

OCCUPANTS' SATISFACTION ON GREEN CERTIFIED FACTORY BUILDINGS IN SRI LANKA

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Abstract:

Factory buildings play an important role in socio-economic environment in Sri Lanka while significantly contributing to the resource consumption. Therefore, the application of green building concept, which ensures the well-being of both human and environment is crucial to this end. While leaving a lighter footprint on the environment, a successful green building should be able to meet the classical building design concerns of economy, utility, durability, and comfort requirements. The occupants' satisfaction also needs to be given a special attention as it directly relates with the occupants' productivity. However, a lack of concern on the occupants' satisfaction can be seen in green factory buildings in Sri Lanka and thus, the research aimed at investigating the occupants' satisfaction and identify the causes for dissatisfaction if any. A semi structured questionnaire survey was conducted among total of 50 occupants selected from five green factory buildings in order to identify their level of satisfaction. The Mean Weighted Rating method was employed for data analysis. The research identified that the satisfaction level of occupants is at a good level though the occupants' dissatisfaction in green factory buildings was mainly caused by difficulties engaged with adjusting the light, room temperature, and room ventilation levels.

Keywords: *Occupants' Satisfaction, Green Buildings, Factory Buildings*

1. Introduction

Green Building concept is a practice of creating and using healthier and more resource-efficient model of construction, renovation, operation, maintenance and demolition (Chan, Qian & Lam, 2009 and Calkins, 2004). According to the United States Green Building Council [USGBC], (2009), green buildings reduce the environmental impact significantly while using energy, water, and other resources efficiently by adopting various sustainable attributes for resource conservation Those attributes are sustainable site conditions, energy consumption, water efficiency, indoor environmental quality, material uses, etc. As Wong and Fan (2013) mentioned, due to global environmental

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concerns, green building design has become a mainstream building design goal in recent time. In the context of Sri Lanka, the green building concept is quite new but, is rapidly expanding all over different industries while searching for more resource efficient buildings for their usage (Green Building Council Sri Lanka [GBCSL], 2011). Manufacturing industry is one such industry and as a result, a number of green certified factories have been launched in the country.

Even though the green buildings provide many benefits and minimize the negative impact on environment, as per the previous researchers, occupants of some green building are not satisfied with their indoor environment (Leaman & Bordass, 2007). According to Abbaszadeh, Zagreus, Lehrer and Huizenga (2006), while some of the best green factory buildings can rank higher than the best conventional factory buildings, in terms of user experience i.e. comfort, health and productivity, a few of the lowest scoring factory buildings on user experience are also reported as being green. The environmental performance is not the only factor that should be considered in green buildings and occupants' satisfaction also needs to be given a special attention as it directly related with the occupants' productivity. Further, knowing about the satisfaction level of employees is important for the management of the factories to take initiatives to avoid such dissatisfactions. This study therefore, aimed at investigating the occupants' satisfaction level of green certified factory buildings in Sri Lanka.

The paper structure begins with a literature review on green building concept and the determinants of occupants' satisfaction in factory buildings. The paper then presents the methodology adopted for this study and discusses findings on the occupants' satisfaction level under each determinant. Finally, the paper is concluded by summarising the findings.

2. Literature Review

The following section reviews the literature findings gathered through a comprehensive literature survey.

2.1 GREEN BUILDINGS

As mentioned by Kats (2003), "green" or "sustainable" buildings use resources such as energy, water, material and land more efficiently than conventional buildings and contribute to improve occupants' health, comfort and productivity by providing more quality indoor environment. The main characteristic of the green buildings is the change of the built environment by creating energy efficient, healthy and productive buildings that reduces of the negative impacts of buildings on environment (Gou, Prasad and Siu-Yu Lau, 2013).

