IMPACT OF WINDOWS FOR DAYLIGHTING ON THERMAL COMFORT IN ARCHITECTURE DESIGN STUDIOS IN DHAKA

By

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Dedicated to my 'NANU BHAI' (Grandfather)

Late **Nakib Ahmed Ali,**

who helped me understand the meaning of life….

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Abstract

Despite the fact that students work and perform better under natural lighting condition, observation shows that most of the architecture design studios in Dhaka are often lit by artificial means and the condition of daylighting is hardly satisfactory. Though artificial light can satisfy visual needs of the students and studio guides, it may cause tiresome and exhausting after a time period. On the other hand, entrance of direct solar radiation for daylighting in the studios can cause overheating, resulting in thermal discomfort with increased cooling loads. Both artificial lighting and overheating situation not only fails to provide the desired environment for teaching-learning in the studio, but also at the same time create pressure on the overall national energy demand. Proper daylighting and thermal strategies should be taken into account during planning and construction of the studios.

As windows have a large-scale impact on daylighting and thermal comfort considering its size orientation and shading configuration, as well as on the energy consumption of the building, it is thus necessary to optimize window design for maximum benefit. This research aims to find out an effective window category from available window configurations of existing architecture design studios, located in Dhaka through simulation studies and investigates the effectiveness of the window configurations to enhance the visual and thermal quality of design studios. To start with, a literature review and field survey were conducted to get the knowledge base and to select available different window configurations for the simulation study. Then a case studio was selected and a dynamic annual Climate-Based Daylight Modeling (CBDM) method considering all weather sky luminance model (i.e. DAYSIM), was used to evaluate the performance of different window configurations installing at the case studio. Additionally, thermal simulation was done by EnergyPlus™ considering four output variables for measuring Predicted Percentage of Dissatisfied (PPD). Finally, daylighting and thermal results were combined to find out the most effective available window configuration for architecture design studios in climatic context of Dhaka.

This research addresses the conflict between balancing visual and thermal comfort of the distinctive architectural featured windows. Results indicate that, segregated viewing window as the most feasible window configuration from the combined result of thermal and dynamic daylight simulation for architecture design studios. Furthermore, window-to-wall ratio of 22%-31% and 450mm horizontal shading device on south façade were found to be most effective in designing window. It is expected that the outcome of this research will help architects and designers to generate some guidelines for window configurations to improve the luminous and thermal environment of architecture design studios in Dhaka as well as in the other cities of Bangladesh.

Keywords

Architecture design studios; window configurations; Daylighting; CBDM simulation; thermal performance; PPD.

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List of Abbreviation

AGS	Architectural Graphic Standards
AIUB	American International University of Bangladesh
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AT	Air Temperature
AUST	Ahsanullah University of Science and Technology
BMD	Bangladesh Meteorological Department
BNBC	Bangladesh National Building Code
BRACU	BRAC University
BU	Bangladesh University
BUET	Bangladesh University of Engineering & Technology
CBDM	Climate-Based Daylight Modelling
CBECS	Commercial Buildings Energy Consumption Survey
CIE	International Commission on illumination
DA	Daylight Autonomy
DDS	Dynamic Daylight Simulation
DF	Daylight Factor
DIU	Daffodil International University
DoA	Department of Architecture
EIA	Environmental Impact Assessment
ERC	External Reflected Component
IES	Illuminating Engineering Society
IESNA	Illuminating Engineering Society of North America
IRC	Internally Reflected Component
ISO	International Organization for Standardization
MIST	Military Institute of Science and Technology
MRT	Mean Radiant Temperature

NSU	North South University
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
RAJUK	Rajdhani Unnayan Kartripakhya
RH	Relative Humidity
SAD	Seasonal Affective Disorder
SUB	State University of Bangladesh
TLC	Tridonic Lighting Components
UAP	University of Asia Pacific
UDI	Useful Daylight Illuminance
USA	United States of America
WC	Window Configuration
WWR	Window-to-Wall Ratio
WS	Wind Speed

1. CHAPTER ONE: INTRODUCTION

Preamble

Problem statement

Aim and objectives

Overview of research methodology

Scope and limitation of the research

Structure of the thesis

Key findings

CHAPTER 1 INTRODUCTION

1.1 Preamble

With the world population exceeding seven billion and about 75 million people to be added every year (UN, 2016), design, construction, and real estate industry will be one of the fastest growing in the world (AUP, 2011). In recent years, many architecture schools have been established in all over the world (Massie, 2015) and Dhaka is no exception. The School of Architecture has a diverse and dynamic learning environment that capitalizes on its unique regional location to improve the human condition through teaching, research, and service (UNLV, 2016). Edification in Architecture schools is primarily based upon dialogue between the student and the teacher (Siddiqi, 2002). Design studios in Architecture schools are generally used as workspace for the students to perform project related activities and often present the outcomes visually in front of the course teachers, jurors and invited experts. All individuals inside the studio rightfully expect to get clear vision of the desired output.

It is light that can make a building bright and airy or dull and gloomy. The use of daylight as the principle light source is an integral part of sustainable building design, because daylighting has been recognized as a useful source of energy savings and visual comfort in buildings. Before electric lighting, daylight was the primary illumination source for all building types. Designers, later tend to rely on electric lighting (Robertson, 2002). One consequence of this move that has not yet been fully explored is the effect of daylight on individuals' health and well-being. Artificial lighting for illuminating in the architecture design studios needs large quantities of electricity, which affects negatively on total energy consumption (Sharmin, 2011). Now-a-days, daylight is encouraged in the buildings, as it is not only a promising green building design strategy for energy savings, but also carries immense physiological and psychological benefits to enhance working performance (Sharaf, 2014).

