e-ISSN 2795-3278
p-ISSN 2795-3274

10.5281/zenodo.7029312 Vol. 05 Issue 08 August - 2022 Manuscript ID: #0688

UTILIZATION OF PLASTIC BOTTLE WASTE AS A BUILDING ENVELOPE

Wardhana

Lecturer of Architecture Study Program, Faculty of Engineering, University of 17 August 1945 Samarinda

Corresponding author: *Wardhana
Email: wardhana@untag-smd.ac.id

ABSTRACT

Used plastic bottle waste contributes to the volume of waste in Samarinda City. This number of used plastic bottles is improperly disposed of every day which results in an accumulation of buildup in landfills, dumped into rivers, and burned. The research began by using plastic bottles as an alternative building material from an architectural point of view, as a thermal reducing envelope in buildings. This promotes the use of plastic bottles as an alternative building envelope material. The building envelope, secondary skin, with a modular eco cooler concept is implemented as a building protector. This study aims to improve indoor thermal comfort and support energy efficiency. The research method is carried out by simulating thermals in buildings with Ecotect and modular comparisons in finding optimal combinations, modular engineering, and implementing eco coolers. Meanwhile, climate data were taken from local climate data in SamarindaCity.The condition of the before-after results showed that the secondary shells with used plastic bottles showed a decrease in the amount of temperature and humidity, and an increase in the amount of wind speed. These results can contribute to improving indoor thermal comfort and energy-efficient building concepts. In addition, the research results can be implemented not only at the design stage but also for alternative building envelopes in Samarinda City. Finally, the opportunity for used plastic bottle materials can be developed in further research.

KEYWORDS:

Secondary Skin, Ecotect, Solar Radiation Simulation

INTRODUCTION

Waste of used plastic bottles is a very real global problem in human life today. The use of plastic bottles in everyday life has been produced on a large scale to meet the needs of human life. Plastic bottles that have become waste cannot be destroyed easily. Plastic production is estimated at 359 tonnes per year worldwide. Plastic is an unsustainable material. For this reason, this research begins with the use of plastic bottle waste as an alternative building material from an architectural point of view, as a heat-reducing envelope in buildings in Samarinda City.

The buildings in Samarinda have not been optimal in responding to the tropical climate and the sun's trajectory. The application of a building style that adopts a non-tropical style causes discomfort and a lot of damage to the building. The result of the application of planning that is often seen is the exposure of walls with a large enough area without using direct sun protection. This causes heat on the walls of the building continuously for a long period of time, so that not only cracks occur in the walls but also heat transfer into the room, which causes the heat in the room to increase. Cracks in the walls can cause fracture potential, resulting in reduced construction strength. Fractures in the walls contribute to a reduction in the overall strength of the building. The impact that arises is that the building becomes tilted, the paint or material fades, and the air in the building becomes hot. In addition, if the building receives an excessive heat load, the air inside becomes hot. and this will trigger the use of cooling devices such as air conditioners. Excessive use of air conditioning not only increases the cost of electricity use but also releases freon gas into the air as a contributor to the greenhouse effect. In addition, the hot air coming out of the air conditioner can contribute to the increase in ambient air temperature due to the hot air released[1][2]. Conditions like this keep recurring and tend to increase. So that existing buildings must respond well to this situation.[3]

The response that can be made to the building is heat reduction. Engineering in response to heat reduction in buildings can use various methods, one of which is the second covering of the building, or better known as secondary skin which functions as a shield from the sun [4]. The filler material on the secondary skin varies widely. The use of used bottles that are cut and arranged in the form of a grid or better known as an eco cooler is one alternative.

Secondary skin engineering by using filler material in the form of eco cooler in existing buildings requires an analysis of its optimal position in the building. The orientation of existing buildings varies. So that the application of the secondary skin position in a building is different. The optimal position of the secondary skin to the building by analyzing the pattern of the sun's path and the orientation of the building.So that the implementation of secondary skin engineering functions optimally, in terms of thermal comfort.When someone is in the room.

