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THE VISUAL PERCEPTION OF OCCUPANTS' ON DAYLIGHT; *Emphasis on the diversity of luminance ambience due to architecture & effect of glare in office environments.*

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Abstract
The research investigates the occupant perception of daylight in office buildings in Sri Lanka. Specific focus is drawn to the potential diversity of a luminous ambiance environments, created by daylight and problems associated with glare effect to the visual comfort. The methodology involves an investigationto find the level of occupants' perception through a questionnaire survey and analysing the data using the SPSS analytical computer software. In addition, pointed Lux levels in selected areas were measured to find out the activeness of day lighting level using Daylight factor. Simultaneously a photographic survey is used to identify the brighter and darker zones and design intervention of the building designs. According to the data analysis, 97% of responses are found to be less sensitive to day lighting. The results suggest the occupants in investigated office buildings consider daylight as an insignificant component in office environments. Further, it was found that glare; due to extensive difference of lighting level between inside and outside, was an issue to be addressed.

Keywords: *luminous environment, visual comfort, luminance ambiance, occupants' perception, daylight, Lux level*

1. Introduction
In tropical countries like Sri Lanka, day light is available throughout the year but most people who live in tropics have less sensitivity towards achieving maximum use of it in their day-to-day activities. Especially in office buildings which mostly function during daytime have anti -daylight integrating windows and methods such as blackout curtains trying to build artificial working environment using artificial lighting systems consuming energy. Evenif the occupants are interested in integrating day light in to their working spaces the building design itself is not flexible enough to satisfy the need. The problem could be, either with the designers of these buildings or the general lack of knowledge and advantages in daylight integration in to buildings of people who lives in tropics. This may be identified as a third world syndrome.

In offices, workers spend longer hours in front of computers, making them particularly sensitive to veiling reflection and glare, in which day light is often found to be the source of discomfort. As a result free source of light has slowly lost interest from architects and clients throughout of the years and mostly until the 1970's in majority of buildings. However, the rising conscience that artificially lit environments significantly increase the energy consumption of buildings (Baker,1998) and often generate unsatisfying or discomfort environments from the occupants' point of view (lam, 1972), have forced architects and scientists to reconsider daylight a serious option in providing comfortable spaces for offices. (Dubois, Demers, &Potvin,2007)

Thus, this research aims to find the reasons for the above scenario in terms of the occupants' perception through analysing the daylight level in the office environment. The research is based on visual perception and that level of perception depends with human sensors and activity pattern. This further investigates the importance of the day light diversity in office buildings, and level of impact to the employees' and their self-satisfaction.

2. Data/variables and their definition in office environment

- Level of daylight

There is a maximum day light level in office buildings 350 lux the challenge is how to control that average 350 lux level and used daylight factor help to use the standard percentage of the day lighting level in the office spaces. However indoor and outdoor lux level variation help to produce more glare. (Szokolay,1975)

- Activity type

In every office building, the level of daylight integration depends on their activity. Sometimes Daylight is a must for that specific activity. Without daylight that activity cannot be function properly.

- Occupancy pattern

In office buildings its occupancy pattern varies with the interior arrangement as an example, open plan office concept is used to get more daylight in to the working areas.

- Occupancy perceptions

3. Field study program

The research was carried out during the month of February as it is considerably consisted with the most days of warm temperatures and low rainfalls throughout the year.

A pilot studyinclusive of a questionnaire survey was carried out to identify best potential two cases where 20 office buildings were studied.There Tripoli market building and SLLRDC building were selected which were identified to be designed for maximum daylight consumption.Both the buildings selected as case study, are located in Colombo area, therefore climatic conditions were constant to the both buildings

- Case Study 1 - Tripoli market building: One participant from each working table was selected to participate in the questionnaire survey. 30 responses were taken.

- Case study 2 - SLLRDC building: Responses from the selected 32 occupants in design division and 20 occupants in wetland divisions were taken.

30 mints were offered for each participant to fill the questionnaire according to their own preferences.

4. Data presentation tools

SPSS (Statistical Package for the Social Sciences) is a statistical analysis and data management software package. SPSS can take data from almost any type of file and use them to generate tabulated data. This package programs is available for both personal and mainframe computers as well as to calculate daylight factor and understand the relationship between the occupants' perceptions and the day lighting level in a selected area. Diagrams which indicate the measured point lux levels,column charts and pie charts using Microsoft Excel and plots of distributions and trends are used as descriptive statistics to conduct complex statistical analyses.

