Energy Saving Measures in Street Lighting

ABSTRACT

Some important aspects of street lighting are discussed. Existing illumination levels at some representative locations on roads in New Delhi, where street lighting was installed a number of years ago, have been measured and luminance values of three types of luminaires have been tested. The effect of shadows of trees on road lighting distribution is examined and a simple design for providing energy-efficient lighting to mitigate the effect of trees is presented. Energy saving by power factor correction is also estimated. Energy losses through the ageing reflectors and refractors of street lighting luminaires as well as cables and connectors are also studied. The need for adequate lighting for public traffic with efficient use of energy and mitigation of glare are discussed. The motive is to reduce energy losses and improve the quality of the street lighting in urban areas.

Key Words : street lighting, luminaires, energy saving, glare, power factor correction

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1. Introduction

The purpose of street lighting is to provide adequate visibility for drivers and pedestrians as well as security and beautification of a locality [1]. The lighting on the road surface should be of proper intensity and sufficient uniformity. It should be free from discomfort-glare. The street lighting furniture, that is, the column, bracket, luminaire etc. should present an overall aesthetic view merging beautifully with its surrounds and skyline. In a lighted road, moving objects are seen in silhouette against the bright road- surface. The brightness (luminosity) of the surface depends on the intensity of light incident on it and also on its texture, colour and reflectivity. For a given amount of incident light, dark and rough bitumen layered surfaces reflect much less light as compared to the light coloured cemented surfaces. The lighting should be such that the drivers' eyes will not undergo undue changes of adaptation from one point of vision to the other. They should not experience repetitive impressions of light and dark which are more rapid and irritating as the speed increases. The main factors that contribute to quality of road lighting [2, 4, 10] are :

a) Level and uniformity of luminance

b) Colour rendition Index

c) Glare Index

d) Optical guidance

1.1 Luminance and Illumination on a Road Surface

Luminance of a surface may be defined as the luminous flux emitted or reflected per unit area of the surface, orthogonally projected in the direction of observation. It depends on the luminous flux incident per unit area of the surface (Illumination) and the nature of the surface itself. A fraction of the incident radiation is absorbed by the surface, depending on its nature (absorptance) and the wave length of the incident radiation. The remaining fraction is reflected in various directions. The visual sensation (luminosity) experienced by an observer is directly related to the luminance which stimulates it. Clearly, the luminance, and not the illumination, of a road surface is the measure of its brightness [3-8]. However, the latter is much easier to determine and therefore generally adopted while specifying the road lighting levels. Table-1 gives the commonly recommended values of illumination and luminance for different groups of roads.

1.2 Street Lighting Lamps

In an urban street lighting system, the following types of lamps are normally used:

a) Tubular Fluorescent Lamps

b) High Pressure Mercury Vapour (HPMV) Lamps

Table-1 Recommended values of Illumination and luminance for Street Lighting

Type of Road	Average Illumination, Lux	Ratio Minimum/Average Illumination	Average Maintained Luminance cd/m²
Important traffic routes carrying fast traffic	30	0.4	1.5/1
Other main roads carrying mixed traffic	15	0.4	1.5/1
Secondary roads with considerable traffic, shopping streets etc	8	0.3	1.0/0.75
Secondary roads with light traffic	4	0.3	1.0/0.75

c) High Pressure Sodium Vapour (HPSV) Lamps

d) Metal Halide Lamps

A tubular fluorescent lamp is a low power, low cost and low pressure mercury vapour lamp. It has many advantages over incandescent lamps [9]. A fluorescent lamp starts immediately on switching on. It restarts at once after an interruption of supply. A 40W, 1.2m long fluorescent lamp gives out a luminous output of about 3000 lumens (75 lm/W) and has a life of about 5000 hours. The colour of its light depends on the type of the fluorescent coating used and it is quite similar to white light.

High pressure mercury vapour (HPMV) lamps are available at much higher wattage with smaller sizes and almost same efficacy (lumens per watt) as that of fluorescent lamps. Their average useful life is around 10000 hours. An HPMV lamp takes 4 to 5 minutes time to start up after the supply is switched on, and in case of an interruption of supply, it takes 2 to 3 minutes to get restarted. Instant-start HPMV lamps with some what lower efficiency are also available. The light from the HPMV lamp is greenish white.

A high pressure sodium vapour (HPSV) lamp has much higher efficacy of about 120 to 130 lm/W. It gives out yellow light. It has much longer life (over 24000 hours) as compared to the HPMV lamp. HPSV lamps not only have high luminous efficiency but also good colour rendering property. They are particularly suitable for foggy conditions.

Metal halide (MH) lamps give almost white light. Although their efficacy is lower than that of HPSV lamps, the effective brightness of a surface using metal halide lamps is much better, due to their excellent colour-rendering property, as compared to HPMV or HPSV lamps. However, their starting time is much longer, of the order of 8 to 10 minutes.