A comfortable thermal condition is a feeling where a person feels comfortable with the temperature state of his environment, which in the context of sensation is described as the condition of a person not feeling hot or cold in a certain environment. Comfort limits for equatorial conditions range from 19°C -26°C. [5]. Several factors that affect thermal comfort are air temperature, radiant temperature, wind speed, humidity, and clothing insulation [6]. Radiant temperature is the heat radiated from an object that gives off heat. Radiant temperature has a greater influence than air temperature in how we release or receive heat from or to the environment. Wind speed is influenced by the characteristics of the surface it passes through. The factors that affect wind speed include barometric gradient, location, location height, and time. While the factors that affect air humidity, namely solar radiation, air pressure, altitude, wind, air density, and temperature.

A person's mental condition will reach the best condition when the human is in a thermally comfortable condition, this means that intellectual-related activities such as studying, working that requires concentration and exhausting the mind, creative work and others can be done well if a person is in a thermally comfortable

condition. A room with good thermal comfort can improve the quality of physical activities such as exercise. Activities related to the perception of the senses of the eyes and ears such as houses of worship, concert halls, cinemas and other art performances also require Kenyan conditions:

Passive Cooling Strategy

Passive cooling strategy is a strategy to reduce heat in a building by using openings or ventilation, wind (air movement), and canopies to maintain thermal comfort in the room [8]. In this cooling strategy, the heat transfer factor that occurs in a building becomes a concern.

As for the acceleration of removing heat, the movement of air or wind is used. In buildings, the wind helps cool the building by moving air that brings hot air from inside the room and then expels it to the outside through available openings. The principle of the movement of air from high pressure to low pressure [9].

Wind movement against buildings can be used as a natural way to cool heat loads. Planning by taking into account the principles of heat transfer and the combination of building materials will help in the efficiency of energy consumption in the space cooling system.

The implementation of solar control with shading can use a secondary skin / second skin / double skin faade. Secondary skin is taken from the idea of double skin as a building skin. Double skin is the concept of the outer skin of the building which consists of two layers of planes (inner skin and outer/secondary skin) which form an intermediate cavity. The form of secondary skin can be in the form of a perforated area with a certain pattern and pattern of holes to filter incoming sunlight, or it can be a combination of fins using an automatic mechanical machine. Secondary skin can help reduce the heat load of the building

The proper placement of heat reduction engineering by using secondary skin is able to optimally reduce heat in buildings caused by sunlight. The trajectory of the sun is the change in the position of the sun due to the rotation of the earth on its axis around the sun. Placement of secondary skin must pay attention to climatic aspects. So that the laying of heat reduction engineering can function optimally.

The concept of using a second skin in buildings was first introduced in the 1900s, but the progress of scientific development was not very developed until the 1990s. Although the second skin concept is more popular in countries that are strict in energy saving regulations, there are still many countries that do not have standards in planning and evaluating the application of secondary skins, and this is a barrier in its implementation [10].

The secondary skin or the second skin consists of the building envelope, the air in the cavity (cavity), and the second external skin. In general, implement a shading system in the cavity between the two skins of the building. The main factor in conditioning the movement of air in buildings is the movement of wind around the building and the difference in pressure due to the buoyancy of heat that occurs in the cavity [11]. In this study, the secondary skin filler is a series of plastic bottles or eco coolers.

Eco cooler

Eco cooler is a series of plastic bottles cut in half and assembled in a grid pattern[12]. The use of eco cooler as a secondary skin filling material is expected not only to protect the building from direct sunlight, but also to drain it (passive cooling strategies) and reduce air temperature, so that this combination can reduce heat in the building.

The approach to air reduction without electricity is already being used in Bangladesh and Pakistan, where nearly 70% of the population lives without electricity. The method is to make a perforated panel (using a

plastic bottle that has been cut) which compresses the air that comes later which is then released at the end of the bottle, this creates a cooling effect,

The effectiveness of the eco cooler varies depending on site conditions, local climate, building, but in Bangladesh, GRAY Dhaka managed to reduce the temperature by 5 degrees Celsius which is almost the same as that of a centralized air conditioning system. Under certain conditions, the eco cooler is able to reduce heat from an uncomfortable and dry atmosphere (300C) to a comfortable atmosphere (25^0C).

RESEARCH METHODS

In engineering heat reduction in buildings and thermal analysis using the Ecotect program, an environmental analysis program for building simulations. Data collection was carried out before and after treatment, starting with determining the location, then taking field data on the selected building. Before taking data, the first step is to turn off the electric current. The goal is to ensure that the thermal space of the existing building is in actual condition without any cooling aids.

