

ON POST OCCUPANCY EVALUATION OF THE PREFERRED LUMINOUS ENVIRONMENT AND OCCUPANTS' SATISFACTION FOR OFFICE BUILDINGS IN MALAYSIA: A SURVEY

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Abstract: Lighting is desired for work and it has an impact to occupants' satisfaction with their workspace to improve the preferred luminous condition in daylit office. This study investigates the acceptable illuminance level that meet the requirement for visual comfort through post occupancy evaluations for office buildings in Malaysia. This paper presents the literature that shows an overview of investigation in daylight distribution and availability that relates to acceptable illuminance levels in daylit offices. The investigations are to know until what extend do people aware on luminance environment by obtaining occupant's feedback. The results of a survey are conducted through occupant's respond of daylight availability in work area by using four different layout in office building and the responses from occupants in the same building with different characterized of fenestrations. The acceptable daylight availability and illuminance levels by occupant for each room can be seen from the field experiment based on photo simulation using High Dynamic Range (HDR) images and field survey on different layout in office building. This study of daylight distribution in an open plan will result the findings on how peoples' attitude toward openings and the acceptable illuminance level is related to visual comfort. Through these variables, it becomes the parameter to this research. It is observed that the office buildings are not designed for daylight utilization, with average daylight factor (DF) lower than 1.5 per cent and not all the office building has achieved MS1525 :2007 minimum work plane illuminance (WPI) recommendation of 300-500 lux when electric lights were on [9]. The combination of

daylighting and artificial light were still needed in office building even though there was plenty of sunlight in this country which was abundance [2]. More than 60 per cent of occupants felt the distribution of daylighting is uneven and caused visual discomfort when electric lights were off. The relationship between luminous condition and visual discomfort had the significant to peoples' attitudes toward windows. This resulting key will provide better understanding for the development of window opening, internal shading control for the office occupants and acceptable illuminance level in office building in Malaysia.

Keywords: Daylighting, Illuminance, Occupant satisfaction, Post-occupancy evaluation, Visual discomfort.

INTRODUCTION

Responses to functional, psychological and aesthetic needs had been explored by Mehmedalp [10], through the assessment on the luminous environment using qualitative approach. The luminous environment has the significant relationship with the building performance, lighting quality and occupant response. In addition to develop and improve the building performance, post occupancy evaluation (POE) was implemented to evaluate quality of luminous environment in office building. The outcomes and recommendations based on POE may be used for future projects.[19]The rationale using post evaluation method in this study on luminous environment in office building in Malaysia was to identify the occupant s' acceptance of luminous conditions. The study was limited to measure the illuminance level, luminous distribution

in workplace, the relationship between luminous environment and human satisfaction. The relationship between human factors and luminous environment was captured through studies by Boyce[14] and lighting conditions that influence human performance [1]. These two independent perspectives which are brightness and interest become the meaningful variation in determining how illuminance level and luminous environment is accepted by occupants. The daylight is so desirable by people who spend almost eight hours throughout the day in office buildings. This study selected three government office buildings in Malaysia to identify the preferred luminous conditions and responses from users. The response from the occupants will show the daylighting was a comfortable light source and the visual comfort had the relationship with luminous environment.

Post Occupancy Evaluation and Pilot Survey

The rationale for conducting studies through post occupancy evaluation is to improve the building design using the systematic survey of the user's attitude towards indoor environment. The post occupancy evaluation was the effective method to evaluate the building performance and introduced the systematic procedures and techniques to emphasize on occupants' need [11]. Performance factors that relates sustainability and occupants' satisfaction were recommended to be established through post occupancy evaluation. The elaboration on the need of occupants was captured in POE method during the evaluation on building performance[15]. The aim of this study on government office buildings were to investigate aspects of occupants' satisfaction and luminous environment in relation to the effect of visual comfort through daylighting. The three buildings were Federal Territory Government Office Building in Taiping (Building B), Federal Territory Building in Pulau Pinang (Building D) and Federal Territory Building in Johor Bharu (Building F). Through this investigation, the occupants' response to illumination level was identified on the open plan office layout. Assessment on luminous environment was based on illuminance recommendation in Malaysian Standard Guidelines MS:1525:2007 that measured in lux.

Luminous Environment.

