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Life Cycle Cost and Evaluation of Performance between Steel Formwork and Plastic Formwork in Concrete Structure Building

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ABSTRACT

It is important to choose the most suitable type of formwork system material for construction projects due to the fact that formwork plays a crucial part in the construction of reinforced concrete structures. However, some parties still did not take note of important factors to consider in choosing the right type of material for formwork. This research study aims to ease the process of selecting the suitable type of formwork by surveying 5 respondents in the related field of matter located in Malaysia on the two types of formworks and by evaluating their Life Cycle Cost (LCC). Based on the respondent's opinions and answers, the preferred formwork was more heavily on steel formwork. It shows that steel formwork is superior in the duration required for setting up, quality of concrete and its surface finishing, cost, strength, durability, handling, and times of reusability. Meanwhile, plastic formwork shows that it is superior in the category of its resistance to leakage and less waste (concrete) production. It was concluded that 7 out of 11 questions were led by steel formwork and 3 out of 11 by plastic formwork, and only 1 question gained the same amount of response from the 5 respondents. By doing the LCC, we obtained that plastic formwork costs RM12,639.60, and steel formwork is RM24,715.50. It shows that plastic formwork is 49% cheaper than steel formwork. Hence it can give more benefits and is more economical for the long-term duration of the company. These findings will provide ease and a better understanding of formworks that can be used based on the information gained from the research to ensure sustainability towards the environment and economy.

1. Introduction

By definition, formwork means a temporary structural tool. The purpose is to provide artificial support below and around fresh concrete. This will continue until the concrete is able to support itself. Formwork is able to mould concrete into various kinds of sizes and shapes. In construction, the advancement of concrete is coextending with the evolution of formworks. Since the world is evolving day by day, improvements have always been tested out in ensuring a product's quality so the effects on the earth can be less harmful every time. For instance, with innovation, innovators are able to

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make separate small components of formworks. These small formworks are then able to be joined together on-site in construction. There are a lot of factors that are to be considered in building construction projects, especially for the type of formwork that will be used in the project as it contributes as much as 40% of the total cost of the project structure. This is because it is one of the crucial parts of ensuring the success of a project in terms of cost, quality, safety, and speed [1].

A system of formwork is defined as the overall support system for newly made concrete. This includes the mould or sheathing which is in contact directly with the concrete, also other supporting structural tools such as members, bracing, and hardware [2]. Meanwhile, another research says that formwork is an impermanent structural tool that supports concrete to become the intended shape that is able to support the loads that were put on top of it until it is strong enough able to support itself [3]. Other than that, formwork has an important part in the construction of building projects. The criteria for formwork selection are crucial so project cost can be lessened, quality can be improved and the construction stage can be done fast [4]. Another study stated that systems of formwork are responsible for a huge part of the cost of reinforced concrete structures. Applying the constructability principle to all parts of the work can decrease the big amount of construction projects cost [5].

This study is conducted to be able to recognize and understand the two types of formworks in construction, which are steel and plastic. In Malaysia, there are plenty of lands yet to be developed for various purposes, such as residential and office buildings. In order to ensure the development of the land goes as planned, it is important to be able to use the best type of formwork that is available in the market. Formwork is one of the most important factors that needed to be considered thoroughly since it has a major effect on the time consumed. To ensure the best type of formwork is selected, the cost, quality, safety, building design, available resources, construction speed, and many more factors have to be identified. Using a shutter with a steel material delivers an indeed smooth finish to a usually rough concrete surface. Steel formwork is a suitable option for structures with shapes such as circular and curved. These, for instance, sewers, water tanks, columns, tunnels, and retaining walls [6]. Formwork plays a crucial role in determining the cost component of a structural frame of a construction building. It has an average value of between 35% and 45% of a concrete structure's cost unit. Meanwhile, for civil engineering structures, it might even exceed 59%. To construct some concrete works, contractors commonly rented the formwork materials needed [7]. In the construction of reinforced concrete, the formwork system is an important factor. Selections of the suitable type of formwork system are mainly from a number of criteria that are conflicting and compromising. The selection should be made by the professionals in the construction field that is involved in the construction project varies from multiple background technical or administrative. The criteria differ with each construction as some of them may have different intentions in selecting a certain kind of formwork system [8].

