Building and Environment 92 (2015) 222–235

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Overheating investigation in UK social housing flats built to the Passivhaus standard

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ARTICLE INFO

Article history:
Received 22 January 2015
Received in revised form
20 March 2015
Accepted 30 March 2015
Available online 18 April 2015

Keywords:
Passivhaus
Social housing
Overheating
Adaptive thermal comfort

ABSTRACT

Global environmental and energy concerns have led to a rapid growth in mandating the construction of more energy efficient dwellings in the UK. This is particularly true for the social housing sector which is partly founded by the government and it is expected to lead the way in this respect.

To address this issue energy efficiency standards such as Passivhaus are increasingly adopted by both private and social housing sectors in the UK. However, data describing actual thermal performance of dwellings built to such standards, particularly in dense social housing flats, are scarce.

This study considers the overheating risk during the cooling season in social housing flats built to the Passivhaus standard in the UK. It considers 25 flats over three cooling seasons in Coventry, UK.

Overheating assessment based on Passivhaus criteria, using a fixed benchmark, suggests there is a significant risk of summer overheating with more than two-thirds of flats exceeding the benchmark. While the level of overheating in different flats varies considerably, detailed analysis indicates that this is more related to occupant behaviour than construction. An alternative approach to evaluating overheating risk is the adaptive thermal comfort model, which takes into account occupant vulnerability and actual outdoor temperature. Use of the adaptive benchmark suggests this overheating risk is lower for normal occupants; but higher for vulnerable occupants. These results not only have implications for the evaluation of overheating risk but also for the way in which social housing landlords place tenants of differing vulnerabilities.

1. Introduction

This paper investigates the risk of overheating in social housing flats built to the Passivhaus standard in the UK. Fixed and adaptive thermal comfort benchmarks are used to assess the overheating risks.

The UK Government's climate change mitigation strategy [1], which introduced zero carbon targets for new homes, has generated significant interest in how this can be achieved [2–4]. In response to such interest and the recast European Energy Performance in Buildings Directive (EPBD) [5], revised ‘zero carbon’ dwelling standards will be mandated in the UK by 2016 [3,6]. This legislation, and the voluntary use of energy efficiency standards such as Passivhaus, BREAAM and LEEDs etc., have resulted in significant changes in the design and construction of new dwellings [7].

In response to new regulations and the UK's move towards zero carbon homes, housing developers are under an obligation to build more energy efficient homes. This situation applies in particular to social housing developers who, as a sector partly funded by housing corporations, are expected to lead the way [8].

The Passivhaus standard was developed in Germany in 1990 as a way of reducing energy consumption and providing ultra-low energy and zero carbon dwellings [7]. Central to this approach is the reduction of space heating demand through minimising thermal transmission and ventilation losses and optimising passive solar gain [4,9]. In recent years the Passivhaus approach has gained popularity in the UK but, while considerable research has been undertaken regarding its effectiveness in reducing heating loads, less attention has been paid to its annual and whole-life performance characteristics [7].

The internal temperature of houses in the summer is of increasing concern, even in the mild summers experienced in the

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http://dx.doi.org/10.1016/j.buildenv.2015.03.030
0360-1323/

UK. High indoor temperatures can be life threatening [10]. The heat-wave of 2003 is estimated to have caused an additional 2091 deaths amongst vulnerable groups in the UK [11] with as many as 70,000 other deaths between June and September across Europe [12].

Whilst the summer of 2003 was very unusual, climate change projections indicate that, by the 2050s, similar extreme weather events will take place every two or three years and by the 2080s such temperatures would be considered unusually cool [13]. Indeed, the Zero Carbon Hub (ZCH) [6] highlighted the risk of overheating and cautioned that “*There is some anxiety that homes we are building today may be at risk of overheating even in the current climate. Given the prospect of significant warming, well within the expected lifetime of homes this risk will increase with potentially serious consequences*”.

While much attention has been focused on ways to mitigate the causes of climate change, mainly by minimising the use of fossil fuels to generate the energy used in buildings, there is wide recognition that climate change is already happening. Consequently, there is a need to examine how the built environment can adapt to change and ensure that all buildings are capable of dealing with greater climate extremes [14].

Any evaluation of the risk of overheating needs to reflect the occupants' perceptions of thermal comfort, particularly those vulnerable groups which are often tenants in social housing. There are two approaches to evaluate the risk of overheating which can be characterised as the fixed and the adaptive approaches. The fixed approach considers a benchmark for evaluating overheating, while the adaptive approach suggests that a fixed maximum temperature is not appropriate and that the benchmark should reflect the outdoor climate at the time and the likely vulnerability of different groups to changing comfort conditions [15,16].

