A Field Measurement of Thermal Comfort in Semi Outdoor Space in Hot-Humid Climate

A S Munawaro1, E Damayanti1, dan Y A Prasetyo1
Universitas Bandar Lampung

Abstract. Thermal comfort is still important in measuring the quality of a place. Many studies have been conducted to measure thermal comfort. In addition, other studies found that thermal comfort has improved user productivities. The last study resulted that thermal comfort in semi-outdoor space in the hot, humid climate, which case study was Canteen of Universitas Bandar Lampung (UBL) have not meet the human comfort standard based on user perception. Although this canteen is a semi-outdoor space, most of the users were feeling hot when fans were not using it. This paper aims to show a present study based on field measurement in that place. The measurement is carried out by thermometer, hygrometer, and anemometer. The thermometer used to measure temperature, hygrometer used to measure humidity, and anemometer used to measure air velocity. Field measurement was done in September and done every hour during work times in five days. The analysis method was done by using https://comfort.cbe.berkeley.edu/ to calculate Sensational, Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD). JMP statistics software is used to show the trend of PMV, PPD, and Sensational based on the calculation result. This study showed thermal sensation in Outdoor was nearly neutral, thermal sensation in Semi Outdoor D was nearest to slightly warm, at the same time it was also closer to neutral than other Semi Outdoor spots. In conclusion, thermal sensation in Semi Outdoor without a wall was accepted than in Semi Outdoor with a wall. If the manager wants to improve thermal comfort at that place, they must add fans as mechanical ventilation in Semi Outdoor A, B, and C. But, if they do not want to use that, they must renovate the place by omitting the wall.

Keywords: thermal comfort; field measurement; semi-outdoor space; hot-humid climate

1. Introduction
Thermal comfort is still important in measuring the quality of a place. Many studies have been conducted to measure thermal comfort. The study found that there was an influence on outdoor thermal comfort and air quality in frontal area density [1]. Another study resulted in
the relation of thermal comfort and its occupants [2]. Thermal performance metric is used to evaluate the process of design scenarios. The study resulted in the impact of geometrical features on neighborhoods at two levels [3]. Similarly, a holistic scenario of thermal comfort done in a low-income apartment is used by diverse climatic categories and related factors [4].

Thermal and air investigated in Japanese schools to find its impact to academic performance. The research resulted that examination scores decreased when temperature and air supply were low. However, the score was not changed when the temperature was high [5]. Another study was conducted by measuring blood flow and blood pressure. This study found that in high temperature, blood pressure was decreased. In contrast, stroke volume, heart rate, arterial blood flow rate and skin blood flow rate were increased [6].

A study of thermal comfort in outdoor (square) and semi-outdoor (under the piloti) was conducted in Taiwan. This study found that the acceptance rate of the thermal environment in the square was nearly a half of under the piloti and the temperature of the square was 9° C higher than under the piloti [7].

A study in Malaysia resulted that thermal comfort can be achieved by the application of passive cooling even though that was limited just for rural residents. While for urban residents, another way needed such improving microclimate strategies. This study also stated that natural ventilation was not sufficient to achieve thermal comfort [8]. Another study in Saudi Arabia found that thermal comfort can be achieved by using building envelope thermal insulation [9].

The study of thermal comfort in Columbia found that the important role on thermal sensation was the temperature, solar radiation and wind speed. Thermal preferences correlated in wind speed and solar radiation. While Relative Humidity (RH) was no a significant factor. Furthermore, the perception was quite influenced by climatic conditions [10]. Thermal comfort in hot humid climate was studied. The measurement was conducted in 24 bedrooms. This study found that the occupants accepted thermal conditions. In addition, occupant’s perception of Indoor Air Quality (IAQ) was quite correlated to thermal comfort perception Sekhar & Goh, 2011). Another study in commercial buildings in hot humid climates resulted that for assess thermal comfort is important to choose appropriate methods [11].

A field measurement was conducted in classrooms in Makasar, Indonesia to find out students’ thermal comfort sensation. This study resulted in the students of secondary school were tolerant of hot temperatures even though they wanted lower temperatures if they have a chance. Most of the students did not feel the airflow and they wanted the higher airflow if they have a chance to. While a few students complained about the air humidity [12].

