

Development of Paving Blocks to Reduce Environmental Heat by Using Mixed Materials

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1 Development of Paving Blocks to Reduce Environmental Heat by Using Mixed Materials

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Abstract: The increase in temperature and climate change of the earth caused by global warming which until now has become an important issue for the lives of humanity. This research aims to: utilization of paving block as heat reduction materials. This research uses quantitativemethods with a field survey, data analysis, and exploration laboratory studies of natural materials and waste. Based on the results of this research: the use of landscape hard materials, that's paving blocks as heat reduction by developing the composition of mixed materials in the manufacture of paving blocks. Obtain 2 (two) forms of paving blocks development material were rectangular and hexagon. Therefore the increase in ambient temperature can be reduced by the utilization of paving blocks using a mixture of basic materials (cement, sand, and water) and natural materials (grass and fibers) and recycled materials (sawdust and styrofoam).

Keywords: Increase in ambient temperature, Utilization of paving blocks, Mixed materials

I. INTRODUCTION

Overheating in the urban area is called urban heat island (Imran et al., 2019). The cause of urban heat island or increasing environmental heat in urban areas is excessive emissions, if the increase in the average temperature of the earth is not limited to 200C then the impact will be difficult to manage by humans and nature (Samidjo and Suharso 2017).

All forms of activities, changes, and consequences of rising environmental temperatures need to be carried out in an appropriate, measurable, and adaptive response, especially in urban areas (Sangkertadi dan Syafriny 2014). The increasing temperature of the environment continuously results in people's complaints about the increase in skin temperature on the surface of the human body (Dede, 2019), so that fulfillment of the thermal comfort aspects of outdoor space is very important (Sazali et al., 2017). The same thing was conveyed by

Munawaroh&Elbes, (2019) aspects of thermal comfort basically have become a part of human life in order to interact with their physical environment.

Research on the outer space in one of the trade areas of Manado City was carried out in connection with the great opportunity for the area to develop into an open and strategic area (Kindangen, 2016), which provides needs on a national and international scale, from the pattern and structure of the city, spatially the City of Manado functions as a city of services and strategic economic trade and as a culinary tourism area (Prijadi&Tarore, 2014).

Based on the phenomena of global warming, the increase in heat of the outer space/environment and the impact on the earth and all living things that exist, the research question can be broken down into: how can efforts to reduce environmental heat in the central trade area in the city of Manado?

The purpose of this study is to use paving blocks as heat reducing material. The benefits of this research are: (1) as an innovation and contribution of ideas/concepts for the development of architectural science specifically for the thermal comfort material of outdoor space and (2) so that urban communities, especially in humid tropics, can utilize the prototype paving blocking as environmental heat-reducing material.

II. METHODS

This research uses a quantitative approach, namely by taking and measuring data directly in the field, data processing, and exploration of natural materials and waste in the laboratory.

Data source

The primary data needed in this study are as follows: The level of solar thermal radiation taken directly at the point of collection, the characteristics of ground cover material; the characteristics of shade plants and the function of the area of the data collection area, the characteristics of natural materials and waste that will be used in exploring the development of paving block materials. Secondary data needed include: Manado City Daily Average Temperature Data, Manado City Daily Average Humidity Data, Material heat absorption rate (albedo) material, Heat standard data for the trade function designation area.

Research Instruments

The research instrument concerning the increase in heat (temperature) of the environment due to motor vehicle activity in Manado City is detailed as follows: Measurement and Observation Area (1) Parking Area of the Shoulder of the Mall: The air temperature in the parking area of the front of the Shoulder of the Mall is based on the processed data, the maximum average temperature of 36.10C. (2) Mall Rear Parking Area: The air temperature in the Mall rear parking area is based on the data processed, the maximum average temperature is 34.80C. Area along Jalan Pierre Tendean (in front of Manado Town Square). (3) The air temperature in the area along Jalan Pierre Tendean (in front of Manado Town Square 3) based on the results of the processed data, the maximum average temperature is 36.40C. Manado Town Square 3 Parking Area: The air temperature in the Manado Town Square 3 parking area is based on the data processed, with a maximum average temperature of 39.40C. Photographs were taken on the elements of the location where the data was collected such as: parking conditions, vehicle traffic, the presence of fences; trees or materials around the car

