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ScienceDirect

Procedia Engineering 180 (2017) 365 – 372

Procedia Engineering

www.elsevier.com/locate/procedia

International High- Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016

A post-occupancy evaluation of a modular multi-residential development in Melbourne, Australia

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Abstract

Modular construction has been promoted to minimise the environmental impacts such as construction material use and waste, embodied energy and carbon emissions as well as construction time and cost reduction. Although the main focus has been on the construction technology, waste minimisation, energy and material efficiency and thermal performance of modular construction, limited attention has been paid to the building occupants. This paper aims to evaluate the resident lived experience of a modular multi-residential development in inner Melbourne. The case study building accommodates a total of 199 apartments and commercial spaces, and to date, it is the largest modular construction building in Victoria. A post-occupancy evaluation (POE) was conducted using the Building Use Survey (BUS) methodology. Overall building design, thermal comfort, noise, lighting and personal control over the indoor environment were evaluated on a seven-point Semantic differential scale. Although the building occupant survey showed a high level of satisfaction with overall building design and performance, two main issues, 'thermal discomfort in summer' and 'noise from outside' were identified. Overheating in summer is not clearly understood in this study, however, it could be interpreted that passive design strategies such as cross ventilation and landscaped shared open space increased noise. A further research on the effects of building design on occupants such as engineered light-weight concrete floor, prefabricated building façade, cross-ventilation, operable openings and the cooling systems of the individual apartments is necessary to resolve the issues and to examine whether the poor thermal performance in summer could be related to modular construction. This case study building was developed as a commercially replicable pilot, providing affordable and sustainable high-density housing in Melbourne's inner suburbs. Thus, it is expected that this POE study could provide an insight into the interaction between the building and its occupants, particularly in the context of modular construction, and further contribute to developing high-performance modular multi-residential buildings.

Peer-review under responsibility of the organizing committee iHBE 2016

Keywords: post-occupancy evaluation (POE); passive design; modular; multi-residential; building occupants

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Peer-review under responsibility of the organizing committee iHBE 2016

doi:10.1016/j.proeng.2017.04.195

1. Introduction

Modular construction is becoming a popular method of construction in Australia due to energy and material efficiency as well as construction time and cost reduction. It consequently reduces negative environmental impacts and greenhouse gas emissions. The main focus of previous research has been on the construction technology, waste minimisation, energy and material efficiency and thermal performance of modular construction based on simulation and experiment [1,2,3,4], however, there seems to be a tendency to overlook the actual performance of the buildings-in-use such as a particular focus on the building occupants of modular construction, due to the difficulties in observing and measuring related data [5].

The project building in this paper is an affordable and sustainable high-density, mixed use development in inner Melbourne. Melbourne is one of the fastest growing cities in Australia, with a prediction that the population will increase from 4 million to 7.7 million by 2051. It is interpreted that the projected population growth requires double the amount of existing residential dwelling by the time [6]. Thus, high-density development in the existing land within inner Melbourne suburbs has been promoted to protect the urban fringe from development as well as to utilize current existing infrastructure. The project building was developed as a commercially replicable pilot, accommodating a total of 199 apartments and commercial spaces. To date, as the largest modular construction building in Melbourne, the individual apartments of the project building were manufactured offsite, delivered to site and stacked and bolted together to form the project building. This method of construction can reduce construction time and environmental impact such as local disruption, construction material use and waste, embodied energy and carbon emissions [7,8].

This paper aims to evaluate the resident lived experience of a modular multi-residential development in inner Melbourne, using a standardized occupant survey, the Building Use Survey (BUS) methodology. A post-occupancy evaluation (POE) was conducted to examine overall building design, thermal comfort, noise, lighting and personal control over the indoor environment.

2. The project

2.1. Climate and building thermal performance

The project building is located in a suburb in Melbourne, Victoria and its local climate is classified as a mild temperate (climate zone 6) in the eight National Construction Code (NCC) climate zones in Australia (Fig. 1). The local climate data have been plotted in Fig. 2, the 38-year statistics (1979-2016) show an average 1 ºC lower than the temperatures in 2014 when this research was conducted. In particular, the summer months from January to March in 2014 show an average 2.75 ºC higher maximum temperature than the same months in the 38-year statistics.

In Australia, under the NCC, the energy efficiency of buildings is regulated so as to use energy more efficiently and reduce greenhouse gas emissions. The compliance requirements can be achieved by either using software rating tools (e.g. AccuRate Sustainability, FirstRate 5 and BERS Pro Plus) based on NatHERS (Nationwide House Energy Rating Scheme) or alternatively complying with all the relevant NCC Deemed-to-satisfy provisions, where minimum allowable elemental R-values are prescribed. A sample of 18 dwellings were selected from the project building and assessed by using the FirstRate software, and the average of 6.17 stars was achieved based on the NatHERS 0 (worst) to 10 (best) scales [9]. The 6 star rating is the current building energy efficiency compliance, meaning that the annual energy consumption for space heating and cooling is 114 MJ/m^2 in inner Melbourne [10]. It is understood that the project building achieved a higher building thermal performance than the compliance requirements when the project building was designed.