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TOTAL QUALITY MANAGEMENT (TQM) EFFICIENCY BETWEEN WOOD MATERIALS AND SCAFFOLDING IN BUILDINGS

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Abstract
The purpose of this study was to efficiently use wood to support concrete casting and ceiling frames, to find out the cost efficiency of implementing two different types of formwork systems, between conventional wood formwork by reusing post-casting scaffold wood for ceiling frame materials, with semi-modern formwork systems. Formwork (Scaffolding) and hollow metal ceiling frame systems. The data collection method in this study was carried out by observing the process of building an office building in JABODETABEK on conventional Formwork, wooden Scaffolding and semi-modern Formwork, interviews, questionnaires on the efficiency of field implementation, and documentation. Tests to compare the two scaffolding formwork systems were carried out in one-story buildings to four-story buildings with a typical floor area of one to a specific four-floor floor area with the same area to compare and measure the two scaffold formwork systems. At the time of project implementation on conventional formwork scaffolding, there is a loss of wood volume of ±40% of the total wood use. Overall calculated from the test results of these two systems in terms of casting costs, it turns out that conventional formwork with wood scaffold formwork system is much better and more efficient, saves implementation time, saves implementation costs, the difference between the two systems on wood is calculated using SNI 7394:2008, ranging from ±122.7 % to ±146.2 % wood is more efficient than the formwork system (Scaffolding). Then in terms of efficiency, the volume of post-casting scaffolding wood, of ±60%, can also be reused more than enough to meet the needs of the ceiling frame material for the high-rise building itself, which means that there is no need to buy new ceiling frame materials. Meanwhile, the semi-modern formwork system for the ceiling frame needs to spend more on buying ceiling frame materials such as hollow iron. Comparing the test results of these two scaffold formwork systems for simple high-rise buildings and low-rise buildings (one-story buildings to four-story buildings) is recommended to use a conventional formwork system, namely the wooden scaffolding formwork system.

Keywords: efficiently, scaffolding, concrete, formwork, buildings.

Introduction

The rampant growth of the property business is in line with population growth with the community's need for property owners and business premises such as residences, storehouses, and office houses. This phenomenon is an excellent opportunity for business entrepreneurs to buy and selling property in the country. Various types of property options are offered to attract consumers' hearts with very tight price competition. With this price competition, entrepreneurs must think wisely about how to deal with the implementation of construction projects to realize efficiency in the use of materials and the low cost of implementation. At this stage, property buying and selling entrepreneurs are cautious in saving the cost of carrying out the work because it is limited by time, the level of convenience, and cost-effectiveness to achieve a high selling price and find the right solution for savings and reducing implementation costs.

The focus of the study is on the implementation of high-rise building projects, in general, the most dominant, which consumes relatively high costs in the implementation of building structure casting work. But in reality, there are many things to consider for this work. We are starting with the policy of selecting the formwork and shore systems that we will use. In this case, it is necessary to consider various considerations in making decisions on the use of Formwork and Scaffolding (shore) in concrete casting work because there is a business relationship in cost efficiency, convenience, and time with profit targets plan.

Formwork is a temporary structure because it will be demolished until a specific time, while the concrete structure is permanent. Previous researchers Ruslan et al. (2011) explained that temporary structures serve as a link between design and construction. Permanent structures cannot be built without them. Implementing the superstructure of high-rise buildings is an iterative process (column, beam, floor, and staircase work). To meet the speed aspect of construction, several formworks are required. Previous researchers Ing, (1992) that the period of the functioning formwork cycle includes a series of periods (durations) for (a) Installation of Formwork, (b) Installation of iron, (c) Casting of concrete, (d) Hardening of concrete, (e) Dismantling of Formwork partially or entirely, and (f) Partial or complete removal of formwork.

