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A STUDY ON INDUSTRIAL DAYLIGHTING IN WARM HUMID CLIMATE.

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Abstract

This paper reports the analysis made in the electronic factory, where daylight is the key indicator. It focuses on the research indicators of daylight such as Workplace illumination, Daylight satisfaction, Thermal discomfort and glare. The primary data was obtained fromobservation of the factory building along with the survey questionnaire for 100 respondents and the data stimulation of the building by using DIALUX EVO software . From the simulation the derived daylight factor is 2.262% and the lux level is 1942lux and the average lux is 650 lux. It concluded that the building is adequately lit. But the corners that is north east, north west, south east and south west is inadequately and irregular lit, hence the daylight to be provided additionally in the corners of the factory building. About 50% respondent experienced thermal discomfort which is due to the daylight harvesting, hence fenestration opening is recommended in order to improve the cross ventilation.

Key Words: Daylight, Glare, Lux level. Industrial lighting

INTRODUCTION

Daylight is an important source of energy and Vitamin necessary for human life and existence[1].It is evident from many researches that daylight is an integral part of the human body and also a key source to light a space. Fenestration that opens and admits daylight not only provides pleasing view but also connects to the outdoors. Daylight provides higher luminance and also good colour rendering, however daylight also produces associated heat and glare additional to lighting.[2]In tropical climate (hot and Humid) where daylight is abundant it's really challenging and takes one expertise to design a well-lit factory space to have adequate daylight factor and daylight satisfaction. The main factors associated with daylight satisfaction are total luminance, thermal comfort, and glare.

The research aims to analyse the Workplace illumination, Daylight satisfaction, Thermal discomfort and glare to enhance the occupant's satisfaction.

LITERATURE REVIEW:

Many studies have shown that natural light in working place improves job satisfaction and productivity.According to a 2011 study at the University of Oregon, the respondent sick time is correlated with their exposure to natural light and view to the outdoor environment. In this study

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it's been stated thatthe respondent who experienced adequate amount of daylight and better view's to the outdoor environment reduced their absenteeism by 6.5% [3].

In designing industrial buildings, daylight entry is not emphasized and its contribution is not adequate but it is a very important element towards workers psychology and physiology of the respondent. The respondent/workers must have a connection to the exterior environment, otherwise their productivity decrease[4]. Unhealthy indoor atmosphere that's lacks lighting has a significant negative impact on human health, and in the case of the office working population day lighting is considered the best source of light because of its unmatched colour rendering index and its wide ray of spectral distribution making it the best solution for human's health, satisfaction and visual comfort[5]. View towards outdoor environment by means of fenestration provides significant positive impact on the occupant's satisfaction, and also enhances the health an productivity.[6]

There are different sources of lighting, but sunlight is the most important and necessary light source for humans as it impacts humans both physiologically and psychologically which lacked in the supplementary lighting. Which is mainly because of sunlight unique quality of spectral distribution. In addition, it is the most important source of vitamin D which is necessary for the strength of human bones and overall health. Along with its role as an agent for vitamin D production, sunlight helps in improving occupant's health, mood and cognitive performance, increased quality sleep[7].

In this paper, the impact of research indicators of daylight and its associated effects on the occupant satisfaction is analysed. The study has the following objectives:

- To assess the required daylight levels in the workplace
- To evaluate the associated heat and glare through daylight entry
- To assess the uniformity of the daylight
- To identify the significant relationship between daylight openings and total luminance.

METHODOLOGY

A case study is conducted for an electronic factory existing at Vallam, Sriperumbudur, Chennai Metropolitan area, South India. The electronic factory is a Pre-engineered building structure factory with a height of 15m. The main means of fenestration for the factory is through, casement windows, cleared storey windows, roof light panels and rolling shutters. The factory is oriented towards the south and north direction with a south facing road approach. The sun path travels from north east to south west of the factory. The walls are R.C.C till 4.0m high and above by PEB sheathing material. Roof is covered with Bare Gal volume sheet with roof light panels and Turbo ventilators provision.

In order to know the daylight characteristics in the working atmosphere, a survey was conducted on thermal comfort, Glare, workplace illumination and rating of daylight at the working place with 100 respondents and the results are compared with bar charts.