In building constructions of traditional reinforced concrete, formwork is one of the crucial parts that play a significant role. In complicated work for a certain construction project, the formwork requires laborers that are professionals or highly skilled such as carpenters of formwork. But since the number of skilled workers for complex formwork is small, many methods to innovate or improve the techniques of the construction, and to create a procedure that requires less dependent on skilled workers are demanding. Other than that, formwork also directly influenced the quality of a concrete surface and its value of tolerance. Nowadays, a huge part of the construction of buildings is using concrete. Hence the formwork quality will establish the stage of workmanship that the construction work needs to obey [9]. Nowadays, waste is a major problem that is confronting the whole world. Engineers have been making improvements to address this matter by applying the principles of

sustainable development [10]. Formwork plays an important part in project construction since it affects the cost and the quality of a project [4].

Malaysia's construction industry has a critical matter relating to reducing the amount of construction waste. This is leaving terrible aftermath on the earth's environment [11,12]. Since the demand for huge construction projects is increasing, the waste generated afterward as a result of the projects is also increasing. Hence it is important on choosing the right type of material in order to avoid producing waste [13]. The production, manufacture, and usage of construction tools for instance such as formworks and steel consume a significant amount of energy. Not only that, but it also results to generate a huge amount of waste that brings a terrible effect on the earth's environment. Engineering formwork requires a significant amount of resources gained from harvesting the forest. Not to forget, attention is necessary relating to the matter of the mass production of waste resulting from the manufacturing of timber formworks. In order to reduce the usage of timber formwork, plastic formwork was exhibited widely and is known for its high reusability amount, less cost required for manufacturing and most importantly it can be recycled. It is widely promoted since it has the benefit of enabling the reuse of the formwork and it is parallel with the sustainability environmental purpose [14,15].

The type of material of formwork and the payroll are some of the huge sums in constructing the structures of reinforced concrete. Hence, the engineering of formwork is the main factor that directly affects the achievement of a project. Traditional formworks used in construction such as timber and plywood have no benefit value, hence resulting in generating waste [16]. To solve this issue on hand, a lean formwork of construction model that is specialized in lessening the waste produced has been developed. The benefit of it is to produce direct quality control on construction sites that ease the workers to get help as soon as possible if a problem suddenly occurs. The formwork operations also known as the Kanban system can lessen the inventory of the construction moulds and gain a successful continuous flow of construction. As for the results after the study, it was shown that the model proposed by the researchers successfully lessened the amount of waste produced in the formwork flow in construction, hence automatically providing a new method to improve the engineering of formwork [17].

The production, manufacture, and usage of construction tools for instance such as formworks and steel consume a significant amount of energy. Not only that, but it also results to generate a huge amount of waste that brings a terrible effect on the earth's environment. Engineering formwork requires a significant amount of resources gained from harvesting the forest. Not to forget, attention is necessary relating to the matter of the mass production of waste resulting from the manufacturing of timber formworks. In order to reduce the usage of timber formwork, plastic formwork was exhibited widely and is known for its high reusability amount, less cost required for manufacturing and most importantly it can be recycled. It is widely promoted since it has the benefit of enabling the reuse of the formwork and it is parallel with the sustainability environmental purpose [15,18-20]. Figure 1 shows steel formwork. Based on a study report on cost, duration, and quality analysis of different formworks in high-rise buildings, stated that the cost for steel formwork for project B RM/day equals RM226.07 [21]. Meanwhile, another study stated that the average cost per meter of a square is RM90.52. The costs that were mentioned are subject to change depending on the market and currency [22]. Systems of formwork are responsible for a huge part of the cost of reinforced concrete structures. Applying the constructability principle to all parts of the work can decrease the big amount of construction projects cost [5]. Plastic formwork is mainly used for casting a slab, walls, and others. The study also found out that there include other factors that influenced choosing the choice of formwork. For instance, the factors are such as the climate situation, effectiveness of labor,

and the reusability of plastic. This is because plastic formwork can be reused up to many times, hence a huge amount of cost can be saved for future project use [23].

