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Passive Lighting Design as a Tool for Energy Conservation

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Abstract
This is the research based on the study of daylighting availability and benefits of daylight inside the office buildings around the Kathmandu Valley and focuses on decreasing the use of electricity during the day hours saving energy and energy consumption. The methodology applied is several case studies, questionnaire survey and literature review, field visit, where the ideas of passive daylighting is generated and eye survey in the respective case studies have been performed regarding daylight and its present condition, use of artificial light during daytime and so on. It is find out that the energy about 1728000W LED bulb light is consuming annually in the office buildings singe floor rooms space. The newly constructed buildings are less able to design the office rooms as per the allowance of daylight during daytime and still using the artificial lights in major part of the buildings. It is clearly seem to be need of passive daylight office environment in office building to save energy and get benefits like concentration, mood refreshing medium and other due to daylighting system in office area.

Keywords
Daylight, Energy conservation, Benefits of daylight, Electrical lights, Office space

1. Introduction

Over the course of the second half of the 20th century, daylighting lost relevance due to the advent of efficient electric light sources, cheap, abundant electricity, and the common belief that electric lighting was superior [1]. Daylighting should be used in offices to reduce the excessive consumption of electricity. The literature frequently mentions a number of benefits of using natural light, including less electrical energy use and enhanced indoor air quality.

Artificial lighting not only used energy but also generated waste heat inside the structure, which ultimately increased the building's heating or cooling burden [2]. Utilizing natural light is think crucial for enhancing a building's energy efficiency and environmental quality [3]. The objectives of this research paper is to explore the benefits of natural light working environment and to explain how the natural light can be tool for energy conservation aspect in office buildings.

2. Literature Review

2.1 Daylight

Daylight is the total amount of both direct and indirect sunlight that is present outside during the day. Appropriate visual perception of color, contrast, and details requires adequate daylight and indoor space-saving time. Beyond this, getting enough sunlight has a significant effect on both physical and emotional well-being. In addition to other beneficial effects, researchers are appropriate for stress, immune system strength, and enhanced drive. From an energy standpoint, more areas with high light levels can cut down on the energy needed for artificial lighting.

2.2 Daylight Factor

The Daylight Factor (DF) is defined as the ratio of daylight illuminance measured at a specific location within a room to daylight illuminance recorded simultaneously under an unobstructed horizontal plane. DF does not take into account the impacts of direct sunshine because it must be calculated under CIE (Commission Internationale de l'Eclairage) overcast sky circumstances. Such numbers are derived from the premise that the outside illuminance under

overcast sky conditions is roughly 10,000 lux: hence, an average DF = 3% means that, even in the absence of direct sun irradiance, a minimum of 300 lux is assured on average over the working plane.

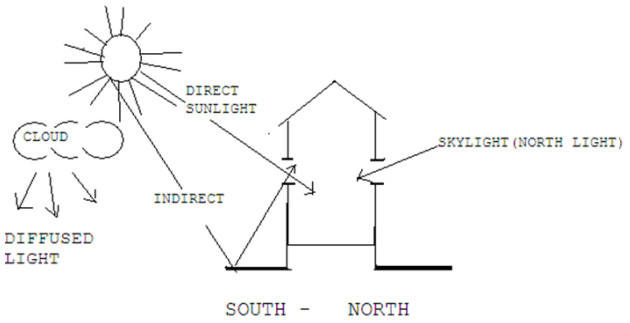

Figure 1: Natural Lighting System

Because of the fluctuation of outdoor lighting levels, calculating indoor lighting in photometric illumination terms is challenging, if not inaccurate. However, at a certain position in a certain building, the ratio of illumination to simultaneous outdoor illumination can be assumed to be constant; this constant ratio, stated as a percentage, is the day light factor (DF).

$$DF = \frac{E_i}{E_o}$$

where,
E_i = Indoor illumination at the point taken
E_o = Outdoor illumination from the clouded sky hemisphere

2.3 Exterior Shading Devices and Welfares

With the right choice of solar shading systems, indoor lighting from daylight, solar heat gains, and glare can be controlled in office buildings while maintaining views out of windows, saving lighting and thermal energy while maintaining visual comfort [4]. In a different study by Gutierrez, it was found that using exterior shading devices, which may minimize solar heat gain more efficiently than interior ones, is an efficient passive design method to manage solar heat gain in buildings. Dubios asserts that the best option for meeting the requirements for daylighting within the space is a 1 meter shade device.

2.4 Design Sky

The amount of daylight is available due to different climates in different places. It also depends upon latitude, location, season and time of the day. For example, bright in summer, diffuse in monsoon and low in foggy winter as per season. So different place has different luminance of the sky. According to the measurement of illumination of sky made by national physical laboratory, the maximum recorded value of illuminance is about 35000 Lux in July for short time at noon.

