Wall Panel and Material for Tropical Area  
Case study: The city of Bandung, Indonesia

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ABSTRACT: The people usually use bricks and concrete blocks for their buildings. They leave bamboo and wood for some reasons such as social status and environment problems. This paper discusses some cases of the use of building material in tropical area, in particular its impact to the thermal environment. For that, we calculated the type and amount of building material in ten districts in Bandung, Indonesia. We also measured the air temperature in the districts from 07.00 to 17.00 every hour. Correlation analysis shows that heavyweight material such as brick and concrete block give bad influence to their thermal environment. In contrary, lightweight material such as metal panel and glass, give better influence to their thermal environment. This is because heavyweight materials have high value of heat capacity, so it absorbs and traps the heat from sun and increase the air temperature at day and nighttime. For that reason, we design a sandwich wall panel with low heat capacity and high thermal insulation that appropriate for tropical area. This material composed of bamboo and coconut fiber as the thermal insulation, covered by thin panel fiber concrete.

Keywords: Building material, urban thermal environment, tropical area

1. INTRODUCTION

Architects and planners could see their built environment as an environment of building material. The districts surface is an arrangement of many kind of building material such as concrete, asphalt, brick, metal sheet, glass, etc. The aims of this paper are to define influence of building material to its thermal environment and to create appropriate concepts of wall panel for tropical city. This paper also reports research on thermal environment, which is developed by building material. The thermal environment investigation was conducted by direct measurement of air temperature at ten districts in Bandung from 07.00 AM – 17.00 PM every hour. The ten districts were also got physical measurement to calculate the type and quantity of building material were used. The correlation between the two conditions was studied with statistical software.

Based on these studied results, we propose concepts of wall panel and material, which is appropriate for tropical city. The appropriate conditions refers to thermal environment that the utilization of the concepts will produce better thermal environment in tropical city.

2. THE POPULAR BUILDING-MATERIAL IN TROPICAL AREA

The most popular building materials in tropical cities like Bandung are brick, concrete block, glass, and metal sheet. Brick and concrete block are categorized as heavyweight-material while the others (glass, and metal sheet) as lightweight ones. They characterize the city surface as dry, hard and dark surfaces as could be seen at satellite RGB images shown in Figure 1.
As shown in this figure, the use of heavyweight materials is clearly showed at buildings facade on the city streetscape. This material dominate the city surface by its volume, area, and weight (Figure 2,) and usually used as wall panel, floor plate, and street covering. On the other hand, the lightweight materials such as glass is used as building opening like windows and façade, while metal sheet is usually used as light façade or roof cover.

In general, composition of the building materials depend on or taking into account the influences of the thermal environment of the districts. Figure 3 presents the composition of the use of building materials measured by its area and volume. We conclude that brick and concrete dominate the used of building material in the city, glass and metal sheet like aluminum composite, steel sheet, etc take the second position, while asphalt at the third.
3. STUDY OF THE USE OF BUILDING-MATERIAL ON THERMAL ENVIRONMENT EFFECT

In this research, we study the fact of building material used in Bandung and it influences to thermal environment. The mapping of quantity of building materials and air temperature are conducted by field measurement and extraction of satellite data images. Moreover, the numeric data was standardized and analyzed with statistical software as shown at figures 4,5,6.

The used of heavyweight building material such as brick and concrete show unique influence. A small quantity of heavyweight material in a district gives positive influence to the air temperature, while a big quantity of heavyweight building material gives negative influence (figure 4). We found that aspect of Heavyweight building material influences the air temperature in quadratic function (solid line). This means that there is optimum value for the use of heavyweight building material to reach the minimum air temperature.

Figure 3: Building material / m²
Case study: Bandung 2008

Figure 4: Effect of the use of heavyweight building material to the average air temperature

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It has been commonly known that generally the heavyweight building material has high thermal capacity. It means that they can absorb and release a big amount of heat. Depend on the thermal environment of the district, the temperature of the heavyweight material could be lower or higher than the air temperature. If the material temperature is lower than the air temperature, it gives positive influence. On the other hand, if the material temperature is higher than air temperature, it gives negative influence. We note, however, that this condition is only possible if the heavyweight materials are placed in different condition. For example, the cool heavyweight material should be positioned at North-South faced of the building, and the hot material should be positioned at East-West direction or in the position of horizontal such as floor, pedestrian way, or street. This phenomenon should be analyzed by taking into account the building orientation (See figure 5).