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As Bombugala and Atputharajah (2010) highlights, green buildings reduce carbon emissions by 35%, water usage by 40%, energy usage by 50%, and solid waste by 70%. Similarly, United States General Services Administration [USGSA] (2011) found out that, green buildings have 19% lower aggregate operational costs, 25% of less energy, and 36% of fewer CO₂ emissions. Nevertheless, green buildings should effectively use natural resources within economic means while supporting the health and wellbeing of the occupants (Wilkinson, Reed, & Jailani, 2011).

According to Gou et al. (2013), series of green building rating systems, protocols, guidelines and standards have been initiated in several countries with the green building revolution in past 20 years to fulfill the requirement of evaluating and benchmarking the performance of the buildings. United Kingdom (UK) started the first green rating system in 1990 known as Building Research Establishment Environmental Assessment Method (BREEAM) followed by United State of America (USA) in 1998, with Leadership in Energy and Environment Design (LEED). In addition, some of the other leading green building rating systems described by Isa, Rahman, Sipan, and Hwa (2013) are Building Environmental Assessment Methods (BEAM) – Hong Kong; Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) – Japan; Green Building Label (GBL) – China; Green Star – Australia; Green Mark – Singapore and Green Building Index – Malaysia. Amongst those green rating tools, LEED is the most popular rating tool which provides third party certification of green buildings and its market share is increasing in both US and international arena. GBCSL came into existence as a result of an emerging trend towards applying greener concepts for the built environment in Sri Lanka (GBCSL, 2011). However, a wide use of LEED rating system can be seen in Sri Lankan context as well, due to its international recognition.

2.2 OCCUPANTS' SATISFACTION ON GREEN BUILDINGS

Workspace satisfaction is directly affected to the job satisfaction. Occupants' needs have to be considered for comfort and workspace quality. These factors are very important for physiological and psychological reasons and play a significant economical role (Wagner, Gossauer, Moosmann, Gropp & Leonhart, 2007). The mental satisfaction, clear mind and reduced stress enhanced their concentration on work and it cause to reduce errors made by employees (Samaranayake & Silva, 2010). Moreover, Frontczak, Schiavon, Goins, Arens and Wargocki (2012) explained that much lower self-estimated productivity is reported by the occupants who worked in uncomfortable work environment than those who felt comfortable with the overall environment.

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The positive influence of green buildings on the occupants and employee productivity has been reported in the literature. The financial rate of return for productivity increases attributable to green building were shown to be nearly ten times than the energy, water, and other benefits. These financial savings are resulting from reduced absenteeism, improved product quality, increased rates of production and increased sales due to the employee satisfaction on green buildings (Gabe, Greenaway, & Morgan, 2007; Kats, 2003; Romm & Browning, 1994). Moreover, as USGSA (2011) highlighted, the occupant satisfaction on green buildings is 27% of higher than the conventional buildings. Further, this satisfaction is affected by indoor environmental quality which consists with thermal, acoustic, visual, indoor air quality, and by other features such as privacy, cleanliness, and personal control over the internal environment (World Green Building Council, 2013).

However, as stated by some researchers (Kim, Hwang, Lee, & Corser, 2015; Altomonte & Schiavon, 2014), although green buildings have the potential to enhance indoor environmental quality, they often fall short. Further, green certifications do not influence the satisfaction of occupants even though the buildings meet the recommended standards (Prakash, 2005). Some evidences from recent post-occupancy evaluations showed that, the green buildings often not perform to their best and therefore, the occupants' satisfaction is at a low level (Abbaszadeh et al., 2006). A study done by Prakash (2005) found that the occupants often complain about various parameters like day lighting and thermal comfort which directly contribute to better indoor environment quality and which has a positive impact on occupants' satisfaction of productivity and performance (Prakash, 2005). A study done by Ranasinghe, Perera, and Halwatura (2012), concluded that there were occupants who were dissatisfied with acoustic quality, artificial lighting and thermal comfort in green buildings. The, correlation between user satisfaction and the self-estimated job performance affects to the employee productivity (Veitch, Charles, Farley and Newsham., 2007) and therefore identifying the satisfactory level of occupants in green factory building seems essential in order to overcome the drawbacks that can be happened as a result.