Table 1: The standard outdoor illuminance of some places

Place	Latitude	Illuminance (Lux)
London	52°N	5000
Hobart	43°S	5500
Sydney	33°S	8000
Brisbane	27°S	10000
Darwin	10°S	15000
Nairobi	1°	18000 Lux

2.5 Daylighting analysis

The designer should run rigorous daylighting computer simulations that compare possibilities in order to establish the best daylighting and glazing technique for each application. You have to be able to input various locations as well as component configurations, such as exterior fins, overhangs, glazing tiles, window treatments, light shelf design, surface reflectance, space setups, ceiling heights, glazing placements, mullion sizes, dirt build-up, dimming options, and time of use schedules, by using program variables.

2.6 Lighting policy and schemes

Lighting policies describe how a specific institution (typically governmental) has chosen to handle lighting-related concerns, such as light distribution and energy use. As a developing nation, Nepal has established a number of guidelines and regulations for the infrastructure sector. The relevance of and difficulties associated with lighting policies and plans are misunderstood in the infrastructure sector in Nepal. The lighting system has a significant impact on the psychological, environmental, and financial aspects of a building's envelope. There are no lighting illuminance policies in place in Nepal for the various spaces within the various building envelopes. The stakeholders and the government sector can use this study to develop the requirements for office building illumination.

2.7 Space of energy conservation in Lighting

A significant part of energy used in buildings is for artificial lighting. By releasing waste heat, the use of artificial lighting also increases the cooling burden on the structure. New lighting fixtures with more efficiency are being developed to help the situation. Researchers' experiments and research have led to the development of the 100 lm/W LEDs that are currently on the market. Additionally, to save energy on lighting, it is usually advised that daylight be included into building design. However, allowing light into structures requires more than just adding windows or glazed surfaces to the building's exterior. To ensure the visual and thermal comfort inside the structure, architects and building designers should have a thorough understanding of how daylight functions.

2.8 Benefits of natural light

In the practice of architecture, daylighting refers to the utilization of natural light, be it brilliant sunlight or muted overcast light, to support the visual demands of building occupants [5]. Designers and experts alike have praised daylighting for its many aesthetic and health advantages. Scientists at the Lighting research facility (LRC), in Troy, N.Y., for instance, have reported that daylight environments increase occupant productivity and luxury, and supply the mental and visual stimulation necessary to manage human circadian rhythms.

Utilizing natural light can cause substantial energy savings. Electric lighting in buildings consumes quite 15 percent of all electricity generated within the U.S., in keeping with the U.S. Department of Energy and also the U.S. Energy Information Administration.

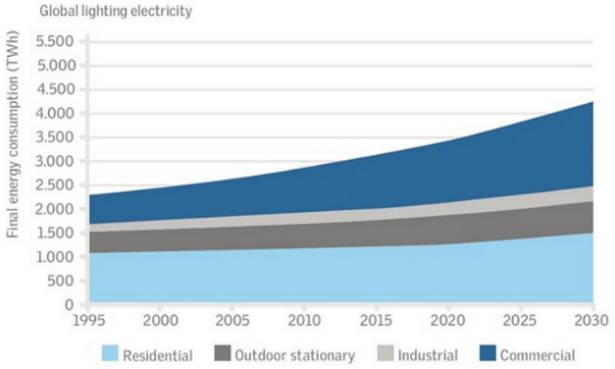

Figure 2: Total Lighting consumption

2.8.1 Conservation of energy

As most of our focus of designing and architecture is basically on sustainability and conservation of energy, proper use of natural lighting can reduce the value of energy consumption up to 40%. Natural lighting may well be used for temperature control within the room, air con, and replacing or reducing the need to large extents. Today AI is additionally used together with advanced sensors to manage lighting within the room.

2.8.2 Improving the quality of spaces

The daylight if used properly can enhance the quality of interior decorations and thus increases the value of space by making the spaces look larger and letting the natural flow of greenery enter within the building through the large openings.

> "*I perceive that material is expended light and that Light is the source of all presences. A shadow is cast by what is made by light, and light is the owner of the shadow.*"
>
> - Louis I Kahn

Figure 3: Dining room showing the spaces inside

2.8.3 Stops growth of fungi

The rooms without proper natural sunlight do tend to the growth of fungi, molds, and home to insects. This results in the room being uncomfortable, gloomy, and bad smell may come from the room.

Figure 4: Growth of black fungus in tiles

2.8.4 Merits of office workers

The folks that add the office, most of them face pressure from different angles, sometimes they don't even prefer to do monotonous jobs and should feel tired after a while of working. Natural lighting within the office environment does play a vital role in better health, reduced absenteeism, increased productivity, and financial savings of the office manager, decrease in accidents, an increased level of mental performance, improvements in sleep quality, and a rise in morale.

3. Methodology

Measurement of the details of office rooms of various government offices in Kathmandu valley were addressed to understand the actual situation of the daylight performance and use of the artificial lights has also been pinned to find out the level of energy consumptions in such spaces. This research aims to find the benefits of daylight and to find how the energy is saved through the use of natural passive light in the office space. To achieve this aim, firstly, a literature review and eye survey in the respective case studies have been performed regarding daylight and its present condition, use of artificial light during daytime and so on. Literature review on the daylight terms, unit and orientation etc. have been reviewed along with few articles.