being measured, road cover material (asphalt, paving blocks), types and car colors. In addition, the photoshoot was also carried out while exploring the material for the development of paving blocks in the laboratory. Recording of data on the measurement of heat (temperature) of the environment is done to identify the heat of solar radiation; identify the surface temperature of the material and measure wind speed at the location of data collection.

Data Collection Tool

The tools used in this study consisted of 9 (nine) tools used from data collection and collection at the research location, shooting and recording data to data processing and exploration of natural materials and waste in the laboratory. Details of the tools used are in accordance with Table 1. The following:

Table 1. List of tools used

No	Parameter	Total	Tool Name
1	Ambient temperature	8	Digital Thermometer
2	Material Surface Temperature (solid)	4	Outdoor
3	Physical area of data collection location	4	Infrared Thermometer
4	Visual Documentation	4	Camera
5	Wind velocity	4	Anemometer
6	Record measurement and observation data	4	Office stationery
7	Anticipate rain and heat	4	Umbrella
8	Adjust the shape and size of the paving block (1 rectangular shape and 1 hexagon shape)	2	Molding
9	Compact material mix	1	Print Tool with Vibrator and Drop

and print paving blocks	Gravity System
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Research scheme

The principles of the research scheme are described as follows:

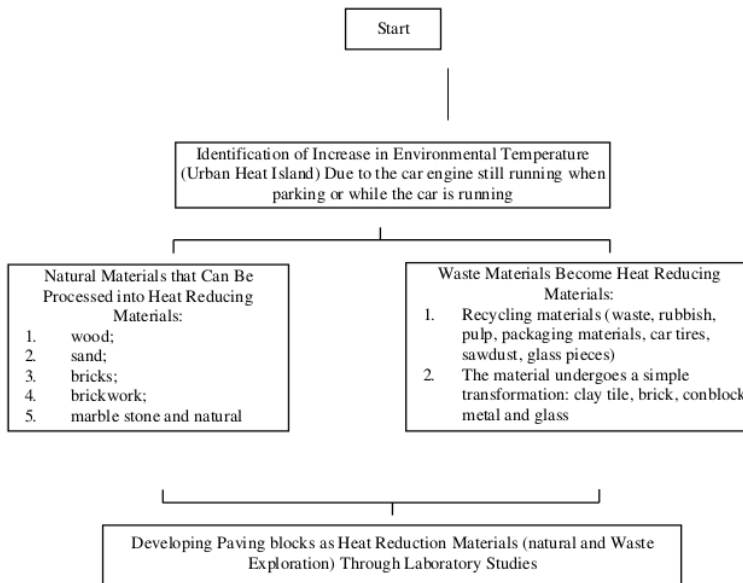


Figure 1. Research Scheme

III. RESULTS AND DISCUSSION

Recapitulation of data processing results for maximum air temperatures at the four points can be seen in Table 2 below:

Table 2. Recapitulation of Heat Rates

Average temperature (°C)	Research Location
36,1	Front Mall Shoulder Parking Area
34,8	Rear Shoulder Mall Parking Area
36,4	Along Pierre Tendean Street (in front of Manado Town Square 3)

39,4	Front Area Parking Area Manado Town Square 3
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Based on data processing at the four data collection points and combined with data on temperature and humidity in the city of Manado, both average and highest and lowest, it was found that an increase in environmental temperature between 50C to 100C. This is due to the number of cars and the dense car activity in the Mall shoulder area, along Jalan PiereTendean and the Manado Town Square 3 area as the center of the Manado City trade area.