The oldest way of bringing light into a building is to let the natural light through openings. Windows, as a key element of building openings, are therefore essential architecturally, socially, and psychologically as well as environmentally (Munner, 2000). Strong arguments for daylight inclusion through windows in building are often associated with comfort and energy benefits (Beevor, 2010). Window has impacts on the thermal environment of the room, which can affect the overall energy consumption. Direct solar radiation can cause overheating, resulting in thermal discomfort with increased cooling loads (Shikder, 2010). Designing a window based on thermal performance only and without provisions for adequate daylight can increase the use of electric lighting, which makes the space dull and unhealthy. Guidance from US department of Energy suggests that window design strategies should consider maximizing solar heat gain in the winter and minimizing solar heat gain in the summer, both of which have links with heating/ cooling loads in a space (DOE, 2009). Designed windows would successfully be used, to address this issue of balancing luminous and thermal comfort in architecture design studios in the climatic context of Bangladesh.

This research focuses on architecture design studios located at different public and private universities in Dhaka to study the potential of different window configurations in providing adequate daylight penetration while keeping occupant's satisfaction towards thermal comfort in account. A passive trend of window configurations, that is only suitable to specific climatic regions, i.e. in tropical countries, such as Bangladesh, can be a significant building design element to correlate between proper luminous environment and human thermal comfort in architecture design studios.

1.2 Problem Statement

Studies on architecture design studios in Dhaka show that, most of the time the luminous environment is poor in the studios and function under artificial means (Sharmin, 2011), even though there is an abundance of natural light in the tropics (Ahmed, 2007). Daylight was the primary light source in the buildings before 1940s, while artificial lights supplemented the natural light. In a short span of 20 years, electric lighting had transformed the workspace by meeting most or all of the occupants' lighting requirements. People prefer to work in daylight as opposed to artificial light (Jackson, 2006) and currently, the emphasis is on sustainable buildings that have a minimal impact on the environment (Sharmin, 2011).

According to IESNA (2000), activities in architecture design studios require minimum illumination level of 300 lux. Research on daylighting in architecture design studios show that, measured illumination levels in the studios in Dhaka are well below the recommend standards (Shimu, 2015). Daylighting design elements e.g. window configuration, window bottom and top level, and window location, which have various objectives to fulfil, such as to ensure adequate daylight without discomfort and glare in the studios are not guided by daylighting and thermal considerations and not designed according to the variety of visual tasks that usually take place in the studios (Sharmin, 2011). Considering annual thermal comfort assessment of a space in the tropics, excessive daylighting near window contributes human discomfort (Trisha, 2015). Visual and thermal comfort thus can be affected by poor natural lighting system and high internal heat gains by excessive solar radiation (Hossain, 2013), which creates an intolerably hot and uncomfortable working environment for the students in architecture design studios.

To address this problem, architecture design strategies should be developed by proposing appropriate window configuration in respect to incorporate useful daylight in luminous environment of the architecture design studios of academic institutions with maximum possible utilization of daylight in the climatic context of Dhaka. Strategies for ensuring combination of thermal conditions (air temperature, relative humidity and wind speed), which can be perceived as comfortable by most of the occupants, according to any internationally recognized comfort index i.e. Predicted Mean Vote-Predicted Percentage of Dissatisfied (PMV-PPD) in architecture design studios should be established in design process.

1.3 Aim and Objectives

The aim of this research is to develop architectural design strategies to incorporate daylight in naturally ventilated architecture design studios considering the impact of combined indoor thermal conditions (air temperature, relative humidity and wind speed) in the context of Dhaka.

To achieve this aim, following three objectives have been developed.

- **Objective 1:** To identify the role of windows for efficient daylighting and thermal comfort in architecture design studios.
- **Objective 2:** To analyse the effectiveness of different window configurations to enhance daylight inclusion in Architecture design studios.
- **Objective 3:** To investigate the impact of different window configurations on indoor thermal conditions in the studios with respect to the achieved daylight.

1.4 Overview of the Research Methodology

This section provides a brief overview of the research methodology for the thesis. A detailed description of the research methodology, used for this research, has been discussed in Chapter 3. Figure 1.1 shows a flow diagram of the overall research process, which integrates the main research methods: literature review, field survey and simulation analysis.

The research started with a literature survey to gather knowledge and information on the national and international illumination standards; climatic context of Dhaka and existing illumination level and thermal conditions in design studios in Dhaka to understand the nature of expected luminous and thermal environment in architecture design studios.

Fourteen universities were selected from the University Grants Commission (UGC), Bangladesh registered list for physical survey based on specific criteria (Section 3.2.4). Measurement of illuminance at design studios, thermal conditions, window details, material, window bottom and top level, shading device, work plane height, aisle width, exterior interior photographs, detail observations and related information were collected for these universities. From the universities, three design studios from three universities were shortlisted and among them, the most suitable one was selected as 'case studio', for simulation analysis.

Through field survey in the universities, fourteen available window configurations under four categories were selected for simulation study under the climatic context of Bangladesh keeping the indoor and outdoor conditions constant. Simulation study was pursued in two phases: daylight simulation by ECOTECT-RADIANCE-DAYSIM software and thermal simulation by Sketchup_OpenStudio-EnergyPlus™ software.

