VISUAL COMFORT ANALYSIS OF VARIOUS WINDOW-SHADINGS FOR OFFICE BUILDINGS IN KABUL, AFGHANISTAN

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ABSTRACT

This study investigates the impact of window shading devices on the visual comfort of occupants in office buildings located in Kabul, Afghanistan. In an office environment where workers spend extended periods indoors, lighting is essential to facilitate their tasks efficiently and effectively. Visual discomfort can negatively impact the health and productivity of building occupants. Therefore, shading devices can effectively enhance visual comfort in indoor spaces, particularly in areas with high solar radiation exposure, such as Kabul. This research aims to identify and compare different shading devices to determine the most effective option for improving visual comfort in office buildings in Kabul. By analyzing simulated shading devices through comparative analysis, this study evaluates the suitability of various window-shading options for enhancing visual comfort in indoor spaces in Kabul, Afghanistan. According to this study, Mashrabyiah shading panels and Vertical shading devices with louvers showed the highest efficiency rates of 50 to 77 percent and 22 to 66.8 percent, respectively. These shading devices were found to be the most successful in decreasing glare levels and enhancing visual comfort in the selected office buildings in Kabul, Afghanistan. The main results indicate that this study is crucial for architects, engineers, and designers to understand the importance of visual comfort in office buildings and to identify effective shading options to ensure the well-being and productivity of building occupants.

Keywords: Daylighting, Visual Comfort, Shading devices, Computer Simulation,

1.0 INTRODUCTION

Visual comfort is a critical factor in ensuring the health and well-being of building occupants. Extensive research has demonstrated that visual comfort promotes occupants' productivity and work efficiency (Boyce, 2010). Visual comfort is a complex response that depends on the quantity and quality of light in a particular location at a specific time. It is influenced by various lighting and photo-sensory factors, such as the source of lighting, lighting intensity, reflection and contrast of lighting, and the photo-sensory response of the eye (Dussault & Gosselin, 2017). In office buildings, where occupants work long hours and rely on different lighting forms to perform their visual tasks efficiently, improving visual comfort is particularly important (Hwang & Jeong, 2010). This study aims to analyze various shading devices and their impacts on reducing the adverse effects of daylighting to improve visual comfort in office buildings in Kabul, Afghanistan. Kabul is located at a longitude and latitude of approximately 34.5553° North and 69.2075° East with high solar radiation exposure, resulting in increased natural luminous conditions and UV indexes throughout the year, with over 300 sunny days annually (Yu Media Group, 2019). Moreover, most office buildings in Kabul rely heavily on daylighting to provide indoor light, which is highly susceptible to high illuminance, glare, and other adverse effects (Sojoudi, 2013).

Shading devices are an effective solution for solar protection systems used worldwide to enhance visual comfort in indoor spaces. Proper window shading systems can provide and improve visual comfort by allowing adequate indoor daylight illuminance, improving illuminance distribution, and avoiding glare effects, enabling occupants to perform visual tasks comfortably (Baumgärtner et al., 2017). Window shadings are particularly important for buildings with higher solar radiation exposure and latitudes where natural luminous conditions throughout the year are high, such as Kabul, Afghanistan. However, shading devices must be well-designed and carefully selected to avoid negative effects.

The study utilized various computer software, including Autodesk Insight, Radiance, and Velux Daylight Visualizer, to simulate different shading devices' performance on selected Kabul case study offices. Overall, the following research objectives are addressed:

1. Studying the main principles and parameters of visual comfort and solar protection in office buildings.
2. Evaluating different window shading devices to avoid negative glare effects in office buildings in Kabul, Afghanistan.
3. Determining the most suitable window shadings for office buildings in Kabul, Afghanistan, to improve their visual performance.

2.0 LITERATURE REVIEW

This section presents the study's literature review by briefly explaining some of the associated terms and terminologies, such as visual comfort, daylighting, glare, and illuminance. Moreover, all types of shading devices utilized in this study, such as louvres, panels, and traditional window shadings (Mashrabiyahs), are described in this section, with the different types of programs used for simulating these shading devices to determine their efficiency in improving visual comfort in offices in Kabul, Afghanistan.

