BILINGUAL PUBLISHING GROUP

Journal of Building Material Science

https://journals.bilpubgroup.com/index.php/jbms

ARTICLE

Cost Comparison of Different Types of Formworks

Kiran Devi* *, *Tushar Yadav

Department of Civil Engineering, SGT University, Gurugram, Haryana, 122505, India

ABSTRACT

Formwork is the temporary moulds in the construction which is fabricated based on the drawing and design of the structure and into which the concrete is poured to form the required structure. Formwork is an essential part of the construction as it has been used by the Romans. The formworks must be strong enough to withstand all types of loads. The joint must be in proper condition to avoid any kind of leakages. The materials used for the formworks should be economical, easily available and durable. The formworks can be made up of different materials such as plywood, steel, aluminum, composite material, etc. In steel formwork the plates used for the slab support are made up of galvanized steel and these are fabricated as per the requirements. Aluminum plates are used in the aluminum framework along with the other components made up of aluminum. The selection of a suitable framework is important in any project because it bears about 25% to 30% cost of the total cost of construction. In the present study, different types of formworks such as steel, plywood and aluminum were studied in a project and a comparison was made on the reusability and easiness in handling and maintenance. Also, a comparison of the formwork used in the construction of the 5th and 11th-floor tower based on the specific plan and drawing was done. The results showed that the aluminum formwork was found to be efficient and suitable among all formworks, although the cost was higher compared to other formwork materials.

Keywords: Formworks; Steel formworks; Plywood formworks; Aluminum formworks; Cost analysis

1. Introduction

Formwork is a mould-like container into which fresh concrete is poured and compacted. When the concrete is set, the formwork is removed and a solid mass is obtained in the shape of the inner face of the formwork. Generally, the top of the formwork is left

*CORRESPONDING AUTHOR:
Corresponding Author: Kiran Devi, Department of Civil Engineering, SGT University, Gurugram, Haryana, 122505, India; Email: kiran-bimbhra@gmail.com

ARTICLE INFO
Received: 6 March 2023 | Revised: 30 March 2023 | Accepted: 10 April 2023 | Published Online: 15 April 2023
DOI: https://doi.org/10.30564/jbms.v5i1.5515

CITATION
Devi, K., Yadav, T., 2023. Cost Comparison of Different Types of Formworks. Journal of Building Material Science. 5(1): 32-38. DOI: https://doi.org/10.30564/jbms.v5i1.5515

open. The geometry realisation and strength development of concrete elements are greatly assisted by formwork. The formwork used to cast the structural elements such as, columns, beams and slabs, is also used for smaller parts of the building such as stairs. Formwork in the building is a crucial task that calls for exceptional accuracy and ability. Lack of precision and ability during formwork building may result in a poor and unsatisfactory quality of work, which ultimately causes a loss of important resources like time and money. The formwork is carefully removed when the concrete has matured and becomes hard. The process of removal of formworks is known as stripping. A good formwork should be able to withstand the forces being applied to it either during or after the concreting process. There is no slurry leakage in the formworks. The surface of a good formwork should be smooth and wrinkle-free after the stripping, consequently producing superior quality and a smoother final concrete product. It should be sturdy enough to be used repeatedly. The causes of failure of formworks are overloading of any props, failure of shuttering due to excessive vibrations of needle surface vibrators, failure due to improper supervision, inadequate design/ planning of shuttering, centring & concreting activity [1-3].

