Cost and time analysis on the selection of formwork installation method

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Abstract. Formwork is a supporting tool for printing concrete of the desired size and shape. Choosing a certain type of formwork method will affect the time and cost of a project. There are two types of formwork method, the conventional method and the semi-system method. This research will compare the two methods on the cost, time and waste products on their application on beams, columns and slab of a construction building project. The aim of this research is to compare the cost, time and waste product of the two formwork method on a construction building project. A high rise construction building project with 24 floors will be used as a case study in this research. Based on this research it is found that the conventional system cost 12% more than the semi-system. It also needed 12 more days to finish and also produce 10% more waste than the semi-system.

Keyword: formwork, comparison, conventional, semi-system

1. Introduction

Fresh concrete is in liquid forms which need to be shaped according to the desired shape. Formwork is used to contain the fresh concrete, and ensure that it sets in the correct place, and has the correct dimension and flatness. The formwork must withstand safely all the loads to which it is subjected to [1]. Formwork will then be removed when the fresh concrete reaches its sufficient strength because the function of a formwork is only as a temporary moulding.

There are several types of formwork method, two of them are the conventional method and the semi-system method. Choosing a certain type of formwork method will affect the time and cost of a project. A conventional formwork method uses hollow steel as its reinforcement and uses wood for its beam. However in semi-system, it uses vertical and horizontal support as an alternative in using scaffolding. Semi-system is also more eco friendly and takes less time than the conventional method. Each type of material used in the two-formwork method has different lifetime. In the semi-system, a phenolic tegofilm can be used up to 6 to 12 times compare to the multiplex used in the conventional method which can only be used up to 3 times [2].
2. Formwork

2.1. Conventional Formwork

The conventional formwork system is referred to as the stick form or hand-over-hand method. Conventional formwork system includes formwork for slabs, beams, and foundation. The system is generally built of lumber or a combination of lumber and plywood (multiplex). Formwork pieces are made and erected in situ. For stripping, conventional formwork system are stripped piece by piece, then cleaned, and may be reused a few times. Conventional formwork system has three major limitations such as high labour costs, high waste and limited number of reuses [3]. In Table 1 it can be seen the material used in the conventional formwork system.

| No | Material                  |
|----|---------------------------|
| 1  | Multiplex 15 mm           |
| 2  | Hollow 50.50.2            |
| 3  | Wood 6/12                 |
| 4  | Nail                      |
| 5  | Screw                     |
| 6  | Kaso 5/7                  |
| 7  | Wire                      |
| 8  | Scaffolding standard      |
| 9  | Beam 6/12                 |
| 10 | Jack base                 |
| 11 | U-head                    |
| 12 | Joint                     |

2.2. Semi System Formwork

Semi system formwork is a formwork that is design for a certain type of project. The dimension of formwork is adjusted to the dimension of the structure of the project. To be able to use a semi-system formwork the structures of the construction project need to be identical, therefore the formwork can be used repeatedly. The phenolic tegofilm used in the semi-system formwork can be used up to 12 times. In Table 2 it can be seen the material used in the semi-system formwork.

| No | Material                                      |
|----|-----------------------------------------------|
| 1  | Multiplex tegofilm (phenolic) 15 mm           |
| 2  | Main frame                                    |
| 3  | Leader frame                                  |
| 4  | Joint                                         |
| 5  | Screw                                         |
| 6  | Pipe support                                  |
| 7  | Cat walk                                      |
| 8  | Double siku                                   |
| 9  | Horizontal vertical rod                       |
| 10 | Jack base                                     |
| 11 | Tie rod                                       |
3. Research Methodology

The research uses a 24 floors high rise building as the case study. Each floor is approximately 469,09 m². Both the conventional and semi-system formwork for the column, beam and plate will be simulated on this building. In this case, the conventional method uses a 15 mm multiplex without a layer and the semi-system formwork uses a 15 mm multiplex with a phenolic tegofilm layer.

The aim of this research is to compare the two-formwork method, the conventional method and the semi-system method in regard to its cost, time and waste product produce. The methodology of the research can be seen in Figure 1.

![Methodology Study of the Research](image)

**Figure 1.** Methodology Study of the Research

4. Result and Discussion

4.1. Data

To analyse the of each formwork method, the life time of each material will need to be accounted for. The life time of each material in the formwork method will affect the cost of the method chosen. In Table 3 it can be seen the life time of each material used in both formwork methods. In Table 4 is the total surface area of each element (column, beam and plate) on 1 floor.
Table 3. Material Analysis Conventional and Semi System

| No. | Material          | Life time                  | Material         | Life time     |
|-----|-------------------|----------------------------|------------------|---------------|
| 1   | Multiplex 15 mm   | Used 3 times               | Phenolic 15 mm   | Used 12 times |
| 2   | Hollow 50.50.2    | During used                | Main frame       | Used 6-12 times |
| 3   | Wood 6/12         | 10% reduction              | Leader frame     | Used 6-12 times |
| 4   | Screw             | once                       | Joint            | Used 6-12 times |
| 5   | Kaso 5/7          | Used 3 times               | Pipe support     | Used 6-12 times |
| 6   | Wire              | once                       | Cat walk         | Used 6-12 times |
| 7   | Scaffolding standard | During used             | Double siku      | Used 6-12 times |
| 8   | beam 6/12         | Used 3 times               | Horizontal vertical | Used 6-12 times |
| 9   | Jack base         | During used                | Jackbase         | Used 6-12 times |
| 10  | u-head            | During used                | Tierod           | Used 6-12 times |
| 11  | Joint             | During used                | Joint            | Used 6-12 times |