The need for research to assess the economy Stivaros, (2006), that is, with maximum reuse of formwork and scaffolding materials, but not overdoing the formwork design. This condition is especially true for multi-story buildings, where the dimensions are standardized and result in several repetitions of the formwork Ing, (1992) Formwork for casting concrete is grouped into three types, namely: (a) Conventional Formwork uses wood entirely for both the formwork and the scaffolding, usually requiring the skills of workers. This type of formwork is often used in low-rise buildings, with the number of repeated castings on floors typical of low-rise buildings. (b) Semi-modern formwork is a combination of conventional wood formwork, fabricated wood on the rafter, and as a scaffold material (shore) made of iron so that the scaffolding allows easy installation and disassembly for repeated casting. (c) Modern system formwork, this formwork system is primarily modular, designed to speed up work and be efficient. Still, modern systems require significant upfront capital support, so their use is currently minimal. This research conducted in one construction company in Indonesia, the company was facing several problems, many projects that already ended have delays (Putra et al., 2021).

Research Objectives Researching to find out how efficient wood is if the use of wood as scaffolding formwork and reused as a ceiling frame. Researching to find out the cost efficiency of implementation on a wood formwork system using wood again for the ceiling frame (Putri, 2015) Researched to find out the cost of casting and compare costs in both formwork systems between conventional wood formwork and the use of wood again for the ceiling frame, and semi-modern system formwork with hollow iron ceiling frames (Rohani, 2014). Researching to determine the effect of wood efficiency on volume loss and wood efficiency on the remaining wood of the ceiling frame material (Sanjaya et al., 2013).

METHODS

Research Stages and Procedures

The stages in data analysis are a sequence of steps that are carried out systematically and logically according to the theoretical basis, so that accurate analysis is obtained to achieve the purpose of writing (Sugiyono, 2012). The stages and research procedures to be carried out are as follows (Moleong, 2007):

Stage I (Preparation Stage)

The steps taken are formulating research problems, research objectives, determining the methods used and digging into the literature, conducting library research, reading articles on concrete, reference books, thesis abstracts about formwork, and civil engineering journals related to research.

Phase II (Phase Determination of Research Objects)

The steps taken are; (1) Identifying and observing researched projects; (2) Determine the object of observation; (3) I am doing permission to implementers for data collection.

Stage III (Collection Stage)

The steps taken in this stage are as follows:

Collecting data that is used as the object of research, in the form of primary data from implementing contractors and supervisors responsible for project implementation. From observations obtained the following data (Sujarweni, 2016); (1) Observation: Direct observation, collecting implementation data on conventional Formwork (wood formwork) and semi-modern Formwork; (2) Interview (interview): Interview with the site manager, foreman, chief handyman, and handyman, asking about ways to use formwork in concrete casting; (3) Documentation: Looking for implementation information, working drawings, photos of implementation documentation, and other related matters.

For secondary data to support research data; (1) Previous Research: Searching and studying previous research and journals related to using formwork and investigating problems that have not been discussed from previous research to be appointed as research topics (Saraswati & Indryani, 2012); (2) SNI for wood and PPKI: Regulations on the standard and quality of formwork wood; (3) SNI for concrete: Regulations on Indonesian concrete standards; (4) Library Sources: Searching for literature and guidance from experts related to research.

Stage IV (Data Analysis Stage)

The steps taken are; (1) Calculating the volume of use of wood as scaffolding wood formwork according to the strength requirements for concrete molds (conventional formwork). The calculation of the volume of wood is repeated from the use of wood for one-story casting to the use of wood for four-story casting Widhiawati et al., 2010); (2) Calculate the cost of material requirements used in the implementation of formwork and ceiling work, both in terms of SNI and the actual method in the field. This calculation is repeated from wood for casting one floor to four floors (Indonesia, 2013); (3) Calculate the efficiency of using wood for formwork (conventional formwork). The wood is reused for the ceiling frame in the building concerned; also calculate semi-modern formwork and hollow ceiling frames as a comparison material only (Nasional, 2013).