The materials used for the formworks are steel, timber, plywood, aluminium, composite materials, etc. Plywood is the manufactured product of timber and consists of veneer sheets or piles in layers. Plywood as formwork material is used due to its smooth finish, lightweight, strong and low finishing cost. The plywood formwork consists of a plyboard, batten, wooden props (balls), nails, binding wires, shuttering oil, clamps, wooden batten (channel), scaffolding. Steel formworks are used in mass structures such as dams, and bridges and provide an excellent finish to the concrete surface and can be reused numerous times. It is strong, easy to dismantle but the cost is higher, corrosion may occur and need the use of lifting equipment due to its heavy weight. Steel is also used for the purpose of formwork. It is quite costly but can be used more times. They are used in structures like dams, bridges, etc. Steel shuttering is installed using clamps, bolts and nuts. They are comparatively heavy compared to other types of formwork. Panels comprised of thin steel plates that are attached around the edges by tiny steel angles make up steel formwork. Aluminium formworks are used in the prefabricated structure. It is lightweight, needs lesser support, is reusable and has good strength. Similarly, aluminium is the major material in the aluminium formwork. It is also known as the Mivan Formwork. The material used is a certain type of aluminium alloy that has the resistive property against different atmospheric conditions like wet, dry, humid. Aluminium as a metal is corrosion free as it reacts with the oxygen present in the atmosphere and forms an aluminium oxide layer which prevents corrosion. Although the initial cost for the fabrication is high it has a high reusability factor, which is it can be reused more times compared to the plywood formwork, which compensates for the high investment cost. The components of aluminium formwork are aluminium panel, pin & wedge, tie rod, wing nuts, kicker, wall tie, vertical soldier, slab mounted brackets, external corner, props, wall attach bracket, scaffolding. When using the flat tie and casting concrete together, a stub pin and wedge are needed. Wall ties, pins, and wedge bolts are used with construction formwork accessory wedge to secure the formwork. In the present study, different materials of formworks such as steel, plywood and aluminium were studied and a comparison was made in terms of cost.

Patil and Mundhada [4] compared the Mivan or aluminum formwork with the conventional formwork. Results showed that the finish obtained from the Mivan formwork was very good and did not require any plasterwork compared to conventional formwork.

Aluminium and steel formwork are fairly comparable to one other. Of course, aluminium makes up the majority of it. The primary distinction between steel and aluminium formwork is that the aluminium is having lesser weight as compared to steel. This is due to the fact that aluminium has a lower density than steel which makes it easier to handle [5].

Terzioglu et al. [6] conducted an analysis that deals

with the criteria which need to be used in order to select the formwork but it does not provide anything related to cost in terms of choosing the formwork and also regarding the quantity of the components. Shrivastava et al. [7] conducted an analysis of planning of formwork materials by which analyses the formwork materials which are used will depend upon the type of building, whether the building is commercial, residential, factory or industrial or another type of building. The selection of the kind of formwork is in it itself a big task and it affects the overall cost of the project. It is one of the major inputs which also affects the design of the building as well. This paper will discuss what kind of formwork materials should be selected for different building typologies. Li et al. [1] conducted a review of formwork systems for modern concrete construction which presents 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 objectives of the present study are to analyse a) components used in the different kinds of formwork: Plywood, steel and aluminium, b) the quantity of the components used in the formwork and c) the components that are used in the formwork. After doing all these at last a comparison has been made among the three formworks in order to choose the best as compared to others. Very few studies are available on the cost comparison of different formworks i.e. steel, plywood, aluminum formworks and their components used for a 2 BHK project. The number of formworks required during the project and their cost were calculated and compared manually.

2. Methodology

In the present study, the design of the floor of the area was calculated manually. The floor plan includes 2 BHK along with the drawing room has been shown in **Figure 1**. After calculating the total area for which the formwork is required manually, the slab area of each floor was calculated. After knowing the area from the plan manually, the total number of plywood, steel and aluminium plates required to