The study of thermal comfort in outdoor campus in Malaysia resulted that there was a number of differences in perceptions significantly between local and international students. This study confirmed that the physiological adaptation and the climatic condition were quite strong influences on the thermal sensation. This study also showed that local students were higher tolerance to the thermal environment than international students [13]. The study of outdoor thermal comfort in a hot humid climate resulted that the important role in achieving outdoor thermal comfort was microclimate. This study also found that the building facing
the west-east was the highest relative humidity (RH) and the building that facing North-South was the lowest air temperature. In addition, the building that square shape was the highest air velocity [14].

The latest study resulted that thermal comfort in semi-outdoor space in a hot humid climate which case study was Canteen of Universitas Bandar Lampung (UBL) have not meet the human comfort standard based on user perception. Although this canteen is semi outdoor space, most of the users were feeling hot when fans were not using [15]. This paper aims to show a present study based on field measurement on that place.

2. Method

2.1 Data Collection
A field measurement carried out using thermometer, hygrometer and anemometer (Table 1). Thermometer used to measure temperature, hygrometer used to measure humidity, and anemometer used to measure air velocity Field measurement was done in September 2020 and every hour during work times form 8.00 AM to 04.00 in a week (Table 2). The place of measurement was Canteen of Universitas Bandar Lampung, Lampung Province Indonesia and the coordinate was 5°27' S, and 105° 16' E. The place of measurement was Outdoor and Semi Outdoor. In semi outdoor there are four measurement spots, namely Semi Outdoor A, Semi Outdoor B, Semi Outdoor C and Semi Outdoor D (Figure 1).

The material used in the canteen floor used ceramics, the walls were used brick and the roof was used asbestos without a ceiling. While on the semi-outdoor D roof used polycarbonate roof. The outdoor measurement location was in the middle in front of the canteen. Around the measurement location there were only a few shrubs and trees. The floor of the outdoor measuring spot was made of paving blocks and there was no roof to cover it at all.

Semi Outdoor A was the far right of the canteen. At the front of the measuring spot there was a wall as high as 0.6 m and on the right side, and the full wall in the back and half of the front. There was also no opening at all. Semi Outdoor B and C were in the middle of the Canteen. At the front of this spots there was a wall 0.6 m high and a full wall at the back.
The surrounding of Semi Outdoor D does not have any walls. There was only a roof using a polycarbonate roof.
Figure 1. The measurement place. (a). Spot of measurement; (b). Front view of measurement place; (c) The atmosphere of a measurement place
Figure 2. The atmosphere of the field measurement spots. (a). Semi Outdoor A; (b). Semi Outdoor B; (c). Semi Outdoor C; (d) Semi Outdoor D

Table 1. Accuracy, range and measurement frequency

| Measurement tools       | Accuracy | Range            | Measurement Frequency |
|-------------------------|----------|------------------|-----------------------|
| Hygrometer and thermom  | T: ±1°C  | T: -50°C-70°C    | 1 h                   |
| eter                      | RH: ±5%  | RH: 10%-99%      |                       |
| Anemometer               | ±0.1 m/s | 0 m/s-30 m/s     | 1 h                   |

Source: Author, 2020

Table 2. Data collection
| Spot       | Date        | Time               | Measurement                                      |
|------------|-------------|--------------------|-------------------------------------------------|
| Outdoor    | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |
| Semi       | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |
| Outdoor A  | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |
| Outdoor B  | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |
| Outdoor C  | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |
| Semi       | 21 – 25 September 2020 | 08.00 AM – 04.00 PM | Temperature, Relative Humidity and Air Velocity |

Source: Author, 2020

2.2 Data Analysis
PMV is an index that predicts the mean value of the thermal sensation votes (self-reported perceptions) of a large group of persons. The scale is -3 to +3 [16]. Predicted Percentage of Dissatisfied (PPD): an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people determined from PMV [16]. Thermal sensation: a conscious subjective expression of an occupant’s thermal perception of the environment, commonly expressed using the categories “cold,” “cool,” “slightly cool,” “neutral,” “slightly warm,” “warm,” and “hot” [16].

The CBE Thermal Comfort Tool at https://comfort.cbe.berkeley.edu/ is visualization thermal comfort indices. The tool updates the chart dynamically and the calculated thermal comfort indices [18].

