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Assessment of Visual Comfort of an Office Building in the Kathmandu Valley

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Abstract

Visual comfort is the primary concern for deciding the quantity of illumination required, and each individual responds to light in a variety of ways that differ significantly based on their surroundings and body temperatures. In both the home and the workplace, appropriate daylighting improves people's psychological well-being and productivity. As the trend toward largely glass façades continues throughout the valley, large fenestration regions usually cause excessive solar gains, greatly changing heating and cooling loads, and glare issues. The study aims to assess the glazing performance and visual comfort of an office building in light of the extensive use of coated/tinted glass. The study was conducted using a survey research method using a typical Prabhu Bank Limited bank office structure. A five-part questionnaire used in a random sample survey of 25 participants was created to collect data on the staff's subjective levels of visual comfort as well as their actual working environments. Additionally, measurements of the ambient temperature, humidity, and standard illumination were taken on-site. Using SPSS 25.0, a statistical analysis application, the data were precisely coded, examined, and evaluated. In the studied office setting, the illumination level at the height of the work plane was only 80–95 lux, which is lower than the suggested range of 300–500 lux. The results showed that illumination and behavioral habits both affect visual comfort. Visual comfort is significantly impacted by behavioral characteristics in people who describe their happiness with daylighting as moderately happy. Statistics show no gender or age-related disparities in the desire for daylighting. Long-term usage of artificial lighting during the day—up to 5-7 hours, and even longer than 7 hours—indicates poor daylighting conditions and reduced luminous comfort. The results demonstrate that office workers are more likely to report being bothered by glare regularly and that uncomfortable glare needs the appropriate intervention for an energy-efficient solution.

Keywords

Visual Comfort, Daylighting, Artificial lighting, Luminous comfort, Glare

1. Introduction

With many glass office towers, Kathmandu valley is one of Nepal's most densely populated cities. Even though the Kathmandu Valley receives a lot of sunlight, the amount of light that enters specific building units can vary greatly based on factors including floor level, orientation, glass type, and outside impediments. Energy expenses are impacted by how much daylight is exposed in buildings. The psychological well-being and productivity of people are improved by increased daylight exposure in both homes and workplaces. Because there is a better awareness of comfort, people are paying more attention to their living conditions, including their thermal, acoustic, and luminous comfort[1]. The primary factor in determining lighting requirements is visual comfort. Good lighting is characterized by the right amount and direction of illumination on the work area, accurate color reproduction, and a lack of discomfort. It also offers a pleasing range of lighting intensity and quality. As a result, to obtain great visual performance, there is typically a strong correlation between illumination levels and visual comfort [2].

Historically, architects were masters of daylighting design, but recently, because of an increasingly oppressive hand of regulation and standardization, the quality of daylighting design has substantially dropped in the majority of building types. People react to light in very various ways depending on their environment and temperature, and they see it not just as a visible spectrum but also in terms of what is acknowledged and felt [3]. Office workers are confined to their workspace for a sizable portion of the day. For a view of the outdoors and access to daylight, which are crucial for productivity and health, windows are a need in the workplace. An appropriate comfort level is achieved in large part through the design and selection of fenestration systems. As a result, while constructing a fenestration system, a number of physical aspects must be taken into consideration, such as visual contact between the interior and exterior, daylight consumption, solar energy gain, glare reduction, thermal loss, and thermal comfort [4].

The majority of recently constructed office buildings in Kathmandu valley are largely glazed. As the trend of highly glazed façades continues, excessive solar gains and widely fluctuating heating and cooling loads are frequently the results of large fenestration regions. In addition, bright sunlight causes glare issues, particularly for office buildings' south-facing façades. There are significant advantages to office users' greater productivity in terms of a more comfortable working environment. It is challenging to measure their impact, though. As a result, in daylit areas with lighting controls, a thorough awareness of the occupants' requirements, convictions, and preferences is necessary [5].

Due to the widespread use of coated/tinted glass in contemporary commercial buildings around the world, colored glazing systems are now often used (with static photometric qualities and performances).The main purposes of these glazing systems are to statically control exterior solar gains, hence decreasing the excessive solar gain that might have an impact on indoor thermal and visual comfort. However, it has been known for more than 20 years that such coated/tinted glass systems may have greater detrimental effects on human pleasure and visual/color perceptions [6].

Considering the prevailing use of coated/tinted glass, this paper is aimed at assessing the visual comfort and glazing performance of an office building in Kathmandu valley.

