The combination of green construction method and the use of tabas waste as a substitute for cement

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Abstract. Green construction is a construction process that carries the concept of sustainability where the construction process can reduce environmental degradation by utilizing existing waste in the surrounding environment, contributing to reducing the level of environmental pollution, and being able to reduce waste from the construction itself. The use of tabas as a substitute for cement is one of the implementations of the green construction concept itself, where the waste of rock that produced by the temple stone craftsmen ranges between 20%-30%, which utilization is not optimal, so it often becomes waste that accumulates in the production area so that it can damage the environment due to the compounds of the tabas waste. The use of rock as a substitute for cement both reducing the amount of cement usage which produces 8% CO2 emissions where the percentage is the third-largest in the world even far beyond aircraft fuel. From the results of the study using tabas rock to replace 10% of the volume of cement in the mixture, obtained a concrete strength of 22.21 MPa so that it meets the criteria as normal concrete. With the combination of green construction methods using a combination of tabas concrete and metal deck floor plates, in terms of the cost of making concrete are obtained savings by 20.48% and a reduction in the amount of construction waste originating from formwork by 35.96%.

1. Introduction

Green building construction is one of the concepts in the conservation of green buildings wherein this case are buildings that are made using materials from construction waste [1]. Increasing industry in the era of globalization and technological advances that continue to develop, resulting in the emergence of various types of waste. Among these wastes there is waste that cannot be recycled and if left unchecked can damage the environment so that it becomes a problem in every country.

In reducing the impact of environmental damage the researchers tried to find solutions to deal with environmental pollution [2]. This is done to support the world campaign "Going Green" which lately has become a major issue to create a clean environment. Many efforts have been made starting from the application of environmentally friendly technology (Green Technology), environmentally friendly buildings (Green Building) that adopt triple zero, namely zero energy, zero-emission, and zero waste for environmentally friendly buildings.

Construction activities have a major impact on physical development, government policies, community activities, and welfare programs. However, over their entire lifecycle, construction activities are also connected with the broader problems and issues affecting the environment, including global warming, climate change, ozone depletion, soil erosion, desertification, deforestation, eutrophication,
acidification, loss of diversity, land pollution, and consumption of valuable resources such as fossil fuels, minerals and gravels [3-6].

Construction waste is the residual material that results from the construction process, whether in the design, implementation, or demolition of buildings that can cause adverse impacts on the environment if not handled properly [7]. Waste originating from the construction of remodeling, repair of houses or commercial buildings, is classified as construction waste. The composition of construction waste in the form of stone, concrete, brick, plaster, valuables, roofing materials, plumbing materials, electrical installation materials, and formwork. About 1-10% of the material used in construction work will become construction waste and generally, 50-80% is waste that can be reused [8]. One of the waste in construction is plywood waste. This plywood waste is generated during the formwork process. Besides, material solutions or innovations that are environmentally friendly and have economic value are needed that can serve as useful components in the field of civil engineering construction, especially those in Bali.

In addition to plywood waste (plywood), there is also waste that comes from the remnants of the craftsmen when making sacred buildings that locals called it as Tabas rock. Tabas rock is one of the igneous rocks of volcanic mountain activity in the form of magma that has dried/frozen that contained Al2O3, SiO2, TiO2, K2O, MnO2, MgO and CaO [9]. The existence of Tabas stone was focused in the Karangasem Regency area where the stones are residuals from Agung Mountain. Particularly in Bali, tabas stone is used by stone craftsmen as the basic material for making monuments such as temples and other buildings characterized by Balinese culture. In the manufacturing process, craftsmen can produce up to 35% waste from the original rock that around 14-15 m3/month and for now this waste has not been used optimally which makes it a pile of waste at the craftsman's workshop and of course it can pollute the land because it can't be carelessly thrown away as can seen on figure 1.

In general, basalt or scoria basalt has a rough, hard, and slightly porous texture. The amount of tabas rock waste in cement replacement is between 5 - 10%. With this percentage, the strength of concrete is equal to the strength of normal concrete, and the permeability of concrete is only reduced by 9.13% [10].

Cement is one of the important materials of construction that is usually used for the adhesive between one material with another material. This cement will function as an adhesive when mixed with water [11]. The construction industry specifically which is related to cement produce 8% CO2 emissions where the percentage is the third-largest in the world even far beyond aircraft fuel [12]. Cement is the basic ingredient in making concrete. The use of concrete increases every year due to the characteristics
of the concrete itself which can be formed so that it has its own aesthetic value. With the increasing demand in the construction sector, a lot of research has been done to find an alternative that can substitutes cement to reduce the greenhouse effect, especially from the construction sector [13].

| Chem Name          | Chem Formula | Notation | % Weight |
|--------------------|--------------|----------|----------|
| Trikalsium Silikat | 3CaOSiO₃     | C₃S      | 55       |
| Dikalsium Silikat  | 2CaOSiO₂     | C₂S      | 18       |
| Trikalsium Aluminat| 3CaOAlO₃     | C₃A      | 10       |
| Tetrakalsium Aluminofent | 4CaOAl₂O₃Fe₂O | C₄AF     | 8        |
| Gypsum             | CaSO₄2H₂O    | CSH₂     | 6        |

Construction opportunities here include preconstruction services, minimizing site disturbance, erosion and sedimentation control, pollution prevention, sustainable site operation, construction waste management, indoor air quality management, green materials management, and commissioning [3,14]. Proper management of construction waste can certainly be done by adjusting implementation methods to minimize waste production which directly affects the project cost while creating a green climate for sustainable development [15, 16].

