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EVALUATION AND ANALYSIS OF DISCOMFORT GLARE BY USING DIALux LIGHTING SIMULATION SOFTWARE

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ABSTRACT

Glare is the one of the significant parameters, which is broadly classified as discomfort glare and disability glare. Glare is subjective and person dependent. Discomfort glare is mainly caused by excessive brightness of the artificial luminaire installed in the workplace. Unified Glare Rating (UGR) is used for quantifying discomfort glare at indoor workplaces. This paper presents UGR calculations of conference room by using DIALux lighting simulation software.3-D modelling and calculation of UGR with the help of software for various different LED lighting fixture distribution is considered. Results are prepared and shown in tabular and graphical representations. Comparison of results obtained from experimental determination and software calculations of UGR is carried out. Further, various LED lighting fixture positions which will give minimum glare are suggested. Conclusions are made about change in UGR with effect of different lighting fixtures and their respective positions and orientation of the line of sight of the observer.

Keywords: *Light-Emitting Diode Luminaires, Discomfort Glare, Unified Glare Rating (UGR).*

Introduction

Glare is the one of the significant parameters, which is broadly classified as discomfort glare and disability glare. Glare is subjective and person dependent. Discomfort glare is mainly caused by excessive brightness of the artificial luminaire installed in the workplace. Unified Glare Rating (UGR) is used for quantifying discomfort glare at indoor workplaces.

By considering the current scenario the occupants or workers spent 80 to 90% of their time at workplaces. So, the quality of light and proper illumination at work environment is essential for wellbeing of the occupant and enhanced productivity.

Creating the right environment is considered essential in today's office designs to foster collaboration, concentration and creativity [2]. Glare is one of the significant parameter of lighting and mostly which is not be considered while installing lighting system. Glare is a visual sensation caused by excessive and uncontrolled brightness in the field of view. So, there is need for evaluation of the glare and limit it to the acceptable. Various tools and methods for glare assessment exist [4, 5, 6], but the most frequently used are glare indices including DGP (Daylight Glare Probability), DGI (Daylight Glare Index), UGR (Unified Glare Rating), and CGI (CIE Glare Index)[3]. A methodology for calculating the dazzle of indoor lighting systems by the indicator Unified Glare Rating (UGR), which is recognised as a normative method by the standard EN 12464-1 [1]

UGR

Unified glare rating is a used to specify glare and is object measure for glare. It helps to control the glare from the artificial lights. Glare affects the occupant in many ways like discomfort, and comes with various side effects like low concentration, headache, loss of productivity etc.

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Generally, the UGR is measured at eye level of person either sitting as given in fig.1 or standing position in fig.2.

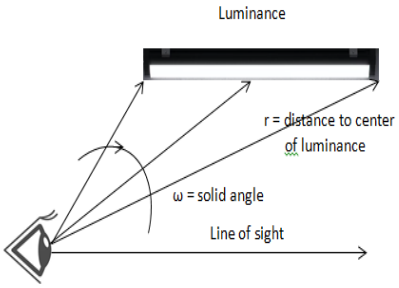

Fig. 1: UGR measurement observer eye level

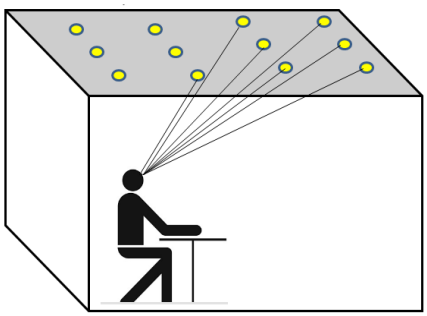

Fig. 2: Glare occurs from different luminaire from observer position point of view

There are various methods to quantify glare of Indoor luminaire/lighting systems had developed using UGR formula. The Unified Glare Rating (UGR) as recommended by the CIE which is given below:

$$UGR = 8 \log_{10}\left[\frac{0.25}{Lb}\right]\sum_{i=1}^{n}\left(\frac{L^2\omega}{\rho^2}\right)$$

Where Lb – background luminance

ω – solid angle of the luminaire from the viewer position

ρ – Guths position index

L– Luminance intensity of one luminaire

DIALux Lighting Simulation Software

The evaluation of conference room /meeting room discomfort glare is evaluated through DIALux lighting design software. As DIALux simulation software is open source and most of the lighting design professional users worldwide like lighting designers engineers, electricians used for planning, Construction, calculations and 3-D visualisation of luminaire arrangement for indoor and outdoor areas with DIALux DIALux support for import and export to DXF, DWG or gbXML (BIM), direct interface (STF).

