

COST EFFECTIVE AND SPEEDY CONSTRUCTION FOR HIGH-RISE BUILDINGS USING SYSTEM FORMWORKS

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Abstract

One of the most important factors in determining the success of a construction project in terms of speed, quality cost and safety of work is the formwork used in the project as it accounts about 40% of the total project cost of the structure. When considering a construction projects both the client and contractor want to finish the job early as the client wants to use the building for the intended purpose as soon as possible. The contractor wants to finish the construction as soon as possible to gain a higher profit. The most efficient way to speed up the work in high-rise building construction is by achieving a very short floor cycle. The floor cycle of a building mainly depend on the formwork type as it is the main time factor of a building project. The aim of this paper is to present about the existing formwork types in Sri Lanka and to show how each one will affect the project duration, project cost and the quality of the work. For that a research has been carried out and the results will present in this paper.

Keywords: formwork, duration, cost, quality

1. Introduction

Formwork is defined as a temporary structure whose purpose is to provide support and containment for fresh concrete until it can support itself. It moulds the concrete to the desired shape and size and controls its position and alignment. The development of formworks is parallel with the growth of concrete construction throughout the 20th century. The advancement of technology, increase of population and the space limitation lead the way to construct high-rise buildings. But the task was not very easy at the beginning but now the man made the task easy by inventing new machinery and new techniques.

The most important factor in terms of cost, quality and speed in a high-rise building construction project is the type of the formwork used in the project. The first formwork type to be used is the conventional type formwork where the timber planks were supported on timber columns. With the advancement of technology it developed gradually and people used ply wood sheets instead of timber planks and steel pipes with jacks were used to support the ply wood. Then people invented small units of formworks and connect the repeating units in the construction. The larger units were invented like formworks for slab panels, formworks for columns, beams...etc. when the same elements are repeating. Then finally the whole system of formwork is made and initially the material used to it was steel and it was very heavy. Then the aim was to reduce the weight of the system and the materials for formwork have extended to aluminium, plastic, fiber glass...etc.

In Sri Lanka plastic and fiber glass are still not in use in the construction industry. Though the system formwork is introduced to Sri Lanka it is still not much used and most of the contractors do not like to shift to the latest technology as they have the doubt of facing losses in their projects and they are very much familiar with the existing formwork type, the modern conventional type. At the same time the contractors are in a belief that the system formwork is suitable only for super tall buildings as the initial cost of the system formwork is a bit high. Though the initial cost of the system formwork is a bit high it reduces the project duration and hence the total project cost. When considering the overall construction of a high-rise building the system formwork is much more economical than to all the other primary formwork types as it reduces the project duration, gives a smooth concrete surface and the repetitive use of the system. This is suitable for even for a two or three storey housing scheme of several houses.

2. Types of Formworks

Conventional Formwork: This is the oldest type of formwork used in the construction industry. This type uses timber, bamboo, masonry and carpentry in the construction. This type is very much suitable for small houses with two to three storeys and still they are in use for such constructions. But this is not suitable for the big projects or high-rise buildings. Low initial cost, low experience factor, low weight are some of the advantages of this type and poor finish, high labor requirement, skilled labor

requirement and consume lot of time are some of the disadvantages.

Modern Conventional Formwork: This type is very much closer to the conventional formwork and in simple words this is one step advanced than the conventional type. The same technique has used in the both types and the only difference is the materials use for the formworks. In modern conventional formwork more advanced materials are used and they can reuse for several times. The differences of both types are that steel 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. Low initial cost, low skilled labor requirement, can even use in small places and when there are lot of deviations in the structure are some of the advantages while poor finish of the concrete surface, high labor requirement and the higher floor cycle are the disadvantages. But this is the most commonly used type in the Sri Lanka for every scale of construction.

Semi System Formwork: This type is much more advanced than the modern conventional type. In this type there are pre-fabricated formwork items such as pre-fabricated formworks for slab panels and supports and ply wood should be used additionally for slab deck, beams and columns for the surface. There are other forms of semi system formwork such as table forms, flying forms...etc. DOCA is the most famous brand for this type of formwork and some people know about this type only as “DOCA formwork”.

