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KVN Naik Arts, Commerce & Science College IQAC OFFICE

Co-ordinator
I.Q.A.C.
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Effect of Reflection and Absorption Properties of Materials in Designing Application Based Illumination System.

P.R.Yawale* ,P.B.Pathakji**, V.G. Wagh***,P.B.Buchade# A.D. Shaligram##

* Dept. of Electronic Science, B.G.CollegeSangvi, Pune -27, ** Dept. of Electronic Science, Modern College Ganeshkhind, Pune-07, *** V. N. Naik College, Nasik-05, #Dept. of Electronic Science, A.G. College, Pune-04, ## Dept. of Electronic Science SavitribaiPhule Pune University, Pune, 07

Abstract

Uniform, adequate and pleasant illumination over a certain target area is a common requirement in many applications.Light emitting diodes gradually becoming the first choice for many lighting applications because of luminance efficacy, compactness and durability. Illumination system consists of one or many light sources and used to create a visual environment for visibility of objects of variable sizes and shapes. LED lighting sources are composed of several individual LEDs mounted on a panel. Denser the LED array,more uniform is the illumination. However, high density of LEDs in an array is restricted due tothe thermal problem, available space and cost. High bright LEDs are intense point sources of light and create bright spots known as LED hotspots that are harmful to human eyes. Technical specifications to be considered for designing of lighting system are desirable intensity distribution, color, energy consumption, cost, effect on health, safety, ambient light effect, etc. To avoid these problems systematic approach is necessarythat provides an optimized design of illumination system. Different configurations of LED arrays such as circular, linear and square are used to obtain anuniform illumination. Therefore, it is important to obtain better uniform illumination using less number of LEDs. One of the ways to obtain anuniform illumination is to use diffusers. Diffusers are essential to distribute the light emitted by the LEDs evenly and reduce their glare. A vast of diffuser materials are available today those have a dramatic effect onillumination. A frosted glass positioned in front of the light source was the traditional method as a diffuser. The frosted glass has high absorption-coefficient and it blocks a large amount of the LED light. Also glass is bulky that increases the overall weight of the final device. Another problem is that glass materials cannot efficiently hide the point sources of light and can result in LED hotspots. In addition, glass is prone to crack during shipping and installation.To overcome these difficulties, plastics (acrylic and polycarbonates) are dominating the LED diffusers. Polycarbonate diffusers convert the point-shaped glary light from LEDs into homogeneous surface spread light with high luminous efficiency and excellent hotspot hiding. Acrylic gives good results, but adds weight, complexity and cost to the overall luminaire design. The acrylic and polycarbonate diffusers offer good uniformity but light efficiency of source is reduced during light diffusion action.Reflection and absorption by surrounding wall coatings, furniture and furnishing materials also affect the uniformity of light. This paper reports simulation results to find effect of different materialsabsorption and reflection properties on uniform illumination. Simulation was carried out using DIALux software. Selection of optimal diffuser material to obtain glare free uniform illumination for a specific application is also highlighted.

Keywords: optical diffusers, uniformity, glare, DIALux, reflection and absorption coefficients.

Introduction: Uniform, adequate and pleasant illumination over a certain target area is a common requirement in many applications.Solid state lighting is replacing traditional lights for many lighting applications because of luminance efficacy, compactness and durability[1].SeveralLEDs are mounted on a panel to produce required illumination level. LEDs have some degree of directionality; uniform illumination over a target area is the major practical problem. High bright LEDs are intense point sources of light and degree of directionalityproduces spots of concentrated lights, known as LED hotspots whichare harmful to human eye[2]. Therefore, to provide glare-free LED lighting, or to create wide viewing angles, designers often choose to diffuse the light emitted. Several diffusing materials are available such as glass, acrylic and polycarbonate etc. Selection of proper diffuser depends on factors like uniform light transmission, absorption and transmission coefficient, durability and flexibility in designing. A frosted glass positioned in front of the light source was

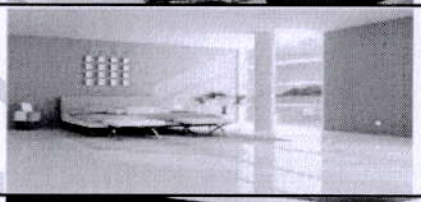
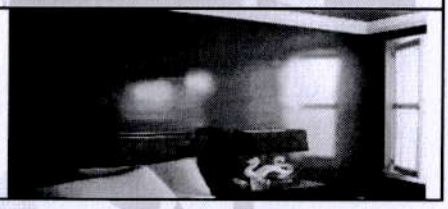
the traditional method as a diffuser. Now-a-days plastic like acrylic and polycarbonates are used as light diffuser[3]. The comparison of glass, acrylic and polycarbonate materials is in table 1.

