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Evaluation of Discomfort Glare by using Lighting Simulation Software for Optimal Designing of Indoor Illumination Systems

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ABSTRACT

Glare is an important factor which affects the comfort of the occupant in any space. It causes visual fatigue and strain. Usually, it is ignored by the people working in indoor spaces. Fluorescent lamps which were used by the people from many years also causes glare. Nowadays, most of the traditional lamps were replaced by the LED lamps. However, LED lamps can cause glare due to its small size and greater lumen output. The effect of glare depends on the size of the source, the contrast between the background light and glare source and even the age of the viewer. It is very complex to measure glare accurately.

This paper presents the comparison of glare due to LED and fluorescent lamp. The glare is evaluated using DIALux lighting simulation software from the point of view of observers/occupants in a particular location in the room. The comparison of the glare due to fluorescent lamp and LED is presented. Further, the paper suggests the best luminaire arrangement which causes minimum glare for a specified indoor area.

INTRODUCTION

The phonomenon called 'Glare' has been a matter of great interest in lighting for many years. Glare is defined as "the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which eyes are adapted to cause annoyance, discomfort or loss in visual performance and visibility" [1]. Glare is also defined as visual condition under which a feeling of discomfort and/or reduction of perceptive abilities takes place [2]. Other definitions of glare are "a course of visual process accompanied by sensation of discomfort or reducing ability to recognize object [3] or as "a sensation caused by bright areas in the field of view" [4]. But despite the definitional differences, these are always the same factors and dependencies which affect the occurrence of glare.

Disability glare and Discomfort glare are the two basic types of glare. Disability glare is caused by the light scattered in the eye. This scattered light in the eye lays a luminous veil over the retinal image which reduces the contrasts in retinal image. The effect of disability glare depends on the ambient light. Disability glare may be well accounted for in terms of scattering of light that result in a veiling luminance [5].

Discomfort glare often referred as "psychological" because it constitutes a serious source of hazards for psychophysical health of the person. Discomfort glare is a sensation of annoyance or distraction caused by high luminance in the field of view [6].

This paper mainly focused on the evaluation of discomfort glare due to LED and fluoresecent lamps using DIALUx lighting simulation softweare.

LITERATURE SURVEY

Many researchers are working on the glare and proposed various evalution methods. Discomfort glare is often measured based on a subjective rating scale. A nine-point, De Boer scale is most widely used in the field of automotive and public lighting [7]. De Boer and his colleagues developed a multi-label scale consisting of nine points with five verbal descriptors [8, 9]. However, there is a possibility of getting false alarm of glare because this rating forces the user to give opinion within the scale as it does not include a 'No Glare' option. Osterhaus and Bailey [10] used a four-point scale with response

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labels defined as imperceptible, noticeable, disturbing and intolerable. They have defined the difference between imperceptible and noticeable as was the changeover point where glare discomfort would be first noticed. Hopkinson in his Glare Index Method suggested and developed a glare theory [11 – 13] based on extensive experimentation and subjective testing. He proposed that glare was dependent on the background level within a space. The field of view and glare source were defined in terms of steradians. This method seemed to address the complex phenomena of glare in terms of contrast between high intensity glare source and background luminances.

To evaluate the discomfort glare rating, the Unified Glare Rating (UGR) system has been recommended internationally by CIE [14]. If the value of UGR is less than 10 then glare is said to be insignificant and it can be ignored. If the value of UGR is greater than 30 then lots of glare is coming due to luminaires / lighting. Nowadays, other glare measurement system used is Visual Comfort Probability (VCP). The Visual Comfort Probability (VCP) of a lighting system is a rating that indicates the percentages of people that will find a given discomfort glare acceptable. According to the IES Handbook (9th Edition, page 9-26), "The visual comfort probability (VCP) is the probability that a normal observer does not experience discomfort when viewing a lighting system under defined conditions. This system was tested and validated using lensed direct fluorescent systems only. VCP should not be applied to very small sources such as incandescent and high-intensity discharge luminaires, to very large sources such as ceiling and indirect systems, or to non-uniform sources such as parabolic reflectors. In 1950 Petherbridge and Hopkinson [15] developed the BRS glare equation at the Building Research Station in England. The sensation of glare was rated in accordance with the following degrees of sensation: just noticeable, just acceptable, just uncomfortable and just intolerable.