In this paper, CBE Thermal Comfort Tool use to calculate the PMV, PPD, and Sensation based on ASHRAE 55-2017. The data from field measurement such as operative temperature, airspeed, the humidity was input. The selected activity, namely the most activity carried out at the measurement site is sitting. In addition the cloth chosen was a cloth that was generally used by users of the measurement place. JMP statistics software was used to show the trend of PMV, PPD and Sensational during the measurement.
3. Findings and Discussion

3.1 Air Temperature

Figure 5 shows the air temperatures that were measured in the Outdoor, Semi Outdoor A, Semi Outdoor B, Semi Outdoor C and Semi Outdoor D at the height of 1.0 m above the floor during the five-day measurement period. The outdoor conditions in this figure represent the values that were measured in front of the Canteen. The location of Outdoor spot was surrounded by man-made surfaces such as paving blocks and asphalt roads. The environment around the measurement site also did not have many plants. There are only a few shrubs and on the cross of the road there are several trees (Figure 1).

The result of temperature measurement at 08.00 AM in five days was between 27°C and 30°C. Mostly the temperature in Semi Outdoor A and B was lower than in Outdoor. While in Semi Outdoor C and D were higher than the Outdoor. But there was one spot that has a completely different temperature from other spots. On 25 September 2020 in Semi Outdoor A, the temperature reached almost 32°C. The temperature at 09.00 AM in five days measurement was between 28°C and 30°C. The Outdoor temperature was higher than Semi Outdoor. Semi Outdoor B was the lowest than other spots on 25 September 2020. The temperature in Semi Outdoor A was under 28°C.

In five days of measurement, the temperature of Semi Outdoor A, B, C and D at 10.00 AM was lower than Outdoor. The Semi Outdoor B, C and D temperature was similar. But, the temperature of Semi Outdoor A was slightly different from the other spots. The temperature in Semi Outdoor A was the lowest during the measurement days. The temperature at 11.00 AM in Semi Outdoor A, B, C and D was between 28°C and 32°C. Generally, all spots were lower than Outdoor temperature even though Semi Outdoor B was highest than Outdoor. On 25 September 2020 the temperature of Semi Outdoor B was almost reached 33°C. The temperature differences were one degree above the Outdoor and two
degrees than the other Semi Outdoor spots. On the other hand, Semi Outdoor A was the lowest temperature than other spots.

The measurement at 12.00 PM in all spots was similar. The Outdoor and Semi Outdoor temperature was under 35°C. The lowest temperature was Semi Outdoor A. While Semi Outdoor spots B was the highest temperature in the five days measurement. The Semi Outdoor temperature in five days at 01.00 PM was lower than the Outdoor. The Range of temperature was above 28°C and under 35°C. But, on 23 September 2010 the temperature was above 35°C. On the other hand, Semi Outdoor B was the lowest temperature on 25 September 2020 and was the highest temperature on 24 September 2020.

The temperature of Semi Outdoor A, B, and D was quite lower than Outdoor temperature. However, the temperature of Semi Outdoor B and C was higher than Outdoor on 22 September 2020. In contrast, Semi Outdoor B temperature was the lowest at 02.00 PM during the measurement. Generally, Outdoor temperature at 03.00 PM was higher than Semi Outdoor. But, on 22 September 2020 the temperature of the Outdoor was lower than Semi Outdoor C and D. The lowest temperature was in Semi Outdoor A, and the highest was in Semi Outdoor D. Temperature of Semi Outdoor A was highest during the measurement period. In addition Semi Outdoor A was also the lowest temperature on 25 September 2020. Semi Outdoor B and C temperatures were higher than Outdoor on 24 and 25 September 2020. Overall, the other spots were lower than Outdoor.
The temperature differences between outdoor and indoor were less than 1 °C in Semi Outdoor A. Whereas in semi Outdoor D was less than 0.3 °C (Figure 6). This has different from research had conducted in China, where the temperature difference between outdoor and semi-outdoor was 9 °C [7]. The temperature difference was not quite big, possibly due to the material used in the semi-outdoor area. The roof used was asbestos and polycarbonate. This results in no reduction or reflection made by the material to sunlight. Semi Outdoor temperature D was almost the same as the outdoor temperature. Semi Outdoor D faces north and south, while Semi Outdoor A, B and C face west. These results are the same as those found in previous studies, where buildings facing north and south have a lower temperature than those facing west and east. [14].