This paper investigates the risk of overheating for social housing constructed using Passivhaus principles during the cooling season; the implications of adopting different approaches to evaluate internal comfort conditions and the likely impact on tenants with different vulnerabilities.

2. Background study

2.1. Social housing

Social housing provides secure and decent homes for those who cannot afford open market prices in the UK.

The development of social housing in the UK started in the late 19th Century and reached its peak by the mid-20th Century. Social housing is one of the most important sectors in the UK, with 3.8 million households representing 17% of all UK homes [17]. This stock belongs to local authorities and housing associations [18]. In 2012, 53% (around 2.1 million) of social tenants rented their homes from a housing association and the rest (around 1.9 million) from local authorities [17].

Social housing also has the highest rate of overcrowding in the UK, at 7%, compared to an overall UK rate of 3% [17]. With the increase in the UK population, social housing providers are under pressure to build more houses [8]. The UK housing sector is also under pressure to move towards zero carbon houses to comply with UK regulations. This applies in particular to the social housing sector, since it benefits from public funds [8]. For example, the government's Standard Assessment Procedure (SAP) is used in the UK to assess the energy and environmental performance of UK dwellings. The average SAP rating of UK homes increased from 45 to 57 (12 points) between 1996 and 2011, while in the same period the rating in the social housing sector rose by 14 points, from 49 to 63. In 2011–2012, the social housing sector also had the biggest proportion of dwellings earning A to C scores, the highest on the UK's Energy Efficiency Ratings (EER) scheme [17].

But in 2012, the social housing sector had the highest unemployment rate, around 10%, amongst occupants and almost two-thirds of social tenants were in receipt of Housing Benefit (HB) to help to pay their rent, approximately 40% more than private tenants [17]. The ability of social tenants to pay their rent both now and in the future is essential for the long-term business of registered social landlords (RSLs).

It has been estimated that in 2011 11% of UK households suffered from fuel poverty (when a household spends more than 10% of its total income on energy) [19]. Average energy bills have also seen a sharp rise (24%) between August 2009 and August 2013, while the average household income increased by only 3% in this period [20]. Unless energy demand reduction techniques are integrated into social housing sector to improve the energy efficiency, there is further risk of more households going into fuel poverty. This risk is particularly relevant for social housing tenants, given that their average gross annual income is noticeably lower than that of private renters and owner occupiers; £17,600 for social renters in comparison to £30,100 and £40,500 for private renters and owner occupiers respectively [21].

Since tenants in the social rented sector also have a higher age profile – 45% aged 55 or over and 29% aged 65 or over [21] – it is important to consider the relative degrees of vulnerability of different tenants.

Given the specific sensitivities of the social housing sector outlined above, it is vital for social housing providers to adopt a standard of supplying energy efficient, comfortable and affordable dwellings now and in future climatic conditions, during both cooling and heating seasons.

2.2. Passivhaus

The Passivhaus standard was developed in Germany in the late 1980s; it sets very high requirements for energy efficiency in building design and construction. The Passivhaus Institute of Darmstadt, Germany, promotes and controls the standard and defines the associated quality assurance process [22]. The main aim of Passivhaus is to minimise the requirements for space heating and cooling. It also largely focuses on avoiding and reducing thermal transmission losses and increasing and optimising the benefits from passive solar gain [9]. Furthermore Passivhaus aims to provide effective indoor air quality and increase thermal comfort. By definition, a Passivhaus home focuses on passive design features such as insulation, airtightness and solar orientation. However, it also allows certain active elements to be included – notably mechanical ventilation with heat recovery (MVHR). The fundamental principle of the Passivhaus standard is for a home to maintain its internal temperature and air quality simply by adding a small amount of heat to the air being circulated by the ventilation system, thereby eliminating the need for a traditional wet central heating system [9,22].

Since the late 1980s, some 37,000 Passivhaus buildings have been constructed worldwide [23]. It is often referred to as a “comfort standard” as well as an energy standard, and the popularity of Passivhaus in Germany – including a 92% positivity rating by occupants – has been largely due to a combination of social, political and financial circumstances which are specific to this nation [22].

The adoption of the German Passivhaus standard in the UK as a template for providing low energy or zero carbon dwellings has increased significantly in recent years. Around 250 Passivhaus certified buildings were completed by 2013 and up to 1000 units are completed, on site, or in the planning phase [24]. According to