

# Assessing Ghanaian Workplace Performance in Multi-Storey Office Buildings.

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## Abstract

The effects of the work space environment on worker productivity as well as comfort and work space quality have been widely researched into and have gained much importance with the European “Energy Performance of Buildings Directive” of 2001. Within the framework of a study on the “Thermal Performance of Multi-Storey Office Buildings”, 195 occupants in such buildings were surveyed before, during, and at the end of a 12 month monitoring period. The objective of the study was to find out how occupants measured their work spaces and to what extent did the work environment affect their day to day activities. Data loggers were mounted in selected offices to record indoor physical parameters. 4 office buildings in Accra were selected for the study: 3 air-conditioned and 1 naturally ventilated building. The results indicated among others that while 2 of the air-conditioned buildings were comfortable, 1 was interestingly uncomfortable together with the naturally ventilated building. Moreover, about 80% of the occupants’ with open plan workstations expressed dissatisfaction about their spaces commenting that they lack privacy while those in enclosed offices had positive comments about their spaces. Furthermore, the users ranked air quality, thermal comfort, and fire safety among others in order of importance as features needed for successful operation of multi-storey office buildings. Thermal comfort was ranked to have a higher importance than acoustic comfort but not air quality. In terms of health complaints, general fatigue, neck pains, stiffness of limbs and backache were amongst the frequently experienced problems. The study would inform building operators/managers on the efficient ways of organising work spaces for occupant satisfaction and maximizing productivity.

**Keywords:** Comfort, Occupants, Health, Air quality, Indoor environment.

## 1. Introduction

The best buildings are not only excellent exemplars of form, grace, aesthetics and building technology; they also help the development of the organizations that use them (Marmot et al., 2005). Well-briefed and well-designed office buildings do not only tell how intelligent the building is but also reflect the values and aspirations of the occupying organization and help to communicate them to the users and the wider public.

Commonly, office spaces have the main purpose of providing comfort to occupants in order to aid in satisfaction and increase productivity. Whereas comfort may depend on the prime factors of temperature, relative humidity, air movement and radiation (Lechner, 2001), there are also psychological factors (organizational policies, culture, social norms, previous experience, etc.) that are known to have effect on well-being.

In Ghana, most of the city’s (Accra) office buildings reflect international architecture with their glass facades and imposing structures. Just as in Brazil (Ornstein et al., 2005), the Ghanaian office real estate industry develop office buildings with the exterior taking priority over the interior which are sometimes not fully developed to expectation due to cost overruns and deadlines. Eventually, occupants’ who use the buildings experience real life challenges and apply all means possible to feel comfortable within the spaces.

Since multiple studies have shown associations between comfort, health, indoor environmental control and productivity in office environment in other countries (Lee and Brand, 2005; Clements, 2002; ASID, 1998), this study is imperative to ascertain the situation in the Ghanaian office environment.

## 2. Literature Review

The notion of comfort has evolved over the years with new meanings, shaped by culture being added to the previous ones as asserted by Rybczynski (1986) in Inkarojrit (2005). Historically, the notion of comfort referred

to domestic attributes such as privacy, convenience, leisure, and ease (Brager & De Dear, 2003). It was not until the nineteenth century that the idea of comfort included values, consumption patterns, and behaviours in which all people were believed to be entitled to the same physical comforts (Crowley, 2001). Thus the first time the term (comfort) was used to refer to physical environmental comforts such as light, heat, and ventilation. Thermal comfort is a key component for quality of indoor environment (Appah and Koranteng, 2012). The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE, 2004) defines thermal comfort as the condition of mind that expresses satisfaction with the thermal environment. This definition of comfort, however, does not convey the complexity of comfort and all of its contextual and cultural influences (Brager & De Dear, 2003). According to ASHRAE, there are four physical parameters of thermal comfort thus: temperature, relative humidity, air movement and radiation and two personal factors which are the metabolism rate of the individual and clothing insulation.

In the European Health Optimization Protocol for Energy-efficient buildings (HOPE) study, (Bluyssen et al. 2011), comfort is seen as being part of the term health, as also by other researchers (Cox, 2005; ISIAQ-CIB, 2004). Bluyssen et al., (2011) adopted the following definition: The indoor environment can be defined as healthy when the combination of its physical, chemical and biological properties are such that:

- It does not cause or aggravate any illnesses in the building occupants;
- It secure a high level of comfort to the building occupants in the performance of the designated activities for which the building has been intended and designed.

This definition allows therefore health to be evaluated in terms of overall response to the environmental conditions in terms of perceived comfort or:

- Acceptability/preference/satisfaction/dissatisfaction (e.g. the air movement in this room is unacceptable)
- Comfort/discomfort (e.g. I am not comfortable).