Daylight availability in the office building has generated the spaces to be comfortable. Daylighting as the major source of light creates more diversity in human's satisfaction and needs [6]. Luminous environment was supported by lighting quality which became the needs to people that use the space. The requirements like visual performance, post-visual performance, social interaction, mood state, health and safety were depends on lighting quality in

luminous environment. A comfortable daylight luminous environment is associated with sensory response to brightness. How people respond and interact with luminous condition in daylight office environment will result the development of lighting and window shading control. [1]

Daylight Quality And Visual Aspects

The benefit of daylighting was contributed to human's biological; higher productivity [17] , more effective learning and clear preference for daylight by workers[6][13]. The workplace in office building has to be enough lighting and proper lighting distribution. Lighting quality in the office has different expectations from the occupants' satisfaction.

Through studies from Boyce [14], on how lighting is considered in working space , it was shown that the prime aspects were quality and quantity of lighting. The daylight quality provide different perception from occupants. In lighting practise, do the occupant feel that the lighting is adequate in visual task? Insufficient lighting may cause visual discomfort.

METHODS

Malaysia receives plenty of sunlight throughout the year [3] and its global illuminance measurement was uncertain due to its climate and sky condition which categorized under intermediate sky[2]. This research provides field measurement and photo simulation to compare the global illuminance and internal illuminance measurement. To judge the occupants' satisfaction on their understanding on illuminance level and preferred condition in luminous environment, the data collection was based on measurement through (a) Field measurement; using equipment light meter Luxtron Lx-107 (b) Photo simulation; the photos were taken using Canon 550D single-lens reflex DSLR camera to produce High Dynamic Range (HDR) photography and analyze through online computer simulation in <http://www.jaloxa.eu/webhdr/roll-your-own.shtml>. (c) Questionnaires .

In order to measure the daylight availability in open plan area, the measurement of luminance (lux) was using Lutron Lx-107 light meter and the equipment was positioned at 800 mm desk level [12]. (Theory – illuminance E) is defined as the luminous flux density at a surface. It is measured in lux.

Room index = $\frac{\text{length} \times \text{width}}{\text{Mounting height} \times C}$ (length + width)

Mounting height x C (length + width)

The room index is needed to know the minimum number of measuring positions from which average illuminance may be calculated.

The Buildings



Figure 1 : The Federal Territory Office Building at Johor Bharu; (a) External view towards the building and (b) image of open-plan office layout (linear).



Figure 2 : The Federal Territory Office Building at Kuala Lumpur; (a) External view towards the building and (b) image of open-plan office layout (linear)



Figure 5 : The Federal Territory Office Building in Pulau Pinang; (d) External view towards the building, (e) image of unshaded windows (f) Typical floor plan and (g) image of interior open-plan office.

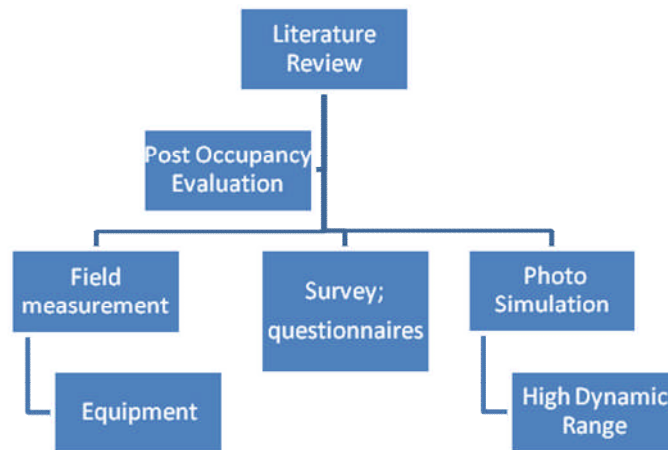


Table 1: Structural Framework of Methodology

Field Measurement



Figure 6: Equipment; Data logger

Building name	Type of room	Window size	Window condition	External	Internal	Orientation	DF(%)	Temp	RH
Building C (Taiping)	Open-plan office	1200	tinted	Overhang (500mm)	vertical blind	North N10	0.04	22.7	60.9
Building D (Pulau Pinang)	Open-plan office	1200	clear	none	none	North & South	0.01	24.7	66.0
Building F (Johor Bahru)	Open-plan office	1500	tinted	Overhang (900mm).	vertical blind	North	0.04	22.0	60.0

Table 2: The Details Of The Open Plan Had To Be Indicated In Forms.