Fig. 1. Steel formwork for RC wall [6]

Since the available time for the plastic formwork is more than 100 times, this makes the total cost low. This is because the purchase value will only be counted once during the initial moment it was bought. For the other projects, the previous plastic formwork from before can be reused since plastic formwork can be reused more than 100 times. Considering the cost factor, plastic formwork is definitely a worthy choice in many types of formwork. Even though compared to steel it has a good amount of usage, the cost factor takes a turn to a not good choice [24]. Based on past research, shows that the selection criteria are mainly taken from the contractors' perspective and none of the professional's perspectives was taken. This is a loss in obtaining more information on learning the opinion and perspective from a professional's side. As for the findings of the research, it was observed that the building construction's whole area and height affect the selection of the formwork criteria significantly [8]. Plastic is resistant to water and has excellent resistance to corrosion. Meanwhile, metal is not resistant to water and is very bad corrosion-resistant [25]. Figure 2 below shows plastic formwork. In this research, objective 1 was achieved by conducting the qualitative method, which is specifically the interview. Meanwhile, objective 2 was achieved by using the quantitative method which involves analyzing data, specifically using the life cycle cost (LCC) method.

Fig. 2. Plastic formwork for concrete wall [6]

2. Methodology

This will be focused on the methods that have been taken to gather information on achieving the objectives. The methods used to achieve the objectives will be stated from starting until the completion of the report.

2.1 Research Approach

Qualitative and Quantitative are the two different types of techniques of research that are widely implemented in research studies. The Qualitative method has the definition of basic investigative or searching research. It is emphasized by less amount size of a sample, usually, the data is gathered by observing and interviews. Meanwhile, if compared with the Quantitative method, it is emphasized more towards the calculations or measurements of the data obtained by conducting a survey, in which the data is represented by using numerical data. In this research, the type that was chosen to conduct the survey is a qualitative method, and collect the data using the quantitative method. For qualitative, the questions prepared were then later asked the individuals that are related to the construction field throughout the Semenanjung of Malaysia. By doing surveys through interviews, it is effective so that the data obtained can be confirmed of its eligibility as the interviews are conducted face-to-face directly with the chosen respective individuals. Once the data has been obtained, it was, later on, discussed in chapter 4 in a detailed manner. The population of research commonly is a group of individuals that has a similar characteristic or in this research, their field of work identified by the researcher. For this survey through interviews, the population contains individuals from various backgrounds, such as engineers, architects, and contractors in Malaysian country, specifically at the Semenanjung Malaysia.

2.2 Analysis Unit

The analysis unit is one of the most crucial items in a research project, it is the main topic that is being observed in a project. The questions such as what or who are taken into account, and they are the objects that were discussed to produce a summary of descriptions of them and to resolve the differences between them. For this project, the analysis unit is the engineers or any individuals that have experience handling directly or indirectly using the formwork material. Individual beings are the

most largely utilized analysis unit, hence in this research, the individual beings which are the respondents gave the data needed by the researcher to be able to do a survey on the two types of formwork material [26].

2.3 Interview Method

Objective 1 was achieved by conducting the qualitative method, which is specifically the interview. All of the interviews were conducted physically and face-to-face with safety precautions taken. This method is chosen because it can ease the data-collecting process and ensure the eligibility of the information collected. Since the COVID-19 virus is still within the country, it is important to practice safe procedures to avoid spreading the disease. An interview is in the category of qualitative method in research containing questions that are open-ended and close-ended. Open-ended are questions that require explanation and cannot simply be answered with a yes or a no. For this project, the questions that were prepared have referred to questions from past papers and papers that are related to formwork in construction to collect all possible information on the two types of formwork material which are steel and plastic formwork that is used in the construction industry in Semenanjung Malaysia. For each interview, the duration varies from 30 minutes until 1 hour. The 5 chosen respondents' backgrounds are all from the Civil Engineering field and were registered under the Construction Industry Development Board (CIDB). The respondents were chosen because of their involvement either indirectly or directly with formworks, specifically steel formwork and plastic formwork, and they also possess an experience of at least 4 years and above in the field and are still currently active during the interview session.