Dialux evo softwareis used by lighting designers all over the world.The software version used for the stimulation purpose is Dialux evo**10.** The various input parameters are considered namely pollution category as medium to heavy traffic. Data inputs as Ground area, reflection factors such

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as Ceiling, Walls, Floor, Light loss factor, Clearance height are measured and fed into the Dialux evo**10** software. The total number of employees in the factory is 900 in total with 131 are in the administration department, 180 no's in the production department,229no's in the assembly side and remaining 360 no's in the packaging department. The employee's strength in the assembly and production department are considered for sample calculation. Taro yamane formula is applied and the sample size of 100 no's is arrived, which is more than 10% of the factory workers strength.

RESULTS AND DISCUSSION

Survey study:The daylight satisfaction is surveyed with 100 respondents in the working place of the electronic factory.

I. Thermal comfort:

The opinion of the respondents about rating the thermal comfort based on their different requirements. The results of the questionnaire is computed by percentage analysis

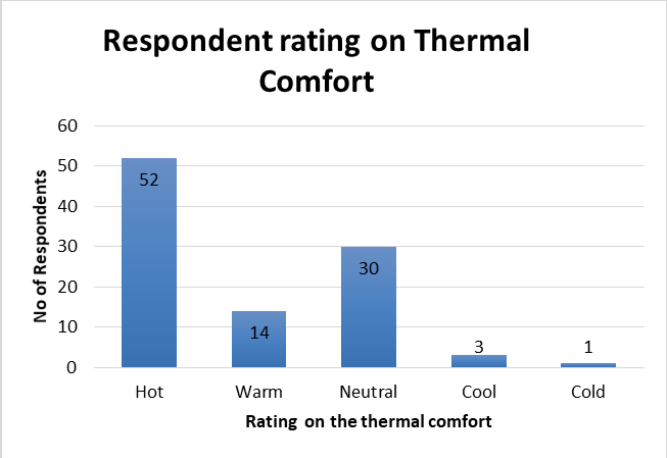

Fig 1.1 Respondent Thermal comfort at the factory

From figure 1.1, it has been observed that 30% of the respondent feels neutral on thermal comfort and the majority 52% of the Respondentexperiences thermal discomfort in the workplace. Only very few respondents feel cool. Hence it is found out that many of the respondents (52%) felt thermal discomfort in the assembly and production area which has to be taken care of in order to provide respondent thermal comfort to the workers. Similarly in research work by **Justine MushoboziKatabaro(2019)** in his work on lighting quality on workers efficiency states that a significant number of the respondents suffered headache during work due to thermal discomfort and non-uniform distribution of light at the workplace.

II Experience of any difficulty (Glare) in viewing the objects placed

To know the respondents experience of any difficulty (Glare) in viewing the objects placed on the workbench

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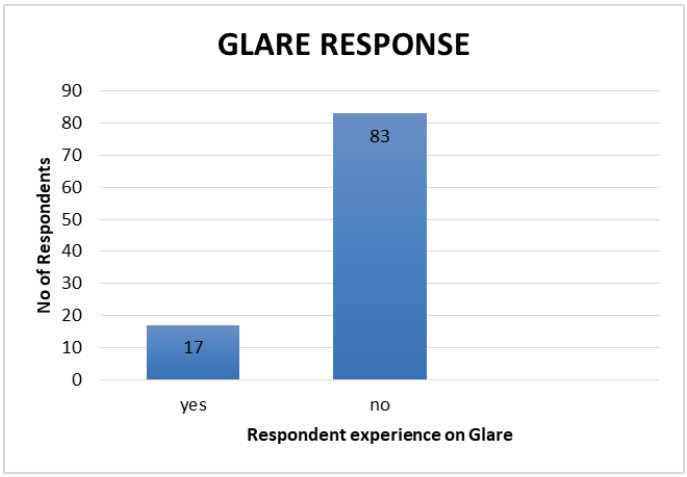

Fig 1.2 Respondent experience towards glare

From 1.2 it has been observed that only 17% of the respondentsexperience glare at the workplace. Majority of the respondents revealed that there is no difficulty (Glare) in viewing the objects placed on the respondent workbench. Similarly in a research thesis by **ApiparnBorisuit(2013)** in the impact of light on visual comfort, stated that the glare caused by daylight is significant between 2-3p.m.

