Cost-Benefit Analysis of Phenolic Board and Polypropylene (PP) Hollow Plastic Board as Formwork Materials in Construction Projects

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ABSTRACT

The choice of formwork materials is one way through which efficiency, productivity, and sustainability can be increased in construction projects. The study compared the economics of Phenolic Boards and Polypropylene (PP) Hollow Plastic Boards as formwork materials through life cycle costing and cost-benefit analysis approach. The study used a descriptive-comparative research design and gathered information from construction practitioners such as project engineers, site engineers, contractors, and foremen. The data were obtained using structured questionnaires complemented by market prices and published construction costs information. The methods used to analyze the economics of the two formwork materials included descriptive statistics, weighted mean, cost per use method, and comparative cost benefit analysis.

The results indicate that while Phenolic Boards have low start-up cost, PP Hollow Plastic Boards performed better in terms of durability, reusability, maintenance, and cost efficiency. Cost per use analysis indicated that PP Hollow Plastic Boards incurred much lower operating cost due to its high reusability and replacement. In addition, the participants viewed PP Hollow Plastic Boards as better for increasing productivity and reducing wastage. The study concludes that life-cycle cost and acquisition cost need to be evaluated in tandem while choosing formwork materials. Utilizing PP Hollow Plastic Boards will be advantageous for cost control, increased efficiency, and sustainable construction.

Keywords: Cost-benefit analysis, life-cycle cost analysis, formwork, phenolic board, polypropylene hollow plastic board

INTRODUCTION

Formworks are crucial temporary structures in reinforced concrete structures since they greatly affect the cost, quality, productivity, and completion of projects. In the construction business in the Philippines, Phenolic Boards have been used extensively as the most favored formwork material owing to their low-cost nature, availability, and popularity among the contractors. The poor durability and susceptibility to water damage of these boards lead to constant maintenance and replacements, resulting in an increase in the cost of the projects. The Polypropylene (PP) Hollow Plastic Boards, on the other hand, offer improved durability and water resistance and can be reused. They may cost more initially but are more economical in the long run. Therefore, there is a rising trend among construction managers to conduct LCCA and CBA for evaluating materials on the basis of the total cost of ownership.

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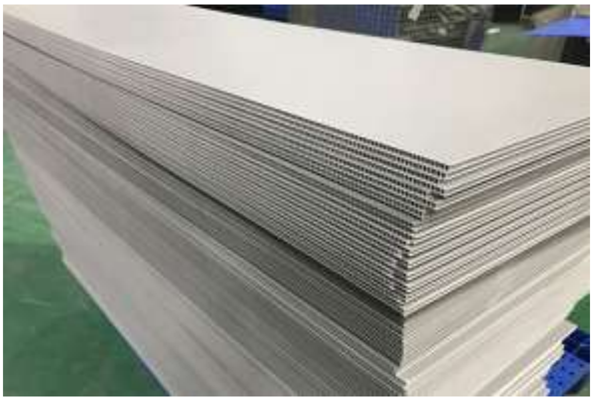
While the number of PP Hollow Plastic Board applications in the Philippines has been increasing, very little research has been done comparing the economic performance of PP Hollow Plastic Boards with traditional Phenolic Boards in practical construction situations. As such, many decisions made during the procurement process still focus more on the initial cost rather than long-term benefits. This research attempts to solve this problem by comparing these two types of formworks based on purchase cost, maintenance, durability, reusability, efficiency, and economic performance in general.

Phenolic Board



Polypropylene (PP) Hollow Plastic Board

METHODOLOGY

This study used a quantitative descriptive-comparative research design to examine the cost-effectiveness of Phenolic Boards and PP Hollow Plastic Boards as materials for use in concrete formworks. The research involved the combination of surveys conducted among construction experts as well as life-cycle cost analysis to facilitate comprehensive evaluation of both materials.

The participants included project engineers, site engineers, contractors, foremen, and other experts in construction who have experience in handling concrete formwork. Purposive sampling method was applied in order to ensure participation of those who are competent and knowledgeable in handling concrete formwork.

Data were gathered in the form of primary and secondary sources. Primary data collection entailed conducting surveys among the respondents. The questionnaire comprised two parts, where part one captured the demographic profile of the respondents while part two involved evaluation of both materials on the basis of their cost, durability, reusability, maintainability, and cost-efficiency on a five-point Likert scale.

