National Conference on Innovative Trends in Science and Engineering (NC-ITSE'16) ISSN: 2321-8169
Volume: 4 Issue: 7 192 - 195

Optimization of Pole Spacing of Road Illumination System using DIALux

P. R. Yawale
Department of Electronic Science
Savitribai Phule Pune University
Pune, India
yawalepravin@yahoo.co.in

V.G.Wagh
Department of Electronic Science
V.N.Naik College
Nasik, India
vgwaghele@gmail.com

A.D. Shaligram
Department of Electronic Science
Savitribai Phule Pune University
Pune, India
ads@electronics.unipune.ac.in

Abstract—Road lighting is important for cities driving safely and safety for vehicle and pedestrian traffic saftey. Lighting design is concerned with the selection and location of lighting equipment so as to provide improved visibility and increased safety while making the most efficient use of energy within minimum expenditure. The required illumination is to be obtained at low cost. There are different software tools are available to simulate different types of luminaries and the lighting systems. This paper reports use of DIALux software to optimize the pole spacing for road lighting. Street light illuminance depend on several factors, here we have reporting the simulation results for two lane standard road using the OSRAM LED street light LM90 by changing the separation between two poles are reported. The pole separation and luminaire height are optimized to 15.25 m and 7.982m.

Keywords- *Road lighting, Uniformity, average luminance and Luminary, pole spacing.*

*****

I. INTRODUCTION

The purpose of road lighting is to make people, vehicles and objects on the road visible without causing discomfort to anyone. Street lights should produce good quality light to ensure good contrast between objects and good color discrimination. In spite of improvements in the efficiency of lighting technologies since the early 20th century, outdoor public lighting systems (streets, parks, public spaces, etc.) can still account for as much as 40 percent of a municipal government’s total electricity use. An important component of power consumption worldwide is street lighting. India is no different. Global trends in street lighting show that 18-38% of the total energy bill goes towards street lighting and therefore this is one domain that needs major attention if we look at improving efficiency of power consumption with an objective of saving energy. Lighting manufacturers are responding to cities’ concerns for reducing costs and greenhouse gas (GHG) emissions by developing more efficient lighting products While LED technology offers a wide range of unique potential benefits, a review of the literature finds that cities are primarily interested in the energy-reducing promise of LEDs for street lighting and traffic light applications with little focus on the performance issues or aesthetic and place making opportunities presented by LEDs and street lighting in general. This emphasis is in response to the high priority concerns of global climate change and financial restraints of governments across all levels.

In this paper we are reporting a simulation case study of street light for a LED luminary for a standard two lane road by varying the pole spacing and height of the luminary. DIALux software is used to study the simulation.

II. DIALUX SIMULATION PROCESS

DIALux Simulation Procedure: Steps in simulation are as per flowchart in fig.1 [1,2]