In a recent study, Kim and de Dear (2012) used the Kano Model to differentiate between Indoor Environmental Quality (IEQ) factors that impact overall satisfaction in negative, positive or in both directions. They concluded that 'temperature' and 'noise' had predominantly negative impact on occupants' overall satisfaction when expectations were not met.

On the other hand, a study conducted on commercial spaces in Hong Kong by Lai and Yik (2009, 2007) showed fairly different results, indicating that thermal comfort had the highest impact on overall IEQ acceptance, followed by air, noise and visual quality. An investigation conducted in China also suggests that thermal comfort has the highest impact on overall satisfaction (Cao et al., 2012).

Choi et al. (2009) and, Astolfi and Pellerey (2008) investigated the importance of environmental conditions only in terms of the subjective evaluations of building users. They examined the importance of indoor environmental conditions for comfort by asking the building users to rank the parameters according to their importance. The results of these studies show that thermal comfort was ranked to have slightly higher importance than acoustic comfort and satisfaction with air quality, and considerably higher importance compared with visual comfort.

In conclusion, all the aforementioned researchers confirm that thermal comfort is ranked to have slightly higher importance than the other factors that affect IEQ. Table 1 below gives an overview of occupant assessment of their IEQ by ranking the parameters in order of importance by different authors.

Table 1: First three parameters of importance to occupants.

Authors	Rank of Importance
Agnieszka and Mats, ( 2013)	1 <sup>st</sup> - Air quality 2 <sup>nd</sup> - Thermal comfort 3 <sup>rd</sup> - Acoustic comfort
Frontczak et al. (2012)	1 <sup>st</sup> - Availability of individual work spaces 2 <sup>nd</sup> - Acoustic comfort 3 <sup>rd</sup> - Visual comfort
Frontczak and Wargocki (2011)	1 <sup>st</sup> - Thermal comfort 2 <sup>nd</sup> - Visual comfort 3 <sup>rd</sup> - Acoustic comfort
Lai and Yik, (2009)	1 <sup>st</sup> - Thermal comfort 2 <sup>nd</sup> - Air quality 3 <sup>rd</sup> - Acoustic comfort
Lai et al. (2009)	1 <sup>st</sup> - Thermal comfort 2 <sup>nd</sup> - Acoustic comfort 3 <sup>rd</sup> - Air quality

In a related study of “Assessing Brazilian Workplace Performance”, the authors (Ornstein et al., 2005) reported that 51% and 60% of the occupants within open floor plan spaces were dissatisfied with visual and telephone privacy respectively. However, over 70% of the occupants studied gave a positive answer to the distance between their workstations with others.

Similar findings have been accounted for by Windsor (2005) who conducted a ‘User satisfaction Survey in Israel’. The author reported that whiles approximately 50% of respondents in open plan spaces had a negative feeling about their spaces, the other half were satisfied with their spaces. Conversely, 89% of occupants in enclosed offices had a very good feeling about their spaces because they could control their spaces installed systems. Typical comments included:

‘I can always close the door if it’s noisy’; ‘It is possible to turn the light on/off and also have private telephone conversations’.

From the above, it is clear that occupants in open plan spaces feel dissatisfied about their spaces and its mainly due to lack of privacy, the ventilation system and noise levels.

A study of educational and office buildings in the UK and in India (Steemers and Manchanda, 2010) showed that occupants’ overall satisfaction varied depending on the ventilation mode applied in the buildings. Moreover, dwelling quality, size and design were also demonstrated to have significant impact on residents’ satisfaction (Lee et al., 2012; Dekker et al., 2011 and Mohit et al., 2010).

This paper partially presents the results of an ongoing study on the thermal performance of multi-storey office buildings in Accra, Ghana with regards to occupants’ personal preference of organizing office spaces and possible health complaints. The objective is to subjectively analyze the feelings of occupants concerning their spaces, Indoor Environmental Quality (IEQ) parameters and health complaints based on their long term experience within the spaces monitored. Consequently, the results may support efforts towards improving office spaces in terms of thermal, lighting and acoustic parameters for occupants’ satisfaction.

### 3. Methodology

#### 3.1 Case-study buildings

Four multi-storey office buildings in Accra were selected for the study. The buildings were chosen for their common physical features: extensively glazed facades and located in the same neighbourhood. They are also a representative of the current trend of office building style in Ghana. These buildings are different in sizes, number of storey and accommodate different organizations, thus representing a broad spectrum of office types

and functions. All four buildings were given special codes which were the initials of their names in this paper: P.T. (Premier Towers), R.T. (Ridge Towers), H.T. (Heritage Towers) and W.T.C. (World Trade Centre). Key information concerning these buildings is summarized in Table 2.