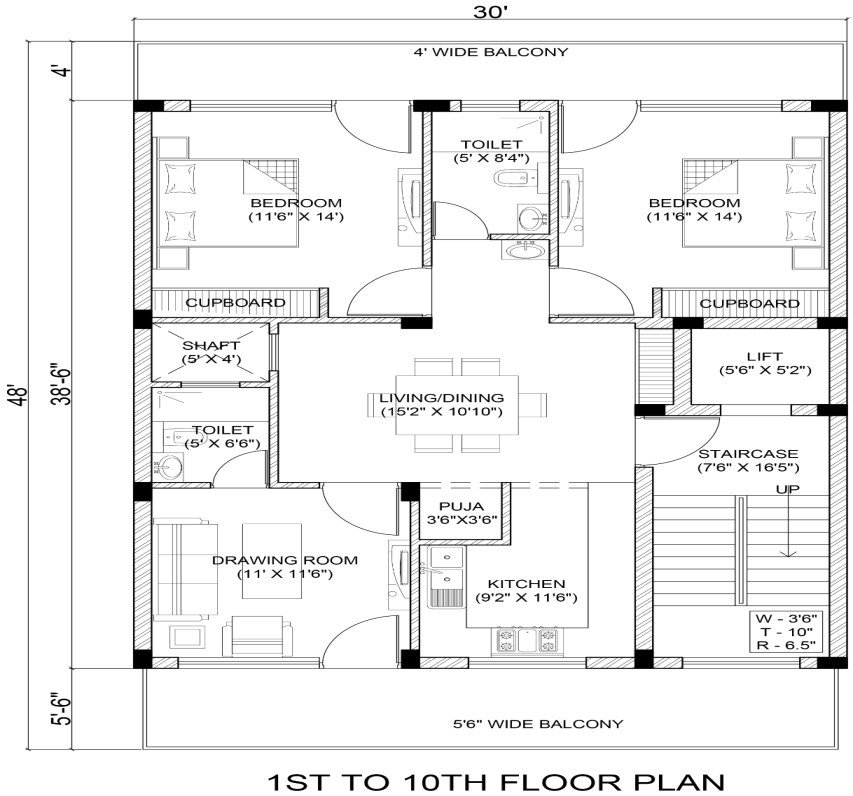

Figure 1. Floor plan.

cover the slab area is calculated manually. Also, the total number of columns and beams to be constructed per floor is calculated. Then based on the calculation the total number of props, channels and other components used to support the concrete for the construction of these elements on the building. All the calculation was done manually. After knowing the quantity of the components that is required. The respective prices and the cost of each component are researched as per the local market. In addition to the formwork it also involves the cost and analysis of the components of the scaffolding required for the construction. For the plywood and steel formwork the rate list is collected based on the components that are used in the analysis. For the Mivan formwork the rates of the component were gathered from the vendor Winntus Formwork Private Limited. For the components used in the scaffolding the rates are collected from the local vendor and then calculated the total cost of the scaffolding is based on the components used. The flow chart of the methodology has been shown in **Figure 2**.

3. Results

The different materials i.e., steel, plywood and aluminum formworks were used in a project and a cost comparison was carried out. Calculation of aluminium formwork was done on a square metre basis. The rate of aluminium panels was Rs 7000 per square metre. Note: The moulds of aluminium formwork were manufactured as per drawings. The different members were used in plywood, steel and aluminum formwork and their prices have been given in **Tables 1a, 1b, 2 and 3** respectively. The total cost of different formworks was evaluated for a particular project and a comparison was made.

It has been observed from **Figure 3** that the cost of the scaffolding of all three formworks is similar whereas the total cost of plywood formwork was least followed by steel and aluminium formwork. However, the overall cost of aluminium formwork was minimum and steel formwork was the maximum among all the formworks.

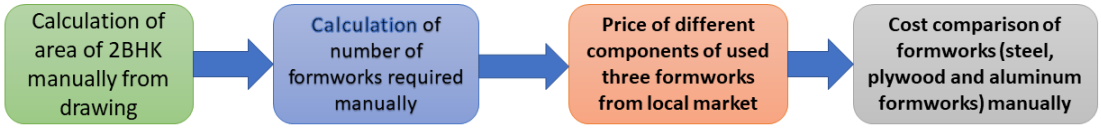

Figure 2. Flow chart for the cost comparison of formworks.

Table 1a. Cost of different members of plywood formworks.

