Analysis on The Thermal Comfort of Malioboro Street Yogyakarta Based On Malioboro Grand Design 2020

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Abstract

Malioboro is one of the main tourism destinations in Yogyakarta. The Local Government has defined that Malioboro area is a cultural heritage and a shopping street. Therefore, this area always crowded by people and vehicles. The area also lack of vegetation and the building material around in this area currently the material with low level albedo. This condition makes the Malioboro area thermally uncomfortable. To improve the visual and thermal quality in this area the local government launched Malioboro Grand Design 2020. This paper aims to analyze the differences thermal condition of Malioboro pedestrian ways before and after implementation of the Malioboro Grand Design 2020. The methods that are used in this research is on site observation to get the existing condition data in Malioboro area and simulation by using Ladybug Sunhour Analysis. After the simulation is done, it shows that the Malioboro area thermal condition become more comfortable before implementation of the Grand Design.

Keywords: Pedestrian ways; thermal comfort; PET; Ladybug

1. Introduction

Malioboro is a shopping street that lies from "Tugu Jogja" to "KM 0" in Yogyakarta. It is a tourism destination in the heart of the city which sells various kind of local goods and foods. Therefore, Malioboro is always crowded by people and vehicles. Currently, the buildings materials used in the area are mostly modern building material with low level of albedo. This condition greatly contributes to high temperature and high air humidity that leads to an uncomfortable thermal condition.

In 2016, in order to improve the visual and thermal quality of the area, the local government launched Malioboro Grand Design 2020 based on the result of a design competition organized by the government itself. The grand design was planned to be implemented gradually in three stages, during 2017-2018, 2019-2020 and 2021-2022.

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This study aims to analyze the thermal comfort in Malioboro street, especially in its pedestrian way based on the grand design. Thermal comfort is central to how people behave in the built environment and directly affects their sense of wellbeing and productivity (Hoof, 2010). Therefore, understanding thermal comfort in Malioboro's pedestrian way is important since the most popular way for tourist to take in the sight in this area is by walking on its pedestrian way.

1.1. Thermal Comfort in Pedestrian Ways

Pedestrian ways is a type of road or path meant to be used only by people who is travelling on foot, whether walking or running, or those who is using tiny wheels such as roller skates, wheelchair and skateboards. In general, the comfort in pedestrian ways is affected by circulation, accessibility, characteristics of nature and climate, safety, cleanliness, and beauty.

In the case of Malioboro's pedestrian way, as it is located in a tropical country that is surrounded by ocean, it has a hot and humid environment. The humid tropical elements that affect the thermal comfort in Malioboro pedestrian ways are solar radiation, air temperature, air humidity, air movement, and vegetation. Moreover, according to Akbar Rahman (2018), thermal comfort in pedestrian ways is also affected by pedestrian ways support facilities, such as:

- Ground cover on pedestrian ways. It can be made from hard materials such as paving, concrete, brick, stone, and asphalt or soft materials such as clay and grass. Planning ground cover depends on the function and type of pedestrian ways.
- Shelter. Whose function can be a place to rest, take the shelter from sunlight or rain, as well as for public transportation.
- Vegetation. Vegetation in pedestrian ways can serve as a barrier by road or parking. Barrier can also reduce noise, vehicle pollution and reduce solar heat radiation.

1.2. Physiological Equivalent Temperature (PET)

PET is a thermal index that gives a thermal component estimation of the given environment. PET is based on a thermo-physiological heat balance model called Munich Energy Balance Model for Individuals (MEMI). PET is applicable for indoor and outdoor environment study. PET is one of the recommended indices in German guidelines for urban and regional planners (VDI, 1998) and is used for assessing the thermal component of microclimate (Honjo, 2009).

PET is defined as the physiological equivalent temperature at any given place (outdoor or indoor) and is equivalent to the air temperature at which, in a typical indoor setting, the heat balance of the human body (work metabolism 80W of light activity, added to basic metabolism; heat resistance of clothing 0.9 clo) is maintained with core and skin temperatures equal to those under the conditions being assessed (Höppe, 1999). PET allows the evaluation of thermal condition in physiologically significant manner.

According to Matzarakis and Mayer (1996), range of PET for different grades of thermal perception by human beings and physiological stress on human beings; internal heat production: 80 W, heat transfer resistance of the clothing: 0.9 clo is:

Table 1. Range of PET

PET	Thermal Perception	Grade of Physiological Stress
	Very Cold	Extreme Cold Stress
4ºC		
	Cold	Strong Cold Stress
8 ºC		
	Cool	Moderate Cold Stress
13 ºC		
	Slightly Cool	Slight Cold Stress
18 ºC		
	Comfortable	No Thermal Stress
23 ºC		
29 ºC	Slightly Warm	Slight Heat Stress
	Warm	Moderate Heat Stress
35 ºC		
	Hot	Strong Heat Stress
41 ºC		
	Very Hot	Extreme Heat Stress

PET can be calculated with the radiant and bio climate model such as RayMan, Ladybug and Honeybee, which are suitable for the calculation of the radiation fluxes and thermal indices in easy or complex environment.