Table 2: General overview of selected buildings

Code	Fl. area(m <sup>2</sup> ) (No. of floors)	Location	Orientation	Floors monitored	Thermal controls	Shades	Windows	Use
P.T.	10, 263 (13)	Accra, CBD	East-West	5 <sup>th</sup> and 6 <sup>th</sup>	Air-conditioned	Internal, Manually controlled	Fixed curtain wall	Multi-purpose
R.T.	14,355.68 (15)	Accra, Ridge	South-East	7 <sup>th</sup> and 8 <sup>th</sup>	Air-conditioned	Internal, Manually controlled	Limited Operability	Multi-purpose
H.T.	9,340.86 (15)	Accra, Ridge	East-West	10 <sup>th</sup> , 11 <sup>th</sup> and 12 <sup>th</sup>	Air-conditioned	Internal, Manually controlled	Fixed curtain wall	Multi-purpose
W.T.C.	14,556.78 (15)	Accra, Ridge	South-East	14 <sup>th</sup> and 15 <sup>th</sup>	Naturally ventilated	Internal, Manually controlled	Operable	Multi-purpose

The method applied in this study was a combination of descriptive and explanatory research based on case studies of the selected office buildings in Accra; Ghana. Over a period of twelve months, data was collected and analyzed for each building according to the Measured-Observed-Perceived-Simulated (MOPS) model of building environment evaluation (Mallory-Hill, 2004). Nonetheless, this study was carried out in the first three stages of the model, thus MOP.

### 3.2 Measured Data

Long term measurement of the indoor environmental factors (temperature, relative humidity, air velocity) was carried out through data loggers from May, 2012 to April, 2013. The variables were measured in 10 minutes intervals throughout the study period. Spot measurements of ambient conditions (lighting levels, noise levels, etc.) were also consecutively made in all of the monitored spaces. Outdoor temperature and humidity values were also recorded and compared with data from the meteorological survey department for the study area. Measurements were taken at a height of 1.1m above the floor, which represent the height of an occupant when seated. The accuracy of the measuring instruments is shown in Table 3 below. Data obtained from the sensors were analyzed with the aid of Microsoft Excel and the result tabulated for inferences.

Table 3: Measuring equipment (Hobo sensors) technical data.

Parameter	Measuring Range	Accuracy
Air temperature (T)	-20 to 70 °C	± 0.4 °C
Relative humidity (H.R)	5 to 95 %	± 3%
Lighting levels	± 5% rdg ±10d (< 10,000Lux)	10% rdg ± 10d (> 10,000Lux).

### 3.3 Observation Phase

Walk-through observation of the monitored floors and areas to be studied was done. Each building was carefully observed at the beginning of the study to track occupants' activities and responses and also during the distribution of the survey questionnaire. The walk-through was carried out in the mornings when the occupants were seated and have started work (from 8:00am). During the afternoons after break, another walk-through was carried out to monitor how fast occupants resume work after some time off (from 2:00pm). The observation phase continued when the occupants worked and their actions in relation to control systems were also captured in a field observation book. Unstructured interviews were held with the property managers and some maintenance and security staff to obtain information on the use, operation, maintenance and management of the building systems and spaces.

### *3.4 Perceived*

User survey with interviews was organized to capture occupants' satisfaction with their environment. The questionnaire was distributed to a sample of the employees which differed from building to building, making a total of 195 occupants'. The questionnaire used had been piloted in a similar study on low-rise office buildings in Kumasi, Ghana (Koranteng, 2010). It consisted of items pertaining to occupants' characteristics, evaluation of the office environment, arrangement of furniture and ambient environmental conditions. Occupants were also asked to rank in order of importance features of an ideal working place and comment on any health issues they might have which they feel is related to their work environment. The subjective assessments were based on occupants' votes on their indoor thermal parameters, thermal acceptance and preference and comparison made to the ASHRAE standards. Each response was keyed into Excel and descriptively analysed with different bar and line graphs generated for interpretations.

## **4. Results and Discussion**

### *4.1 Participants in the study*

In all, 195 occupants participated in the study. All participants were workers on the floors monitored and had stayed in their current offices from between a year to ten years. The respondents in total consisted of 80 females and 115 males. Greater majority of the respondents (131) were between the ages of 25-35 years, while 8 were under 25 years, 29 participants were between 36-45 years and 37 were above 45 years. In all the buildings, more than 50% of the respondents had either a degree or a postgraduate degree. This made the survey self explanatory since they were familiar with 85% of all the questions.

54 of the respondents were from the P.T building out of which 7.4% had enclosed offices while the rest were allocated open workstation measuring a total of 50.4m<sup>2</sup>. In the R.T building, while 11.9% had enclosed offices, 88.1% of the workers had open workstations within a floor area of 90.1m<sup>2</sup>.

Of a total of 60 occupants in the H.T building, 6.7% had enclosed offices while the rest were in 3 enclosed spaces each measuring 23.46m<sup>2</sup>. The distribution was 15 occupants each in two of the spaces and 26 in the last space. With 39 respondents from the W.T.C building, occupants were in smaller groups of between five and eight within 4 enclosed spaces each measuring 35.5m<sup>2</sup>.

