Occupant Indoor Environmental Quality (IEQ): Results of a survey in office buildings in Iran

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ABSTRACT

The Indoor Environment Quality (IEQ) is an important determinant in the comfort and hence productivity of workers in office buildings, and a number of studies have been undertaken in the Western world which shows this. This paper explores the Indoor Environment Quality (IEQ) in six office buildings in Tehran (Iran) with particular attention to thermal comfort. The study is based around a questionnaire survey of the occupants in the Case Study Offices.
The results from the study indicate that in the buildings surveyed 25% of the respondents were thermally comfortable in their workspace in winter, and 22% in summer. The survey also reveals that the respondents in open-plan office cubicles with high or low partitions were most satisfied with their environment, compared to workers in fully open-plan offices and cellular offices. They also reported an enhanced perceived productivity in comparison with other workspaces. The overall conclusion was that there is considerable scope from improving the thermal condition as well as other aspects of IEQ.

1. INTRODUCTION

'Indoor environment is a dynamic interaction of spatial, social, and physical factors, which affects productivity, health, and comfort' (Clements-Croome, 2000).
The Indoor Environmental Quality (IEQ) is a mixture of factors such as indoor temperature, humidity, noise, lighting, space design and layout, building envelope, and structural systems (Dorgan and Dorgan, 2006). It also has been proposed by Leaman and Bordass (2006) that improving indoor environmental factors in offices not only improve output but also can bring better occupants perceived health, comfort and satisfaction.
This statement invites the obvious question of whether cultural values affect the perception of the Quality of the Indoor Environment.
This short-term questionnaire study of six Office buildings in Tehran, Iran provides an initial answer to this question, and also helps to assess whether the working conditions in these offices are conducive to thermal comfort and hence productivity.
Clements-Croome and Baizhan (2000) have proposed that crowded workplaces, thermal problems and sick building symptoms are the most significant factors affecting environmental satisfaction. Their study also suggested that productivity could be increased by 4 to 10% if the office environmental conditions were improved.
Lorsch and Abdou (1994) also noted a link between temperature and factory / industrial worker's productivity. They found that optimum thermal comfort occurs in short term laboratory experiments at 80.5 ±1°F (26.9 ± 0.6 °C) but that the workers showed the least amount of productivity in this optimum comfort. The workers were perceived as being most productive at 68 °F (20 °C) where they reported feeling uncomfortably cold. They also suggested that air conditioning can increase productivity in office and industrial workplaces. In a study Wyon (2001) also suggested that there is a direct link between thermal environment and productivity. The overall observation from the above studies is that the thermal environment in Offices has a significant role to play in the overall satisfaction of the user with their environment.
To establish how the occupants perceived their internal environmental conditions in the six office buildings studied in Tehran, a questionnaire survey was undertaken during the hot season in 2005 (July and August), to which 195 occupants responded. The Office buildings surveyed were a mixture of designs up to 30 years old. These included highly glazed, high-rise and heavy weight and light weight structures.

2. METHODOLOGY

The scope and format of the questionnaire is based on a mixture of the Indoor Environmental Quality (IEQ) survey questionnaire from the Centre of the Built Environment (CBE) at the University of California, Berkeley (Huizenga et al 2002) and a questionnaire for the study of Sick Building Syndrome (SBS) used by the Building Research Establishment (BRE) (Raw 1995) in the UK. There were also some additional questions that were necessary for the research that were not covered by either of the two reference surveys, and were therefore added by the author. Satisfaction with the indoor envi-

ronmental quality (IEQ) is evaluated by several criteria, including thermal comfort, air quality, lighting and noise. The occupants' perception of satisfaction with IEQ is assessed on a scale ranging from very satisfied (+3) to very dissatisfied (-3). The occupant perception of thermal comfort is evaluated by a scale based on the ASHRAE 55 (2004) seven-point thermal sensation scales which ranges from hot (+3) to cold (-3). The perceived health of occupants is also being asked for and is based on the sick building syndrome questionnaire from BRE (Raw 1995). Occupants are asked whether they experienced one or more symptoms on a list of eight common SBS indicators. The symptoms are considered as being building related in office buildings. The approximate time required to complete the questionnaire was 5-10 minutes. Of the studied office buildings the response rate was 92% (195 out of 210).

