

Cost Effective and Speedy Construction for High-Rise Buildings in Sri Lanka by Using Aluminium Panel System Formworks

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Abstract: Formwork is one of the most important factors in determining the success of a construction project in terms of speed, quality cost and safety of work as it accounts about 40% of the total project cost of the structure. To minimize the costs the contractor needs to complete the project as soon as possible and the client wants the building to use the building as early as possible for the intended purpose. In high-rise building construction the most efficient way to speed up the work is by achieving a very short floor cycle. That directly depends on the selected form work type for the construction. This paper will present about the existing formwork types in Sri Lanka and the available new techniques in formwork erection. This paper will clearly present an analysis and comparison of costs and durations of projects when using different types of formworks. The main objective of this paper is to identify the least no. of typical storeys required in a high-rise building construction project, to use aluminium panel system formwork.

Keywords: Formwork system, duration, total project cost, preliminary running cost, typical storeys.

1. INTRODUCTION

The development of formworks is parallel with the growth of concrete construction throughout past few decades. With the development and increasing of population people tend to construct high-rise buildings and construction of a tall building was not easy at the early days. With the development, the man made the tasks easy by inventing new machinery and new techniques. One such area related to high-rise construction is the type of the formwork used in the construction. At the early days people used conventional type formwork where the timber planks were supported on timber columns. With the advancement of the science man used plywood instead of timber planks and pipe supports with various kinds of jacks instead of timber supports.

Then the man invented small units of formworks when the same structure is repeating such as slab forms, flying forms for the walls...etc. finally the greatest invention came for the complete system. At the beginning the system was made out of steel and which was very heavy. Then the man paid his attention towards reducing the weight of the formwork system. Now the materials for formwork have extended to aluminium, plastic, fiber glass...etc.

But still the aluminium panel system formwork is not much used in Sri Lanka and most of the contractors do not like to shift to the latest technology as they have the doubt of facing losses in the project and they are very much familiar with the existing formwork type, the modern conventional type. At the same time contractors have a false belief that aluminium panel system formwork is only suitable for very tall buildings which are having thirty to forty storeys. Though the aluminium panel system formwork reduces the project duration and hence the total project cost, the formwork system is a bit expensive. So this research was carried out to analyze the cost for each formwork type and compare the values obtained for the total project cost when different types of formworks are used in the construction project and find the least no. of storeys sufficient to use the system formwork in the construction project.

1.1. Available Formwork Types in Sri Lanka

1.1.2. Conventional Type of Formwork

This is the most traditional type of formwork and this uses timber, bamboo, masonry and carpentry to complete construction. Low initial cost, low experience factor and low weight are some of the advantages while high floor cycle, poor finish, and high labor requirement are the disadvantages of this formwork type.

This formwork type is still in practice in two – three storey building construction projects.

1.1.3. Modern Conventional type of Formwork

Modern conventional type formwork is as much the same as the traditional slab formwork method and the only difference is 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. The advantages of this type are low initial cost, low skilled labor requirement and can use in places where there are a lot of deviations in the structure. Poor finish, high labor requirement and high floor cycle are some of the disadvantages. This is the most commonly used formwork type in Sri Lanka even in the big buildings.

1.1.4. Semi System Formwork

This is a more advanced formwork type than the modern conventional type as there are pre-fabricated formwork items. For example there are pre-fabricated formworks for slab panels and supports. When using this type of formwork ply wood should be used additionally for slab deck, beams and columns for the surface. There are several types 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”.

1.1.5. Aluminium Panel System Formwork

System formwork has prefabricated modular components with casting panels. The system formwork can suit the required shape of concrete structure. The speedy and quality construction is the biggest advantage in this type while high initial cost is the main disadvantage and hence this 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 (more than 10) typical storeys.

2. RESEARCH STUDY

This research is the continuation of the MSc. Study done by Eng. Arjuna Gunatilaka. There he has done the study based on more than 25 storeys. The expectation of this study is to find the optimum typical storeys required (least no. of typical storeys) to use an aluminium panel system formwork in a building construction project.

There are many cost components in construction projects contributing to the total cost of the project. Preliminary running cost is a key cost component when comparing the total cost of a project and the duration of the project is the governing factor of the preliminary running cost.

$$\begin{aligned} \text{Total Project Cost} = & \text{Cost for the materials and labour} + \text{Preliminary running cost} + & (1) \\ & \text{Machinery and equipment cost} + \text{Waste material handling cost} + \text{Cost for} \\ & \text{safety in the site} + \text{Cost for finishes} + \text{Walking/working platform cost} + \dots \end{aligned}$$

When a 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 totally depending on the technologies and the construction methods used in the project. One of the most time consuming activities in a high-rise building construction project is the construction of the main structure. At the same time it requires more labor. But when the latest technologies are used it can reduce both the time and labor requirement in constructing the main structure.

