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# Microclimate effect toward indoor and outdoor temperature of Villa Isola UPI

**Beta Paramita[1], Titim Fatimah Zahro[1]**
[1]Department of Architectural Education, Universitas Pendidikan Indonesia, Indonesia

**Abstract.** Villa Isola is one of the heritage buildings with art deco relic of the Dutch East Indies, now became the rectorate of Universitas Pendidikan Indonesia (UPI). The building was built in October 1932 – March 1933 and changes its function into office in 1954. The changes of the spatial structure from 4 floors into five floors to meet the needs of space, it also changed the interior with a segmented room. Measurement of the globe temperature (Tg); air temperature (Ta) and the surface temperature (Ts) were performed at a point indoor and outdoor with a 15 minutes interval. The phenomenon of heat temperature difference (ΔTs) at 0.50°C indoor, meanwhile the outdoor ΔTs = 2.2°C. This paper then, will give a description of Villa Isola, its temperature alteration both indoor and outdoor.

**Keywords:** microclimate, Isola Bumi Siliwangi, indoor and outdoor temperature

## 1. Introduction

A microclimate is a local atmospheric local zone where the climate differs from the surrounding area. Microclimates can be influenced by urban building configuration and can differ considerably to the local meteorological data that is usually measured for that region. Urban microclimate consists of local variations of the wind, humidity, solar radiation, and temperature, as a result of many factors.

Indonesia University of Education (UPI) occupied 61.5ha has made this university as the largest educational facilities in Bandung. Located in 6.861°S 107.594°E with altitude 920asl and annual average temperature of Bandung is 25.6 °C. Villa Isola is one of the heritage building in UPI and the construction was only within six months from October 1932 – March 1933. It was considered fast at that time, this complex having two large gardens and covered an area about 12ha. The use of the building itself as a Villa was only in short time. After Baretty, the owner died, this building was transformed into the hotel then in 1942 became Japanese army's headquarters. The renovation has added one floor after Indonesian independence, and this building was named "Bumi Siliwangi." Finally, on October 1954 this building designated for used to be pedagogical institute in Bandung (Indonesian: IKIP Bandung). Since then Villa Isola remarked as the headmastership office and campus' landmark.

The study about microclimate in UPI has been done in a botanical garden that composed of 150 species of plant which has implication to support the life of creature [1]. On the previous research has

revealed that mean radiant temperature (Tmrt) of UPI was higher than settlement area at Taman Sari and industrial area in Cigondewah. Later, this research also provides the diurnal temperature of Northern Bandung city, which show the higher air temperature in the afternoon compare in the morning [2]. This phenomenon has occurred in Bandung within this 20years, and the trend of average air temperature increase at about 0.8℃. The weather data of Bandung from a satellite on October 2015 as shown at figure 1 describes that air temperature at 6am (Ta = 24°C) increase dramatically into 28°C at 9 am. Temperature kept increasing until reached peak hour at 12 am, about 34°C. After peak hour, Ta declined to the lowest 24°C at 9 pm (same value at 6 am), but one hour later (10 pm) it increased to 27°C. This evidence gives the understanding that geographical location less significant on the formation of microclimate. Meanwhile, microclimate influenced by form and layout of the building and surrounding surface conditions.

The study of surface temperature and microclimate in open space has been conducted in The University of California, Berkeley Campus. The material of open space with asphalts, concretes, brick pavers, and lawns. The study said that there is no significant difference at a surface temperature of the material, but Ta (air temperature) has a correlation with surface temperature [3].

The study also has conducted in five sites with different urban geometry, ground cover, and above sea level in Colombo city, Sri Lanka. The study found that the three elements effected on thermal comfort [4].

