Processing of sheath shape of the Fatmawati MRT station in South Jakarta using Parametric Method

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Abstract. This research aims to reduce solar radiation on elevated MRT station Fatmawati in South Jakarta. The method used is a parametric method using simulation software to determine the solar radiation and the Mean Radiant Temperature (MRT). Analysis building skin forms processing through exploration of shapes and use of building materials as a parameter. The result achieved is by using the data of the analysis results can produce skin shape building that can reduce the impact of solar radiation on the station building.

Keywords: Sheath, station, Parametric Method

1. Introduction
Indonesia is one of the five most populous countries in the world. Automatically, it is necessary to develop tools that support the productivity of its inhabitants. No exception in the field of transportation. Due to limited space, large cities in Jakarta are unable to meet the high demand for population movement only through the addition of roads and public transport with small capacity. The condition is getting worse with the emergence of vehicle emissions that can cause health problems and a decrease in environmental quality. The amount of time spent on the road can cause psychological impacts in the form of a decrease in emotional instability and an economic impact in the form of a decrease in the level of work productivity. Realizing that the arrangement of the city is not possible to add to the fleet on the dirt road, the government plans to build an MRT (Mass Rapid Transit) throughout Jakarta. The plan starts from Lebak Bulus and will continue to grow until it reaches the entire city. This development is expected to help the community and city development.

Jl. R. A Kartini, West Cilandak is one of the places that support the development of phase 1 (initial stage) of the MRT system in Jakarta which will divide and connect Jakarta from South to North. Jl. RA Kartini was chosen because at that point area there is a lot of offices, trade, and service areas, and there are hospital facilities namely Fatmawati Hospital so that a new transportation mode is needed to facilitate all activities in the area. Because of the limited vacant land in the area, the government decided to build an elevated station where the station would be on the road section. The station is planned to be built on a highway next to the Lingkar Luar Jakarta toll gate.

The MRT project on RA Kartini Road has entered the construction stage, at the stage of making the rail poles, but the construction of the station design has not yet been carried out. The construction of this station has a template from other MRT stations which will be built such as width and height of
platform size, railroad lane poles, as well as the use of concrete, steel, and metal materials which are common in the current station building.

The problem with the RA Kartini road is that the site on which the station will be built is very hot. Based on the temperature measurement of RA Kartini, the area around the Station building footprint during the day can reach the number of 40°C while the lowest temperature reaches 26°C. The condition around the site which is a toll road and also with very dense vehicle traffic, and many buildings with concrete materials, all pavement with waterproof material results in absorption of heat capacity and high heat conductivity. These conditions will cause urban heat island, namely the concentration of heat in urban areas, so the air temperature in urban areas is higher than the air temperature in rural areas.

The impact on the building is the potential for temperature rise that can disrupt daily activities at Fatmawati Station. An increase in temperature outdoors will automatically have a direct impact on the temperature inside the building. This temperature rise is caused by solar radiation exposure to the surface being absorbed and cannot be reflected by the surface due to the use of surface covering material as well as the influence of the shape of the building itself.

Based on the issue of Environmentally Sustainable, Healthy, and Livable Human Settlement, the problem of high temperatures on the MRT Station site on the RA Kartini road planned by the government, a solution is needed to reduce solar radiation that affects the temperature rise which can have an impact on the building of the station. In this case, the form of the sheath is one of the factors that can reduce the heat of the station. The veil itself serves as a cover for buildings which is also one of the factors that cause urban heat islands. The shape of the envelope and the use of materials that have a low u-value can be a solution to reduce solar radiation.

