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Thermal comfort of wood-wall house in coastal and mountainous region in tropical area

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Abstract

Thermal comfort theory of Predicted Mean Vote (PMV) is proven incompatible for tropical area. Actual Mean Vote (AMV) is a way to recognize the thermal comfort based on inhabitant's behaviour and psychology (adaptive thermal comfort). The purpose of this research is to analyse the difference between AMV and PMV in wooden walls traditional houses in coastal and mountainous region which will be used to establish the theory of adaptive thermal comfort. Method of this research is quantitative by measurement thermal variable (temperature, globe temperature, velocity, relative humidity) use thermal measurement tools. This measurement carried out in conjunction with filling out the thermal comfort questionnaire from ASHRAE (American Society of Heating, Refrigeration, Air conditioning Engineering) standard. The number of sample taken is 25 houses in coastal region and 25 houses in mountainous region with criteria of more than one inhabitant in each house. Mountainous region chosen is Wonosobo Regency whereas coastal region selected is Demak Regency. The analysis is conducted by using PMV program from ASHRAE and statistic test undergone is to obtain the difference of PMV and AMV. The result obtained is the average difference between AMV and PMV in coastal region in the amount of +0.73, while the houses in mountainous region have the average difference of -0.81. It is concluded that bias in the wood-frame houses in mountainous region are bigger than those in coastal region. AMV Value for the houses in coastal is -0.28 and AMV value for the houses in mountainous is -1.12, it mean that occupants in the coastal houses are more comfortable than occupants in the mountainous houses.

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1. Introduction

PMV (Predicted Mean Vote) is a thermal comfort theory that becomes a reference for many researches in predicting thermal comfort before 1990. PMV is a thermal comfort theory which is based on thermal balance. It discards the existence of adaptation so that it creates bias in several research locations, especially in buildings with natural ventilation [1,2,3]. Adaptive theory in thermal comfort (adaptive thermal comfort) emphasizes on three main categories influencing it, they are physiological adaptation, behavioral adaptation, and psychological adaptation. The measurement for those categories has been developed, such as in the using of AHP (The Analytic Hierarchy Process) in thermal comfort measurement in UK and China [4].

Nomenclature

PMV	Predicted Mean Vote	AMV	Actual Mean Vote
Ta	Air Temperature	MRT	Mean Radiant Temperature
Du Bois	Skin surface area	Top	Operative Temperature
Met	Metabolism	Clo	Clothing
ET	Effective Temperature	SET	Standard of Effective Temperature
PPD	Predicted of Percentage Dissatisfied		

Considering the developing adaptive thermal comfort, Fanger, an inventor of PMV thermal comfort theory, re-conducts the research and revises to PMV by adding a revision factor between 0.5 and 1, that can be used for a natural and ventilated building included in the standard of ASHRAE 55-2004 [5]. Yao and friends also make a revision by stating that the adaptive comfort theory is an unidentified black box. They also make a revision factor of λ as an adaptive factor of PMV to predict thermal comfort in natural and ventilated buildings [6].

Even though the standard of adaptive comfort has been stated in ASHRAE and the revision factor for PMV has been founded, many researchers still check other buildings and locations. As a result, many adaptive thermal comfort models in other buildings and locations are generated [7,8,9,10,11]. The adaptive comfort theory has also generated theories about energy saving in buildings. It can be applied to buildings that become the objects of researches [12,13,14,15]. The application on information technology has also been conducted to sharpen the adaptive thermal comfort. It is done by making the adaptive thermal comfort model with fuzzy logic that use several parameters of adaptive thermal comfort based on black box theory [16]. The adaptive thermal comfort theory is resulted from field data from AMV (Actual Mean Vote).

Indonesia is an area of tropical rainforest that covers from areas of equator to 15° to the north and south. The climate of humid tropic is characterized by precipitation (rain) and high humidity with mostly high temperature. The annual temperature is about 23°C in rainy seasons to 38°C in dry seasons. It is a little bit windy and it has medium to high sun radiation. The thermal exchange is low because the humidity is high. There are two seasons in every year, dry season in March to August and rainy season in September to February [17]. Some areas in Indonesia have different characteristics, although they are included in humid tropic areas. Those are plateaus or mountain ranges. It happens because there is a difference in the altitude of the areas. The variation of temperature in Indonesia is influenced by the altitude of the areas. There are three areas; they are plateau, plain, and coast (beach). From the characteristics of tropical areas stated by Lipsmeier, mountain range in tropical areas is not included in the criteria mentioned previously. The mountain range in tropical areas has a cold temperature. The thermal intensity is from low to medium. However, there is still a similar criterion among those areas. All of the areas have two seasons. Although in certain condition there is snow in some areas, it cannot be considered into winter season [18]. Based on Houbolt theory, the correlation of temperature and the altitude location of sea surface shows that the maximum temperature in Indonesia decreases to $0,57^\circ\text{C}$ for each elevation of 100 m height in areas under the latitude of 60°C [19].

This study analyzes the difference between houses with timber walls in two areas with different altitude, in mountain range and beach areas. The mountain range area is represented by Wonosobo Regency, and the coastal area is represented by Demak Regency. Wonosobo Regency is one of regencies that is situated in central Java, Indonesia. It is an area that is confined by mountain range and mountains; they are Dieng Plateau and Sindoro Mountain. Meanwhile, Demak regency is located in the northern coast of Java. Based on the difference of those

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