Material conservation as part of environmental sustainability in architecture—case study: Mesvara House, Yogyakarta, Indonesia

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Abstract. Buildings use variety of materials at different stages and the choice of materials will affect its overall life cycle and performance. The conservation of non-renewable resources has crucial part for sustainable future. Therefore it is vital for designers and practitioners of architecture to apply material conservation in order to support environmental sustainability. This study aims to see the awareness of architects in conserving building materials and whether designing tools like sustainable building framework is applicable in the field. The case study was Mesvara House located in Yogyakarta. Data were collected through direct observation and interviews, and analysed using the sustainable building framework. Result of the study revealed that Vignette has awareness of sustainability by implementing all methods of material conservation strategy such as design for waste minimization, specify durable materials, specify natural and local materials, design for pollution prevention and specify non-toxic or less-toxic materials. The result also shown that sustainable building framework as designing tool are applicable in the field and can help designers and practitioners in the building industry to realize sustainability.

Keywords: Architecture, material conservation, sustainability, sustainable building framework

1. Introduction

Buildings have significant impact on the environment as they consume non-renewable energies and also produce waste. Sustainability has become one of the popular topics in the building industry, as it can help reducing the environmental impact. The concept of sustainability involves enhancing the quality of life by improving social, economic and environmental conditions [1]. In term of environmental aspect, the idea was to reduce waste materials and use the natural resources efficiently. Buildings use variety of materials at different stages so they will affect its overall life cycle performance [2]. Therefore, it is important for architects, as the building designer, to select and manage building materials effectively since the early stages of design.

Among several studies discussing sustainability design principles in architecture, Akadri et al [1] proposed a sustainable framework and methods that can be applied in building projects. The framework includes objectives which has strategies and methods to facilitate sustainability in building
projects from a life-cycle perspective. One of the objectives was Resource conservation, which related to environmental issues. According to Akadri et al [1], Resource Conservation means how human can efficiently manage to use the natural non-renewable resources in order to provide maximum benefit. This objective includes strategies such as conservations of energy, material, water and land. This paper will only focus on material conservation, as building materials are the key to sustainability in the built environment [3].

This study will try to discuss about material conservation in an architectural project based on the sustainable design framework by Akadri et al [1]. A private house designed by Vignette, an architectural firm in Yogyakarta was chosen to be the case study. From this research, it is expected to have a view on the awareness of architects in conserving building materials in order to support sustainability in the building industry. This study will also try to assess whether designing tools like sustainable building framework is applicable in the field.

2. Building Materials and its Impact on Sustainability

The term of “materials” defined as all of the physical substances that are assembled to create a building, both for the exterior and interior [4]. The building materials life cycle includes extraction of raw materials, the manufacturing and transportation process, and the maintenance and renovation requirements during building operation [2]. The materials selection process for the design and construction phase is a complex issue. Building materials can influence many things, such as lifetime energies, user comfort and durability. Therefore, to achieve high-performance building, it is very important to apply stable, attractive, and environmentally responsible building materials [4].

Building materials are crucial to sustainability in the built environment. In the study of Mohamed et al [3], according to Kibert from the study called ‘Sustainable construction” in 1994 , the choice of building materials affects many value properties relevant to sustainability including weight, embodied energies, fuel related and chemical emissions, lifetime energies, user comfort and health, use of recycled wastes, durability, recyclability and the properties of wastes. Buildings use variety of materials at different stages and this will also affect its life cycle performance [2].

3. Material Conservation based on A Sustainable Building Framework

Akadri et al [1] did a literature review on sustainability design principles in architecture. The result was a sustainable building framework of strategies and methods for implementing sustainability in buildings, which related to environmental, economic, and social aspects. In the environmental sustainability, one of the strategies in resource conservation objectives was material conservation. The methods for material conservation in order to achieve material efficiency are design for waste minimization, specify durable materials, specify natural and local materials, design for pollution prevention and specify non-toxic or less-toxic materials.