In designing the envelope of the station, an adequate method is needed that can be a solution for processing shapes that can reduce the impact of solar radiation on the station building directly and accurately. Therefore the writer will use the parametric method. The parametric method itself is a
method that can define relations using parameters. Parametric methods function to translate a non-parametric form into a parametric form by generating mathematical numbers using a computer. In this case, the design of the station building itself requires variable shape and material usage that will be a parameter in the design. The form of the envelope will be more easily explored through parametric methods due to the use of computerization in its planning. Through the parametric U-value, the material used can be measured so as to reduce the impact of radiation, while the sun’s radiation data can be measured and can be processed to produce effective shapes that also reduce the impact of heat on buildings. Based on the background problems on Jl. R. A Kartini caused by heat radiation that can cause urban heat island effects, the authors will use the Parametric method intended to produce a design of the sheath shape that can reduce heat radiation to the Fatmawati station building.

2. Literature review

2.1. Reducing solar radiation

Heat transfer is the process of heat transfer from the hotter object to the object that is less hot. There are three ways of propagating heat:

- Conductive heat propagation: heat transfer from a hotter object to a less hot object through contact (touch)
- Convective heat propagation: heat transfer from a hotter object to a less hot object through the flow of wind (or other flow substances)
- Radiative heat propagation: heat transfer from a hotter object to a less hot object by means of a beam.

![Visualization of solar radiation of buildings](image)

Along with the development of technology in the world of coatings, there are several ways to reduce heat absorption by materials (walls, roofs) and reduce heat in a room, including:

- Through the aspect of reflecting heat / infrared sunlight into buildings, using reflective pigment technology (reflecting pigments) on the coating material (coating) and paint.
- Through the aspect of insulation to prevent heat propagation, using advanced ceramic fillers (materials made from ceramic fillers).
- Through the waterproofing aspect to protect water damage.

2.2. Reduction through the roof angle

Flat roof surfaces 0° gets more solar radiation than the roof that has a slope. The slope of the roof affects the amount of radiation received by the building.
4th International Conference on Eco Engineering Development 2020
IOP Conf. Series: Earth and Environmental Science 794 (2021) 012235
doi:10.1088/1755-1315/794/1/012235

On the building envelope, the angle of the formation will affect the amount of radiation exposure to the building.

2.3. Problem formulation

- What is the shape of the sheath that can reduce the impact of solar radiation on the station building?
- How to apply the Parametric method that can improve the performance of the building envelope at Fatmawati Station?

2.4. Research purposes

The purpose of this research is to obtain a form of envelope that can reduce the impact of the sun on the station building.

3. Research methods

3.1. Research design

The method used in this research is qualitative and quantitative methods. Using qualitative methods because it needs to make observations directly to the site, do documentation and analyze sites that are there. Use quantitative methods to find out numerical data such as solar radiation data that have an impact on station buildings and surroundings.

3.2. Research paradigm

The research paradigm used in this study is paradigm positivism because in this study, the analysis process and proof of design theory, researchers must be directly involved with reality and analyze with a variety of methods or more than one viewpoint of the community about the problem to be able to get valid data. As this research applies, the positivism paradigm also applies where a hypothesis is tested with empirical data and simulation through software which is then implemented as a design.

3.3. Research Strategies

Quantitative research strategies include quasi-experimental and correlation studies and also research that only involves one subject in the research. The strategy that used in this study is experimental, the goal is to determine the effect of a treatment on research variables. This experiment was conducted through computer software, namely analysis Ecotech and Rhinoceros. Qualitative strategies for getting exact numbers.

3.4. Research methods

Data is a description of a situation or problem that is related to place and time, which is the basis of a plan and is a tool in decision making.

The stages of research to be carried out in the analysis of this report are:
• Data collection
  o Primary data - obtained through direct observation in the field. Primary data include:
    - Temperature measurement data.
  o Secondary data - data used as primary data support, namely:
    - Land Use Data from the government for the area under review.
    - Peak Hour data and number of station users.
    - Standard Station Area Calculation Data.
    - Station Building Technical Requirements Data.

