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Adoption of Smart Structures for Prevention of Health Hazards in Buildings

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Abstract. The importance of building quality to the health and well-being of occupants and surrounding neighbors cannot be overemphasized. Smart structures were construed to proffer solution to various issues of sustainable development including social factors that is concerned with health and safety of people. Based on existing literature materials on building quality, smart structures and general aspect of sustainable developments, this study examined the benefits of smart structures in the prevention of various health issues in infrastructural buildings, which has been a concern for stakeholders in the architecture, engineering and construction industry. The criterion for indoor environmental quality was adopted and various health and bodily issues related to building quality were explained. The adoption of smart structure concept will help to manage physical, chemical, biological and psychological factors of building with a view to enhancing better quality of life of occupants.

1. Introduction

Chemicals of interest in the built environment [1] are volatile and semi-volatile organic compounds (VOC's), pesticides, and some chemicals produced during combustion such as carbon monoxide and nitrogen oxides. Health issues such as cancer, resulting from combustion occurring indoors have been a growing concern for researchers studying the phenomena of the sick building syndrome and indoor environmental quality. However, these studies have also included VOC'S (such as benzene, toluene, ethyl, benzene and xylene among others) and the health effects thereof, primarily because building occupants are continuously experiencing inexplicable discomfort in their homes. The reasons for this happenings need to be identified as being separated directly from the construction or physical attributes of the building [1-4].

A more chemical approach can be taken to understand illnesses such as cancer, asthma and the likes, as the chemical reactions occurring in and around the building could well be the contributing factor for their occurrence. However, these chemical reactions and the products thereof need to be taken into consideration whenever a survey of indoor environmental quality, which is an aspect of smart structure concept, is carried out. Leukaemia in children has also been attributed to the presence of plastic in the dust particles within the building that could have been obtained or transported in small fragments from the external environment, and the mixture attacks the children's weak immune system and causes chronic illness [1-3].

In the early 2000's, researchers embarked on studies comparing the relationship and connection between VOC's and children contracting leukemia as well as asthma contraction amongst building occupants. The study [5] showed that depending on the child's age, the likelihood to contract any chronic illness was dependent on the amount of VOC's the baby or toddler was exposed to. This contradicts a study performed in England [6] where it was found that the likelihood was not based on the exposure to VOC's excluding exposure to formaldehyde, but, rather the degree of dampness that



the building had and the inhalation, or constant inhalation of the damp air in and around the building. There has been leading to higher illness amongst children in the UK as compared to teenagers and adults [1]. From the view of indoor environmental quality and based on existing literature materials, the purpose of this research is to discuss the implications of the adoption of Smart structure concept on health and safety of buildings occupants.

2. Health and bodily issues of building quality

This section discusses various health and safety risks associated with the quality of infrastructural buildings. They are explained based on their manifestations among the people living within or around a sick building.

2.1. Nasal manifestations

Nasal stuffiness: The sudden stuffiness of the nasal passage is a common occurrence in buildings with stuffy air but the sensation does not last as the stuffiness perishes soon after the person leaves the premise of the building and changes environments. However, for the duration of the stay in the building giving the sensation, the occupant will continue to experience the discomfort. Although, this stuffy sensation doesn't lead to itching, it is however linked to the temperature levels that prevail within the building [7, 8].

Nasal irritation and rhinorrhea: These nasal discomforts are not as common in buildings but are worth note as these are as a result of allergic conditions that the occupants have been experiencing, and are therefore not prevalent in the general population that enters a given space [8-10].

2.2. Ocular manifestations

The Ocular manifestation is related to the discomfort of the eyes. Sick building occupants experience an array of eye-burning sensations as a result of the breaking up tear film in the eyes but, fortunately these manifestations are prevalent on people who wear contact lenses rather than those who do not wear such [8].