3.2 Air Velocity

Air velocity at 08.00 AM was different among the measurement times (Figure 7). In the Outdoor the air velocity about 0.1 to 0.9 m/s. While, air velocity in semi Outdoor for some
days was steady at 0 m/s. Although in two days, air velocity in Semi Outdoor A, C and D were above 0.6 m/s. At 09.00 AM air velocity in Outdoor was steady for five days. The air velocity was 0-1 m/s. In contrast, in Semi Outdoor A, B, C and D the air velocity were stacked in 0m/s. Air velocity at 10.00 AM in Outdoor was above 0 m/s and in five days. But, in Semi Outdoor A, B and C the air velocity was steady at 0 m/s. On the other hand, the air velocity in Semi Outdoor C and D was quite varied. Similarly, at 11.00 AM air velocity in Outdoor. In Semi Outdoor A and B, air velocity was still 0 m/s. In contrast, air velocity in Semi Outdoor C and D was about 0 m/s and above 1 m/s. The air velocity in Semi Outdoor C and D was highest at 12.00 PM. But, from 01.00 PM to 04.00 PM the air velocity of Outdoor was the highest. Overall, air velocity in Outdoor was the highest during five days measurement. Then, Semi Outdoor C and the lowest was Semi Outdoor A and B.

The difference between air velocity outdoor and in semi-outdoors was between 0.20 - 0.80 m/s (Figure 8). In Semi Outdoor D the difference was the lowest. This was because in Semi Outdoor D there were no walls at all, so that the wind can pass through the place very easily. On the other hand, in semi-outdoor A, air velocity is very different from outdoor. It was because on the back, sides and front of this place there was a full wall to the top.
3.3 Relative Humidity

Figure 9. Relative Humidity Differences

Figure 10 Relative Humidity Differences Between Outdoor and Semi Outdoor

Relative Humidity (RH) at 08.00 AM to 10.00 AM tended to similar. Only in Outdoor at 10.00 AM, the RH was quite different than others. At 11.00 AM and 01.00 PM RH was varied and back to similar at 12.00 PM, 02.00 PM to 04.00 PM. The Relative humidity in all spots was between 50% and 80%. But, there were two spots that under 60% i.e. Semi Outdoor A, B and C, on 23 September 2020 at 02.00 PM and 03.00 PM also one spot under 40% i.e. Outdoor spot on 24 September 2020 at 10.00 AM.

Figure 10 shows the difference in relative humidity between Outdoor and Semi Outdoor ranges from 0.5-2.5%. Relative humidity in Semi Outdoor A is the most different from
Outdoor. Whereas in Semi Outdoor C, the relative humidity is smaller than Outdoor. This is probably because Semi Outdoor C is close to the toilet, where the toilet door is always open. So that the cold effect of the toilet spreads to Semi Outdoor C.

3.4 Predicted Mean Vote (PMV)

Figure 12 shows PMV at 08.00 AM in five days was quite varied based on ASHRAE 55 2017. These resulted by calculated PMV using https://comfort.cbe.berkeley.edu/. Generally, the PMV in Outdoor was lower than Semi Outdoor. But, three spots PMV that higher than Outdoor were Semi Outdoor A and B on 21 September 2020 and Semi Outdoor C on 23 September 2020. On the other hand, PMV in Semi Outdoor A was the highest on 25 September 2020.

In five days measurement, PMV of Outdoor at 09.00 was lower than Semi Outdoor. PMV of Semi Outdoor B on 25 September 2020 was difference significantly from other Semi Outdoor. While PMV of Semi Outdoor A, B and C were different with Outdoor. PMV of Semi Outdoor D was steady during the day’s measurement. PMV of Semi Outdoor A, B and C at 10.00 was higher than Outdoor. Expect PMV of Semi Outdoor C on 22 September 2020 was lower than others. In contrast, PMV of Semi Outdoor D was lower than Outdoor all day of measurement.

The Outdoor PMV at 11.00 PM was lower than the Semi Outdoor except in Semi Outdoor B on 25 September 2020. The PMV in Semi Outdoor C on 22 September 2020 was totally different from other Semi Outdoor. Similarly, the differences occurred on 25 September 2020.

The PMV of Outdoor and Semi Outdoor at 12.00 PM was similarly in September 2020. In contrast, on 22, 23, 24 and 25 September 2020 the PMV was quite fluctuating. On 22 September 2020 tended to decrease even though Semi Outdoor D was increased. On 25 September 2020 the PMV in Semi Outdoor B was highest.