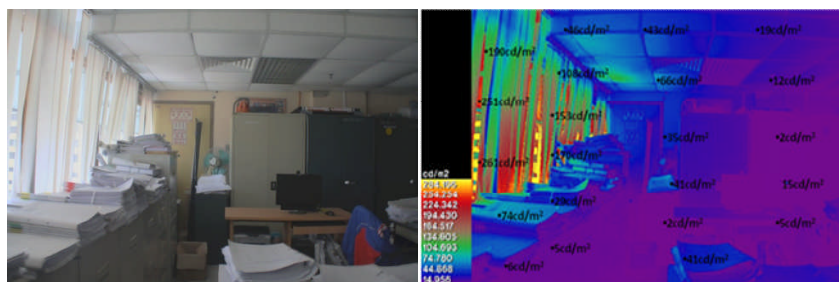


Figure 7: Photo had been loaded in photographic simulation software.

Photo Simulation; High Dynamic Range Images

HDR approaches is to measure the lighting distribution [10], examining the visual comfort and for evaluation complex luminous in complex environment. By using Canon 550D single-lens reflex DSLR camera, the results on luminance and illuminance level can be determined through photo taken and loaded in <http://www.jaloxa.eu/webhdr/roll-your-own.shtml> which is an online computer simulation software.

Questionnaires

Survey based on questionnaires had been distributed to occupant in open plan office. These questionnaires were to access the awareness and satisfaction through daylighting. The questionnaires form consists of 20 questionnaires that had three sections to access:-

(a) Respondents' Behaviour (b) Respondents' understanding on daylight (c) Awareness towards luminous environment. Respondence had to evaluate the questionnaires which will provide a respond in preferred luminous environment and respond to visual comfort. The awareness towards luminous environment was achieved in order to provide a better window development, a good visual health with a good office layout. The questionnaires consisted of 5-likert scale where 1= strongly disagree and 5= fully agree.

Procedure

The questionnaires were distributed to employees at their work place and 94 (n=94) employees managed to complete the questionnaires in 20 minutes. These questionnaires were analysed by using SPSS program.

RESULTS AND DISCUSSION.

Field Measurement; Observation On Illuminance Level

The illuminance level captured through light meter and HDR computer simulation. Example of illuminance measurement in Federal Territory Office Building in Johor Bharu. By using light meter Luxtron Lx-107. Measurement taken during light on and light off.

Based on Malaysian Standard 1525:2007, the recommended standard for lighting in general office area is 300-400 lux and for open-plan office is 300 lux [9]. Most of illuminance level at measurement nodes below 300 lux. The result using light meter measurement showed that Building D had the lowest illuminance level which is 50 lux.. When people choose to work in combination lighting condition (light on), the illuminance level still not meet the minimum standard guideline. The distribution of

daylight showed the illuminance level at open-plan office in Building D was not evenly distributed. Figure 7 showed that most of the offices building in Malaysia were not met the minimum standard guidelines even though the measurement of illuminance level taken during lights was on. Many occupants wanted to save energy but the size of the room and the distance from the window was not available to get benefit from daylight. Based on IESNA[8] and code of practise in lighting from CIBSE [5] for open plan office is 500 lux. From the observation, the illuminance level using Malaysian Standard MS 1525 should be added from 300-400 lux to 500 lux in general office and open-plan office [9].

Survey: Occupants Respond And Satisfaction On Visual Comfort

Existing knowledge on how people respond to daylight-linked lighting and shading controls in the workplace is very limited. Several surveys had documented that people believe that daylight was superior to electric light in its effects on people [1]. In this study, three buildings were chose to see the relationship between occupants' perception and glare condition from the window of the office. The field survey of 40 respondents which were general staffs were given the questionnaires to get feedbacks. The government office provides open plan layout in different positions which are next to external wall (linear plan layout), open plan at the corner of building and open plan in the center of building as shown in figure 10. Breakdown of the survey from 40 respondents showed 36% of the respondent were working at next of external wall (linear plan layout) and center of building, 24% of the respondents were working at the corner of the building and 4% of the respondents were working at next of the external wall (deep plan layout) as shown in figure 11.