2.3.1 Interview analysis

The type of interview selected was unstructured, which lets an interviewer freely ask any questions in order to gain more information or details from an interviewee and still be able to compare and make a conclusion based on the responses that were received. For data analysis, in this project, the data was analyzed by conducting a discussion on all of the information based on each of the questions that have been gathered from all 5 of the interviewees. This interview was designed to facilitate the views and opinions of the professionals in the matter. This research purpose is to gain more knowledge on the two types of formwork so that it could ease any choosing process between them for a construction project.

2.4 Life Cycle Cost (LCC) Method

Objective 2 was achieved by using the quantitative method which involves analyzing data, specifically using the life cycle cost (LCC) method [12,27]. For this research, a deterministic approach where the exact cost is determined was used. Fixed discrete values are assigned to many different parameters and all types of uncertainties are ignored. Although the exact cost is determined, for this research, it is only used as an assumption for the costing since the costs involving construction stuff change very frequently, hence any changes can be made based on the latest or current cost that is used during the specific time. The indicator for the LCC is basically calculated using the formulas contained in the formula below. Hence it is required to know the estimated values to fill in the formula [28]:

$$LCC = Ci + Cinst + Co + Cm + Cd$$

Where, Ci shows the initial cost, Cinst shows the delivery and installation cost, Co shows the operational cost, Cm shows the maintenance cost and Cd shows the disposal cost. For this research, an assessment of the life cycle cost (LCC) of steel formwork and plastic formwork was done separately according to each material. However, the LCC was only done for a dimension of a standard room size, which is 10' x 12' (4 walls), 11.15m²/wall to ease the process of understanding how the LCC works for formworks. For any future use, the dimension used should be followed according to the requirement needed by a project.

3. Results and Analysis

The results of the research conducted will be discussed and analyzed further in detail. Hence, the content of this part should be able to achieve the main objectives of the project that has been conducted.

3.1 Interview Method

Based on the 20 questions that were asked, 11 of the 20 questions are comparative question that requires the respondent to choose one or both between the two types of material, which is the best type of material. All of the questions were asked two times, the first one for steel formwork and the second one for plastic formwork to ease the data collection process. The comparative questions and the summary of their answer are as below:

i. Question 1: Which type of formwork can be set up fast?
   - All of the respondents can agree that steel formwork is a type of formwork material that can be set up faster than plastic formwork. This is correlated to a saying, which says that steel formwork is easy to be installed [6].

ii. Question 2: Which formwork can produce good quality concrete and surface finishing?
   - All of the respondents can agree that steel formwork produces better concrete quality and also surface finishing compared to plastic formwork. This correlated to a saying, which says that most steels have a smooth surface, hence this will provide the concrete member with a smooth surface finish [6].

iii. Question 3: What is the type of formwork that can have more savings for a project?
   - 4 out of 10 respondents agreed on steel formwork can have more savings for a project compared to plastic formwork. This correlated to a saying that says that steel can be reused up to 100 times making the total cost lessened for every project after the first purchase [6]. Only 1 out of 4 respondents say that plastic formwork can have more savings compared to steel formwork.

iv. Question 4: Which formwork has more strength?
   - All 5 of the respondents can agree that steel formwork has more strength compared to plastic formwork. This correlated to a saying that says that steel in general has good strength and durability [6].

v. Question 5: Which formwork has more durability?
   - All 5 of the respondents can agree that steel formwork has more durability compared to plastic formwork. This correlated to a saying that says that steel in general has good strength and durability [6].

vi. Question 6: Which formwork has more resistance to leakage?
   - All 5 of the respondents can agree that plastic formwork has more resistance to leakage compared to steel formwork.

vii. Question 7: Which formwork is easier to handle?
   - 4 out of 5 of the respondents can agree that steel formwork is easier to handle compared to plastic formwork. This correlated to a saying that says that steel is easy to be installed [6]. Only 1 respondent chooses plastic formwork.

viii. Question 8: Which formwork can be reused?
   - In conclusion, all 5 of the respondents can agree that both formworks can be reused again. This correlated to a saying that says that plastic formwork can be reused up to many times [23].