The highest air temperature of the city of Manado occurred in August, which could reach 31.9 ° C, while the lowest temperature occurred in January, which was 26.6 ° C. The distribution of the highest and lowest temperature and humidity data in the city of Manado in 2018 is presented in Table 3. following:

Table 3. Average Temperature and Humidity

Month	Temperature (°C)	Humidity (%)
January	26.6	89.5
February	28.8	87.1
March	28.5	90.2
April	29.3	87.9
May	29.6	85.3
June	29.9	82.7
July	30.3	75.6
August	31.9	71.6
September	29.6	83

Research Findings

The need for the use of a material that can reduce heat, the material is a solid object that can reduce the level of heat available(Munir et al., 2018).Environmental architecture, especially sustainable architecture, contributes to the utilization of natural materials and processed materials from waste to be able to be developed into heat-reducing materials. In line with that, Mediastika inImran, Wuisang, & Rahmat (2019), sustainability and environment-friendly factors become the main factors for heat reducing materials. The strategy of utilizing natural materials as heat reducing in urban areas can be through several considerations as follows:

1. *Benchmarks* (land use or landscape), especially green open spaces, in urban areas, material to reduce heat can be in the form of city parks (Mulyandari, 2011),
2. Increase the types of plants and trees to reduce the quantity of solar radiation that falls to the earth's surface to the ground surface (Mediastika, 2013),

3. Reducing the form of soil pavement with reflective materials such as concrete; asphalt and metal, instead using a layer of soil with grass material, garden, brick, and so on (Sangkertadi dan Syafriny 2014).

According to Mediastika (2013), Indonesia is a tropical country that is rich in natural diversity, a variety of natural materials that can be processed into heat-reducing materials. Some natural materials include: (1) wood; (2) sand; (3) bricks; (4) concrete block; (5) marble and natural stone; (6) palm fiber and thatch. Meanwhile, according to Frick (2007), natural materials (natural stone, wood, bamboo and clay) do not contain substances that interfere with health, there are artificial materials that can function as heat-absorbing materials that are safe for health namely: (1) Material recycling: waste rubbish, pulp, packaging materials, car tires, sawdust, pieces of glass. (2) Experiencing simple transformations: red stone, tiled clay, brick, conblock, metal, glass, and cement. In line with that, the use of land and softmaterial in a landscape in the development of contextual concepts with nature is the main thing for the synergy of humans with the environment. (Srinaga et al., 2018).

Knowing the insulation value of a material is not enough to determine the energy performance of the material in storing a heat, it is because the entire surface area of the material is not completely filled with insulating material (Purwanto, 2019). Therefore, the natural material and the waste material will be explored the characteristics and original properties of the material by conducting laboratory studies to be able to produce a heat-reducing material mix, selected materials with relatively large heat absorption according to table 4 below:

Table 4. Heat Absorbance Numbers

Material	Surface Absorbance Numbers (α_w)
Thick concrete	0,91
Red brick	0,89
Bitumen sheet	0,88
Slate stone	0,87
Lightweight concrete	0,86
Asphalt trail	0,82
Smooth surface wood	0,78
Exposed concrete	0,61
White tile	0,58
Dark yellow brick	0,56
White roof	0,50
Aluminum paint	0,40
Gravel	0,29
White zinc	0,26

White glazed brick	0,25
Shiny aluminum sheet	0,12

source: Satwiko, 2008

Based on the characteristics of the material properties and heat absorption numbers that are owned by natural materials and waste materials, the natural materials and waste materials which are used as a mixture in the manufacture of paving blocks, namely: grass, fibers, sawdust, and styrofoam. The use of natural material ie wood sawdust in a mixture of cement and sand will be absorbed on the surface of mineral / concrete particles so that it will provide additional bonding strength between particles due to adhesion and dispersion properties, as well as inhibiting the diffusion of water in the material due to its hydrophobic nature(Saifuddin et al., 2013). In addition, natural materials that can be used as a mixture with concrete namely coconut fiber and coconut fiber can also be used as reinforcing concrete because coconut fiber and coconut fiber have a density of lighter than sand(Wahyudiet al., 2014). In line with that, sand and fibers as a mixture material also meet the standards of non-structural compressive strength or in other words construction, in addition to the use of natural fibers (sawdust, grass and or fibers) completely without combustion thereby reducing energy consumption and air pollution(Prastyatama & Maurina, 2018). Heat reducing material that also functions as a water provider, namely grassblock, is a type of paving block which is part of the landscape hard materials in the form of pavement and functions as a material for pedestrians, can be used in parking areas, parks and footpaths(Prasetyo et al., 2019).