The Outdoor PMV was higher than Semi Outdoor A on 23 and 25 September 2020. But, generally the PMV of Outdoor was lower than Semi Outdoor, except in Semi Outdoor C on 22 September 2020. In Semi Outdoor D the PMV was almost the same for four days measurement (22-25 September 2020). While on the first day of measurement, it was quite different. But it was still above the Outdoor PMV.

The difference in PMV between Outdoor and Semi Outdoor is between 0.1-0.4. Semi Outdoor A was a place that has the most different PMV value from Outdoor. Meanwhile, PMV which was closed to the PMV Outdoor value is semi Outdoor D.
Figure 11. Predicted Mean Vote (PMV) (a) Outdoor and Semi Outdoor; (b) Distribution; (c) Differences
3.5 Predicted Percentage Dissatisfied (PPD)

![Figure 12](image1.png)

Figure 12. Predicted Percentage Dissatisfied (PPD) Differences

Figure 13 and 14 shows the Predicted Percentage Dissatisfied (PPD) in Semi Outdoor A was the highest and in Outdoor was the lowest. PPD was the opposite of PMV. It was confirmed that the result of the analysis was related to standard [16].

![Figure 13](image2.png)

Figure 13. Predicted Percentage Dissatisfied (PPD) Distribution
3.6 Thermal Sensation

Based on the analysis as a whole used by JMP statistic software, the thermal sensation of Outdoor is the nearest to slightly warm and neutral. Then, Semi Outdoor D was near to slightly warm and Semi Outdoor A was nearest to hot. Semi Outdoor B and C were nearest to warm. This statistic confirmed the latest study found thermal comfort based on user’s perception that they were felt hot when fans were not working [15].

![Thermal Sensation using JMP Analysis](image)

**Figure 14.** Thermal Sensation using JMP Analysis

4. Conclusion

This paper shows the data of temperature, air velocity and relative humidity collected in five days. The field measurement was done by using a thermometer, hygrometer and anemometer. The measurement was conducted every hour at Outdoor, Semi Outdoor A, B, C and D.

The result showed in some measurements that were differences of temperature, relative humidity and air velocity between Outdoor and Semi Outdoor. The temperature of Semi Outdoor in some measurements resulted higher than Outdoor. In addition, relative humidity in Semi Outdoor also was higher than Outdoor. In contrast, air velocity in Semi Outdoor was lower than in Outdoor.

The PMV in Semi Outdoor A was the highest in a negative meaning. Then, Semi Outdoor B and C were under the PMV of Semi Outdoor A. In contrast, PMV of Outdoor and Semi Outdoor B was the lowest. Whereas PPD was opposite of PMV, PPD Semi Outdoor A was
the lowest followed by PPD Semi Outdoor B and C. Then PPD in Outdoor and Semi Outdoor D was highest.

The thermal sensation that nearly neutral was Outdoor. Although thermal sensation in Semi Outdoor D was nearest to slightly warm, it was also closer to neutral than other Semi Outdoor spots. It was because in Semi Outdoor D there was no wall. Thermal sensation in Semi Outdoor A was near slightly warm and hot. Semi Outdoor A has a wall on three sides i.e. in the back, left and a half in the front. So, it led to no air velocity and trapped high temperature. While, Semi Outdoor B and C were nearly warm. In Semi Outdoor C and D, there was the only wall on the back. Finally, we can conclude that thermal sensation in Semi Outdoor without a wall was accepted than in Semi Outdoor with a wall. It was mean, if the manager of that place wants to improve thermal comfort, they must add fans as mechanical ventilation in Semi Outdoor A, B and C. But, if they do not want to use that, they must renovate the place by omitting wall.

This study conducted in five days in September 2020 and confirmed that field measurement and the last research about thermal perception in this place [15] was the same meaning. The advantage of this research is that September was the peak of summer. But, this research also has limited. We did not record the global temperature. Further research is needed by adding the globe temperature to know the effect of radiation.