The initial data obtained are temperature in Celsius, humidity in percent, wind speed in km/hour, and the orientation of the direction of the building to the North-South axis. In the engineering of thermal reduction in selected buildings, one-story buildings, the position of the secondary skin placement is analyzed with Ecotect. The goal is to place secondary skins for use in specific building orientations to obtain optimal thermal reduction as shown in Figure 1.

After getting the position of placing the secondary skin on the building, make itsecondary skin simulation on buildings,

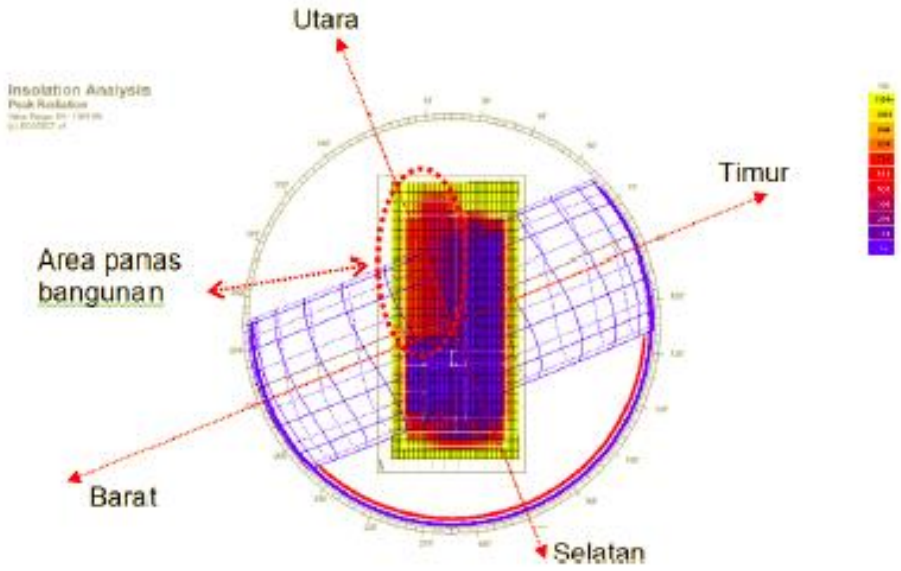

Figure 1. ***Secondary Skin Position***

Then proceed with making several combinations of layouts (Figure 2).

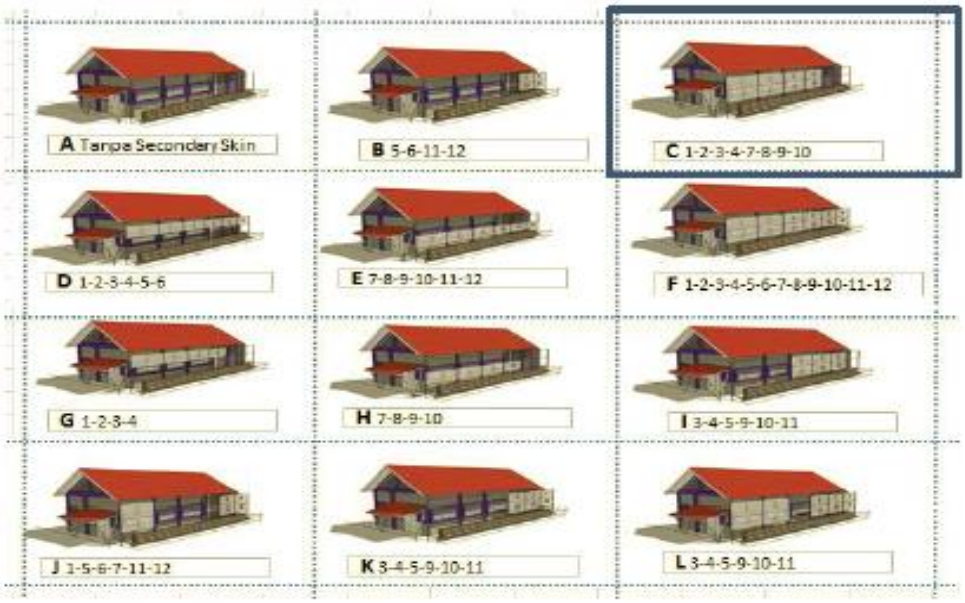

Figure 2. ***Alternative Secondary Skin Combination***

Figure 3A. ***Position and Layout of secondary skins on buildings***

By using Ecotect, we get an optimal combination of secondary skin layouts (Figure 3A)

Furthermore, thermal reducing engineering was made by using eco cooler as a secondary skin filling material, placement position and its combination based on the results of ecotect analysis. After engineering the secondary skin with eco cooler filling material, the environmental measuring variables will be compared again with the initial conditions before being given the secondary skin, namelyin the form of temperature, humidity, and wind speed.

