Quantitative Measurement Techniques Daylight and Artificial Light: Housing Design

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ABSTRACT

Lighting forms an important functional aspect of building design. Suitable lighting levels are required for case in execution of visual task and case in the adaption for different brightness encountered within the task, background and the surrounds. Task illumination depends upon the fineness of visual task to be executed. The recommended lighting levels for circulation, reading /writing, cooking and drawing work are 70 Lux, 150 Lux, 200 Lux and 300 Lux respectively. Recommended ratio of the task brightness, background brightness and the surrounding is 10:3:1. Inadequate illumination levels and brightness ratios cause stress on visual sense and adversely affect the well-being and efficiency of occupants. Besides a feeling of discomfort, the productivity in terms of physical and mental output decreases, under the stress of the above visual factors. Also a poor lighting design results in a recurring consumption of energy for making up the de-efficiencies of design. Provision of adequate natural lighting is one of the most effective means of energy conservation in buildings.

Keywords: Daylight, Architecture, Housing Design

1. INTRODUCTION

Sunlight is the primary source of daylight. But direct sunlight is undesirable for lighting design. It casts harsh shadows, creates brightness imbalances and causes glare. It also brings in considerable amount of heat. Therefore, the sunlight scattered in the atmosphere i.e. the sky forms the principal source of daylight. The sunlight reflected off the terrain is also equally important in the tropics.

Knowledge of daylight availability and the distribution of light in the sky are necessary for arriving at a design basis. The amount of daylight available in the open varies with the transit of sun from morning till evening as well as with the condition of the sky from season to season at a place. This necessitates the evaluation of the same rational design criteria on a statistical basis, such that day lighting design holds good for most of the working hours without proving to be an over design. In tropics the sky conditions are mostly clear or partially clear and there is a considerable amount of sunlight incident on the ground and most building facades. This is in contrast to overcast sky conditions adopted for design in Western Europe. A new basis of day lighting design conforming to the prevalent sky conditions has recently been evolve for India and several countries of South

East Asia. Based on extensive measurements of daylight availability in India, a clear sky opposite the sun for a solar altitude of 15 degree has been standardized as the design sky. The outdoor design sky illumination on a horizontal plane is 8000 Lux. From the knowledge of sky luminance distribution and day light availability outdoor, it is possible to calculate daylight at any point indoors through a given set of windows. Daylight indoors is expressed as Daylight Factor (D.F) which is a percentage fraction of the above value of design sky illumination. Accordingly, 01 % DF = 80 Lux.

D.F. = S.C. + E.R.C. + I.R.C.

- S.C. is the fraction of the light due to visible sky.
- E.R.C. is the fraction of the light due to reflection from external surfaces.
- I.R.C. is the fraction of the light due to inter-reflection within the room.

S.C. and E.R.C. are called the direct component of daylight factor, and I.R.C. is called the indirect component. The indirect component is zero in a perfectly dark colored room, and is considerably large when the room surfaces are of light finish.

Daylight design of windows based on the clear design sky holds for about 90 % of the working hours. For periods of poor daylight availability supplementary artificial lighting is needed.

2. DAY LIGHT DESIGN

Design of windows is important, as it greatly influences the indoor environmental conditions. The functions of windows are to provide a view outside and to admit daylight and breeze. Glass being transparent is quite suitable for enabling a view outside and admitting daylight. But since glass is transparent to short wave solar radiations and opaque to longwise radiations it can bring in excessive solar heat and retain it indoors. Therefore, the windows have to be so designed as to exclude solar heat in summer and admit it in winter, as far as possible. Wherever there is a noise problem, the windows should provide a reasonable sound insulation. The provision of windows in suitable orientation from the consideration of solar incursion and wind direction is very important. A suitable orientation also helps, in achieving better thermal conditions indoors. Ventilation being relatively less affected by slight changes of orientation up to 30 degree from normal to the wind direction, the more critical factor is solar heat. Long axis of a building along 3-W with windows on longer sides facing North and South provides advantage of solar heart in winter while minimizing it in summer.

This orientation is, generally, suitable from ventilation point of view for most part of the country. Also, the shading devices required for North and South facing windows are simpler than these required for other directions. Wherever a compromise is to be made in regard to orientation due to site conditions the long axis of the building may be tilted towards NE-SW direction. In hilly regions, the advantage of solar radiations from all possible directions viz. East, West and South should be taken.

Heat gain in summer and heat loss in winter through windows in proportional to the glass area. Hence a minimum of glass area need be provided for satisfying the daylight requirements and a good part of this glass area should be open-able for allowing in the flow of outdoor breeze. The recommended values of still height for office and residential buildings are 1.0 -1.2 m and 0.9 m above floor level. Window height of 1.2 m or more is desirable for providing a good penetration of daylight indoors.

For day lighting design has provided simple graphs Lux grid, protractors and monograms. The graphs give the required percentage fenestration for the desired day-light factor at the centre or rear point in a room. The Lux grid method enables the determination of day light factor at any point indoors as well as the design of windows for the required day light factors. The protractors and monograms help in detailed analysis of day light at any point in a room. The day lighting design based on these methods ensures adequate day light indoors for most of the working hours.

3. SUPPLEMENTARY ARTIFICIAL LIGHTING DESIGN

Energy consumption of day time lighting in office and other buildings is at least 10%-15% of total energy consumption. A substantial portion of this energy expended on artificial lighting can be efficient design of supplemental artificial lights.

It has evolved a rational method of design of supplementary artificial lighting for such periods when day light availability is poor. Most of the office and educational buildings which function during day time need be provided with minimum of supplementary artificial lights for day time use depending upon the day light availability indoors. According to this rational design method the supplementary artificial lights of the order of 3 to 5 w/m^2 are required as against conventional practice of providing $9w/m^2$ which higher installation cost results in wastage of electrical energy.