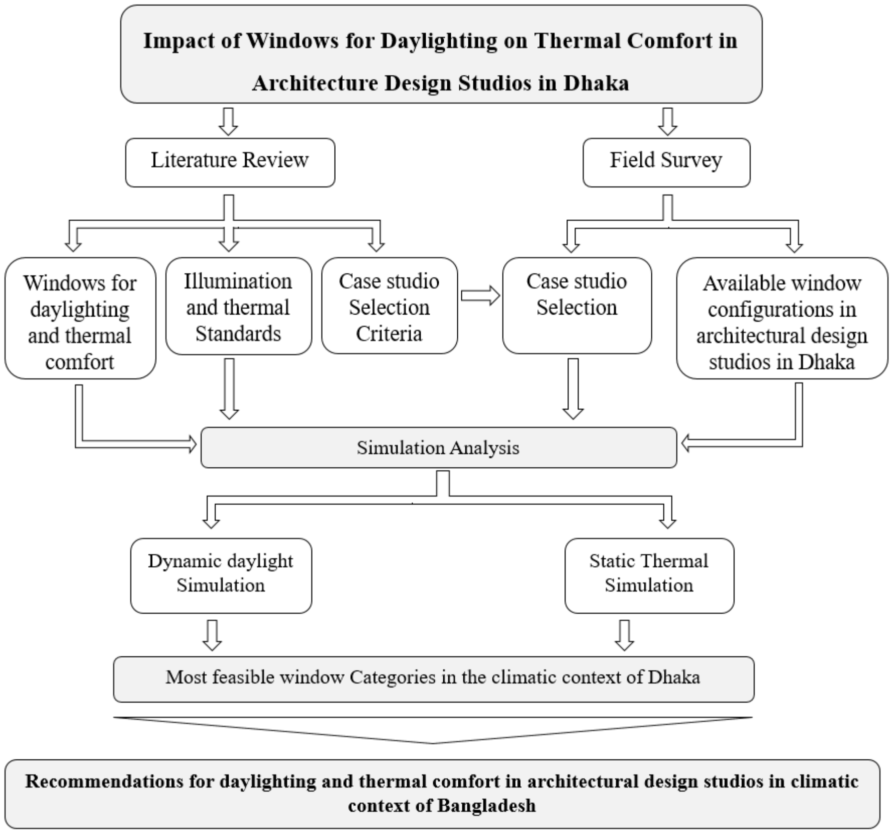


Figure 1.1: Flow diagram of the research process.

1.5 Scope and limitation of the research

In this research, recommendations and design guidelines are made considering simple modifications of existing window configurations for the studios that can be applied easily in the context of Dhaka. This study concentrates on strategies for daylight inclusion and thermal comfort in architecture design studios under the climatic context of Dhaka region to save energy for lighting and comfort purpose, though visual performance during study period, aesthetics, sound transmission, economics, glare control, ventilation, safety, security and subjective concerns of privacy and view of a space may be affected. Considering time and resource constraint for the research, the said concerns were kept beyond the scope of this thesis, which may be addressed by further studies.

1.6 Structure of the thesis

This Section provides an overview of each of the following six chapters, which is shown graphically in Figure 1.6.

Chapter 1 is an introduction to the thesis; describes subjects that might be necessary for understanding this research, problem statement with the aim, objectives, brief methodology, scope of the research and limitations.

Chapter 2 focuses on the outcome of the literature review, based on established research and published sources, to provide a knowledge base for this research, which helped to focus on the issues on which the simulation is conducted later.

Chapter 3 provides a general climatic overview of Bangladesh based on published data from different published thesis books, papers and collected data from Dhaka Meteorological Department, mainly focused on the case area of this thesis- Dhaka city. The purpose is to formulate an environmental database for field study, to select the whole year for dynamic daylight simulation and the most critical part of the year for thermal simulation study. This chapter also describes the detail steps of the methodology for simulation study for this research. Field investigation, explained in this chapter focuses on the criteria of the selection of the case studio for simulation study.

Chapter 4 provides the detail description and output of the simulation exercise. This chapter consists of three major parts. To start with, in the first portion, Dynamic climate based daylight modelling (CBDM) simulation are conducted to find out the best window configuration for natural lighting in architecture design studios in the climatic context of Dhaka and then the second portion describes the thermal simulation study to propose the best window configuration for comfortable combined indoor thermal conditions. Finally, the most feasible window configuration is proposed by combined result from the daylight and thermal simulation. This chapter also validates the existing indoor conditions measured with lighting and temperature meters with computer simulated data to understand the deviation from real world.

Chapter 5 discusses the architecture design strategies for incorporation of useful daylight illumination and comfortable thermal condition in architecture design studios. This chapter also provides some general recommendations along with some directions and guidelines for future research, in the field of daylighting and thermal sensation, within the defined context.

Figure 1.2 shows the structure of the thesis with organization of the chapters.

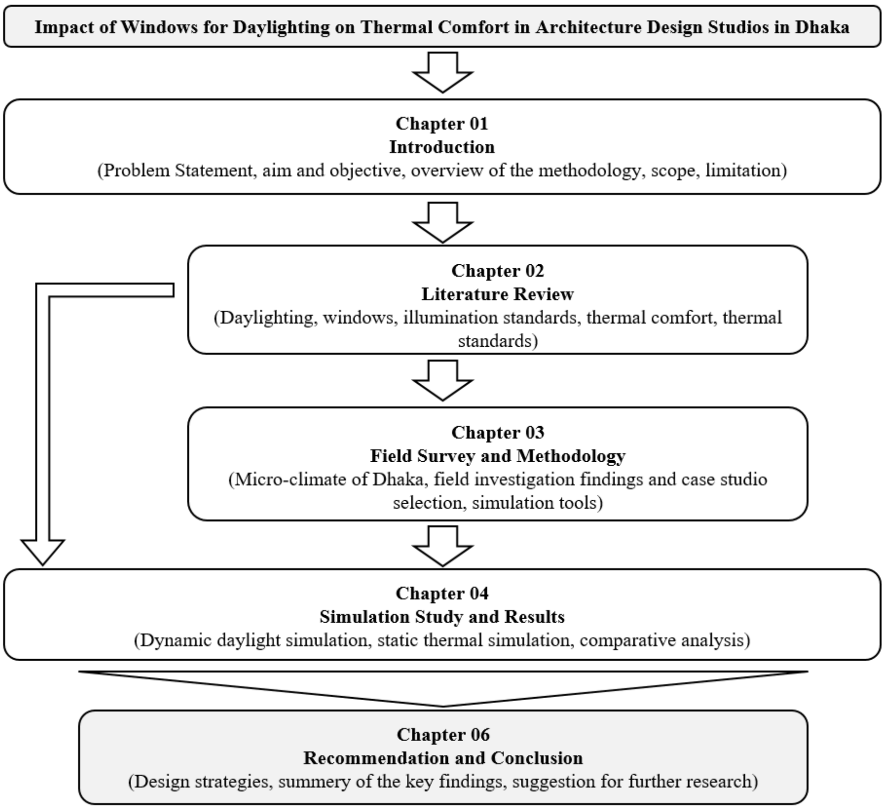


Figure 1.2: Organization of the chapters and structure of the thesis.