2.1 Visual Comfort

Visual comfort is a subjective response to the quantity and quality of light in a given space at a given time. The concept of visual comfort is related to our ability to control the condition of light around us (Elzeyadi, 2011). Visual comfort norms consider the capability of an individual to perform tasks comfortably concerning their photosensory perception of their environment. In other words, keeping a person visually comfortable means having enough light to perform his activities. The light has an acceptable quality and balance and has a satisfactory view (San-José Lombera & Cuadrado Rojo, 2010). Visual comfort is a multifaceted concept, and there are numerous definitions and measurements of its components. Some define visual comfort as providing adequate natural and artificial light, effective glare control, and access to outdoor views within a room (Sok, 2020). Several factors affect visual comfort, including light intensity, light source direction, surface reflection, surface contrast, task type, and the photo-sensory response of the eye. Good lighting is crucial for creating a comfortable and productive work environment, and natural lighting can significantly enhance visual comfort compared to artificial lighting (Mardaljevic & Christoffersen, 2017).

2.2 Daylighting

Daylighting is a critical asset in office spaces, providing numerous benefits such as increased worker productivity, improved morale, and better health (Boubekri, 2008). Before the advent of reliable and affordable electrical lighting systems in the twentieth century, daylighting was the primary light source in buildings (Reinhart & Selkowitz, 2006). Despite its importance, building designers sometimes fail to adequately account for daylight during the design phase, resulting in extra electric lighting and glare. Implementing daylighting techniques to utilize natural light in office buildings is particularly beneficial, as it can achieve adequate levels of visual comfort, resulting in a significantly better working environment with substantial benefits for staff productivity and well-being. A study by Boyce et al. (2010) evaluated the effects of different lighting conditions on office worker performance, health, and well-being. They experimented with direct and indirect lighting and individual lighting control. They found that a direct/indirect system is more pleasing than a straightforward system and that individual control increases motivation and vigilance throughout the day. Office buildings in Kabul have been relying on daylighting for many years to light their interior spaces and perform visual tasks more efficiently, mainly due to the energy shortage in the city and the abundance of solar radiation, with the city experiencing more than 300 sunny days per year (Yu Media Group, 2019). However, despite its benefits, daylighting does impose some negative impacts on the occupants, such as glare effects. Hence, this study aims to study different window shadings in office buildings in Kabul and analyze their impact on reducing the adverse effects of daylighting and promoting visual comfort within office buildings in Kabul, Afghanistan.

2.3 Glare

However, one of the primary shortcomings of daylighting or natural lighting is glare impact, which is discomfort produced due to the contrast between the bright outside and the relatively darker interior of the room. Glare is a subjective human that expresses "light within the field of vision that is brighter than the brightness to which the eyes are adapted" (Kent et al., 2017). Glare is a critical issue in building design, as it can lead to discomfort and health problems for occupants. Teachers, for example, have reported experiencing eyestrain, nausea, and headaches due to glare (Gifford, 2020). Disability glare and discomfort glare are two types of glares that can occur. Disability glare results in a lack of vision due to scattered light inside the eye, causing a reduction in contrast. Discomfort glare, on the other hand, can cause symptoms such as eyestrain and headaches due to light sensitivity. The intensity and brightness of the glare source and the surroundings' brightness play a significant role in the level of discomfort glare induced. Shading devices such as Venetian blinds, awnings, vertical blinds, roller blinds, and traditional Mashrabiyahs can be employed to reduce glare levels effectively. Such shading devices are particularly beneficial in office buildings located in areas with high solar radiation exposure, such as Kabul. By reducing glare levels, occupants' comfort, productivity, and overall health and well-being can be improved (Boyce, 2010).

It is important to note that the design of shading devices should take into account the orientation of the building and the specific solar path of the location. For instance, in the northern hemisphere, south-facing windows receive more direct sunlight and require more shading than north-facing windows. Similarly, shading devices should be adjustable to allow for flexibility in controlling the amount of light that enters the building at different times of the day and in different weather conditions. Another important aspect to consider is the impact of artificial lighting on visual comfort. While natural light is preferred, artificial lighting is still necessary in most office buildings. However, poorly designed artificial lighting can also cause discomfort, glare and other adverse effects on visual comfort. Therefore, it is crucial to strike a balance between natural and artificial lighting to achieve optimal visual comfort in office spaces. Finally, it is worth noting that visual comfort is important not only for office spaces but also for other building types, such as schools, hospitals, and homes. The benefits of optimal visual comfort extend beyond just productivity and well-being to include energy savings, reduced absenteeism, and increased property value. Therefore, it's essential to prioritize visual comfort in building design and maintenance.