Plywood formwork				
Sr. No.	Member	Total no. of member	Price (Rs.)	Total cost (Rs.)
1	Plywood (Beam, Column, Slab)	93	1550	144150
2	Batten (Beam, Column)	371	195	72345
3	Batten (Slab)	192	185	35520
4	Wooden batten	39	550	21450
5	Prop (Beam)	96	135	12960
6	Prop (Slab)	156	145	22620
7	Clamps (Beam, column)	336	150	50400
8	Ledger	296	680	212080
9	Base Jack	16	190	3040
10	Challi	24	1540	36960
11	Base jack	22	190	4180
12	Challi	36	1540	55440

Table 1a continued

	Scaffolding	Length	Cost of scaffolding	Total cost
1	Length of standard	208*3 = 624	680	424320
2	Length of ledger	518*1.5 = 777	680	528360
3	Guard rail	24	680	16320
4	Length of bracing	39	680	26520
5	Length of standard	286*3 = 858	680	583440
6	Ledger	740*1.5 = 1110	680	754800
7	Ledger	296*1 = 296	680	201280
8	Guard rail	34	680	23120
9	Length of bracing	45	680	30600
3	Shuttering Oil	19	60	1140

Table 1b. The unit price of different materials.

Sr. No.	**Product**	**Weight (kg)**	**Price (Rs.)**	**Total cost (Rs.)**
1	Nail	28	85	2380
2	Binding wire	4	85	340
3	Shuttering Oil	19	60	1140

Table 2. The number and cost of members in steel formwork.

Steel formwork				
Sr. No.	Member	Number	Cost of member	Total Cost
1	Total Nos of steel plates (beam, column, slab)	484	1540	745360
2	Total no. of nuts and bolts	685	12	8220
3	Shuttering oil	190 Lit	60	1140
4	No. of Channels	63	1750	110250
5	Total no. of props	348	1400	487200
6	Total no. of scaffolding (30 ft side)	624	680	424320
7	No. of ledger (1.5 m)	777	680	528360
8	No. of ledger (1 m)	296	680	212080
9	No. of base jack	16	190	3040
10	No. of challi	24	1540	36960
11	Guard rail (24 m)	-	680	16320
12	Bracing (39 m)	-	680	26520
13	Total length of standard (scaffolding, 48 ft side)	286	680	583440
14	No. of ledger (1.5m)	740*1.5= 1110	680	754800
15	No. of ledger (1 m)	296	680	201280
16	No. of base jack	22	190	4180
17	No. of challi	36	1540	55440
18	Guard rail (length = 34 m)	-	680	23120
19	Bracing (length = 45 m)	-	680	30600

Table 3. Cost of different aluminum formwork members.

Aluminium formwork				
Sr. No.	Member	Area/no.	Cost per unit	Total cost
1	Area of beam, column, slab	269.64 sq. m.	700	1887480
2	No. of props	186	1400	260400
3	No. of pins and wedge	1210	12.85	15548
4	No. of bracket	32	1700	54400
5	Vol. of shuttering oil	19 lit	60	1140
6	No. of external corner	60	350	21000
7	No. of vertical solider	30	400	12000
8	No. of tie rod	54	90	4860
9	No. of wing nut	60	45	2700
10	Total length of standard (Scaffolding 30ft side)	624	680	424320
11	Length of ledger (1.5 m)	777	680	528360
12	Length of ledger (1 m)	296	680	212080
13	No. of base jack	16	190	3040
14	No. of challi	24	1540	36960
15	Length of guard rail	24 m	680	16320
16	Length of bracing	39 m	680	26520
17	Length of standard (Scaffolding 48 ft side)	858	680	583440
18	Length of ledger (1.5 m)	1110	680	754800
19	Length of ledger (1 m)	296	680	201280
20	No. of base jack	22	190	4180
21	No. of challi	36	1540	55440
22	Length of guard rail	34 m	680	23120
23	Length of bracing	45 m	680	30600

