JSACE 4/13

Improving Occupant's Satisfaction and Productivity in Sustainable Building Design

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Received 2015/07/03

Accepted after revision 2015/08/29

http://dx.doi.org/10.5755/j01.sace.13.4.13048

Indoor environmental quality in green buildings is generally assumed to be superior to conventional buildings. This assumption stems from prerequisites in indoor environmental quality credits in LEED, BREEAM and other green building certificates. But the viewpoint of green building occupants on this subject is also needed. Quality in lighting, air, acoustics, thermal environment and other environmental aspects must be in accordance with competences for the green building certifications, furthermore they must be in accordance with occupant expectations from an indoor environment. Green buildings must provide a productive workplace for its occupants and that is not possible without occupant's satisfaction and comfort. This paper presents the findings of the literature research about occupant satisfaction, health and productivity in green buildings-particularly in offices and the results of the survey which is administered in a LEED EBOM (Existing Buildings Operation &Maintenance) certified office building in Istanbul. Two questionnaires are carried out within the context of the study; one is before and the other is after the renovations done so as to get the LEED certificate. The study shows that having a LEED certificate doesn't guarantee the maximum employee satisfaction. Analysis of the research findings indicate that, green buildings must be designed, renovated and operated considering not only energy and material regulations but also indoor environmental issues that the occupants could face.

KEYWORDS: indoor environmental quality, satisfaction, LEED, office buildings, health.

Introduction

While sustainability becomes more and more important for energy and material usages, it also becomes a key word for organizations. Indoor environmental quality and individual performance, health, comfort and overall satisfaction are key factors to determine overall organizational success. Current green building practices generally tend to undervalue user factor and they miss the opportunity to use building as a strategic asset (Heerwagen, 2000). Rating systems like LEED or BREAM rewards Indoor Environmental Quality (IEQ) on designated standards but even though these standards are met, occupant satisfaction of these standards is another research subject for more productive green buildings and more productive organizations. Analyzing and embedding occupant satisfaction in green design practices are also valuable for future development and improvement of green buildings (Abbaszadeh et.al, 2006).

IEQ is quite related to sick building syndrome symptoms, respiratory illnesses, sick leave and losses in productivity (Seppänen &Fisk, 2006).Especially in working spaces, improving indoor con-