2. Literature Review

2.1 Glazed Facade in Office Buildings

Architects have observed a rise in the popularity of office structures with glass facades in recent years. Similar to several buildings to enhance the thermal performance of the building envelope, it has evolved into a common element in commercial construction [7]. These days, glass is tinted, polished, laminated, sealed, rubbed, perforated, stitched, wired, tempered, adjusted, and in lots of forms. Modern technologies have made it easier to create a broad variety of unique styles of substances that may be effectively used in building construction, producing greater performance, as compared to earlier materials technology [8].

2.2 Optical and Thermal Performance

A building's windows are essential for ventilation, daylighting, solar heat gain, and aesthetics. The U-value, the Solar Heat Gain Coefficient (SHGC), and visible transmittance are the three main metrics that can be used to analyze the thermal and optical characteristics of a window. The three widely accepted routes of heat transfer—conduction, convection, and radiation—are used to evaluate the aforementioned attributes [9].

Figure 1: The use of new materials in building architecture[8]

2.3 Visual Comfort

Lighting conditions are frequently thought to have a significant impact on how well vision works. Human eyestrain and experience discomfort in both circumstances of excessive brightness and dimness. The desired illuminance can be exactly achieved with artificial illumination, however, measurements of sky/sunlight are subject to fluctuations due to environmental factors. The significant challenge of ensuring acceptable levels of illumination while using daylight as the source of light, as is the case for all metrics of visual comfort, appears to arise from the fluctuation in solar circumstances. Visual comfort is determined by the following parameters [10]:

- Luminance and illuminance
- Reflectance(s)
- Color temperature and color index
- View and daylight
- Frequencies

2.4 Discomfort glare

A significant amount of sunshine entering interior rooms can be used as the primary light source in office buildings with high levels of glazing. As a result, it is now vital to prevent eye strain caused by excessive sunlight exposure. It is customary to take discomfort glare into account when determining visual comfort in interior spaces, and the discomfort glare indices are now being recommended as a method of application [11].

3. Research Methodology

A survey research method was used to carry out the study by taking a typical bank office building. A random sample survey of 25 respondents belonging to Prabhu Bank Limited located at Dhobi Khola, Baabrmahal, Kathmandu was taken between June 26-29th of 2022. The five-part questionnaire was designed to gather information on the staff's subjective levels of visual comfort as well as their objective working conditions. The survey's questions were based on research done by [1]. The survey's objectives, the researchers' presumptions, and other sources were taken into consideration when crafting the questions. The authors received a total of 30 completed surveys and 25 were selected for additional examination. On-site measurements were also done using a light meter (RT-912) to measure standard lighting and a digital thermo-hygrometer was used to measure both the temperature and humidity. With the aid of SPSS 25.0, the data were precisely coded and examined. Before evaluating the general consistency of the psychometric questions, the statistical reliability was assessed. The internal consistency of the two measures, as well as the degree of daylighting satisfaction and people's lighting-related behavior, were all determined using the Cronbach's alpha coefficient.

4. Research Setting

4.1 Selection of study area

With a population of 2.54 million, Kathmandu Valley is one of South Asia's fastest-growing urban areas, rising at a pace of 6.5 percent per year. Numerous business and financial establishments with both formal and informal workforces can be found in the valley. The extensive use of glazing in building facades has increased in Kathmandu Valley in recent years, despite a lack of accurate awareness of such developments in terms of numerous key aspects of structures, such as energy use, demand, and desired comfort level.

4.2 Climatic Study

The Department of Hydrology and Meteorology Nepal's research of meteorological data from 2012 to 2021, revealed that the average minimum temperature for the year is found to be 13.74°C in January. Summertime's yearly average maximum temperature is reported to be 26.04 °C in July. The highest monthly average humidity is 85.20 percent in September, while the lowest monthly average humidity is 76.85 percent in March. July is when the monsoon season often begins. The predominant wind direction in the Kathmandu valley is westerly, with the yearly highest average wind speed occurring in April and the minimum wind speed occurring in January.

