DII-2017-052

Effect of Indoor Environmental Quality (IEQ) on the Comfort of Building Occupants in Gauteng, South Africa

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Abstract

There is continual argument about the potential negative impacts that poor indoor environmental quality can have on the wellbeing and comfort of occupants. The aim of this study is to investigate the effect of indoor environmental quality on the comfort of occupants of social mass housing projects in South Africa. The study was conducted in Ekurhuleni Metropolitan Municipality (EMM) where low-salary earners mostly reside in South Africa. The descriptive survey research method was adopted and the questionnaire used for the study was targeted at occupants of low-salary housing units in South Africa. The convenience sampling technique was employed for the study. The methods of data analysis basically include percentages and mean item scores. The results of the study indicate that furnishing, quality of air and thermal comfort on the fourth floor does not give occupants satisfactory comfort. The thermal comfort on the third floor is also unsatisfactory. Cleanliness and general maintenance and acoustic quality on the first floor are unsatisfactory to building occupants. Based on these, it was recommended that the acoustic designs of units on the first floor should be increased beyond those of second floor and above. It also recommended that attention should be specially paid to general cleanliness and maintenance of the first floors of building units. Finally, it was recommended that the thermal comfort of building units needs to generally be improved from the design stage. The significance of this study is that building designers and clients will subsequently see the reason to pay more attention to the thermal comfort during construction planning and increase acoustic and cleanliness activities for the first floor of buildings

Keywords: building occupants, housing project, indoor environmental quality, low-salary earners, South Africa.

1. Introduction

After the South African apartheid that ended in 1994, providing accommodation for citizens especially the poor has been a major challenge for the government according to the Department of Housing. In a bid to solve this problem, various policies, strategies, programmes and projects were introduced. In spite of these policies, housing problem remains unsolved (Othman and Mia, 2008). In view of this, government started social and rental lodging programs which concentrated on encouraging access to rental housing and supporting urban rebuilding and incorporation.

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Social housing primarily seeks a formal technique for recovering and taking care of valued housing for low-salary workers, with the point of giving adequate comfort to low-wage families. Therefore, social housing ventures are accepted to address more extensive personal satisfaction needs (Onatu, 2010). Also, most people have been said to spend much of their time in their homes, in which they direct the primary exercises of day-to-day living and rest consequently (Afacan and Demirkan, 2016). As a result, houses ought to be given in the right areas with vital social luxuries which eventually prompts enhanced personal satisfaction (EMM IDP, 2012). For this reason, it is imperative that an investigation of occupants' comfort level with indoor environmental quality (IEQ) in social housing projects in South Africa.

There is steady civil argument about the potential negative impacts that poor indoor environmental quality can have on the wellbeing and comfort of occupants (Afacan and Dermikan, 2016). The need to guarantee quality and clients' fulfilment has become noteworthy to government and those involved in housing arrangements in many nations (Ibem, 2012). According to Ngxubaza (2010) the South African housing delivery plan is faced with various economic and social challenges which include a high unemployment rate, low income, huge housing backlog and lack of infrastructure.

Moreover, Suleiman *et al.* (2013) noted that IEQ is often not considered as a major aspect of design during development planning and management. This leads to imbalance indoor environmental quality which consequently results in negative impact on facilities, building and occupants. The imbalance contributes to the health quality of occupants and Sick Building Syndrome (SBS) in most cases.

According to Afacan and Dermikah (2016) there are continual debates about the potential negative effects of poor indoor environmental quality on health, quality of life, user satisfaction, comfort, performance and productivity. In addition, the Department of Local Government and Housing explained their awareness of poor development quality of houses and urban offices for new ventures. In addition, the effect of poor indoor natural conditions, such as high indoor contamination, low or high indoor temperatures, absence of light, commotion and so on can be lead to discomfort for occupants (Lavelle, 2010).

Therefore, ensuring high IEQ requires a complete approach towards lighting, acoustics, commotion control, ventilation and warm solace. Although, many studies have been conducted on IEQ; none has been found to examine the IEQ of social housing projects in South Africa. Having a solid indoor environment is essential for occupants and it is based on this position that the study evaluates the effect of IEQ on the comfort of occupants in social housing projects in South Africa. The findings of the study are mostly beneficial to designers such as architects and services engineers as design areas with shortcomings will be highlighted in this study for further design attention.

2. Literature Review

Indoor environmental quality (IEQ) refers to the environmental qualities within a building and it is commonly utilized as a part of connection to the well-being and comfort of building occupants (Samari *et al,* 2013). It covers variables such as temperature, ventilation, indoor air quality, day lighting quality, warm solace and access to see. In addition, indoor environmental quality makes up one of the five classes of the Leadership in Energy and Environmental Design (LEED), created by the Green Building Council of the United States of America (USGBC).