Results from the survey in figure 12 showed that 77% of the respondent found there was glare from the windows of their office during light were off. During the lights were off, the exact daylight conditions of the their working space was as shown in figure 13, 14, 15. When the working space had a little daylight, the internal illuminance and external luminance at the window will produce glare. This will affect the visual discomfort to the occupants in that space where 39% of the respondents agreed that the existence of glare in visual discomfort (Refer to figure 16). According to studies by Anca D. Galasiu and J.A Veitch [1], there was relationship between windows, lighting, work performance, workers' mental and physical well-being, and subjective perceptions in six Canadian office buildings speculated that both "too much daylight" as well as "too little daylight" may affect the occupants' physical well-being.

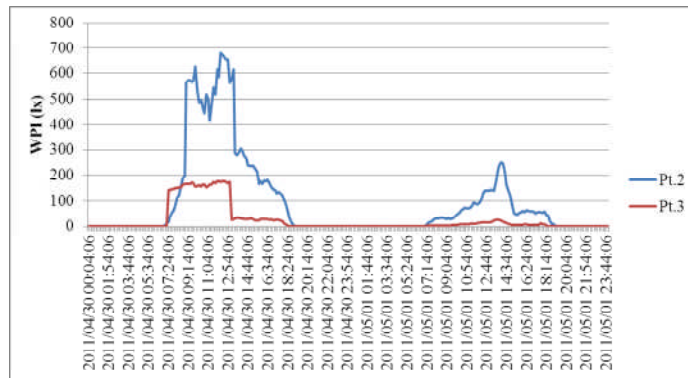


Figure 8: Work plane illuminance(lux) in open-plan office during light off from 30 April to 1 May 2011.



Figure 8: Work plane illuminance(lux) in open-plan office during light on from 27 April to 28 April 2011.

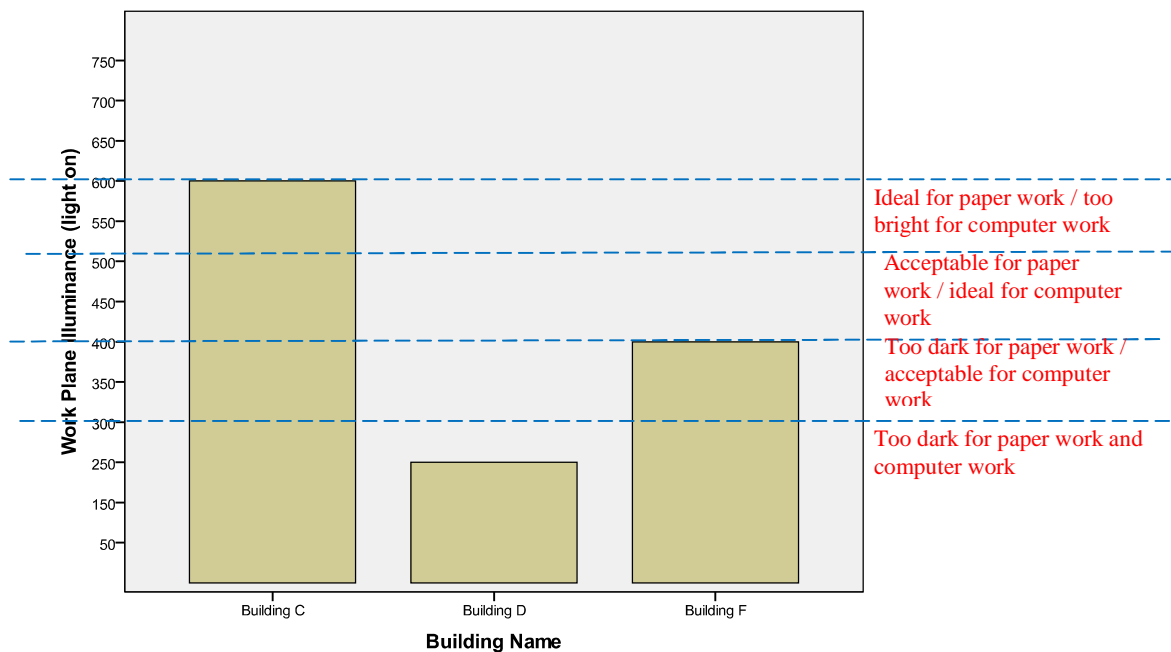


Figure 9: Work plane illuminance (lux) in open-plan office during light on for Building C (Taiping), Building D (Pulau Pinang) and Building F (Johor Bharu).