III Rate of workplace illumination

The respondents rating on the workplace illumination

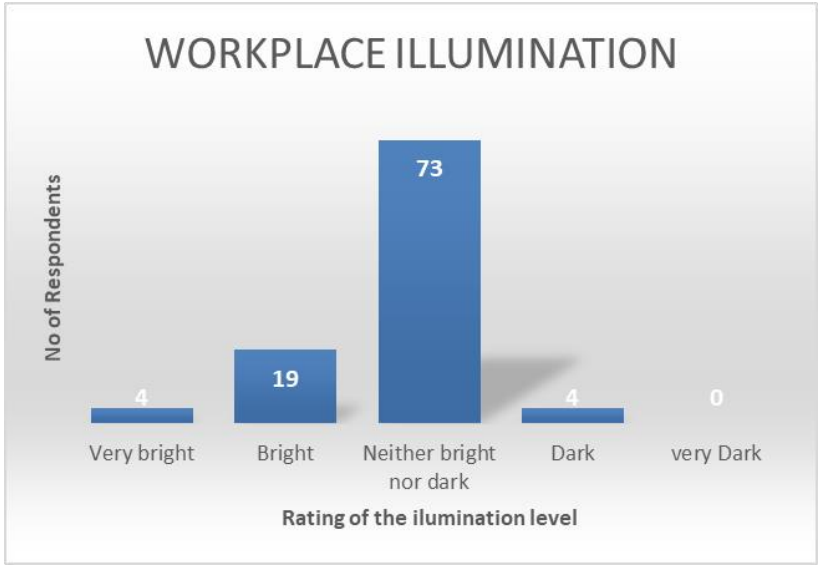

Fig 1.3 Rating of the workplace illumination

It's been observed from the figure 1.3, Majority of the respondents (73%) feel neither bright or neither dark at the workplace. No respondent feels very dark in the working place. From there it is clear that major respondent ratings are neither bright nor dark. In the research by**Karin FridellAnter(2013)** on Visual comfort on quality of light stated that the average illumination is very less resulting in respondents choosing higher luminance on greater daylight variation. The

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research states that uneven lighting, thermal and visual discomfort has adverse impact on human health (Manju et.al., 2020).

IV Rating of daylight in theWorkplace

Overall rate the daylight in the workplace has been evaluated through rating in the following ways namely Very Satisfied, Satisfied, Neutral, Dissatisfied, Very Dissatisfied.

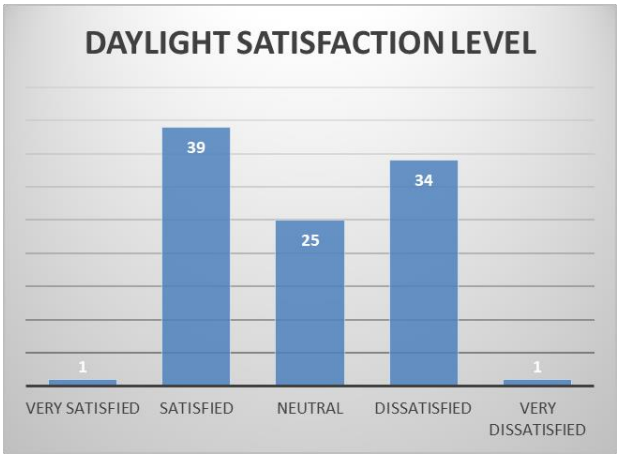

Fig 1.4 Respondent rating on Daylight satisfaction

Around 39% of the respondents from figure 1.4 are satisfied with daylight and 34% of the respondents are not satisfied with daylight satisfaction. It means there is not a significant number of respondents difference between both satisfied and dissatisfied. About 25% of the respondents are neutral satisfaction. Similarly in research work by **A Nabil and J Mardaljevic year (2004)** in the useful daylight illumination, have noticed that lighting levels that is higher than the required work plane levels (e.g500 lux) are tolerated by the occupants unless there is glare or direct day lightingat the work desk. The lower level of daylight is supported with supplementary lighting or added fenestration area.

Simulation studies: Daylight simulation is carried out on the clear day to ascertain the daylight illumination of the factory.

