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Thermal Assessment of Buildings Based on Occupants Behavior and the Adaptive Thermal Comfort Approach

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Abstract

The adaptive approach promotes sustainable ways for the occupants to obtain thermal comfort using strategies such as natural ventilation (opening and closing windows), suitable clothes and shading. When applied to typical housing modules, the adaptive approach reduced the time required for mechanical heating or cooling by more than half compared with a typical energy based approached (AccuRate). The study was performed for four test modules located in Newcastle, Australia incorporating four different walling types (Cavity Brick, Insulated Cavity Brick, Insulated Brick Veneer and Insulated Reverse Brick Veneer) subjected to a range of seasonal conditions in a moderate climate.

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Keywords: Adaptive thermal comfort, Building thermal simulation, Occupants behaviour

1. Introduction

Buildings are responsible for almost one-third of the greenhouse gases (GHG) emissions and two-fifths of acid rain[1]. That is largely because 40% of the world's total energy used for operating and constructing buildings mainly come from burning fossil fuels[2].

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The reduction of the impact of global warming and climate change can be achieved by reducing energy consumption. To tackle climate change and global warming and to reduce greenhouse gases emissions, an accurate thermal simulation approach is required to assist in designing energy efficient buildings and reduce heating and cooling loads to reach acceptable thermal comfort for inhabitants.

The behavior of the occupants has a great influence on the overall thermal performance, as they can adapt to their environment and save energy by: closing curtains to prevent heating in rooms from the summer sun; adjusting shading and ventilation if necessary; use energy efficient air-conditioning/fans with appropriate thermostat settings; drinking more water and switch off when not in use and change clothes to adapt to the surrounding environment (heavier clothes in winter and lighter in summer).

The field of predicting the occupant's behavior to assess the thermal performance of complete buildings needs more research due to the limited research in this area to date. A method of weighting the physiological, psychological and behavioral weightings of the adaptation thermal comfort process specifies that physiological adaptation is the leading aspect contributing to the establishment of an acceptable thermal environment, while the other two adaptations, the behavioral and psychological, share similar weightings[3].

Inhabitants with greater individual control over their environment have a tendency to accept wider ranges of indoor temperatures. On average, they accepted a 2.6oC lower operative temperature and showed a lower motivation to modify their current environment (by using air-conditioning) compared with those without personal control. It is recommended that inhabitants have a chance to interact with their thermal environment through openable windows and doors, low energy fans and minimizing the usage of controllable heating/cooling systems[4].

This paper presents a new approach which gives occupants the opportunity to adapt to a wider range of weather conditions instead of relying on mechanical heating and cooling.

2. Methodology

The observations from full-scale housing test modules and the results from an AccuRate software are used to assess the thermal performance of the modules, with the adaptive thermal comfort model used in this analysis.

2.1. Full-Scale Test Modules

In the Priority Research Centre for Energy at the University of Newcastle, Australia an extensive research program has been proceeding for the past decade on the thermal performance of Australian housing. This has involved the construction and monitoring of the behavior of four full scale housing modules under a range of different weather conditions. All modules have a square floor plan and are shown in Fig. 1.

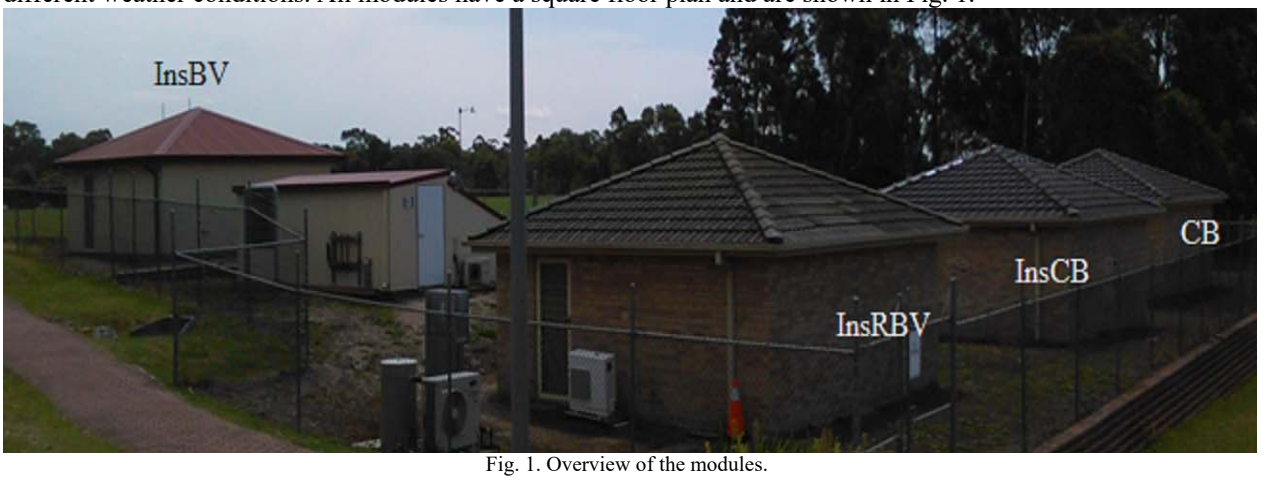

Fig. 1. Overview of the modules.

The main difference between the modules is the walling systems so each module will be named based on their walling system as shown in Table 1.