2. Methods
The analysis of this study uses a quantitative descriptive approach because the retrieval of variables can be done by interviewing, through documentation, previous research, and the results of research analysis using numbers, starting from data collection and data interpretation. in this study analysis, the author wants to convey a comparison of the total cost to make concrete especially floor plate with conventional and alternative methods with the combination of using powdered tabas as a substitute for cement.

2.1. Data collection
The primary data analysis of this research is in the form of data obtained from field surveys about the average percentage of tabas waste generated in the process of making temples per month from each of 10 different craftsmen. Secondary data obtained from project documents, unit price analysis issued by Dinas PUPR, unit price analysis issued by contractors and pre-cast concrete manufacturer, searching for information available through journals, through library studies by studying books that support the analysis of this research.

2.2. Comparative method
In this implementation method uses a comparative method that provides similarities or differences of the studied variables, the author provides an opinion or estimated value by analyzing the comparison variables and comparing them with the variables to be assessed.

3. Results and discussion
From this research obtained the data for the Third Floor Residential Development Project Area on Jalan Tukad Badung 23 Renon, Denpasar, Bali that conventional formwork produce construction waste of 35.96% that comes from plywood and wood beams for floor plate casting.

3.1. Conventional methods
In the installation of begesting work usually uses conventional methods that requires a long time, great effort, and produce much waste on finishing phase.

From Table 2, the total cost can be known, where the used formwork will become waste and it can be said as a waste of resources because it has to thrown away after the project is done and to do so, you
have to disburse as much as Rp 41,731,101. Besides you still have an issue about greenhouse effect that comes from the usage of cement.

Table 2. Conventional method cost.

| Work Item            | Volume | Unit Cost | Total Cost  |
|----------------------|--------|-----------|-------------|
| Concrete Plate fc 21,7 | 11.3 m³ | 874,660   | 10,337,772  |
| Wiremesh M8          | 197 m² | 324,744   | 63,974,568  |
| Conventional Formwork| 98.5 m²| 423,666   | 41,731,101  |

Total Overall (Rp) 116,043,441

3.2. Alternative methods

Alternative methods offer a more environmentally friendly implementation method by reducing the use of cement and the use of formwork in the process.

3.2.1. Combination of tabas concrete and metal deck. With a substitution of 10% cement by tabas powder gained strength equal to 22.21 MPA. With this percentage, the strength of concrete is equal to the strength of normal concrete, and the permeability of concrete is only reduced by 9.13% that can be improved in the finishing phase.

Table 3. Combination of tabas concrete and metal deck cost.

| Work Item          | Volume  | Unit Cost  | Total Cost |
|--------------------|---------|------------|------------|
| Concrete fc 22.21  | 11.3 m³ | 727,441    | 8,220,083  |
| Wiremesh M8        | 147.75 m²| 324,744    | 47,980,926 |
| Metaldeck Formwork | 98.5 m² | 309,905    | 30,525,643 |

Total Overall (Rp) 86,726,652

From table 3, the cost of concrete reduces because tabas waste has no economical value so it can be obtained freely around the craftsmen workshop. The amount of wire mesh m8 volume is also reduced because of the characteristic of the metal deck itself as a one-way reinforcement, so it only needs as much as 75% of the initial reinforcement bar volume. The unit cost of the metal deck is also reduced because it uses less scaffolding, it also has increasing value because it attaches permanently on the concrete floor plate, so that its use reduces construction waste.

3.2.2. Combination of tabas in pre-cast concrete. Can be seen from table 4 and 5 that the cost was greatly increased, because of the method of casting the concrete is different from others that used cast-in-situ method. The cost itself consist of fabrication cost, mob-demob cost, and erection cost on-site using an additional tool. However, this combination produces almost zero waste on site.

Table 4. Pre-cast concrete cost.

| Work Item            | Volume  | Unit Cost  | Total Cost |
|----------------------|---------|------------|------------|
| Concrete fc 22.21 Precast | 98.5m² | 1,142,996 | 112,585,106 |

Table 5. Tabas pre-cast concrete cost.

| Work Item            | Volume  | Unit Cost  | Total Cost |
|----------------------|---------|------------|------------|
| Concrete fc 22.21 Precast | 98.5m² | 1,028,696 | 101,326,556 |
4. Conclusion
From the results of the study, it can be said that using alternative methods has various advantages in terms of cost, contributing to reducing pollution due to reducing the use of cement by substituting it with another material such as tabas waste and being able to reduce waste due to the implementation of construction methods.

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