DIALux display output in various forms like Illuminanace on reference plane and in the table form, 3D view, conference rooms floor plan, 3D rendering, 3D representation of lighting distribution, rendering in false color, It provides various output options for visualization and simulations to understand the data.

Evaluation of Glare using DIALux

In this paper the office workplace is considered and application is like conference or meeting room. The conference room is constructed and DIALux general settings mentioned below

Conference Room Details

Seating Capacity = 8 to 10 Persons

Conference Table Size (ft) : 10′ X 4′ (L X W)

Actual Room Size Length = 6m = 19.685′

Width = 5m = 16.4042 ′

Height = 3m = 9.84252 ′

Area = L×W = 30 m^2

DIALux General Setting

Uniformity = Emin / Emax = 0.5

Maintenance Value (MF) = 0.80

DIALux software standard = EN12464-1

Recommended Values (EN12464-1 Indoor Environment)

Lux values = 500 lux

UGR = UGR<19

The model of conference room and its 3D view is shown below,

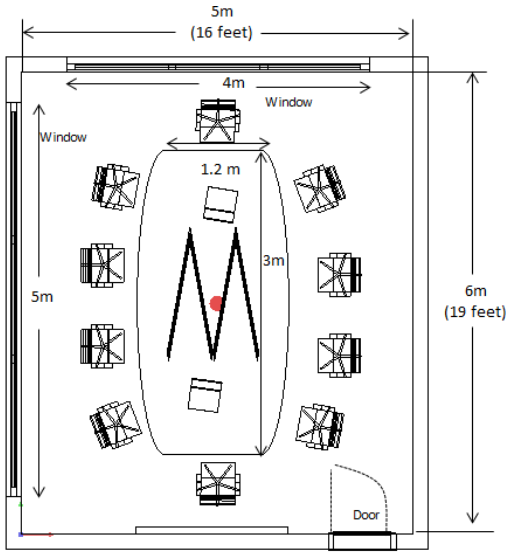

Fig. 3: Model of Conference Room in DIALux

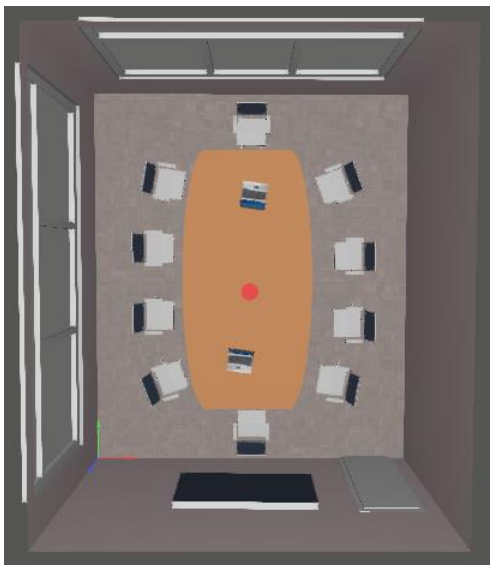

Fig. 4: 3-D View Conference Room in DIALux

Methodology

The following steps are followed for evaluation of glare in conference room:

- Construction of Conference room in DIALux lighting simulation Software.
- Selection of appropriate luminaire fixture, photometric diagram and its orientation to achieve the required lux level and UGR.
- For UGR surface / point calculation done by following setting
  - Height = 1.2m (Sitting position) /1.6m (Standing)
  - Step width = 15° (observing angle)
  - Viewing sector = 180 °
- Run the DIALux project by selecting light scene.
- Verify the achieved lux level and UGR value on calculation surface.

The following luminaire photometric file is selected for the experiments

Table 1: Luminaire Selection for Conference Room in DIALux

Exp.		Article Name (Philips)	Power (Watt)	Luminous (lm)	Efficacy (lm/W)	Quantity
1	Aesthetics View	BN126C L1800 1 xLED20S/830	17.0	1800	105.9	8
2	LED Lights only	BN126C L1200 1 xLED23S/830	18.0	2100	116.7 l	8
3	Recessed + Down Lights	RC132V G4 W30L120 PSU 1 xLED36S/840 OC DN145B 1 xLED10S/830 O	29.0 13.0	3600 1100	124.1 84.6 l	2 8
4	Suspended + Down Lights	SP400P POE W30L120 DIR 1 xLED28S/830 DN560C 1xLED12S/930 F SG-O 11.2 W	24.5 11.2	2798 780	114.2 69.6	2 6