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Journal of Sustainable Architecture and Civil Engineering
Vol. 4 / No. 13 / 2015
pp. 39-48
DOI 10.5755/j01.sace.13.4.13048
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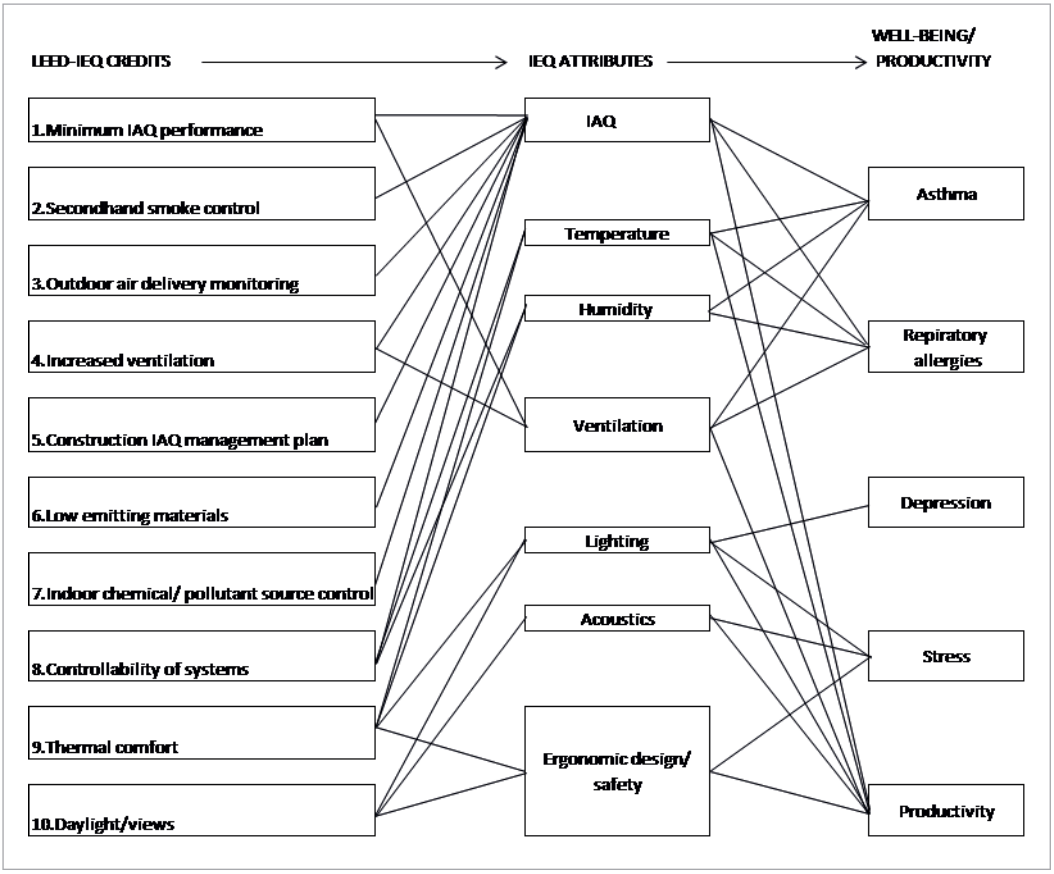
ditions and ensuring occupants satisfaction and well-being is essential. Today's work culture is team oriented, hence if one employee is absent or not working at full productivity, then the team is hurt exponentially (Miller et al., 2009).Improving IEQ in workplace increases performance which can be expressed in a directly quantifiable reduction of absenteeism, such as a reduction in the number of employees that leave work too early or take long lunch breaks (Roelofsen, 2002). Fig.1 presents LEED IEQ criteria and corresponding health issues.

IEQ of green buildings is generally assumed to be better than conventional buildings. There are many reasons to make this assumption, including improved ventilation, increased personal control, removed indoor pollutants, more usage of day lighting, task lights, green materials etc. (Abbaszadeh et al, 2006). However, literature research gives confounding results about perceived IEQ and occupant satisfaction in green buildings compared with conventional buildings.

While some of the studies present a strong relationship between green buildings and higher occupant satisfaction, some of them present weak or no relationship at all. For example, Newsham et.al (2013) assert that green buildings have superior indoor environmental performance compared with similar conventional buildings in terms of environmental satisfaction, satisfaction with thermal conditions, satisfaction with a view to the outside, aesthetic appearance, less disturbance from HVAC noise, workplace image, nighttime sleep quality, mood, physical symptoms, and a reduced number of airborne particulates. Therewithal, Abbaszadeh et al. (2006) assert that, lighting and acoustics quality is not sufficient in green buildings as against with air quality and thermal comfort. Another study (Issa et al., 2011) shows that green schools in Toronto offer better lighting, thermal comfort, indoor air quality, heating ventilation and air conditioning of indoor environments but does not indicate any significant difference for absenteeism and student performance. Miller et al. (2009) performed a study to measure green buildings contribution to productive en-