Colour Rendition

An ideal light source should render all colours as sunlight does. Most objects to be seen under lighting do not have a single colour but a combination of several colours. If a light source is deficient in certain colours then it will change the appearance of the objects. The Colour Rendition Index (CRI) is a 1–100 scale that measures a light source's ability to render colours. The peak value of the CRI scale (100) is based on illumination by a 100-watt incandescent lamp.

The CRI for an HPMV lamp is around 50, for HPSV lamp it is around 20. The colour rendering index of a Metal Halide lamp depends on nature of the metal used in the construction of the lamp and it may be as high as 85 [7]. The higher CRI of MH lamps compensates for their lower lumen/W efficacy as compared to their closest competitors- HPSV lamps.

Glare

Glare is the excessive brightness from a direct light source that makes it difficult to see. A bright object in front of a dark background usually causes glare. Intense light sources such as bright HPSV, MH and HPMV lamps produce more glare than large fluorescent lamps. However, glare primarily depends on placement of light sources with respect to the observer and the objects to be seen.

The glare index (GI) may be computed using the following expression [10] :

$$GI = (0.45/B) \sum L^{1.6} \omega^{0.8} / p^{1.6} \qquad (1.1)$$

where

L is the luminance of the glare source (cd/m^2)

B is the back ground luminance

ω is the solid angle extended by the source at the point of observation

The glare index (GI) of 24 and above is uncomfortable. It should be preferably lower than 20.

The Surround Ratio

The ratio of average illumination on the area adjacent to a side of carriage way to the average illumination on the carriage way is called surround ratio (SR). The recommended value of SR is 0.5 [10]. The maintained value of SR on a road, with trees on its sides, is quite significant, since it represents the reduction of lighting level due to trees.

2. The Present Study

For the purpose of this study we examined 3 types of luminaires that are already functioning on some of the roads in the New Delhi.

Type A : These are large luminaires, housing 250watt HPSV lamps. These were installed more than 20 years ago. Their reflecting surfaces have got badly corroded. The glass covers are generally missing. However the lamps and accessories have been replaced whenever required.

Type B :These luminaires are much smaller in size as compared to type A. They were installed

Table-2 Measured values of illumination near the kerb lines on roads with different luminaires

Distance From Pole(m)	Illumination with Type A luminaire (lux)	Illumination with Type B luminaire (lux)	Illumination with Type C luminaire (lux)
0	7.5	17.2	4
1	6.4	16.6	3.5
2	5.4	15.6	3
3	4.5	15.2	2.5
4	3.3	13.8	2
5	2.5	12.7	1.5
6	1.5	8.9	1.0
7	0.5	4.2	0.2
8	0.5	3.3	0.1
9	0.5	1.0	0.1
10	0.5	1.0	0.1

2-3 years back. They also contain 250 watt HPSV lamps. The glass cover, the reflector and other accessories are in working order.

Type C : It is decorative luminaire. It doesn't have any reflector inside. The light comes out of the four windows in the vertical sides of the luminaire.

Measurements were taken for illumination level maintained by the above luminaires with help of a well calibrated illuminance meter (Sl. No.51001, Yokogama make, made in Japan). Since the middle portion of road surfaces was not available for measurement of illumination, reading were taken near the kerb lines. The readings are recorded in Table-2. The values of current voltage, wattage, power factor, waveform etc. were also recorded.

2.1 The Effect of Reflector and Refractor of the Luminaire

In order to obtain photometric data, 5 fittings* (3 fittings of type A, 1 fitting of type B and 1 fitting of type C)were removed from street lighting poles and taken for testing. The values of luminous intensity (I) in 4 vertical planes making angles of 0, 30, 60 and 90 degrees with road axis were measured. The reflecting surfaces of type 'A' luminaires have got corroded. Its performance can be improved by replacing the reflecting surface. In the present study a reflecting sheet consisting of anodized aluminium was fixed inside the old luminaire. Readings for luminous intensity with the reflecting sheet were also taken.

Calculation for Illumination Level

The value of illumination (E) at a point on a surface due to a source of light with intensity (I) in the direction of the point, may be calculated as follows:

$$E = I \cos\Phi / R^2 \quad (2.1)$$

where Φ is the angle of incidence and R is the distance between the point and the source of light.

In the present study a stretch of a typical urban road, 30m long and 12 m wide is considered. It is assumed that the road is illuminated with 250W HPSV lamps fitted in one of the luminaires (Type A, B or C) described above. The spacing between two poles on one side of the road is 30m and another pole is located on the opposite side of the road, in the staggered formation. The stretch of the road is divided into a set of smaller areas over which the values of E can be assumed to be constant. These areas are separated from each other by angular displacements of 15° in the horizontal and vertical planes. The total luminous flux received by the road surface is equal to the sum of fluxes incident on the component areas. The average illumination is calculated by dividing the total flux by total area. The results for type A are depicted in figure 1, which clearly shows the improvement achieved by providing a new reflecting sheet inside the old luminaire.

