

Effects and use of natural light to enhance productivity in the workplace

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Abstract - It is well known that lighting controls in combination with daylighting in any work place can save up to one half of the lighting energy in buildings, but the positive impacts of natural illumination on productivity, well-being and mental health may be more compelling reasons to incorporate daylight into the design of buildings. Light can affect human circadian systems and the light levels required to engage the visual system differ from those required to activate the circadian system. Lack of exposure to natural light during the day may result in the disruption of circadian system and may lead to feelings of depression, poor sleep quality, lethargy and even illness. This paper is an attempt to understand the effects of natural light on human mind, productivity and ways by which natural illumination can be incorporated in buildings.

Key Words: Day lighting, Productivity, Circadian system, mental health

1. INTRODUCTION

Light appears to have the greatest impact on building inhabitants, among many other factors. Light is an essence for humans and it is known that it has physical, physiological, and psychological influences.

In the early part of the 20th century, natural light was the primary source of building illumination. Because of their ease, electric lighting sources became the major source of illumination in just a few decades. In recent years, energy conservation and environmental concerns have gradually increased and changed those practices. And because of this daylighting is once again becoming an important factor in building design. Until recently, an acceptable lighting design was found on the idea that it should meet the needs of the occupants, particularly in terms of visual job performance and cost. However, new studies linking building occupants' health and well-being to illumination have pushed lighting quality to the forefront of environmental concerns in architectural design. Recent studies have proven that there is a correlation between lighting and human's health and performance. Light does not only provide visual information but also has a major impact on non-visual functions including state of alertness, mental focus, and cognitive performance.

SPECTRAL CHARACTERISTICS OF DAYLIGHTING

According to WBDG (*Whole Building Design Guide*) "Daylighting is the controlled admission of natural light, direct sunshine, and diffused-skylight into a structure to reduce electric lighting and save energy". Daylighting helps create a visually engaging and productive environment for

building occupants by giving a direct link to the dynamic and continually shifting patterns of external illumination, while saving up to one-third of overall building energy expenses. Light's spectral quality refers to how warm or cold it is (CCT correlated colour temperature of light) as well as colour shift (CRI-colour rendering index). In general, the higher the CRI, the more true the colour of an object will appear. The sun produces a wide spectrum of light in order to offer enough wavelength for everyone to perceive the majority of colours. As a result, it is assumed that sunlight has a CRI of 100, which is the highest rating a light can obtain. Various studies have shown that daylight provides a plethora of benefits in terms of spectral properties, such as the generation of Vitamin D through our skin. This is due to the nature of the light spectrum in sunlight, which makes it unique in terms of human health enhancement and is not found in electric lighting.

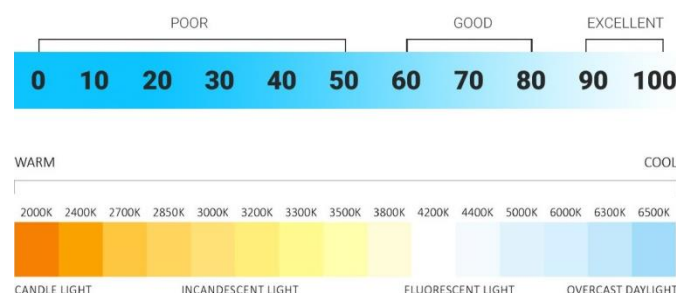


Fig -1: Colour rendering index(CRI) & correlated colour temperature(CCT) of light

IMPACT OF DAYLIGHTING ON HUMAN BODY AND HEALTH

The human body is affected by light in both physical and psychological ways. Light has two physical effects on our bodies: it interacts with our skin through photosynthesis and creates vitamin D. Calcium absorption is aided by vitamin D, which strengthens our bones. Vitamin D deficiency is caused by a lack of exposure to sunlight, which can lead to a variety of ailments. Through our vision system, light can alter our metabolism, endocrine, and hormonal systems in the second method. Natural light has a non-visual impact on our biological processes, and it is necessary for synchronising our circadian clock, boosting blood circulation, and managing the levels of several hormones. The circadian rhythm, which is responsible for synchronising the human internal body clock and sleep cycle, is influenced by natural light.

Physically		Psychologically	
Improve	Decrease	Improve	Decrease
Circadian rhythms	Rickets	Brain activity	Stress
Visual system	Osteomalacia	Mood	Depression
Sleep quality	Cancer Possibility	Mental performance	Sadness
Vitamin D	-	Alertness	Violent behaviour

Table -1: Impact of natural light on human body & health

According to a study conducted by Northwestern University in Chicago, office workers who worked under artificial light and had no exposure to natural light slept 46 minutes less than those who worked in an office with windows. In addition, because more sleep equals more productivity, persons who suffer from insomnia typically have difficulty concentrating and hence are unable to be as productive as those who are well rested. Lighting has an impact on one's mood and attitude. Daylighting has been linked to improved mood, increased morale, decreased weariness, and decreased eyestrain.