The principle of providing wood in the pattern of casting implementation on the use of ideal wood formwork in maintaining the quality of the concrete molds with a maximum of three times repeatedly according to the RKS (Work Plan and Conditions) is (Frick, 1982); (1) The building is each typical floor, the area of the first floor to the fourth-floor area of each floor is the same; (2) One-story building casting, two times casting, providing wood for one-floor level; (3) Two-story building casting, casting three times, providing wood for one-floor level[(4) We are casting three-story buildings, four times of casting, providing wood for two floors; (5) We are casting four-story buildings, five times of casting, providing wood for two floors.

RESULTS AND DISCUSSION

In this data analysis section, the calculation results of wooden scaffolding formwork with wooden ceiling frames will be presented in low-rise buildings (Marpaung, 2021). At this calculation stage will be displayed testing the use of wood in several stages:

Stage I. One-story building (two floors), the volume of use of wood for casting is calculated, and then the use of the wood is calculated again for the ceiling frame (Nasional, 2002).

Stage II. Two-story building (three floors), the volume of wood used for casting is calculated, and then the use of the wood is calculated again for the ceiling frame (Nasional, 2012).

Stage III. Three-story building (four floors), calculated the volume of use wood for casting, and then the use of the wood is retaken into account for the ceiling frame (Nasional, 2013).

Stage IV. Four-story building (five floors), the volume of use of wood for casting is calculated, and then the use of the wood is calculated again for the ceiling frame (Nasional, 2000).

In the use of formwork wood in the casting process based on the initial agreement on the RKS (Work Plan and Conditions) a maximum of three times of use, where the condition of the wood is

still in good condition used for structural concrete molds (Umum, 1971). However, technically it still requires a level of awareness from the community to carry out the health protocol while in the mosque environment (Cardiah et al., 2021).
From the several stages of the calculation, we will compare the stage of using wood for building casting how many levels; if the wood is reused, it is maximally used for the needs of the ceiling frame of the building concerned (Adams, 2005). At the stage of the maximum use of wood, we will test it by comparison with the cost of casting using scaffolding on the building and the cost of using a hollow iron ceiling frame (Trijeti & Hernawan, 2011). To find out the correlation between the use of wood in the foundry and the need for wood for the ceiling frame, it can be statistically tested using the multiple linear regression, following the cost of using a hollow iron ceiling frame (Sujarweni, 2016).

Preparation of Data Analysis

The data needed for this research are as follows; (1) PKKI NI-5 wood standard, National Standardization Agency (BSN); (2) SNI wood 7973-2013 and the price of processed wood in the JABODETABEK area.; (3) SNI for concrete to guide the unit price calculation; (4) The price of JABODETABEK processed wood; (5) Rental prices for scaffolding in the JABODETABEK area; (6) The price of hollow iron for ceiling frames in the JABODETABEK area; (7) Building drawing data to apply the calculation of the use of wood for casting needs and ceiling frames.

Data Analysis

The implementation observation data in this research is the construction of a multi-story office building with the implementation of a wooden formwork system and a wooden ceiling frame, on Jalan Bean Garden IX Tanah Abang, Central Jakarta with the following data:
Building Name: Three-Story Office Office Building.
How to implement: The use of Formwork and wooden Scaffolding, wooden frame ceilings.
Location: Peanut Garden Road IX Tanah Abang, Central Jakarta.
Owner: Henny Nilawaty.
Contractor: PT KDS Jakarta.
The test data for calculating the use of wood to examine the most efficient and economical level of wood use, by comparing the use of wood in several cases of low-rise buildings, with the same floor area, are as follows:
Building Name: Office Rental.
Location: Daan Mogot Street West Jakarta.
Construction: Reinforced Concrete Structure.
Building height: Four Floors (floor area of each level is the same).
Owner: PT SDB Jakarta, South Jakarta Sunday Market Street.
Planning Consultant: STUDIO Redesign, senopati road 26 New Kebayoran Jakarta.
The reason for the tests carried out on this building is so that it can be seen clearly and compare the calculation of the amount of wood used at each level, with the research target of the most efficient use of wood, if this type of multi-story building is considered the same, and applied to one-story buildings, two-story buildings, three-story and four-story buildings (data and pictures attached)[24]. The application of testing the use of wood-based on the number of building levels is as follows (Wijaya et al., 2012); (1) One-story building (two floors), floor area= 1290 m2 ; (2) Two-story building (three floors), floor are = 1935 m2; (3) Three-story building (four floors), floor area = 2580 m2; (4) Four-story building (five floors, floor area = 3225 m2.