In a high-rise building projects formwork plays a major role 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 each project is using all the three types of formwork types. (Some of the results are directly taken from the Eng. Arjuna Gunatilaka’s MSc. Study and the same thing is done for some other projects which are having different no. of storeys. At the same time the lots of calculations are done to find an optimum no. of storeys (least no. of typical storeys) to use the aluminium panel system formwork in a high-rise building. The calculations are adjusted for different storey levels to find the least no. of typical

storeys in a high-rise building. At the same time some relationships of cost components are derived to ease the calculations for future study.

3. THE RESULTS

3.1 The Obtained Results

The calculations are done for several selected high-rise building construction projects when different types of formworks are used in each project and the obtained results can be shown in a tabular form as follows.

Table 1 Summary of the analysis
(Data is taken from Sanken Construction (Pvt) Ltd.)

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

3.2 Results for the Emperor Apartment Tower at Kolpity

In this project the used formwork type was semi system (DOCA) formwork and all the values are in LKR and in millions. The building is a 35 storey building. The main contractor for this building is Sanken Construction (Pvt) Ltd. (earlier Sanken Lanka (Pvt) Ltd.).

Table 2 Summary of the analysis (Emperor Apartment Tower)
(Extracted from COST COMPARISON OF FORWORK TYPES FOR ABOVE 25 STOREY BUILDINGS)

	Aluminium panel system formwork	Semi system formwork (DOCA)	Conventional formwork
Duration	14 months	21 months	31 months
Formwork cost	48.63	43.81	36.8
Preliminary cost	144.07	216.1	319
Finishes affected by the formwork	43.34	52.24	69.54
Waste disposal affected by the formwork	0	13.45	19.66
Machinery affected by the formwork	14.45	25.81	40.55
Total	2102.93	2203.68	2325.26

When the results are presented graphically it is easy to compare the results it can be shown graphically as follows.

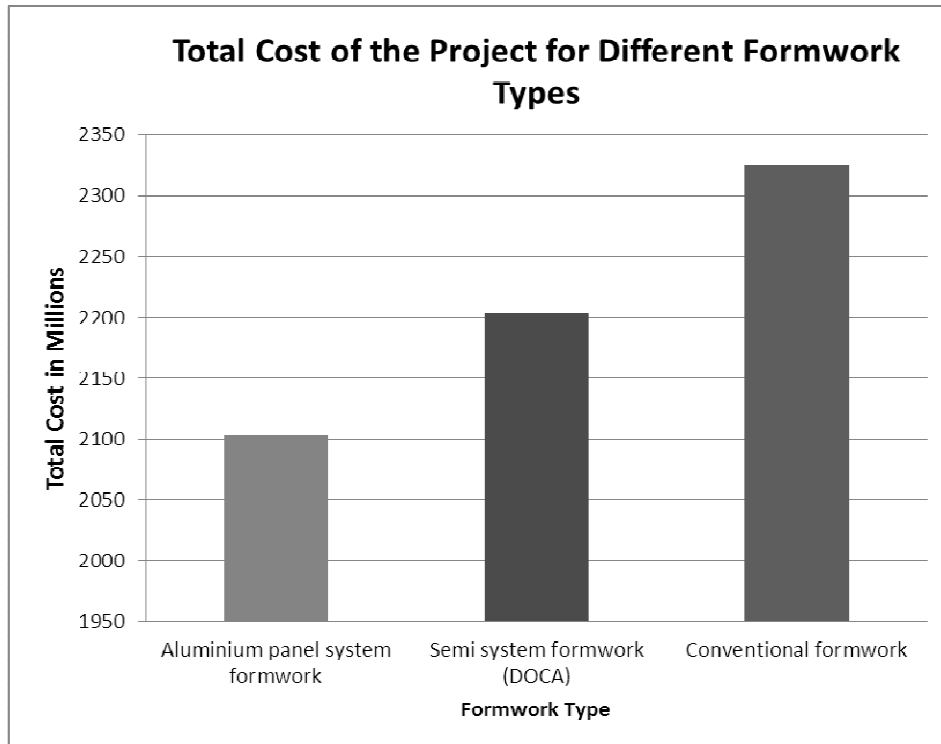


Figure 1: Cost of the total project when using different type of formworks (Emperor Apartment Tower)
 (Extracted from COST COMPARISON OF FORWORK TYPES FOR ABOVE 25 STOREY BUILDINGS)