2.3. Oropharyngeal manifestations

Although, examination of the throat does not reveal any inflammation, the most prevalent symptom of oropharyngeal infection is throat dryness. Studies also revealed that these can be resolved by the consumption of large quantities of water or any other liquid as the dampening of the throat will alleviate the pain experienced, and these manifestations generally have no serious aftermath [7, 9].

2.4. Cutaneous manifestations

Female occupants of sick buildings are privy to a certain phenomenon that causes dryness of the skin, which is generally contracted from the working environment over a period of time. These manifestations have been attributed to the heat prevalent in the building and how the building humidity affects air movements and subsequently transfers to the exposed skin of the building occupant, particularly the females [7-10].

2.5. Respiratory manifestations

Existing studies have shown that respiratory manifestations are not linked to asthma but, building related manifestations do cause the tightening of the chest and difficulties in breathing. However, like cutaneous manifestations, these can also be alleviated with a simple remedy, that is, stepping outdoors for a breath of fresh air [8, 9].

2.6. Constitutional diseases

Constitutional diseases include diseases such as eczema and sinusitis and these may be exacerbated in certain buildings. Sensations such as fatigue occur mostly during the second half of the working day, and cannot be alleviated by simply manipulating one's dietary intake at lunchtime. Previous studies have shown that constitutional diseases are often linked to high room temperatures [7, 8].

2.7. General manifestations

One of the most frequent experiences in buildings that create discomfort are headaches and excessive fatigue, which may be frequently experienced or on several days. They usually affect the frontal lobe of the brain in similar fashion to a migraine and are attributed mainly to the presence of artificial lighting and fluorescent lights in buildings. These can be alleviated by moving from the artificially lit room and or the wearing of sunglasses in order to prevent the sensation of these headaches which in effect do lead to fatigue [9, 10].

3. Benefits of smart structures

When considering the manner in which smart buildings can affect building occupants, it is essential to distinguish the factors that will be of significance to the occupants and how these factors can subsequently be grouped. Existing studies have classified the factors into four groups, which include physical factors, chemical factors, biological factors and psychological factors [8]. The focus of this study is on the physical factors since they have a more external effect on the building occupants of building and are subject to standards. These include aspects such as temperature, humidity, ventilation as well as other physical aspects of infrastructural buildings [5, 9, 11].

3.1. Temperature

In order for comfort to be ensured, the standard room temperature is to be set at a range between 20 and 26 and in order to compensate for the added heat on bodies due to clothing. The recommended temperature between the 6 degree range is 23 so as not to impair mental thinking ability and focus during the day as a result of added body heat [7].

High room temperatures lead to not only fatigue and reduced mental ability, but when overheated, the gaseous chemicals contained in materials begin to release and contaminate the air affecting the indoor air quality of the given building, and increases the likelihood of occupant dissatisfaction with the indoor environmental quality of the building and so too the perception of what constitutes the IEQ.

3.2. Relative humidity

Mold development due to rising temperatures causes discomfort through as a result of humidity level at varying times during day. As a result of this, many issues of discomfort especially in cold regions, the change in temperature reacts negatively with the building materials used to construct the house as these were used with the thought in mind that the conditions are a certain way and temperatures remain in a particular range. However, if these change, the building can react by means of cracking [8, 9, 11].

With the increase or decrease of the humidity, the experiences and reactions from both people and buildings are different, meaning that exposure to low humidity can result in fever and other ill responses by the body if it is used to more arid and humid temperatures, thus, if the humidity lowers or raises and remains that way for a while, the chemical reactions takes place, which may be injurious to the people and also affect the building negatively.

The reactions of the people and buildings will not surface until the predominating humidity level has adjusted and remained that way. Therefore, it can be deduced that while studying the concept of smart building, indoor environmental quality and or sick building syndrome, the researcher is obliged to be aware of the humidity situation of the area being surveyed. This will help to direct survey responses to either a lack of knowledge of humidity change and or the ignorance thereof, so the two will not be confused with the actual IEQ criteria being studied. Also, all responses from the former categories must be discarded as fruit of the poisonous tree.