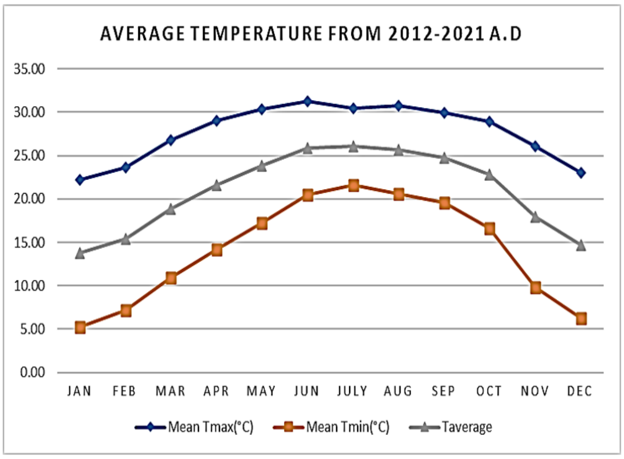

Figure 2: Yearly average maximum and minimum temperature data of the Kathmandu valley from 2012-2021

4.3 Case Study

In Nepal, the number of banking institutions is increasing, along with the number of buildings housing them. A banking office provides the ideal setting for conducting a thorough study with reliable working hours and the ability to assess the visual comfort and glazing performance of office workers.

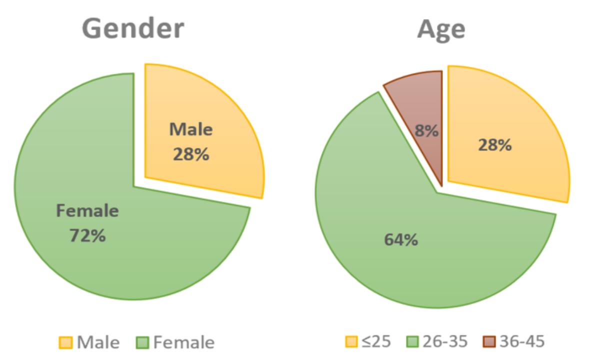

Figure 3: Gender and age based responses

The corporate office of Prabhu Bank, which was chosen for the case study, is situated in Babarmahal on the west side of Dhobi Khola. It is a Nepalese Class A private commercial bank. With a total site area of 2400 m2, the plinth is 1110 m2. There are eight stories and 8884.96 m2 of built-up space overall. The modern structure features a green-tinted glass facade in the East and ACP cladding at the East, North, and South-East corners. The remaining walls are standard 9" brick walls. The flooring is a standard tile/marble finish over a concrete floor, and the roofing is CGI Sheet with a False Ceiling. The floor is 3.15 meters high.

Figure 4: Front View of the Prabhu Bank (Prabhu Bank Limited)

5. Disscusion

5.1 Reliability of the questions - Results

The internal consistency of a survey or questionnaire can be assessed using Cronbach's Alpha. The reliability of a survey or questionnaire is shown by the range of Cronbach's Alpha, which is 0 to 1, with higher values. The Cronbach's Alpha coefficient is determined for the daylighting-related items in Table 1 to assess the internal consistency of respondents' answers to the questionnaire.

Table 1: Cronbach's Alpha coefficient (Reliability of the dependent variables)

Daylighting in Office	**Cronbach's Alpha**
Hours of abundant daylight	0.818
Perception of uniform illumination	
Actual sunlight hours (Summer/Winter)	
Expected sunlight hours (Summer/Winter)	

5.2 Demographic Characteristics of the Respondents

72 percent of the 25 responses received were from women, and 28 percent were from men. The participants' age ranged; from 28 percent, 64 percent, and 8 percent, respectively, in the age groups of greater than or equals to 25, 26 to 35, and 36 to 45. Figures 3 shows the split in answers according to gender and age based responses.

5.3 Satisfaction with Daylighting – Gender

There was a cross-tabulation done between gender and daylighting satisfaction. Gender-based variation in the replies was investigated. Figure 5 shows how the replies varied from one another.

In comparison to male respondents, female respondents reported considerably higher satisfaction levels. In contrast to the 20 percent of female respondents who disagreed, just 4 percent of the male respondents out of the total answers strongly disagreed. 24 percent of the female respondents and 16 percent of the male respondents expressed satisfaction with daylighting. Only 4 percent of the respondents who identified themself as female

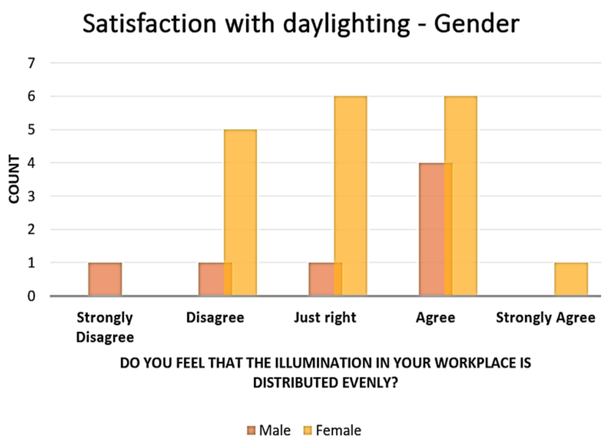

Figure 5: Satisfaction with Daylighting - Gender

strongly agreed with how well-lit the area was.