2.4 Illuminance

Organizations like the Illuminating Engineering Society (IES) and the National Research Council of Canada (NCR) recommend different light levels for offices. According to some research (Lau et al., 2016), workplace comfort differs depending on the culture; hence, adequate daylighting levels for office work in Kabul were determined to be 100-300 lux. The IESNA (Illuminating Engineering Society of North America) advocates for a harmonious visual environment by recommending a maximum-to-minimum illuminance ratio of 1:10. This guideline, as stated in the IESNA Lighting Handbook of 2013 (IESNA,2013), aims to create an optimal visual experience for occupants. Conversely, the NRC Institute for Research in Construction proposes a slightly broader range of up to 1:20, as supported by the National Research Council Canada. This broader range allows for acceptable justifications, such as accentuating specific objects on the working plane, while still maintaining a satisfactory level of contrast. The Useful Daylight Illuminance (UDI) metric is another essential factor. It includes the percentage of the year when daylight illuminance at an interior point of interest is judged to be at "useful" levels between 100 and 2000 lux (10 and 200 FC), very low levels below 100 lux (10 FC), and high levels above 2000 lux (200 FC), which is more likely to cause glare or discomfort.

2.5 Shading Devices

Window shading provides utmost importance in the solar protection of buildings and the visual comfort enhancement of indoor spaces (Baumgärtner et al., 2017). Window shadings can allow adequate indoor daylight illuminance, improve illuminance distribution, and avoid negative sunlighting effects such as glare (Lau et al., 2016). Solar protection through shading devices is significant in locations with high solar radiation exposure and UV Indexes, such as Kabul, Afghanistan. Window shadings can be categorized into three types: exterior shadings such as Venetian blinds, screens, and rolling shades. Depending on the altitude of the sun and the angle of the façade that has to be shaded, there are two types of exterior shading systems. Horizontal and vertical shading devices fall into these two groups (Faisal & Aldy, 2016). All of these shading devices have their implications within office buildings in Kabul and around the world because to generate visually comfortable offices, a sum of these systems should be integrated which can distribute sunlight and daylight across the room's working plane and avoid glare effects within the office buildings (Michael et al., 2017, Vassiliades et al., 2018). Another famous shading device utilized in Kabul's buildings is Mashrabiyahs, which are highly effective against intense direct sunlight and are used in houses, schools, offices, and other governmental buildings.

2.5.1 Mashrabiyah

Mashrabiyah is a form of window shade that covers openings and windows in buildings with ornamental patterns to break the direct sunlight while allowing natural light to enter the interior spaces. In other words, it avoids glare effects while allowing suitable amounts of daylight into the buildings while providing a satisfactory view of the outdoors (Fathy, 1986). The word Mashrabiyah came from an Arab root, a place where the jars of drinking water were being put to cool; Mashraba is the noun form of a verb in Arabic "yashrab", meaning "drink". Mashrabiyah is also thought to be a distortion of Mashrafiya, which comes from the Arabic verb "yoshrif", which means to overlook or observe because the Mashrafiya is the conspicuous part of a window where the ladies of the house could observe the road outside in total privacy (Fathy, 1986). Besides its deep roots in Afghan culture and its functionality, Mashrabiyah has several other essential functions, such as glare control, airflow management, and privacy. While each function influences the others, each must be comprehended clearly and straightforwardly to fully understand Mashrabiyah functions. Furthermore, any assessment of architectural projects should be founded on solid scientific evidence and give a persuasive foundation for design parameters as well as the significance of the mechanism employed to carry out the functions (Akçay & Alotman, 2017). Another characteristic of Mashrabiyahs which makes it attractive in the Afghan community is its privacy improvement because privacy is an essential and susceptible factor in Afghan culture. Mashrabiyahs provide excellent privacy to the interior spaces while allowing sufficient amounts of natural light and airflow.

3.0 METHODOLOGY

This section discusses the methodology of the study. As shown in Figure 1 and 2, this study starts with an introduction to the case studies that are existing offices in Kabul, Afghanistan. Then, the process of model development is explained, which is accomplished for each of the case studies as well as for the shading devices in two categories of contemporary and traditional window shadings through different computer programs, mainly in Autodesk Revit. After that, the design of shading devices specifically simple overhang shadings, is explained further in detail with appropriate graphics. The simulation analysis is done to study daylighting, illuminance and glare effects with different computer programs, including Revit, Insight, Radiance and Daylight visualizer, and the results are then compared to each other through the process of comparative.

Initially, three-dimensional models of the offices were developed in Autodesk Revit, incorporating precise architectural, engineering, and climatic data. Special attention was given to the visual settings of the buildings. Subsequently, the chosen shading devices, particularly external window shadings like overhang window shading, were designed. The objective was to establish the dimensions of the overhang panel relative to the window, considering the latitude and shading height, enabling automatic seasonal adjustment.

Next, these shading devices were assigned to the existing windows of the selected case study offices. Multiple simulations were conducted using various computer software programs, such as Autodesk Insight, Radiance, and Daylight visualizer. These simulations aimed to evaluate the impact of the shading devices on enhancing visual comfort in the selected offices located in Kabul, Afghanistan.