Fig. 1
LEED and IEQ
(Singh et.al, 2010)



vironment for workers in comparison with non-green buildings and the outcome is the following; 12% strongly agree that employees are more productive, 42.5% agree that employees are more productive, and 45% indicate no change. Considering absenteeism, participants indicated %45 fewer sick days, %45 same as before and %10 more sick days after moving to green building. Taking into account only the workers claimed increased productivity and fewer sick days, the result is %4.88 increase in productivity and 2.88 fewer sick days taken on average. Paul and Taylor (2007) compared green Charles Sturt University and conventional La Trobe University in terms of the occupier comfort and satisfaction; they differed only in perceived temperature. Other aspects like noise, ventilation, serenity or aesthetics were rated nearly the same. This equality is attributed to the inoperative cooling system in CSU building and it is asserted that the negative effect of the warmer environment at Charles State University building must have outweighed any positive effects of air quality. Another survey in China (Gou et al., 2013) shows that green building users are slightly more satisfied than non-green building users in terms of design, needs, productivity and health but they are not significantly more comfortable with indoor environments. Even in winter, air, temperature and noise are less comfortable as against non-green buildings. Six-star green educational Tyree Energy Technologies Building (TETB) in Australia is analyzed by Wang and Zamri (2013).The results demonstrate that occupants are mostly not happy with their space/room layout quality followed by indoor air quality, acoustic quality, lighting quality and lastly thermal quality. It is also mentioned that there is no significant relationship between study/work performance and overall indoor air quality and overall lighting quality. Acoustic quality, thermal quality and room/space layout are more significant factors that possible to effect study/work performance.

Current researches on IEQ clearly indicate the necessity to develop an occupant-centered green philosophy which is supported with the regulatory actions. A green building must be designed, constructed and operated considering user requests and needs. This paper aims to investigate how a green building improves the occupant's satisfaction, comfort and productivity and focuses on user satisfaction and expectations from green indoor environments. With identifying dissatisfactory factors and their sources in green building indoors, architects and facility managers can also concentrate on this issues as well as certificate competences. Results of the former studies will be supported with a survey in a LEED certified office building in İstanbul.

Indoor Environmental Quality Parameters

As far as IEQ in green buildings is concerned, parameters like lighting quality, thermal quality, air quality, acoustics quality and cleaning quality must be analyzed in order to understand the occupant's requests and needs.

Lighting Quality

LEED certificate rewards indoor lighting quality by access to daylight and outdoor views, controllability and energy performance. However, occupant visual comfort and eye health is up to many other parameters like illuminance and luminance, control of glare, distribution, uniformity and light source color (Hwang and Kim, 2011). The quality of lighting in a space not only depends on the lighting installation itself, but also on many other nonphotometric factors such as the layout of the furniture, color of the room and furniture surfaces, the occupants and how the space is used (Chung and Burnett, 2000). Hwang and Kim (2011) describe a standard lighting environment as: 'visible- safe and able to work effectively, has clear working view; and visually comfortable- has a suitable mood for work and able to work happily and comfortably.'

As a sustainable strategy typically used in green buildings, day lighting can be defined as maximum utilization of sunlight and minimum usage of electricity with the use of all-glass curtain walls, skylights, solar connectors and concentrators, and tubular day lighting devices. Beside reduction of energy consumption, it increases occupant well-being, comfort and productivity through connecting indoor spaces and outdoors. U.S. Green Building Council (2003) presents some correlation between

the daylight and productive learning environment. For example, two year study in North Carolina proves, children attending schools with full-spectrum light are healthier in general and they are 3-4 days less absent than students in conventionally lit classrooms. Another study in California proves that, students in classrooms with the most natural light score 20 percent higher on math tests and 26 percent higher on reading tests than students in classrooms with the least amount of day lighting. In another study, store with skylights is observed to have a sales index higher than an equivalent store without skylights (Heschong et al., 1999).Increase in sales can be expounded as a result of sales person productivity as well as customer psychology. Nevertheless, day lighting can also cause some problems in a working place. Successful daylight must prevent or reduce glare and thermal discomforts that arise from windows and direct sunlight (Sharp et al., 2014).

Controllability is another important issue for both green certification and occupant satisfaction. According to Heerwagen (2000): 'Personal control over ambient conditions is especially important to reduce discomfort coping and to achieve conditions appropriate to personal preferences and task needs.' Lighting controllability is significant because of the diversified tasks that require different lighting conditions in an office environment. Task lighting as desk lamps, reading lamps and under-cabinet lights are very useful to adjust lighting conditions according to personal needs. Manual controls also provide remarkable energy savings.

