



A structured approach to overall environmental satisfaction in high-rise residential buildings



P. Xue, C.M. Mak*, Z.T. Ai

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China

ARTICLE INFO

Article history:

Received 20 June 2015

Received in revised form

20 November 2015

Accepted 6 January 2016

Available online 11 January 2016

Keywords:

Overall environmental satisfaction

Residential buildings

Air quality

Thermal comfort

Luminous comfort

Acoustic comfort

ABSTRACT

A survey was conducted with a sample of 482 residents in high-rise residential buildings to investigate the impact of aspects of indoor environmental quality (IEQ) on occupants' overall environmental satisfaction (OES). A three-step approach was proposed to structure the OES. The structure was first tested by the non-parametric tests and the results of statistical analysis showed that the combined aspect of air quality and thermal comfort had the greatest influence on OES in apartments, followed by luminous comfort and acoustic comfort. A detailed structure was then developed and proved residents' subjective feelings about certain sub-factors, such as air freshness, had strong correlations with each IEQ aspect. The individual items, namely gender, age, physical environment, and adaptive behaviors, were further explored and tested. The results show that most of the items had significant impact on occupants' feelings regarding sub-factors. The adaptive behaviors of shading and lighting affect luminous comfort significantly and activity intensity and mental stress decides acoustic comfort most. In further studies, the OES could be quantified with the data from both real condition simulation and questionnaire survey.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

People spend nearly 87% of their time indoors [1] and over half of this time in their homes. Some studies have shown that indoor environmental quality (IEQ) has a significant impact on human productivity [2], health [3], and satisfaction [4]. Unlike human productivity and health, satisfaction is subjective, but a high level will lead to good mood and health in the long term [5]. Therefore, it is necessary to investigate the way in which residents' perception of their indoor environment affects their overall environmental satisfaction (OES). A number of studies have indicated that it is complicated to break down satisfaction into categories and determine how these categories contribute to overall satisfaction. Some results are contradictory due to the researchers' different purposes, methods, and hypotheses.

Rehdanz and Maddison [6] showed that higher noise levels and local air pollution significantly diminish occupants' subjective satisfaction when controlling other factors. Frontczak et al. [7] claimed that the acceptability of overall indoor environment could be estimated by combining the acceptability of thermal, visual, and acoustic conditions and air quality. Beside these aspects, privacy has also been considered to have a great impact on OES [8–11]. Lai

and Yik [12] said that IEQ attributes were intended to give more consistent judgment by residents who have familiarized themselves with their living environment over time. Newsham et al. [13] investigated occupants' satisfaction by focusing on other physical measurements, such as furniture dimensions, and an assessment of potential exterior view. Kim and de Dear [10] estimated the individual impacts of 15 IEQ aspects on occupants' OES and distinguished between aspects that have a linear and a non-linear relationship with overall satisfaction. These studies recognized thermal, visual, and acoustic conditions and air quality as the key contributors to OES, even when other aspects were accounted for. Therefore, it is reasonable to state that OES decreases if occupants have problems with these IEQ aspects. Leaman and Bordass [14] developed sophisticated approaches for capturing and understanding user requirements. With new approaches, the Building Use Studies (BUS) methodology could help design a questionnaire and make it possible to obtain quantitative and qualitative feedback through post-occupancy evaluation.

Frontczak et al. [15], Frontczak et al. [7] found that noise level and sound privacy had a significant influence on office occupants' satisfaction. Humphreys [16] conducted a survey about office in Europe and found that air temperature and quality were more important than satisfaction with lighting. Leaman and Bordass [17] reported that building attributes, such as the depth of the building, can affect the occupants' satisfaction. As the buildings get deeper, the satisfaction levels with buildings and self-reported

* Corresponding author.

E-mail address: cheuk-ming.mak@polyu.edu.hk (C.M. Mak).

productivity will decrease. Lai and Yik [12] conducted a survey in residential buildings in Hong Kong and showed that residents who have familiarized over time with their living environment tend to give more consistent judgment of the relative importance between pairs of: thermal comfort, air cleanliness, odor and noise. A strong positive correlation was also found between perceived Indoor air quality (IAQ) and OES by Chan et al. [21]. However, the ranking of OES aspects differs in residential buildings. An occupant survey conducted in Danish homes [7] concluded that the relationship between air quality and overall acceptability was the most important, followed by visual, acoustic, and thermal quality. A similar conclusion, that indoor air had the highest impact, was also obtained in a study of Swedish apartment buildings [18]. Frontczak and Wargocki [19] drew the conclusion that thermal comfort is ranked by occupants to be of greater importance than other aspects. An investigation conducted in China also suggested that thermal comfort has the highest impact on OES [20].

From the results mentioned above, one can see that the relative importance of the four key aspects differs from country to country. Different regions, cultures, and population densities make it impossible to develop a valid general formula to evaluate OES. It is therefore reasonable to evaluate each key aspect separately rather than relying on a combined index [16].