ix. Question 9: How many times the formwork can be reused? Which formwork is higher?
   - 3 out of 5 respondents mentioned that steel formwork can be reused up to 90 times and 2 of them mentioned that steel formwork has a higher value of reusability than plastic. This is correlated to a study, which says that steel can be reused up to 100 times or even more [6].

x. Question 10: Which formwork produced less waste?
   - All 5 of the respondents can agree that plastic formwork produces less waste (in terms of concrete) compared to steel formwork.

xi. Question 11: Which formwork has more variety in size and shape?
   - All 5 of the respondents can agree that plastic formwork has more variety (in terms of size and shape) compared to steel formwork.

According to the comparative questions that were asked, the results that were obtained from the interview method from 5 respondents show that based on their choice of answer, steel formwork was their preferred type of formwork. This is proven because 7 out of 11 questions were led by steel formwork, 3 out of 11 questions were led by plastic formwork and 1 question gained the same amount of response from the respondents. Figure 3 below shows the clustered column chart based on the results obtained from the interview session.

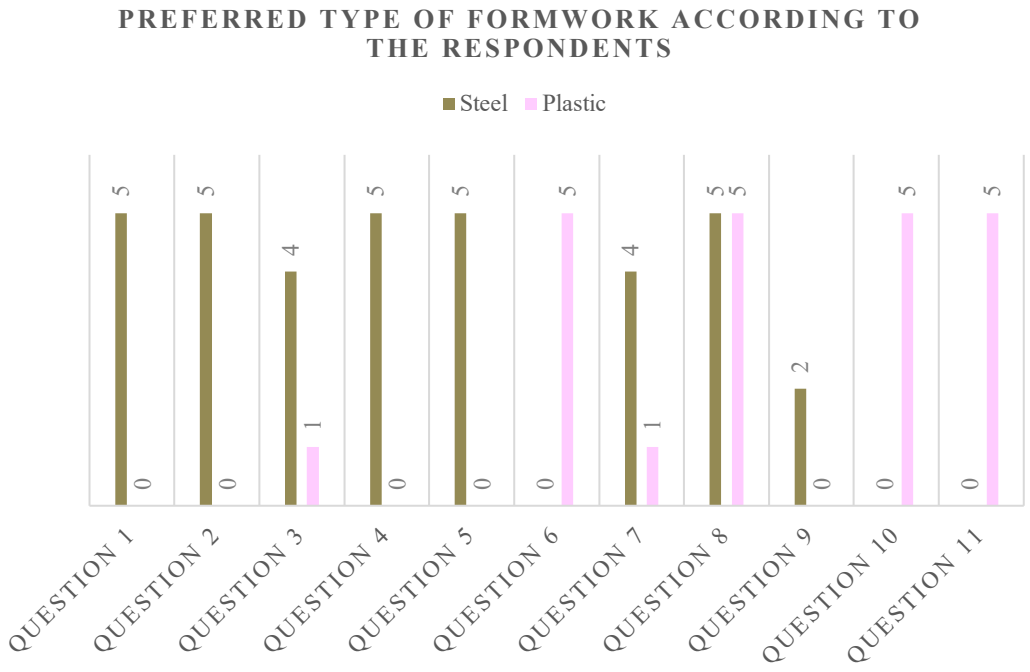

Fig. 3. The clustered column chart

For the balance of 9 out of 20 questions that are not in the comparative category, they are in the informative category. The answers and opinion that was gained should be able to help in ensuring the right type of formwork for the company was chosen. This is so that any difficulties that may be costly and wasteful can be avoided in the near future. The informative questions and the summary of their answer are as below:

i. Question 12: What are the costs that can be saved by using the right type of formwork?
   - The costs that can be saved by using the right type of formwork are the cost of buying new formwork each time, the maintenance and service cost, and the laborers' cost.

ii. Question 13: What criteria for selecting formwork?
   - The criteria to look for when selecting formwork are cost, reusability, durability, the ability to produce good formwork, availability in terms of sizing, strength, ease to handle, and the duration of time that it takes to complete one process of concreting.