Air Quality-Ventilation

Air quality in offices is quite important because of the crowded working spaces. Air quality problems like inadequate ventilation, chemical contaminants from indoor and outdoor sources, biological contaminants are major factors to causing SBS (Sick Building Syndrome) symptoms (U.S EPA, 1991). Causal agents of SBS may be chemical, physical, biological, psychosomatic or the synergistic effects of one or all of these agents (Singh, 1996).

Harmful chemicals and biological agents that indoor air can potentially contain are , carbon dioxide, volatile organic compounds (VOCs), molds, various allergens, and infectious agents (U.S. Green Building Council,2003).To avert harmful effects of these, LEED certificate prerequisites prohibiting tobacco smoke, using low-emitting materials, controlling indoor chemical & pollutant sources and meeting minimum ventilation and air quality requirements.

A few office-based studies indicate asthma and allergy associations with indoor environmental conditions and likely to have significant reductions in asthma and allergy symptoms if the moisture problems are prevented or repaired, indoor smoking was reduced, and dogs and cats are maintained outdoors of the homes of allergic subjects (Fisk,2000). Besides health problems, inadequate air quality also causes performance decrease in offices. A study indicates that every 10% decrease in the proportion dissatisfied with the air quality below the air quality level causing 70% to be dissatisfied can improve the performance of typing by 1.4%, of addition by 1.1% and of proof-reading by 2.3% (Kosonen and Tan, 2004) .It is also stated that, productivity loss due in thinking is more severe than productivity loss in typing. Wargocki et al. (1999) experimented 30 subjects in different air pollution levels. They performed tasks simulating office work and performed psychological tests. The strongest effect of pollution load was on the performance of text typing, fewer characters were typed and there were more typing errors. Following performance decreases were seen respectively in addition, logical reasoning, serial addition and stroop. Moreover, subjects exerted less effort because they had more severe headaches that reduced performances.

Among strategies to improve indoor air quality, natural ventilation is the cheapest and easiest option. As against mechanical ventilation, natural ventilation is energy-efficient, environmentally friendly, and inexpensive and it rarely needs maintenance (Spengler and Chan, 2000).But in some cases, thermal instabilities and window inadequacies oblige mechanical ventilation. If the building is designed considering natural ventilation in advance, mechanical ventilation is rarely needed and additional energy consumption is averted.

Thermal Quality-Temperature

Thermal quality in offices is closely related to employees comfort and well-being. Even Frontczak and Wargocki (2011) assert, thermal environment is generally considered to be most important factor achieving overall indoor environmental quality. In green buildings, building facade is designed as transparent glass curtain walls to allow daylight and views into building. Especially in summer, green building is overheated because of direct sunray. As a result, air conditions are set to cooler value to balance indoor temperature to normal value and it leads to increase in energy consumption. Complaints of being too hot or too cold are often associated with headaches, fatigue, and mucosal irritation (Hodgson, 2002).Thermal quality not only affects health and well-being but also productivity of employees. Hedge et al. (2005) conducted a field study in a company with using data loggers placed on the workers desks. They state that 'Keystroke productivity improves as air temperature approaches a predicted thermal comfort zone.' They also assert that in the warm climate the study conducted, lowering the indoor temperature reduces productivity; on the contrary, increasing the indoor temperature can improve productivity.

An important factor affecting employee satisfaction about thermal comfort is control and adjustment of temperature. A web-based survey that Center for the Built Environment (CBE) conducted (Abbaszadeh et al., 2006) indicates that 76% of all occupants with a thermostat were satisfied with the temperature in their workspace as compared to 56% satisfaction for those without a thermostat. Operable windows contribute to thermal comfort as well.