• Data collection technique
  o Literature study, looking for data in studies of public transport stations, and terminals from articles, journals and books to strengthen the discussion of the final project in designing the Fatmawati Station project.
  o Field survey, direct observation, and temperature measurement at the location of the site and its surroundings, to obtain information.

3.5. Data analysis method
• Analysis is done using virtual computer software or models which are the latest development of CAD software that refers to parameters that exist in 3d objects (height, depth, thickness, and attributes such as material type and properties)
• Make a model using Grasshopper which is a plugin from Rhinoceros in making building envelope designs with parametric systems.
• With the help of Geco, which is a plugin from Grasshopper, models that have been made in Rhinoceros through Grasshopper can be connected directly to the analysis software, namely Autodesk Ecotect Analysis.
• Ecotect Software will then perform calculations in accordance with input climate data and building conditions to be able to display the results of heat input through the building envelope.

3.6. Hypothesis
If the sheath shape (independent variables) can be set according to the data of the sun and building materials, then the solar radiation received by the building will be reduced (the dependent variable).

3.7. Framework of thinking
In similar studies many quantitative methods are used as a methodology. Below is a study of data that forms the design of the envelope to be applied.
4. Results and discussion
Planning the processing of the building envelope is to reduce the urban heat island effect in RA Kartini street where if the sheath is redesigned will reduce the impact of solar radiation that radiates into buildings and prevent the impact of UHI in the area.

4.1. Sheath shape analysis
The following are the results of the Form analysis:
- Flat roof formations get more radiation than other forms.
• Arched roof formations receive less radiation than other roof formations because the uneven surface of the building makes certain parts not exposed to maximum sunlight.

• The sides of the Saddle roof have different solar radiation simulation results, proving that the angle and orientation of the sides affect the radiation that is exposed to the building. Based on these considerations, the sheath forms:

Curved form is applied to the building envelope, and given many sides so that there are many surfaces that are slightly touched by solar radiation.
Afternoon sun gives high heat radiation to the building. In the west the surface is made smaller so that it gets less radiation at the hottest time of the day, which is afternoon to evening on the building. This form is based on the structure of the building that will be used that is a wide span structure.

4.2. Form results analysis
Form that has been obtained, it will be analyzed again with ecotect software to determine the ratio of radiation received by the results of the formation with other forms that have been analyzed. The form to be analyzed is taken from the "results analysis" module (Figure 10).

![Figure 8. Forms results of form comparison (top)](image1)

![Figure 9. Forms results of form comparison (side)](image2)

![Figure 10. Notching modules](image3)
Based on Figure 11-14 above, the results of the latest form of solar radiation analysis, the side most exposed to solar radiation is up to 540Wh/m². But the spread of radiation that is exposed is not like in other clashes. In the formation of the analysis results, the shape of the curve obtained divided, and not evenly affected radiation.

![Figure 11. Formation results of comparison of shapes](image1)

![Figure 12. Top view of formation results](image2)

![Figure 13. Side view formed results](image3)

![Figure 14. Front view formed results](image4)

The conclusion from this analysis, the formation of the comparison results is better than the previous forms which were simulated to have a wider surface exposed to solar radiation. Form the results of the comparison, the curved surface is less exposed to radiation, the difference in the degree of surface affects the solar radiation.

4.3. Sheath uses parametric

Based on the results of the exploration form analysis that has been carried out (Figure 15-18), it obtained the shape of the Curved roof as the best form of reducing heat. With the form that has been explored, variables will be added to make the envelope better.
The picture above is the result of the addition of shape variables, by adding to the surface with angles based on the results of the comparison, after analysis, the radiation received by the casing is reduced. In the picture above the small side shows the part that is exposed to high radiation in the building, this part is the hottest part that is exposed to higher solar radiation. Parts will be applied material which has a higher reflection of sunlight. With the addition of the variable formation in the comparison sheath, then in the picture above there are many sides that are protected directly from solar radiation. On that side, an opening will be made as a circulation in the veil.