### *4.2 Environmental Comfort Evaluation*

The measurement of temperature, relative humidity, lighting levels were made at standard locations and distributed in a relatively symmetrical and repetitive manner throughout the spaces.

### *4.3 Thermal Comfort*

Buildings R.T and P.T had central air-conditioning systems with constant air volume and as a result their indoor air temperature was 24°C±1°C with an average relative humidity of 51.2% and 54% respectively. These results indicate similar conditions in Brazilian office buildings (Ornstein et al., 2005) and also within the ASHRAE summer comfort standard of 23°C to 26°C and humidity of 30% to 70%. In the R.T building, 7% of the occupants' said their spaces were cold while 40.6% complained of feeling 'cool' as against 13% and 21.7% correspondingly in the P.T building. From the above it can be noticed that both temperature and relative humidity values are well within the standards in both buildings.

In all, 52.2% of the occupants in the R.T building voted between the ASHRAE (2004) comfort zone of slightly cool and slightly warm (-1, 0, +1) on the sensation scale: an indication of comfortable working spaces. P.T building saw 55.6% voting within the comfort zone. Occupants with the open plan workstations were dissatisfied with their thermal conditions (feeling cold and cool) all the time since they could not individually alter the settings of the air-conditioning systems. More than 50% of them during sometime within their working hours had to go outside for about 5-10minutes to ease the condition.

In the H.T building, conditions were quite different even though it's also an air-conditioned building with split units. Air temperature was usually kept at 26.7°C± 1°C and relative humidity between 54% to 68%. Again, occupants' here grumbled of feeling uncomfortable with 15% feeling cold/cool and 21.7% feeling warm. Though on the average, H.T building had parameters within the standard, occupants' felt uncomfortable probably due to

the buildings' east-west orientation and its' almost 99% inoperable glazing to wall ratio as exterior window accounts for 25% to 28% of the total heat gain within a space (Al-Najem, 2010 and Yu et al., 2008). 38.3% of the users voted within the comfort zone.

W.T.C building recorded a temperature of between 26.7°C to 29.5°C corresponding to relative humidity of 70% to 73.3%. These results made the building very uncomfortable with the respondents feeling warm to hot in the afternoons. As a result, 90% of the respondents in the building spent as little time at the workstations as possible: attending to their company's assignments elsewhere in the afternoons. W.T.C also has adaptive opportunities (opening windows, using personal standing fans) which could be operated based on the collective agreement of the occupants. 15.4% of the respondent felt comfortable by voting within -1, 0, and +1.

#### 4.4 Visual Comfort

Ratings were positive in all buildings in terms of lighting levels since more than 70% of the users rated their light levels ( daylight and artificial) as good. Artificial lighting was switched on from the start of work till occupants' closed around 5pm. Actual light level measured ranged from 220 lux( W.T.C.) through 350 lux (H.T.), 480lux (P.T. ), 640lux (R.T.). With a standard illuminance level of 500lux (Burberry, 1997), only R.T could be said to have met the standard. This is so because in the R.T., blinds were not often deployed as in the other buildings. Again, the spatial configuration in the R.T is more open with less enclosed offices which are only above head height. In 'Assessing Brazilian Workplace Performance', illuminance levels ranging from 400lux to 600 lux were measured (Ornstein et al., 2005) making the performance of P.T. and R.T. buildings similar to that of Brazil. From the observations, it was realized that there were considerable difference in light levels with more light at the perimeters and insufficient lighting at the core. In the W.T.C. building, the low measurement could be due to the blind deployments in the afternoons, the spatial configuration, depth of the spaces, and the number of bulbs mounted within the spaces. The behaviour of the occupants having to leave the artificial lighting on all day is a problem since this could have a huge impact on energy given the fact that Lighting represents a major energy-user in commercial buildings: around 15% (Galasiu and Veitch, 2006; Energy Consumption Guide, 2000).

#### 4.5 Personal Preference of Organizing the Current Work Space/Ideal workspace

Graphs presented here summarize occupants' response on the following questions in the order that they appear.

'Are you satisfied with your office layout?'

'Do you have enough privacy at your workstation?'

'Generally, how do you find your office climate?'

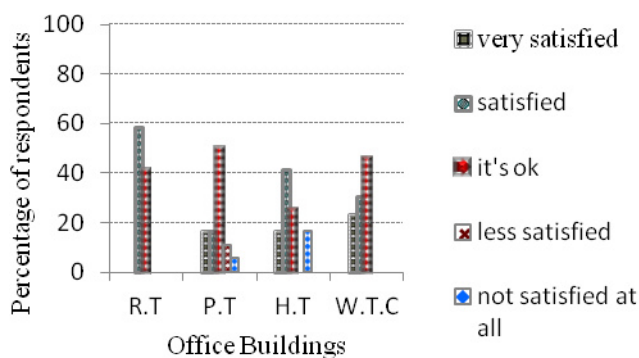


Figure1: Satisfaction with office layout.