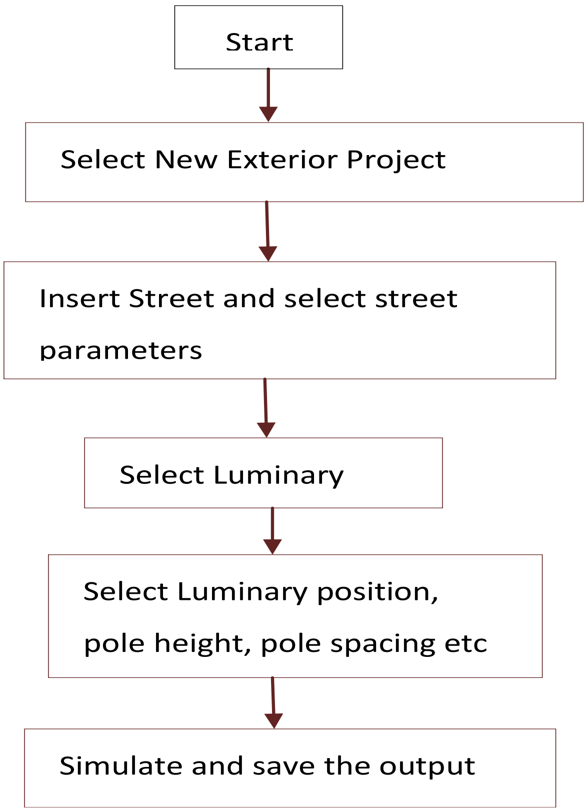

Fig.1: Steps in DIALux simulation

III. ROAD LIGHTING

The basic goal of roadway lighting is to provide patterns and level of horizontal pavement luminance and of horizontal and vertical illuminance of objects. A driver's eyes discern an object on or near the roadway due to contrast between the brightness of the object and the brightness of the background or pavement, or by means of surface detail, glint, or shadows. Lighting design is concerned with the selection and location of lighting equipment so as to provide improved visibility and increased safety while making the most efficient use of energy within minimum expenditure. There are two basic concepts of lighting design, i.e., the illumination concept and the luminance concept. The illumination concept, which is almost universally used in the United States, is based on the premise that, by providing a given level of illumination and uniformity of distribution, satisfactory visibility can be achieved. The luminance concept, which is fairly popular in part of Europe, and is promoted by some people in the United State, is based on the premise that visibility is related to the luminance of the pavement and the objects on the pavement. Estimation of the reflectivity of varying pavement surfaces and objects within the driver's vision are difficult [3,4].

A. Street Lighting Design

The basic goal of street light is to provide patterns and level of horizontal pavement (target surface) illuminance and horizontal and vertical illuminance. Several factors are instrumental in determining the quality of visual perception and the performance of street light luminaries

- Initial lumen by the lamp.
- Nature of road surfaces
- Color rendering ability
- Ratio between maximum lumens, average lumens and minimum lumens
- Uniform distribution of light
- Cut off angle of the fixture
- Height of the mounting pole – Optimum pole height is important for the correct lighting density. As the height of the mounting pole increases the footprint of the light increases but light density decreases.
- Distance between two poles. Optimum pole separation is important for proper illumination of road surface.

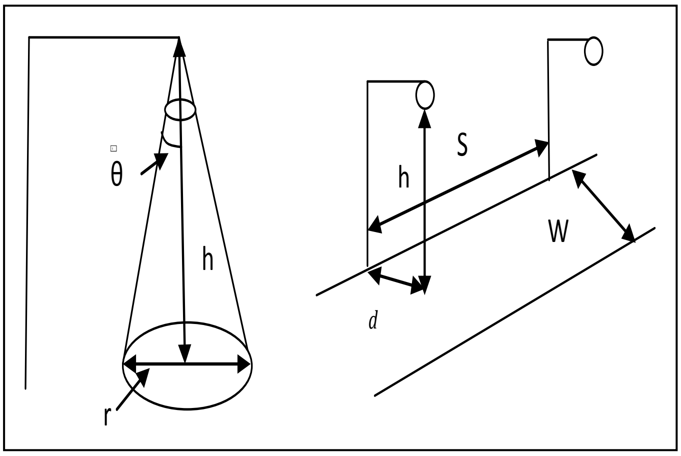

Fig2. Road lighting basic model

There are different types of road lighting arragment. The possible arrangments are as shown in fig 2,

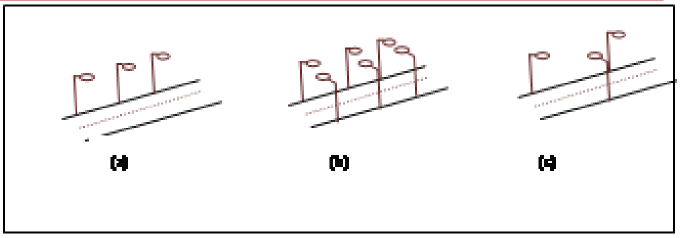

Fig3. Two lane road with luminary arrgment a) single side b) Parallel on both side c) Both side with offset Different sources of illumination vary significantly with respect to the quality of light they provide. This, in turn, has a dramatic effect upon the appearance and safety of the street at night. High-pressure sodium, the light source typically used in city street-light fixtures, casts a yellowish-orange glow that results in poor color rendition; it compromises visual clarity and detracts enormously from the overall quality of the nighttime urban environment. By contrast, metal halide as a light source produces a soft, white glow that renders color accurately; it offers better visual clarity, improves reaction time for vehicles, and requires less wattage for the same perceived visibility. Quality of light is also influenced by quantity of light or more specifically, by the relationship between the brightness of a light and one's distance from it. Light becomes more diffuse farther away from the source, so for a given brightness, there is a range of heights within which the source should be located to create the desired quality of light in fig 1[5].