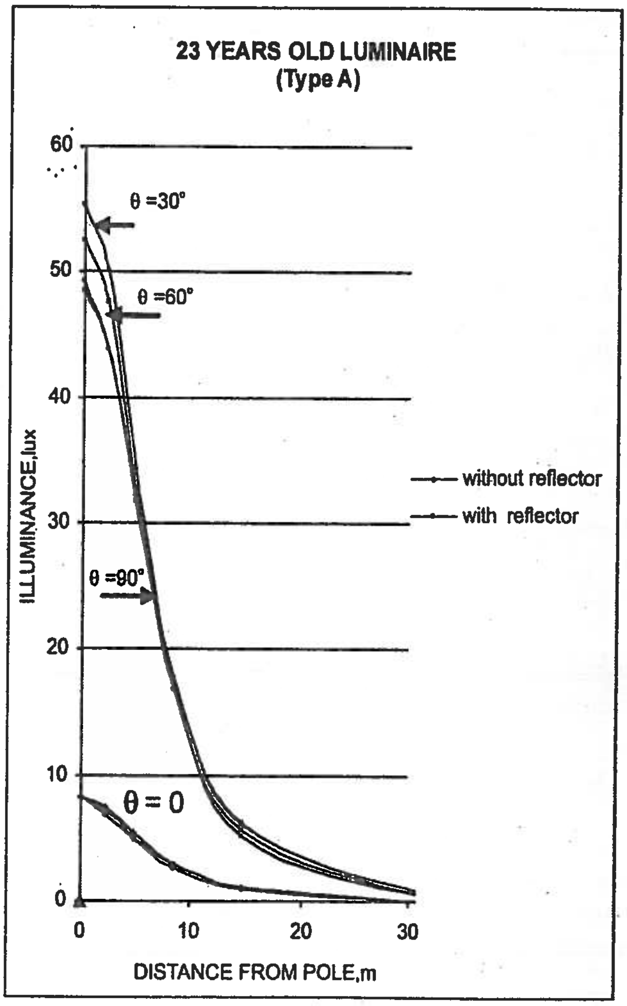

Fig.1 Illumination on a road with a 23 years old luminaire (Type A) having 250W HPSV lamp.

In case of type B the reflecting surfaces of glass were thoroughly cleaned with the detergent and readings were taken before and after the cleaning process as shown in figure 2.

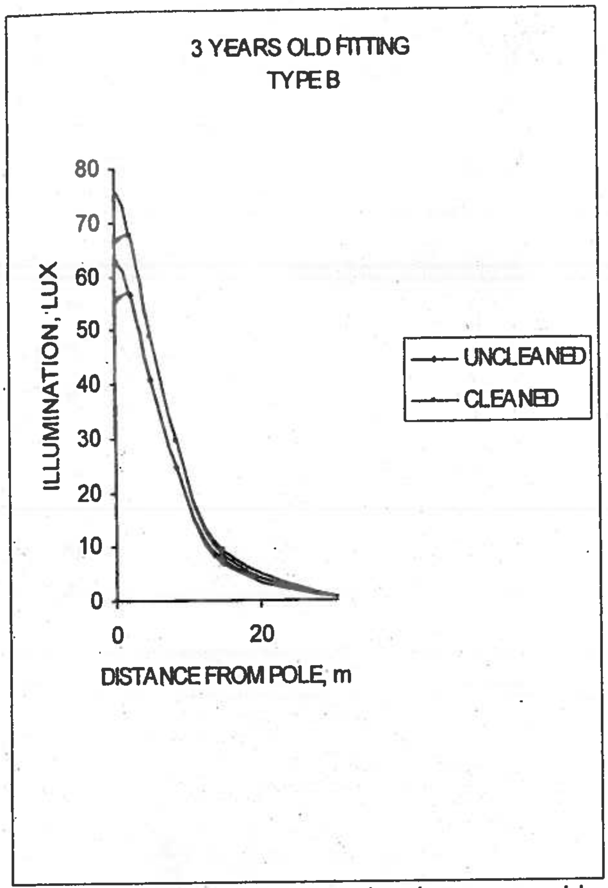

Fig.2 Illumination on a road with a 3 years old luminaire (Type b) having 250W HPSV lamp.

Average values of illumination with the different types of luminaries have been computed. The results are given in Table-3.

The decorative lantern (type C luminaire) did not have any polished reflector inside it. In the experiment a reflector made of anodized aluminium sheet was provided on vertical back side of the window and readings were taken with and without this reflector. The results are plotted in figure 3.

