NATURAL LIGHTING IN GREEN BUILDINGS-AN OVERVIEW AND A CASE STUDY

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ABSTRACT
India is an energy deficient country. The energy produced by various means is not sufficient to meet out the demand. The only proactive route for survival is to save energy. The daylight is the primary source of lighting in building to save electricity. In typical buildings, lighting accounts for 25-40% energy consumption. Fortunately during the last quarter of the 20th Century, architects and designers have recognized the importance and value of introducing natural light in buildings. Most people appreciate daylight and also enjoy the outside view that windows provide. Good day-lighting design can result in energy savings and can shift peak electrical demand during afternoon hours when daylight availability levels and utility rates are high. The object of this paper is to develop a scientific, engineering and economical integration of day-lighting concepts into the building design. This paper promotes daylight conscious building design by saving energy through greater utilization of natural light, while at the same time improving visual comfort and control of solar gains. As a case study, the various data available in rural region of Karaikal were collected and analysed to show the use of daylight for buildings are also highlighted.

KEYWORDS
Daylight, climate, glare, overheating.

1.0 INTRODUCTION
Energy efficiency of buildings can be improved by the planned use of natural light and thereby eliminating carbon emission and global warming. Introduction of innovative, advanced day-lighting strategies and systems can significantly improve the quality of light in an indoor environment. Working long hours exposed to artificial lighting (i.e lighting electricity) is believed to be deleterious to health and working in daylight is believed to result in less stress and discomfort. Daylight provides the condition for good vision (provides high illuminance and permits excellent colour discrimination and colour rendering). It also produces uncomfortable solar glaze and very high luminance reflection on display screens, which can interfere with good vision. Appropriate, low-cost, high performance daylight systems are required to integrate daylight planning in building design. The common barriers that have hindered the integration of daylight in buildings in the past are: i) lack of knowledge regarding the performance of advanced day-lighting systems; ii) lack of appropriate, user-friendly day-lighting design tools and iii) lack of evidence of the advantages of day-lighting in buildings. Now, the barriers are completely resolved by the invention of new techniques and planning of buildings.

2.0 BENEFITS OF DAYLIGHTING
Day-lighting can significantly improve life-cycle cost, increase user productivity, reduce emissions, and reduce operating cost. Day-lighting can save considerable money which is utilized for purchasing ballasts, fixtures & controls for artificial lighting (electricity) and increases user comfort and satisfaction, leading to improved performance. Daylight also reduces emission of green house gases (GHGS), slows fossil fuel depletion and total energy costs by one third, than that of artificial lighting.

3.0 DAYLIGHT AVAILABILITY
Daylight strategies depends on: i) the availability of natural light (based on latitude of the building site and surrounding conditions of the building); ii) climate; iii) orientation of buildings. High latitudes have distinct summer and winter conditions, whereas, the seasonal variation of daylight is less apparent at low latitudes. Hence building designers should aim to maximize daylight penetration in buildings in winter, at high latitudes. In tropical region, as the daylight levels are high throughout the year, designers should prevent overheating by restricting the amount of daylight entering in to the building. Therefore, the designer should calculate the
availability of daylight under different climatic conditions and fix the orientation of building, which will permit maximum daylight to penetrate the building without producing overheating.

4.0 SKY CONDITIONS

Day-lighting design is usually based on sky condition of the building site. There are three common sky conditions: clear sky, overcast sky and partly cloudy sky. Clear sky includes sunshine and is intense and brighter at the horizon than at the zenith, except in the area around the sun. Over cast sky includes dense cloud cover over 90% of the sky and is characterized by diffuse and variable levels of light and three times brighter at the zenith than at the horizon. Partly cloudy sky includes cloud cover that ranges from heavy to light and is similar to the clear sky at one moment and the partly cloudy sky at the other side. Since it is constantly changing, the designers do not take any decisions on the partly cloudy sky.

5.0 DESIGN CRITERIA

The climate, geographic location, building type and client preferences will influence the design of day-lighting in buildings. The following guidelines are applied while designing a building for the penetration of maximum daylight: 1) avoiding direct sunlight and skylight unless needed for thermal comfort; 2) bouncing of daylight to create indirect daylight; 3) bringing daylight from above to obtain deeper penetration; 4) filtering of daylight into buildings; 5) using of sustainable design principles; 6) maximizing ceiling height to gain better light distribution; 7) providing separate view glass from daylight glass; 8) determining whether daylight is primary or supplementary in lighting design; 9) adopting combined external and internal controls; 10) proper planning of building geometry and interior space; 11) creating low contrast between window frame and adjacent walls to reduce glare and improve vision; 12) integrating artificial lighting with day-lighting through control systems. The day-lighting is distributed to the interior space through openings from the side, top or a combination of the two. Some of the common day-lighting strategies are: 1) single side lighting; 2) bilateral lighting; 3) multilateral lighting; 4) clerestories; 5) light shelves; 6) borrowed light; 7) top lighting (sky lights, roof monitors, saw teeth, court yards, light wells and Atria).