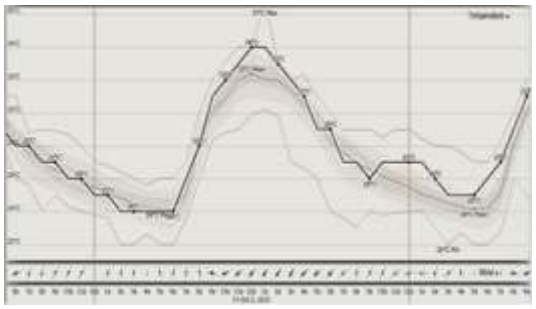

**Figure 1**. Satellite Data of Bandung Temperature
(source: weatherspark.com)

## 2. Study area

| | |
|---|---|
| Address | : Jl. Setiabudi No. 229 Kelurahan Isola, Kecamatan Sukasari, Bandung. |
| Geographical location | : 6° 51’ 40” LS (latitude), 107° 35’ 40” BT (longitude) |
| Altitude | : 920 mdpl |
| Architect | : Charles Prosper Wolff Schoemaker |
| Relic | : Art Deco |
| Construction | : October 1932 – March 1933 |
| Land area | : ± 1 ha |
| Ground floor area | : 373 m2 |
| Number of floors | : from 4 floors (1932) turned into 5 floors (1954) |

**Figure 2**. Villa Isola in the UPI's complex

## 3. Measurement method

The measurement held on Friday, October 2nd, 2015, by using two temperature devices within 7.20am – 5.50 pm. Espec thermo recorder used to measure Ta (air temperature) and Tg (globe temperature) with 15 minutes interval. And IR thermometer used to measure the floor surface temperature.

Indoor and outdoor temperature measured by putting Espec thermo recorder at two places. The first device put in the lobby (point A) and the second device in Plaza (point B) as shown in figure 3. Meanwhile, surface temperature measured by using IR thermometer. The step is by directing the device to the floor surface and recorded the numbers that appeared on the device every 15 minutes.

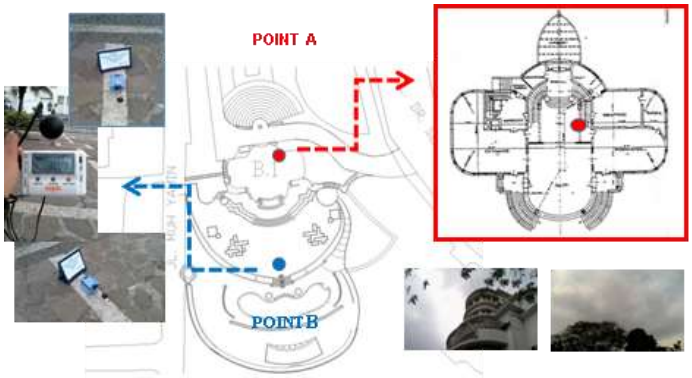


**Figure 3.** Measurement Spot

## 4. Measurement results

The air temperature (Ta), globe temperature (Tg), and surface temperature (Ts) in indoor and outdoor of Isola building as shown in Figure 4 and Figure 5 below.