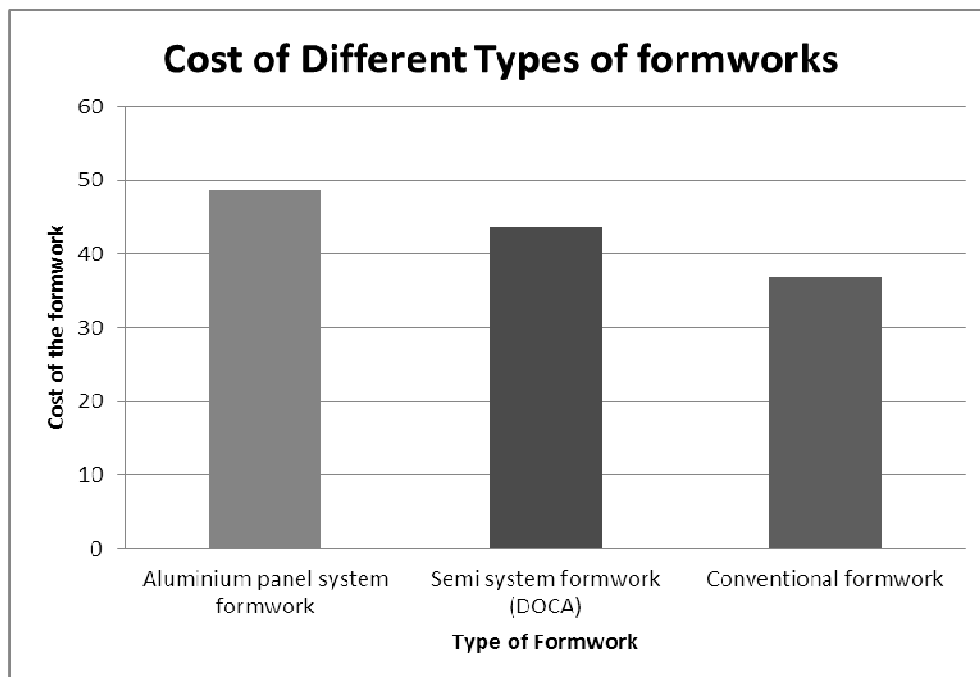


Figure 2: Cost of Different type of formworks (Emperor Apartment Tower)
 (Extracted from COST COMPARISON OF FORWORK TYPES FOR ABOVE 25 STOREY BUILDINGS)

The calculations are done for each case assuming the necessary conditions to find the optimum no. of storeys (least no. of typical floors) to use the aluminium panel system formwork. The result obtained was using aluminium panel system formwork is economical for high-rise buildings of more than 10 storeys.

The results obtained for an assumed project of 10 storeys is as follows. Here all the other conditions are taken as same for the above mentioned Emperor Apartment Tower project. In this calculation all the values are in LKR and in millions.

Table 3: Summary of the analysis (Assumed 10 storey building)

	Aluminium panel system formwork	Semi system formwork (DOCA)	Conventional formwork
Duration	8 months	10 months	13 months
Formwork cost	41.2	29.7	12.3
Preliminary cost	82.33	102.90	133.77
Finishes affected by the formwork	12.38	14.93	19.87
Waste disposal affected by the formwork	0	3.84	5.62
Machinery affected by the formwork	14.64	17.8	22.54
Total	144.11+X	166.17+X	192.86+X

where X is the common cost for the building (which are not affecting by the formwork type)

In a construction project most of the other cost items are same. So the total cost of the above project is obtained by adding those costs to the costs which are varying due to the formwork type used in the project. In selecting the aluminium panel system formwork the most important thing to pay our attention is whether the cost saving due to shortening the project duration (preliminary running cost, machinery cost), in less finishing work and in less waste disposal is greater than the excess cost for the formwork system.

The aluminium panel system formwork can be used, so far the following inequality is satisfied for no. of typical storeys

$$(P-Q) NA \leq Y (D - 14N) + M (D - 14N) + W \quad (2)$$

where P is the cost for aluminium panel system formwork per square meter, Q is the cost for modern conventional formwork per square meter, N is the no. of typical storeys, A is the floor area of a typical floor in square meters, D is the project duration in days, Y is the preliminary running cost per day, M is the machinery cost per day and W is the cost saving in waste disposal.

4. CONCLUSIONS

From the results it is clearly seen that the total project cost is vary as follows for the building which are having more than 10 typical storeys.

$$\text{Modern Conventional Formwork} > \text{Semi System formwork} > \text{Aluminium Panel System Formwork} \quad (3)$$

And the most important thing obtained this study is that identifying of the optimum no of storeys for use aluminium panel system formwork in the high-rise building construction. That is if there are 10 or more typical storeys in the building the most economical formwork type to use is aluminium panel system formwork.

If the construction is properly controlled this is worth even in buildings which are having less than 10 typical storeys. But for the Sri Lankan context; with less experience and less technology it is recommend to use aluminium panel system formwork in buildings which are having 10 or more typical storeys.

Not only the seen benefits, there are many unseen benefits of using aluminium panel system formwork in the high-rise building construction project.

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), less waste disposal hence the cost for waste disposal is saved and can obtain a high quality concrete surface and due to that less finishing work will be there and hence the cost for finishes will be reduced.

5. ACKNOWLEDGMENTS

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