3. SUMMARY AND FINDINGS FROM THE SURVEY

The data for the occupants responding to the survey are summarized in Table 1. The questionnaire was undertaken during August 2005, which is the summer season in Iran.

3.1 Data analysis

The questionnaire responses were analysed using the SPSS statistical analysis program.

3.2 Results of all case studies

The results of this survey are divided into the following six sections:

3.2.1 Satisfaction with temperature

Figure 1 compares the results of the questionnaire over all the offices studied with the ASHRAE Standard 55 (2004) thermal comfort condition (80% or more of the occupants are satisfied with the temperature). It reveals that only 57% of the occupants reported they were satisfied with the temperature in general. Moreover, more than 23% of the occupants were positively dissatisfied with the temperature in their workspace which is more than the acceptable dissatisfied range (10%) specified by ASHRAE Standard 55 (2004). Therefore, it appears that the occupant's perceived satisfaction with the temperature is not in compliance with the acceptable thermal satisfaction rate within ASHRAE Standard 55 (2004).

Table 1: Summary of occupant's characteristics

Occupants' data		
Time spent at workspace (hours)	10 or less	9.8%
	11-30	24.2%
	More than 30	66.0%
Type of work	Managerial	6.3%
	Professional	73.8%
	Clerical/Secretarial	19.9%
Age	30 or under	36.9%
	31-50	51.8%
	Over 50	11.3%
Gender	Male	63.1%
	Female	36.9%
Clothing insulation (Clo)	Male	0.7
	Female	0.75

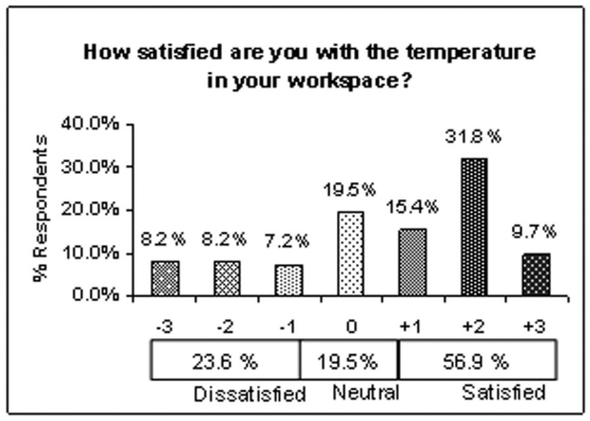

Figure 1: Respondent's satisfaction with the temperature in their workspace (All buildings over the whole year).

Figure 2 shows the results of the survey in more detail. It reveals that thermal neutrality was achieved in only around 22 - 25% of the occupants in winter or summer.. As a general observation it was found that the occupants whose offices were evaporatively cooled were more likely to report feeling too hot, while those who were in mechanically air conditioned offices tended to report feeling too cold in summer. A further observation, comparing the respondent's satisfaction with the temperature and workspace type, indicates that, among all workspace types, cubicles with low or high partitions were identified as the preferred workspaces for most thermal satisfaction, while open offices with no partitions were identified as the workspace type with the least thermal satisfaction.

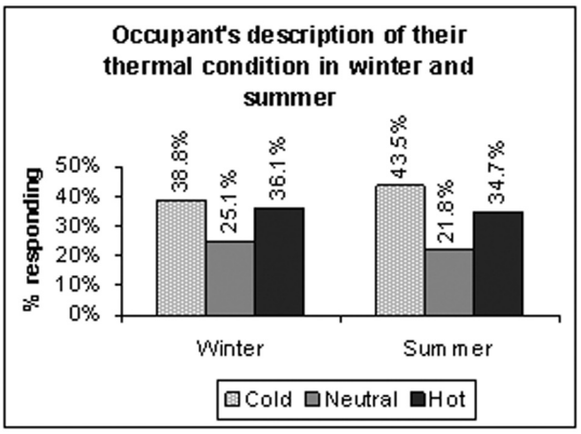

Figure 2: It shows the occupant's description of their thermal condition in winter and summer (All buildings).