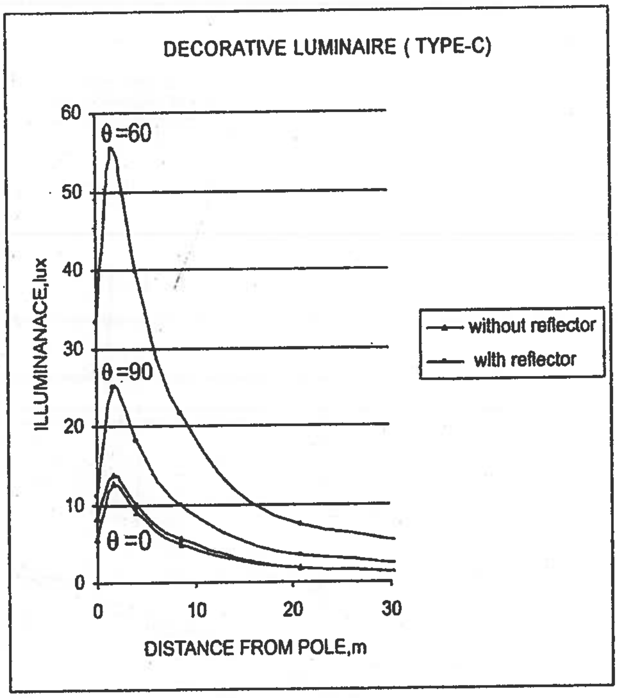

Fig.3 Illumination on a road with a 23 years old decorative luminaire (Type C) having 250W HPSV lamp.

Table-3 : Average Illumination with Different Types of Old Luminaires

Type of Luminaire	Average Illumination with the old luminaire without retrofitting/ cleaning (lux)	Average Illumination with the old luminaire with retrofitted/cleaned surfaces (lux)	Improvement due to retrofitting/cleaning (lux)
Type A (23 Years old)	3.42	16.99	13.57
Type B (3 Years old)	25.26	30.3	5.04
Type C (23 Years old)	2.07 (without any reflector)	4.13 (with reflector on one side)	2.06

2.2 The Effect of Trees

On some roads in Delhi, lighting is severely affected by the shadows of the trees. This represents a significant component of energy loss. The shadows also reduce the minimum to average illumination ratio and the surround ratio. For proper visual guidance and perspective on a road with tree on its sides, some kind of special lighting arrangement is required to be made.

In the present study, a typical stretch of a shadowy road is considered. It is assumed that the width of the affected area is 9m and lighting columns are to be provided at a spacing of 20m, as shown in Fig.4. With a view to mitigating the effect of tree shadows, it is proposed that luminaires consisting of 1.2m long, 40W tubular fluorescent tubular fittings be installed at a mounting height of 5m. The illumination provided by a single luminaire of this type is calculated as follows:

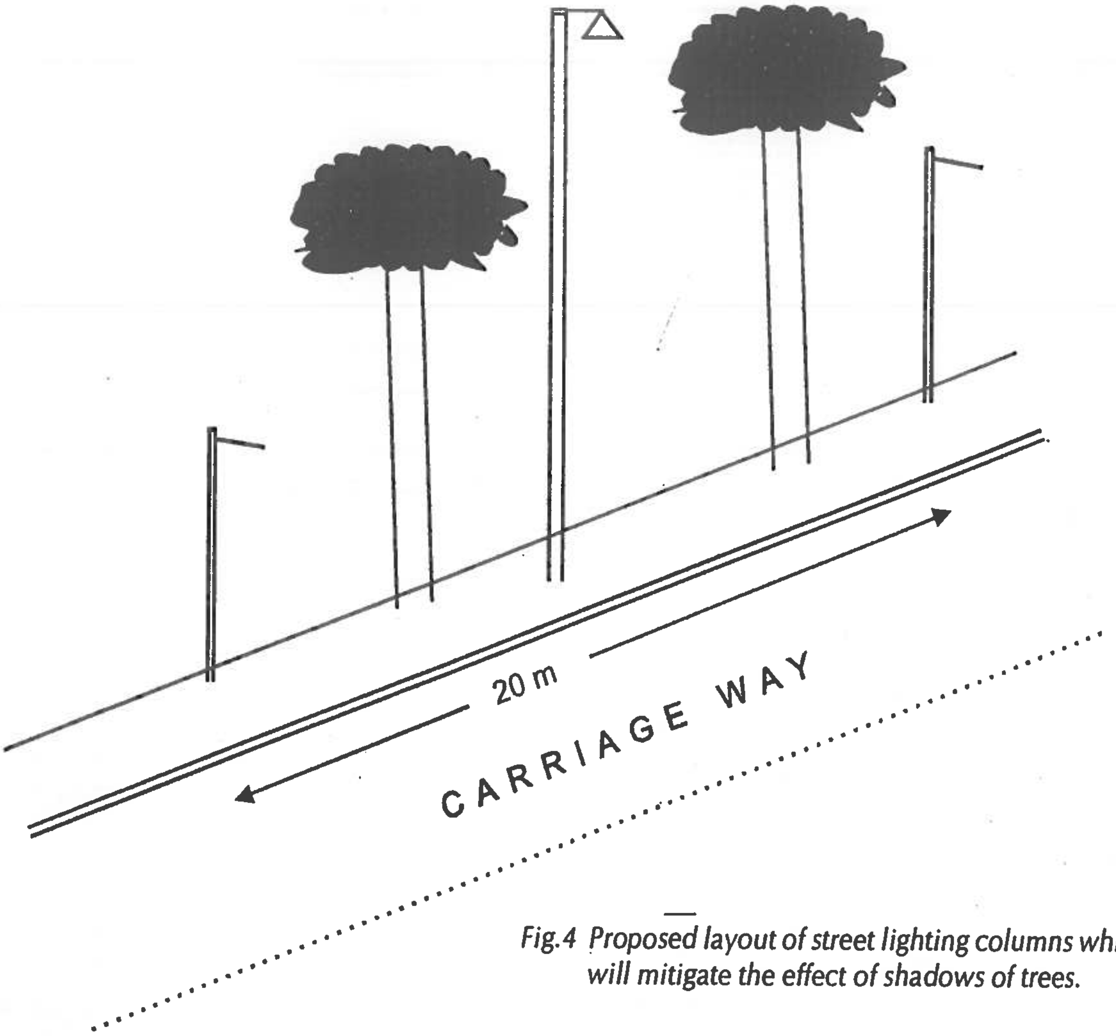

Fig.4 Proposed layout of street lighting columns which will mitigate the effect of shadows of trees.

Area of road surface covered = 6m × 20m = 120m²

Total lamp lumens = 3000 lm

Utilization factor (assumed) = 0.4

Average illuminance that will be achieved = 3000 ×0.4/120 = 10 lux

Surround ratio = 10/20 = 0.5
(assuming that the average illumination on the carriage way near the kerb line is 20 lux)-

The glare resulting from one such luminaire is calculated from the following expression:

$GI = (0.45/B) \sum L^{1.6} \omega^{0.8}$

Here, B = 10 lux

$L = 3000/1.2^2 0.8 = 3125 \text{ lm} / m^2$

$\omega = 1.2 \times .16 \ / 60^2 = 0.0002$

$GI = (0.45/10)\ 3125^{1.6}\ 0.0002^{.8} = 19.3$

The colour rendition of the fluorescent lamp is around 50.

2.3 The Effect of Power Factor

The observed value of power factor in type- A luminaire = 0.5

Power = 250 W

Current = 250/215 × .5 = 2.33 A

Resistance of cable and wires from luminaire to feeder pillar = 2Ω

Power loss = $2.33^2 \times 2 = 10.8$ W

Assuming that the power factor will be corrected to .95

Then the power loss will be $2(250/21 \times .95)^2$ = 3 W

Saving due to power factor correction = 10.8-3= 7.8 W

Percent saving = 3 %

3. Results and Discussion

It is seen from figure1 that illumination level on the roads with type A fittings has been considerably deteriorated over passage of time. Assuming that the initial illumination was provided in accordance with Indian Standard (30 lux for group A roads) with a ratio minimum to average of 0.4. The existing illumination level has gone down to about 10 % of initial values. This is the major factor of energy loss in street lighting fitting with type A luminaires. By providing a new reflector inside the old luminaire, its performance can be considerably improved (in the present study the improvement is 47 % of initial value). In case of type B the lux levels have gone down to about 80% and it is seen that by thoroughly cleaning the reflector and refractor of the luminaire, its performance can be brought back to almost its designed values. In case of type C, the illumination level is the poorest. It does not conform to Indian Standards at all. However it is seen that using the reflector sheet on the backside of luminaire, its luminance can be considerably improved in the direction of carriageway. Assuming that the efficacy of HPMV lamps used in these luminaires is 130 lm/W. The loss of energy due to the corroded reflector in type A and absence of any reflector in type B comes to about 50W per luminaire. In type B the energy loss due to un-cleaned reflector and refractor is 10W per luminaire.

The power factoring case of type A and type C is very low of the order of 0.5. Consequently the current taken by these fittings is twice the value of current with unity power factor. The loss of power due to excessive I^2R dissipation through the length of cable from luminance up to the feeder pillar has been computed. It is seen that this loss can be reduced by about 8W per luminaire if the power factor is corrected from 0.5 to 0.95. Also, it is to be kept in mind that street light lamps consisting of HPSV require very high voltage pulses of the order of several Kilovolts. At each start up these pulses gradually eat up the insulation of the wires resulting in loss of energy and faults. The ends of these wires get worn out due to mechanical, electrical and thermal stresses. The resulting loss of energy can be minimized by replacing the old worn out cable-ends, connectors and accessories.

Conclusion

The major component of energy loss in street lighting is through worn out and corroded reflectors. This can be minimized by retrofitting/ cleaning. The other major component of loss of the luminous flux is due to the trees. The shadows of trees also result in severe non-uniformity in road lighting which will require additional lighting. Here, energy can be economized by using fluorescent tubular lamps that have high values of efficacy and colour rendition and cause low glare. Some energy saving is also possible by correcting power factor and replacing the wiring inside the street lighting poles.

