

# Evaluation of Indoor Thermal Comfort on Office Building in Ternate City

M Rahim<sup>1</sup>, B Hamzah<sup>2</sup>

<sup>1</sup> Associate Professor, Department of Architecture, Khairun University, Ternate-Indonesia.

*E-mail: mustamin\_rahim@yahoo.co.id*

<sup>2</sup> Professor, Department of Architecture, Hasanuddin University, Makassar-Indonesia.

**Abstract.** This study aims to evaluate the thermal comfort in office building by analyzing temperature, humidity, and wind speed conditions in the room. Research method is performed with the measurement of thermal condition using LSI-LASTEM Multi Logger, HOBO data logger, and HOBO data logger with external sensor. At the time of measurement, thermal condition perceived by employees is observed through the questionnaires of Thermal Sensation Vote (TSV) and Thermal Comfort Vote (TCV). The results show that the thermal condition in office building is uncomfortable level. Natural ventilation system is not effective because of orientation and dimension of ventilations are minimal or not suitable standard, therefore the usage of air conditioning is increased. Key words: Thermal Comfort, Office Building, Natural Ventilation

## 1. Introduction

Climate change occurs in recent years due to increase of CO<sub>2</sub> gas emission in the atmosphere. It causes the rising of temperature especially in metropolitan cities. The rise of outdoor temperature has a significant effect on temperature increase inside building, so that it becomes harder to achieve thermal comfort in summer and caused more utilization of Air Conditioner in building. The effect of AC utilization yields to the increase of energy consumption.

Buildings account for almost a third of final energy consumption globally and are an equally important source of CO<sub>2</sub> emissions in atmosphere<sup>[1]</sup>. Buildings contribute as much as one third of total global greenhouse gas emissions primarily through the usage of fossil fuels during their operational phase. The building sector contributes up to 30% of global annual green house gas emissions and consumes up to 40% of all energy, both in developed and developing countries<sup>[2]</sup>.

In Ternate City, energy resources is very limited, it only produces by diesel power plant, while demand of energy is continue to increase, primarily because new buildings are constructed. Based on the field observation, cooling system in building is generally using air conditioning. It causes the increasing of energy consumption in building, so that the supply of energy is not enough and power outages are done every day in rotation. This condition can influence to the ventilation system and thermal condition in building especially office building. Therefore, this paper will discussed thermal comfort in office building with condition of natural ventilation system.

## 2. Research Methodology

Research method is performed with the measurement of thermal condition using LSI-LASTEM Multi Logger, HOBO data logger, and HOBO data logger with external sensor. At the time of measurement, thermal condition perceived by employees is observed through the questionnaires of Thermal Sensation Vote (TSV) and Thermal Comfort Vote (TCV).

## 3. Results And Discussions

Thermal comfort is important both for one's well-being and productivity. There are many factors affecting human thermal comfort, such as temperature of surfaces, air temperature, humidity, air movement and personal variables like clothing insulation, activity and metabolism rate. Relative humidity is the percentage of water in air compared to the maximum the air can hold. For ideal comfort relative humidity has to be kept low in hot temperatures. High humidity (60% or above) might become a serious issue in extreme climates as it could cause condensation, destroy or decompose

materials that can hold water and even promote growth of microbes. Low humidity (20% or less) can cause health problems such as dry nose and throat nosebleeds, reducing the strength of materials or unstable such as shrinking<sup>[3]</sup>. Provision of air flow in indoor can effectively improve people's thermal comfort. For a typical sub-tropical humid summer day with a relative humidity of 80%, an increase of air speed around 0.5-1.5 m/s can raise the neutral air temperature about 28.5-31°C<sup>[4]</sup>. Indoor natural ventilation to an air speed of about 1.0-1.5 m/s would likely to satisfy the thermal comfort requirement of 80% of occupants on summer period in Hong Kong<sup>[5]</sup>.

Thermal comfort in hot-humid tropic area is 24°C-26°C, relative humidity: 40-60%, wind velocity: 0,6-1,5 m/sec with the activity of relaxed and a thin dress<sup>[6]</sup>. Observation results portrays that the temperature is generally exceed 29°C, relative humidity is around 70 %, and wind speed is very low of about 0 – 0.3 m/sec (see table 1). It indicates that thermal condition in office building is uncomfortable. This condition can influence the work productivity. According to the Lawrence Berkeley National Laboratory that productivity of work increases 7-13% in building with better air quality and 15 - 50 % in the building with better sunlight quality<sup>[7]</sup>.