When considering how to improve thermal comfort in existing buildings, strategies should be based around building infiltration, insulation and shading (FMA Austraila,2012).Air conditions are one of the leading energy consumers in buildings and they are generally calibrated to extreme values. In summer, offices are excessively cooled and in winter, they are excessively heated. Minimizing air condition usages, or at least calibrating an optimum value considerably reduces energy consumption. It also helps to avoid health problems arising from excessive usage of air conditions.

Acoustics Quality

Acoustics quality in offices generally refers to silent working environment without any distracting noise factors, while also refers to good transmission of the sound in learning spaces like classrooms or lecture halls. The quality of the sound environment is linked to numerous physical parameters like the physical properties of sound itself and the physical properties of a room (Frontczak and Wargocki, 2011). Acoustics quality of green buildings is generally the least satisfactory aspect among others (Hodgson et.al, 2008 Abbaszadeh et al., 2006).This general dissatisfaction can derive from low partitions to allow daylight and views into building, or hard ceilings and floors to improve air quality. Ventilation system relying on operable windows obliges occupants to open windows and office doors; which lowers acoustics quality as well (Newsham et.al, 2013; Hodgson et.al, 2008). Green offices are generally designed as open offices to have a collaborative, broad and spacious working area but it brings along some acoustic problems like background noises and speech privacy.

Mak and Lui (2011) conducted a survey with 259 office workers to assess environmental factors relation with office productivity. The results show that, most annoying noise sources are conversation, ringing phones and machines, with 11.2%, 8.9% and 7.7%. Background noise, closing doors, human activity, and non-specified noise sources inside or outside the office are the other noise sources that annoy the workers, respectively. Knirk and Knirk (1983) assert that, absorbable material surfaces that govern speech intelligibility, or masking sounds or 'white noise' can be used to secure acoustical privacy and to counteract distracting conversation noises. Thayer et al. (2010) report a decrease from 62 db. to 58 db. in low-frequency background noises with sound masking after renovation. It also ended up in considerable increase in noise level and sound privacy satisfaction.

The key factors to provide a comfortable acoustic environment are the selection and application of acoustically absorptive surface finishes especially in classrooms and collaborative learning spaces (Boglev, 2008).It's also necessary in open offices in which many employees work together.

Cleaning Quality

Cleaning quality implicitly affects air quality because of dust, bad odors, and harmful particles in the air in case of inadequate cleaning. Especially in crowded offices which are possible to contain many viruses and microbes, regular cleaning service is substantial. To ease cleaning services, furniture and carpeting must be easy-effaceable, anti-dust and antiallergic.

Methods

This paper analyses the effects of IEQ parameters in green buildings on occupant satisfaction, comfort and productivity. For this reason an office building located in İstanbul is selected and occupant satisfaction from indoor environment is analyzed. The office building belongs to a construction group company headquarters which received first LEED EBOM (Existing Buildings Operation &Maintenance) certificate in Turkey. Building was first constructed in 1980's and then renovated before application to LEED certificate. In the renovation period a couple of improvements performed in building indoors. Purchasing policy is changed with selection of sustainable materials and most of the waste materials are recycled. Energy performance of the building is measured by ASHRAE standards and energy consumption is decreased with proper systems. Lighting system is replaced with energy efficient fittings, electronic devices are selected from between energy efficient ones and water consumptions are monitored on a weekly basis. Partitions between spaces are changed with glass curtain walls to allow more daylight into building. Open office layout is changed with cubical open office for increased privacy. Natural ventilation is changed with mechanical ventilation to increase indoor air quality.

The survey includes the questionnaires with the occupants of office building in Istanbul. Two web-based questionnaires are carried out within the scope of study; one is before and the other is after the renovations .In the first questionnaire in 2011, the number of participants was 110 and in the second one in 2012, the number of participants was 116. The participants are subjected to the questions at five main categories of IEQ as lighting, thermal, acoustics, air and cleaning quality. The change between two questionnaires gives some specific information about the green building contributions to occupant satisfaction, which renovations lead up to.