2.3 DETERMINANTS OF OCCUPANTS' SATISFACTION ON GREEN FACTORY BUILDINGS

Under the support of Marks & Spencer's eco-initiative, one of the leading companies in Sri Lanka has built the world's first purpose-built green factory for apparel manufacturing and currently, most of other leading apparel manufacturing buildings are being certified as green (Mendis, 2013). The occupants' satisfaction level of the factory buildings should be in a higher level since they incorporate productivity driven business process (Kamaruzzaman &

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Sabrani, 2011). Therefore, there is a need of investigating the occupants' satisfaction on green certified factory buildings in Sri Lanka and identify the causes for dissatisfactions to achieve better performance from the green buildings. Before evaluating the occupants' satisfaction level, the identification of determinants of occupants' satisfaction on green certified factory buildings is essential. Thus, following shows the determinants of occupants' satisfaction on green certified factory buildings, identified through a comprehensive literature review.

2.3.1 *Thermal comfort*

According to Wagner et al. (2007), temperature is considered as an important factor for the general satisfaction in the workplace and it also might affect occupants' productivity. Occupants are more satisfied with the controllable indoor climate and effects of their different inventions strongly influence the satisfaction with thermal indoor conditions. Further, there are design standards such as American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) and ISO that provide guidance promising comfortable conditions (Levin (2003). Warm climate conditions could be occurred due to inefficient lighting systems. According to ASHRAE Standards (2004), air temperature, mean radiant temperature, air speed, humidity, metabolic rang, clothing insulation are the factors that affect the thermal comfort of occupants.

2.3.2. *Indoor air quality*

Levin (2003) described that indoor air quality generally consider about the outdoor air ventilation to control concentrations of contaminants indoors. Humidity level has an effect on occurrence of bacteria indoors and it leads to health problems. Chemical contaminants in indoor air cause health problems such as nausea. Individual chemical sensitivity differs from person to person. Therefore, when one person is infected, another one will not be infected. A special system has to be designed for those people but it is impossible to write guidelines for particular situation (Levin, 2003).

2.3.3. *Acoustic comfort*

According to Altomonte and Schiavon (2013), the noise level in workspace and sound privacy in workspace (ability to have conversations without neighbours overhearing and vice versa) are considered when talking about the acoustic comfort. The main objective of acoustic comfort is to reduce interferences for conversations or disruption of concentration (Levin, 2003). Noise affect to concentration and conversation, and cause health and safety issues such as pain, headache, nausea and permanent hearing loss. Therefore, standards, regulations and guidelines are presented to provide quality indoor environment

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as well as prevent physiological damage. As per Altomonte and Schiavon (2013), acoustic absorption and acoustic cover techniques are arranged to suck up excessive sound such as sound attenuators.

2.3.4 Visual comfort

As mentioned by Levin (2003), there must be adequate illumination level with enough contrast and accurate colour rendition for reading and other visual task performance. High lighting condition and low lighting condition can cause eye damage, headaches and stress and as a result it will reduce the productivity of occupants. Hirning, Isoardi and Cowling (2014) brought forward the idea that both health and energy benefits can be achieved by controlled use of daylight. Efficient lighting conditions can be provided and work performance and visual comfort can be enhanced by using natural lighting.

2.3.5 Spatial comfort

According to Frontczak et al., (2012), the satisfaction with the amount of space was ranked to be the most important for workspace satisfaction regardless of age group, gender, type of organization, distance of workspace from a window or satisfaction level with workspace. Satisfaction with the amount of space was not related to an approximate evaluation of the amount of space available per person at the work space. As mentioned by Altomonte and Schiavon (2013), amount of space available for individual work and storage, level of visual privacy, ease of interaction with co-workers, comfort of office furnishings (chair, desk, computer, equipment, etc.), ability to adjust furniture to meet employees' needs as well as colours and textures of flooring, furniture and surface finishes also determine the satisfaction of an occupant. Further, as Levin (2003) described, open plan environments are promoting low maintenance and operational costs, but it cause stress from loss of acoustic and visual privacy, from noise, and from a loss of occupant control over the indoor environment. Proper space planning and management provide cause to spatial comfort in work place. Thus, proper space planning and management concentrate about the efficient and effective use of work space.