1. Design for Waste Minimization. As building industry contributed as major waste generators, waste minimization can save considerable amounts of non-renewable resources. It can be achieved by reducing and recovering construction waste; reuse and recycling; and the storage and disposal of construction waste;

2. Specify Durable Materials. Materials with high durability that require less frequent replacement will require fewer raw materials and produce less landfill waste;

3. Specify Natural and Local Materials. Natural materials generally have low embodied energy and toxicity, require less processing and have less environmental damage. The use of local building material can help lessen the environmental burdens, shortens transport distances, thus reducing air pollution;

4. Design for Pollution Prevention. Includes becoming aware of which manufactures use environmentally sustainable manufacturing methods, specifying their products, and avoiding highly polluting methods for producing materials.
5. Specify Non-Toxic or Less-Toxic Materials. Using building materials with lower or non-toxic substances can help avoid environmental health problems for the residents and reduce the need for air scrubbers.

4. Research Method
This research is a descriptive-qualitative research [5]. The data was assessed and analyzed based on the sustainable building framework by Akadiri et al [1]. The result of this study will be discussed through descriptions. The data collection is done through interviews with the architectural firm and client. To receive better visual and information, direct observation also had been done.

5. Case Study
Mesvara House was designed and built by Vignette architectural firm from Yogyakarta in 2018. This house belonged to Mrs. Risa Kurniawati and her family. It is located in Gang Antasena no. 42, Jl. Candi Gebang, Sleman, Yogyakarta. Mesvara House has an U-shaped mass with Scandinavian concept using natural materials like bricks, exposed concrete and wood. The exterior of Mesvara house can be seen in Figure 1.

![Figure 1. Exterior of Mesvara House](image)

The client wanted the house to accommodate as residential as well as the office for the husband. The 2-storey house was built on a 91 m² land, where 40 m² is for the ground floor area and the rest 51 m² areas was provided for open spaces. The house has a living room, family room, 1 master bedroom, 1 guest bedroom, 2 bathrooms, 2 kitchens, and also facilitated by an office for the husband to work. The Mesvara house floor plans can be seen in Figure 2.
6. Result and Discussion
This part of the study will try to discuss the case study based on the material conservation methods in the previous sustainable building framework. Methods of material conservation to be discussed include design for waste minimization, specify durable materials, specify natural and local materials, design for pollution prevention and specify non-toxic or less-toxic materials.

6.1. Design for Waste Minimization
For Mesvara House project, Vignette tried to minimize waste production since the early construction phase. The key is to select efficient materials. They also tried to use material that is not used only once or disposable.

For construction, Vignette choses to use composite floor deck and metal tube scaffolding. Composite floor deck is a substitute for conventional systems that use plywood as formwork or floor plate cast molds. It can minimize the use of wasted columns and supporting beams compared to using plywood. Using composite deck flooring results in faster construction and lighter floors [6]. It can also reduce the volume of concrete cast by approximately 15% to 25%. In addition for minimizing construction waste, they chose iron or metal tube scaffolding. This tool can help reduce the use of bamboos.

Other attempt was they used the tools and materials from the previous project, like batter boards, plywood, roofing for the workers shelter, and also granite flooring for the interior. Wooden doors in the bedroom and office, as well as glass doors to the terrace on the upper floor are also re-used material from the previous project. They only re-paint it so it looks new. Reusing material, like what Vignette did, was one of the key for minimizing waste [1]. They are considered as one of the way for resource efficiency and criteria for green construction [4]. The re-used materials for the interior of the house can be seen in figure 3.

As for unavoidable waste, Vignette tried to make the best use of it in order to continue to be useful. One material is bamboo. If it has been used, the bamboos will be used by workers as fuel for cooking water to drink. This can be another way for construction waste disposal. The actions above can be categorized as reducing and recovering construction waste, which is the most effective measure of reducing the environmental impact of construction waste. Thus, it can also provide economic benefits, reduce greenhouse gas emissions, saves energy, and reduces the use of raw materials [1,7].