References

[1] Z. Li, H. Zhang, C. Wen, A. Yang, and Y. Juan, “Effects of frontal area density on outdoor thermal comfort and air quality,” Build. Environ., vol. 180, no. March, pp. 1–16, 2020.
[2] M. K. Senin and M. A. O. Mydin, “Significance of Thermal Comfort in Buildings and Its Relation to the Building Occupants,” Eur. J. Technol. Des., vol. 1, no. 1, pp. 54–63, 2013.
[3] R. Aghamolaei, M. Mehdì, and B. Aminzadeh, “Urban Climate A tempo-spatial modelling framework to assess outdoor thermal comfort of complex urban neighbourhoods,” Urban Clim., vol. 33, no. March, pp. 1–16, 2020.
[4] S. Banerjee and S. Chattopadhyay, “Urban Climate A meta-analytical review of outdoor thermal comfort research: Applications, gaps and a framework to assess low-income settlements in Indian megacities,” Urban Clim., vol. 33, no. March, pp. 1–18, 2020.
[5] T. Goto and K. Ito, “Thermal/air environment effects on academic performance of late-teen students,” J. Environmental Eng., vol. 75, no. September, pp. 767–777, 2010.
[6] T. Goto, T. Hayase, and K. Funamoto, “Measurements of blood flow and blood pressure under different indoor temperature and body postural conditions, and development of a new human simulation model,” in Healthy Building Europe, 2015, vol. 2015, no. May, pp. 1–8.
[7] Z. Zhou, H. Chen, Q. Deng, and A. Mochida, “A Field Study of Thermal Comfort in Outdoor and Semi-outdoor Environments in a Humid Subtropical Climate City,” J.
Asian Archit. Build. Eng., vol. 12, no. 1, pp. 73–79, 2013.

[8] Z. Zain, M. N. Taib, S. Mohd, and S. Baki, “Hot and humid climate: prospect for thermal comfort in residential building,” vol. 209, pp. 261–268, 2007.

[9] M. S. Al-homoud, A. A. Abdou, and I. M. Budaawi, “Assessment of monitored energy use and thermal comfort conditions in mosques in hot-humid climates,” Energy Build., vol. 41, pp. 607–614, 2009.

[10] K. Villadiego and M. A. Velay-dabat, “Outdoor thermal comfort in a hot and humid climate of Colombia: A field study in Barranquilla,” vol. 75, pp. 142–152, 2014.

[11] R. Forgiarini and E. Ghisi, “What is the most adequate method to assess thermal comfort in hybrid commercial buildings located in hot-humid summer climate?,” Renew. Sustain. Energy Rev., vol. 29, pp. 449–462, 2014.

[12] B. Hamzah, R. Mulyadi, and S. Amin, “Analisis Kenyamanan Termal Ruang Kelas Sekolah Dasar di Kota Makassar,” IPLBI, no. 1, pp. 1–6, 2016.

[13] N. Makaremi, E. Salleh, M. Z. Jaafar, and A. Ghaffarianhoseini, “Thermal comfort conditions of shaded outdoor spaces in hot and humid climate of Malaysia,” Build. Environ., vol. 48, pp. 7–14, 2012.

[14] B. Paramita, H. Fukuda, R. P. K. Khidmat, and A. Matzarakis, “Building Configuration of Low-Cost Apartments in,” no. May, 2019.

[15] E. Damayanti, A. S. Munawaroh, T. S. Surjana, and D. Hartabela, “Thermal Comfort in Semi-outdoor Space in Lampung Indonesia (Case study: Canteen of University Og),” in International Conference and Workshop “Less is Moody – REboot the City,” 2020, pp. 391–396.

[16] ASHRAE, Thermal Environmental Conditions for Human Occupancy, vol. 2017. America, 2017.

[17] A. P. Gagge, A. P. Fobelets, and L. G. Berglund, “A Standard Predictive Index of Human Response to The Thermal Environment,” ASHRAE Trans., vol. 2, no. 1, 1986.

[18] F. Tartarini, S. Schiavon, T. Cheung, and T. Hoyt, “SoftwareX CBE Thermal Comfort Tool: Online tool for thermal comfort calculations and visualizations,” SoftwareX, vol. 12, no. 2020, pp. 1–5, 2020.

Acknowledgement

The authors thank to Universitas Bandar Lampung that was funded to this research. This work was also supported by the Ministry of Research and Technology/ National Research and Innovation Agency of Republic Indonesia. Simulasi Kinerja Bangunan dalam Proses Studio Desain Grant numbers 458/UN40.D/PT/2020 under LPPM Universitas Pendidikan Indonesia.