5. Methodology and tools to measuring daylight

Working office hours were divided in to four segments as 8.00am to 10.00am, 10.00am to 12, 12 to 2.00pm and 2.00pm to 4.00pm to take the average lighting levels using lux meter as a light measuring instrument. The measurements were taken at selected points in a (5'x5') grid pattern to get more accurate average values. Each grid point gives variable values and each point measurements were taken at 30 minutes intervals within each segment of two hours. Simultaneously the day light factor is found tounderstand the standard lux level in the selected office buildings.
Measurement heights

- Common areas (lobbies, corridors, courtyards)

Measurements are taken @ zero level and lux meter is moved on the ground level using cord or cable.

• Working areas

Measurements taken @ 2’6” level and lux meter is moved on the working plane. (Figure 01)

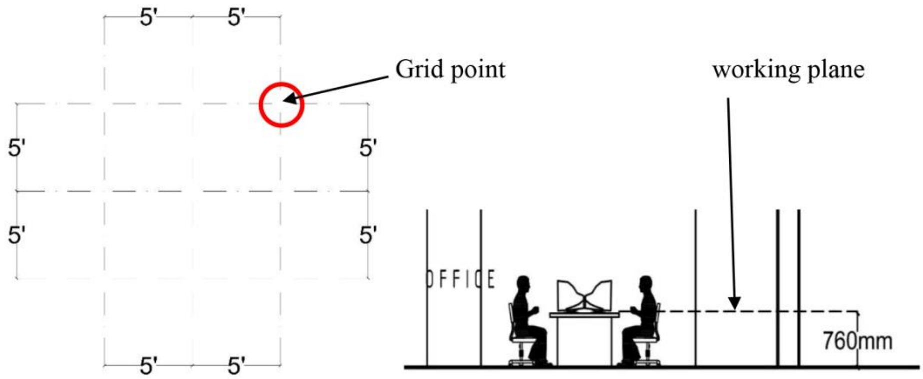


Figure 132; 5’x5’grid point and 760 high working plan (Source; author)

6. Method of analysis

The data gained through SPSS analysis and questionnaire survey is analysed and compared with the lighting level condition which then is used to construct a relationship between the lighting level and occupants’ perception.

6.1 Expected Research outcome

The diversity of the daylight environment has been explored by various researches and ,according to those researches, the diversity of the daylight environments indeed addresses the inherent subjectivity to each individual, leaving him/her the choice of selecting various lighting levels according to the specific activities and locations . However, day light directly affect to the professional rendering outcome. This hypothesis is investigated along with the reasons to prefer enclosed office environments.

6.2 The daylight distribution in two buildings

As shown in the figure 02, in Tripoli market shade blinds are used to avoid glare. As a result, inside daylight factor become less than 2% and dim daylight conditions prevail in daytime.