5.4 Satisfaction with Daylighting – Age

A cross-tabulation between the age group and daylighting satisfaction was conducted. The responses' variance by age group was examined. Figure 6 demonstrates how the responses varied from one another. From 4 percent strongly disagreeing to 16 percent disagreeing and neutral, to a whopping increase of 28 percent agreement in daytime satisfaction, the percentage increases for the age group of 26 to 35. Responses from the age range less than or equal to 25 were 4 percent disagree, 12 percent indifferent, 8 percent agree, and ultimately, 4 percent strongly disagree. In the elder age range of 36 to 45, there is an equal percentage of disagreement and agreement (4 percent).

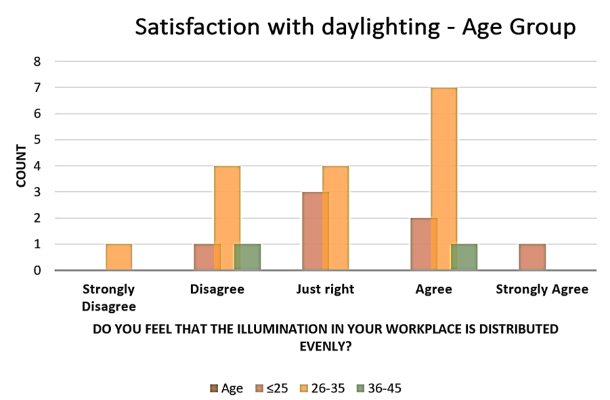

Figure 6: Satisfaction with Daylighting - Age group

Another crucial element is the amount of sunlight, as this has a big impact on how satisfied people are with daylighting. The actual summer sunlight hours and the expected winter hours are a key determinant of how satisfied a person will be with daylighting. The participants would have experienced less daylight hours in winter because in actuality there are fewer daylight hours in winter than there are in summer[1]

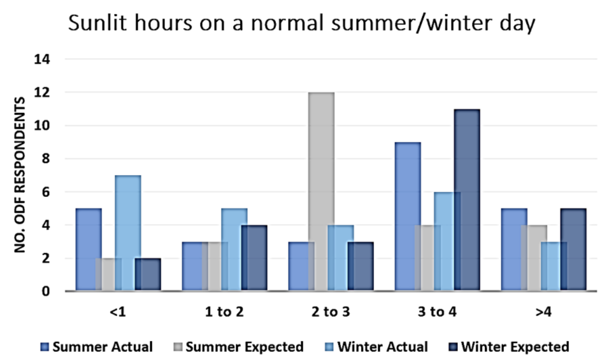

Figure 7: Sunlit hours on a normal summer/winter day

On a warm day, most office workers wanted to enjoy more than two or three hours of sunlight. They hoped for 3 to 4 hours of sunlight per day, and occasionally even more, during the winter. We can attest that our participants chose winter months over summer ones to get as much sunlight as possible. This outcome might be a result of how office spaces can be heated effectively during the winter by sunshine.

5.5 Human Behavior

To change or enhance their indoor lighting environment, people frequently use internal shading and artificial lighting. However, different tasks require various types of illumination, and various lamps offer various color temperatures. The usage of artificial illumination should therefore be considered when evaluating human behavior and luminous comfort. 16 percent responded that the hours of artificial lighting needed in the office ranged from 1-3 and less than an hour.

However, 24 percent, 28 percent, and 16 percent of respondents responded that 16 percent of respondents said that between 1-3 and less than an hour's worth of artificial lighting was required in the workplace. However, a greater rise in the number of hours of artificial lighting from 3-5, 5-7, and more than 7 hours was indicated by 24 percent, 28 percent, and 16 percent of respondents, respectively.