The main purpose of these multiple simulation programs is to compare the outcome results found through different simulating programs with each other and ensure their efficiency and effectiveness in improving visual comfort in office buildings in Kabul, Afghanistan. Another reason for utilizing these programs in this study is that they complement each other. For instance, in most cases, a three-dimensional model of the case study has been developed in Autodesk Revit and then exported to other platforms for simulation analysis or, in some cases, a plugin was installed within the Revit interface to complete the study of glare effects, sun radiation and sun distribution analysis. A comparative analysis of all window shading will determine the most effective window shadings to improve the visual performance of office buildings in Kabul, Afghanistan.

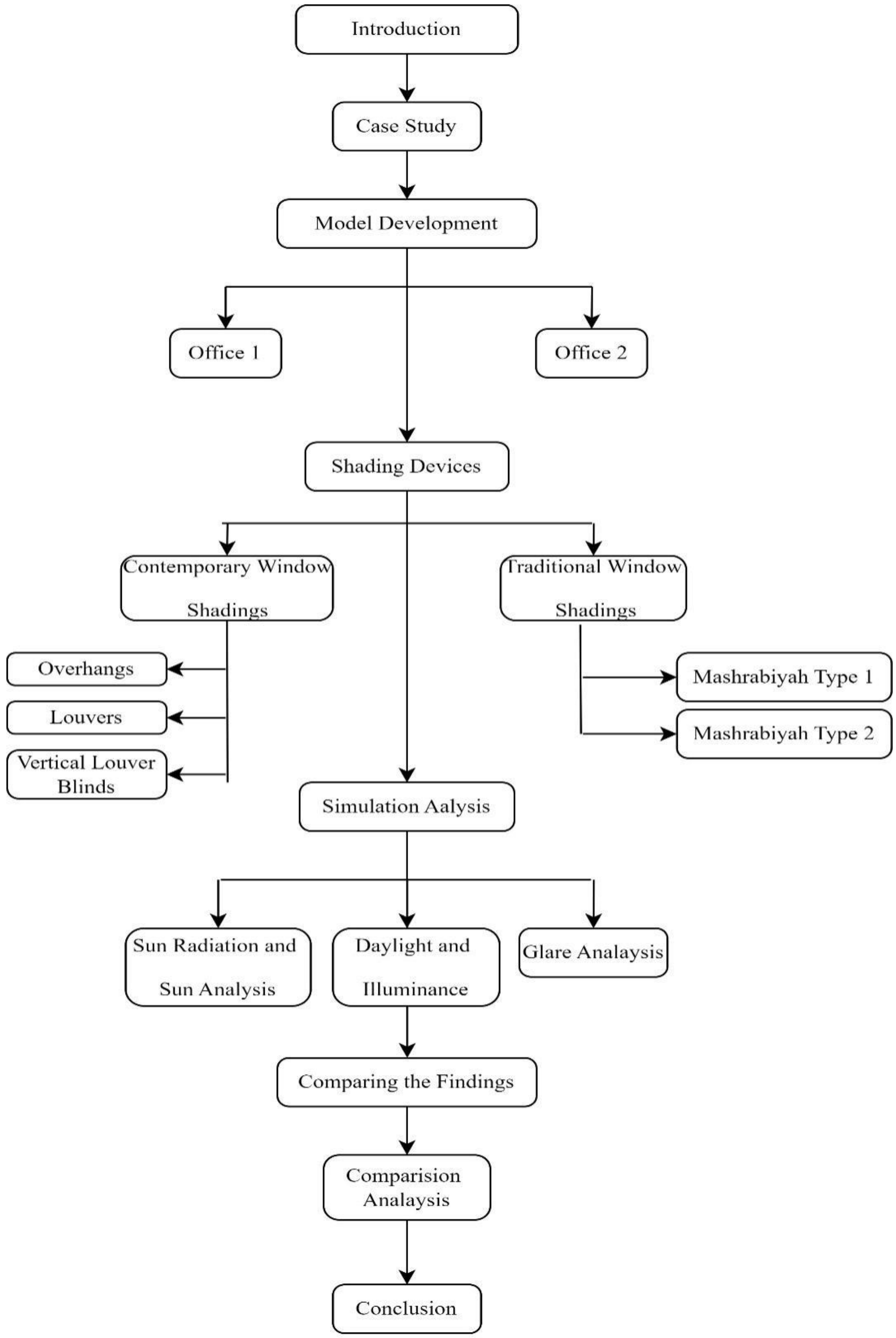


Fig. 1: Flow chart on the method of data collection.