1.3. Malioboro Grand Design 2020

In Malioboro Grand Design 2020, the pedestrian ways design which is proposed is like in the fig.1.

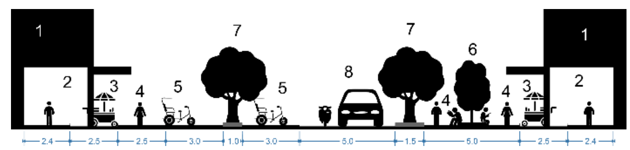

Fig.1. Pedestrian ways in Malioboro Grand Design 2020

Figure Legend:
1. Retail
2. Building corridor
3. Street vendor
4. Pedestrian way
5. Road for horse cart
6. Bench
7. Vegetation
8. Road

2. Methods

2.1. On Site Observation

On site observation is one of the research methods employed in this research. This methods was conducted to get site data such as site existing condition. The observation was conducted for two days on 16th and 23rd December 2018.

Table 1. Measurement Period and Instruments

Description	Explanation
Measurement Items	• Building height • Vegetation
Measurement Instruments	• Clinometer • Gauge
Measurement Period	• 16th December 2018 (09.00 am – 11.30 am) • 23rd December 2018 (09.00 am – 11.30 am)

From the observation, there were some differences on implementation of The Grand Design such as:

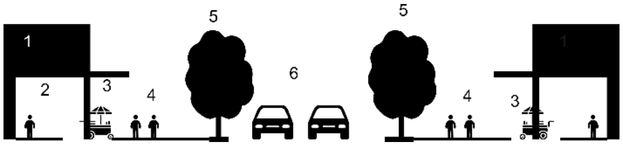

Fig.2. The Grand Design Implementation in Malioboro Street

Figure Legend:
1. Retail
2. Building corridor
3. Street vendor
4. Pedestrian way
5. Vegetation
6. Vehicle road

2.2. Model Simulation

The first step to do model simulation was making the 3D visualization. The 3D data was obtained from Open Street Maps, on site observation and Google Earth. The 3D map was made by using SketchUp application then, the map was imported to Rhinoceros.

In this research, the building and vegetation geometries were simplified. For the building geometry only the building mass (length, width and heights around 12 – 35 meters) was made without building corridor. And for vegetation only used one type of trees and the tree geometry diameter that is used is the mean of trees geometry (5 meters).

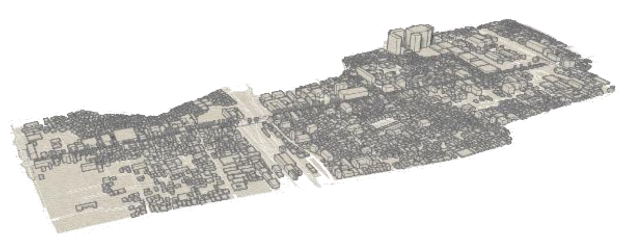

Fig.3. Malioboro Map Area

Model simulation was conducted to calculate the PET result by using environmental simulation plug in called Ladybug inside the Grasshopper plug in of Rhinoceros. Ladybug imports standard EnergyPlus Weather files (.epw) into Grasshopper and provides a variety of 3D interactive graphics to support decision-making process during the initial stages of design. This plugin enable a dynamic coupling between the flexible, component-based, visual programming interface of Grasshopper, and validated environmental data sets and simulation engines (Aksamija and Brown, 2018).

The simulation will test the baseline scenario of situation before and after the grand design be done with roads, pedestrian ways and vegetation in the area. The variables that were used are time span, sunpath, building heights, and color range for sunhours analysis diagram legend. To simulate the pedestrian ways, the map was divided into three area to avoid technical problem as follows:

1. Margo Utomo Street (showed in Fig.5)
2. Malioboro Street (showed in Fig.6)
3. Margo Mulyo Street (showed in Fig.7)

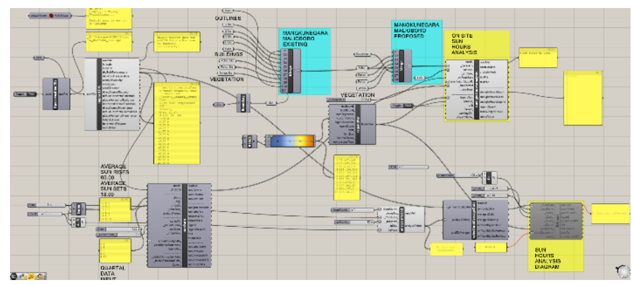

Fig.4. Grasshopper plugin Ladybug Sunhour Analysis platform illustration

The simulation calculated how long Malioboro area hit by sunrays in time variable. From Ladybug Sunhour Analysis obtained that the Malioboro area hit by sunrays for 58 hours which is shown by orange color.