IEQ influences client fulfilment and efficiency. Also, guaranteeing high IEQ requires a thorough approach towards lighting, acoustics, clamour control, ventilation and warm solace. Solid indoor environment is essential for tenants and diminishes the requirement for reconstruction and renovation (Afacan and Demirkan, 2016). The theory relating to indoor environmental quality is extremely wide and fuses different components which incorporate temperature, relative humidity, air speed, wind stream, inhabitancies, clamour, and lighting (Almeida et al., 2015). Furthermore, Liang *et al.* (2014) stated that IEQ refers to the ability of a building to deliver an indoor environment to occupants beyond their expectations. These expectations include occupants' health, comfort, well-being and productivity.

Thermal comfort is that state of mind that expresses fulfilment with thermal environment (Frontczak and Wargocki, 2011). Navai and Veitch (2003) described acoustic condition as a condition of happiness with acoustic conditions. The nature of sound environment is connected to various physical parameters, which incorporate both the physical properties of sound itself and the physical properties of a room. Sound is described by the sound weight level in a fleeting and long-haul period and by sound recurrence. The acoustic environment is affected by such physical room properties as sound protection, assimilation and resonation time.

The term comfort is not regularly utilized as a part of connection to indoor air quality and it is mainly associated with the absence of distress because of smell and tactile aggravation. Satisfactory air quality is characterized as air when there are no known contaminants and with which a dominant part of the general population does not express disappointment.

3. Research Method

This study was conducted in Ekurhuleni Metropolitan Municipality (EMM) where low-salary housing projects are concentrated in South Africa. The targeted respondents were the occupants that dwell within the social housing projects that are managed by the Ekurhuleni Development Company (EDC), an organisation that was set up in 2000 for the advancement and administration of rental lodging for low and direct pay families in South Africa. The rationale for choosing buildings managed by EDC is that, many of the housing units managed by the company are occupied by low income earners and it is not unlikely that some design deficiencies will be present in those buildings due to the cost of provision of those houses. Thus, this study was conducted only on the social-housing projects that are under the management of EDC.

Hence, 150 copies of structured questionnaire were administered on occupants of social housing projects in EMM in South Africa. All occupants of the housing projects in EMM were qualified for this study but for convenience, those that were interested in participating in the study were given the questionnaire. Hence, the convenience sampling technique was adopted for this study and only 50 questionnaires were returned. The methods of data analysis include percentages, mean scores, t-test and analysis of variance (ANOVA).

4. Data Analysis

Table 1 shows the general information of respondents and their houses. 66% of the respondents were females while 34% were males. This shows that there are more female respondents in this study than males. Also, 2% of respondents were 20-25 years, 20% were 26-30 years, 32% were 31-35 years, 22% were 36-40 years, 16% were 41-45 years and 8% were above 45 years. This indicates that majority of

the respondents fall within 26 and 45 years. In the same vein, 74% of the respondents are Africans by ethnicity while 22% were mixed-race.

Table 1: General information about respondents and their houses

	Percentage (%)
Gender	
Male	34
Female	66
Age	
20-25	2
26-30	20
31-35	32
36-40	22
41-45	16
Above 45	8
Ethnicity	
African	74
Mixed-race	26
Number of years in building unit	
Less than 1 year	16
1-5	44
6-10	40
Floor level of respondent	
First	50
Second	22
Third	18
Fourth	10
Direction of occupants' buildings	
North	20
East	26
West	8
Core	18
Do not know	28
Type of unit occupied	
2- bedroom unit	74
1- bedroom unit	26

Table 2 indicates the mean scores and ranks of the effect on indoor environmental quality on the comfort of occupants based on the floor level they stay. The results revealed that lighting quality was ranked first by occupants at first floor (MIS =3.68). It also ranked first in the overall analysis of respondents (3.70), However occupants in the second (3.36), third floor (3.67) and fourth (4.60) floor ranked it second. In addition, cleanliness and maintenance of buildings ranked first amongst occupants in the second floor (4.46) and third floor (4.00). First floor occupants ranked it fifth (2.88), occupants in the fourth floor ranked it third (4.20) and the overall ranking was third (3.56).

The study further indicates that on the fourth floor, furnishing (2.20), quality of air (1.60) and thermal comfort (1.40) do not give occupants satisfactory comforts. The reasons for these were not investigated in this study; hence it may require further investigation. Also, the thermal comfort on the third floor is also unsatisfactory (2.78). The reason for this too may be subjected to further investigation. Lastly, the cleanliness and general maintenance (2.88) on the first floor is unsatisfactory just as acoustic quality (2.80) is not satisfactory. It is understandable that first floors are closer to surrounding noise and dirt.

Therefore, sounds from vehicles, moving objects and persons may easily penetrate apartments on first floor and as such, they are susceptible to acoustic and cleanliness problems.