Hong Kong is one of the world's most densely populated cities, with the largest number of skyscrapers and high-rise buildings. Residential buildings of 40-plus stories are the most common type of housing in Hong Kong, and most citizens live in these high-rise apartment buildings. Private housing is generally occupied by high-income owners. Although the living space in these flats is larger than average [12], the per capita area is still smaller than in other countries. Owing to its position in the sub-tropic of Cancer and its dense buildings, most occupants tolerate higher air temperatures, dimmer daylight inside their residence, higher noise levels, and higher dust concentration in their daily life than average [21].

The objective of the present study is to propose an approach assessing the impact of IEQ aspects on occupants' OES. This survey also aims to understand how sub-factors such as air freshness affect each IEQ aspect separately and to investigate the effects of physical environment and residents' adaptive behaviors on their subjective feelings about those sub-factors. The analysis is based on response data collected during the autumns of 2013 and 2014. The results offer insights into how residents perceive OES in high-rise residential buildings. This result is a fundamental work to quantify the OES. It will also be possible to find and benchmark the key parameters with these questionnaire data and future simulation results. Therefore, guiding the building-efficiency design without eroding occupants' satisfaction with overall environment could be achieved.

2. Literature review

OES, as a subjective evaluation, can be affected by various aspects. The literature provides evidence that IEQ, building physical environment, and adaptive behaviors contribute significantly to how occupants perceive their indoor OES.

2.1. Indoor environmental quality

Air turbulence transfers energy and the velocity field has a great impact on concentration and temperature fields. Air temperature is the key sub-factor of thermal comfort and air quality [22]. In the thermal comfort equation, air velocity and humidity should also be measured first [23]. Nicol and Roaf [24] clarified the relationships between clothing insulation, metabolic heat, and the thermal balance of the body. Research groups under the supervision of Mak

found that building features could reduce the indoor average velocity for most rooms [25]. The incursion of outdoor pollutants by infiltration and ventilation has also been found to be an important sub-factor in IAQ [26,27]. Givoni et al. [28] expected humidity to be another important sub-factor, but their result shows that humidity level had a very small impact upon the thermal comfort of their subjects. Though air quality and thermal comfort are two important aspects of IEQ, many studies have investigated them together [29–31].

Luminous comfort is satisfaction with the luminous environment, and the level is most affected by the quality of daylight [32,33]. The window is the medium by which daylight accesses indoor areas and it is a significant predictor of satisfaction with lighting [13,34]. Features (such as floor plan, façade elements, type and shape of exterior shading, interior shade type, window size) [35], uncomfortable glare [36–38], luminance distribution [39], and solar access hours [33] are also thought to be key sub-factors determining luminous comfort.

Satisfaction with acoustics is strongly affected by physical environmental parameters [40] and sound insulation performance when residents want a quiet environment for relaxation and sleeping [41]. Studies have shown that building features can reduce the level of noise from outside, such as traffic noise [42–44]. Indoor noise sources, such as conversation, ringing phones, and machines, can also reduce satisfaction [45].

2.2. Building physical environment

Physical environment has been shown to have relationships with satisfaction with lighting, ventilation, and acoustics [13]. Floor level, orientation, window area, living room area, building features, and external obstructions have been confirmed as significant sub-factors of IEQ [33,46,47]. Dynamic façade technology also has an important role in balancing various aspects of IEQ [48].

2.3. Adaptive behaviors

OES is influenced not only by physical conditions, but also by residents' psychological adaptive behaviors [49,50]. Studies have demonstrated that adjusting behaviors, such as opening windows, closing blinds, and fitting clothing, is important to enhancing indoor comfort effectively [51,52]. Experiments have revealed that these behaviors are often affected by physical environment [53] and climate [54,55], though there is a little difference between females and males in perception of the same environment [56]. Residents are aware that their behavior is influenced by IEQ [7,15], so qualitative behavior studies are still called for to establish a reasonable range of indoor comfort levels [57].

2.4. Improve the OES structure

The literature review indicates that occupants' OES depends mostly on three aspects of IEQ, but that the perception of these IEQ aspects depends on sets of occupants' subjective feelings about sub-factors. In addition, buildings' physical parameters and individual behaviors have impacts on feelings about these sub-factors. Therefore, we proposed a three-step approach to assess OES (Fig. 1) in order to achieve the objectives mentioned in Section 1.

In the first step, the impact of IEQ aspects on occupants' OES is investigated. The second step aims to understand how sub-factors such as air freshness affect each IEQ aspect separately. Then the third step investigates the effects of physical environment and residents' adaptive behaviors on their subjective feelings about those sub-factors.

Download English Version:

<https://daneshyari.com/en/article/6730466>

Download Persian Version:

<https://daneshyari.com/article/6730466>

[Daneshyari.com](https://daneshyari.com)