In Figure 3B, a modular eco cooler is implemented on the heat-affected side of the building. Eco cooler is a series of plastic bottles cut in half and assembled in a grid pattern. The use of eco cooler as a secondary skin filling material is expected not only to protect the building from direct sunlight, but also to drain it (passive cooling strategies) and reduce air temperature. So this combination can reduce heat in the building.

Figure 3B. ***Implementation of plastic bottle waste as a building envelope***

RESULTS AND DISCUSSION

From the results of the study by comparing the initial conditions before and after being given a secondary skin. There is a decrease in temperature and humidity, as well as an increase in wind speed.

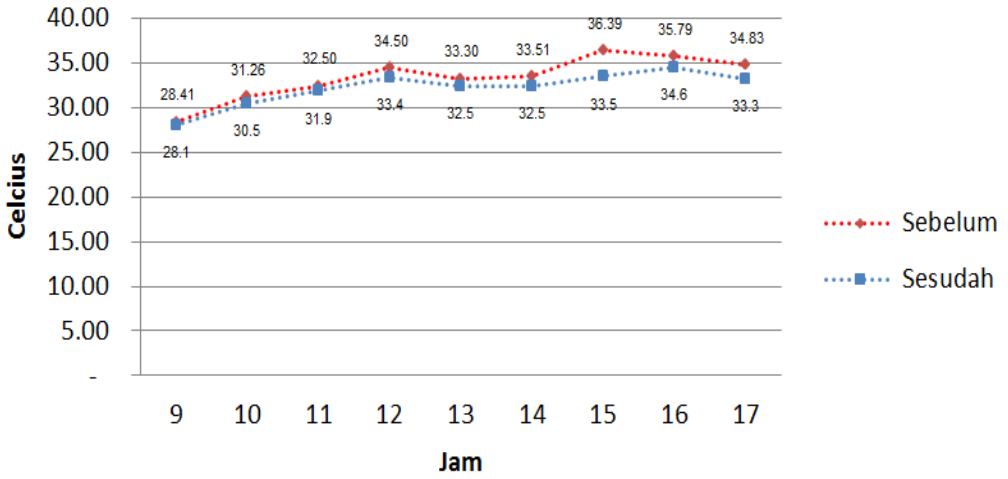

Figure 4. ***Average Surface Temperature of the Outer Wall***

Figure 4 shows that on the surface of the outer wall there is an average temperature decrease of 1.10C or 3.3%.

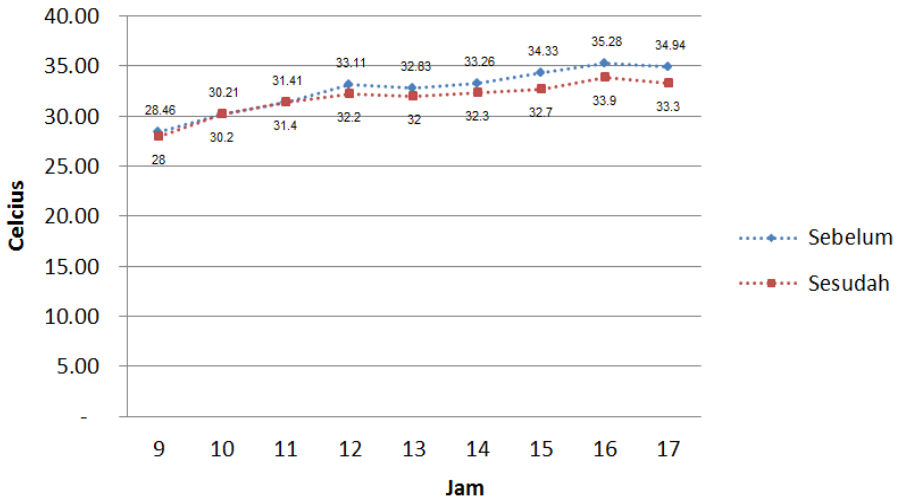

Figure 5. ***The Average Surface Temperature of the Inner Wall***

In Figure 5, the surface of the inner wall decreased by an average of 0.90C or about 2.6%