2.3.6 Building maintenance and cleanliness

This includes cleanliness of the overall building and cleaning service provided to the workspace and general maintenance of the building. As Minnesota Department of Health (2008) described, inadequate cleaning is a significant aspect when considering about the deficiency in indoor environment quality. Dirty, dusty and minimally cleaned environment may cause allergy and possibly other symptoms to sensitive building occupants. Therefore, factors such as general cleanliness, general maintenance of the building and personal

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workspace should be considered when assuring satisfaction regarding building maintenance and cleanliness (Altomonte and Schiavon, 2013).

3. Research Methodology

The research was approached using survey method and a semi structured questionnaire survey was carried out to evaluate the satisfaction level of occupants and occupants' expectations for comfortable working environment. Total of fifty numbers of occupants were randomly selected from five green certified factories for the survey, which have obtained the green certification before minimum of three years. Mean Weighted Rating system was used to analyse the questionnaire findings. Arithmetic Mean of responses was calculated for each criterion and based on the calculated mean values, satisfaction levels were evaluated.

4. Data Analysis and Discussion

4.1 OCCUPANTS' SATISFACTION LEVEL OF GREEN CERTIFIED FACTORY BUILDINGS IN SRI LANKA

The Occupants' satisfaction survey was conducted to measure the level of satisfaction of employees towards green certified factory buildings under 07 categories i.e. Thermal Comfort, Indoor Air Quality, Acoustic Comfort, Visual Comfort, Spatial Comfort, Building Maintenance and Cleanliness and Overall Satisfaction level. Further, 1-5 Liker scale, where 5, 4, 3, 2 and 1 represent Excellent, Good, Moderate, Poor and Very Poor satisfaction levels respectively was used in data collection. Mean Weighted Rating system was adopted to analyse the collected data and to determine the user satisfaction level on each criteria. *Figure 1 to Figure 7* shows the calculated mean values of the occupants' satisfaction under the above mentioned 07 criteria.

According to the *Figure 1*, "ability to adjust the room temperature" scored as the lowest mean value (2.20) which indicates a poor satisfaction level of the occupants under the thermal comfort criterion. Except that criteria, occupants have good satisfaction level on other two parameters.

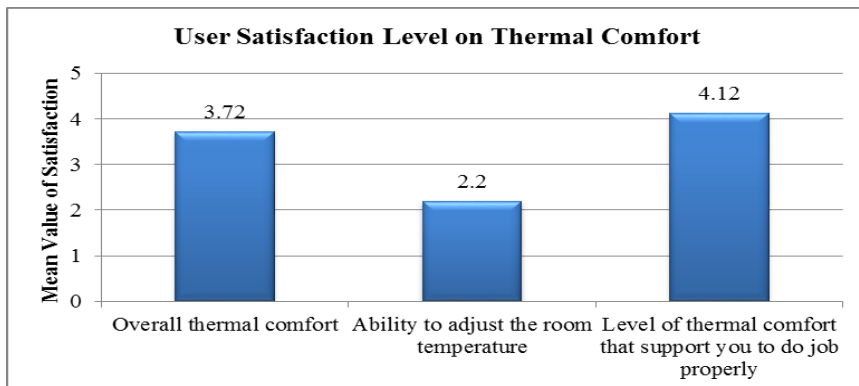


Figure 1: User satisfaction level on thermal comfort

As it is shown in *Figure 2*, Indoor Air Quality criterion is considered, “ability to adjust the room ventilation scored approximately mean value of 02 and scored as poor. The factor “moisture controlled ventilation” scored approximately mean value of 03 and rate as moderate. Further, all the other criteria (06 out of 08) scored approximately mean value of 04 showing that the occupants’ satisfaction level is good.