iii. Question 14: Were there any incidents that happened during handling the formwork?
   - All 5 of the respondents has no incident that occurred during handling the formwork.

iv. Question 15: What type of incident happens?
   - Since all 5 of the respondents had no incident occurred, no type of incident was able to be clarified. But respondent A stated that one of the common incidents that could happen is fall hazard, which is the mishandling of the formwork.

v. Question 16: Which method is more preferred, the traditional or modern technique? Why?
   - All 5 of the respondents choose modern techniques over traditional techniques. This is because it is safer and easier to handle.

vi. Question 17: What advantages of each formwork?
   - The advantages of steel formwork are the material itself is strong, and durable, and it won't affect the concrete's water content. The benefit of the material itself is it is strong and durable. Meanwhile, for plastic formwork, the advantages are it has a variety of options, lighter, and eases the handling process [6]. Plastic is much lighter than plywood, and plastic is light while metal is heavy [25,29].

vii. Question 18: What disadvantages of each formwork?
   - The disadvantages of steel formwork are the material is expensive, needs extra care during handling, is limited in terms of size and shape, and can cause excessive loss of heat. Steel formwork has less variety in shape and size [30]. Meanwhile, for plastic formwork, the disadvantages are it is not durable, has less strength compared to steel, less known here in Malaysia. The elastic modulus or the stiffness of any kind of plastic formwork is approximately low [31].

viii. Question 19: Can damaged formworks be repaired? Is the cost greater than buying a new formwork?
   - All 5 of the respondents agreed that the formwork can be repaired and that the cost of repairing is lesser than the cost of buying new formwork.

ix. Question 20: Can the formwork that cannot be used anymore be recycled? What kind of recycling that they do to that specific material?
   - All 5 of the respondents agree that both types of formworks can be recycled. The steel formwork can be sold to any individual or organization that wants to buy the material, while plastic formwork can be sent to any recycling centers that accept the formwork. The response about plastic from respondents correlates to a study that states that plastic formwork can be recycled after its usage [24].

3.2 Life Cycle Cost (LCC)

For this LCC analysis of data, the initial cost (Ci) was the total cost of purchasing the material needed for a certain size of room. Second, for delivery and installation (Cinst), the total cost was including the delivery cost per trip and also the laborers' cost for installation. For operational (Co) and maintenance (Cm), the total cost included the laborers that will be handling the formwork's cost. Lastly, for disposal cost (Cd), the total cost includes the transportation cost for disposal and the laborer's cost for the dismantling process. Let's say a construction company wanted to buy formwork for a project that they have received. The project requires building a room with a specific size. Prior to buying the formwork, the company wanted to be able to use the formwork for as long as its life span. For this case study, there are two alternatives available for the company to choose from, to purchase the steel formwork and to purchase the plastic formwork.

3.2.1 Steel formwork

For steel formwork, Ci involves the cost of formwork, depending on the size it is needed. A sample of formwork needed for a standard room with a size of 10' x 12' (4 walls) was used, which resulted in 11.15m²/ wall. Next, Cinst involves the cost of transportation and installation of formwork workers including the welder (for steel). The workers' costs were assumed for their by-day rate, which is

usually for 8 hours/day. Hence the day rate divides by the hours and multiplied by the assumed duration of installation equals RM15.00/m². The value is then multiplied by the size of the room. Moving on to the Co and Cm, the cost included was also as Cinst except for the welder. This is because welders are usually no longer needed for the Co and Cm category. Lastly, Cd, the cost included were the transportation cost, and the workers' cost for uninstallation, the same as the rates in Cinst, Co, and Cm.

The details and analysis of steel formworks can be observed in Table 1, where the Ci obtained was RM23,217.00, Cinst obtained was RM918.00, Co & Cm obtained was RM230.25, and Cd obtained was RM350.25.

