit mixers. Formwork systems for buildings are classified into two types- horizontal or vertical formwork. Horizontal formwork systems are those which are used to form the horizontal concrete work (slabs or roofs), while vertical formwork systems are those which are used to form the vertical supporting elements of the structure, e.g., columns, core walls, and shear walls. Aluminium Formwork System is highly suited for load bearing wall construction whereas traditional formwork consisting of plywood and timber is not suitable to the high pressures of fresh concrete on the wall. Advantages of this technology is that it is fast, simple, adaptable and cost – effective. It produces total quality
work which requires minimum maintenance and when durability is the prime consideration. This system is most suitable for Indian condition as a tailor–made aluminium formwork for cast–in–situ fully concrete structure.

1. Necessity of the Aluminium Form work System

- To fulfill the swiftly increasing demands for houses due to rapid urbanization which cannot be fulfilled using conventional materials and methods of construction.
- Since conventional formwork system is a slow process, therefore it is obligatory to work out a method or a scheme where the speed and quality of construction are controlled automatically by a systematic approach.

- Therefore Aluminium Formwork System (AFS) is identified to be suitable for Indian conditions for mass housing construction where quality and speed can be maintained at a reasonably high level.
- The traditional or conventional method of construction for mass housing & high rise buildings is comparatively, a slow process and has limited quality control, particularly when a large size project is involved.

2. Advantages of Aluminium formwork over conventional construction

- **Time:** For 100 per cent work, aluminium formwork takes 1/6 th of the total time required by conventional formwork.
- **Cost:** Use of this formwork in load bearing design gives an average of 15 per cent cost saving in the structure of the building and increased usable floor space of 8 per cent over RCC design.
- **Environment Friendly:** As there is no use of timber, it is environmental friendly. The formwork gives the box or cellular design resulting in the walls giving support to the super structure in two directions. As a result, the structures are more resistant to earthquakes than the traditional RCC column and beam designs.
- **Lifting:** Tower cranes are not required for the AFS as they are lightweight unlike in tunnel framework.
- **Load Bearing Capacity:** AFS is highly suited for load bearing wall construction whereas traditional formwork consisting of plywood and timber is not suitable to the high pressures of fresh concrete on the wall.
- **Labours:** As the procedure is simple, only unskilled labours are required.
- **Repetitions:** The Aluminium Formwork System is removable and can be reused hundreds of times with little maintenance (250-300).
- **Scrap Value:** Moreover, the requirement of aluminium is also reduced in this technology as aluminium has a higher scrap value.

3. Disadvantages of Aluminium formwork

- **Finishing:** Because the sizes are small, finishing lines are seen on the concrete surfaces.
- **Concealed services:** Concealed services such as plumbing, electric wiring etc. become difficult due to small thickness of components.
- **Uniformity:** It requires uniform planning as well as uniform elevations to be cost effective.
- **Changes:** Modifications are not possible as all members are caste in RCC.
- **Not suitable for small work**: Large volume of work is necessary to be cost effective i.e. at least 200 repetitions of the forms should be possible at work.
- **Problems related to cracks**: The formwork requires number of spacer, wall ties etc. which are placed @ 2 feet c/c; these create problems such as seepage, leakages during monsoon. Due to box-type construction shrinkage cracks are likely to appear.
- **Heat of Hydration**: It is high due to shear walls.

Comparison table between AFS and conventional formwork system

1	Construction speed	Cycle time = 4 days	Cycle time = 21 days
2	Finished surface quality	Very smooth	Requirement of plastering
3	Pre-planning of formwork system	Necessary	Not necessary
4	Construction type	Cast-in-situ Cellular	Simple RCC framed
		construction	construction
5	Wastage of material	Very less	In great amount.
6	Construction accuracy	Accurate construction	Accuracy is Less than

7	Coordination between different	Highly required	Not necessarily required
	agencies		
8	Seismic resistance	High resistance	Limited resistance
9	Removing of floor slab forms without	Can be done	Cannot be done
	removing props		
10	Re-usage value	250 – 300 times	Maximum 50 times
11	Suitability for high rise construction	Very much suitable	Not suitable
12	Initial investment	Expensive	Less expensive
13	Economy in construction	Economical for mass housing	Economical on small scale

IV. INVESTIGATION AND RESULTS

Investigation of the influence of formwork materials on the quality of concrete was performed by comparing four types of formwork materials namely softwood timber, hardwood timber, plywood and aluminium.

Before fabricating the formwork, samples of these materials (except aluminium) were taken and their moisture contents and water absorption determined. The obtained results are shown in Table 1. It has to be noted that wood is considered to be dry if the moisture content is less or equal to 19% and saturated if it is greater than 28%.

Using formworks fabricated from the above mentioned materials, concrete beams of dimensions 150 x 150 x 750 mm and columns of 230 x 230 x 1000 mm were casted Concrete was placed and uniformly compacted.. Concrete ratio used was 1:2:4 with a water/cement ratio of 0.48.

Table 1: Moisture content and water absorption of formwork materials

S/n	Type of material	Moisture content (%)	Water absorption (%)
1	Softwood timber	13.01	31.93
2	Hardwood timber	9.05	9.8
3	Plywood	12.93	28.1

The formwork for beams and columns were stripped off after 24 hours which is the minimum recommended time. After curing for 28 days, concrete cores were drilled and their densities and water absorption determined. The compressive strengths along the drilled cores were also determined. The results of the densities and water absorption determined are shown in Table 2.

Table 2: Densities and water absorption of concrete cores

S/n	Concrete samples		
	Formwork material	Density (kg/m3)	Water absorption (%)
1	Softwood Timber	2310	1.25
2	Hardwood Timber	2195	1.31
3	Plywood	2299	1.01
4	Aluminium	2179	1.55

The estimated compressive strengths of the concrete along the drilled cores at the centre and the surface (outer zone) of concrete were determined using the rebound hammer. The average estimated compressive strengths results are shown in Table 3.

Table 3: Rebound hammer test results

S/n	Estimated compressive strength		
	Formwork material (N/mm2)	Surface	Inner (Centre)
1	Softwood Timber	39.5	42.6
2	Hardwood Timber	39.4	41.8
3	Plywood	39.5	41.3
4	Aluminium	39.3	40.7

The drilled concrete cores were crushed to determine their compressive strengths and the results are shown in Table 4.

Table 4: Concrete compressive strengths

Sr. no.	**Formwork material**	**compressive strength (N/mm^2)**
1	Softwood Timber	23.5
2	Hardwood Timber	23
3	Plywood	23.4
4	Aluminium	22.3

V. CONCLUSION

From the above review we conclude following points:

1. Selection of aluminium formwork construction depends on the project type and project requirements.
2. Aluminium formwork construction technique is cost effective for the mass construction and repetitive projects.
3. AFS is a rapid construction technique.
4. AFS offers high quality of construction and low maintenance at the minimum cost.

From the results and observations in section three above, we can conclude:

1. Formwork material has an influence on the compressive strength and durability of concrete. The surface strength vary with the rate of water absorption of formworks

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