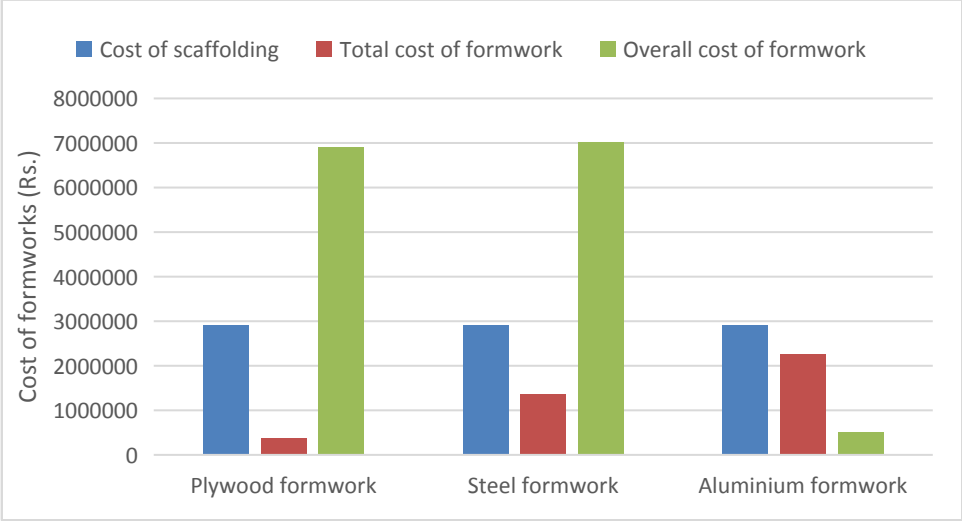

Figure 3. Cost comparison of different formworks.

4. Conclusions

In the present study, different formworks such as plywood, steel and aluminium were used for a project. The calculation of area, number of formworks, cost of formworks and their components were compared manually. The following conclusions were found from the above study:

- The cost of plywood formwork is high because its reusability is very less a number of times, resulting in a higher cost of plywood formwork. Therefore, it is not considered and useful for high-rise or large construction projects.
- The overall cost of steel formwork is highest as compared to plywood and aluminium formwork. In addition to the higher cost, the finishing after deshuttering of the steel formwork is not good and it requires further plastering which contributes to a hike in cost. Also, these formworks are not corrosion-proof, which reduces their strength over a period of time. Due to its heavy weight, it is tough to transfer the steel formwork from one floor to another.
- Aluminium formwork is corrosion resistive, lightweight, easy to handle and transfer and the finishing after deshuttering the formwork is smooth. So, no need for further plastering is required. The initial high cost of aluminium formwork is compensated due to its very high reusability as it can be reused more than 150 times. Due to this the overall cost of the aluminium formwork is less as compared to steel and plywood.
- After considering all the aspects it can be concluded that the aluminium formwork is the most suitable and economical formwork for the construction of high-rise buildings due to its lower cost and good characteristics compared to other formworks.

Author Contributions

Kiran Devi: design and draft of article; and Tushar: concept and analysis of data for the article.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Li, W., Lin, X., Bao, D.W., et al., 2022. A review of formwork systems for modern concrete construction. Structures. 38, 52-63.

[2] Yudina, A.F., Zhivotov, D.A., Tilinin, Y.I., 2023. Additive technologies for manufacture of formwork. Proceedings of ECSF 2021: Engineering, construction, and infrastructure solutions for unnovative medicine facilities. Springer: Cham. pp. 311-318.
DOI: https://doi.org/10.1007/978-3-030-99877-6_37

[3] Donker, D.K., Mahamud, S., 2022. Comparative assessment of formwork systems used in construction projects in the tamale metropolis of Northern Ghana. SSRG International Journal of Civil Engineering. 9(2), 44-50.
DOI: https://doi.org/10.14445/23488352/IJCE-V9I2P104

[4] Patil, P., Mundhada, P., 2022. Comparative analysis of Mivan formwork and conventional formwork. Smart Technologies for Energy, Environment and Sustainable Development. 2, 239-245.
DOI: https://doi.org/10.1007/978-981-16-6879-1_24

[5] Terzioglu, T., Turkoglu, H., Polat, G., 2021. Formwork systems selection criteria for building construction projects: A critical review of the literature. Canadian Journal of Civil Engineering. 49(4), 617-626.
DOI: https://doi.org/10.1139/cjce-2021-0190

[6] Terzioglu, T., Polat, G., Turkoglu, H., 2021. Analysis of formwork system selection criteria for building construction projects: A comparative study. Buildings. 11(12), 618.
DOI: https://doi.org/10.3390/buildings11120618

[7] Shrivastava, A., Saxena, S., Chourasria, D., 2021. Planning of formwork materials. Materials Today: Proceedings. 47(1), 7060-7063.
DOI: https://doi.org/10.1016/j.matpr.2021.06.121