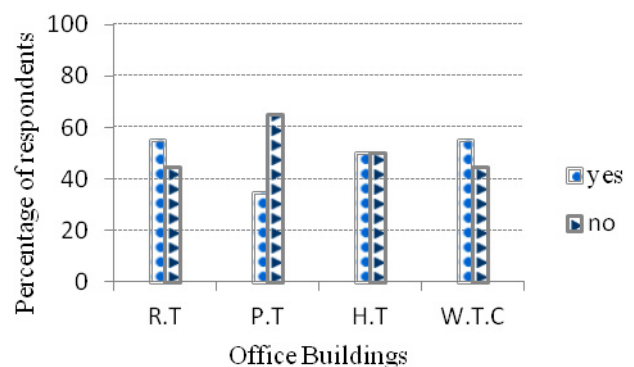


Figure 2: Privacy at workstations.



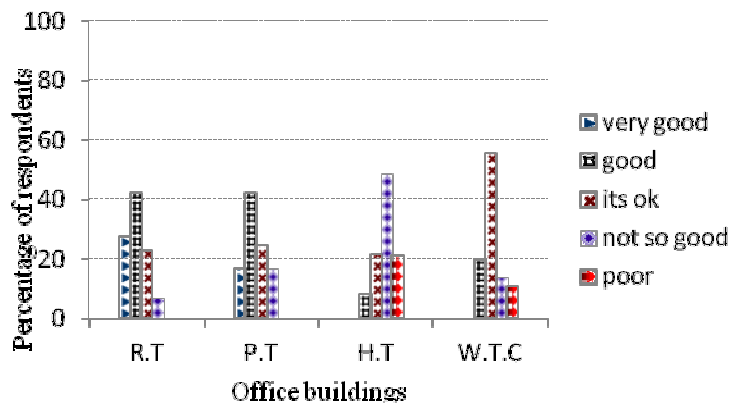


Figure 3: General perception of office climate.

From Fig. 1, 58.6% and 41.7% of the occupants' were satisfied with their layout in the R.T. and H.T. buildings respectively. This is because though only, 11.9% and 6.7% accordingly had enclosed offices, the open floor workstations were spacious (90.1m<sup>2</sup> for R.T. and 23.46m<sup>2</sup> each for H.T.) and the workers felt they had control over their spaces. Most of them had personalized their spaces with photographs and other personal elements. In the P.T. building, occupants felt uncomfortable as they complained they had no privacy. They could not personalized their spaces and got distracted and interrupted most of the time. Situation in the W.T.C. building was quite subtle since each space occupied a smaller group of users. However, they (users) carped about lack of telephone privacy as well as interruptions for those who occupied window side workstations as others wanted them to open and close windows to maximize the thermal conditions within the spaces. Occupants in the enclosed offices across all buildings felt good about their spaces and gave positive comments about it. A similar result was reported by Windsor (2005) in his study on 'User satisfaction surveys in Israel'.

In the H.T. building, because the glazing is fixed and cannot be opened, occupants had negative feelings about their office climate (Fig.3). They complained that the split units are inefficient and as a result preferred opening the unoperable windows when the outside conditions are favourable. Again, due to the east-west orientation of H.T., the late afternoon sun had direct impact on the indoor climate: a situation which the air-conditioning units sometimes fail to set right and therefore occupants' become agitated. Shading devices (Koranteng, 2010) should have been provided to counteract the conductive gains from the direct solar ingress in the H.T building.

From the interviews, it was reported that from the design stage, the users' needs are not satisfied. The buildings are built as ordinary open plan office blocks with only the vital areas provided for (washrooms, lift areas, staircase areas, and main circulation spaces). Any company who comes in will have to re-organize the interior spaces to suit their workers. This could account for all the buildings having prominent open plan workstations. The few enclosed offices are for the top management staff.

#### 4.6 Indoor Environmental Quality Parameters

As part of the survey, occupants were asked to rank their indoor parameters and building features in order of importance. Table 4 shows the results expressed in mean votes: where the least mean is the most important. Air quality was ranked as the most important parameter by occupants in both the R.T. and P.T. buildings followed by thermal comfort for the same buildings in addition to the H.T building. This result shows a divergence from the study by Choi et al. (2009) and Astolfi and Pellerey (2008) who both reported that thermal comfort was ranked to have slightly higher importance than acoustic comfort and satisfaction with air quality. In the present study, thermal comfort does have a higher importance than acoustic comfort but not air quality. Acoustic comfort was ranked 4<sup>th</sup>, 7<sup>th</sup>, and 7<sup>th</sup> in P.T., R.T. and W.T.C. respectively. The least ranked parameter for P.T., R.T. and W.T.C. was 'Beauty/aesthetics of the building', while H.T. ranked acoustic comfort as the least important parameter. Occupants from P.T., R.T. and W.T.C. all commented that the beauty of the building did not really matter to them as much as their indoor conditions as well as how the building responded against fire and the options it gave

them to feel comfortable at their work stations.