Descriptive statistical tools which include frequency distribution, percentage, weighted average, and ranking, have been utilized to provide summaries of the assessments made by respondents. In determining the economic performance of the forms, life cycle costing and cost per use analysis were performed with the aid of the following formula:

$$\text{Cost per Use} = \frac{\text{Initial Material}}{\text{Cost Number of Reuse Cycles}}$$

Field validation in addition to the survey was done by making observations on a real reinforced concrete construction project. Two boards were assessed based on their condition after being reused for concrete casting. The criteria used included surface condition, water absorption, cleaning, dimensional stability, and reusability after each cycle.

From the observations it was noted that Phenolic Boards would develop edge swelling, surface delamination and instability in dimensions after each cycle due to moisture and concrete pressure. On the other hand, PP Hollow Plastic Boards retained their structure, did not develop any surface degradation, were waterproof, and needed

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only simple cleaning after each use. The findings of this field assessment substantiated the answers obtained during the survey.

The findings were analyzed through cost-benefit analysis through comparison of factors such as cost of acquisition, number of replacements required, maintenance considerations, waste generated and long term economic efficiency. This method helped in establishing the type of formwork which gives the best economic benefit over its lifetime as opposed to just initial costs.

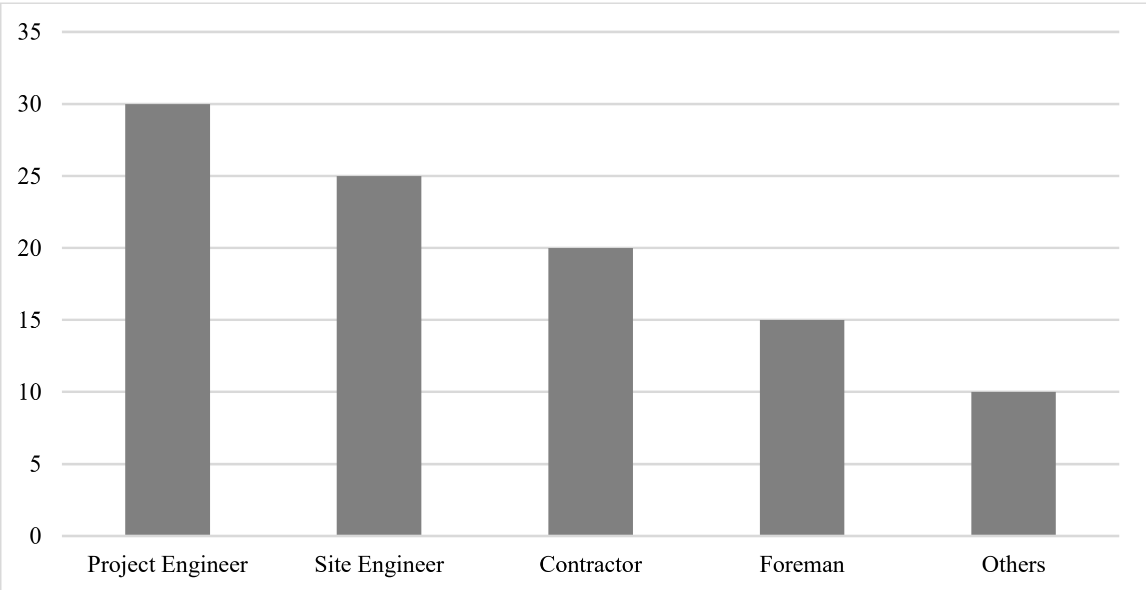
RESULT AND DISCUSSION

A total of 40 construction experts were involved in the research. The roles and experience of the participants suggest that they had enough technical expertise and field experience to assess the efficiency of the formwork materials.

Table 1 Distribution of Respondents According to Position

Position	Frequency (f)	Percentage (%)
Project Engineer	12	30
Site Engineer	10	25
Contractor	8	20
Foreman	6	15
Others	4	10
Total	40	100

Figure 1. Distribution of Respondents According to Position



The group of Project Engineers made up the highest number of respondents (30%), while Site Engineers constituted 25%. The fact that these engineers are mainly tasked with planning, supervision, and selection of construction materials means that their judgments can serve as an accurate source for assessing formwork materials. Information from the side of contractors and foremen helped to get practical experience, which makes the study have a dual approach.