1.7 Key findings

The research started to overcome some constraints mentioned at Section 1.2. With the gradual development of the research from the literature review and incorporation of research findings at different stages made objectives, methodology and limitations of the research more defined, refined and detailed. Table 1.1 presents a summary of the key findings of the research in relation to the objectives, methodologies and concerned chapters.

Table 1.1: Summary of the key findings of the research in relation to the objectives, methodologies and concerned chapters.

Objective	Methods	Chapter	Key findings
• **Objective 1:** To identify the role of windows for efficient daylighting and thermal comfort in architecture design studios.	Literature review	Chapter 2	The distance that adequate daylighting will penetrate into a room depends upon window size and location on the wall (Robertson, 2002). The appropriate proportion of window to external wall reduces cooling loads and increase thermal comfort considering solar radiation during the summer period (Alibaba, 2016).
	Field Investigation	Chapter 3	The standard of uniformity ratio between the daylight levels in the front and back are not maintained in most of the design studios in Dhaka due to improper window size and location.
Objective 2: To analyse the effectiveness of different window configurations to enhance daylight inclusion in Architecture design studios.	Dynamic daylight simulation analysis	Chapter 4	Segregated viewing window was found as the most feasible window configuration considering enhanced daylight inclusion in architecture design studios in Dhaka.
Objective 3: To investigate the impact of different window configurations on indoor thermal conditions in the studio with respect to the achieved daylight.	Thermal simulation analysis	Chapter 4	Segregated viewing window was found as the most feasible window configuration from the combined result of thermal and dynamic daylight simulation for architecture design studios. Furthermore, window-to-wall ratio of 22%-31% and 450mm horizontal shading device on south façade were found to be most effective in designing window.

2. CHAPTER TWO: LITERATURE REVIEW

CHAPTER 2 LITERATURE REVIEW

2.1 Preamble

The first chapter introduces the research. This chapter discusses the outcomes of the literature review to describe the basic information required to study the impact of windows for daylighting on thermal comfort in architecture design studios in the context of Dhaka. This chapter mainly consists of five major parts. The first part describes daylight as a potential source of lighting. The second part discusses the benefits of daylighting and factors influencing daylight penetration in architecture design studios. The third part highlights the window as the most important building component for daylighting. This part also describes the daylighting strategies for fenestration design in academic buildings. The fourth part focuses on national, international and local illumination standards for architecture design studios. The fifth part of this chapter presents the factors which influence thermal comfort and impact of windows on thermal comfort in the context of Bangladesh. Finally, the key findings of this chapter have been highlighted. The methodology for simulation studies and field investigation are discussed in the next chapter (Chapter 3), developed with respect to the outcomes of this chapter.

2.2 Source of Daylight

The sun is the source of natural light energy and the path of the sun determines the available sunlight at a particular building location. The solar altitude and the solar azimuth are the two angles through which the sun's position can be defined at a reference point on earth's surface (Figure 2.1). The overcast sky, clear sky, and partly cloudy sky are three light conditions to be considered in daylighting design, according to the IESNA Lighting Handbook (IESNA, 2000).

The light may reach at a work space via a number of paths (A.G.S. 2000). Direct sunlight is, no doubt, the brightest source. The other sources are the bright overcast sky, which is brighter than the clear blue sky (Ahmed, 1987). Daylight entering through windows under clear conditions illuminates an indoor point from five different sources as the day progresses. These are the sun, the circum-solar sky, the ground, opposite surfaces and the blue sky, with light entering downwards, upwards and horizontally (Evans, 1980). The available daylight that can replace artificial lighting is both direct sunlight and diffuse light from the sky (Joarder, 2007).

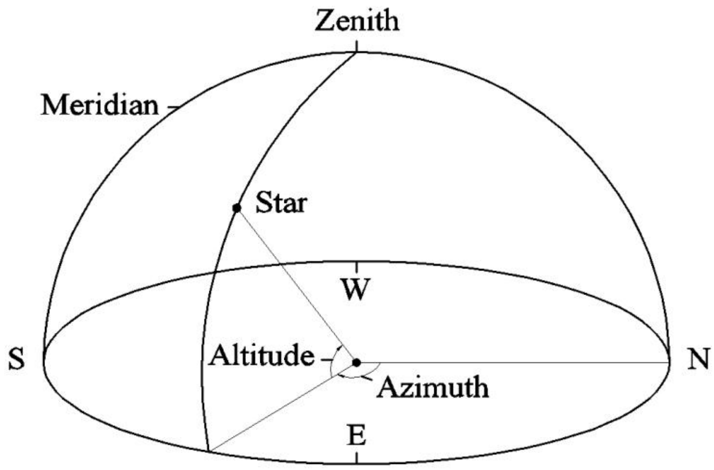


Figure 2.1: Solar altitude and the solar azimuth angle (Source: Sharmin, 2012)

2.3 Components of Daylight

Light from the sky reaching a particular point in a room is composed of three distinct components as mentioned below (Figure 2.2).