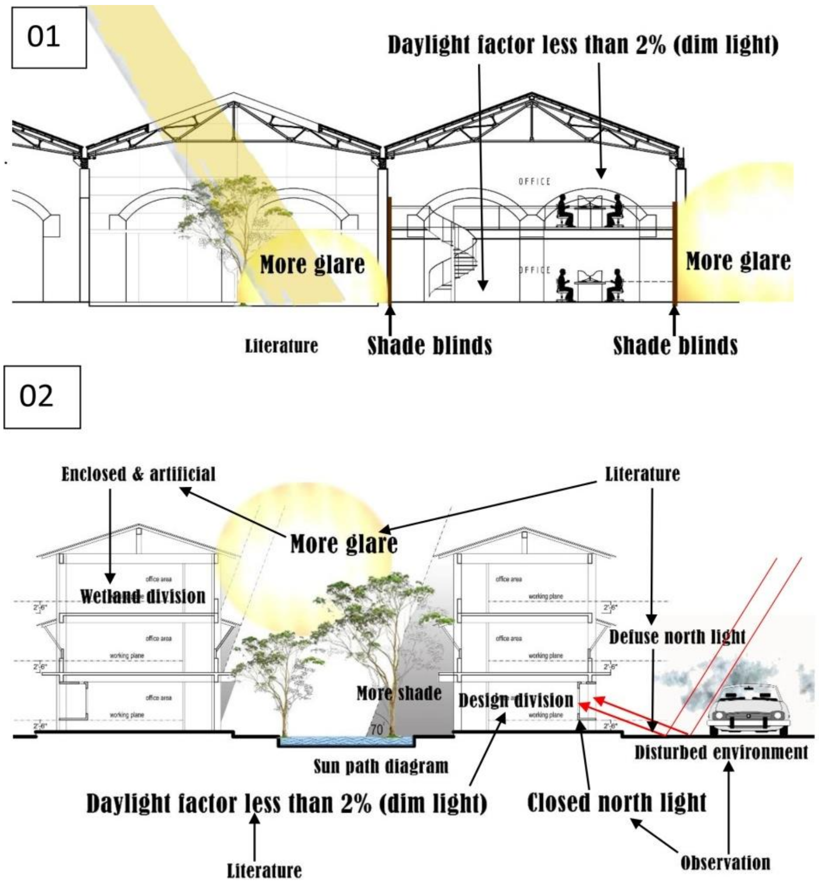


Figure 2; daylight distribution analysis in 1) Tripoli market and 2) SLLRDC

In SLLRDC, in design division; the north light is disabled to avoid unfavorable outside environment due to dust and vehicle fumes and noise.this has resulted inside daylight factor to be less 2% and has caused dim daylight in daytime.

In wetland division a considerable contrast between inside and outside (figure 02) could be visible which cause higher amount of glare. Thus the occupants are tend to operate in that division using artificial lighting and ventilation.

6.3 Data analysis

T test statistic methodology

The t-statistic was introduced in 1908 by William Sealy Gosset, a chemist working for the Guinness brewery in Dublin, Ireland. (Richard, 2004)
A t-test helps you compare whether two groups have different average values (for example, whether men and women have different average heights).

What is a t-value?

The t-value is a test statistic for t-tests that measures the difference between an observed sample statistic and its hypothesized population parameter in units of standard error. A t-test compares the observed t-value to a critical value on the t-distribution with (n-1) degrees of freedom to determine whether the difference between the estimated and hypothesized values of the population parameter is statistically significant.

Main Questionnaire Analysis

The questionnaire was developed with one to five scales according to the statistic methodologies and each answer given by occupants.Five optional questions are analyzed using two tail t-test in statistics.

A; 95% valid Data **P**; 5% negligence data

Observer values close to the '0' become significant, where asobserver values close to the two tail't' values, become insignificant. Critical't' Value is selected according to the test sample for the barrier analysis. The following table shows results captured from two tail't' value table.

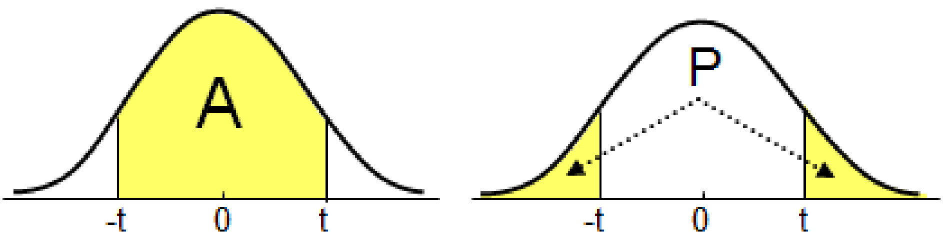


Table 01; two tail t-test in statistics

Critical 'T' value modular table

According to the 'T' test statistic methodologies, Critical T value modular table is a constant and can download from any statistical websites and refer from statistical books. The important thing is, number of occupants' or responses who answer the questionnaire survey.

(N-1)=X

N; number of responses
X; value must include to the 'T' value table of Critical 't' value selection

In Tripoli market building Critical't' value selection for analysis

Area of right	0.2 60%	0.1 80%	0.05 90%	0.0025 95%	0.01 98%	0.005 99%	0.001 99.90%
Confidence level = 29	0.854	1.311	1.699	2.045	2.462	2.756	3.396

Table 2; Table of critical 't' value selection
Source; www.ruf.rice.edu/~bioslabs/tools/stats/ttable

Data analysis were based on hypothecs testing and testing statement given as follows,

1) Ho: |- μ| ≥ μ0 vs H1: μ ≤ μ0
2) Ho: |- μ| ≥ μ0 vs H1: |- μ| ≤ μ0

μ= observers''t' value
μ0= critical't' value

Observer 't' value |2.045 ≥ +/-2| critical 't' value (significant factor)
Observer 't' value |2.045 ≈+/-2| critical 't' value (insignificant factor)
Observer 't' value |2.045≤ +/-2| critical 't' value (significant factor)

Observer 't' value; 't' value taken from T test table't' value taken from T test table (given by SPSS after enter the excel data sheet)
Critical 't' value; 't' value taken from critical T value section (that is the constant)

Table 03 clearly shows the responses have high't' values and it become insignificant according to the hypothesis, Observer't' value [2.045> +/-2] critical 't' value. However significant values indicates higher value such as (2.045+2 =4.045) and observer 't' value higher than the 4.045.