![Figure 2. Floor plans of Mesvara House](image-url)
6.2. Specify Durable Materials
The Mesvara house uses several durable materials in this project such as bricks, concrete, steel, stones, wood and aluminum for doors and windows frames. The brick in this house uses clay material with good combustion so it has a good quality. Its large size also minimizes the use of cement for species. Besides brick, this house also uses concrete material, which is known for its unbelievable strength. Steel is used mainly for roof construction. Steel is strong, durable and also recyclable. For door and window frames, this house uses aluminum frames as a substitute for wooden frames. Aluminum frames have stronger durability and also do not experience porousness. Another advantage of this material is that it is considered weather and fire resistant. Using durable materials will stand the test of time and require little maintenance. This will save time, money and energy on repairs at a later date [4].

6.3. Specify Natural and Local Materials
This project was located near building materials manufacturing. The steel for building structure, roasters and bricks on the second floor, and paving for outdoor areas are materials manufactured near the building site. Parquet wood for flooring is also purchased from local production at an affordable price but has good quality. For the building structure, Vignette used sands and stones for foundations. The application of some local material used in the building can be seen in Figure 4.

Figure 3. Re-used materials in the interior of Mesvara House

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6.4. Design for Pollution Prevention

Vignette’s contribution in pollution prevention is by choosing local materials. Mostly, the manufacturing of the materials in Mesvara House are close from the project site. Steel, roasters, bricks, paving and wood flooring are examples of local materials in the house. Transporting construction materials to site contributes very significantly to the total pollution emissions [1]. By using local materials near the project location can shorten transport distance, thus minimizing air pollution by vehicles [1,7].

6.5. Specify Non-Toxic or Less-Toxic Materials

Mesvara House used water based duco paint for painting the doors in order to minimize the toxicity inside the house. Water based duco paint is considered an environmentally friendly paint. The water based duco paint used in Mesvara house also doesn't have any scent. Most duco paint on the market emits a strong scent because it contains volatile organic compounds (VOC) and formaldehyde emissions. Those pollutants have serious harmful effects on human health, comfort and productivity [2].

7. Conclusions

Selecting building material is crucial part in sustainable built environment. The selection of materials used will affect the building’s overall life cycle performance. Thus it is important for building designers and practitioners to understand and select building materials effectively in order to achieve a sustainable high performance building.

Vignette, as one of architectural firm in the building industry in Indonesia, has tried to conserve building materials in their project. Mesvara House as the case study in this research has been assessed on its contribution to environmental sustainability based on material conservation strategy from sustainable building framework by Akadiri et al [1].

Using natural and local materials are one of the features for sustainable building materials [7]. Natural materials are generally lower in embodied energy and toxicity than man-made materials, because they require less processing thus they are less damaging to the environment.
The result of the study shown that Vignette has applied the methods for material conservation in the sustainable building framework such as design for waste minimization, specify durable materials, specify natural and local materials, design for pollution prevention and specify non-toxic or less-toxic materials. In design for waste minimization, the attempt was to reduce and recover the amount of construction waste and also reuse building materials. As for specify durable material, Vignette used durable materials in the building structures and components like bricks, concrete, steel, stones, wood and aluminum. The architecture firm also used natural and local materials like steel, bricks, wood, sand and stones. In term of pollution prevention, the key was to shorten transportation distance by using local materials manufactured near the building site. And for specify non or less-toxic materials, Vignette focused in the interior by using duco paint.

Based on the results, this shows that architect do have awareness in conserving building materials in order to support sustainability in the building industry. And also designing tools like sustainable building framework is applicable in the field and can help designers and practitioners in the building industry to realize sustainability.

Because this study is an initial research, the results still need to be tested and confirmed. The findings of this research can be a reference for implementing sustainable design in architecture.

8. References

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