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References

1. J.M. Waldram, 1952. "Street Lighting", Edward Arnold &CO, London.
2. Bureau of Indian Standards, 1971, " Code of Practice for Lighting of Public Throughfares" IS: 1944 (Parts I and II)-1970, Fourth Reprint April 1991.
3. M.A. Cayless and A.M. Mardsen, "Lamps and Lighting" Third edition, Edward Arnold, London.
4. Cornel Bianchi and Camelia Burlacu, 2001. "Conception / Design of Lighting System for Urban TrafficRoads" , Iluminat 2001, June 28-30,2001, Cluj-Napoca
5. Fordergemeinschaft Gutes Licht, "Lighting with Artificial Light", http://www.fgl.de, 2006.
6. Keitz HAE, 1971, "Light Calculations and Measurements", 2nd Edition, Macmillan, London.
7. Geoff Popple, 2005, "Street Lighting Guide for Private Development", http://www.northlincs.gov.uk, April, 2005.
8. California Energy Commission, 2002, "California Outdoor Lighting Standards Synopsis", Eley Associates, February, 2002.
9. Darrin Hoyle, "Fluorescent Lamps-An Old Idea with New Value", dhoyle@cooperlighting.com
10. Leonardo Assaf, 1977, "Glare and Illuminance uniformity as Components of Innovative Glazing", Right light, 4, vol. 1, 1977.

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or non-switching of respective circuits. These situations are encountered quite frequently and call for emergent deployment of man and machine. Such measures require a substantial investment with a certain degree of compromise in the service quality. A computer based fault detection & control system provides a better and highly reliable operation over a period of time. Though it requires a high capital investment, the same is recovered in due course of time. Further, the data collected by the system can be effectively used for drawing the preventive and perfective maintenance schedules.

2. An Innovative Switching and Fault Detection System

Each city has a network of roads consisting of streets, lanes etc. These are provided with sufficient number of pole mounted luminaires. The types of poles and the supported light sources are many. A unique identity of these poles is a must for speedy detection and rectification of faults occurring quite frequently. Hence there is a need for their classification. Pole types, their height, their physical location, type of luminaire, its manufacturer, power rating etc. are a few parameters for such a classification. We propose a scheme as given below (however, any other suitably designed scheme can be adopted for implementation). The lighting load has been divided into a number of zones, then into roads, lanes and so on. Further, the load is of different varieties. These details have been taken into consideration while devising the scheme for fault detection and controls as follows:

2.1 The Proposed Coding Scheme

1. Zone : there are 10 zones in all.
2. Main Road / Back lane/ service Lane etc:
3. Round About No. / Main Road No. / Service Lane No. etc.
4. Pole No. – (Up to a maximum of 999 per lane per road etc.)
5. Pole Type – (9 types of poles.)
6. Light Fitting Types (9 types)
7. Wattage of the light source (9 Variants)

A code of 12 characters has been devised which will take care of all these parameters while the fault report generation is being carried out. This is our control key: i.e. Code for any pole = 12 digit numeric number (nature of this code is modifiable if required. However, the total length of this field should remain the same.)

The system is a microprocessor based monitoring and control system where the signal from each pole is being analyzed. The poles are identified by a specific code as allotted earlier and converted into digital form through appropriate algorithm viz.

Digital-Code-of-the-pole = f(already allotted data code).

Any fault detected on a specific circuit shall be converted into respective pole details and reported either in a hardcopy fashion or an analog signal for local consumption (either to switch ON or OFF a device if the situation demands). The designed system will work on a real time basis as under :

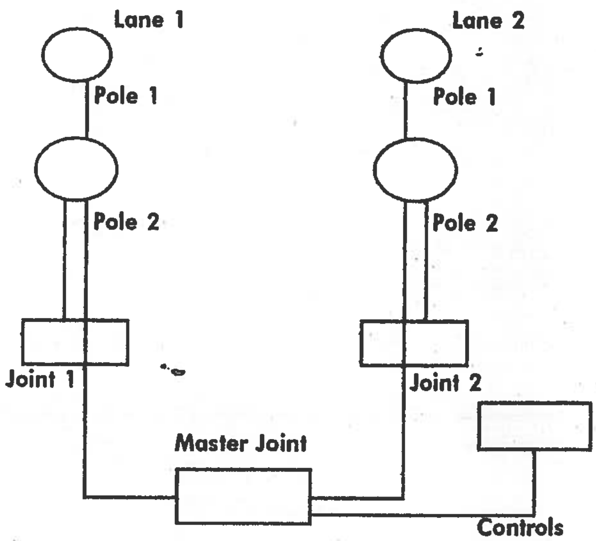

Fig 1. A logical diagram of the automated control system.

The pole1 of lane1 will be catalogued as L11

The pole2 of lane1 will be identified as L12

Similarly, Pole1 of lane2 will be called as L21 where as, the pole2 of lane2 will be identified as L22 and so on.

The Master joint and the individual joints are 8 bit microprocessors which can handle a very large no. of poles to be monitored (256 ideal nos.). We require a practicable no. of 64 poles per joint.

The master joint (a station where individual lane joints shall be merging) is also a 8 bit microprocessor which is programmed to identify either lane1 or lane2 in the description given above. The code of Joint1 is J1 which signifies all the poles of lane1 and for the Joint2, it is J2 signifying all the poles of lane2.

The Controls are in the form of a programming station (a physical desktop computer system). It is programmed to logically analyze and decipher a set of codes reported as faulty. Further, it can also be programmed (Once fully operational) to:

1. Program switching time for either the complete system or partially.
2. Program to take off a single pole / light selectively for maintenance.
3. Program to bring emergency lights into operation as and when required.
4. Program to monitor a lane/ road/ zone from a single point.
5. Analyze operations and performance for a specified period and devise optimization procedures and policies as and when required.