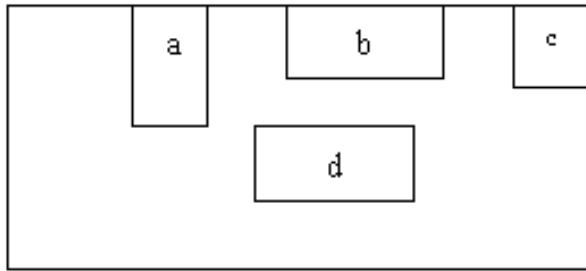


Figure 10: Parameter set out in the building.

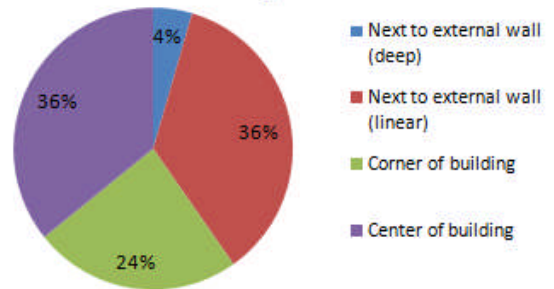


Figure 11: Percentage of the respondent according to room position.

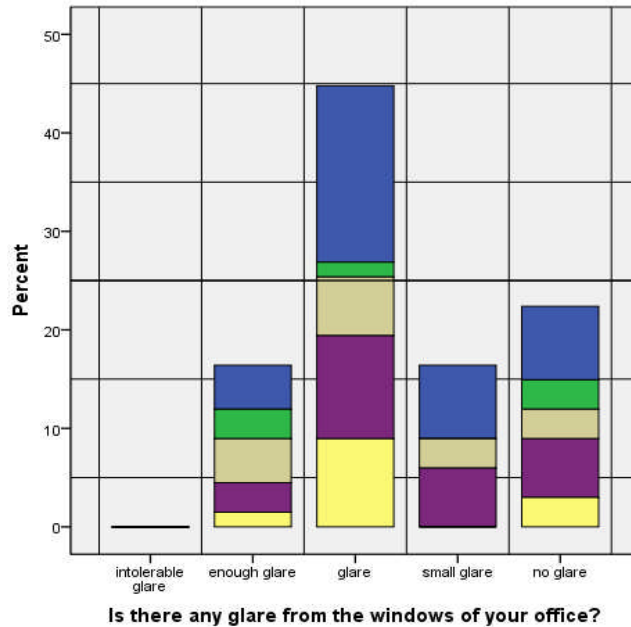


Figure 12: Glare from windows in office

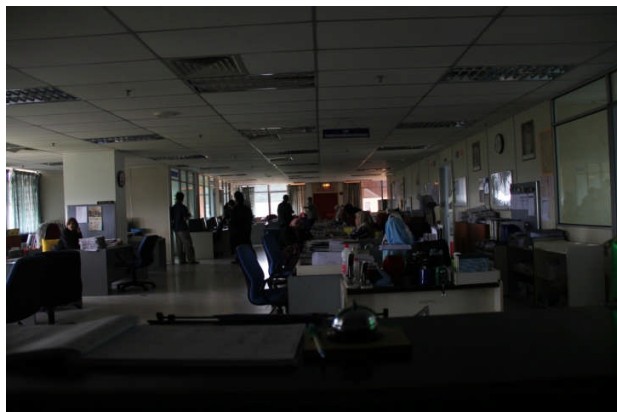


Figure 13 : Natural lighting condition in Taiping Federal Building when light was off.



Figure 14 : Natural lighting condition in Penang Federal Building when light was off.



Figure 15 : Natural lighting condition in Johor Bahru Federal Building when light was off.