3.2.2 Satisfaction with ambient conditions

Comparing the results of satisfaction with the ambient conditions across all buildings reveals that the occupants were most satisfied with the amount of light in their workspace and were least satisfied with the noise level in their workspace (figure 3).

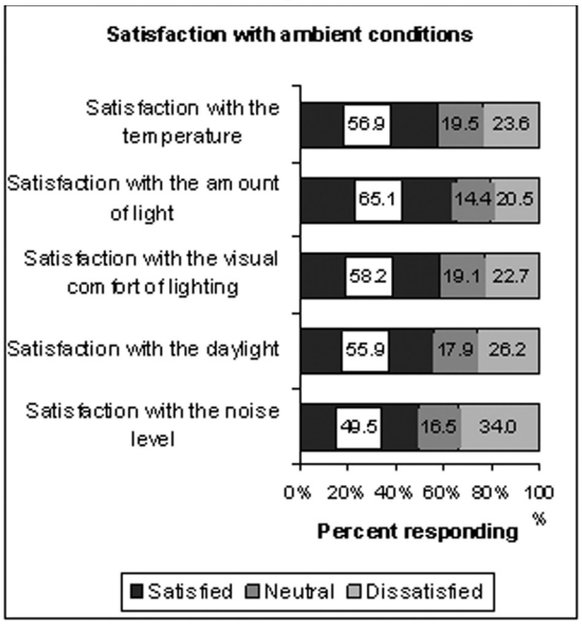

Figure 3: Respondent's satisfaction with the ambient conditions for all buildings

3.2.3 Satisfaction with office layout

It has been suggested by researchers that there is a close relationship between productivity and workplace satisfaction (Clements-Croome, 1997 & Lorsch and Abdou, 1994). Leaman (1995) also suggests that there is a relationship between people's satisfaction with the workplace environment and office productivity. Therefore, it seems likely that environmental condition such as heat, lighting, ventilation, and noise would affect people's productivity in offices. The data from figure 4 shows that the majority of the respondents were satisfied with their office layout. Analysing the data in more detail for the relationship between the respondent's satisfaction with *the amount of space for work and their workspace type* shows that respondents who were in cubicles with low OR high partitions were more satisfied with their personal workspace than those respondents who were in workspaces in open plan offices with no partitions.

The relationship between the respondent's *workspace type and satisfaction with their visual privacy* revealed that the respondents who were in cubicles with low or high partitions were more satisfied than respondents who were in enclosed offices shared with other people or were in workspaces in open plan offices with no partitions. Respondents who were in workspace types with low or high partitions were also more likely to be satisfied with the ease of interaction with co- workers than respondents who were in enclosed offices – either shared with other people or private. The relationship between the type of workspace and perceived productivity indicates that cubicles with low or high partitions were the two workspaces that appeared to enhance the occupant's productivity, whereas workspaces in open plan offices with no partitions interfered with the occupant's productivity.

3.2.4 The effect of ambient conditions on productivity

Figure 5 shows that, when considering the ambient conditions, the respondents reported that thermal comfort has the greatest effect on their perceived productivity.