Table 4: The most important features of an ideal working place from occupants' point of view.

Parameters	Mean Votes			
	R.T	P.T	H.T	W.T.C
Thermal comfort	3.29 (2 <sup>nd</sup> )	3.29 (2 <sup>nd</sup> )	2.73(2 <sup>nd</sup> )	3.23(4 <sup>th</sup> )
Air quality	2.79 (1 <sup>st</sup> )	3.18 (1 <sup>st</sup> )	4.27(4 <sup>th</sup> )	3.38(5 <sup>th</sup> )
Visual comfort	4.50 (5 <sup>th</sup> )	4.88(4 <sup>th</sup> )	3.91(3 <sup>rd</sup> )	3.62(6 <sup>th</sup> )
Acoustic comfort	6.07 (7 <sup>th</sup> )	4.88(4 <sup>th</sup> )	5.73(10 <sup>th</sup> )	3.85(7 <sup>th</sup> )
Acoustic and visual privacy	6.14 (8 <sup>th</sup> )	4.35(3 <sup>rd</sup> )	4.45(5 <sup>th</sup> )	3.85(7 <sup>th</sup> )
Comfort of furnishings and dimensions of workstation	3.86 (4 <sup>th</sup> )	6.35(6 <sup>th</sup> )	4.82(8 <sup>th</sup> )	2.85(3 <sup>rd</sup> )
Fire safety	3.43 (3 <sup>rd</sup> )	5.12(5 <sup>th</sup> )	1.64 (1 <sup>st</sup> )	2.15(1 <sup>st</sup> )
Security against theft	5.07 (6 <sup>th</sup> )	6.35(6 <sup>th</sup> )	4.55(6 <sup>th</sup> )	2.31(2 <sup>nd</sup> )
Liberty to control your own work environment	6.43 (9 <sup>th</sup> )	7.61(7 <sup>th</sup> )	4.73(7 <sup>th</sup> )	3.85(7 <sup>th</sup> )
Beauty/aesthetics of the building	7.64 (10 <sup>th</sup> )	9.24(8 <sup>th</sup> )	5.55(9 <sup>th</sup> )	4.85(8 <sup>th</sup> )

In the W.T.C building, occupants reported that when it came to issues concerning thermal comfort, air quality, acoustic comfort etc., they were less informed and always thought about fire safety, security against theft, etc. These two they believe were talked about more and could be fatal if attention is not paid to it. Additionally, occupants may have been psychologically affected by the emergence of the frequent fire outbreaks in Ghana (commercial buildings, markets etc.). They however expressed interest in the indoor comfort parameters and wanted to know more about them.

#### 4.7 Health Complaints

Results concerning health complaints from occupants are presented in the illustrations below. As many as 28.6% and 33.3% of the respondents at the R.T and P.T respectively (air-conditioned buildings) reported of nasal irritation occasionally: Perhaps due to the effect of the air-conditioning systems.