Table 4. The Total Surface Area of Element Per Floor

| No. | Element | Quantity | Total Area (m²) |
|-----|---------|----------|-----------------|
| 1   | Column  | 40       | 23.25           |
| 2   | Beam    | 120      | 3193.89         |
| 3   | Plate   | 29       | 469.10          |

4.2. Cost Analysis

The coefficient in the cost analysis uses the Ministerial Regulation of Public Work No. 11/2013 Standards [4]. The total cost comparison between the conventional and the semi-system formwork method for all the elements (column, beam and plate) on the 24 floors high rise building can be seen in Table 5. The cost may differ from the contractor’s calculation, as there might be a 1.80% cost difference between using the coefficient in the Ministerial Regulation of Public Work No. 11/2013 Standards compared to the contractor’s coefficient [5].

Table 5. Comparison of Formwork Method Cost

| Floor | Beam       | Conventional | Semi System |
|-------|------------|--------------|-------------|
| 1-6   | 2.537.938.529 | 2.655.781.488 |
| 7-12  | 2.446.563.703 | 2.445.485.403 |
| 13-18 | 2.537.938.529 | 2.389.838.010 |
| 19-24 | 2.446.563.703 | 2.157.553.867 |
|       | 4.140.032.358 | 4.701.935.723 |
|       | 4.417.887.929 | 4.402.919.732 |
|       | 4.140.322.358 | 3.937.712.973 |
|       | 4.417.887.920 | 3.891.640.789 |
|       | 5.029.739.927 | 5.063.877.346 |
|       | 4.832.102.272 | 4.982.804.518 |
|       | 5.229.739.927 | 4.300.548.034 |
|       | 4.832.102.272 | 4.282.804.518 |
| Total | Rp 47.008.819.326 | Rp. 45.812.902.399 |

Based on Table 5, it can be seen that for a 24 floors building a semi-system formwork method costs less than the conventional formwork method. If the cost is breakdown per floor and analysed further, it can be seen in Figure 2 that below 7 floors the semi-system formwork method cost higher than the conventional method. However, above 7 floors the semi-system formwork method started to
decline in cost compared to the conventional formwork method. This is due to the fact that the materials in the semi-system formwork method have a longer lifetime than that of the conventional formwork method.

![Cost Comparison between Conventional Formwork and Semi-System Formwork](image)

**Figure 2.** Cost Comparison Between Conventional and Semi System Formwork Method

### 4.3. Time Analysis

The duration of each formwork method is based on survey and interviews with workers on site. The analysis is done per 1 floor with the total area of 469,09 m² and 8 hours of work per day. It is obtained that there is 12 days difference between the conventional and semi-system formwork method which can be seen in Table 6. The time analysis in this research does not analyse the duration to move the materials and equipments from one floor to another, it only calculates the duration to mobilise and demobilise materials and equipments on one floor.

| Works | Methods       | Time (days) |
|-------|---------------|-------------|
| Beam  | Conventional  | 20          |
|       | Semi System   | 15          |
| Floor | Conventional  | 16          |
|       | Semi System   | 11          |
| Column| Conventional  | 12          |
|       | Semi System   | 10          |
| Total | Conventional  | 48          |
|       | Semi System   | 36          |
|       | Difference    | 12          |

**Table 6.** Time Analysis

### 4.4. Waste Analysis

In calculating the waste product produce from each formwork method, the waste produce from the wood used as the main formwork is calculated. According Table 3, the conventional formwork method uses 15 mm multiplex, whereas the semi-system formwork method uses 15 mm multiplex with a phenolic tegofilm layer. The multiplex can be used up to 3 times, whereas the phenolic tegofilm can
be used up to 12 times. The waste analysis is based on these assumptions and the result can be on Table 7.

Table 7. Waste Analysis

| Methods / material   | Beam (m²) | Plate (m²) | Column (m²) |
|----------------------|-----------|------------|-------------|
| 15 mm multiplex      | 466,87    | 1039,38    | 1128,96     |
| Phenolic Tegofilm   | 338,08    | 682,09     | 740,88      |
| Difference           | 128,79    | 357,29     | 388,08      |

5. Conclusion

Based on the result of this research using a 24 floor high rise building typical floor area of 469,09 m² as its case study, a preliminary conclusion can be stated that:

a. A semi-system formwork method cost less when applied for more than 6 floors, less than 6 floors the conventional formwork method still costs less,
b. A semi-system formwork is 12 days faster than that of the conventional formwork method to finish the formwork mobilisation and demobilisation on one floor,
c. A conventional formwork method produces 33% more waste product than a semi-system formwork method

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