In the field visit, office workers from the case study buildings is asked to answer few questions prepared from the research questions about the benefits and the contribution of passive daylight in energy savings, also the views regarding the working environment and the office rooms. Different opinion is listened and noted in the results outcome. Here the different ideas for questions were derived from the framework prepared for the case study during the research program.

Among many cases, few of those (CIT and Karmachari S. K. Building) has been finalize for case topic by consultation and approval with supervisors for the further continuation and data collection. The office buildings was selected as per the comments during pre-liminary thesis presentation during June month, 2022 that was to select the government office for easy collection of required data in survey. In addition, offices has been chosen with the help of internet surfing. Lastly, the various result obtained during the study have been compared, analysed and suggestions on the selected strategies have been made.

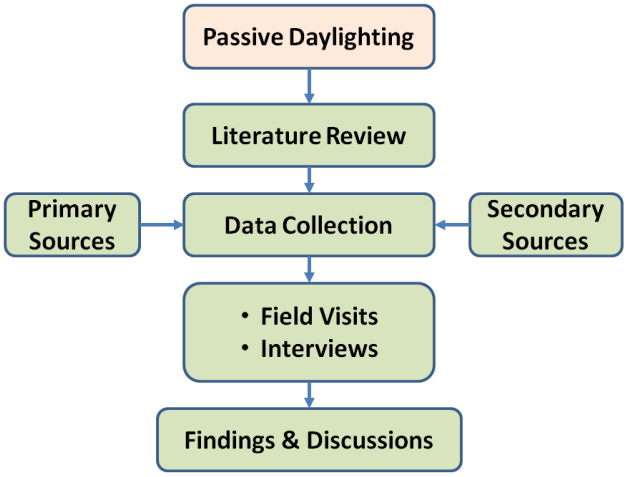

Figure 5: Research Framework

4. Results

Almost every building rooms have been using artificial light in partial manner and whole dependent manner. In comparison KSK buildings was better designed in terms of passive daylight and others. CIT buildings office area are more reliant on artificial lights. Only few rooms were well exposed to daylight. Regarding benefits, all the office staff were agreed with the daylight benefits it carry and they wish to work in daylight environment if possible. Ms. Neupane, an officer in KSK building, one of the respondent, said of health impact due to working in artificial light and pointed out the eyesight defect due to working in such lighting condition. She even gave example of Singha Durbar building; even every building wish to be design in that way, if possible to work in good environment and save the energy consumption to gain much more other benefits too. The other staff of the same building, Mr. Parajuli explained the fact that the role of daylighting plays in increasing working efficiency, energy saving and other positive effect due to passive lighting. He emphasizes to work in daylight space area if possible giving the

reasons why.

Mr. Parajuli says - "*Human being is natural so they will be compatible to work with nature too.*"

With the use of passive daylight, electricity use will be minimize conserving the energy, which will save annual electricity up to 1728000W for LED bulb (12W) only as per the calculation done in the procedure to find out the energy conserving data. The passive daylight enhances mood, relax the mind, good for eyes and important for quality workplace and many other, said by few respondents during the questionnaire survey on IOE students. Mr. Tamrakar, one of the staff of KSK building added the benefits of daylight by saying it would contribute in pressure relief activity too. Daylight is essential for making the working space livable converting the less light reaching working space to good working space and making it a good working environment space.

Tamrakar says - "*Daylight space will make the office workers to work again and again that means continuously for longer time, less tired feeling.*"

The main thing is that the office space is ought to be designed with enough daylight space and if required the office could add additional artificial light to lit the darker areas. However, important is approximately whole room should be well lighted Tamrakar added.

5. Discussion

With the findings about passive daylight, it seem to be learned that daylight is important in terms of many aspects including health and energy conservation sector by which the staff are able to work in good working environment increasing the productivity and improving the health condition.

The newly constructed buildings are also less able to design the office rooms as per the allowance of daylight during daytime and still using the artificial lights in major part of the buildings. Office workers are deprive of daylight during their completely daylong work and have to be patient of other health effects due to spending much hour longer in artificial lights (maybe). In the other hand, people are expensing money on electricity extra. So it is clearly seem to be need of passive daylight office environment in office building to save energy and get other benefits due to daylighting system in office area.

6. Conclusion

It is concluded that the importance of daylight is being well known by many but still there is poor day lighted building almost around in Kathmandu valley which may be due to some other constraint. Offices uses artificial light during the day hours bringing the weight to the energy sector in the peak demand hour. One of the way to reduce this could be the maximum use of passive daylight in effective manners in the buildings and minimum use of artificial light in the office buildings. Not only this there are still other measures too which need to be further expose in near future. To make this possible we might give little more effort on the design phase or renovation phase with the daylight design ideas and steps considering the guidelines which results in making the office rooms' look improved with sufficient daylight. And in the long run office workers will be benefited, be able to work in good office premises making their working experience better, saving energy and increasing the productivity.

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