Although luminaries mounting heights have typically increased over the past few decades as lamp technology has allowed for higher and brighter road lights, the result is often lighting designed for the car or the parking lot, not for the person walking on the side of the street. Reducing the luminaries height, and adjusting it to the scale of the person on the sidewalk, calls for more fixtures, which in turn means that the luminaries, the poles, and their placement can have an impact on the streetscape. However, as a luminaries' height is lowered, the lamp's brightness must be adjusted so that is does not create excessive glare for pedestrians. At the same time, the wattage must also be capable of adequately lighting the road. For instance, 2.75 m luminaries might be augmented with overhead lights because, depending on the street width, the wattage needed to light the street would create a blinding glare for the pedestrian.

In addition to the height (h), pole spacing(S), road width(W) and boom length (d) are the other factors on which road illumination dependence as shown in fig.2.of the light source Appropriate spacing of light fixtures is critical to achieving consistent illumination of streets and sidewalks, and to preventing the pedestrian from encountering intervals of darkness. Consistent light coverage is important, particularly along the sidewalk, because the perception of light is relative to its surroundings. Therefore, a poorly bright area will seem so much darker in contrast to a small bright area nearby. The possible pole arrangement for two lane road is as shown in fig.3. Single side arrangement is simple for installation.

Parallel on both side and alternate opposite arrangement are also useful but increases the installation cost and power maintenance.

The minimum required space between lights might meet lighting standards, but may or may not achieve the desired effect. Single side arrangement is simulated for two lane 7.982 m (23 feet) wide without median road for different spacing between te poles. Luminary used is OSRAM STREETLIGHT LUM 90 having luminance flux of 6100 lm and luminary wattage is 90 watt. The variation of average luminance, uniformity, longitudinal uniformity and threshold increment factors are studied for different pole spacing. It is important to optimize the pole arrangement for street lighting. If they are very close then more will be the luminance but cost of the arrangement and power utilization is more. If they are far away then arrangement will be cost effective but light uniformity is not on the surface and may not be sufficient for street drive. The important criteria which decide quality of road lighting are average luminance, uniformity, longitudinal uniformity, glare and threshold increment.

Luminance: The most generally used approach to selecting quality criteria for lighting roads for motor traffic is based on the luminance concept. This is the minimum value to be maintained throughout the life of the installation. It is dependent on the light distribution of the luminaries, the luminous flux of the lamps, and the geometry of the installation and on the reflection properties of the road surface. Same illuminance may result in different visual scene because of difference in road surface. It is obvious that road surface luminance rather than illuminance should be the accurate measure of the effective light in a road surface. In the present state of technique and the knowledge of reflection properties of road surface, calculation and measurement of luminance is difficult. Thus illuminance values are taken as standards for road lighting. However, it shall be kept in mind; the visual appearance of a road is solely determined by the luminance values and uniformity. Same illuminance may result in different visual scene because of difference in road surface reflectance and uniformity. **Uniformity**: A good overall uniformity ensures that all spots on the road are sufficiently visible. **Overall uniformity (U_o):** It is the ratio of the minimum to the average road illuminance. A good overall uniformity ensures that all spots on the road are sufficiently visible. **Longitudinal uniformity (U_L):** It is the lowest ratio of the minimum to the maximum road illuminance in the middle of each lane. **Glare:** It is caused due to the sudden presence of very bright source in the visual field. Glare in Public Lighting is caused by luminaries. a) Disability glare impairs vision b) Discomfort glare of lighting cause visual discomfort. Glare depends on the illumination produced by the luminaires on the eye of the observer. The light from the glare source scattered in the direction of the retina will cause a bright veil to be superimposed on the sharp image of the scene in front of the observer. Threshold Increment: The percentage increase in the luminance level required to make an object equally visible as in the absence of glare. Glare Control Mark is a measure for discomfort glare in Road Lighting designs. It is calculated from certain luminaires and installation characteristics. A measure to express the loss of visibility caused by the disability glare of luminaires of a road lighting installation is the threshold increment TI [CEN2003a]. It expresses the amount of extra contrast required to make the object just visible again under glare conditions.

