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The role of post occupation evaluation in achieving high performance buildings through diagnostics

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Abstract

Buildings are major consumers of energy for heating and cooling. The number of buildings is growing rapidly with demand for energy. To reduce consumption, governments worldwide have implemented codes, standards, and building practices. In New South Wales, Australia the planning department introduced a web-based energy-modelling tool intended to increase the thermal performance of the residential building's envelope prior to development applications. The modelling tool, Building Sustainability Index (BASIX) was introduced in 2004. Building codes and standards in them selfs are not perfect instruments but guidelines to achieve building objectives.

However, there is evidence in literature stating that buildings are not achieving the predicted results in thermal performance leading to increased energy consumption. This research looks into the predicted modelling aspects to the BASIX program for thermal performance and undertaking a diagnostic study in verifying the building envelope meeting its objectives. This study considered the building envelope the key factor in thermal performance, in which building practices may undermine codes and standards delivering sub-optimal performance. The research justifies the need for diagnostics as a tool to evaluate building practices in reducing the performance gap between the modelled and the delivered results. This would provide building professionals, and government bodies in understanding and addressing the cause of performance gaps between the predicted and actual results for thermal performance in future buildings.

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Keywords: Building envelope; diagnostics; thermal performance

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1. Introduction

Buildings are major consumers of energy, especially for mechanical heating and cooling of the built environment [1]. To achieve high-performing buildings the technology of building materials has advanced with the aim of increasing the thermal performance of the building envelope. With the advancement of technology, government bodies globally are also introducing new codes and standards to achieve better performance. The building envelope is the key factor in reducing energy consumption while also achieving thermal comfort.

In Australia, development applications in most states require that accredited modelling software's be used prior to building application at the local council for thermal performance. The modelling tool needs to achieve a set target for heating and cooling loads in order for the building application to proceed. In the state of New South Wales, prior to submission of the development application to the local council, the design has to fulfil the requirements of the Building Sustainability Index (BASIX) web-based tool for thermal performance. The BASIX tool was launched in 2004. Further to BASIX requirements, the building needs to meet the guidelines of the Building Code of Australia (BCA) for building sealing in the construction process. The BASIX tool can be used by the homeowner in the Do It Yourself (DIY) mode or by a certified energy assessor.

In spite of the rigorous requirements, there is growing concern that buildings are not achieving the thermal performance as designed at the post occupation stage [2, 3]. Wray, Walker, Siegel, and Sherman [4] states, California in the United States of America (USA) has one of the most advanced energy codes in the country. In spite of this, houses still do not perform optimally. The modelling results are heavily relied as the optimal performance of the building, and when buildings are completed, it is rarely verified against the modelled criteria. There are limited information of actual case studies of buildings in Australia verifying the results of the post occupation thermal performance for thermal irregularities and other attributes contributing to increased energy use.

Insulation in walls and ceilings forms part of BASIX requirements for thermal performance. Sub-standard on-site practices in insulation installation can significantly reduce the thermal performance of the building. Thermal irregularities are the results of missing and gaps in insulation. Publication by Mosher and McGee of Your Home [5] indicates that small gaps in insulation can reduce the overall R-Value. Thermal irregularities are also the results of thermal bridges, direct connection of materials between the exterior face to the interior wall, gaps between the insulation and the framing structure of timber and steel, which can reduce the thermal performance of the building envelope [6, 7].

Building sealing is a requirement not modelled in the BASIX program, but referred to meet the requirements of the Building Code of Australia (BCA). There is no method of measurement that can be uniformly stated across the building sector in validating the extent of sealing, it is based on professional judgement. If air sealing cannot be measured, then thermal performance of the envelope cannot be managed efficiently. McGee [8] states that air leakage accounts for 15-20% heat loss in winter and a significant coolth loss during the use of air conditioners.

The current setback in achieving post occupation verification can be invasive and destructive. Most of the features of a building envelope that make a home thermally efficient are hidden within the walls. Homes have excess panels on the ceiling to inspect the attic, and some areas can be overlooked due to constricted spaces. There are homes that the ceiling cannot be checked due to the ceiling lying on the same plane of the roof, and the insulations sandwiched in-between. The present destructive nature would deter validation of the building envelope against the modelled outcomes and also lead to wastage and damage to the existing structure. A great amount of energy could be saved if the building quality can be diagnosed non-destructively and rectify any discrepancies for thermal performance to match the design and modelled outcomes. Energy efficiency in buildings is becoming a mainstream requirement and should be meticulously scrutinised for proper compliance.

Thermal irregularities and reduced infiltration are not tangible attributes that can be visually observed when buildings are completed. It is difficult for homeowners or governing bodies to determine if the thermal requirements in the built stage have been achieved. In most cases, the measured energy consumption is taken as the determinant factor in verifying the performance of the building envelope, which can lead to bias results. For example, two similar houses, House A with poor thermal envelope may use less energy due to occupant behaviour and of the lower socio economic group, concerned with increasing energy costs, compared to House B, which is a better thermal performing envelope of a higher socio economic group with the increased use of space heating and cooling. Based on the energy consumption results between House A and House B, it may indicate that House A has better thermal