IMPACT OF MORNING SUNLIGHT ON HUMAN MIND

It's crucial to keep in mind that different wavelengths of sunlight have varied impacts on the human body, particularly the eyes. In reality, the visual and non-visual effects of light on brain processes and responses are dependent on the wavelength of light received by the eye. As a result, the effect of morning sunlight with a short wavelength spectrum on people's bodies differs from afternoon sunlight with a long wavelength spectrum. There is a direct relationship between early morning light and alertness, cognitive performance. Daylighting is the most appropriate lighting source in workshops, educational institutions and workplace as it can deliver requisite spectrum, quantity and duration of light exposure.

MEDICAL CURES FROM LIGHT

Light can promote health and aid in the treatment of medical conditions by influencing the chemistry of the human body. Improved indoor lighting, according to Terman et al. (1986), could decrease frequent subclinical disorders in the general population, such as oversleeping, overeating, energy loss, and work disruption.

Rickets & Osteomalacia

In 1919, it was discovered that natural light was the key to healing rickets. In 1985, independent studies by Neer and Hollick (A Summary of Light-Related Studies 1992) stated that UV radiation from sunlight causes the skin to produce vitamin D, which can prevent or treat rickets. Although the reason for sunlight's efficiency was first unknown in 1980s, it was subsequently discovered that sunlight impacting the skin triggered a chain of events in the body that resulted in the formation of vitamin D, which is required for the absorption

of calcium and other minerals from the food. Vitamin D deficiency prevents the body from absorbing the calcium needed for regular bone growth and development. This deficiency causes rickets in children and osteomalacia in adults, both of which are marked by a weak, porous, and deformed skeleton. The ability of the body to absorb calcium and phosphorus is known to have a role in the creation and maintenance of healthy bones.

Seasonal Affective Disorder (SAD)

SAD has been one of the most studied aspects of light-related diseases. SAD has been linked to a number of repeating events, but the amount of light available to individuals has been clearly linked. Our circadian cycles are disrupted and our susceptibility to SAD is exacerbated when we don't get enough light. In the winter, the availability of outside light and latitude play a role in SAD occurrences. Because the availability of outdoor light influences the occurrence of SAD, light can play an important role in both preventing and treating SAD.

DAYLIGHTING AND PRODUCTIVITY

DAYLIGHTING IN WORKPLACE

The importance of natural illumination in the workplace cannot be overstated. Light is essential for generating creativity in people who work in creative industries such as writing, drawing, and singing. Boyce et al. defined the productivity of an individual, or an organization, as the ability of improving work production by increasing in either quantity and/or quality of the product or service to be delivered.

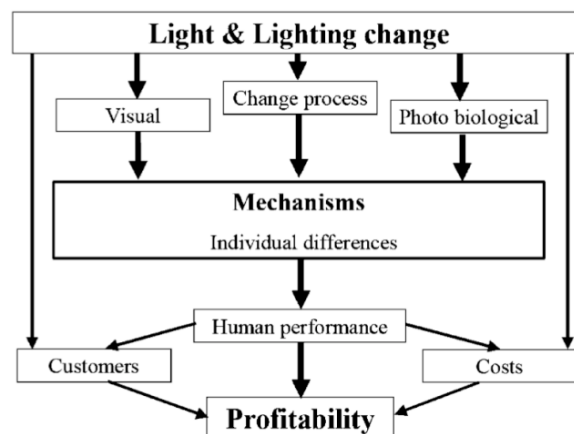


Fig -2: Model of the impacts of light and lighting change on profitability in the industrial environment

George Bernard Shaw, a well-known Irish author, was noted for commissioning the construction of a well-lit 'writer's hut' with a mechanical turn table within. The table's aim was to move with the movement of the light, ensuring that he was always exposed to natural light while writing. The effects of light on human productivity have been studied since the 1920s. One of the first research looked into the effects of lighting on silk weavers. Tennesen and Cimprick (Heerwagen, et al. 1998) discovered that people who have views of natural vegetation or outdoors from their work environment pay more attention during working hours. The view from the windows isn't the only factor to consider when using daylighting

techniques. Natural light has been demonstrated to improve concentration and alertness during the post-lunch slump, as well as for monotonous and repetitive work. (Photobiology, Sight, and Light, 1998)

Workers in office environments with optimized natural light reported an 84 percent drop in symptoms of eyestrain, headaches and blurred vision symptoms, which often result from prolonged computer and device use at work and can detract from productivity.