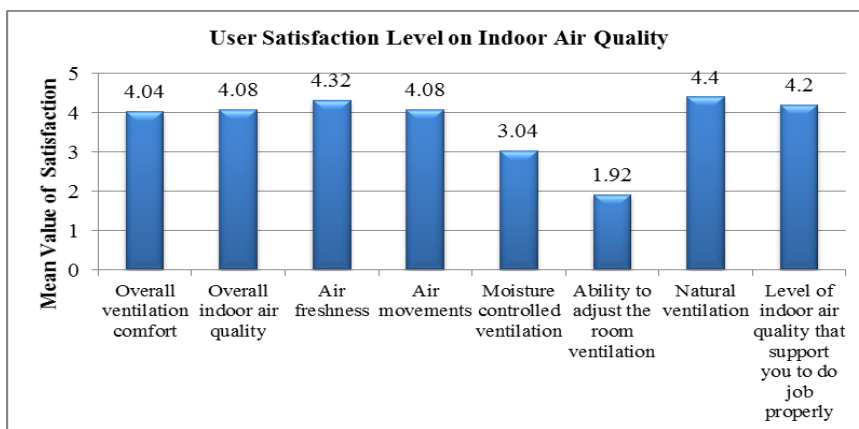


Figure 2: User satisfaction level on indoor air quality

All the factors affecting Acoustic Comfort were scored as less than 04 (Refer *Figure 3*). The analysis indicated that the “noise from ventilation system” was scored mean value of 03 approximately which means the

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satisfaction is in a moderate level. However, the mean value scores, the satisfaction on acoustic comfort lie between moderate to good level.

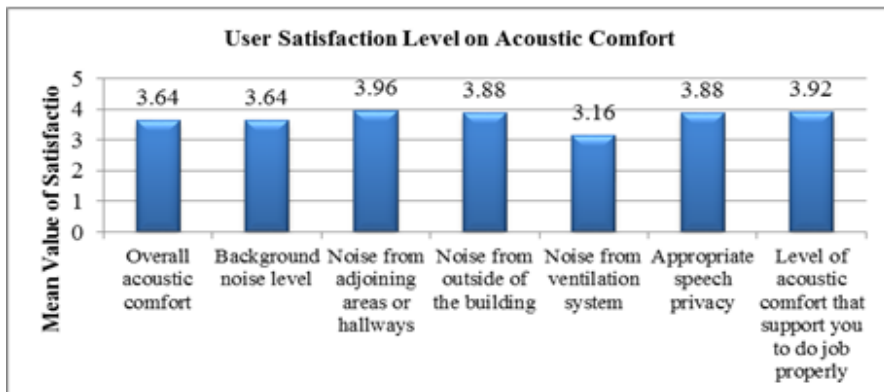


Figure 3: User satisfaction level on acoustic comfort

Further, according Figure 04, “noise from the lights” and “ability to adjust the light level” under Visual Comfort, indicate the highest and lowest satisfaction on the given scale respectively. Except those criteria, occupants comprise with a good satisfaction level on other criteria (09 out of 11), which scored approximately mean value of 04.