EVALUATION OF GLARE USING DIALUX

DIALux lighting simulation software is easily available on internet. Dialux is free of charge and millions of people are using it. It gives the energy calculations and has the facility of plug-ins. DIALux serves as an advanced marketing tool for lighting manufactures. DIALux offers an import and export to DXF, DWG or gbXML (BIM), direct interface (STF). DIALux can display output in anyone of the following forms: Illuminance on reference plane in the form of a table, room's floor plan, 3D rendering, False Color rendering, workplane Photometric chart, and workplane isolines, 3D representation of the light distribution and 3D view. DIALux has many output options to visualize and understand data from simulation. Output options include 3D rendering, false Color rendering, workplane photometric chart and workplane isolines.

The glare due to fluorescent lamps and LED lamps is measured by using DIALux lighting simulation software. Numbers of GR observers are placed at different locations in the room. Glare due to various arrangements of both the lamps is calculated by using DIALux for each observer.

The room dimensions are: Length: 18 ft.

Width: 18 ft.

Height: 12 ft.

Light loss factor/Maintenance factor: 0.80

The lamps installed in the room are:

Fluorescent lamp: DIAL 27 LZA 2/35W T16 EVG LME (1.000)

Luminous flux (Lamps): 6860 lm

Luminaire Wattage: 75.0 W

LED lamp: SITECO

5DN11BD7VL356C
+5DNA4100W Lunis 2® Mini

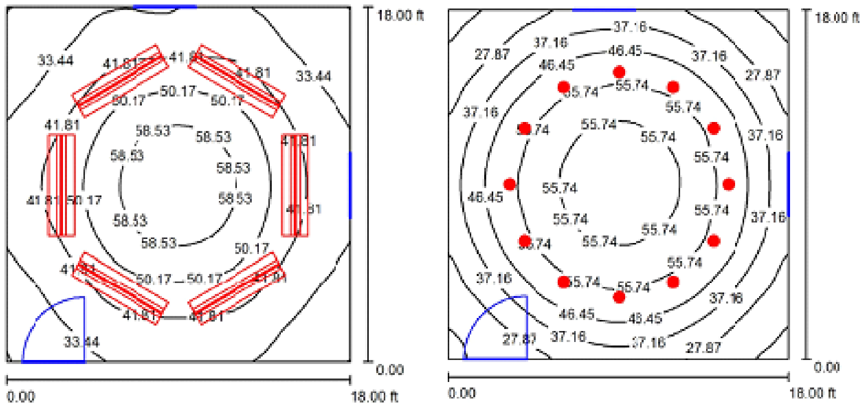
Luminous flux (Lamps): 1755 lm

Luminaire Wattage: 29.0 W

Six fluorescent lamps and 12 LED lamps were installed in the room to have average illuminance (around 400 Lux) in the room. Glare is evaluated for three different arrangements of luminaires; Field arrangement, circle arrangement and line arrangement.

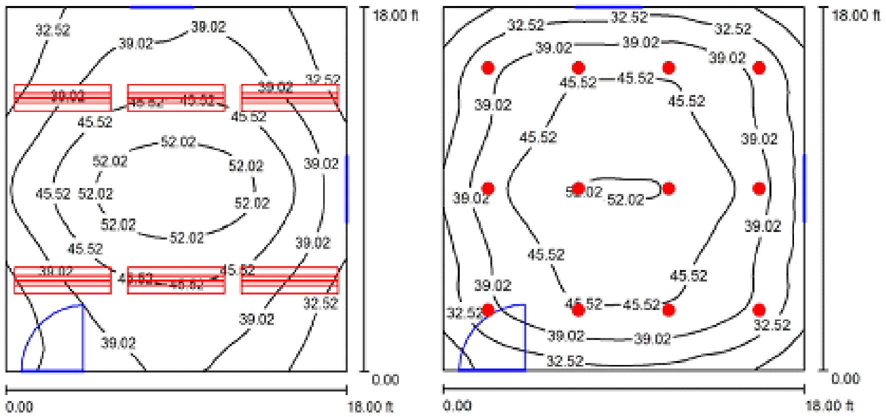
RESULTS

Average illuminance is evaluated by using DIALux lighting simulation software for three different arrangements of luminaires as shown in figure 1.