Table 2 Distribution of Respondents According to Years of Experience

Years of Experience	Frequency	Percentage (%)
Less than 1 year	3	7.5

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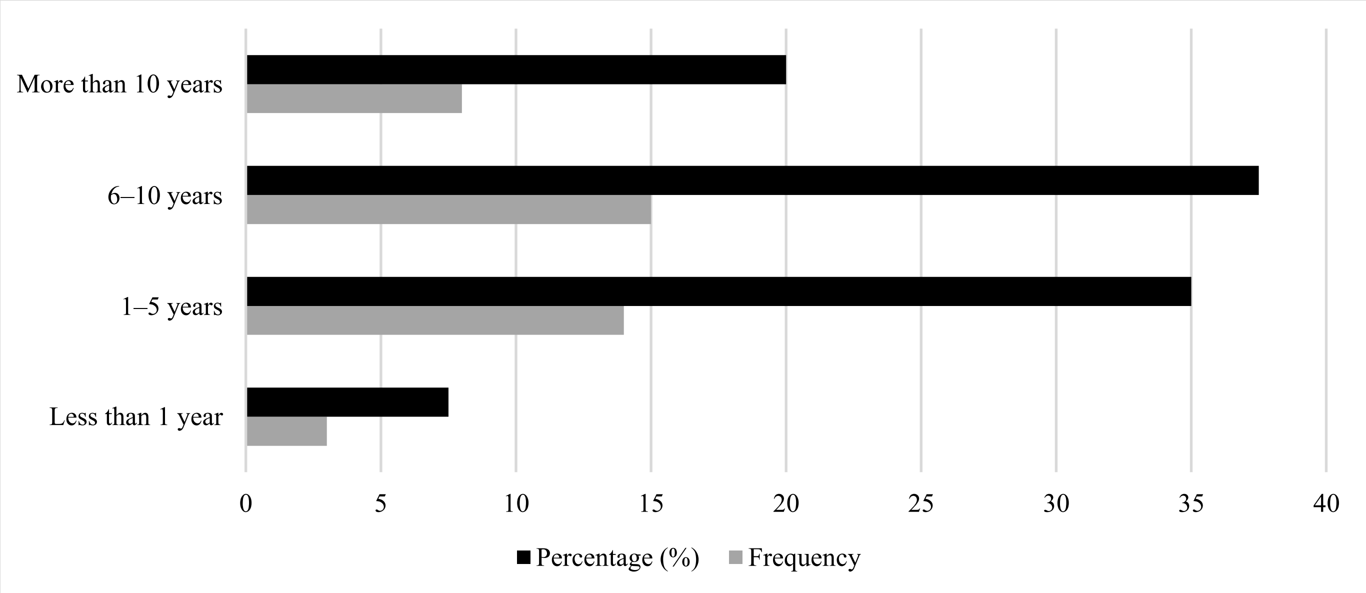
1–5 years	14	35
6–10 years	15	37.5
More than 10 years	8	20
Total	40	100

Figure 2. Distribution of Respondents According to Years of Experience



Most participants had from six to ten years of experience in construction work (37.5%) and 35% had one to five years of experience. This means that the respondents had enough experience to critically assess the actual performance of the formwork material. Through their experience of working repeatedly on the same construction tasks, they were able to give credible judgments about the durability, maintenance, labor efficiency, and costs.

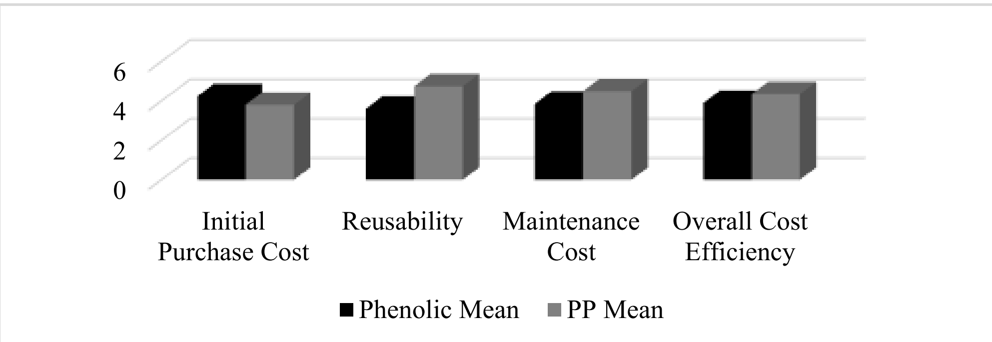
Comparative Assessment of Phenolic Boards and PP Hollow Plastic Boards

The survey respondents assessed both materials based on parameters associated with the cost of acquisition, reusability, maintenance requirements, and economic efficiency in general.