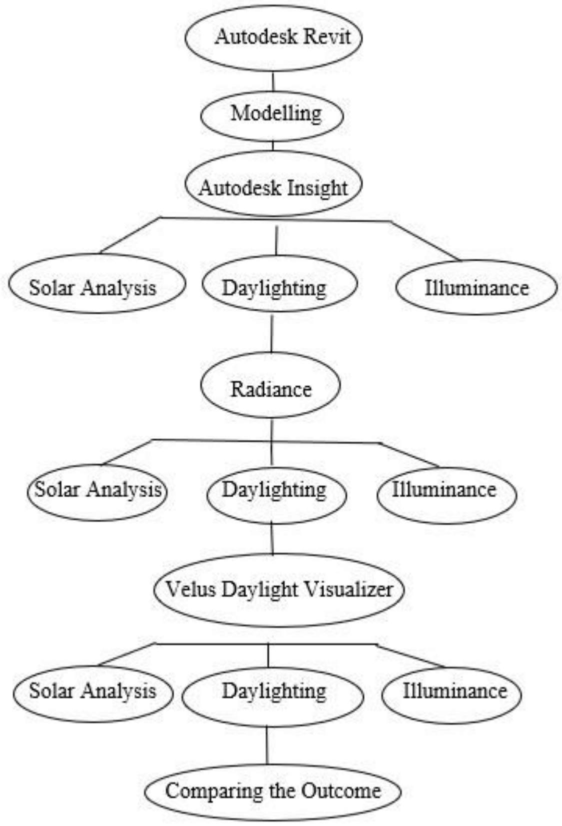


Fig. 2: Flow chart of the simulation process.

3.1 Case Study

The selected case study building for this research is a governmental office building within the Ministry of Rural Rehabilitation and Development Afghanistan, located in Dar-Al-Aman main street, Kabul, Afghanistan, with longitude and latitudes of 34°28'18.4542"N, 69°7'8.9796"E, respectively. It is an old building with a classical design and bricks and concrete as its primary construction material. This office building has two floors, accommodating engineers who work on different rural habitational projects in Afghanistan. Figure 3 shows the three-dimensional model of the case study building, generated using Autodesk Revit, 2021. Two offices were selected within this building as case studies highlighted in Figure 4 and 5. The first office is located on the ground floor on the Eastern side of the building with dimensions of 600 by 350 centimetres and a single window with dimensions of 180 by 90 centimetres and 35 centimetres height from the ground level. The second selected office is also located on the ground floor in the Northern section of the building with dimensions of 600 by 500 centimetres. This office has two windows with dimensions of 180 by 140 centimetres and 90 centimetres of height from the ground level. One of the windows faces the North while the second window faces the west direction. The main reason behind selecting these offices, one in the North and another in the southern part of the building, was due to their extreme solar exposure (lowest and highest) and the functionality of these offices. Figure 3 demonstrates the three-dimensional model of the case study building which Autodesk Revit developed with exact input data of the existing building. Figure 4 shows the ground floor plan of the case study building, which encapsulates the first selected office for this study, shown as "dedicated office". Finally, Figure 5 depicts the floor plan of the case study building's first level, emphasizing the designated office identified as Office 1.

Fig. 3: Three-dimensional model of the case study building.

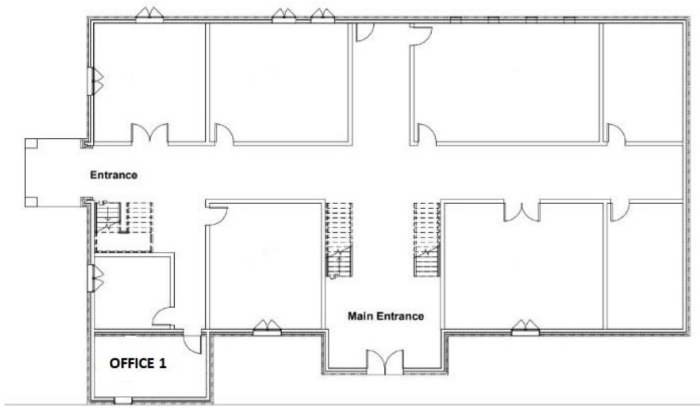


Fig. 4: Ground floor plan of the case study building (Not to scale).