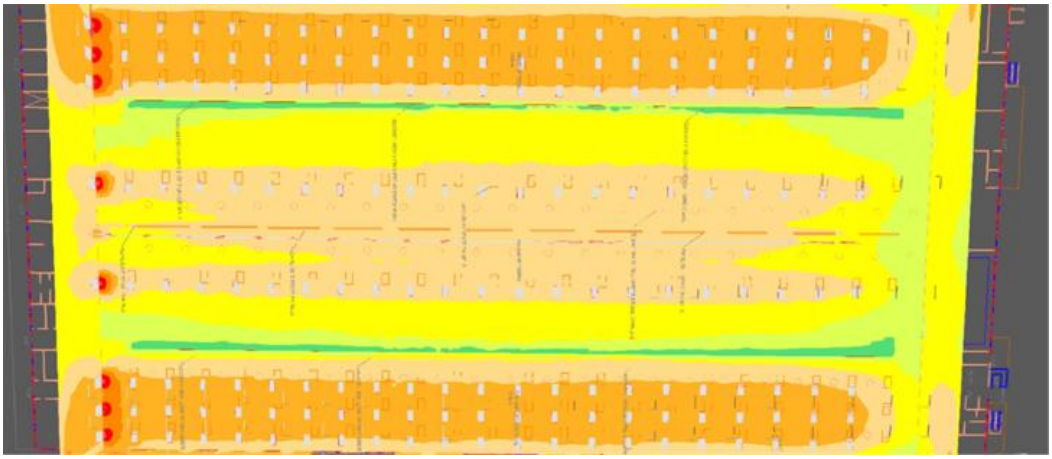

Fig2.1 Factory floor level daylight stimulation false rendering

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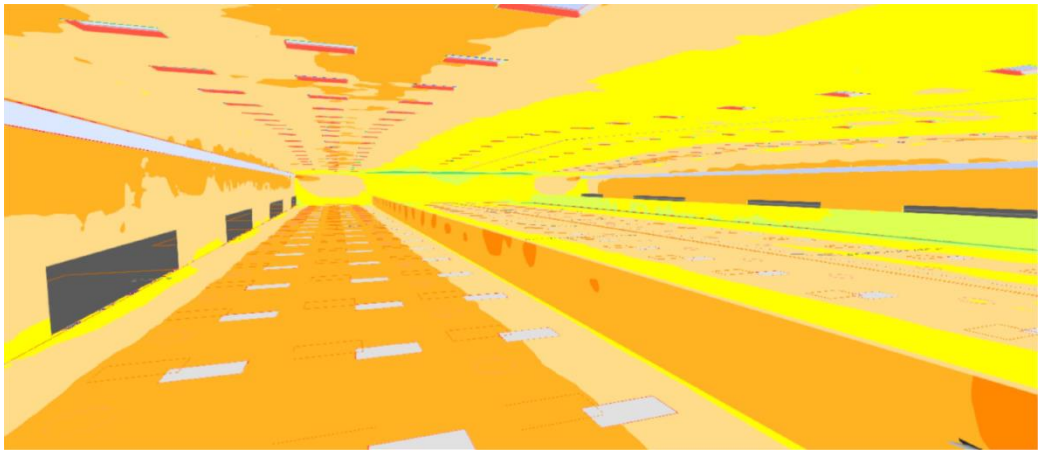