4.4. Sheath material analysis

A good material has a high emittance. Emissivity is determined by the surface of the material (or layer). The following is a list of materials and their magnitude.

| Material                        | Emissivity (ε) |
|--------------------------------|----------------|
| Aluminium alloy-oxidized       | 0.40           |
| Aluminium highly polished      | 0.04           |
| Aluminium-oxidized             | 0.11           |
| Aluminium-oxide sheath         | 0.88           |
| Brass-Chipified                | 0.60           |
| Brass-pickled                  | 0.03           |
| Chromium-pickled               | 0.10           |
| Copper-pickled                 | 0.02           |
| Copper-plated at 500°C         | 0.02           |
| Gold-pure highly polished      | 0.02           |
| Iron-pickled                   | 0.03           |
| Lead-oxidized                  | 0.44           |
| Metal-oxides                    | 0.65           |
| Iron-nickel steel plate        | 0.96           |
| Lead-gray and oxidized         | 0.39           |
| Copper                        | 0.09           |
| Mercury                        | 0.12           |
| Nickel-pickled                 | 0.37           |
| Nickel-oxidized                | 0.05           |
| Platinum-pure polished plate   | 0.05           |
| Platinum-nickel                | 0.05           |
| Silver-pure and polished       | 0.02           |
| Stainless steel polished       | 0.03           |
| Stainless steel polished       | 0.04           |
| Tin-bright                     | 0.07           |
| Titanium-aluminum              | 0.02           |
| Zinc-pickled commercial pure   | 0.09           |
| Zinc-oxidized sheet            | 0.31           |

| Material                        | Emissivity (ε) |
|--------------------------------|----------------|
| Aluminum                        | 0.10           |
| Aluminum alloy                  | 0.04           |
| Brass                            | 0.00           |
| Chromium                        | 0.00           |
| Copper                            | 0.00           |
| Molybdenum                        | 0.00           |
| Nickel                            | 0.00           |
| Silver                            | 0.00           |
| Lead                              | 0.00           |
| Iron                              | 0.00           |
| Copper                            | 0.00           |
| Nickel                            | 0.00           |
| Titanium                          | 0.00           |
| Zinc                               | 0.00           |

Based on some material specifications that have been described, metal is a material that has a large heat absorption. But there are some materials that have good emittance that can be applied to stations. The material to be used is Aluminium-Anodized sheet, in addition due to the level of emittance, it also due to weather resistance considerations. Aluminium metal has an advantage because it has no more shape constraints than other materials, so if this material is heat-suppressed using other materials, the advantage of not having this shape limit can be used to make the building envelope.
5. Conclusions and suggestions

5.1. Conclusion
The conclusion in this report is the concept of planning and design which is the result of the analysis in the previous chapter. Seeing the reality of the location condition of the government's plan to build the Fatmawati MRT station which is a type of elevated station, the conditions that exist at the site are very hot, there are UHIs on the RA Kartini road section. UHI can affect the temperature of the building so that it can affect the activities of the Station.

To reduce solar heat with the necessary research from various available sources, including being able to use building simulation applications to determine the best form and material. From the analysis carried out, we concluded:

- Flat surface, exposed to more radiation than the curve shape. Notching the shape of the curve can reduce the solar radiation of the flat formation with a certain angle.
- Building materials affect the capacity of heat absorbed in the building.
- By using the theory of sunlight reflection and applied to the form, will reduce solar radiation even better.
- Proof of Research Hypothesis if the shape of the envelope (the independent variable) can be adjusted according to solar data and building material, then the solar radiation received by the building will decrease (the dependent variable) is correct.

5.2. Suggestion
Based on research that has been done, then the writing can give some suggestions for the next research, namely:

- Architectural research that pays attention to aspects of form processing using parametric methods requires good skills in aspects of using supporting software
- Search for comparative studies on buildings that use the theory of defensible space is also still very minimal information so it is difficult to find a comparative study.

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