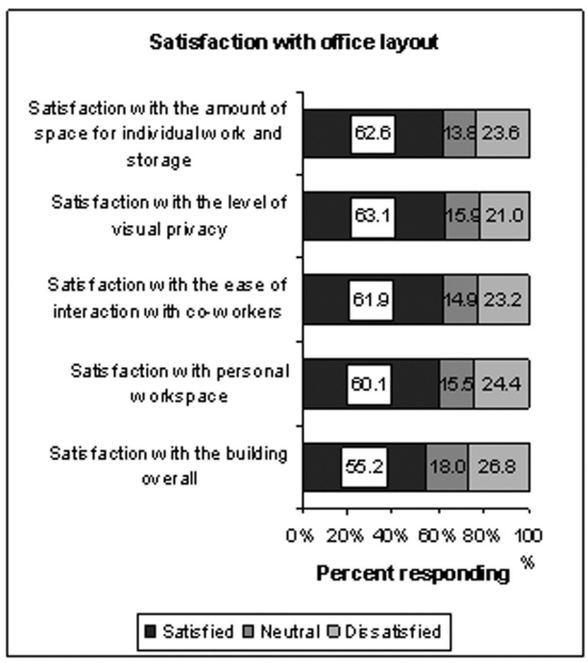

Figure 4: Respondent's satisfaction with office layout in all buildings

Taking this into account with their perceived low percentage of thermal comfort with temperature in winter and summer (figure 2) it can be reasonably suggested that improvement in the thermal conditions over the heating and cooling period would increase their perceived productivity.

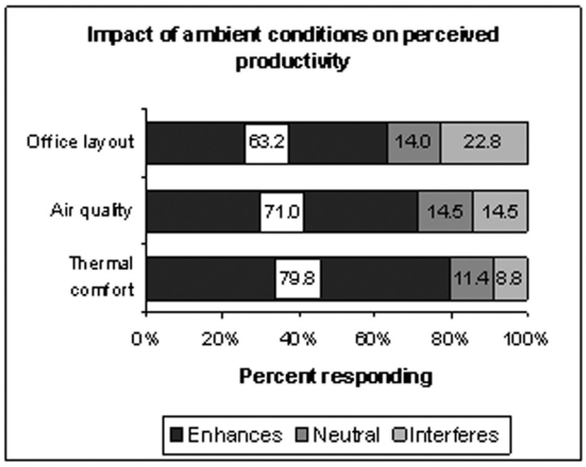

Figure 5: Respondent's perceived productivity with some of the main components of the ambient conditions (all buildings).

3.2.5 Personal controls

Research has shown that having, or perceiving to have, personal control over the thermal environment can bring thermal satisfaction for occupants (Schiller, et al 1988). Even if they do not use the controls they tend to feel more comfortable than those with no perceived personal controls. The perception of control for occupants is an important variable in analysing buildings and it has been linked with health, energy efficiency and productivity in buildings (Bordass et al, 1994).

Raja et al (2001) noted that thermal sensation and the application of various control techniques by occupants play a major role in improving the indoor thermal environment. The use of opening windows and blinds or curtains are the preferred way to modify thermal conditions in a building, and the use of a fan has the same effect as opening windows and curtains. These results show that the lack of access to windows and fans is highly related to discomfort. Thus, the feeling of comfort by occupants is related to the accessibility of controls, and it means that those who are closer to windows and fans are likely to feel more comfortable than others.

Wyon (1996) has indicated that individual control of the thermal microclimate would considerably increase productivity even if the room temperature is maintained at the group mean neutral temperature.

The results from figure 6 show that in the offices studied, the respondents have good access to a few personal controls such as window blinds or shades, operable windows and room air conditioning units. However, due to problems such as a lack of system maintenance,

broken thermostats or a lack of thermostats in their workspace the occupants cannot easily control the temperature to achieve comfort. This suggests that the actual personal control of the thermal environment by the occupants in the Tehran offices studied is poor, and therefore we would expect that the perceived thermal comfort ratings in these Offices would be below those for Offices where personal control was achievable.