Table 1
LCC of Steel Formwork

Details	Cost (RM)
Initial Cost	
- Cost of steel formwork	520.56/ m²
- Size of room: 10' x 12' (4 walls)	11.15m²/ wall
Total Initial Cost	23,217.00
Delivery and Installation Cost	
- Transportation	120.00/ trip
- Installation:	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Welder (272/day)	
- 1.5 hours / person	51.00
- Total cost for a standard room	568.65
Total cost for DI	918.00
Operation and Maintenance Cost	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Total cost for OM	230.25
Disposal Cost	
- Transportation	120.00/ trip
Dismantle:	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Total Cost for Disposal	350.25

3.2.2 Plastic formwork

For plastic formwork, Ci involves the cost of formwork, depending on the size it is needed. A sample of formwork needed for a standard room with a size of 10' x 12' (4 walls) was used, which

resulted in 11.15m²/ wall. Next, Cinst involves the cost of transportation and installation of formwork workers. The workers' costs were assumed for their by-day rate, which is usually for 8 hours/day. Hence the day rate divides by the hours and multiplied by the assumed duration of installation equals RM15.00/m².

The value is then multiplied by the size of the room. Moving on to the Co and Cm, the cost included was also as Cinst. This is because welders are usually no longer needed for the Co and Cm category. Lastly, Cd, the cost included were the transportation cost, and the workers' cost for uninstallation, the same as the rates in Cinst, Co, and Cm. The details and analysis of plastic formworks can be observed in Table 2, where the Ci obtained was RM11,708.85, Cinst obtained was RM350.25, Co & Cm obtained was RM230.25, and Cd obtained was RM350.25.

Table 2
LCC of Plastic Formwork

Details	Cost (RM)
Initial Cost	
- Cost of Plastic formwork	262.53/ m²
- Size of room: 10' x 12' (4 walls)	11.15m²/ wall
Total Initial Cost	11,708.85
Delivery and Installation Cost	
- Transportation	120.00/ trip
- Installation:	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Total cost for DI	350.25
Operation and Maintenance Cost	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Total cost for OM	230.25
Disposal Cost	
- Transportation	120.00/ trip
Dismantle:	
Skilled worker (80/day)	
- 1.5 hours / m2 / person	15.00
- Total cost for a standard room	167.25
Semi-skilled worker (60/day)	
- 0.75 hours / m2 / person	5.65
- Total cost for a standard room	63.00
Total Cost for Disposal	350.25

Based on the result obtained from the analysis as in Table 3, steel formwork has as much as 50% higher initial cost (Ci) compared to plastic formwork, which is RM11,508.15. This could happen because the production of the material itself already consumed a large sum of the cost of steel. For the delivery and installation cost (Cinst), steel is 62% higher than plastic formwork, which is RM567.75. This happens due to the fact that steel formwork installation requires a welder for the welding process, while plastic does not require a welder, automatically decreasing the cost of

installation. Other than that, steel formwork is also very heavy in terms of weight compared to plastic formwork. Meanwhile, for the operational (Co) and maintenance (Cm), and disposal costs (Cd), both of the materials obtained the same value, hence making it a 0% difference in terms of cost. Summing up all of the values, the life cycle cost (LCC) for plastic formwork is RM12,639.60 and RM24,715.50 for steel formwork. The two values have a difference of 49%, which is RM12,075.90. This can be seen that plastic formwork is the better option compared to steel formwork in terms of the life cycle cost (LCC).

Table 3
Shows the value obtained based on the life cycle cost (LCC) method

Alternative	Initial Cost (RM)	Installation Cost (RM)	Operational & Maintenance Cost (RM)	Disposal Cost (RM)	LCC (RM)
Steel formwork	23,217.00	918.00	230.25	350.25	24,715.50
Plastic formwork	11,708.85	350.25	230.25	350.25	12,639.60

The calculation of LCC for steel formwork and plastic formwork can be seen in Table 1 and Table 2 respectively. While for the summary of the final costing for 4 of the categories can be seen in Table 3. Figure 4 below shows the graph of the cumulative value of the LCC cost between the two types of formwork.