Poor design of windows constitutes a major factor responsible for wastage of energy. Inadequate window sizes result in poor illumination indoors and consequent recourse to artificial lights by the occupants. Over-size windows admit considerable heat in summer and involve increased consumption electric energy for cooling. The other wasteful energy is in improper artificial lighting design which totally ignores day light availability. Choice of low efficiency lamps also causes wastage of energy.

Energy conservation in lighting can be affected by the following measures;-

- Design of windows for optional day lighting.
- Rational design of supplementary artificial lighting.
- Choice and use of efficient lights and luminaries.
- Suitable color finishes of internal reflecting surfaces and adequate periodic schedule for maintenance of interior finish.
- Adequate periodic schedule for cleaning of windows and luminaries.
- Appropriate control of window brightness in summer.
- Administrative control for minimizing wastage of energy through strict orders of switching off lights during non-occupancy periods and also during good day light conditions. Automatic controls may be employed in future when reliable and economical photo-electric devices become available in the country.

The duration and amount of supplemental artificial lighting required depends up on the day light availability indoors. For recommended window sizes the required duration of supplementary lighting is expected to be about 20% of the total working hours. This is true even for summer period when curtains are drawn and supplementary artificial lights are used. If the actual window sizes are half the recommended size or less, supplementary artificial lights will be required through the entire working hours.

For occasional work beyond day light hours, supplementary lights can provide general lighting and spot lighting can be switched on for providing task illumination. Luminous efficiency of light sources has considerable bearing on energy conservation. A source of maximum lumen output per watt of electrical energy has the minimum power consumption. For office buildings cooled day light fluorescent tubes are recommended for supplementary artificial lighting of work areas. For corridors and stair cases white fluorescent tubes with about 10% higher luminous efficiency are to be preferred. Some office buildings are still using incandescent lamps for supplementing day light. The replacement of incandescent lamps by cool day light fluorescent tubes in work areas and by white fluorescent tubes in corridor and stair cases will considerably reduce the consumption of electrical energy for lighting. Luminous efficiency of incandescent and fluorescent lamps is given in Table A.

It is clear that for the same amount of light output the consumption of electrical energy with cool day light fluorescent tubes (recommended for offices) will be only ¼ of the corresponding consumption with incandescent lamps. Similarly, with the use of white fluorescent tubes in corridors and stair cases, the electrical consumption reduces to 1/4 of the energy consumption with incandescent lamps. The choice of on luminaries should be such that it is efficient not only initially but also throughout its life. If cleaned periodically it can retain its initial efficiency. For offices semi-direct type of luminaries are recommended so that both the workplace illumination and surround luminance can be effectively enhanced. For corridors and stair cases direct type of luminaries with vide spread of light distribution are recommended.

Internal shading devices which are used for reducing heat and glare from windows in summer, should be such as to perform these functions effectively without excessively cutting off day light. In summer, the consumption of energy on lighting is primarily due to unsuitable internal shading devices. Venetian blinds or light curtains are recommended for controlling heat and glare from windows and for admitting a good amount of day light indoors. It is thus possible to effectively utilize day light even under summer conditions.

TABLE – A: Luminous Efficiency and Life of Light Source at 100Hours and 230 V

S.No.	Light Source	Efficiency (LM/Watt)	Average working Life (hours)	Recommendation for
1	Incandescent	10 -18	1,000	Localized Lighting such as table lamps
2	Cool day light fluorescent tubes	61	5,000	Supplementing day light in rooms
3	White fluorescent tubes	67	5,000	Lighting of corridors and stair cases
4	High Pressure	40-57	5,000	Compound lighting

This can considerably reduce consumption of energy for most of the working hours.

Design of night time artificial lighting is required for residential buildings and for such buildings which function all the twenty four hours as for example hospitals and industrial buildings. The measures discussed under supplementary artificial lighting design for saving energy viz. use of efficient light sources, efficient luminaries, good interior finish, periodic maintenance and cleaning schedule bare also applicable for night time artificial lighting. In the wake of energy crises and awareness of energy conservation, the conventional lumen method of artificial lighting design for providing task illumination over entire area in a room need be discarded. The rational design approach should be based on estimating and providing the required illumination in actual work areas and general illumination in the remaining area for circulation and for providing acceptable surround brightness. In other words, night time artificial lighting should provide the required local lighting and a minimum of general lighting in a room. This design method is as such not as simple as the conventional lumen method. However, it can be simplified by providing the data on lumen output and illumination availability for various types of luminaries for different mounting heights.

Researchers have shown that artificial lighting in residential buildings can be made most energy effective by lowering the mounting height of wall mounted fixtures from conventional 3.0 -2.4 m to 2.1 m above floor level. The use of fluorescent tube also need be encouraged in residential buildings for more effective and energy economic lighting of study rooms, drawing rooms, living rooms and kitchens. A single light point along centre of a longer wall is found to be most adequate for rooms up to 12 m^2 floor area. For larger rooms up to 22 m^2 floor area two light points may be provided on the same longer wall or opposite walls at a lateral separation of 3.0 m.

4. CONCLUSIONS

Architectural Design a well as town and city planning needs to consider the day light for sustainable building design which may consume less energy. The building should be designed so that it has sufficient light according to need/ utility of the place. Sufficient daylight may be achieved through proper orientation of building. If daylight is not possible then the good quality artificial light may be the option. LED is cheaper and better solution and is need of hour. Provision of adequate natural lighting is one of the most effective means of energy conservation in buildings.

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