The significant influence of the building orientation to the air temperature is shown in Figure 5 as a linear function. This plot shows that if the average of building orientation (east west / north south) in two districts is differ one, then the air temperature will differ 0.53 °C. This analysis complements the previous analysis of relationship between heavyweight materials with air temperature (figure 4). It explains that the position and direction of building material is very important to the thermal environment. The heavyweight building material at east west wall collect the heat, trap and release it to increase the air temperature. As a consequence, the east west wall has higher temperature than the air temperature as well. In contrary, the north south wall do not gain solar radiation, so the material temperature is lower than the air temperature. However, this material can absorb heat from the air, and so the air temperature is decreased.

![Figure 5: Ratio of building orientation and its effects to daily air temperature](image)

The other analysis is relationship between street areas with the air temperature (figure 6). The street area gives very significant influence to air temperature although the quantity of asphalt in the city relatively small if it is compared to other heavyweight material. The street area increases the air temperature linearly; it is means that asphalt has higher heat capacity than brick and concrete.
4. DESIGN CONCEPTS FOR WALL PANEL IN TROPICAL AREA

The tropical city needs an appropriate concept of heat balance of thermal environment. Buildings with heavyweight material in this area absorb and trap heat and make the environment hotter.

Based on the building material and orientation analysis, the tropical areas need an appropriate wall panel for east west wall of buildings. The concept consists of several points, such as:

1. The east-west wall material should be low in heat capacity and high in thermal insulation. Low heat capacity wall panel allows a little amount of heat absorption, while high thermal insulation allows a little amount of heat transferred through the material.

2. The east-west wall material should have good direct reflection or screening solar radiation to reduce direct heat gain.

By the concept of east-west wall material, we evaluate the recent wall material and proposed several conceptual designs of the east-west wall-panel. The recent wall systems are categorized in concept of frame and block, which is shown in Figure 7.
The quantity analysis of heavyweight building material is extremely popular then the lightweight ones. The block system use their density and weight to against external and internal forces such as wind and dead load. The block system is popular for single and low-rise building due to economic consideration, and social status. The people believe that this material could produces indoor thermal comfort. The new release of block system takes hollow concept in the design. The hollow block use lower quantity of heavy material such as clay and concrete to save the energy for air conditioning.

The frame system used thin or lightweight panel such as glass and metal sheet for walls. The lightweight panel does not need strong structure due to its weight. In order to reduce the energy consumption, the glass technology offers several concepts of reflection and absorption of heat or light.

Based on the results of this research, in this paper we propose a sandwich wall-panel, which consist of low heat capacity, high thermal insulation, and high reflective surface (figure 8).

![Conceptual design of east-west sandwich wall panel](image)

**Figure 8:** Conceptual design of east-west sandwich wall panel

The sandwich wall-panel conducts three mechanisms of heat transfer, namely
1. reflective surface to against the direct solar radiation.
2. wall shaft to conduct convective cooling
3. thermal insulation to avoid heat transfer through the material

5. CONCLUSIONS

Building material design in tropical area plays important rule in thermal environment. An inappropriate using of building material will reduce the quality of environment and raise another negative implication such as higher energy consumption. From this building material and thermal environment studies we conclude that

1. Heavyweight building material is inappropriate for east west wall of buildings due to its high heat capacity that could change the outdoor thermal environment.
2. Lightweight building material such as glass and metal sheet are also inappropriate for east-west wall of building due to its heat transmission through the material and increase the indoor air temperature.
3. East-west wall of buildings need special design concept that differ with north-south wall material due to the nature of sun path in the tropics.
4. Sandwich wall panel with low heat capacity, high thermal insulation and high reflective surface could be fit for east-west wall due to the tropical extreme heating condition.

Architects must take responsibility to the quality of thermal environment through their design. The wide scheme of design put the building material design into its concepts and consideration.

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Google Map