a. Sky Component

b. Externally reflected component

c. Internally reflected component

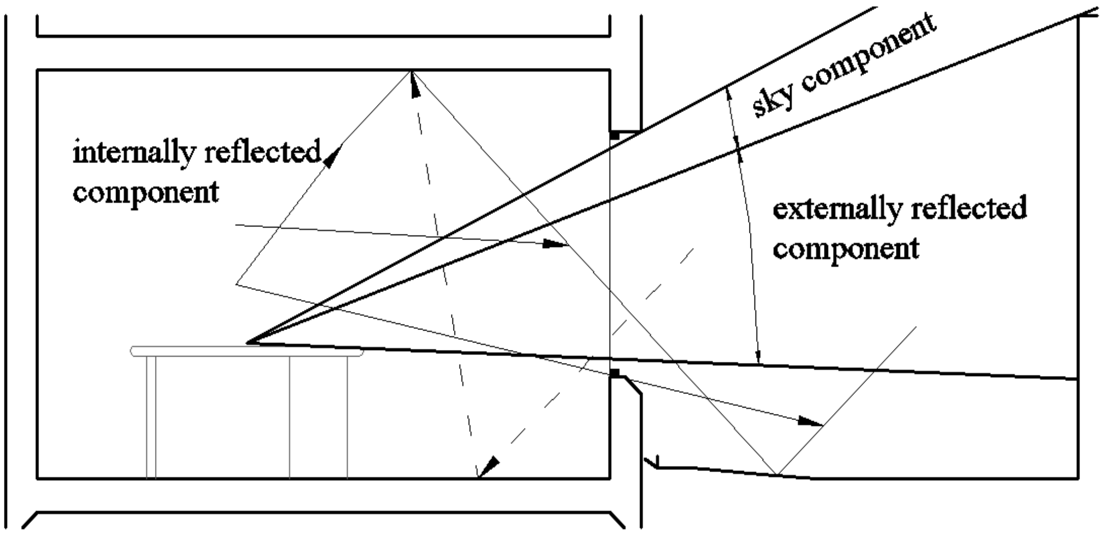


Figure 2.2: The components of daylight at a point in a room. (Source: Baker, 2002)

2.3.1 Sky component

Sky component (SC) is the illuminance received at a point in the interior of a building, directly from the sky. The SC normally refers to the diffuse sky: i.e. it is not used to describe direct sunlight. This component depends upon there being a view of the sky from the point in the room being considered. It is the view of the sky that gets larger as the point considered approaches the window, and thus it is mainly the sky component that leads to the strong variation of light intensity in a side lit room (Joarder, 2007) (Figure 2.2).

2.3.2 Externally reflected component

The externally reflected component (ERC) is the illuminance in the interior due to light reflected from external obstructions (Figure 2.2). The ERC is particularly relevant in dense urban situations, where, owing to the closeness of buildings, a view of the sky may be limited or even completely absent for all but positions very close to the window.

The ERC will tend to corner from a low angle, close to horizontal. Depending on reflectivity of the obstruction, this may penetrate deeper into the space than the sky component, but because of the absorption of light by the external obstruction it will generally, be much weaker (Joarder, 2007).

2.3.3 Internally reflected component

The internal reflected component (IRC) is the illuminance received at a point and is composed of light received indirectly from daylight that is inter-reflected around the internal surfaces of the space (Sharmin, 2011) (Figure 2.2).

2.4 Benefits of Daylighting

Daylighting has direct impact on individual’s performance, psychology, health, energy saving and productivity and indirect impact on ventilation and good view (Ahmed, 2014).

2.4.1 Human performance

The three ways in which lighting conditions affect individual performances are through the visual systems, through the circadian system and through the perceptual system. The circadian system establishes an internal biological rhythm by which humans set a daily cycle of dark-light within the 24-hour diurnal cycle (Ahmed, 2014).

It is said to be the platform from which individuals operate to perform their activities, showing decreased performance during the circadian night in comparison to the circadian day. Research suggests that the sensitivity of the circadian system to light exposure varies significantly over the 24-hour day (Veitch, 2003). Lacks of daylight during the day can phase-shift the circadian rhythm, as can excessive electric light during the night (Fontoynont, 2004). The most common disorder due to lack of daylight exposure is called seasonal affective disorder (SAD) (Ahmed, 2014).

There are so many external influences that the impact of lighting alone is hard to isolate, and can masked by uncontrolled variations in other influences. The reason for preference of windows in spaces is that they provide daylight, sunlight, ventilation, information about the passage of time and weather conditions and about events outside the building (Ahmed, 2014).

Research shows that, daylight is preferred over electric lighting and windows are valued for the space to increase visual and psychological stimulation (Boyce, 2003).

2.4.2 Psychological

Daylight, due to its changing nature throughout the day and in different seasons, has the capacity to create drama in spaces. Depending on the weather, daylight can create low-contrast (during overcast days) or high-contrast environments (during bright sunny days). In offices, those working close to windows are considered more privileged that those who do not have such access. Psychologically, those further away from daylight feel deprived of this right to natural light (Ahmed, 2014).

Working for a long time in architecture design studio needs sufficient daylight penetration in sense of Cortisol, known also as the 'stress hormone,' is a corticosteroid hormone produced by the adrenal cortex. It follows a diurnal pattern with high values during the day and low values at night (Hollwich, 1979; Scheer, 1999).

2.4.3 Physiological

Light affects individuals' bodies in two ways. In the first, light impinges on the retina of human eyes and, through vision system, affects metabolism, endocrine and hormone systems. In the second, it interacts with body skin by way of photosynthesis and produces vitamin D (Boubekri, 2008).