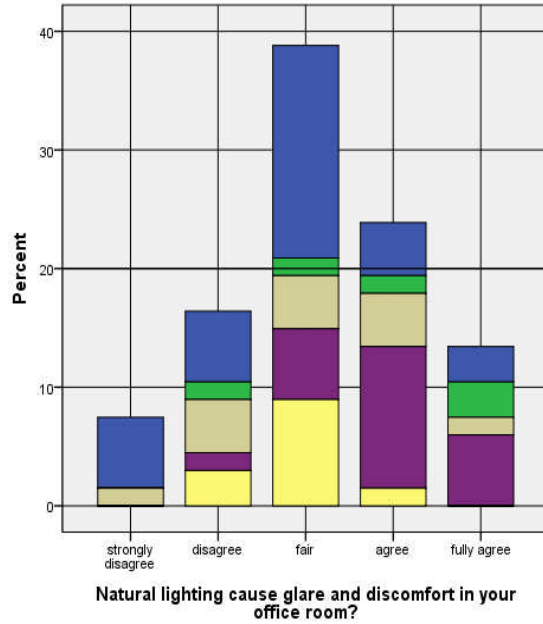


Figure 16: Natural lighting and discomfort in office room

What kind of view through the window that you have in your office room now?

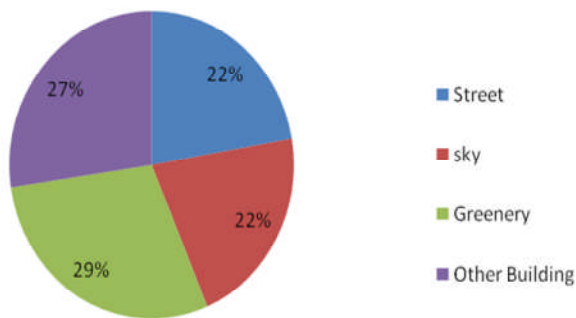


Figure 17: Existing view to outside window

What kind of view through the window that you prefer to have?