System Formwork: System formwork has prefabricated modular components with casting panels. The system formwork is fabricated as it suits the required shape. The biggest advantage of this type is the speedy and quality construction. But the high initial cost is the main disadvantage and hence it is not economical to use in low – rise buildings. But this is the most economical form of formwork type to be used in high-rise building construction when it is having few typical storeys.

3. Research Study

The expectation of this study is to find the most economical formwork type to be used in a high-rise building project. When considering a construction project there are many cost components contributing to the total cost of the project. Preliminary cost is a key cost component when comparing the total cost of a project, and the duration of the project is the governing factor for the preliminary running cost.

Total Project Cost = Materials and labour + Preliminary cost + Machinery & equipment + Waste material handling + Safety + Finishes + ...

Preliminary Cost = Salaries + Electricity + Telephone + Welfare + Security + ...

When a building construction project is considered the material requirement is unique as it depends on the design. But the labor requirement and the duration of the project are directly affected by the technologies and the construction methods used in the project. The speed of the project is directly affected by the formwork type used in the project. This is the most critical in high-rise building construction. When using latest technologies, the labor requirement and the time duration can be

minimized in the project, mainly for the super structure.

In high-rise building projects time controlling factor is the formwork as it directly affect the floor cycle and hence it will reduce the time taken to construct the main structure and because of that the total duration of the project will go down drastically. In this research cost comparisons of total project cost has done for several projects when all the three types of formwork types are used in the same project.

4. The results

4.1 The Results Obtained

Data is collected to several projects and calculations are done for the total project cost of the selected projects when using different types of formworks in the construction. In the calculations all the parameters are kept same and only the formwork type is changed. At the same time all the factors affect due to the formwork type is considered. The results can be shown in a table as follows.

Table 1: Summary of the analysis

Project	No. of Storeys	Total project cost (LKR in millions)		
		Aluminium panel system formwork	Semi system formwork (DOCA)	Conventional formwork
Emperor Apartment Tower	35	2102.93	2203.68	2325.26
On three 20 building	38	1849.43	1926.56	2027.52
Green path Hotel complex	25	1864	1942.56	2032.38
Residential apartments at Rajagiriya	22	912.5	957.6	1012.32

4.2 Results for the On Three 20 Building at Union Place

In this project the used formwork type was system formwork and all the values are in LKR and in millions. The building is a 38 storey building. The main contractor for this building is Sanken Construction (Pvt) Ltd.

Table 2: Summary of the analysis (On Three 20 Building)

	Aluminium panel system formwork	Semi system formwork (DOCA)	Conventional formwork
Duration	40 months	47 months	57 months
Formwork cost	35.6	33.69	27.8
Preliminary cost	227.36	267.15	323.99
Finishes affected by the formwork	38.23	40.94	62.76
Waste disposal affected by the formwork	0	12.63	19.46
Machinery affected by the formwork	16.91	40.63	50.16
Total	1849.43	1926.56	2027.52

For further clarification the graphical presentations of the results for the above comparison are as follows.