DAYLIGHTING IN LEARNING ENVIRONMENT

The main purpose of any educational institute or teaching workshops for any subject such as art, craft, music, writing, sports etc, is to promote learning as well as enhance physical and emotional health and this can be achieved by incorporating daylighting techniques into the architecture of these learning spaces. Use of light with poor spectral quality can create a strain in students' eyes and lead to decrease in information processing and may cause higher stress levels. The impact of morning exposure to daylight was also examined by Keis et al. The results of this study prove that the blue-enriched white light seems to have an effect on basic information processing among high-school students. Blue light appears to improve processing speed and concentration of students compared to standard lighting. Furthermore, a recent study showed that one hour of exposure to morning bright white light advances sleep and wake-up parameters and affects cognitive performance and alertness. These studies suggest that a sufficiently applied light intervention could enhance alertness, and thus performance, at work significantly.

DAYLIGHTING DESIGN GOALS

The benefits of integrating daylight into an area can be nullified if the daylight is not handled properly. Poor daylighting can cause adverse conditions such as uncomfortable glare and heat conditions, as well as veiling reflections and high contrast ratios. As a result, it's critical to take a methodical and efficient approach to daylighting design. The recommended method for daylighting design starts with the definition of daylighting performance goals and design criteria, followed by the development and evaluation of daylighting design alternatives that meet these goals and requirements. General daylighting performance goals for daylight spaces that represent successful daylighting design characteristics are mentioned below

1. **Quantity**
Provide ambient lighting requirements during daytime hours for the majority of the year.
2. **Quality**
 - Create uniform distribution of daylight to reduce uncomfortably high brightness ratios.
 - Control direct sunlight when necessary and utilize beneficial passive solar strategies when needed.
3. **Usability** Allow for user adjustment and override.
 - Ensure adequate daylight to all occupants of the daylight space.
 - Provide view and connection to the outdoors.
4. **Building Integration**
 - Fully integrate with the architectural expression of the

building inside and out.

- Fully integrate with other building systems -- HVAC, Lighting, Structural, Interiors.

DAYLIGHTING DESIGN PROCESS: METHODS AND CONSIDERATIONS

Daylighting is most successful when it is correctly integrated into a building's overall architecture. Daylighting and solar control strategies that are addressed as an afterthought and applied to an already constructed building are rarely successful in integrating with the architecture and layout of the building. As a result, while programming the various spaces, it is best to handle daylighting and sun control issues early in the design.

Daylighting Appropriateness – For each space in a building, it is important to consider whether daylighting is appropriate or not. Providing natural light to the spaces where the use of natural light is minimal or not necessary could be delinquency. Spaces with highly specialized lighting requirements, where excessively high light levels could be troublesome (e.g., a laser-based electronic laboratory), should have a low priority for daylighting. Furthermore, facilities that are rarely utilized and/or used for brief periods of time, such as storage rooms, bathrooms, and copier rooms, should be given a low priority for daylighting.

Direct Sunlight Tolerance – For each space with a high daylighting priority, consider its tolerance to direct sunlight relative to glare and solar heat gains. In more public, transitory spaces, some direct sunlight, especially during the colder winter months or colder mornings, can be very pleasant and tolerated, adding sparkle and warmth to the space. These spaces are ideally located towards the south, east, and west sides of the building. To use solar gains to help heat a public space on cold mornings, orient the space to the east.

Views and Connection to the Outdoors — A view to the outdoors gives most of the psychological benefit of daylighting, even when the daylight resource is insufficient to meet the lighting requirements.

CONCLUSION

Lighting appears to have the largest impact on the human body of all the factors in the interior environment.

For over a century, several studies have explored the effects of light on individuals from various perspectives. These studies show that light has both visual and non-visual effects on humans. Because of its dynamic quality and spectrum qualities, sunlight appears to be the most important source of illumination and cannot be simply replaced by artificial light. It is also the most important source of vitamin D, which is essential for bone health and overall well-being.

Natural light can increase students' and workers' subjective mood, attentiveness, cognitive performance, physical activity, sleep quality, and alertness in addition to its role as a vitamin D-producing agent. All of these elements could be regarded important for achieving optimal academic and professional results.

The use of daylighting reduces utility expenses while also improving the occupants' well-being. Since many studies have proven the tremendous influence light has on individuals in

many ways, the effects of natural light on building occupants should be an important concern for building design. Building occupants, owners and visitors can benefit from daylighting.

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