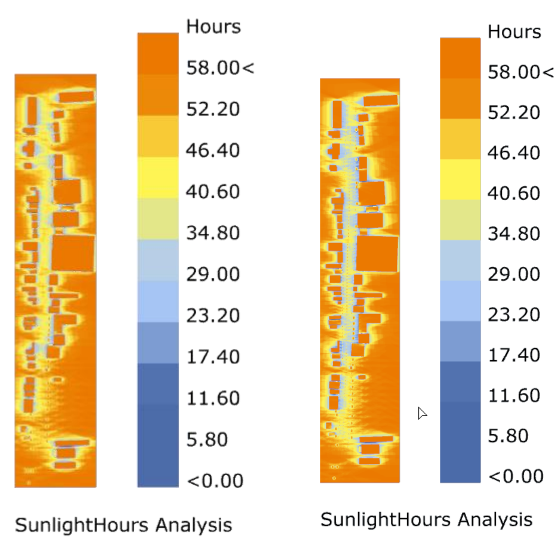

Fig.5. Margo Utomo Street before The Grand Design implementation (left) and after the implementation (right) simulation result

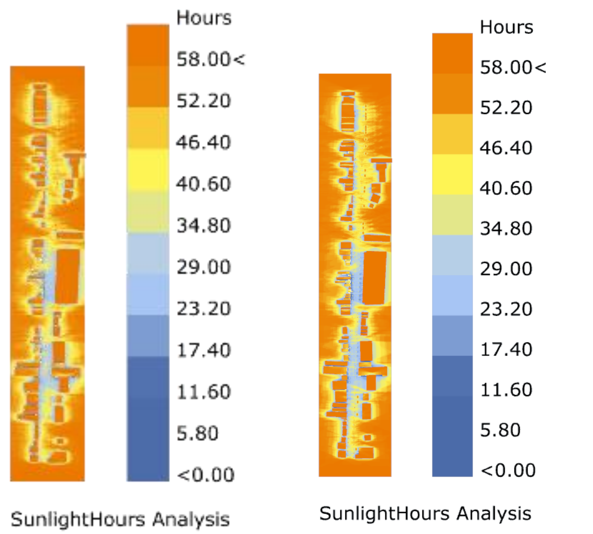

Fig.6. Malioboro street before (left) and after (right) The Grand Design implementation simulation result

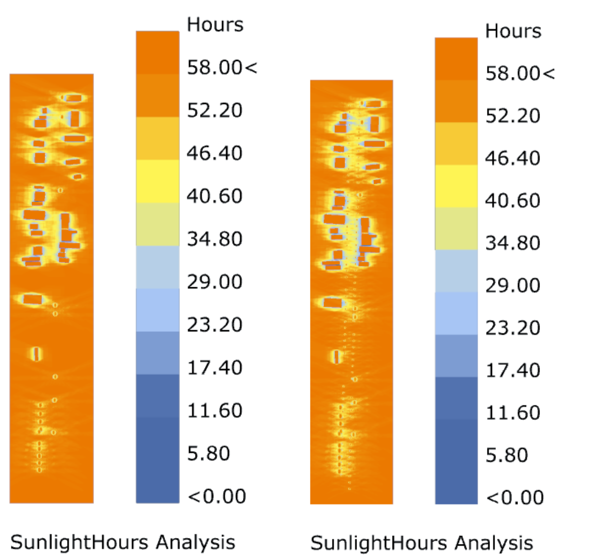

Fig.7. Margo Mulyo street before (left) and after (right) The Grand Design implementation simulation result

From The Ladybug Sunhour Analysis simulation result, showed the differences thermal condition before and after The Malioboro Grand Design 2020. Before The Grand Design has not implemented yet, the Malioboro area was lack of vegetation which makes the area thermally uncomfortable. This condition is showed by how many the orange color in the area. And after The Grand Design has already implemented, the blue color becomes more than before. It shows that the thermal condition in Malioboro area become more comfortable.

3. Conclusions

The simulation obtained the color range which shows how long the sunrays hit the surfaces in Malioboro area especially the pedestrian ways. The new vegetation which was applied in the area after the grand design implementation done affects the sunrays radiation duration. More vegetation was added, more comfortable the thermal condition.

And the width of pedestrian ways also affects the thermal condition in its area. Wider pedestrian ways led to larger surface area hit by sunrays. Consequently, more vegetation was needed.

4. References

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