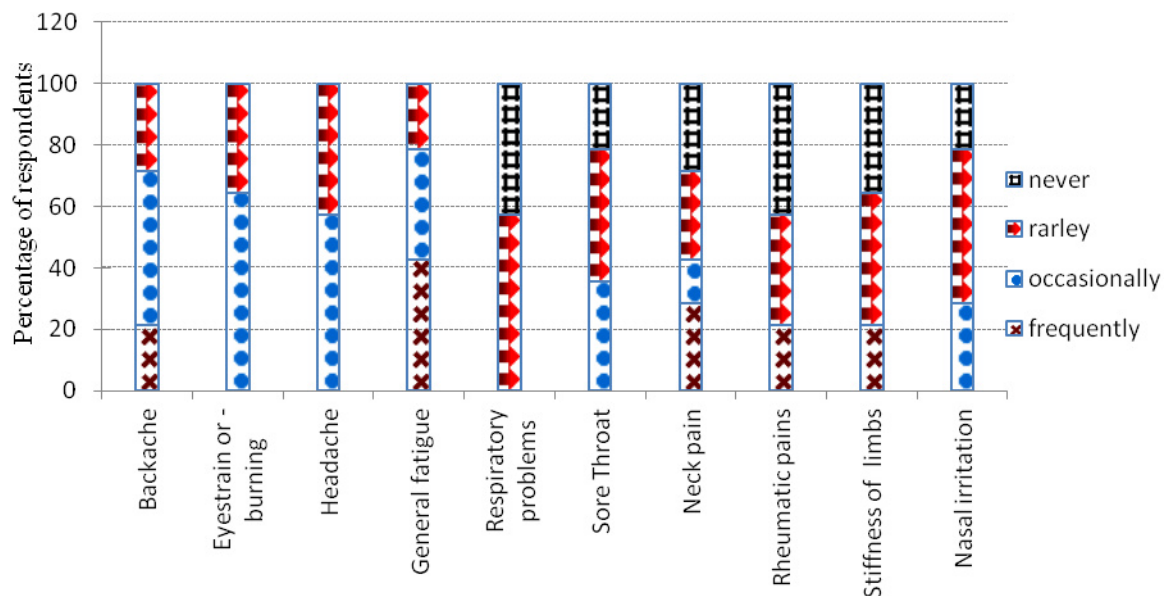


Figure 4: Health complaints at the Ridge Towers (R.T)

Frequently experienced health complaint from all the buildings included backache: 33.3% in the P.T building,



21.4% in the R.T, 15.4% in the W.T.C. Higher percentages were recorded by Koranteng (2010) in a similar study of low rise office buildings in Kumasi. In his study, the author reported that 60% of occupants on the average reported of backache in three air-conditioned buildings and suggested that lack of proper ergonomics might be the cause.

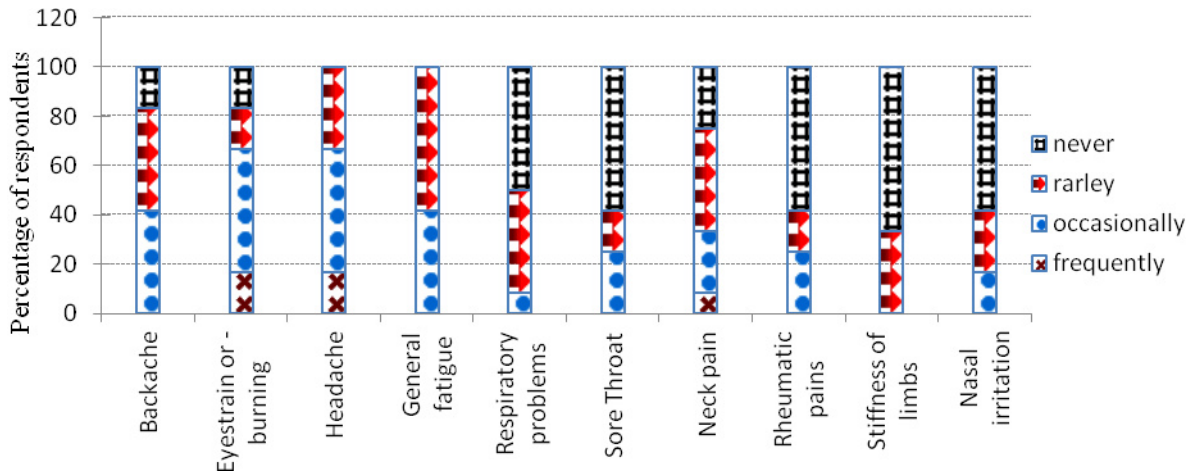


Figure 5: Health complaints at the Heritage Towers (H.T)

Other frequently reported health problems at the R.T included general fatigue, neck pains and stiffness of limbs. Since occupants complained of feeling cool/cold in the R.T building, this could be the reason for the above health complaints. In P.T, it was eyestrain/burning and general fatigue. H.T also recorded eyestrain/burning, headache and neck pains as the most frequently occurring health issues. This could be caused by the poor lighting (350 lux) within the building. In the W.T.C building, occupants said eyestrain/burning, headache and general fatigue were the frequently experienced issues probably caused by the same poor lighting issue (220 lux). Occasionally, all the health issues showed in the diagram were experienced by occupants in both the W.T.C and the P.T building. Meanwhile, stiffness of limbs was neither an occasional nor a frequent happening at the H.T building. The reason for this could be because occupants usually took intermittent breaks from their workstations mainly due to their displeased indoor conditions.