The following fig. shows the luminaire arrangement of each experimentation

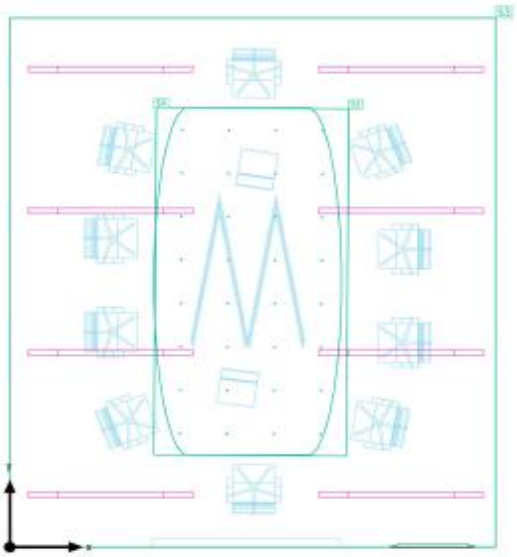

Fig. 5: Top view of calculation surface points using LED Battens

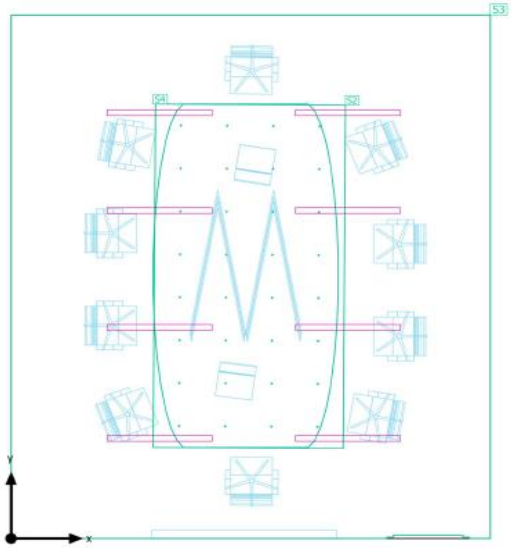

Fig. 6: Top view of calculation surface points using LED Battens

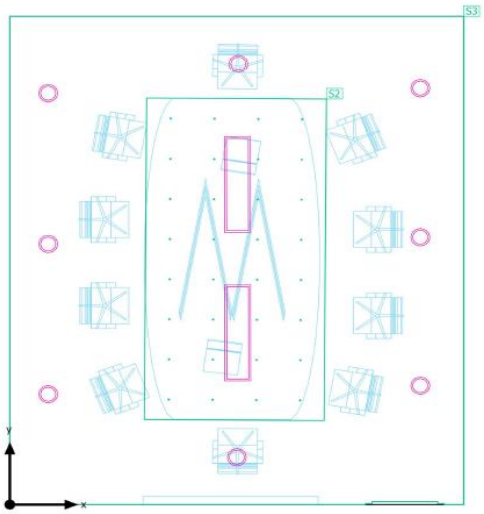

Fig. 7: Calculation surface points using Recessed Light and down lights

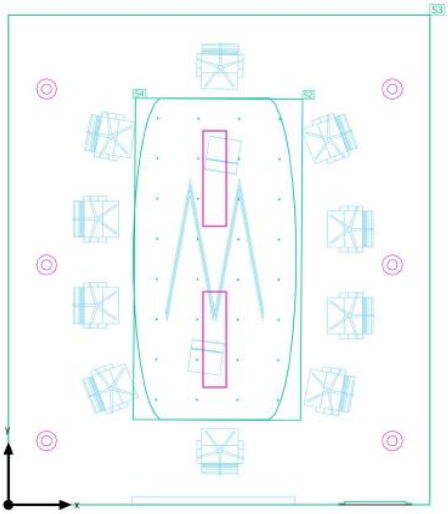

Fig. 8: Calculation surface points using LED Battens

The UGR values are calculated through the calculation surface on the table by creating 8-Rows and 4-Columns as shown in above figures. Discomfort glare criteria average UGR value range from 10-13-16-19-22-25-28. The relationship between calculated UGR value and Hopkinson's discomfort glare criteria is as follows:

Table 2: Discomfort Glare Criterion

UGR	Discomfort Glare Criterion	UGR	Discomfort Glare Criterion
10	Imperceptible	22	Unacceptable
13	Just perceptible	25	Just uncomfortable
16	Perceptible	28	Uncomfortable
19	Just acceptable		

Experimentation result after simulation of four experiments following UGR values on table.