Table 1
Comparison of Formwork Costs How to Calculate SNI and Actual Field Methods Starting from Building Casting to Finishing JABODETABEK Prices in 2017

Skyscraper	**Method**	**Price (IDR)**	**Large (M^2)**
One-Story Building:			**L= 1290**
Wood Formwork + scaffolding	SNI 7394: 2008	1.049.298.966,3	
	Field Actual	1.067.814.833,3	
Wood Formwork + Wood Steer	SNI 7394: 2008	788.187.486,3	
	Field Actual	798.166.165,3	
Two-Story Building:			**L= 1935**
Wood Formwork + Scaffolding	SNI 7394: 2008	1.286.142.966,3	
	Field Actual	1.304.658.833,3	

Wood Formwork + Wood Steer	SNI 7394: 2008	788.187.486,3	
	Field Actual	798.166.165,3	
Three-Story Building:			**L= 2580**
Wood Formwork + Scaffolding	SNI 7394: 2008	1.932.477.815,0	
	Field Actual	1.980.366.597,4	
Wood Formwork + Wood Steer	SNI 7394: 2008	1.503.682.055,0	
	Field Actual	1.538.310.790,4	
Four-Story Building:			**L= 3225**
Wood Formwork + Scaffolding	SNI 7394: 2008	2.145.637.415,0	
	Field Actual	2.193.526.197,4	
Wood Formwork + Wood Steer	SNI 7394: 2008	1.503.682.055,0	
	Field Actual	1.538.310.790,4	

Table 2
Number of Uses of Scaffolding Wood for Casting of Up-Story Buildings Finished Casting Price JABODETABEK 2017

Building Type	**Count Method**	**Before Casting (stem)**	**Destroyed 40% (stem)**	**Good Wood (stem)**
Graded I	SNI 7394: 2008	5.450,68	2.180,27	3.270,41
	Field Actual	5.231,78	2.092,71	3.139,07
Graded II	SNI 7394: 2008	5.450,68	2.180,27	3.270,41
	Field Actual	5.231,78	2.092,71	3.139,07
Graded III	SNI 7394: 2008	10.867,76	4.347,10	6.520,66
	Field Actual	10.643,56	4.185,42	6.278,13
Graded IV	SNI 7394: 2008	10.867,76	4.347,10	6.520,66
	Field Actual	10.643,56	4.185,42	6.278,13

Table 3
Scaffolding Costs for Casting of Multi-Storied Buildings until Finished Price JABODETABEK 2017

Building	Method	Cost (IDR)	Information
Graded I			
	Field Actual	473.688.000,-	Rental fee from
Graded II			Scaffolding on foundry
	Field Actual	710.532.000,-	multi-story building
Graded III			low is more expensive than

	Field Actual	852.638.400,-	use of wood.
Graded IV			
	Field Actual	1.065.798.000,-	

Table 4
Costs and Prices of Supporting Timber for Casting of Multi-story Buildings Up to Finished Casting Price JABODETABEK 2017