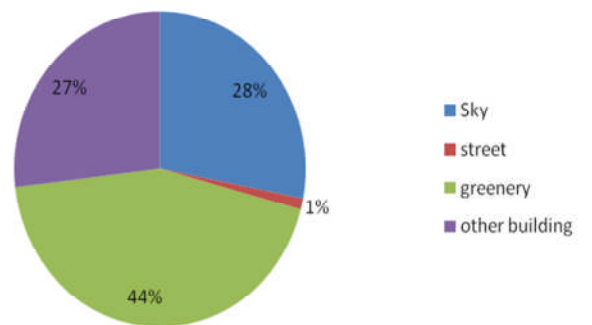


Figure 18: Preferred view to outside window

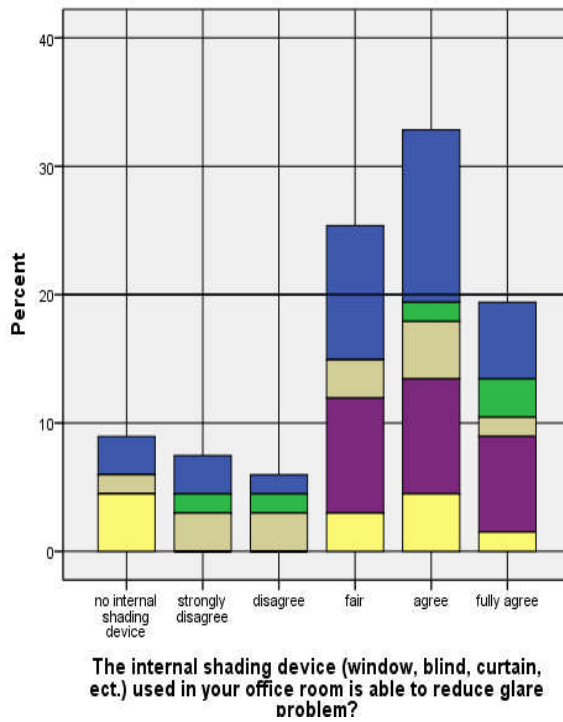


Figure 19: Respond occupant on internal shading device

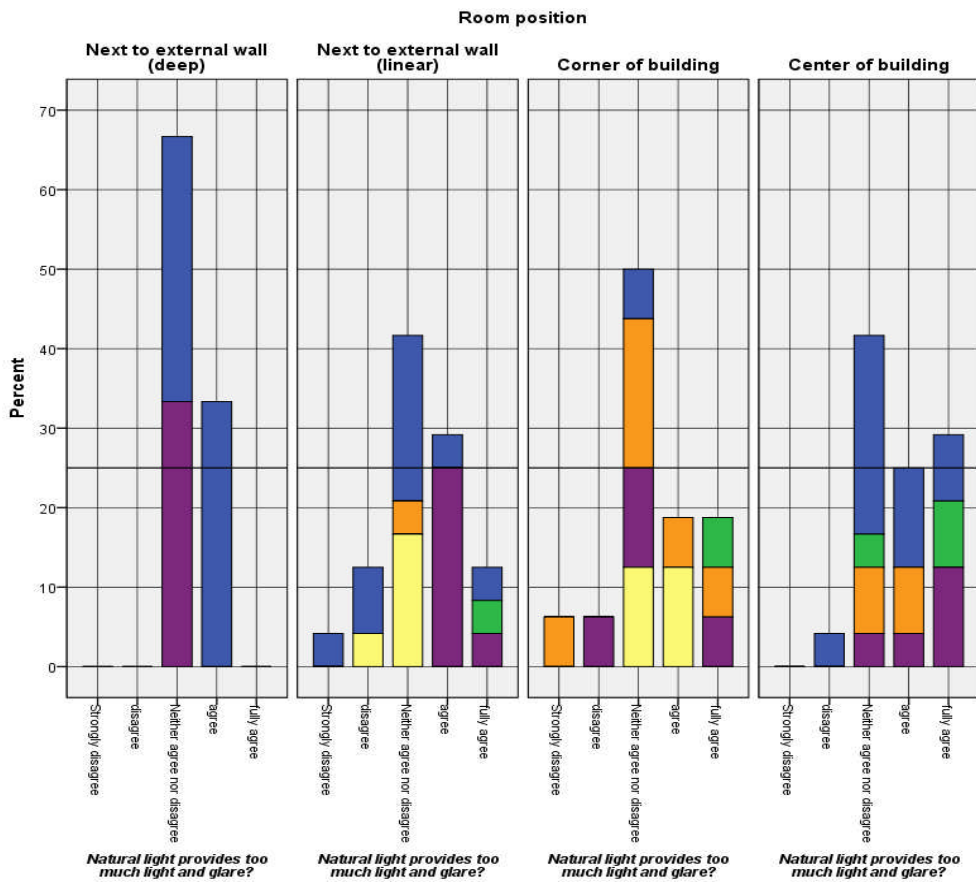


Figure 20: Glare condition according to position open plan

Results from the survey in figure 17 showed that 29% of the respondents preferred greenery view from their working space through the window and this position will affect the perception of the occupants toward the glare condition. According Anca D. Galasiu and J.A Veitch [1], successful prediction of discomfort glare from daylighting had not achieved in a form useful for widespread practical application. Less attention to the wide individual variability in discomfort glare response [7][18], and the importance of the view outside were the reasons how the glare problem exist. Anca D. Galasiu and J.A Veitch [1] found that the people may accept the glare condition from daylight environment rather than glare caused by artificial lighting.

Figure 18 showed that 44% of the respondents preferred to have greenery view rather than view towards sky, street and other building. This showed that users' perception toward glare had significant relationship with the external view. According Hopkinson [7], to validate his calculation method on glare index, he found that participants did not complain the glare from windows. People used to tolerate the daylight glare when there was view from openings

Figure 20 showed that 51% of the occupants agreed that internal shading device was able to reduce glare problem. Biilow-Hiibe, H [4], in his studies suggested that several aspects of shading devices must be considered. Even if the shading devices were positioned in the centre, the daylight properties must be considered due to its effects on view, presence of sunlight patches and adjustability [4].

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The internal shading devices were able to reduce glare problem but without proper understanding of its function, the external view was blocked and only natural light penetrates the internal space. According to Osterhaus[18], glare problem was ignored in the office buildings which faced to east and west orientation. The survey indicated that the level of glare was not correlated with the window orientation. As shown in figure 20, occupants who sit at the center of the office and next to external for linear plan layout had high visual discomfort condition due less interaction with external view.

CONCLUSIONS

As the conclusion, the survey resulted that visual discomfort due to the glare from the windows have significant relationship towards occupants' perception in luminous condition from the window and external view[16]. The luminous condition in daylight environment through illuminance level provides different attitudes and behavior to occupants. The existing recommendation on illuminance level in office building was insufficient. The combination of daylighting and artificial light was still needed in office since the sky condition in Malaysia provides diffused daylight. Evaluation method by POE will help designers during schematic design to improve the development of internal office layout, openings and the needs of occupants for future design.

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