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Assessment of the Thermal Performance of Complete Buildings Using Adaptive Thermal Comfort

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Abstract

The paper presents a method of assessing the thermal performance of complete buildings using the adaptive thermal comfort concept. This facilitates the assessment of the thermal performance of whole building envelopes accounting for the percentage of time over which the building internal air temperature remains within a specified adaptive thermal comfort range.
This method promotes sustainable and energy efficient design by using an adaptive approach to assess the thermal comfort for occupants instead of energy usage, the common practice in existing rating tools. This universal approach can be used to compare the thermal performances of various buildings and is applicable anywhere in the world.
When the technique was applied to the assessment of the thermal performance of various walling types in several housing test modules over a 12 month period, the results indicated that the Insulated Cavity Brick module (InsCB) had the best building thermal performance, followed by the Insulated Reverse Brick Veneer (InsRBV), Insulated Brick Veneer (InsBV) and Cavity Brick modules (CB). These results were consistent with the previous findings from University of Newcastle (UON) research on walling systems and the AccuRate building assessment tool used in Australia.

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Keywords:Thermal performance; adaptive thermal comfort; sustainable buildings.

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1. Introduction

The accuracy of any thermal simulation has direct influence on the thermal performance of any building and the design of heating and cooling loads required to sustain thermal comfort. Many variables affect the thermal performance of a building and both independent and interconnected variables influence the thermal performance, with some having a greater impact than others (Rabah, 2005).

Due to the dynamic nature of weather conditions, these variables are constantly changing, which makes it difficult to accurately predict the thermal energy performance (Alterman, Page, Moghtaderi & Zhang, 2015), (Moffiet, Alterman, Hands, Colyvas, Page & Moghtaderi, 2015). To obtain an accurate assessment of the thermal performance of a building, an account must therefore be taken of the building as a complete system under the variable external conditions (Alterman, Moffiet, Hands, Page, Luo & Moghtaderi, 2012).

Energy assessment programs are different, depending on the country; various rating methods are used in the developed countries with few or no building energy assessment tools in developing countries. Therefore there is a need for a universal energy assessment tool for buildings, as well as techniques to encourage energy saving by using adaptive practices to obtain a thermal comfort level (e.g. open windows, changing clothes or low energy solution such as fans).

In this research, the aim is to find a new approach capable of predicting the thermal performance of a building envelope for any given set of climatic data based on adaptive thermal comfort. This approach can be used to compare the thermal performance of different buildings, taking into consideration the various building materials, orientation, shading, occupant behavior, weather at the site and the environment surrounding the building.

2. Methodology

The first step is determining the internal air temperature of a building under varying external conditions. The weather data used in this research was recorded over one year from four housing test modules on the campus of the University of Newcastle. The adaptive thermal comfort range was found by computing the fraction of time over which the internal air temperature of a building remained within the 90% adaptive thermal comfort limit.

2.1 Full Scale Test Modules

The research program on the thermal performance of housing in Australia in the Priority Research Centre for Energy at the University of Newcastle, Australia, has been underway for the past 10 years. The research has involved the construction of four full-scale housing modules, then monitoring the modules under different weather conditions.

The modules were selected to represent typical forms of construction in Australia, and were built at the University of Newcastle, Callaghan Campus (Longitude 151.7 E and latitude 32.9 S). The modules were placed 7m apart to reduce wind obstruction and avoid shading. With the exception of the walling system, all modules (Cavity Brick Module (CB), Insulated Cavity Brick Module (InsCB), Insulated Brick Veneer Module (InsBV), and Insulated Reverse Brick Veneer Module (InsRBV)) had a similar layout, with a square floor plan of 6m x 6m (see Fig. 1).