Building	Method	Cost (IDR)	Information
Graded I	SNI 7394: 2008	212.576.520,-	Count Way SNI 7394: 2008
	Field Actual	204.039.332,-	slightly expensive than
Graded II	SNI 7394: 2008	212.576.520,-	Conventional.
	Field Actual	204.039.332,-	
Graded III	SNI 7394: 2008	423.842.640,-	
	Field Actual	408.078.664,-	
Graded IV	SNI 7394: 2008	423.842.640,-	
	Field Actual	408.078.664,-	

Table 5
Price Comparison of Hollow Frame Ceiling with Wood Frame based on Price JABODETABEK 2017

No	Building	Ceiling Volume **(stem)**	Hollow Price Total (IDR)	Total Wood Price (IDR)
1	Multi-story building 1	1953,2	34.181.000,-	76.174.800,-
2	Multi-story building 2	2929,8	51.271.500,-	114.262.200,-
3	Multi-storey building 3	3906,4	68.362.000,-	152.349.600,-
4	Multi-storey building 4	4883,0	85.452.500,-	190.437.000,-

Note: Wood materials are obtained free of charge from the sorting of the formwork scaffolding demolition.

Graph of Comparison of Analysis Results

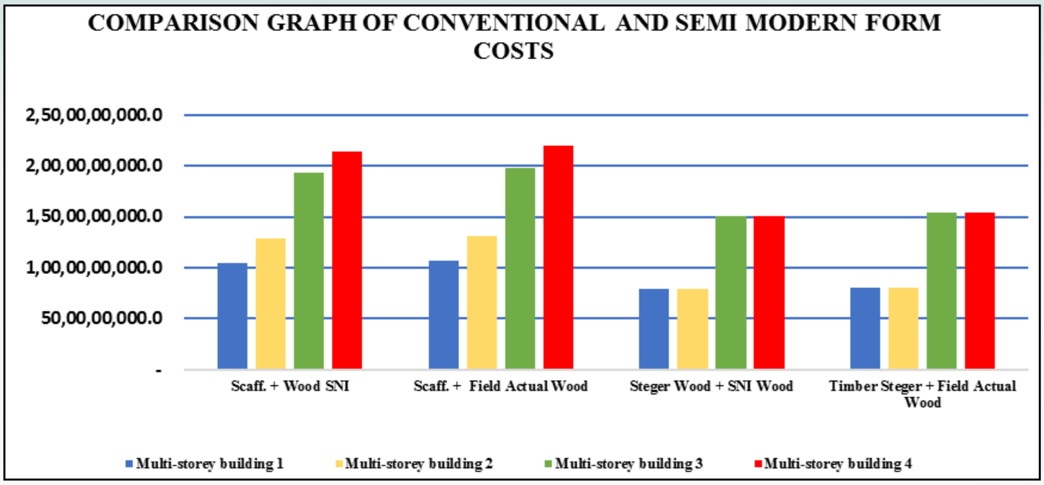

Figure 1 Overall Formwork Cost Comparison

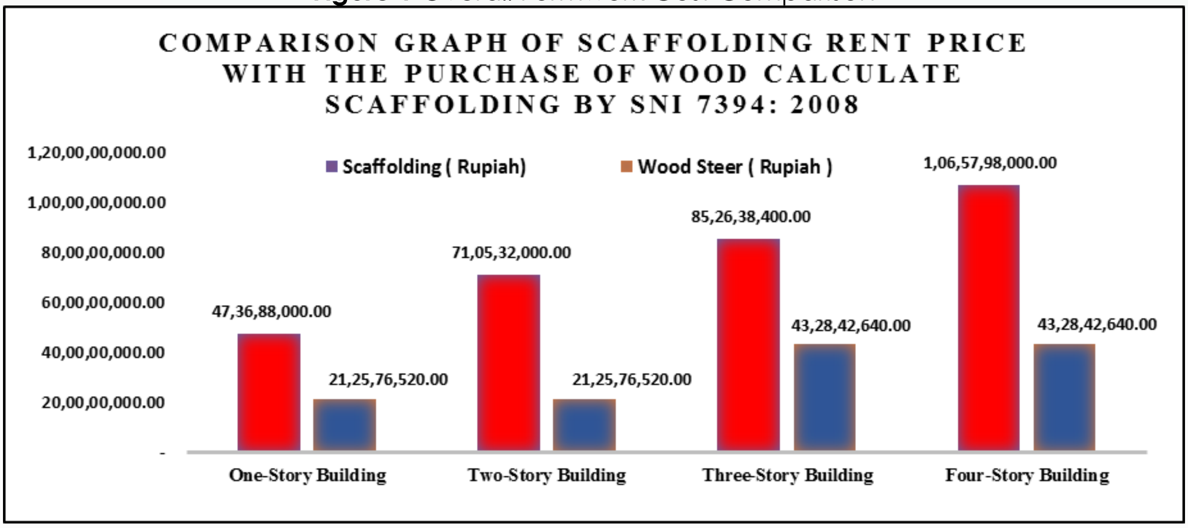

Figure 2 Comparison of Scaffolding Rental Prices with the Purchase of Wooden Stegers Calculation of Timber Needs Method SNI 7394:2008

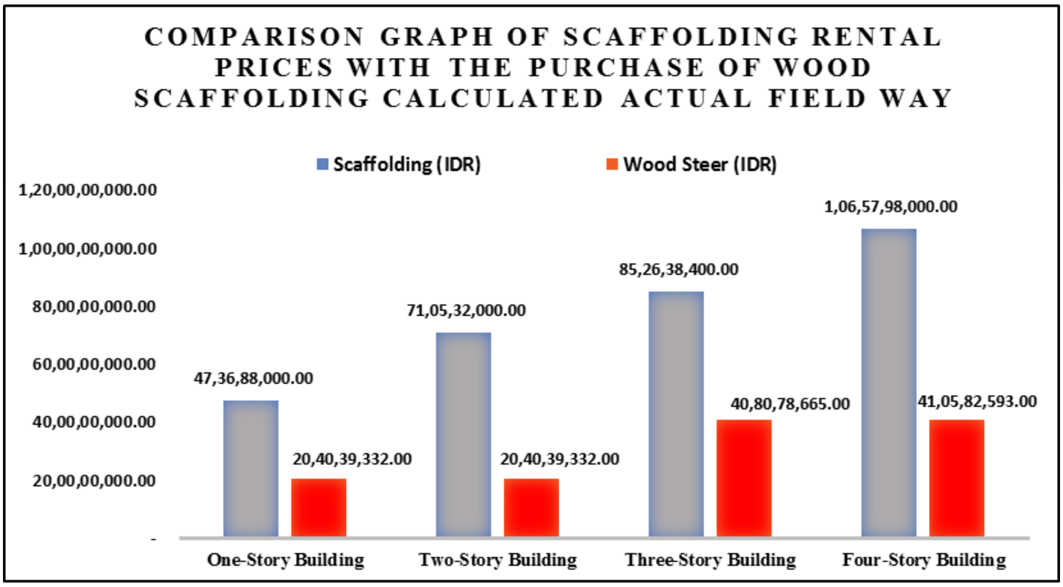

Figure 3 Comparison of Scaffolding Rental Prices with the Purchase of Wooden Stegers Calculation of Timber Needs Actual Field Method