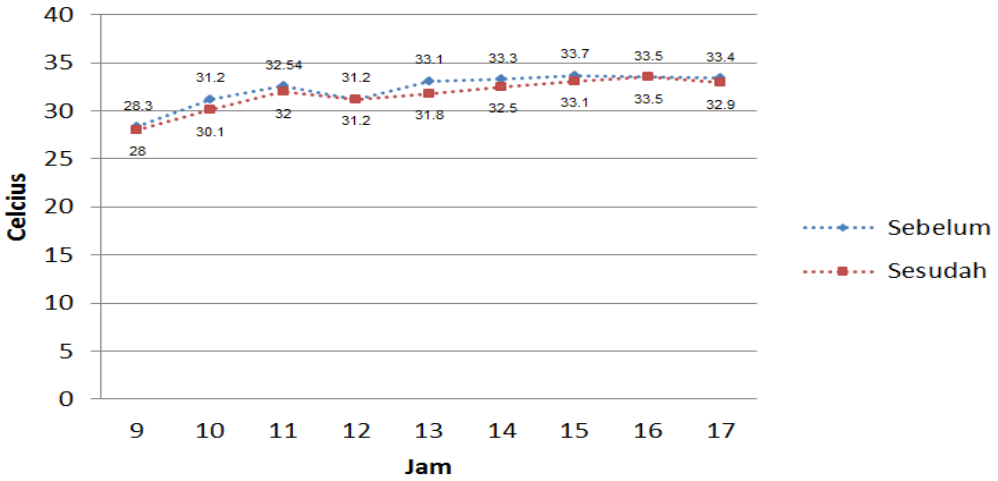

Figure 6 ***Average Surface Temperature of the Insider Wall***

Figure 6 shows a decrease in indoor air temperature, this is due to a decrease in the temperature of the building walls (outside and inside surfaces) due to shading, secondary skin using eco cooler material.

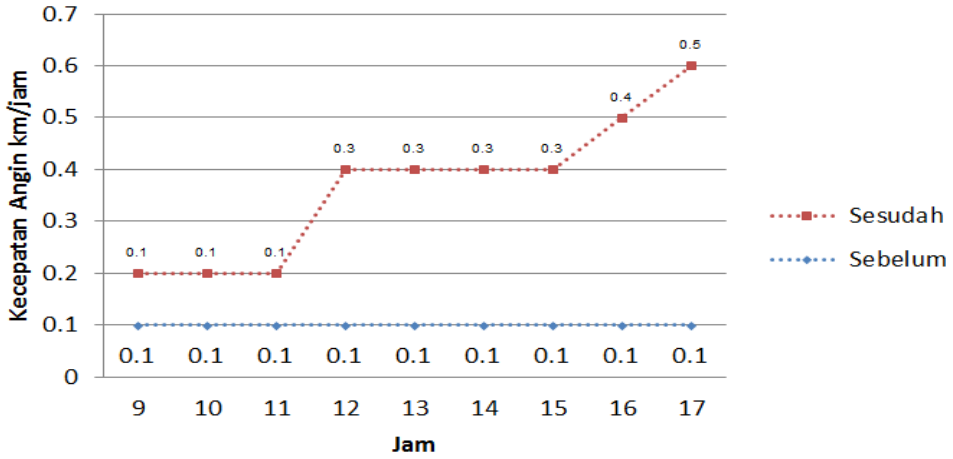

Figure 7 ***Average Wind Speed / Air Movement***

Figure 7 shows the average wind speed at the entrance to the building after the secondary skin tends to increase. This happens because the eco cooler gives acceleration to the wind speed. The wind comes at a certain time.