IV. RESULTS

The variation of avarage luminnace, unifirmity, longitudinal uniformity and threshold increment are as shown in fig.4(a,b,c). The selected road is 7 m wide two lane without median also called standard road.The luminary height is fxed to 7.982 m (26 ft) and no tilt with boom. The boom length of 0.65m and light loss factor 0.67. Simulation is also obtained for for the luminary height of 7.4 m to 8.6 m and it is obser that uniformity and avarage luminance is better for height 7.982m so for remaing simulation this height is selected. Simulation pattern shows that as we increases the pole spacing the uniformity, average luminance, longitudinal luminance decreases and the threshold increment increases with the pole spacing. For the selected road and luminary distance between two poles changed from minimum 10.668 m (35 ft) to 48.768 m (160 ft). All parameters shows variation but average luminance and uniformity decreases rapidly with increase in pole separation. Threshold increment does not crosses the threshold values for all any pole spacing between 10.668 m to 48.768 m. Longitudinal uniformity can be main tented up to maximum 80 ft separation while average luminance and uniformity permits only maximum separation up to 15.24 m (50 ft). If distance is less than 10.675 m glare is predominant and discomfort level increases.

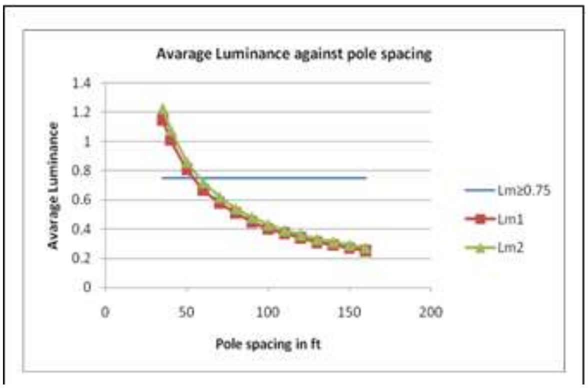