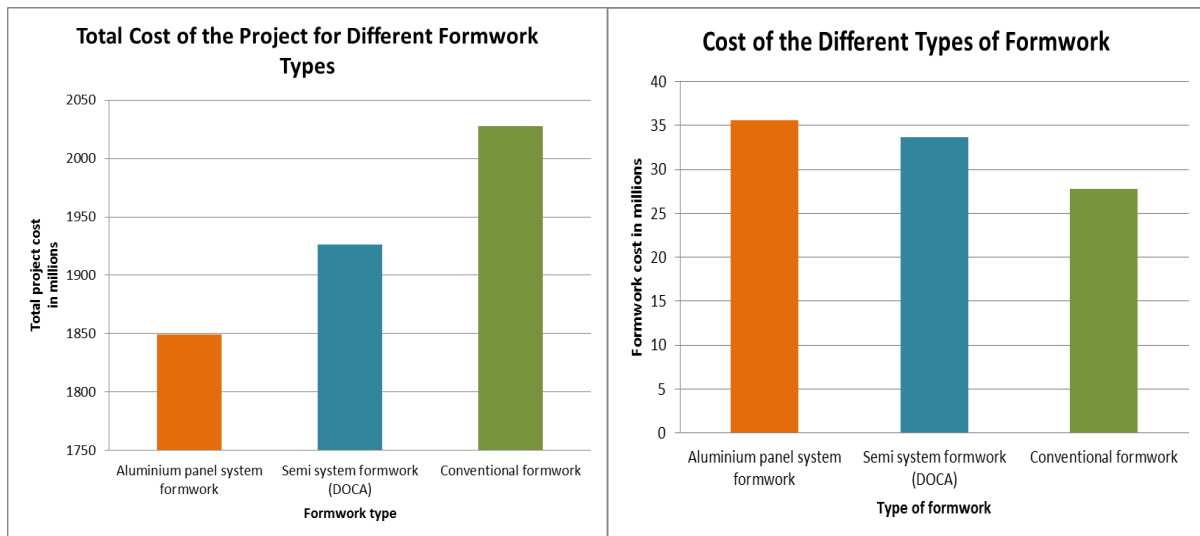


Figure 1: Total project cost for different type of formworks

Figure 2: Cost of Different type of formworks

4.3 Other Comparisons

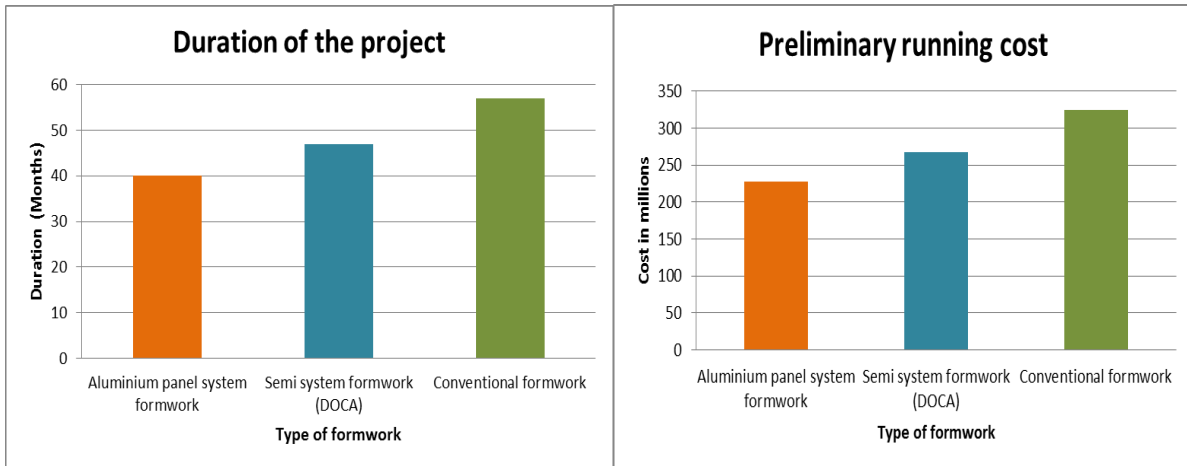


Figure 4.10: Duration comparison

Figure 4.11: Preliminary cost comparison

5. Conclusions

From the results obtained we can come to a conclusion that when the system formwork is used in the construction project, the total project cost and the duration of the project is lesser than the other formwork types.

Modern Conventional Formwork > Semi System formwork > Aluminium Panel System Formwork

The main important thing is that the aluminium panel system formwork is the most expensive formwork type from those three types. At the same time the highest total project cost is obtained when modern conventional type of formwork is used in the building construction project which is the least expensive formwork type. So it is clearly seen that that not the cost of formwork directly affected to the total project cost but the type of formwork.

The floor cycle will be 6-10 days when the system formwork is in use and hence the total project duration will be reduced. At the same time a smooth concrete surface can be obtained as the system can be assembled without any discontinuities in the surface and hence less finishing work will be there and hence the cost for finishes will be reduced. There will be less waste disposal and less machinery usage. Not only the direct benefits, there are many indirect benefits of using aluminium panel system formwork in the high-rise building construction projects. For example the system can be sold after using, it can be used in other slabs doing slight variations (there is no need to buy materials again).

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