After that, mixing the ingredients/materials as a dough in the manufacture of paving blocks as a heat reduction material development with the following steps:

1. Material Mixing Process

The composition of the mixture is grass 15%, palm fiber 15%, wood powder 15%, streform 15%, sand 15%, cement 20%, and water 5%. Mixing the mixture must be evenly distributed manually, it can be seen in Figure 11 below:



Figure 11. Material Mixing Process

2. Manual Paving Block Printing Equipment

The simplest paving block molding tool used manually is made of wood that adjusts the shape of the paving block, the mixed dough is put into the mold (molding) and then closed after being beaten to compress the dough, can be seen in Figure 12.



Figure 12. Molding Tool

3. Printing Process

The molding process is carried out on this dough in order to get the quality of paving blocks with optimum strength, as can be seen in Figure 13.



Figure 13. Printing Process

4. Printing Equipment with Vibrator and Drop Gravity System

In addition to manual printing equipment, this study also uses a vibrator and gravity drop printing machine which is a paving block molding machine with the principle of gravity and vibration. The mixture that has been mixed is put in molding and then compacted by the force of gravity and vibrations are carried out so that it is even and dense. Paving blocks are of high quality with a strength level of $\pm 160 \text{ kg / cm}^2 - 180 \text{ kg / cm}^2$.

5. Drying Process

After that, the next step is the drying process, just by placing it and arranged it in the Building Materials Technology and Physics Laboratory, Architecture Department, Faculty of Engineering, Sam Ratulangi University and Structural and Materials Laboratory, Civil Engineering Department, Bina Taruna STITEK, can be seen in Figure 14.



Figure 14. Drying Process

Produces 2 (two) types of heat reducing material mix products namely: Paving rectangular blocks have characteristics: More solid, Has a compressive strength of 14.94 MPa which is equivalent to 180 kg / cm², heat-reducing materials contained namely: grass, fibers, powder wood and styrofoam. This material is mixed evenly and compacted in each section evenly as thick as 6 cm (thick paving blocks) with a size of 21 cm x 10.5 cm x 6 cm, static shape, heat reduction rate ± 0.5 0C - 1.5 0C / square meter (as many as 44 pieces)

Hexagon paving blocks have the following characteristics: Solid; It has a compressive strength of 13.28 MPa which is equivalent to 160 kg / cm², the heat-reducing material contained namely: grass, fibers, sawdust, and styrofoam. This material is mixed evenly and compacted in each section evenly as thick as 6 cm (thick paving blocks) with a size of 21 cm x 21 cm x 6 cm, dynamic shape, and heat reduction level ± 0.5 0C - 1.8 0C / square meters (as many as 25 pieces).

IV. CONCLUSION

Based on the results of this study, it can be concluded that: (1) the maximum environmental temperature is in the Manado Town Square 3 parking area which is 39.4 0C due to the large number of motorized vehicles parked especially when the engine is running, various types of vehicle colors and types vehicle. In addition, there are no trees or shade in the parking area and the area which is directly adjacent to the PiereTendean shaft road, resulting in high average ambient temperatures. (2) the increase in environmental temperature can be reduced by the use of paving blocks as heat reducing material by using a mixture of materials such as sand, water, cement, grass, fibers, sawdust, and styrofoam. Development material obtained in 2 (two) forms, i.e. rectangular and hexagon (grass block), the placement of this prototype material in open space/border area effectively reduces the impact of global warming (urban heat island).

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