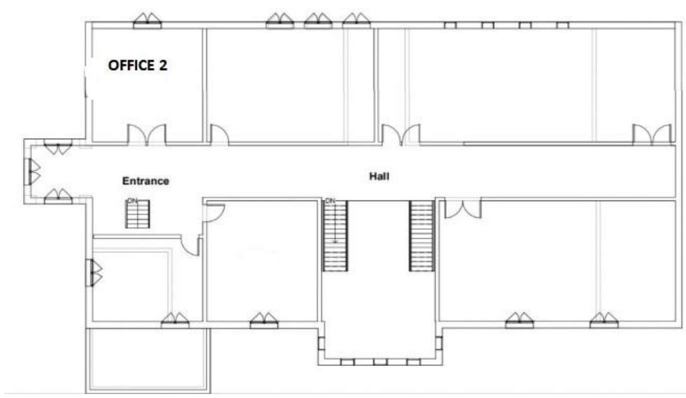
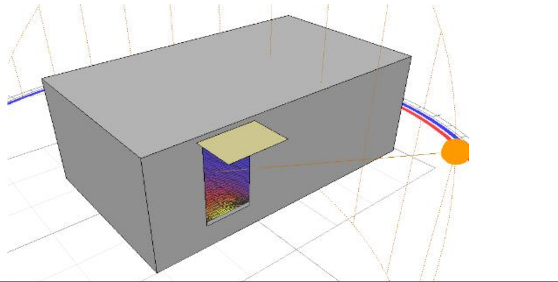
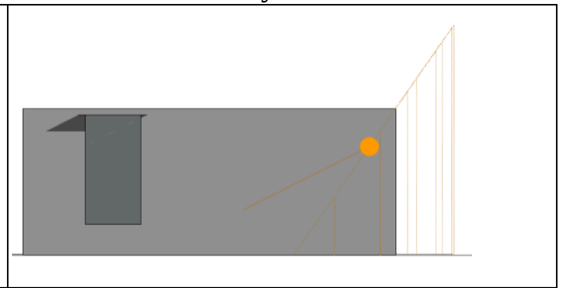
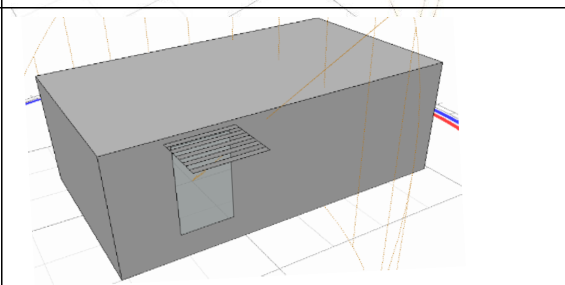
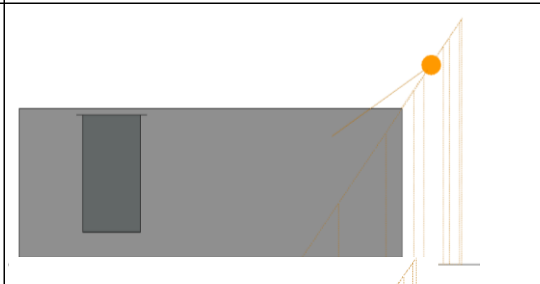
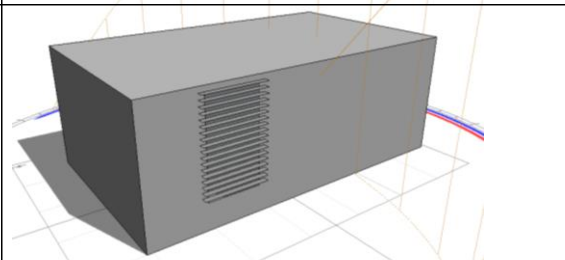
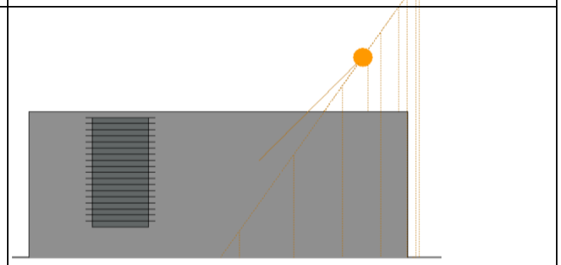
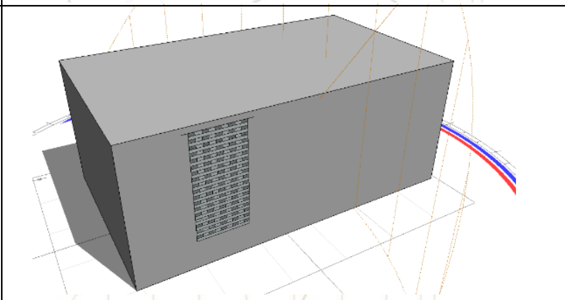
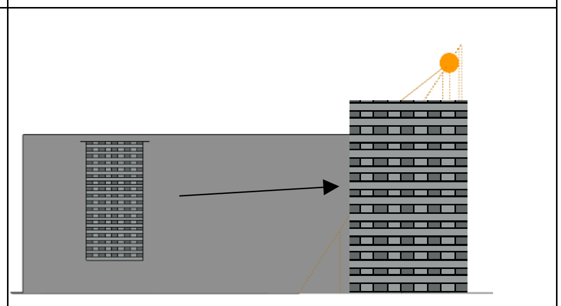
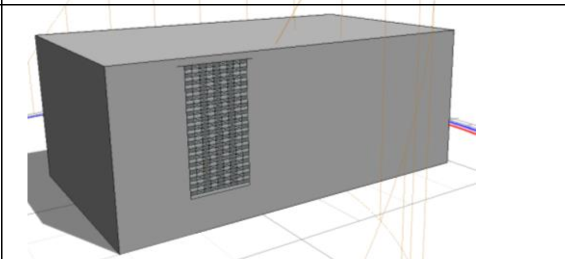
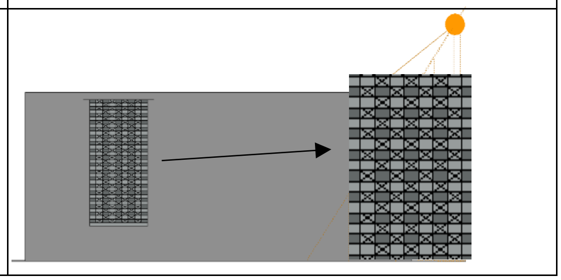