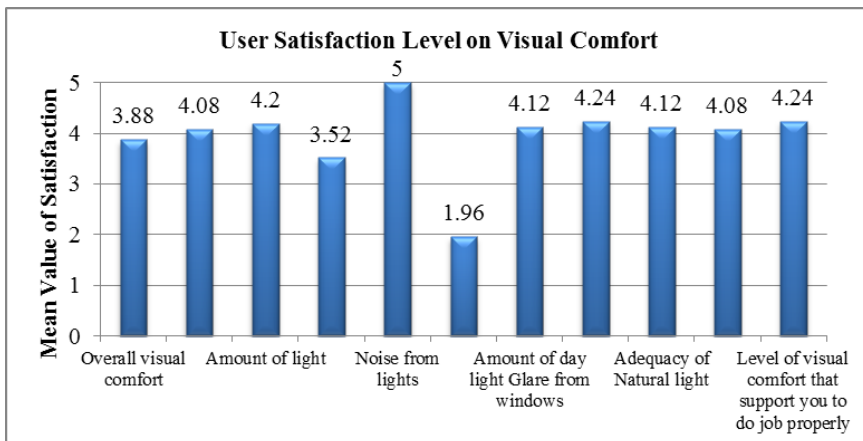


Figure 4: User satisfaction level on visual comfort

In Spatial Comfort category, most of the criteria (4 out of 5) scored as the satisfaction is in a good level while, “overall spatial comfort” varies from moderate to good level (Refer Figure 5).

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Figure 5: User satisfaction level on spatial comfort

As it is shown in Figure 6, the occupants are moderately satisfied about the “cleaning service provide for work space while the occupants’ satisfaction on Building Maintenance is at a good level.

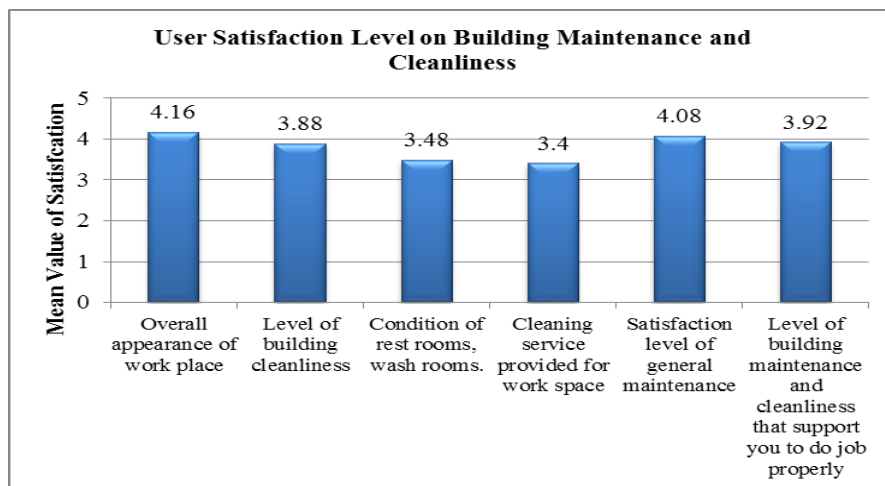


Figure 6: User satisfaction on building maintenance and cleanliness

According to Figure 7, overall satisfaction level indicate the general satisfaction level of occupants and that was scored approximately mean value of 4, which means the overall satisfaction of the occupants’ in green factory buildings in Sri Lanka is at a good level.

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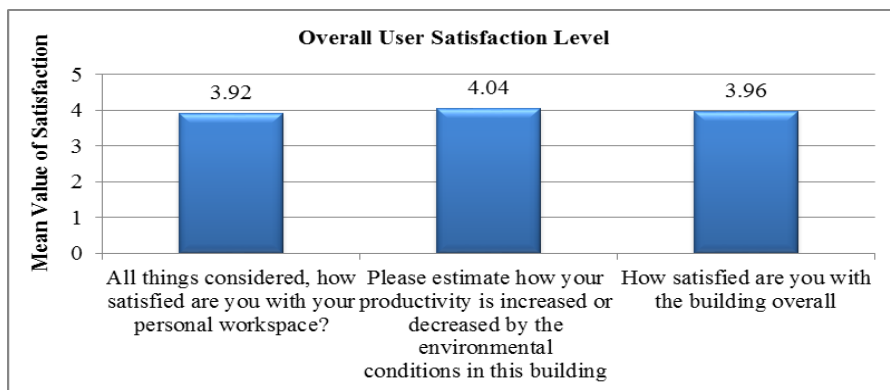


Figure 7: Overall user satisfaction level

The above analysis identified the factors which the occupants are satisfied with and dissatisfied with. The areas on which occupants’ dissatisfied with are adjusting the light, room temperature, and room ventilation levels. Further, the analysis also indicated that the factors which the occupants are moderately satisfied with. They are moisture controlled ventilation, noise coming from ventilation system, condition of rest rooms and washrooms, and cleaning service provided for work space. The next section analyses the causes for occupants’ dissatisfactions.