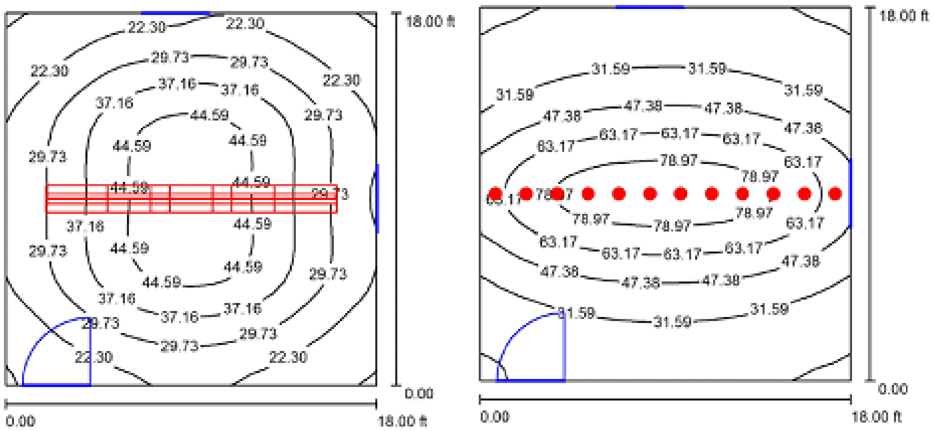
(a) **(b)**

Circle arrangement of fluorescent lamps (a) and LED lamps (b)



(a) **(b)**

Field arrangement of fluorescent lamps (a) and LED lamps (b)

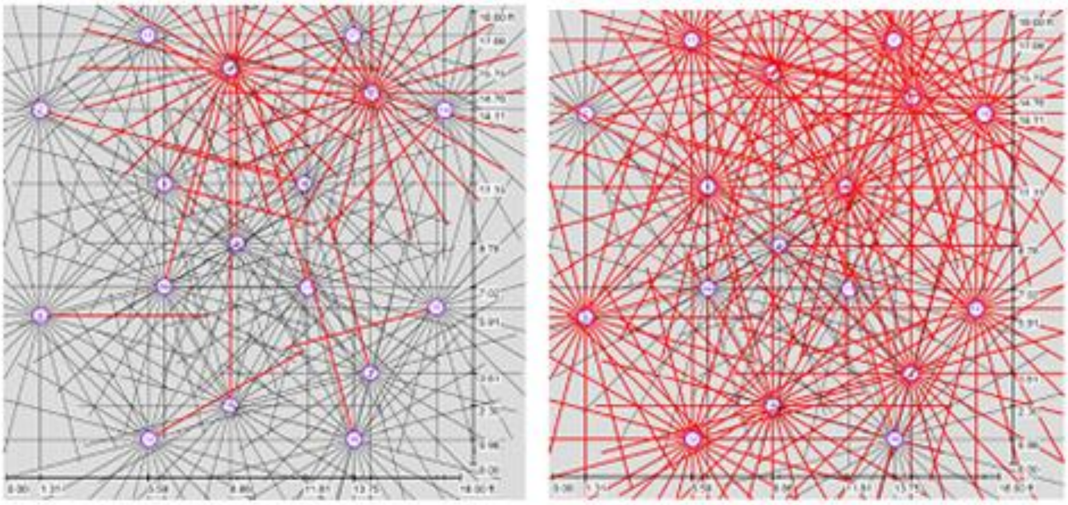


(a) **(b)**

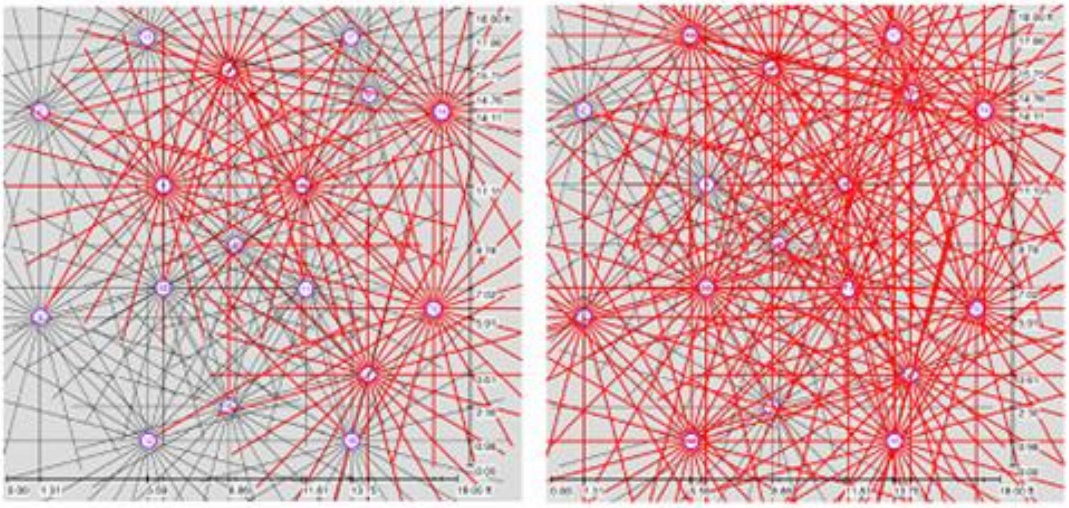
Line Arrangement of Fluorescent Lamps (A) And Led Lamps (B)

