

This result is relevant to the thermal comfort finding in Wonosobo stating that cold regions have different thermal comforts than hot areas [21], [22]. The comfort zone in the residential houses is quite low, ranging from 27.93°C to 21.63°C which is different from that at the office or college buildings which are ranging from 22.2°C to 29.0°C. Due to the low temperature, the respondents who participate in the research conducted at the residential houses in Wonosobo feel more comfortable than at the office or college buildings in Jakarta or Bandung.

The difference between the Humphreys' neutral temperature prediction (21.9°C) and the result obtained from the field study on neutral temperature (24.47°C) is 2.57°C. Meanwhile, the difference between the result obtained from the field study on neutral temperature and that of the Auliciems' (22.94°C) is 1.53°C.

There is no significant difference between PMV prediction (0.057) and AMV value (-0.06), which is equal to only 0.117. However, the results of PMV show that the average occupants of residential houses are predicted to feel neutral to slightly warm while those of AMV show that they feel indifferent to cold. These findings are following those of the previous studies assuming that PMV is less feasible to predict the naturally ventilated buildings [23][24].

IV. CONCLUSION

Comfort temperature for the traditional residential houses located in the mountainous tropical areas is 24.47°C T_a or 24.14°C T_g or 24.17°C T_o or 25.08°C T_{ET} or 24.69°C T_{SET} . The comfort zone is ranging between 21.85°C – 27.11°C T_a or 21.63°C– 26.65°C T_g or 21.65°C – 26.68°C T_o or 22.22°C – 27.93°C T_{ET} or 22.07°C – 27.30°C T_{SET} . All the obtained comfort temperatures are lower than those in Jakarta and Bandung.

Humphreys' comfort temperature prediction is 2.57°C lower than the neutral temperature obtained from the field study. Conversely, the Auliciems' comfort temperature prediction is 1.53°C higher than the neutral temperature obtained from the field study. It suggests the presence of adaptation to the local temperature. The result of respondents' thermal prediction using PMV shows a slight difference of only 0.117 points.