Ceiling Frame Wood Graphics

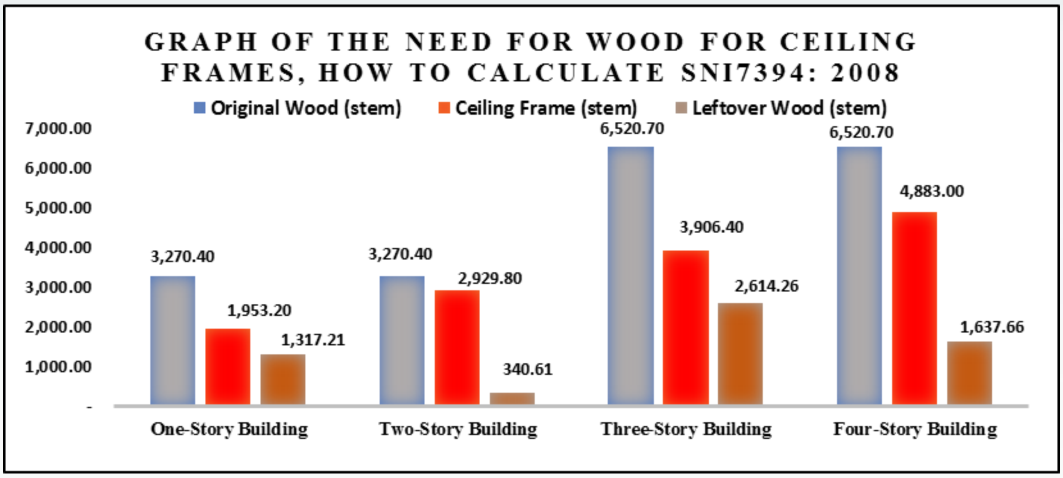

Figure 4 The use of wood for the need for the ceiling frame is calculated using the SNI method 7394: 2008

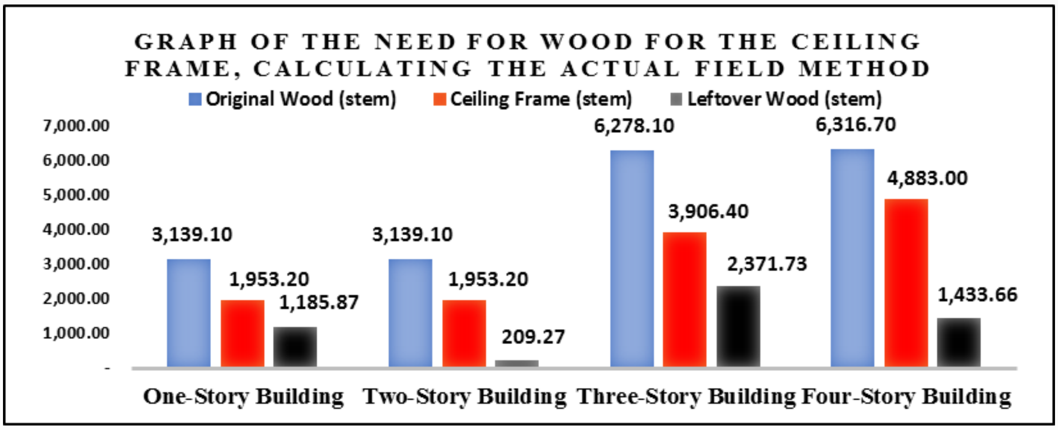

Figure 5 Use of Wood for Ceiling Frame Needs Counts in a Field Actual

Based on the comparative analysis of calculations on four types of high-rise buildings, it can be seen that the most efficient use of wood is found in the construction process of a Two-Story building with the number of castings three times (Sahid et al., 2015). This study aims to develop knowledge of how the effect of revitalization on buildings in cultural heritage areas, especially the Sarinah Braga Building, from initially an abandoned building to finally becoming a building with the implementation of new functions (Andiyan, 2021). In this implementation, the remaining tigerwood used for casting can be used more optimally for the needs of the ceiling frame compared to the use of wood in the analysis of other low-rise buildings. The wood data from this work can be concluded as the best data from various other low-rise building analysis experiments. The details of the data are shown as follows (Wijayanto et al., 2014):
Calculation data according to SNI 7394: 2008; (1) Good Steger wood from the final sorting of the casting for the primary material of the ceiling frame wood: 3,270.4 rods; (2) Total ceiling truss requirement: 2,929.8 rods; (3) Good wood residue: 340.61 sticks.
Actual Field Calculation Data; (1) Good Steger wood from the final sorting of the casting for the primary material of the ceiling frame wood: 3,139.1 stick; (2) Total ceiling truss requirement: 2,929.8 rods.
Good wood residue: 209.27 sticks