Fig 4(a).Variation of L_{av} with pole spacing

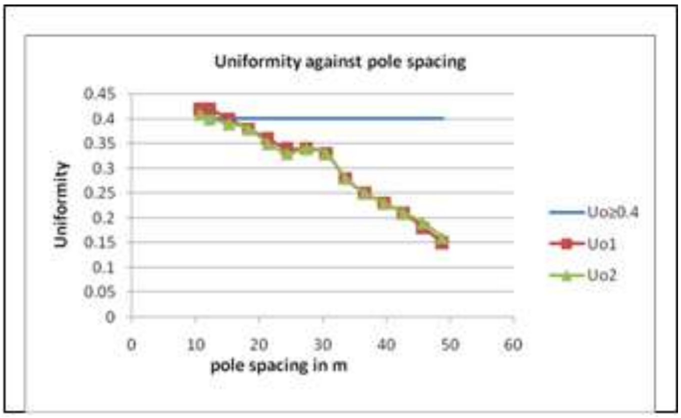

Fig 4(b).Variation of Ui with pole spacing

ISSN: 2321-8169
192 - 195

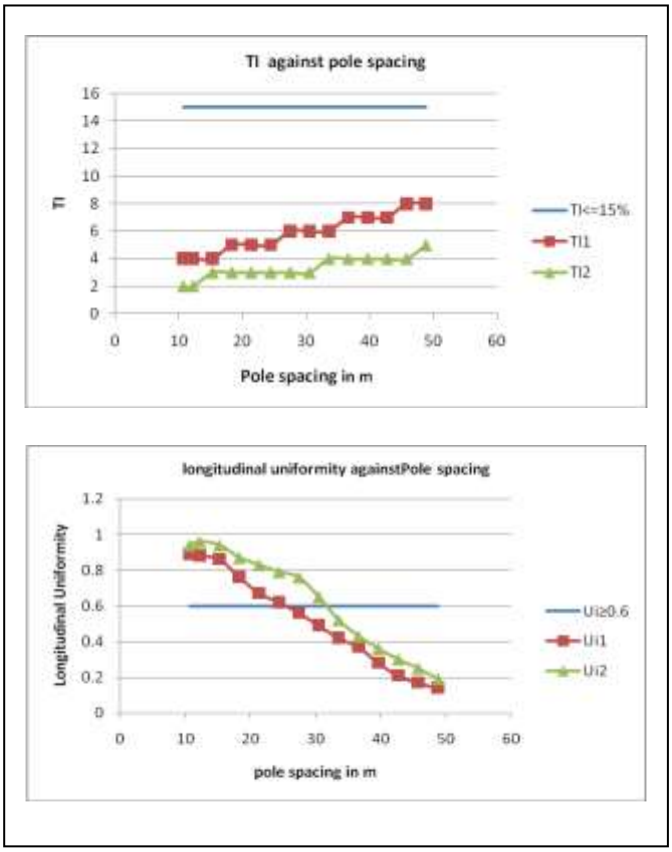

Fig 4(c).Variation of Ul and TI with pole spacing

The simulation pattern obtained for 12.2 m and 15.25 m are as shown in fig 5.

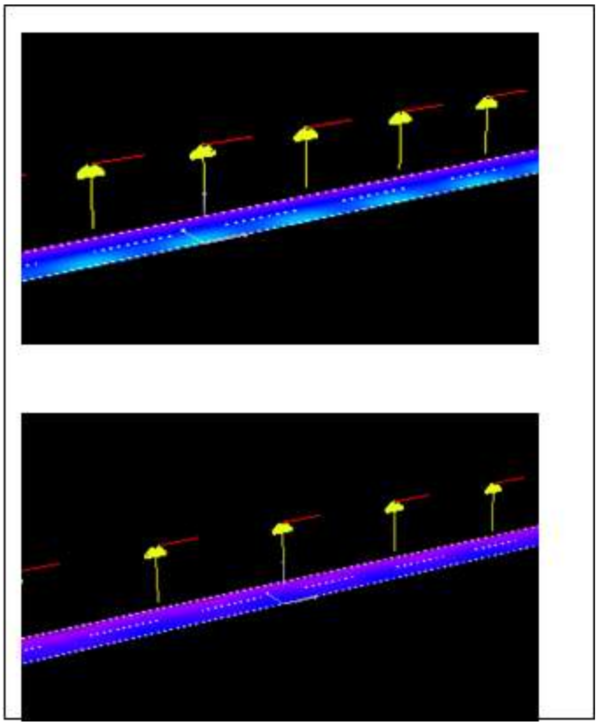

Fig.5 simulated Illumination on the road surface for pole spacing 12.2 m and 15.25m

V. CONCLUSION

The number of poles required for a selected road along single side luminary arrangement are 94 per kilometer when pole spacing is 10.675 m and 82 poles per kilometer for pole spacing of 12.2 m while it only 66 poles are required per kilometer when spacing is 15.25 m. Therefore we can obtain the required luminance at optimal distance of 15.25 m which is cost effective and energy saving arrangement.

REFERENCES

[1] " A guide How to use DIALux"
[2] "DIALux basic tutorials" https://www.youtube.com/watch?v=oOITu-qMk6A
[3] D. R. Nuttall*, R. Shuttleworth*, G. Routledge "Design of a LED Street Lighting System" by, Power Electronics, Machines and Drives, 2008. PEMD 2008. 4th IET Conference .
[4] "CIE technical Report on Road Lighting Calculations", ISBN 3 901 906 54 1
[5] Ivan Moreno, Maximino Avendaño-Alejo,Tonatiuh Saucedo-A,and Alejandra Bugarin "Modeling LED Street light", , APPLIED OPTICS / Vol. 53, No. 20 / 10 July 2014