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REFERENCES

- [1] R. Kramer, L. Schellen, H. Schellen, and B. Kingma, "Improving rational thermal comfort prediction by using subpopulation characteristics: A case study at Hermitage Amsterdam," *Temperature*, vol. 4, no. 2, pp. 187–197, 2017.
- [2] S. Chowdhury, Y. Hamada, and K. Shabbir Ahmed, "Indoor heat stress and cooling energy comparison between green roof (GR) and non-green roof (n-GR) by simulations for labor intensive factories in the tropics," *Int. J. Sustain. Built Environ.*, vol. 6, no. 2, pp. 449–462, 2017.
- [3] J. K. Maykot, R. F. Rupp, and E. Ghisi, "A field study about gender and thermal comfort temperatures in office buildings," *Energy Build.*, vol. 178, pp. 254–264, 2018.
- [4] G. M. Elrayies, "Thermal performance assessment of shipping container architecture in hot and humid climates," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 7, no. 4, pp. 1114–1126, 2017.
- [5] A. S. Hendriani, Hermawan, and B. Retyanto, "Comparison analysis of wooden house thermal comfort in tropical coast and mountainous by using wall surface temperature difference," *AIP Conf. Proc.*, vol. 1887, 2017.
- [6] H. Hermawan, H. Hadiyanto, S. Sunaryo, and A. Kholil, "Analysis of thermal performance of wood and exposed stone-walled buildings in mountainous areas with building envelop variations," *J. Appl. Eng. Sci.*, vol. 17, no. 3, pp. 321–332, 2019.
- [7] M. Indraganti and D. Boussaa, "Comfort temperature and occupant adaptive behavior in offices in Qatar during summer," *Energy Build.*, vol. 150, pp. 23–36, 2017.
- [8] M. L. Costa, M. R. Freire, and A. Kiperstok, "Strategies for thermal comfort in university buildings - The case of the faculty of architecture at the Federal University of Bahia, Brazil," *J. Environ. Manage.*, vol. 239, no. August 2018, pp. 114–123, 2019.
- [9] R. Maiti, "PMV model is insufficient to capture subjective thermal response from Indians," *Int. J. Ind. Ergon.*, vol. 44, no. 3, pp. 349–361, 2014.
- [10] S. Thapa, "Insights into the thermal comfort of different naturally ventilated buildings of Darjeeling, India – Effect of gender, age and BMI," *Energy Build.*, vol. 193, pp. 267–288, 2019.
- [11] Y. Xiong, J. Liu, and J. Kim, "Understanding differences in thermal comfort between urban and rural residents in hot summer and cold winter climate," *Build. Environ.*, vol. 165, no. September, p. 106393, 2019.
- [12] M. C. Katsfygiotou and D. K. Serghides, "Thermal comfort of a typical secondary school building in Cyprus," *Sustain. Cities Soc.*, vol. 13, pp. 303–312, 2014.
- [13] A. Albatayneh, D. Alterman, A. Page, and B. Moghtaderi, "The significance of the adaptive thermal comfort limits on the air-conditioning loads in a temperate climate," *Sustain.*, vol. 11, no. 2, 2019.
- [14] Hermawan, E. Prianto, and E. Setyowati, "The analysis of thermal sensation vote on the comfort of occupants of vernacular houses in mountainous areas of Wonosobo, Indonesia," *Int. J. Adv. Sci. Technol.*, vol. 130, pp. 33–48, 2019.
- [15] W. Khalid, S. A. Zaki, H. B. Rijal, and F. Yakub, "Investigation of comfort temperature and thermal adaptation for patients and visitors in Malaysian hospitals," *Energy Build.*, vol. 183, pp. 484–499, 2019.
- [16] F. Khalvati and A. Omidvar, "Summer study on thermal performance of an exhausting airflow window in evaporatively-cooled buildings," *Appl. Therm. Eng.*, vol. 153, no. January, pp. 147–158, 2019.
- [17] H. Choi, Y. An, K. Kang, S. Yoon, and T. Kim, "Cooling energy performance and thermal characteristics of a naturally ventilated slim double-skin window," *Appl. Therm. Eng.*, vol. 160, no. July, p. 114113, 2019.
- [18] E. Prianto and P. Depecker, "Characteristic of airflow as the effect of balcony, opening design and internal division on indoor velocity: A case study of traditional dwelling in urban living quarter in tropical humid region," *Energy Build.*, vol. 34, no. 4, pp. 401–409, 2002.
- [19] E. Prianto and P. Depecker, "Optimization of architectural design elements in tropical humid region with thermal comfort approach," *Energy Build.*, vol. 35, no. 3, pp. 273–280, 2003.
- [20] T. H. Karyono, S. Heryanto, and I. Faridah, "Air conditioning and the neutral temperature of the Indonesian university students," *Archit. Sci. Rev.*, vol. 58, no. 2, pp. 174–183, 2015.
- [21] Hermawan, E. Prianto, E. Setyowati, and Sunaryo, "The comparison of vernacular residences' thermal comfort in coastal with that in mountainous regions of tropical areas," *AIP Conf. Proc.*, vol. 1903, no. November 2017, 2017.
- [22] Hermawan, Sunaryo, and A. Kholil, "A thermal performance comparison of residential envelopes at the tropical highland for occupants' thermal comfort," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 200, no. 1, pp. 0–7, 2018.
- [23] S. Aghniaey, T. M. Lawrence, T. N. Sharpton, S. P. Douglass, T. Oliver, and M. Sutter, "Thermal comfort evaluation in campus classrooms during room temperature adjustment corresponding to demand response," *Build. Environ.*, vol. 148, no. November 2018, pp. 488–497, 2019.
- [24] L. A. López-Pérez, J. J. Flores-Prieto, and C. Ríos-Rojas, "Adaptive thermal comfort model for educational buildings in a hot-humid climate," *Build. Environ.*, vol. 150, no. September 2018, pp. 181–194, 2019.