— A Basic flowchart of the operations of the system is given as below:

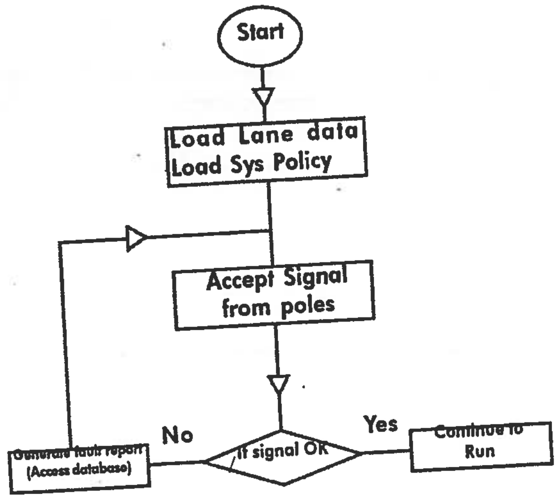

Fig 2. System flow chart.

The policies for the system are decided at the time of setting up of the system and can be modified anytime after the system is in operation depending upon the requirements. This will be made possible through easily understandable software utilities. The pole data will be sensed through a set of electronic sensors mounted on each and every pole. Options to have either wireless mode of communication or a wired one have been tried out and the factors like technical and financial feasibility, reliability and maintainability would be considered before being recommended for use. A few policy matters may be listed here for information as :

1. Time of monitoring: Since the lights are switched on during evening time only, a programmed policy can be implemented to monitor during a specific time interval only. However, the decision lies with the monitoring agency and whatever they feel suitable, that can be built into the system by themselves.
2. A decision as to whether a complete feeder line needs to be put under maintenance or a selected set of poles only need to be taken off for maintenance.
3. Whether to go for automated controls or to use manual operation during which the system will remain suspended. This is a programmable decision and shall be available with the customer of the system.

2.2 Fault Monitoring

The system is tested for the following type of faults:

1. No Voltage: If there is no power supply to the designated pole, a fault report shall be generated after the policies have been taken into consideration. A cable break will also be reported the same way. However, if a complete lane is down, then all individual pole-wise no voltage faults would trigger a joint fault and a report on the same pattern would be generated.
2. No Load: A no load condition can occur when there is supply voltage present and there should be a current value sensed by the electronic sensors mounted on the poles. Such a fault can be encountered whenever either the light source has gone off or damaged. Pole damage cases would also be covered by the same.

3. Whenever there is any fault of the above nature reported from any pole, a small emergency battery based light will become operational for a duration defined by the capacity of the battery. The battery shall be charged once normalcy has been restored.

2.3 Reports

The data collected by the system shall be maintained in a database file (.dbf) which can be interfaced to other systems if so desired. The fault reports will be designed to take care of the following details:

- Date and time of fault occurrence.
- Zone
- Lane / Road/ Round About / Pole No./ Pole Type/Light Source Type & Wattage/
- Type of fault
- Type and number of spares required.
- Type of jigs required for repairs viz. lift / crane etc.
- If any expert service required? If yes, an explanation of the same in detail.
- Probable time of repairs.
- Based upon the category of installation, whether the repairs are URGENT / IMMEDIATE /NORMAL.

The captured data will be maintained in flat files which save space and provide independence from application. Such data can be converted to any other application format for easy understanding and view viz. MS-Excel. Further, the same data can be used for analysis in the future to generate preventive maintenance schedules, spares planning and man power deployment as and when the requirement arises. A log can also be generated for performance analysis, cost estimation and quality assessment of the techniques adopted. Such applications are of immense importance to human and system safety, its reliability and secured operation.

3. An Innovative Auxiliary Lighting System

In case of power failure due to any of the faults listed above, the roads cannot be surrendered to the mercy of nature. A suitable emergency measure needs to be employed. A small capacity battery mounted on the existing pole (there by avoiding additional poles) is proposed which will be sufficient to feed an eighty-watt luminaire .We propose LED lamp for this application(some manufacturers have developed LED lamps for street lighting).These lamps have long life of about ten years and they have excellent properties of color rendition , low glare and high efficacy. In a LED electrical energy is directly converted into light energy. Its efficiency of conversion is higher as compared to incandescent lamp in which energy is first converted into heat and then into light.

The battery can be charged from a photovoltaic array, where available. The advantages of photovoltaic energy have been emphasized by several authors

[6,7].However in urban areas a photovoltaic array can not be easily mounted on each and every street lighting pole. In the present study it is assumed that the battery will be charged from street lighting mains.

The amount of light given out by such a luminaire, though insufficient to illuminate the whole area, can avoid ugly incidents which can take place in absence of any light. It will also provide the ***visual guidance*** to drivers, which is considered to be an essential requirement of street lighting [1-4].