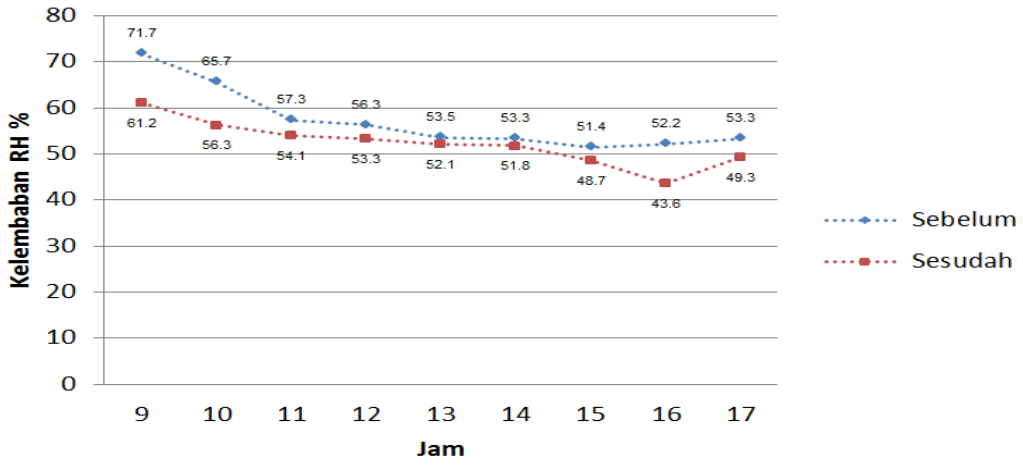

Figure 8 ***Average Humidity***

Figure 8 shows that the average humidity in the indoor space has decreased. The movement of air and the acceleration of its flow provide a boost to the existing humidity, so that the humidity slowly decreases.

CONCLUSION

Based on the results of calculations and analysis, conclusions can be drawn as follows :

1. Thermal reducing engineering in buildings can use eco cooler filling materials
2. The use of ecotect helps in finding the position of the heat source in the building.
3. Implementation of plastic bottle waste, eco cooler, in buildings reduces wall surface temperature, indoor space, humidity, and increases wind speed.
4. The use of eco coolers can be developed for the benefit of the wider community because in addition to being easy to make, it can also support the concept of energy saving.

References

[1] D. Iasillo, G. Application, U. Manager, P. Manunta, and P. Manager, "Urban Heat Island," vol. 1, no. 21913, pp. 1–176, 2011.
[2] M. Sebagian, P. Guna, M. Gelar, and S. Pendidikan, "Kajiankenyamanantermalruanggambarpaketkeahlianteknikgambarbangunansmknegeri 2 pengasihtugasakhirskripsi," 2015.
[3] M. M. S. Ahmed, A. K. Abel-rahman, A. H. H. Ali, M. Suzuki, and E. Resources, "Double Skin Façade : The state of art on Building Energy efficiency," *4th International Conference on Clean and Green Energy*, vol. 4, no. 1, 2015.
[4] F. H. Abanda and L. Byers, "An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling)," *Energy*, vol. 97, pp. 517–527, 2016.
[5] B. Talarosha, "MenciptakanKenyamanan Thermal DalamBangunan," *JurnalSIstemTeknikIndustri*, vol. 6, no. 3, pp. 148–158, 2005.
[6] Ansi/Ashrae, "ANSI/ASHRAE 55:2004 Thermal Environmental Conditions for Human Occupancy," *Ashrae*, vol. 2004, p. 30, 2004.
[7] G. F. Enric and P. Oscar, *International Handbooks of Quality-of-Life Handbook of Environmental Psychology and Quality of Life*.
[8] P. Cooling and O. F. Buildings, *No Title*.
[9] J. O. Waani, "Kenyamanantermalpadasebuahrumahadattradisionalgorontalo," vol. 11, no. 1, pp. 55–65, 2014.
[10] W. Choi, J. Joe, Y. Kwak, and J. H. Huh, "Operation and control strategies for multi-storey double skin facades during the heating season," *Energy and Buildings*, vol. 49, pp. 454–465, 2012.
[11] A. De Gracia, A. Castell, L. Navarro, E. Oró, and L. F. Cabeza, "Numerical modelling of ventilated facades: A review," *Renewable and Sustainable Energy Reviews*, vol. 22, pp. 539–549, 2013.
[12] Http://grey.com/apac, "Eco Cooler," 2016.