Table 1

Parameter	**Glass**	**Acrylic**	**PC**
Density(gm/cc)	2.4 to 2.8	1.16 to 1.18	1.2
Transmission	Moderate	Very good	Good
Light diffusion	Good	Very good	Excellent
UV resistance	Average	Very good	Average
Thermal resistance	Excellent	Good	Very good
Im*pact resistance*	Poor	Poor	Very good

Surrounding light in a room affects the human mood and the efficiency of the individual. To perform specific task in the room, always pleasant and sufficient light intensity is required[4]. When artificial light is installed in a room for specific task, the actual illumination of the room is total effect of natural sunlight from windows ;doors, artificial light and reflections from walls ; floors ;ceilings ; fixtures and furniture's in the room. For performing specific task, minimum required illuminations standard values in LUX are well known. While designing application based illumination systems, if the effect of reflections from surrounding surfaces in the room is not taken into account then illumination developed might be more or excess than required standard illumination. This situation might cause glare problem to the persons in the room while performing specific task. In this paper, the walls of the room are considered as reflecting surfaces and we have reported the effect of the wall paints different reflection coefficients on illumination at specific location in the room. Table 2 shows different types of wall paints and there reflecting property.DIALux simulation software is used to simulate the different conditions. DIALux 4.12 is freeware available having good performance for pure daylight scenes and artificial light scenes[5].

Table2

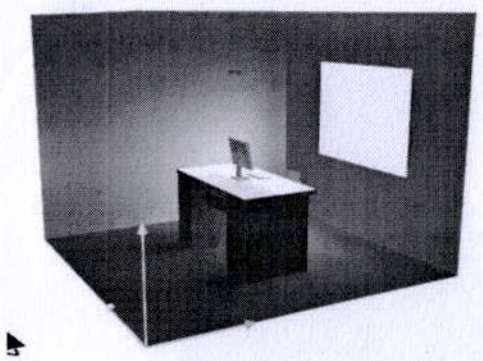
Type of paint	Reflectivity	Images of the wall paint
White Wash / Water based paints / Distemper paint / Matte Finish Paints	Less Reflectivity	
Oil based paints / Emulsion paint	Moderate Reflectivity	
Satin Paint/ Gloss Paint / Luster	More Reflectivity	

Simulation Using DIALux: A room of 12' x 12' having height of 9' with a window size 6' x 4' located 3' above the floor and a door of size 6' x 4' is considered. A glass window has 90% transparency and a non transparent door has 75% reflectivity. A Phillips LED lamp of 13 watts having 1000 lumen light output is installed at the top of workspace 7" above the floor. Sunlight from window and the reflections from walls, floor, ceiling, furniture and furnishing materials contribute in actual illumination. Workspace is above the 2.5' from floorand a glare observing point is at location (6.5', 6', 4'). In this paper we have studied effect of wall reflectivity on the total illumination and reported its effect on uniformity of illumination.

There are several interior paints such as distemper, luster, enamel and emulsion. Distemper paints are water based paints, and there major constituents are chalk, lime, water and some colouring agents if necessary.

Luster paints, Enamel paints and Oil paints all come under the category of solvent based paints.

The effect of reflection coefficient variation from 40 % to 90 % is simulated. The fig. 1 shows simulation model for 40 % and 60 % reflection coefficient of wall surfaces. Fig. 2 illustrates the intensity variation in the work plane for these varied reflecting conditions.The average illumination variation with respect to reflectivity is shown in fig. 3(a), uniformity variation against the reflectivity is plotted in fig3 (b).