Fig 2.2 false rendering image of the factory walls, roof and floor

Fig 2.3 lux output from stimulation on a clear day

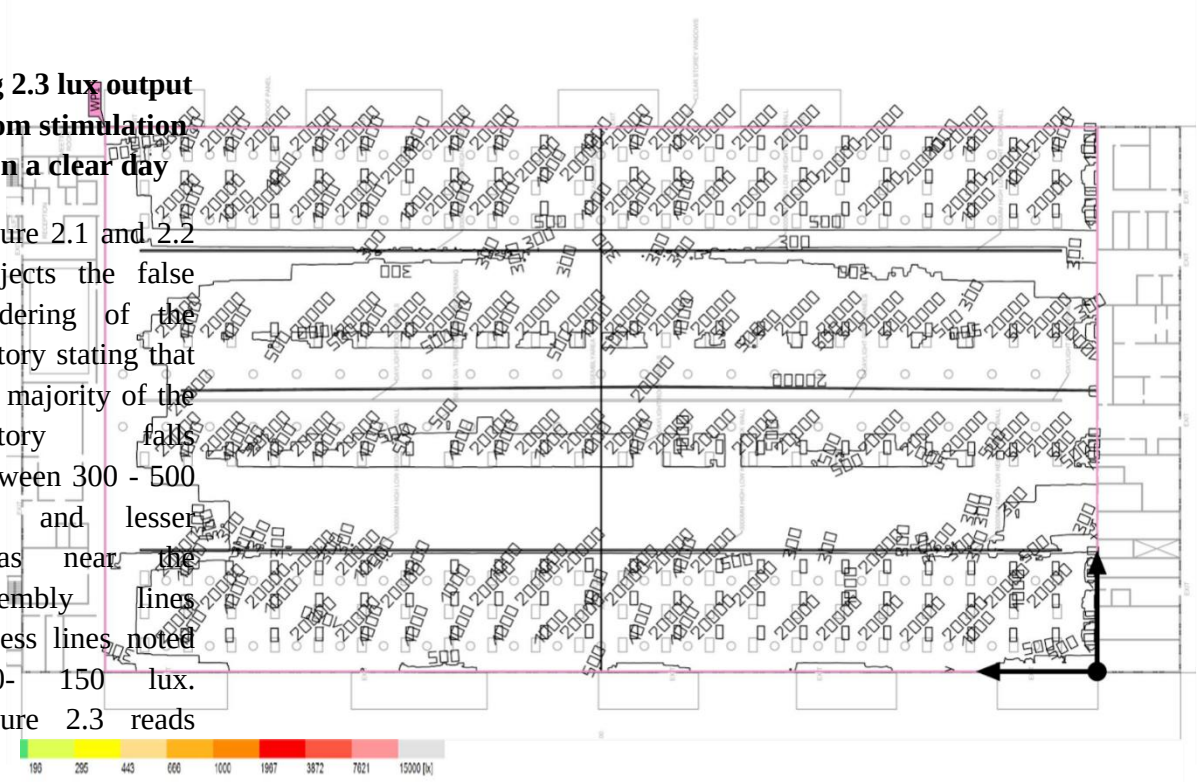

Figure 2.1 and 2.2 projects the false rendering of the factory stating that the majority of the factory falls between 300 - 500 lux and lesser areas near the assembly lines access lines noted 100- 150 lux. Figure 2.3 reads majority of the daylight areas in the factory range from 300 to 450 luxwith the corners having lesser lux level comparatively.

Properties	Ē	Emin	Emax	g1	g2	Index
Workplane (Factory)	1942 lx	189 lx	51709 lx	0.097	0.004	WP1
Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m						

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Daylight						
Properties	Dm	Dmin	Dmax	g1	g2	Index
Daylight factor effective area (Factory) Daylight factor	2.262 %	0.713 %		-	-	DF1
Height: 0.850 m, Wall zone: 1.000 m,						
Glare (UGR) Strongest glare at -33° maxmax<10						
Viewing sector 0° - 360°						
Step width 30° Angle of inclination -2°						
Height 0.000 m Index CG2						
Method Simplified calculation as per EN12464						

Table 1.1 Data stimulation reading

From the table1.1 its been observed that the daylight factor was 2.262% and the lux level as 1942lux and the average lux is 650 lux. Since the daylight factor is 2.262 , states the building is adequately lighted as daylight factor values between 2 to 5 is considered as adequately lighted (BS EN 17037:2019).

It has been clearly demonstrated by **M. Stojkovic, M. Pucar, A.Krstic-Furundzic (2016)** that a desired level of illumination is necessary for performing daily activities at the workplace without tiredness, while the excessive or under lighting causes discomfortat the work desk. Significant variations in the spatial illumination can lead to the visual discomfort and stress to the occupant.

In the research article by **DusanKatunsky, Erika Dolnikova and Saeed Doroudiani (2017)** on integrated lighting efficiency analysis in industrial buildings stated that although daylight wasn't given significant importance while designing industrial buildings, it plays a very important and crucial role in the workers psychology and physiology. Occupants' connection to the exterior environment is established by daylight enhancing their productivity. Lighting accompanied with heat is one of the major elements that's to be considered for building value and quality, which in turn influences the occupant’s health, thermal and visual comfort. Consideration of these two major elements into design optimization impose a great challenge and complication to the design (Manju et.al., 2020).

Maira Vieira diasi, Paulo Sergio Scarazzato(2013) in their work on the daylighting, well being and occupant health discussed the daylighting inclusion in the industrial design by means

of standards into the building typology and also by understanding the relationship between lighting and workplace. Illumination levels required at the workplace serves as the main key indicator for the occupant comfort on the visual task.

CONCLUSION

It is been inferred from the stimulation, that even though the factory is adequately lighted, it lacks on the uniform illumination especially the corners of the factory floor that are north east, north west, south east and south west are inadequately and irregularly lit, hence the daylight to be provided additionally in the corners of the factory building. The main factor associated with daylight as per the above reading is thermal discomfort as the majority of the respondent experience thermal discomfort which is due to the daylight harvesting under the daylight panels and also due to the trapped heat in the factory area.

Hence the fenestration opening is to be additionally provided near the north east and south west corner which would increase the daylight in the corners as well as increase the cross ventilation in the buildings for the thermal heat reduction. Thermal comfort along with suitable visual comfort compliment the daylight satisfaction on the occupant in the industrial workplace.

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