**Table 1.** Thermal Conditions in office Building

Thermal Condition	Offices			
	Basarnas	Parawisata	Diknas	PU
Temperature (°C)	29.10	29.24	30.86	30.61
RH (%)	69.62	70.87	76.41	75.58
Wind Speed (m/s)	0.13	0.23	0.26	0.26

*Source: Survey result in 2017*

Table 2 show that the thermal sensations are felt by employees in office buildings during daytime; where more than 50 % employees feel comfortable warm and too warm. Natural ventilation system is not effective because of orientation and dimension of ventilations are minimal or not suitable standard, therefore the usage of air conditioning is increased at office building in Ternate. An office which is too warm making its occupants feel tired and one that is too cold causing the occupants' attention drifted, making them restless and easily distracted. Even, minor deviation from comfort affects stressful, performance and safety. Workers already under stress are less tolerant of uncomfortable conditions. Thus, improving the thermal comfort conditions in the offices are very important.

**Table 2.** Thermal Sensation of Employees in office Building

Thermal Condition	Offices			
	Basarnas	Parawisata	Diknas	PU
Much too cool	0	0	0	0
Too Cool	0	0	25	0
Comfortably Cool	10	0	8	27
Comfortable	0	20	8	18
Comfortably Warm	50	50	33	27
Too Warm	20	10	8	27
Much too warm	20	20	17	0
<b>Total (%)</b>	100	100	100	100

*Source: Survey result in 2017*

Indoor thermal conditions are determined by outdoor thermal conditions. Efforts at room cooling to the comfort level can be made through natural ventilation systems and cross ventilation if the outdoor temperature covering the area around the building is at comfortable levels. Outdoor temperatures are determined by land surface characteristics.

Outdoor microclimatic conditions have profound influences on the comfort sensation of people and therefore are important factors to be considered in the design of urban outdoor spaces. In tropical and sub-tropical cities where summer is hot and humid, the usage of outdoor spaces is often hindered due to thermal discomfort. For the pleasantness and well-being of urban dwellers, the provision of a thermally desirable outdoor environment is essential.

For outdoor environment, the effect of wind is more complicated because it often inter-related with solar exposure. In general, in order to achieve the same level of thermal comfort, an increased intensity of solar exposure will result in a higher comfort wind speed. For outdoor urban environment, at an air temperature of 28°C, an increase of solar exposure from 200 W/m<sup>2</sup> (shaded under trees) to 800 W/m<sup>2</sup> (direct exposure under partial cloudy sky) will lead to an increase of comfort wind speed from about 3.5-6.0 m/s<sup>[8]</sup>. Outdoor thermal comfort; the air temperature is about 28°C and wind speed about 0-3 m/s for a pedestrian in shade. The highest comfort wind speed was obtained in cold climate regions; high wind speed is needed to compensate for the high temperature in order to achieve thermal comfort in summer. In hot and humid sub-tropical regions, under a typical summer day, wind speed ranging from 1-2 m/s is required for achieving thermal comfort of people in shade with short-sleeve T-shirt and trousers (0.6 clo) involving in sedentary activities<sup>[9]</sup>.

#### 4. Conclusions

Thermal condition in office building is uncomfortable level, with temperature is generally exceed 29°C and more than 50 % employees feel comfortable warm and too warm during daytime. Natural ventilation system is not effective because of orientation and dimension of ventilations are minimal or not suitable standard. It causes usage of air conditioning is increased at office building in Ternate. Impact, consumption energy is increased and power outages are done every day in rotation due to supply of energy is limited.

#### References

- [1] Energy-efficient Buildings: *Heating and Cooling Equipment. Technology Roadmap*, International Energy Agency, 2011.
- [2] Building and Climate change, *United Nations Environment Programme*, 2009.
- [3] <http://isvox.blogspot.com/2009/10/thermal-comfort.html>.
- [4] Khedari, J., Yamtraipat, N., Pratintong, N. & Hirunlabh, J. *Thailand ventilation comfort chart. Energy and Buildings* 2000, 32, 245-249.
- [5] Cheng, V., NG, E. *Comfort temperature for naturally ventilated buildings in Hong Kong. Architectural Science Review* 2006, 49(2),179-182.
- [6] Satwiko, P. *Building physic 1*. published: Andi , Yogyakarta-Indonesia, 2003.
- [7] *The relation of climate and architecture*. <http://rizkilesus.wordpress.com>
- [8] Tacken, M. *A comfortable wind climate for outdoor relaxation in urban areas. Building and Environment* 1989, 24, 321-324.
- [9] Cheng, V., NG, E. *Thermal comfort in urban open spaces for Hong Kong. Architectural Science Review* 2006,49(3),236-24.