Studies show that, ultra-violet rays have proved to be essential to man and when most of the daylight hours have to be spent indoors, provision must be made to supply the ultra-violet rays indoors (Ahmed, 2014). This can be achieved most economically by providing daylighting, but its effects on humans is found to be beneficial, making daylight indispensable for mental and physical well-being. Ultra-violet rays of a certain range can also be the cause for skin cancer, but at the lower latitudes that range is largely screened out from sunlight by the outer atmosphere (Ahmed, 2014). Studies indicate that monotonous lighting, while producing visual efficiency, is often associated with mental fatigue.

A window can convey the changing effects of daylight, every hour of the day, and so provides the inmate mental relief. In recognition of the importance of daylight for human health, in the Netherlands health regulations forbid buildings where staff sit further than 6m away from a window (Muneer, 2000). Vertigo is a common ailment of inmates of buildings without external windows and these occupants soon lose time and weather condition (Ahmed, 2014).

2.4.4 Energy savings

The most obvious vehicle for energy saving in buildings is in exploiting the most abundant source of light available to human - daylight (Philips, 2004). Many building owners and architects have reported energy savings received from daylighting.

Looking at the energy consumption of commercial buildings in the United States demonstrates the importance of saving energy.

According to the Commercial Buildings Energy Consumption Survey (CBECS), educational buildings used 649 trillion Btu of total energy, which is 11 percent of total energy consumption for all commercial buildings (EIA, 2003). Much of a school's energy budget is for lighting. This can be greatly reduced with well-designed natural lighting (DQLSL, 2007). A reduction in the energy consumption of a building can be achieved by decreasing the need for, or use of artificial light (Sharmin, 2011).

Reduced peak electricity demand is a major benefit for buildings that experience their greatest load during daylight hours. Cooling loads can also be reduced in buildings occupied during daylight hours, since daylight provides more energy as visible light and less as heat, compared to electrical lighting (Robertson, 2002). For example, at a given level of illumination, a tungsten light produces between 5 and 14 times more heat than daylight (Baker, 2000). The energy savings from reduced electric lighting through the use of daylighting strategies can directly reduce building cooling energy usage an additional 10 to 20 percent. Consequently, for many institutional and commercial buildings, total energy costs can be reduced by as much as one third through the optimal integration of daylighting strategies (Ander, 1986). Given the current strong dependence on fossil fuels for electricity generation, any reductions in the consumption of electricity for lighting and cooling can ultimately lead to the lower production of greenhouse gas emissions (Sharmin, 2011).

2.4.5 Productivity

The use of natural light in buildings can increase productivity of the occupants of buildings and therefore positively impact on the finances of an organization (Heschong, 2003). The first study on schools was performed in three districts in the USA. The Heschong-Mahone research team (1999) analyzed standardized math and reading test scores of more than 21,000 elementary school students from the three districts of Orange County, CA, Seattle, WA, and Fort Collins, CO for over one year. California students with the most daylighting showed a progress of around 20-26 percent in their test scores over the entire year, while Seattle and Fort Collins students reported an increase of 7-18 percent at the end of the year (HMG, 1999).

Another study based itself on the earlier daylighting and student performance studies conducted by the Heschong-Mahone research team. Using multiple regression analysis, more than 8,000 students from 450 classrooms were analyzed in their academic performance (HMG, 2002). A detailed analysis was also made of the effect of factors such as indoor lighting, windows, views and other room factors on the student performance. Pleasant views from windows were found to affect students positively, whereas glare, direct sun penetration, and negligence to window control and shading were found to affect student performance in a negative manner. The two studies by the Heschong Mahone Group are significant in establishing that daylighting has a direct effect on student performance (Sharmin, 2011).

The study by Dunn et al. (1985) reviewed past research and literature on the effect of lighting on student performance and character, and confirmed the fact that good lighting (daylighting and artificial) can contribute immensely to the psychological and physical well-being of a student. Students were shown to achieve better when tested in rooms with the required foot-candles of light, in contrast with their scores in low, dimly lit rooms (Dunn, 1985).

Heerwagen and Heerwagen (1984) suggested "It was reasonable to expect that windowless environments may be more stressful and psychologically uncomfortable than windowed spaces" (Heerwagen, 1984). 350 students from northern England primary schools were studied by Stewart for their behavior and attitudes towards their visual environment, with particular attention to factors associated with fenestration and daylight in the schools. It was seen that more than 70 percent of the children chose to sit close to the windows (if given a free choice), thus preferring higher daylight levels (Stewart, 1981).

2.5 Factors Influencing Daylight Penetration

Influencing factors for daylight penetration in the interior space is presented in this section.

2.5.1 Window size and placement

The amount of light that penetrates a room depends upon the window orientation, size and glazing characteristics. The distance that adequate daylighting will penetrate into a room depends upon window size and location on the wall (Robertson, 2002) (Figure 2.3). On the other hand, window size should be controlled to protect the room from excessive daylight penetration, which may create glare (Muneer, 2000).

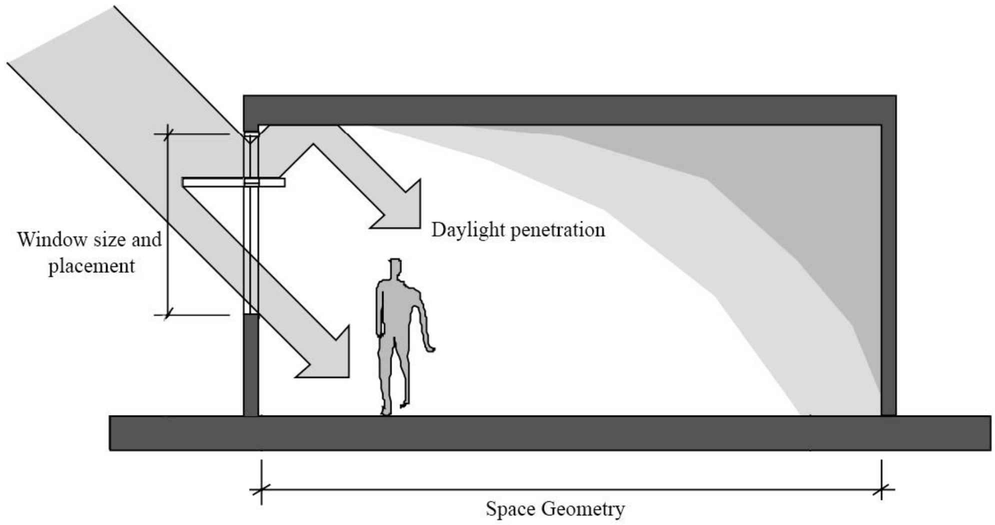


Figure 2.3: Factors influencing daylight penetration in a room (Source: Robertson, 2002)