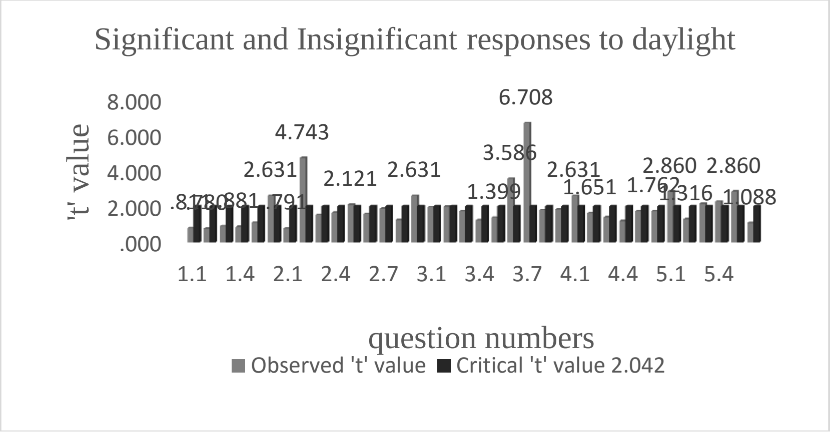


Table 3; Significant and insignificant response to Daylight in Tripoli Market (Source; Excel column draft use with SPSS data)

6.3.1 'T' value analysis in Tripoli office building

According to the't' test in the Tripoli market 93% of observer't' value lies within the **[2.045 +/-2]**range and resulting majority of responses to be insignificant. This suggests Tripoli market occupants' are less considerate or less sensitive to the day light.

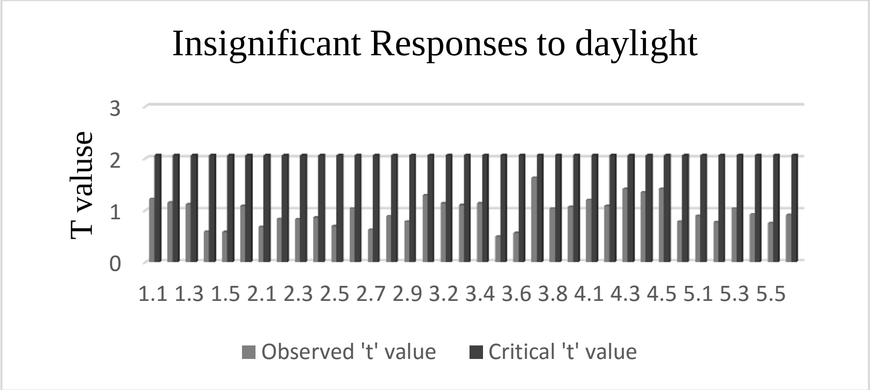


Table 4; insignificant responses to Daylight in Design Division Source; Excel column draft use with SPSS data

The column draft of the insignificant responses in design division in SLLRDC occupants clearly shows the insignificant responses to the all questions and all Observer't' value in [2.064 +/-2] range. However insignificant values are indicated between 2.064-0 range. (Refer Table 04)

6.3.2 'T' value analysis of Design division in SLLRDC

As per the analysis of 't' test in the design division 100% of observer't' value lies within the **[2.064 +/-2]** range resulting majority of responses to be insignificant. The result signifies occupants working in the design division of SLLRDC, are less considerate or less sensitive to the day light.