CONCLUSIONS

The results of the research analysis show that the implementation of casting using wood as Formwork and Scaffolding, the volume of post-casting scaffold wood damaged/lost is only ±40% of the total scaffold wood, while the volume of wood suitable for use for ceiling frame materials is ±60% of the volume of wood, this amount of wood is more than enough for that need. So this ± 60% wood volume can provide a significant cost efficiency to cover other implementation costs when compared to using a scaffolding system that requires buying a new ceiling frame such as hollow iron; this is what is different between the two formwork systems because this dramatically affects the selling value on the building if the building is a business building. In the calculation of the analysis, 1 m2 of hollow iron ceiling frames spends 0.9 hollow iron rods with a current nominal price of (0.9 x Rp.17,000 = Rp. 15,300,-), when using a wooden ceiling frame, this value is obtained for free and can cover the cost of the ceiling truss work. If the building is large, this value will significantly affect the overall cost of the building and the selling value to consumers, especially to business people and developers in the property sector. The results showed that the efficiency of wood when used for Formwork and Scaffolding includes; (1) The use of wood for scaffolding is straightforward and efficient because the demolition, removal, and removal of scaffolding can be done in a zigzag row of scaffolding wood and gradually following the development of the strength of the concrete until the concrete hardens and can carry its weight. The transfer of this scaffolding is faster in terms of execution time for the next scaffold and floor formwork requirements; without having to dismantle at once while waiting for the concrete to harden completely, this kind of implementation cannot be applied to the framework (Scaffolding) system, because this formwork system is a series of intact together with each other so that the disassembly is challenging to remove one by one. Here, it is clear that this wooden scaffolding system can also save time in executing concrete-casting work for high-rise building construction; (2) Wood provides cost efficiency of implementation and added value to the work of the ceiling frame; the results of the analysis show that after casting, the scaffolding wood is still feasible and reasonable to use for the ceiling frame by ±60% of the total supply of scaffolding for casting, in the sense that the wood material is used as a ceiling frame can cover the needs of the ceiling frame even more than they need for the ceiling frame of the building we are building. That means you don't need to buy a new ceiling frame anymore because it already exists, and you can get it for free from used wood scaffolding; (3) When viewed in terms of implementation efficiency, the results of the analysis in the study show that the use of wood is more efficient and maximal in the implementation of three castings, or according to the RKS (Work Plan and Conditions) rules, in this study, the results of the analysis show that the use of wood is more efficient. In a two-story building (three floors with three castings), the rest of the wood used to support the ceiling frame is relatively used up, or there is little left of the entire used scaffolding wood that is suitable for use for the ceiling frame; (4) By using wood as a scaffolding material and formwork in casting concrete, from the results of the study, the cost of using wood is much cheaper when compared to the formwork system (Scaffolding), because the cost of renting Formwork (Scaffolding) is prohibitive when applied to business buildings, especially in business buildings. Small-scale properties, shop houses, office houses, and other low-rise buildings. Regarding ceiling work, if you use a scaffolding system, you must buy another ceiling frame such as hollow steel; this adds another cost burden to the cost of implementing the building. The analysis results using the SNI 7394: 2998 method and the actual method in the field are very striking price differences between the two systems, which range from 38.5% to 43%; it is more cost-effective when using a wooden scaffolding system. The use of wood is much cheaper than the use of Formwork (Scaffolding), even post-casting scaffolding wood can be reused for ceiling frame needs, increasing the efficiency of implementation costs, it's just that in terms of the implementation of wood as Formwork and this Scaffolding is only effective for low-rise buildings (buildings). 1-story building to 4-story building), and this formwork system is more suitable for small-scale property entrepreneurs.

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