Table 3 Comparative Assessment of Formwork Materials

Indicator	Phenolic Mean	PP Mean	Interpretation
Initial Purchase Cost	4.25	3.8	Agree
Reusability	3.6	4.75	Strongly Agree
Maintenance Cost	3.85	4.5	Agree
Overall Cost Efficiency	3.9	4.35	Agree
Grand Mean	3.9	4.35	Agree

Figure 3. Comparative Assessment of Formwork Materials



DISCUSSION

According to the findings, Phenolic Boards are cheaper to acquire and can be used in low-budget projects. Nevertheless, PP Hollow Plastic Boards were found to be superior in reuse and maintenance as well as in cost-efficiency since they are durable and waterproof, hence reducing the need for replacements and minimizing maintenance expenses. Even though they involve relatively higher initial costs, they prove cheaper in the long run.

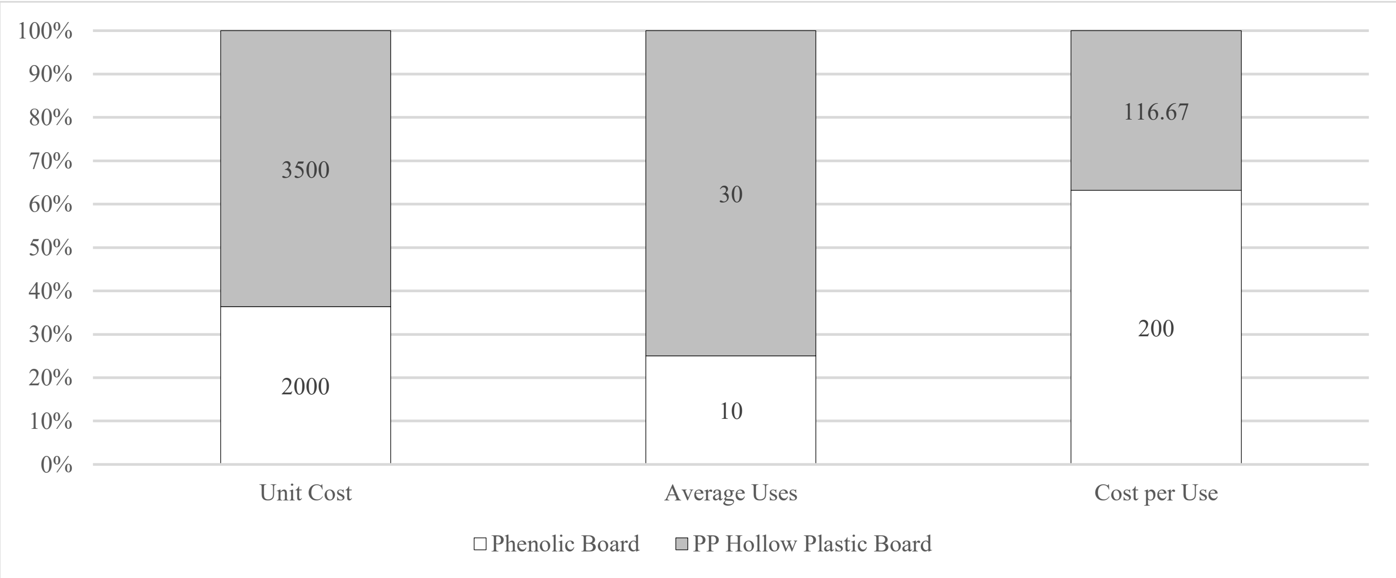
Cost-per-Use Analysis

In order to analyze the economic efficiency of the materials over a long period of time, cost per use was determined through dividing the total cost of purchase by the number of reuse cycles expected.

Table 4 Cost-per-Use Analysis

Material	Unit Cost	Average Uses	Cost per Use
Phenolic Board	2000	10	200
PP Hollow Plastic Board	3500	30	116.67

Figure 4. Cost-per-Use Comparison



The results from the cost-per-use analysis reveal that PP Hollow Plastic Boards are more cost-efficient in the long run despite having a high cost at the time of purchase (₱3,500), compared to Phenolic Boards (₱2,000). Having a cost per use of just ₱116.67 compared to ₱200.00 for Phenolic Boards, PP Hollow Plastic Boards are worth more because of their increased reusability and durability.

These results show that focusing on the initial purchase price may cause less efficient material choices. Although Phenolic Boards may work well for shorter projects and low budgets, PP Hollow Plastic Boards have better life cycle cost efficiency and less wastage of materials and labor.