Table 3: Conference Table UGR Surface Calculations for exp.1 and exp.2

Experiment 1					Experiment 2				
UGR	C1	C2	C3	C4	UGR	C1	C2	C3	C4
R1	20	19	18	16	R1	18	17	16	15
R2	19	19	18	16	R2	18	17	14	13
R3	18	18	17	15	R3	18	17	15	15
R4	19	19	18	16	R4	18	17	15	14
R5	19	19	18	17	R5	18	17	15	15
R6	18	18	17	15	R6	18	17	15	15
R7	19	19	17	16	R7	18	17	15	12
R8	20	19	17	16	R8	19	17	16	16

Table 4: Conference Table UGR Surface Calculations for exp.3 and exp.4

Experiment 3					Experiment 4				
UGR	C1	C2	C3	C4	UGR	C1	C2	C3	C4
R1	18	17	17	17	R1	17	16	16	17
R2	17	17	17	17	R2	15	16	16	16
R3	17	17	17	17	R3	15	15	15	15
R4	17	16	16	17	R4	17	16	16	16
R5	17	17	17	17	R5	17	16	16	16
R6	17	17	17	17	R6	15	15	15	15
R7	17	17	17	17	R7	15	15	15	16
R8	18	17	17	17	R8	17	16	16	17

Comparisons

Table 5: Comparison of Experiment's after Result

	1. Aesthetics View	2. LED Battens Lights only	3. Recessed and Down Lights	4. Suspended and Down Lights
Strongest Glare at	90	90	150	135
Max	19.8 (UGR>19)	18.4 (UGR<19)	18.1 (UGR<19)	17.5 (UGR<19)
Eavg (Lux)	410	605	475	450

In experiment 1 UGR value is more than recommended value and lux level is less than 500lx.In other experiments by rearranging the luminaire and putting recessed/suspended lights with down light we are able to achieved the UGR value 19 or less than 19 that was recommended for office environment.

The proposed luminaire arrangement out of these 4 options is Recessed and Suspended light fitting with down lights as shown in fig.9 and lux level distribution on conference table as shown in fig 10.

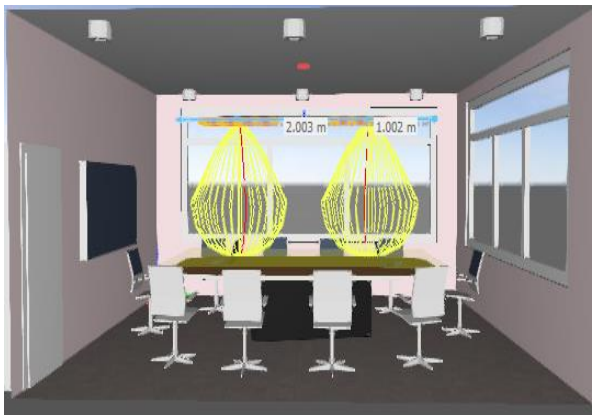

Fig. 9: 3D view of Suspended Light with down lights

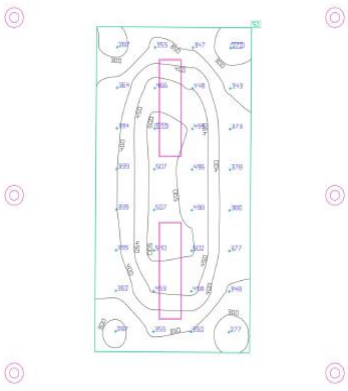

Fig. 10: Lux values on Table

Result and Conclusion

As glare is mainly depends on brightness of glare source and background, size and position of the source. This paper investigated the discomfort glare in four different luminaire arrangements for conference room by using UGR method. The best luminaire fitting is proposed for conference room like recessed light and suspended light with down lights. In present study 3D modeling using lighting design software computation as well as experimental measurement and determination of the UGR indication performed.

For the best luminaire arrangement, we need to consider - Human needs, Architecture, Economics. Quantifying lighting quality criteria: Illuminanace level, Luminance distribution, Directionality of the light, Glare limitation, Colour characteristics like CCT, CRI etc. Lighting influences mood and atmosphere, Well-being, Aesthetics, Social communication, Ambience.

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