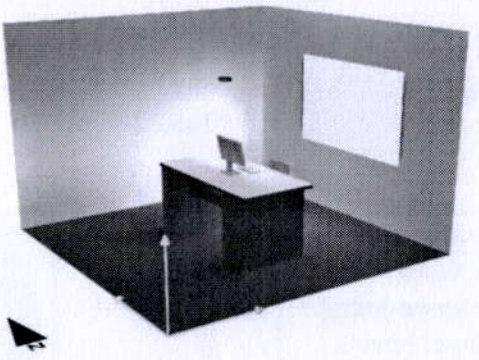
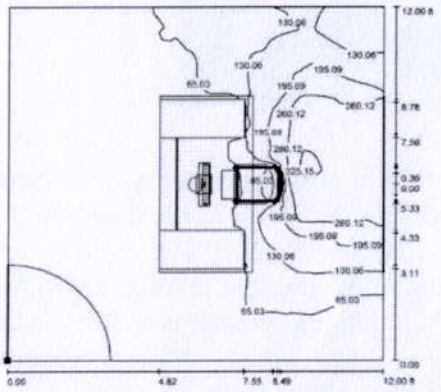


Fig1. a) Reflectivity 40 % *b) Reflectivity 60 %*



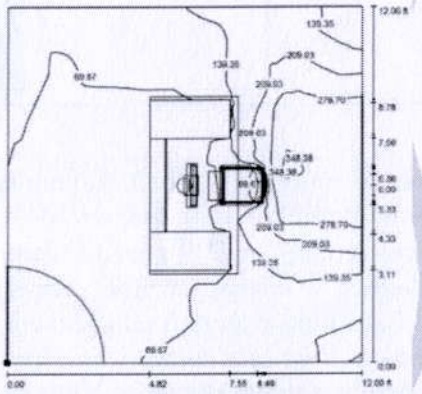
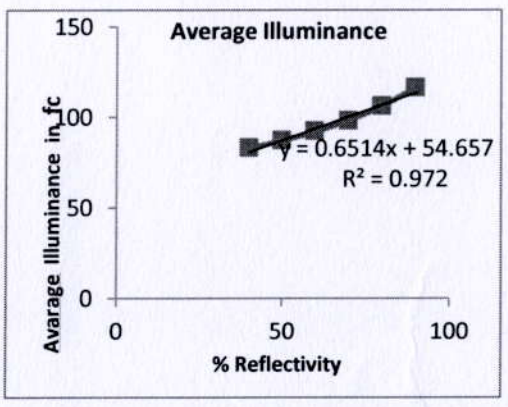
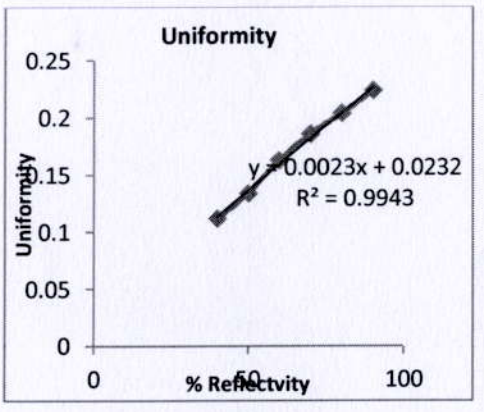


Fig2. Isolines. a) Reflectivity 40 % *b) Reflectivity 60 %*

Fig3. a) Average Illumination against reflectivity *b) Uniformity against reflectivity*





Results: As can be seen from the graphs, the average illuminance and uniformity level increases as the reflectivity of wall paint increases.We can also see the similar effect in the simulated picture of the room at varied reflectivity of the wall paints.The isolines curve shown in the above figures indicate the illuminated area of the room. It can be clearly seen from the figures that the illuminated area of the room increases as the reflectivity of the light in the room improves due to wall paints increased reflectivity factor.Due to variation in the reflectivity levels of wall for the selected colour paint,we have not seen the effect of glare at the workspace location from various light sources.

Conclusions:- The simulated results indicate that you can increase the reflectivity level of the specific wall paints for better and uniformly spread illumination in the room for specific task.
By selecting proper type of the wall paint, we can keep the glare factor from all the lighting sources controlled when observed from workspace location. Uniformly lit environment also provides eye comfort for those working with PC screens, which are by themselves light sources.

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