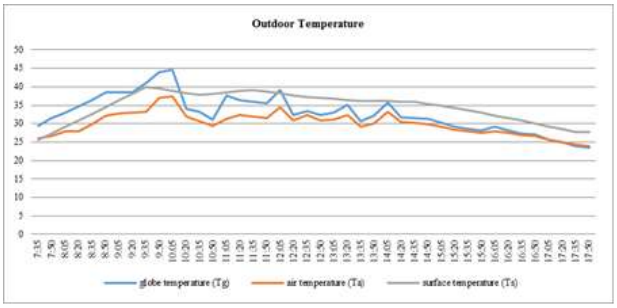


**Figure 4.** Outdoor temperature

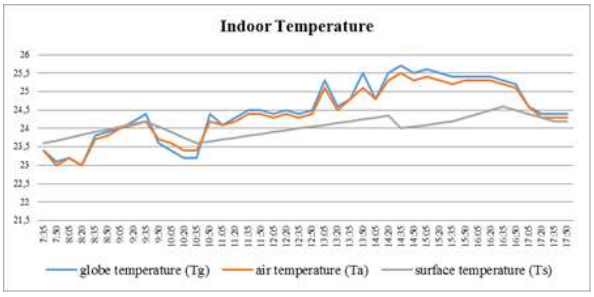


**Figure 5.** Indoor temperature

The graphic above (Figure 4) indicated that every 15 minutes temperature air (Ta) increased and increased among 0.7-5.4°C. Ta reached the highest temperature (37,4°C) at 10.05 am. Tg shown the differences in temperature between 0.4-10.4°C. Highest Tg also happened at 10.05 am, 44.5°C. Meanwhile ΔTs = 0.2-7.4°C. After reached the highest temperature, both Ta and Tg declined drastically. Ta declined from 37.4°C to 32°C (declined 5.4°C), Tg declined from 44.5°C to 34.1°C (declined 10.4°C); meanwhile, Ts increased from 32.6°C to 40°C (increased 7.4°C).

The different measurement result is shown in Figure 5. Ta indoor changed constantly in the range 23-25°C (ΔTa = 2°C). During peak hour, both Ta and Tg declined at 9.20 – 10.35 am but slowly increased at 2.35 pm. The highest Ta = 25.4°C and Tg = 25.7°C. After reached the highest temperature, Ta, and Tg slowly declined but there's an anomaly, afternoon temperature are higher than daytime.

## 5. Discussions

The temperature difference of indoor and outdoor of Villa Isola affected by some factors:

### *5.1. The layout of building mass*

Isola has building orientation 8° to the Northeast. Front façade of Isola located on the north side, and there is a park named Baretty park. The rear facade has the same axis with the main gate of UPI now. Isola layout as seen on Figure 6: North side is Baretty Park, south side is plaza, park and botanical garden, and the southeast side is guardian house and bank.

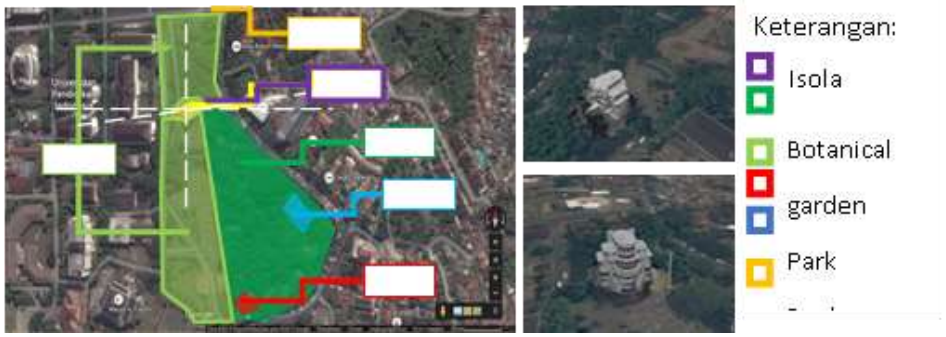


**Figure 6.** Urban Form and Layout of ISOLA's complex

### *5.2. Type and number of window*

The building orientation (slope = 8°) caused the wind to keep moving in the building. At UPI area, the wind blows from the southeast and northwest. Isola building has the number of windows in the south and north side, so the wind could blows across in the building. Moving air/wind can be seen in the picture below at figure 7.