Fig. 5: First-floor plan of the case study building (Not to scale).

3.2 Shading Devices Utilized in this Study

This study focuses on external shading devices, mainly on five different window shadings, including simple overhang window shadings, simple overhang window shadings with louvers, vertical window shadings with louvers, and two types of Mashrabiyah shading panels which are illustrated in the following table. Type 1 Mashrabiyah has a very simple pattern of sun-shading, whilst type 2 Mashrabiyah has traditional ornamentation on the surface.

Table 1 Types of shading devices utilized in this study

Simple overhang window shading		
Simple overhang window shading with louvers		
Vertical window shading with louvers		
Mashrab-iyah window shading Type 1		
Mashrab-iyah window shading Type 2		

4.0 RESULTS AND DISCUSSION

The resulting outcome of the simulation analysis of different shading devices on selected case study offices in Kabul, performed through various computer software, including Autodesk Insight, Radiance, and Velux Daylight Visualizer, is shown in the Table 2 and Table 3. The result shows the simulation analysis of the various shading devices assigned to existing windows of the selected offices in Kabul, Afghanistan. All selected shading devices have been proven effective in enhancing visual comfort and reducing the overall glare levels in Kabul; however, their efficiency rates differ.

Table 2 Simulation-based findings based on % of efficiency at Ground Floor

First Selected Office (Ground Floor)			
Various shading devices were assigned to the windows of the first selected case study office in Kabul, Afghanistan.	Autodesk Insight (Revit)	Radiance	Velux Daylight Visualizer
Simple overhang window shadings	≈ 10 %	≈ 10.5 %	≈ 26.6 %
Simple overhang shadings with louvers	≈ 0-5 %	≈ 5-18 %	≈ 20 %
Vertical window shadings with louvers	≈ 40 %	≈ 42.1 %	Does not Support
Simple Mashrabiyah shading panels	≈ 50 %	≈ 52 %	Does not Support
Ornamental Mashrabiyah shading panels	≈ 50 %	Does not Support	Does not Support

Table 3 Simulation-based findings based on % of efficiency at First Floor

Second Selected Office (First Floor)			
Various types of shading devices were assigned to the windows of the second office selected case study office located in Kabul, Afghanistan.	Autodesk Insight (Revit)	Radiance	Velux Daylight Visualizer
Simple overhang window shadings	≈ 22.2 %	10.5-36.3 %	23.5-26.6 %
Simple overhang shadings with louvers	≈ 22 %	≈ 10.5-36 %	≈ 16-16.6 %
Vertical window shadings with louvers	≈ 22-66.8 %	Not Included	Does not Support
Simple Mashrabiyah shading panels	≈ 77 %	≈ 45.4-73.6 %	Does not Support
Ornamental Mashrabyah shading panels	≈ 77 %	Does not Support	Does not Support