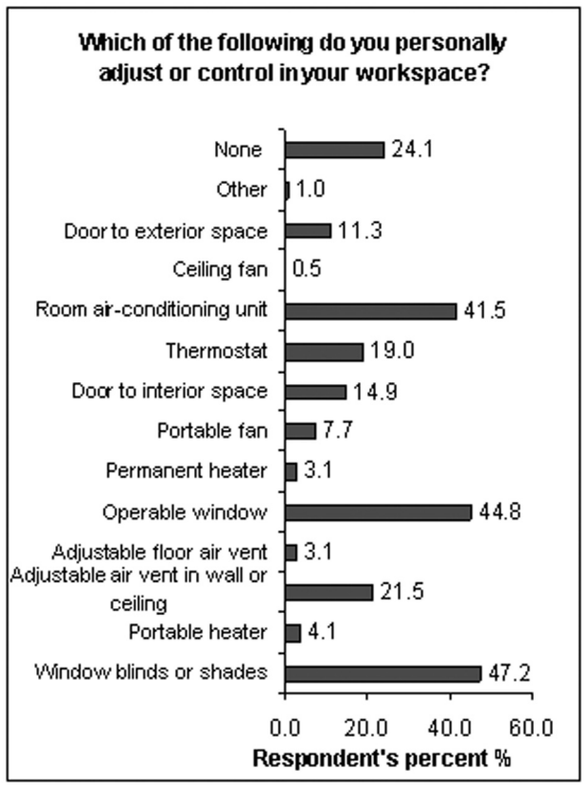

Figure 6: Respondents perceived access to personal controls in all the buildings studied.

3.2.6 Sick Building Syndrome (SBS)

The final criterion that can be assessed from the survey is the relative incidence of factors that influence SBS. SBS is a collective term to describe the factors that cause ill-health that might be directly attributable to the building and its services. The 'Sick building' is described as a building in which a significant number (more than 20%) of its occupants report illness perceived as related to building. Sick building syndrome (SBS) also is identified as a range of symptoms including eye, nose and throat irritation, dryness of mucous membranes and skin, nose bleeds, running nose, skin rash, mental fatigue, headache, cough, hoarseness, wheezing, nausea, and dizziness (ASHRAE Environmental Health Committee 1987). Clements-Croome (2000), has noted that SBS is more

likely with warmer room conditions, and this paper has already shown that when temperatures reach uncomfortable levels, worker productivity is reduced.

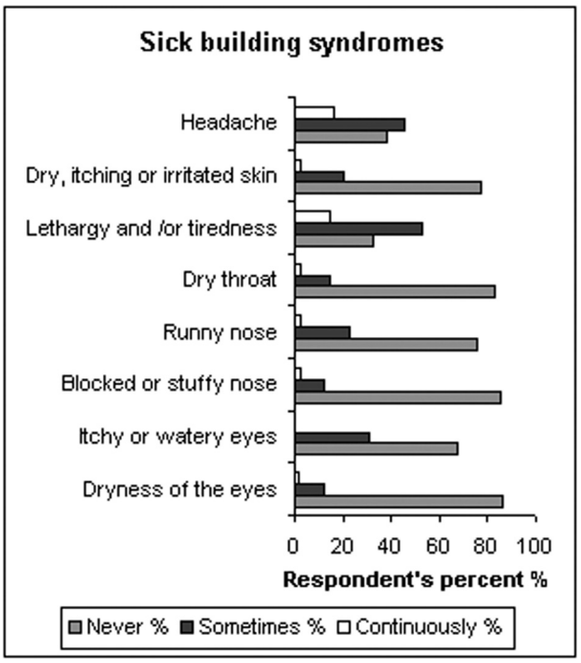

Figure 7: Perceived sick building syndrome in studied offices.

Therefore we would expect output to improve when high temperatures are reduced by air-conditioning. In all the case studies in this paper, a variety of sick building syndrome indicators were reported by the respondents (figure 7). The main SBS symptoms reported were lethargy/ tiredness and headache.

4. CONCLUSION

The main conclusions from this work are:

• Only around 22 - 25% of the occupants report being thermally comfortable during the heating and cooling seasons in the Iranian Offices studied.

• The office layout has an effect on the perceived worker productivity, with workers occupying cubicles with high or low partitions in open-plan spaces reporting the highest perceived productivity.

The overall conclusion therefore is that there is considerable scope for improving the indoor environment in Iranian offices if the sample studied is representative of the wider population.

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