2.5.2 Space geometry

The influence of the size and proportion of a space, i.e. the space geometry is one of the key factors for daylighting (Figure 2.3). As internal reflected component (IRC) is highly dependent on surfaces near the task, therefore towards the center of large rooms, the ceiling becomes and important contributor to daylight, while in spaces near walls, the vertical surfaces gain in importance (Ahmed, 2014).

2.5.3 Obstructions

The presence of obstructions outside a window can severely limit the entry of daylight. In rough calculations for external reflected component (ERC), it was found that the same area of sky lets in 10 times more light if unobstructed than if obstructed (Ahmed, 2014) (Figure 2.4).

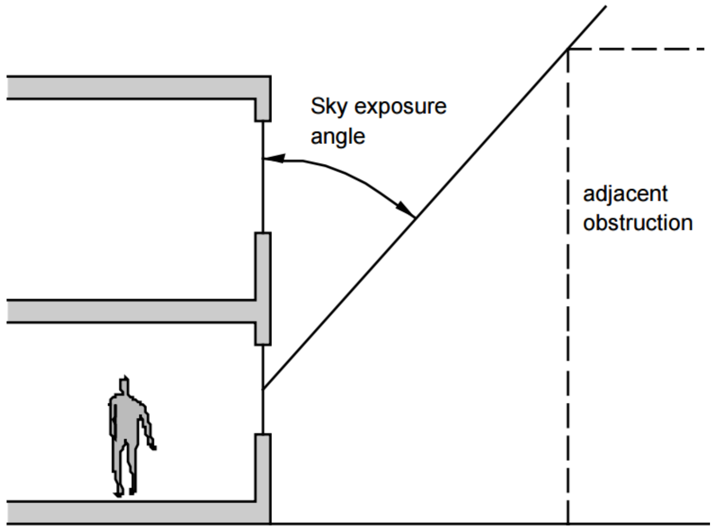


Figure 2.4: Sky exposure angle (Source: Robertson, 2002)

The sky exposure angle from a point in an existing building can be used to determine the maximum building height and setback required for a new project to allow adequate light to reach existing buildings (Robertson, 2002).

2.5.4 External and internal shading devices

Devices used on the windows for shading influence daylight penetration, as it can significantly cut off sky view and act as obstructions. Horizontal shading curtails more daylight that vertical ones when high altitude sky is excluded (Ahmed, 2014). Having done all the calculations for ensuring adequate daylight penetration in a space, it may still have inadequate light because of internal shading options which are not considered during the prediction phase. This may be in the design of the internal blinds and curtains (Robertson, 2002). Solar control is necessary in most buildings for reducing discomfort glare from windows.

2.6 Window-to-Wall Ratio (WWR) and Glare

Window-to-wall ratio is the ratio of the window area to the gross exterior wall area (CEC, 2013). On the other hand, glare is the excessive brightness contrast within the field of view. Inappropriate size of windows may give rise to glare (Muneer, 2000). The appropriate proportions of window to external wall reduce cooling loads and increase thermal comfort considering solar radiation during the summer period

(Alibaba, 2016). Boubekri and Boyer (1992) studied the effect of window size on sunlight presence and glare and noted that the discomfort glare of sunshine can compete with the positive psychological effects of sunlight. Window size accounts for less than 30% of variation in perceived glare (Boubekri, 1992). Figure 2.5 shows that perceived glare rises from 1.4 to 4.7 as the window area increases from 20% to 50% of the wall area, and then decreases as the window size increases beyond 50%.

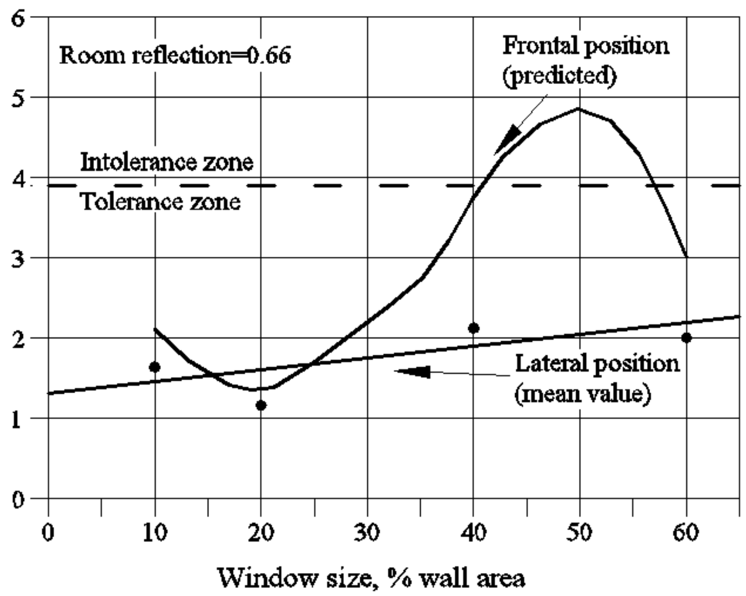


Figure 2.5: Influence of window size on glare. (Source: Boubekri, 1992)

The occupant experiences discomfort when the perceived glare value rises above a value of 4. Perceived glare is in the tolerable range, except when the window size is 40—55% of the wall area (Muneer, 2000). The basic features of widow sizes and glare conditions are as following.