Fig1. *Average illuminance due to three arrangements of fluorescent and LED lamps in the room*

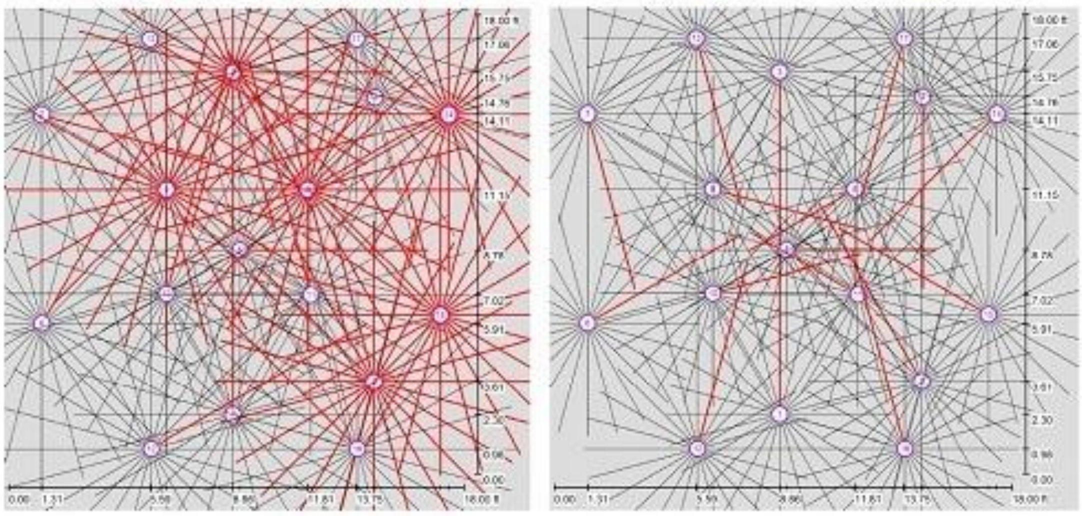
The glare is calculated for each observer in the room. The locations of the observers along with the glare are shown in figure 2. The viewing sector is from 0° to 360° with 15° increment.



Circle arrangement of fluorescent and LED lamps



Field arrangement of fluorescent and LED lamps



Line arrangement of fluorescent and LED lamp

Fig2. *Locations of GR observers in a room and glare factor for each observer due three arrangements of fluorescent and LED lamps*

The table 1and 2 gives the values of maximum glare for each GR observer having three different arrangements of luminaires in the room.

Table1. *Glare values for Fluorescent lamps*

GR Observer	**Circle Arrangement**	**Field Arrangement**	**Line Arrangement**
	Max Glare	Max Glare	Max Glare
GR1	13	10	25
GR2	10	<10	21
GR3	<10	<10	20
GR4	<10	10	21
GR5	16	12	12
GR6	11	13	19
GR7	16	11	20
GR8	10	<10	13
GR9	10	<10	18
GR10	14	15	17
GR11	14	15	13
GR12	12	16	20
GR13	12	16	19
GR14	12	<10	18
GR15	10	<10	19
GR16	12	13	20
GR17	10	13	18

Table2. *Glare values for LED lamps*

GR Observer	**Circle Arrangement**	**Field Arrangement**	**Line Arrangement**
	Max Glare	Max Glare	Max Glare
GR1	<10	11	22
GR2	<10	<10	18
GR3	<10	<10	18
GR4	<10	<10	17
GR5	14	11	13
GR6	10	<10	16
GR7	11	11	16
GR8	<10	<10	11
GR9	<10	10	14
GR10	11	<10	14
GR11	11	<10	11
GR12	<10	<10	17
GR13	<10	<10	15
GR14	<10	<10	16
GR15	<10	<10	15
GR16	10	<10	18
GR17	<10	<10	15

CONCLUSIONS

To evaluate the discomfort glare, DIALux uses Unified Glare Rating (UGR) system recommended by CIE [19]. If the value of UGR is less than 10 then glare is said to be insignificant and it can be ignored. If the value of UGR is greater than 10 then some amount of glare is coming due to luminaires at that location of the room. From table 1 and 2, it is cleared that the line arrangement of fluorescent and LED lamps causes glare. For circle arrangement, some of the observers can feel glare. Field arrangement of the luminaires gives minimum glare. So, the field arrangement of both the luminaires is said to be the best arrangement to have minimum glare for most of the GR observers in the room.

This research work can also help as a guideline for office building designers to find the best arrangements of the luminaries in a building to have minimum glare. Additional work is needed to calculate the glare due to various luminaires arrangements which includes daylight coming from the windows.

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