Results and Discussion

Table 1 presents the distribution of responses and how the satisfaction is changed between 2011 and 2012 .The results of the questionnaires show that occupant's satisfaction increases in all parameters after the rehabilitations in the building. Most significant increases are in thermal quality with %19, acoustic quality with %18 and air quality with %13, while cleaning quality is with %8. The least remarkable increase is in the lighting quality which will also be analyzed.

Thermal quality of the building is increased after the renovations. Renovations include some sustainable actions like; using light colored roofing material to avoid heat islands, restoring exterior insulation and windows and adjusting the indoor temperature to a proper value. According to the results of the analysis by the company, degree of the heat was more than the ordinary; and it is lowered from 24° to 22°.This adjustment not only increased occupant satisfaction but also enhanced natural gas savings to %25.After the renovations, satisfaction increased from %44 to %63 but is still not sufficient mainly because of the insufficient airstream and crowded and constricted working area. Ongoing complaints about thermal quality are being too cold or too hot which can be expounded to personal preferences about ambient temperature.

Acoustic quality is the next most increased factor after the renovations. Acoustic complaints before renovations were mostly because of the open office systems which are underperformer in acoustic privacy. To improve acoustic quality in office spaces, open office system is replaced with cubical open

Table 1

Indoor Environmental Quality survey results of LEED certificated Construction Company headquarters in İstanbul

	thermal comfort			acoustics comfort	lighting comfort		indoor air quality	cleaning comfort
	instant office thermal comfort	winter thermal comfort	Summer thermal comfort	Noise level	illumination level	illumination haracteristic (glare, reflection, etc.)	Office air quality	Cleaning services
Very satisfied	13	19	12	4	16	17	7	18
Quite satisfied	12	11	8	15	24	19	7	14
satisfied	48	47	48	24	56	45	27	68
neutral	8	10	23	10	14	22	12	15
not really satisfied	16	10	11	19	5	7	10	
dissatisfied	9	12	8	19	1	4	31	3
Very dissatisfied	10	7	5	18		2	22	3
TOTAL SATISFACTION SCORE	218			43	177		41	100
TOTAL NEUTRAL SCORE	41			10	36		12	15
TOTAL DISSATISFACTION SCORE	88			56	19		63	6
TOTAL SCORE	347			109	232		116	121
2012 SATISFACTION PERCENTAGE (%)	63			39	76		35	83
2012 NEUTRAL PERCENTAGE (%)	12			9	16		10	12
2012 DISSATISFACTION PERCENTAGE (%)	25			51	8		54	5
2011 SATISFACTION PERCENTAGE (%)	44			21	74		22	75
2012 NEUTRAL PERCENTAGE (%)	11			9	14		11	11
2012 DISSATISFACTION PERCENTAGE (%)	45			70	12		67	14
Causes of dissatisfaction	İnsufficient airstream	Too hot	Too cold	Noise of people and engines	İnsufficient natural light, insufficient controllability, distracting light color		İnsufficient Airstream, food smell, dust	Dirty rest rooms, presence of carpet

offices. Replaced office furniture also has sound absorber panels in each cubical space to enhance better acoustic privacy. Photocopiers were also another source of acoustic complaints; therefore they are moved away from the office area. With these renovations, acoustic satisfaction is increased to %39 from % 21 but still relatively poor based upon open offices and noisy HVAC system.

Lighting quality is also increased between 2011 and 2012. According to the daylight computation before certification, productive lighting fixtures are replaced by old ones. Private offices and meet-

ing rooms are on the building periphery and open offices are in the middle of them. The partitions between private offices and open offices are changed with glass partitions to allow more daylight into building. With these renovations, satisfaction degree is increased to %76 from %74 but still not enough to make use of only natural daylight without artificial lighting in all working spaces. The amount of daylight in the open offices is restricted due to the building's old style small-sized windows. Thereby usage of artificial lights is compulsory.