Recycling and End-of-Life Value

An additional economic advantage of the use of PP Hollow Plastic Boards is the possibility of their residual value at the end of their useful life. Whereas Phenolic Boards usually possess very limited or no scrap value due to degradation, PP Hollow Plastic Boards in poor condition may be collected by plastic recycling companies and sold as scrap polypropylene boards.

Though the current research does not establish local scrap prices, construction professionals agree that polypropylene materials can be sold to recycling companies in various regions of the Philippines. Thus, there is the possibility that PP Hollow Plastic Boards will offer an additional economic advantage due to scrap value along with construction waste reduction.

Table 5: Summary Comparison of Phenolic Board and PP Hollow Plastic Board

Criteria	Phenolic Board	PP Hollow Plastic Board	Better Material
Average Number of Reuses	10	30	PP Hollow Plastic Board
Cost per Use (₱)	200	116.67	PP Hollow Plastic Board
Cost Savings per Use	-	₱83.33 (41.67%)	PP Hollow Plastic Board
Maintenance Requirement	Higher	Lower	PP Hollow Plastic Board
Water Resistance	Moderate	Excellent	PP Hollow Plastic Board
Expected Service-Life	Shorter	Longer	PP Hollow Plastic Board
End-of-Life Value	Minimal	Recyclable (Scraps value)	PP Hollow Plastic Board

A direct comparison between the two types of formworks is provided in Table 5 using the key economic factors. While the Phenolic Boards have a low initial cost, the PP Hollow Plastic Boards were able to have three times the number of average reuse cycles (30 compared to 10), with a cost per use of ₱116.67 as opposed to the Phenolic Boards at ₱200.00. Thus, there is a savings of ₱83.33 per use, which is about 41.67% reduction in cost per use. These results imply that the high cost of acquiring PP Hollow Plastic Boards is offset by their durability, reduced maintenance, and longer service life.

CONCLUSIONS

In this research, the economic performance between Phenolic Boards and Polypropylene (PP) Hollow Plastic Boards in their function as concrete formworks was assessed by applying the Cost-Benefit Analysis (CBA) and Life-Cycle Cost Analysis (LCCA) method. It was found out that although Phenolic Boards continue to be better due to its low initial acquisition cost, its poor performance in terms of durability and reuse ability increased its ownership cost throughout the years.

From the results of the study, PP Hollow Plastic Boards were proven to perform better economically than Phenolic Boards despite the latter's relatively low initial purchase cost. As can be seen from the comparison of both boards, the number of times of reusability was 30 for PP Hollow Plastic Boards, while the number of times Phenolic Boards can be reused is 10, which amounts to a cost per use of ₱116.67 for PP Hollow Plastic Boards and ₱200.00 for Phenolic Boards, saving roughly 41.67% per use.

On the other hand, the PP Hollow Plastic Boards emerged as better in terms of durability, reuse, maintenance, labor-efficiency, and economic value in general. Its ability to withstand up to three times the number of reuse made the calculated cost per reuse lower than the latter, making them more economical even when having higher initial acquisition cost. Lastly, respondents viewed the PP Hollow Plastic Boards to be more effective in increasing productivity in construction due to its easy cleaning, water-resistant characteristic, and minimal maintenance.

These results indicate that the utilization of Life Cycle Cost Analysis is a better approach compared to procurement cost alone. Economic performance analysis for the long term allows for the optimization of costs in terms of projects while minimizing waste and improving efficiency during construction. Thus, PP Hollow Plastic Boards are preferred for medium-scale and large-scale construction projects where formworks have to be used again and again, but Phenolic Boards are still a choice for budget-friendly projects.

RECOMMENDATIONS

In light of the results of this study, the following recommendations are put forth:

1. Life-Cycle Cost Analysis (LCCA) and Cost-Benefit Analysis (CBA) should be incorporated in the material selection process in order to ensure that procurement processes take into account long-run economic performance rather than cost of acquisition.

2. The use of PP Hollow Plastic Boards is recommended for construction projects that involve repetition of concrete construction work due to its higher level of durability, lower need for maintenance and better cost effectiveness compared to other reusable formwork systems.

3. For future research on the subject matter, one can consider environmental effects of reusable formwork systems using LCA, comparison of PP Hollow Plastic Boards with other formwork systems made from aluminum and steel or experimental research carried out in different construction sites.

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