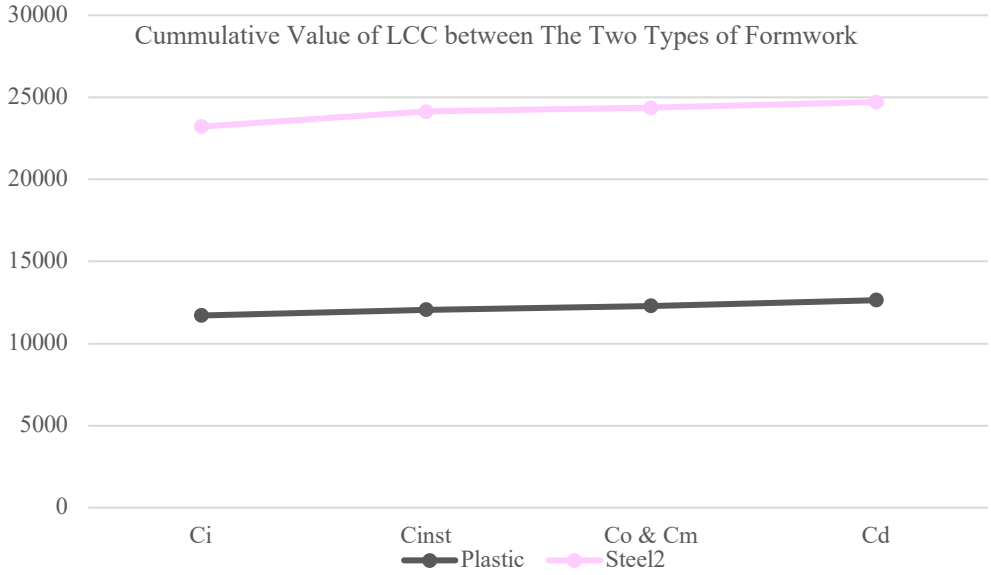

Fig. 4. The line chart of the cumulative value of LCC between the two types of formwork, where Ci = Initial Cost, Cinst = Delivery and Installation Cost, Co = Operational Cost, Cm = Maintenance Cost, and Cd = Disposal Cost

4. Discussion

For discussion, according to the data that was obtained for the interview method, it was observed that 7 out of 11 questions were led by steel formwork, 3 were led by plastic, and 1 question was where both types of material gained the same amount of respondents. Hence, it can be concluded that the preferred type of formwork according to the respondents are steel formwork. It is the better material compared to plastic formwork in accordance with the opinion of the 5 respondents that were being interviewed. Meanwhile, looking at the long-term effect, which is the Life Cycle Cost (LCC)

between the two types of material, plastic formwork has a much lower value which makes it a better option than steel formwork. This difference can be noticed easily because of the cost of the steel formwork material which is very high compared to plastic formwork in the sizing per meter square. From the calculations that have been made, it is observed that for steel and plastic formwork, the highest cost was for the initial cost (Ci). This is because the first cost of purchasing the formwork is usually high for a project, but for upcoming projects, the same formwork can be used hence automatically eliminating the purchasing cost. This is because both of the formwork can be reused almost 100 times according to the interview session that was made. It can be seen that plastic formwork has a lower initial cost (Ci) than steel formwork almost half times the initial cost (Ci) of steel. Hence, this automatically makes it the better option than steel formwork, in terms of cost.

5. Conclusion

In conclusion, the first and the second objective that was contained in this research study was achieved, hence the comparative analysis between steel and plastic formwork in construction was complete. The details regarding the two types of formworks were received from 5 of the respondents that were interviewed. 7 out of 11 questions were led by steel formwork, 3 were led by plastic and 1 question gained the same amount of respondents. Hence the preferred type of formwork obtained from the respondents' choice of answer is steel formwork. The LCC cost was also obtained for an example of a one-room construction price. For plastic formwork it is RM12,639.60 and for steel formwork, it is RM 24,715.50, this concludes that plastic is 49% cheaper than steel material which costs RM12,075.90. All of the information and knowledge gained based on the two types of formworks can be compared based on this study. It can be concluded that choosing the right type of formwork based on the criteria needed can save costs and give better benefits to a construction company, the economy, and the environment. The findings that were gained in this research may help any individual or organization to have better insight on deciding which type of formwork is the most suitable one for their own current demand with proper planning and procedures. Extra information about the formwork was also gained from one of the respondents. Both of the objectives were concluded separately below for an easier understanding of the matter that was obtained and gained from the study.

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