To examine the connection between the two, a cross-tabulation between the perception of glare in the office area and the employment of interior shading

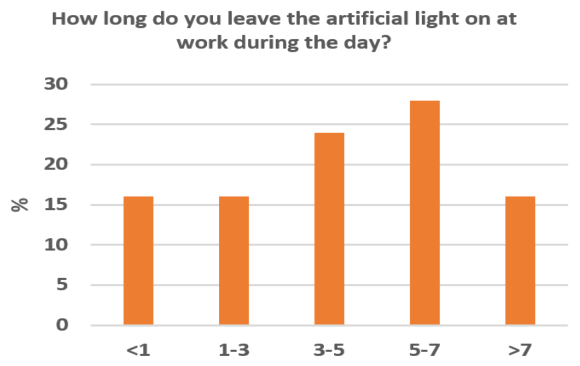

Figure 8: The number of hours of artificial lighting

tools such as curtains and blinds was conducted. Figure 9's findings make it clear that respondents are more likely to report experiencing glare in an office setting.

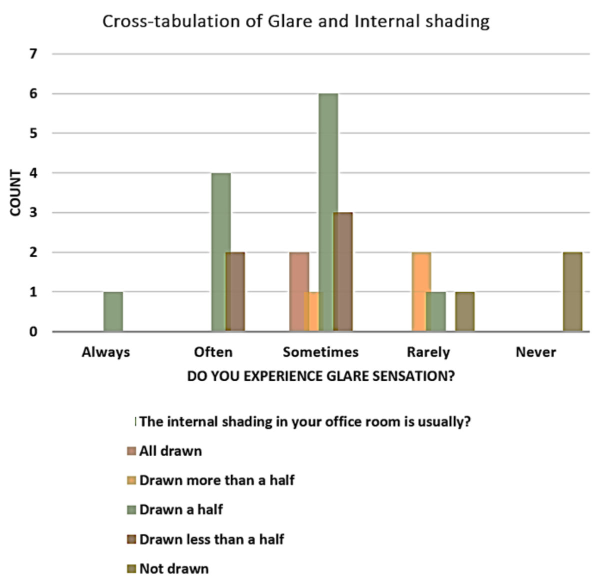

Figure 9: Cross-tabulation between Glare sensation and the use of internal shading device

The cross-tabulation results reveal that the internal shading device is often drawn to half when glare is present. Shade is not necessary when there is no glare sensation. This demonstrates how crucial it is to minimize excessive sun radiation in the workplace for optimal visual comfort. This can be done with the proper installation of energy-efficient glazings and ideal shading components.

6. Findings

Statistics show no gender or age-related disparities in the desire for daylighting. We can confirm that participants chose the winter months over the summer months to receive the greatest sunlight. The findings show that office workers are more likely to claim that glare bothers them frequently. It was discovered that the maximum number of hours for artificial lights was 5-7 hours, and some people responded even longer.

The on-site measurements revealed that the illumination level at the height of the work plane was only 80–95 lux, which is less than the recommended range of 300–500 lux for office work. Table 2 lists the results of the on-site measurements made with a thermohygrometer and light meter:

Table 2: On-site measurements of standard illuminance, temperature and humidity of office building

Features	Prabhu Bank Limited
Location	Babarmahal, Kathmandu
Date of Measurement	11th July 2022
Time	12:45 to 1 pm
Sky Conditions	Partly Cloudy/Partly Sunny
Standard Illuminance	West - At the height of the work plane - (80-95 lux) Light source -(300-350 lux) Main façade east side Green tinted window-(890-900 lux)
Temperature	29.6 degree Celsius
Humidity	59 Percent

7. Conclusion

This investigation's primary goal is to evaluate the glazing performance and visual comfort of a Kathmandu Valley office building. The study, which was conducted using a typical bank office structure in the Kathmandu valley, involved a survey research approach and on-site measurements. The data analysis allows for the following conclusions to be drawn regarding the elements that enhance visual comfort.

- People who believe themselves to be relatively satisfied with daylighting say that behavioral aspects have a significant impact on their visual comfort.
- We can confirm that participants preferred winter months to summer months to acquire the

maximum sunlight, which may be related to the fact that sunlight can efficiently heat offices in the winter.

- The findings show that office workers are more likely to report being affected by glare frequently and that this problem calls for the right kind of intervention to find an energy-efficient solution.
- People routinely enhance the indoor lighting environment with internal shading and artificial lighting, and these various actions have an impact on their comfort levels.
- The length of time spent using artificial lighting is the behavior that has the biggest impact on comfort levels in the light. Long-term usage of artificial illumination is associated with decreasing luminous comfort and poor daylighting conditions.

The limitation of this study is that it only examines the glazing performance of the case building that was chosen for examination, which has tinted windows. It does not consider the daylighting and behavioral consequences of other types of glazing. Only under specified climatic conditions are the on-site measurements that were made during the above-mentioned survey dates applicable.

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