An electronic circuit will be used for voltage boosting to switch such a system ON. This position will be sensed by a photo cell and a log will be maintained by the controlling station as to the duration of the emergency light being used.

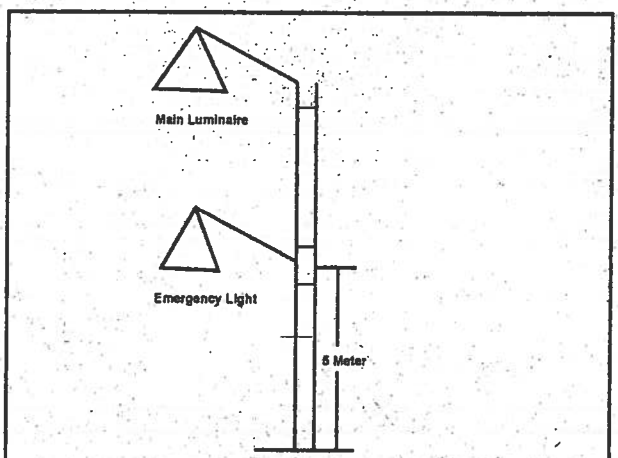

figure 3 Positioning of emergeny lighing system

This device will go off as and when normalcy is restored in respect of power conditions/ back ground luminance. The discharged battery, now, gets charged for future usage. The charge-discharge cycles of the battery can be used to generate maintenance schedule for the emergency lighting system.

Figure 3 depicts an auxiliary lamp that will be mounted at a lower height of 5 meters from ground, just below the main luminaire. The device can also be used to provide lighting during the early sun-set and early morning, when the main street lighting is off, thereby saving considerable amount of energy as illustrated below.

As long as the auxiliary lamp receives light either from the main luminaire or from the sun, it remains off. (A photo sensor based device can be used for the purpose.) When the The light falling on the photo-sensor stops due to poor sun-light or failure of the main luminaire, the emergency lamp comes ON.

In the present study, it is proposed to use a luminaire of 80 watts LED based lamps that will be energized by a cadmium sulphide battery which can, further, be charged by either the mains or a photo-voltaic array depending upon the available resources. The illumination available from such a device will be as follows :

Total lamp lumens : 2 x 40 x 75 = 6000 lumens.

Road area covered : 15 x 8 = 120 m^2

Utilization factor (assumed) 0.6

Average illumination provided
= (6000 x 0.6) / 120 = 3 lux.

This value of illumination is comparable to the existing lux-levels on some of the roads in Delhi.

Energy Saving through the auxiliary lighting system

The proposed auxiliary luminaire will be switched on one hour before the main luminaire is switched on and it will be switched off one hour after the main luminaire is switched off. This arrangement will result in energy saving during two hours everyday when certain amount of natural lighting is also available. If an eighty watt lamp is used in place of a 250 W lamp for 2 hours daily, the saving in energy will be 340Wh per pole per day (8.9 x 10^6 MJ per year for the area considered). Moreover, the colour rendition index of LED lamp and glare index of the proposed luminaire will be of quite desirable values [8].

4. An Emergency Power Source

A portable power source has been designed and tested for emergency repairs of the system on solitary pole basis, without having to energize the entire energy supply system for carrying out repaires/maintenance during day time. A cable-end pole box has been designed and fabricated for taking the street light pole off the mains for emergency repairs. The emergency power source will be connected to this box to provide energy to the pole only. This source is a battery based device which can feed a light source of up to 500W rating.

Conclusion

In a modern street lighting system, a computer based control system is a necessary requirement. Strengthened with capability for an effective preventive maintenance schedule and a fail safe auxiliary lighting in place, near perfect illumination of a road is within achievable limits.

References :

1. Bureau of Indian Standards, 1971, " Code of Practice for Lighting of Public Throughfares" IS: 1944 (Parts I and II)-1970, Fourth Reprint April 1991.
2. J.M. Waldram,1952, "Street Lighting", Edward Arnold &CO, London.
3. California Energy Commission, 2002, "California Outdoor Lighting Standards Synopsis", Eley Associates, February, 2002.

4. Cornel Bianchi and Camelia Burlacu, 2001. "Conception / Design of Lighting System for Urban TrafficRoads" , Iluminat 2001, June 28-30,2001, Cluj-Napoca.

5. Duffie, J.A., Beckman, W.A., "Solar Engineering of Thermal Processes", John Wiley & Sons, Inc., 1980.

6. Leonardo Assaf,1997, " Glare and Illuminance Uniformityas components of Innovative Glazing", Right Light, 4, vol.1, 1997.

7. R.Gunning, J.R.Bates, Z.Li and B.McNelis, "Deployment of Photovoltaic Technologies :Cooperation with Developing Countries" ,Task 9 of international Energy Agency's Photovoltaic Power System Programme report, 1999.

8. Imtiaz Ashraf, A.Chandra and M.S. Sodha, "Techno-economic and Environmental Analysis for Grid Interactive Solar Photovoltaic Power System of Lakshdweep Islands", International Journal of Energy Research, Vol. 28, issue 12, 2004.

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