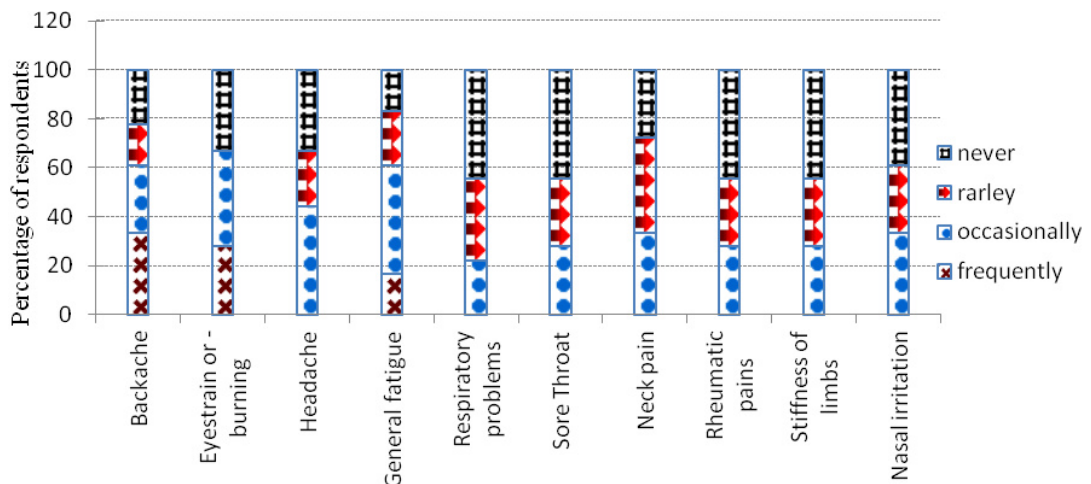


Figure 6: Health complaints at the Premier Towers (P.T.)

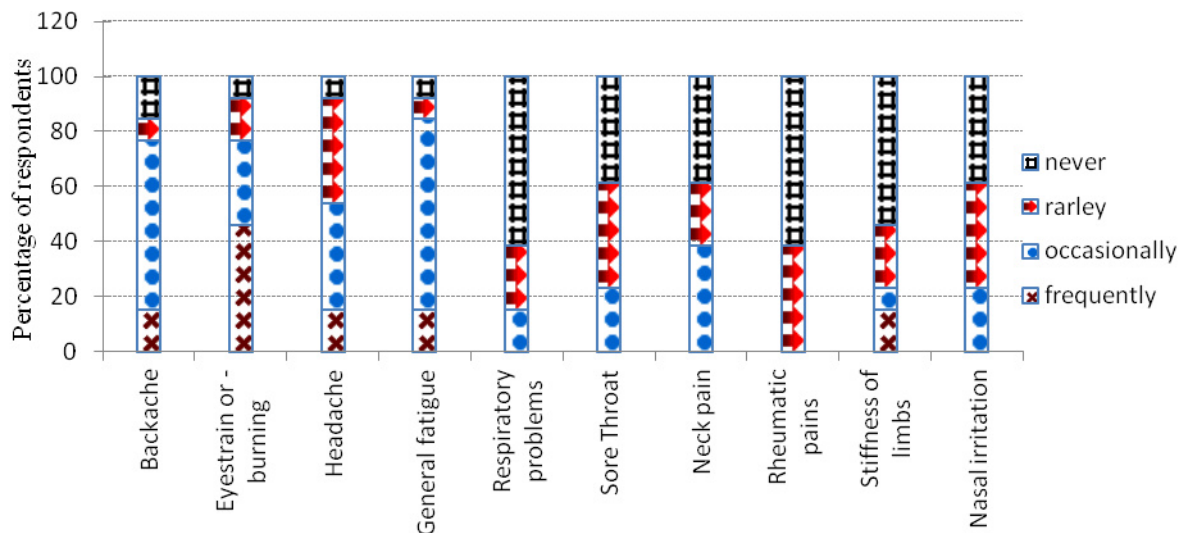


Figure 7: Health complaint at the World Trade Centre (W.T.C)

## 5. Conclusion and Recommendation

With both subjective and objective measurements, the Ghanaian workplace environment has been assessed. The objective was to find out how occupants measured their work spaces and to what extent did the work environment affect their day to day activities. With the exception of buildings R.T. and P.T., whose occupants voted satisfactorily concerning their indoor thermal conditions (mainly due to the air-conditioners); H.T. which is also an air-conditioned building captivantly had negative votes from the occupants. Indoor temperature measurements suggest that building H.T. barely meets the ASHRAE summer comfort standard of 26°C. The H.T. building could employ the use of fans which is known to have a temperature reduction capability of 2°C. Although the W.T.C. building with an average of 28.1°C is above the standards (ASHRAE), occupants have mechanism of evading the harsh afternoon temperatures. They do this by 90% of them leaving their workstations for other tasks assigned to them outside the building. Also thermal comfort had a higher importance than acoustic comfort in all the buildings. Occupants' in the W.T.C. building felt that fire safety was the most important parameter to pay attention to whiles thermal comfort and air quality were the most important parameters for the other buildings.

There is therefore the need for Ghanaian standards to be set and to depict local climate and cultural conditions. Again, workshops on indoor environmental quality parameters should be organized for occupants to educate them about the conditions experienced at the workstations.

Finally, further studies should be conducted into the detailed relationships between the health complaints and the indoor thermal conditions.

Additionally, companies should focus on providing work environments that are enclosed or semi-enclosed to keep occupants focused and un-distracted during working hours to increase productivity.

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