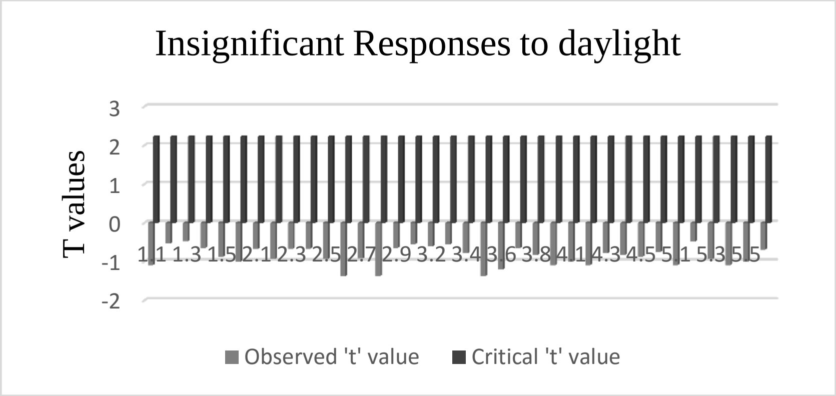


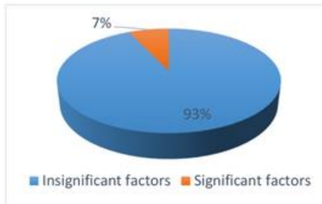
Table 05; insignificant responses to daylight in Wetland Division

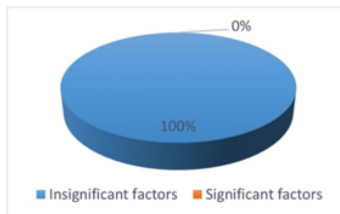
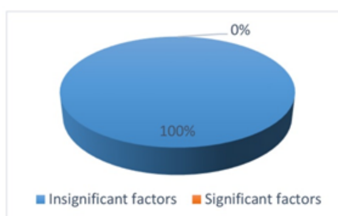
The column draft of the insignificant responses in wetland division in SLLRDC occupants clearly shows insignificant responses to all the questions and Observer 't' value lies within [2.228 +/-2] range. However insignificant values are indicated with miner value (refer table 05).

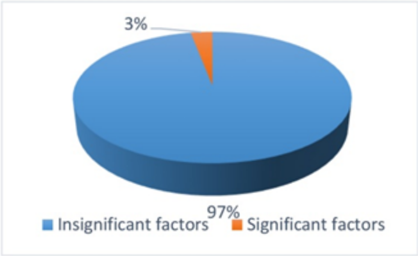
6.3.3 'T' value analysis of Wetland division in SLLRDC

According to the 't' test in the wetland division 100% of observer't' value lies within the **[2.228 +/-2]** range and majority of responses are insignificant. The result points out that the occupants working in the wet land division of SLLRDC, are less considerate or less sensitive to the day light.

Summary of data analysis

Tripoli market office building		**Pie chart diagram**
Significant responses %	insignificant responses%	
(2/30)x100=7%	(28/30)x100=93%	
2= significant responses 30= number of occupants	28= insignificance responses 30= number of occupants	

Design division (SLLRDC)		**Pie chart diagram**
Significant responses %	insignificant responses%	
(0/25)x100=0%	(25/25)x100=100%	
0= significant responses 25= number of occupants	25= significant responses 25= number of occupants	
Wetland division (SLLRDC)		**Pie chart diagram**
Significant responses %	insignificant responses%	
(0/11)x100=0%	(0/11)x100=0%	
0= significant responses 11= number of occupants	11= insignificant responses 11= number of occupants	

Average responses in selected two buildings		**Pie chart diagram**
Significant responses %	insignificant responses%	
(2/66)x100=3%	(64/66)x100=97%	
2= significant responses of two selected buildings 66= number of total occupants	64= insignificant responses of two selected buildings 66= number of total occupants	

According to the scientific analysis, 97% of responses are found to be insignificant in respect to performance to daylight by occupants and 3% responses are found to be significant. In addition, daylight factor and the glare has effected to emphasis the analytical result and discuss with the comparison between the occupants perception level and the day lighting level with its diversity.

According to the results of the data analysis, 97% of responses are found to be less sensitive to day lighting by occupants. The evidence suggests that the occupants in investigated office buildings in Sri Lanka consider daylight as an insignificant component in their office environments. Further, it was found that glare; due to extensive difference of lighting level between inside and outside, was an issue to be addressed. The results suggest that glare be a reason of this poor perception to daylight and how it needs to be investigated and applied innovatively and appropriately in future designs.

Conclusion

The research findings assume that in tropical countries like Sri Lanka glare is a major problem and architects must careful when designing daylight integrated buildings, especially in tropical countries. As the result of that simulations it was identified that there is a huge lux level differences between the inside and outside in Sri Lankan context. This lux level difference creates more glare and it causes uncomfortable office environment, which is a critical issue in an office environment. The occupants have been used some design strategies for reduce glare and which is the reason for the enclosed spaces using curtains and partitions. The architects must try to integrate day light with the building design considering all the benefits such as energy saving, aesthetic purposes and more importantly user perception of the building.

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