6.0 ANALYSIS AND DESIGN TOOLS

Over the past 50 years, many day-lighting calculation tools have been developed. Some of them are: 1) hand book methods; 2) nomographs; 3) computer models etc., Computer software are used to analyze complex interior lighting systems including daylight, direct/indirect lighting, mixed and even-aimed luminaries. Some of them are 1) Lumen-micro; 2) super lite 2.0; 3) DOE 2.1; 4) Radiance; 5) energy-10 etc.

7.0 MATERIALS AND METHODS OF CONSTRUCTION

The different type materials utilized and latest technique adopted for maximum daylight penetration into the buildings are: 1) exterior shading and control devices-in hot climate, exterior shading devices such as light shelves, overhangs, horizontal louvers, vertical louvers and dynamic tracking or reflecting systems are used to reduce heat gain diffuse natural light before entering into buildings; 2) glazing materials daylight is maximized by increasing glazing area. U value, shading coefficient and visible transmittance of the glass play a vital role in day-lighting. A wide variety of tints, metallic and low emissivity coatings, multi-paned liters of glass with inert-gas fills such as argon or krypton are utilized for day lighting (pgs. 1 to 4); 3) aperture location-a thumb rule is that the depth of daylight penetration is about two and half times the distance between the top of a window to sill; 4) reflectance of room surfaces-it is desirable to keep ceiling reflectance over 80%, walls over 50% and floors around 20%; 5) integration with electric lighting controls a successful day-lighting design to integrate with the electric lighting systems. The electric light is adjusted with advance lighting controls when sufficient daylight is available (switching controls, stepped controls and dimming controls); 6) other lighting controls like occupancy controls (in frered, ultrasonic/micro-wave technology, occupancy sensors etc..) and timers are extremely cost effective devices and are utilized for energy-efficiency in buildings.

8.0 FUNCTION OF WINDOWS

The window is an aperture in an opaque envelope which provides a view to the outside. The size and position of windows should be designed in relation to the eye level of building occupants. Day-lighting is one of the main functions of windows and it is inseparably linked to solar gain. In cold countries, if solar gains are desirable, windows are good route to provide them. In hot climates the solar gain is controlled by several ways and some of them are: i) shading systems ii) installation of collector windows and double-skin facades (iii) use of heat control glass. The main function of a window is to distribute daylight in to the depth of a space, to provide enough light to perform a task in the room while avoiding glare and allowing a view to the outside. Generally facades have a limited ability to distribute daylight into the depth of a space. During conceptual design phase, the daylight zone may be considered to be a depth of about two and half times the window height.
9.0 TOP LIGHTING
Unilateral top lighting can only be used on the top floor of a building. Solar shading is usually essential to prevent overheating since top lighting is exposed to high incident sunlight. Roof light should be designed properly to meet lighting, thermal performance and shading requirements. Roof lights are often glazed with light-diffusing glass to protect the interior from direct sun rays. Light shafts, awnings are applied to shade large roof lights. Top lighting concepts have been used at high latitudes with predominantly cloudy skies. With the help of advanced–redirecting shading systems such as laser-cut panels, holographic optical elements and optically treated light shelves, the roof lights can provide cooling effect in hot sunny climates. Bilateral and multilateral lighting is also applied to provide lighting in deep spaces / rooms that cannot be lit adequately by unilateral lighting. Atria and courtyards are often used to provide bilateral lighting. The most common bilateral day-lighting is to combine a window that provide lighting for large floor space with a clerestory to increase the illuminance level in the depth of the space (pgs. 5 and 6).

10.0 OVERHANGS AND SHADE
Properly dimensioned overhangs are very effective in many climates to block sunlight during the summer months. Longer the shadow is generated by the overhang along the face of the wall when the sun is higher and more vertical in the summer whereas shorter the shadow is generated when the sun is lower and less vertical in the winter. Overhangs are most effective at mid-day for the sunny facing walls (south walls, in the northern hemisphere). If the building wall is more than 30° off, true south / north, the effectiveness of the overhang will decrease proportionately.

11.0 CASE STUDY
Karaikal district, a part of Puducherry was chosen for the case study for implementation of day lighting. Karaikal is located on the coast of Bay of Bengal in 10°58’29”N latitude and 79°49’43”E departure. Since the sun rises around 6:20 AM and sets around 6:00 PM every day, Karaikal is receiving sufficient amount of day lighting from the sun and as such the length of daytime is around 12 hours. This daylight can be used for lighting purpose during day time. It is calculated that around 35% of electricity can be saved by using the daylight in Karaikal district.

12.0 CONCLUDING REMARKS
Day-lighting concepts are assessed according to energy saving potential, visual aspects and the control of solar radiation. This paper summarizes the use of daylight in buildings with climate and weather, sky conditions, design criteria and strategies for day-lighting design. Method of construction and materials used in building industry to penetrate maximum day light and thereby tailoring energy bill is also highlighted. This paper will encourage Scientists, Engineers and Architects to incorporate natural light through various designs, methods and materials in the building design by minimizing glare and overheating. If the incorporation of day-lighting with electric light is achieved, it can save considerable amount of energy used during day time in the next decades. The use of daylight for lighting purpose during day time in Karaikal district is highlighted, as a case study. It is also observed that around 35% of electricity can be saved by using the daylight in lighting purpose during day time at Karaikal district.

13.0 REFERENCES
[3] Implications: Daylight in buildings