4.2 CUASES FOR DISSATISFACTION

The causes for dissatisfactions are summarised in the *Table 1*.

Table 1: Causes for Occupants’ Dissatisfaction

Dissatisfaction Factor	Cause
Adjusting the light level	Light dimming facilities are not available for the workers
	Lighting controllers are at the engineering control rooms
	Automation of artificial lighting system
Adjusting the room temperature level	Temperature controlling facilities are not available for the workers while employees in the top management can adjust their room temperature
	Controllers of the ventilation system are at the engineering control rooms
Dissatisfaction Factor	Cause
Moisture controlled ventilation	Use of evaporative cooling systems
	Moisture controlling systems are not available

Adjusting the room ventilation level	Room ventilation controlling facilities are not available for the workers while employees in the top management can adjust their room ventilation
	Controllers of the ventilation system are at the engineering control rooms
Noise from ventilation system	Additional noise due to the operation of diffusers in ventilation system, other than the sound from machinery which the occupants always get use to
Condition of rest rooms and washrooms	Deficiencies on the housekeeping systems of the factories
Cleaning service provided for work space	Deficiencies on the housekeeping systems of the factories

According to the *Table 1*, the main causes for occupants' dissatisfactions on adjusting the light, room temperature, and room ventilation levels are, the unavailability of relevant controlling facilities for the light, room temperature, room ventilation and moisture level with the workers and those controllers are available at the engineering control rooms.

5. Conclusion

Conventional buildings have more impact on environment and consume more resources. With the global environmental conditions, limitation of resources and competition, organisations tend to develop green buildings. The green building concept can be identified as a new approach to develop facilities with reducing adverse impact on environment, save energy, water and material resources in construction and operation of the buildings as well as minimising the cost.

When considering about various types of buildings, a considerable impact is occurred to the environment by factory buildings as their resource consumption is high compared with other facilities. Therefore, management of factory buildings tend to follow green concept in their factory buildings. Management should implement green strategies in the factory buildings while concerning about the satisfaction of occupants on the factory environment. Because, Occupants' satisfaction is identified as very essential factor that is directly affect to occupants' productivity, efficiency as well as organizations' profitability.

A comprehensive literature identified thermal comfort, indoor air quality, acoustic comfort, visual comfort, spatial comfort and building maintenance and cleanliness as the key criteria which affect the occupants' satisfaction in building. Based on the identified criteria, a user satisfaction survey

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questionnaire was prepared and Mean values were calculated. In addition, the overall satisfaction level of the occupants was also measured. Based on mean values, user satisfaction level on each criterion was determined. By evaluating mean values, it was identified that there is a good satisfaction level on each criterion except the criterion adjusting the light, room temperature, and room ventilation levels, moisture controlled ventilation, noise from ventilation system, condition of rest rooms and washrooms, and cleaning service provided for work space.

Further, causes for dissatisfaction of occupants on green certified factory buildings were also identified through semi-structured questionnaires. The unavailability of relevant controlling facilities for the light, room temperature, room ventilation and moisture level with the workers, and controllers are available at the engineering control rooms are the main causes for dissatisfaction. Use of evaporative cooling systems and deficiencies of the housekeeping and maintenance systems are contributing factors to this end.

Hence, the research identified that the satisfaction level of occupants is at a good level though there are some factors that lead to occupants' dissatisfaction. Addressing those factors and eliminating the causes of dissatisfaction will help to achieve better performances from the green certified factory buildings in Sri Lanka in the near future.

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