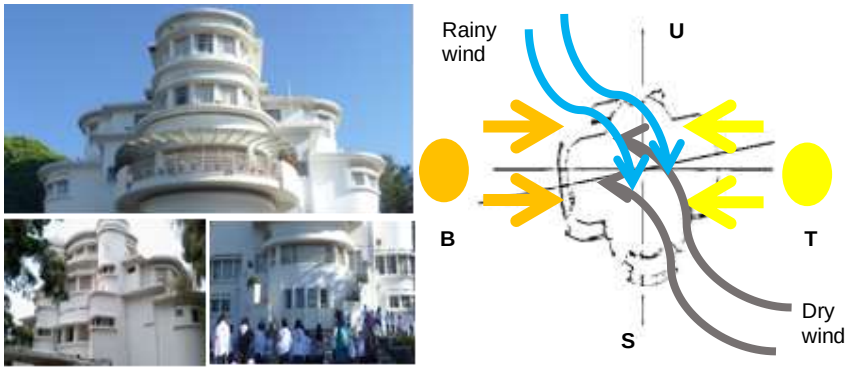


**Figure 7.** number of window in Isola and its wind circulation

*5.3. Surface albedo*

Albedo is the Latin language which means whiteness. The reflection of surface material from incident sunlight is called Albedo value. Solar radiation that is not reflected by surface material will be absorbed. This will surely lead to an increase in surface temperature. Thus, the absorbed energy raises the surface temperature including the heat exchange within the outdoor and indoor material [5]. The whole Villa Isola is surfaced with white color, which means its albedo = 1. The highest albedo value able to reflect 100% of solar radiation and significantly influence into surface temperature. The combination between hardcover and softcover in Villa Isola gives the benefit for its microclimate. The botanical garden which located in the southeast area helps the solar radiation absorption by the varied vegetation. The open space in surrounding Isola is covered by natural stone material, even the concrete as well as asphalt to cover the pavement. This hardcover is absorbing the heat and keep it within a certain time. The stored heat then flowed to the air when the surrounding air is cooler, in the afternoon until night (characteristic of heat movement is moving from heater material into the cooler material). The characteristic of coverage in Isola is shown in figure 8.

**Figure. 8** Isola's coverage : hardcover and softcover

In the northern area, this villa also equipped with the park, which is also called the Villa Isola's owner, Baretty Park. The park's placement strongly considers the local microclimate. Based on the measurement of five public housing in Bandung, geographically, the Northern region is an area exposed to radiation for a long duration of time [6]. The pool in this park able to give humidity value to reduce solar radiation

*5.4. Building envelope and facade*

Building envelope and façade play the most important part of heat transfer. It is proven that the use of lighter surface color and thermal mass can dramatically reduce maximum indoor temperatures [7]. Heat transfer on building material which stated as u-value used to measure how effective elements of a building's fabric as an insulator. It means that how effective this material able to prevent the heat from

transmitting between the inside and the outside of a building. [8] Isola building envelope and façade as seen in figure 9 which its construction using the Dutch method which is double brick. This thermal mass somehow has a large u-value, which requires extra energy to achieve indoor thermal comfort. On the other hand, in line with the experiments already undertaken by Givoni, who found that buildings are continuously ventilated thermal mass can be lowered in the indoor maximum temperatures [9]. The benefit of art deco building style of Villa Isola with shading device for each orientation and their windows give the benefit of solar radiation reduction. The similar phenomenon in Singapore for building façade design with window to wall ratio to > 0.24 can largely improve indoor thermal comfort by increasing indoor air velocity [10].

**Figure. 9** Building Envelope and Façade
(Left: north facade, right: south facade)

## 6. Conclusion

The different characteristic of outdoor and indoor temperature in Villa Isola has shown that urban surface; building form and massing significantly create the microclimate. The characteristic of outdoor temperatures such as air temperature (Ta), globe temperature (Tg) and surface temperature (Ts) have shown the similar phenomenon, that the value is rising in the morning and reached the peak temperature at 10.05 and decrease slowly after that. It shows that solar radiation in Isola's urban environment Meanwhile the opposite happen in the indoor temperature, the characteristic of the graphic of Ta, Tg and Ts increase until 9.20 but then decline until 10.35 and increase again until the afternoon. This characteristic gives the understanding that the heat trapped through material and release when the solar radiation decline. Building envelope and façade then proved able to reduce the maximum temperature between indoor and outdoor more than 10°C.

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