Table 2: Effect of IEQ elements on the comfort of social housing occupants based on floor level

IEQ Elements	1st floor Mean	Rank	2nd floor Mean	Rank	3rd floor Mean	Rank	4th floor Mean	Rank	Overall Mean	Rank
Lighting quality	3.68	1	3.36	2	3.67	2	4.60	2	3.70	1
Cleanliness and Maintenance of the building	2.88	6	4.46	1	4.00	1	4.20	3	3.56	2
Unit layout	3.32	3	3.00	5	3.56	5	4.80	1	3.44	3
Furnishings	3.44	2	3.00	5	3.56	5	2.20	5	3.24	4
Air quality	3.32	3	3.36	2	3.67	2	1.60	6	3.22	5
Acoustic Quality	2.80	7	3.36	2	3.67	2	3.40	4	3.14	6
Thermal comfort	3.24	5	3.00	5	2.78	7	1.40	7	2.92	7

5-Very high; 4-High; 3-Average; 2=Low; 1=Very low

Table 3 shows the mean scores and ranks of the effect of IEQ elements on occupant comfort based on type of units they occupy. The results are set against each other in order to study the variance in perception amongst different groups of occupants in the social housing project. The table reveals that lighting quality was ranked first by both the 2 bedroom (3.57) and 1 bedroom occupants (4.08) occupants. Also, Thermal comfort was ranked last by two bedroom (3.03) and one bedroom (2.62) occupants. Generally, the occupants agree that lighting quality (3.70) affects their comfort the most, followed by cleanliness and maintenance of building (3.56), layout of unit (3.44), furnishing (3.24), air quality (3.22), acoustic quality (3.14) and thermal comfort (2.92). It is noticeable that thermal comfort has low effect on the comfort of one bedroom occupants. This may be determined by the number of occupants in the apartments because the more people in an apartment, the less the thermal comfort will be.

Table 3: Effects of indoor environmental quality on the comfort of social housing occupants based on type of unit

IEQ Elements	**2-bedroom Mean**	**Rank**	**One bedroom Mean**	**Rank**	**Overall Mean**	**Rank**
Lighting quality	3.57	1	4.08	1	3.70	1
Cleanliness and maintenance of the building	3.38	4	4.08	1	3.56	2
Unit layout	3.35	5	3.69	3	3.44	3
Furnishings	3.43	2	2.69	6	3.24	4
Air quality	3.41	3	2.69	5	3.22	5
Acoustic Quality	3.03	6	3.46	4	3.14	6
Thermal comfort	3.03	7	2.62	7	2.92	7

5 = Very high; 4 = High; 3 = Average; 2 = Low; 1 = Very low

5. Discussion of Findings

This study investigates the effects of IEQ on the comfort of occupants of low-incomes houses in South Africa. The study revealed that the thermal comfort of the buildings is generally not acceptable to the occupants. Besides, the quality of air and furnishings in some of the apartments are also not satisfactory to occupants. The thermal condition of a building, whether too hot or too cold will not make occupants to enjoy the house, thus affecting their health negatively as claimed by Afacan and Dermican (2016). This is consistent with the findings of Lavelle (2010) that the effect of poor indoor natural conditions such as high indoor contamination, low or high indoor temperatures and absence of light can be lead to discomfort for occupants.

Furthermore, Liang *et al.* (2014) stated that IEQ refers to the ability of a building to deliver an indoor environment to occupants beyond their expectations which include occupants' health, comfort, well-being and productivity. This is in recognition of the fact that, a poor indoor environment will lead to sick building syndrome for occupants. As claimed by EMM, IDP (2012), this situation would leave to search for house in urban centres, hence the prompt for enhanced social personal satisfaction. Therefore, it is important to state that, regardless of the kind of houses or people to be catered for, indoor environmental quality should not be compromised because of the adverse effects it has on the occupants. Hence, designers are required to pay attention to thermal quality and indoor air quality when buildings are being designed for construction purposes.

6. Conclusion

Based on the findings of this study, the study concludes that generally, except for thermal comfort in building units, lighting quality; general cleanliness and maintenance; units' layout; furnishings in the units including chairs, dining set, wardrobes and kitchen cabinets; air quality and acoustic quality give satisfactory comfort to building occupants. The study further concludes that on the fourth floor, furnishings, quality of air and thermal comfort do not give occupants satisfactory comforts.

Also, the thermal comfort on the third floor is also unsatisfactory to occupants. Moreover, the cleanliness and general maintenance and acoustic quality on the first floor is unsatisfactory to building occupants. Finally, the study concludes that the thermal comfort in one bedroom units gives unsatisfactory comfort to building occupants.

Based on these conclusions, the study recommends that the acoustic designs of units on the first floor should be increased beyond those of second floor and beyond. It was also recommended that, attention should be specially paid to general cleanliness and maintenance of the first floors of building units. Also, the study recommends further investigation into the reason for poor thermal comfort and air quality on some floors of building units. Finally, it was recommended that thermal comfort of building units needs to generally be improved from design stage.

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