3.3. Ventilation

Ventilation standards differ from areas with and without smokers but, a lack of ventilation is the main reason for the building occupants experiencing poor air quality as any and every contaminant that enters the building can create a stuffy atmosphere therein and the resulting discomfort [9, 11].

In non-smoker areas, a rate of ventilation of 8l/s/person would be sufficient to permit the transfer and removal of animal and human body odors from the room or building, therefore making for a

pleasant atmosphere for all who are within it. Whereas, if the same rate of ventilation is applied in a room but the CO₂ rate was 0.1%, a fifth of the people entering that given room would be displeased with the atmosphere meaning that the ventilation rate need be reduced as this will also reduce the amount of unwanted odors and air entering the room or building [7, 11]. In a smokers room, the contrary applies, as the building would be satisfying for any person who smokes or is used to smoking would find the place pleasant. If a person enters the building or room and finds it unpleasant, rather than reducing the ventilation rate, in this case it would be increased as a result of the presence of more unpleasant air [7]

Building ventilation contributes to the reduction of building contaminants' concentration caused by building materials and processes occurring within any given building [7, 8]. The best way to reduce building contaminants is through source control, and the understanding that ventilation alone is not prone enough to cause issues detrimental to building health such as draughts and odors [9]. Therefore, close attention must be observed when maintaining and using ventilation equipment so as to ensure a clean breeze, and not to impair the building beyond that which it is except is due to third-party contaminants other than ventilation problems.

3.4. Artificial light

The adoption of artificial light as compared to the conventional lighting that is used in homes, that is, fluorescent tube lighting, can result in the reduction of eye stress and discomfort. This is because the artificial light releases a lower light into the building thus, lower strain is imposed on the eyes and the prevalence of headaches as the conventional lighting creates a painful glare and strain which leads to unwanted health and challenges [8, 9].

3.5. Noise/Acoustic comfort

Excessive noise is attributed to fatigue and discomfort as the high noise levels create annoyance and frustration, thus affecting one's mental capabilities such as rational thinking, and can hamper one's quality of sleep [1, 9]. Although, dizziness and nausea are attributed to the prevalence of infrasound, it is not likely to affect the building occupants as these would be sounds that our ear cannot hear but, the noise created by a building consists of cracks and creeks and rumbling which creates the disturbances and unwanted noise due to outdoor contributions such as a loud neighborhood. A very good example is a railway track that produces loud vibrations [8].

People are sensitive to noise, and the building they reside has to provide them with a means of shelter from excessive noise in an attempt to create a peaceful indoor environment. Therefore, the amount of noise or the noise levels experienced within a house is fundamental aspect of the indoor environmental quality criteria that determines the satisfaction of occupants with a building.

3.6. Particles and fibers

Dust develops in buildings due to various reasons such as the degree of ventilation, the degree of hygiene or cleanliness within the home, the amount of traffic outdoors, the type of traffic (such as trucks), the proximity of vehicles from the building (such as how far the fence is from the roadway) as well as the degree of tobacco smoking in and around the building. These impact of these factors increases if there is a dirt road near the building as the dust particles from the outside will be transported into the building, creating chest tightness in time and wheezing as the dust particles stick to the chest [7, 9]. In dustier environment, the building occupant can inflict self-discomfort through contact with man-made fibers which can be contracted from the ceilings of buildings, this usually create eye discomfort and skin irritation through hand contact.

4. Conclusion

This study has been able to discuss various health hazards in buildings and the benefits of smart structure concept in addressing them. The study concluded that the adoption of smart structure concept will improve the indoor environment of infrastructural buildings, thereby enhancing the work performance of the building occupants. The research will also help construction professionals and other stakeholders in considering the provision of buildings that contributes to the effective

performance of building occupants in the work environment. This will help the architecture, engineering and construction sector of any economy to incorporate strategies that will result in improvement in the reduction of health and safety issues of infrastructural buildings.

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