A comparative analysis of these simulations on different shading devices concluded that the Mashrabiyah shading panels and vertical shading devices with louvers were the most efficient in reducing glare levels and enhancing visual comfort in the chosen office buildings in Kabul, Afghanistan. Based on the simulation analyses of different shading devices, vertical shading devices with lovers demonstrated about 40% efficiency in reducing glare levels in Autodesk Insight simulations and 42.1% in reducing glare levels in Radiance simulations. For the second selected case study, office Vertical Shading Devices with Louvers demonstrated a 22% to 66.8% efficiency in mitigating glare effects. According to simulations carried out throughout this study, Mashrabiyah shading panels demonstrated around 50% efficiency in mitigating glare levels during simulations with Autodesk Insight and around 52% in reducing glare levels during simulations carried out with Radiance for the first office. For the second selected office, Masharbiyahs demonstrated about 77 % efficiency rate in mitigating glare levels with Autodesk Insight simulations and up to a 73.6% efficiency rate with Radiance simulations. It renders Mashrabiyahs the most effective shading device among the selected window shadings and the most suitable for reducing glare impacts and improving visual comfort in office buildings in Kabul, Afghanistan.

6.0 CONCLUSION

In this study, different types of shading devices, including simple overhang window shadings, simple overhang window shadings with louvers, vertical window shadings with louvers, and two types of

Mashrabiyah window shadings were assigned to the existing windows of selected case study offices to study and analyze their impact on visual comfort of the office buildings in Kabul, Afghanistan. The process of simulation analysis of different shading devices was completed through different computer software, including Autodesk Insight, Radiance, and Velux Daylight Visualizer, to compare the outcome results and ensure overall precision, accuracy, and efficiency of simulation analysis. Based on the comparative analysis of the simulations carried out throughout this study on various shading devices and their impacts on improving the visual performance of the office buildings in Kabul, Mashrabiyah shading panels and vertical shading devices with louvers with 50% to 7% and 22% to 66.8% of efficiency rates, were found to be the most effective in reducing glare levels and improving visual comfort in selected office buildings in Kabul, Afghanistan.

The findings of this study can be a stepping stone toward improving the visual comfort of office buildings and providing a comfortable work environment for office occupants in Kabul, Afghanistan because visual comfort is crucial in ensuring the overall health and well-being, productivity, and efficiency of office building occupants. Moreover, most office buildings in Kabul are highly dependent on daylight for providing indoor light, which is proven to be highly prone to high illuminance, glare, and other negative effects, especially in offices where the occupants consistently work for long hours, highly depending on different forms of lighting to perform their visual tasks efficiently. Office buildings in Kabul can utilize these shading devices to mitigate negative glare effects, improve their workspace's visual comfort, and provide their occupants with better health and efficiency. Furthermore, to select the most suitable and appropriate type of shading device for improving the visual comfort of their interior spaces, they can refer to the simulation analysis of each of the various common shading devices in Kabul included in this study and select the best option based on the existing glare levels in their offices and the efficiency rate of the selected shadings device. This study also introduces the methodology for simulating different shading devices in offices, which can be utilized by other researchers in Kabul and other cities to analyze other types of shading devices common in their locality and discover their efficiency rates in mitigating glare levels and improving visual comfort within interior spaces.

Although this study is specifically focused on improving the visual comfort of office buildings in Kabul, it can be used in other cities with similar weather and climatic patterns, such as some neighboring countries of Afghanistan, Middle Eastern countries, and other cities and countries around the world because visual comfort is necessary for all building occupants no matter where they are located, as it directly impacts their health productivity and efficiency, especially in offices and cities with high solar radiation exposure, high UV indexes and high dependency to daylighting like Kabul, Afghanistan. This study only focuses on the visual comfort performance of office buildings by studying various types of shading devices, mostly external window shadings. Hence, there are substantial research gaps for future studies in the field of visual and thermal comfort enhancement by studying various types of window shadings for diverse kinds of buildings, including but not limited to offices.

- This study only focuses on visual comfort analysis of different window shadings only for office buildings; hence, it is deemed necessary for a study to be made on other types of buildings, such as commercial, educational, and industrial buildings, as they all have different visual comfort parameters and lighting requirements.
- This study only concentrates on visual comfort analysis of various window shadings and does not include the thermal impacts of window shadings on interior space; and since window

shadings directly affect both visual and thermal conditions of the buildings, it is essential to study the effects of shading devices on the thermal performance of the buildings as well.

- This study only focuses on external shading devices as they are the most common window shading types in Kabul, Afghanistan. However, studying other types of shading devices is important, such as internal and in-between shading devices. Moreover, a study can be made on kinetic shading devices, which are becoming more common in most developed countries.
- This study intends to improve the visual comfort of the buildings through the analysis of various shading devices; however, visual comfort in buildings depends on many other factors as well, such as colours and materials (especially on the finishing surfaces), window sizes, and orientation, types of glass and other factors which can systematically improve the visual comfort of different types of buildings if studied and analyzed thoroughly.

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