Air quality of the building is the least scored as satisfactory by building occupants. Despite renovations performed, occupant satisfaction increased only to %35 from %23. Mechanical ventilation is allocated instead of natural ventilation because small sized windows were not sufficient for ventilation .This mechanical ventilation consists of conditioning procedures of outdoor air and ventilating it to office indoors. Current dissatisfaction of air quality after the renovations can be expounded to crowded and constricted working area.

Cleaning satisfaction showed increase by %8 from 2011 to 2012. This increase can be attributed to change of the cleaning company. Complaints about cleaning were also because of the existence of carpet. Between 2011 and 2012, carpet is overhauled and consequently, complaints are reduced. The dust that the carpets spread is also reduced and it also increased air quality satisfaction.

The study shows that having a green certificate doesn't guarantee the maximum employee satisfaction. In the LEED EBOM certified green buildings, it is possible to face some difficulties for occupant satisfaction because of the reasons like the age of the building and inadequate spaces. In the survey conducted in the LEED EBOM certified office building in Istanbul, occupant responses indicate some indoor environmental design implications:

1 Open offices are preferable because of more social and participative nature but they are ineffective at sound privacy and acoustic quality. Absence of the walls brings along humming noise of people and office equipment which complicates to concentrate. To avert these kinds of acoustic dissatisfactions, office furniture must have sound absorber panels or they must be made of sound absorber materials. Cubical open offices perform much better in sound privacy and acoustics quality, so if the working area is designed as open office, modules can be grouped and separated to have an acoustically qualified workplace.

2 If open offices are placed in the middle of the building storey like the building studied in this study, they do not receive enough natural light and usage of artificial light is required. Larger windows are necessary to provide more natural daylight. Besides, areas on the building periphery must be separated from open offices with glass partitions instead of brick wall to ensure the sunlight diffusion all over the storey.

3 Crowded and constricted workplace affects both thermal and air quality negatively.

4 Existence of carpet affects both cleaning and air quality negatively.

There are a number of limitations identified in this study. One of them is that only one building is examined within the scope of paper. Larger studies, with more buildings and participants would allow for more elaborated evaluation of the occupant's satisfaction and productivity in sustainable buildings. Another limitation of this study is that, there is no evidence of the relationship between IEQ in green buildings and occupant performance and health. Survey doesn't include self-assessed productivity questions or objective performance analysis in different indoor environmental conditions. It mostly consists on subjective measures of IEQ. Even if the survey doesn't' include any objective data for occupant performance and health; occupant satisfaction is a considerable fact to ensure and maintain occupant comfort and well-being in a workplace. Yet another limitation of the study is the EBOM certificate that the building has. Company headquarters is a 30 year old building, therefore survey results can differ in a newly constructed green building.

Conclusions

The primary goal of this paper is to investigate occupant's satisfaction and productivity in sustainable buildings, especially in offices. IEQ is a key factor to determine occupant's health, well-being and productivity in a sustainable building. Analysis of former studies and survey conducted within the paper shows that, green buildings present a qualified indoor environment but it is not possible to generalize all indoor environmental aspects in green buildings as satisfactory. While air quality is generally satisfactory, acoustic quality is generally unsatisfactory. Green design practices mostly concentrate on certification requirements, and this can push some occupant needs into the background. Occupant participation into green design and green operation is a key for preventing indoor environmental problems that the occupants could face after having a green certificate. In this way, the green building is healthy and productive building with its healthy and productive occupants inside.

Green buildings are more than energy efficient structures with renewable materials. They cannot complete their mission without satisfied, healthy and productive occupants. Especially in green office buildings, occupant satisfaction from indoor environments also brings organizational success and continuity. Sustainable environment is much better with sustainability of human comfort, morale, health and productivity.

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