- Small windows - glaring source is small and perceived sensation is not disturbing.
- Medium windows - a high contrast between glare source and surrounding adjacent wall leads to a higher perceived glare level.
- Large windows - though the glare source is large, the contrast between the source and the surroundings is small, raising the adaptation level of the eye and reducing the glare sensation and the level of discomfort.

2.7 Daylighting Strategies for Windows

Daylight has two components: sunlight, where the source is the sun, and skylight, where the source is the sky (Boubekri, 2008). Daylighting strategies may be divided into two groups. The first includes side-lighting systems, where light is brought from the sides of a building into the interior space. A window is the simplest example of that strategy. The second group includes top-lighting systems, where light is brought from the top of a building and distributed into the interior (Boubekri, 2008).

Window as side lighting system, can be said as the most important architectural feature of a building; this is the first experience that a visitor will have when seeing the building for the first time, and architects have naturally considered the form of the window and its relationship to the exterior to be vital (Joarder, 2007). Because the design of windows has a decisive effect on the potential daylight and thermal performance of adjacent spaces, it needs to be checked very carefully (O'Connor, 1997; IEA, 2000). A window of a given size will provide the most daylight deep in a space when it is located as high as possible on the wall (Figure 2.6).

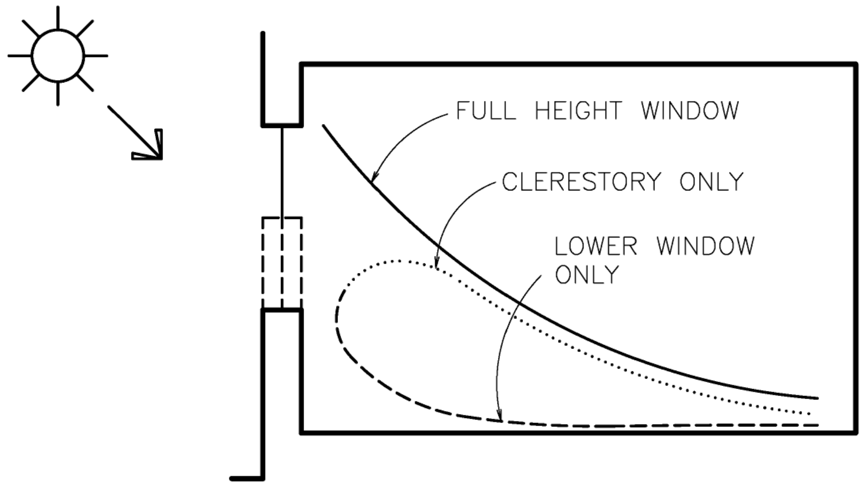


Figure 2.6: Relative indicators of light levels with different apertures. (Source: A. G. S., 2000; cited from Joarder, 2008)

Narrow windows at sufficient height may often provide more light than wide windows at lower levels (Ahmed, 2014). Deeper spaces need larger windows to provide more light but larger windows have other drawbacks (Joarder, 2008). The uniformity ratio between the daylight level in the front and back of a room becomes larger as the room becomes deeper and should not exceed a ratio of 10:1 (A.G.S. 2000).

A splayed window reveal will reduce glare and ease the transition from bright exterior to darker interior. Distribution of daylight in a space can be greatly improved if it is introduced from multiple apertures - for example, windows on two sides of a space, or windows and clerestories, or windows and skylights (Figure 2.7). Whether to use side-lighting or top-lighting, daylighting strategies should be decided during a building's conceptual design stage (IEA, 2000).

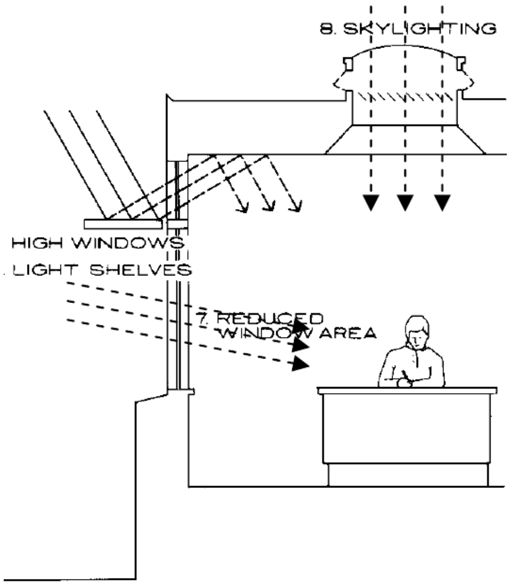


Figure 2.7: Distribution of daylight in a space from multiple apertures. (Source: A. G. S., 2000; cited from Joarder, 2008)

The following part of this section will discuss about daylighting strategies based on side lighting system.

2.7.1 Side Window

Side windows include view and non-view elements, that is, windows and clerestory, respectively. Traditional side windows tend to produce overly lit areas near the window and dimmer conditions elsewhere, especially if the room is deep (Sharmin, 2011).

The light distribution differs depending on sky conditions. Overcast skies provide a deeper penetration of diffuse daylight than clear skies; the shadows are, however, much softer and glare tends to be more severe because the sky is brighter (Robbins, 1986). In addition to sky conditions, factors that influence the spread and depth of daylight penetration include the orientation of the window, the location of the window within the wall and in relation to the rest of the room, the effective height of the window (from the bottom to the upper limit of the window), and its width (Sharmin, 2011). An overall consensus suggests that the depth of the 'useful' daylit area ranges between 1.5 and 2.0 times the head height of the window (Figure 2.8) (Boubekri, 2008).

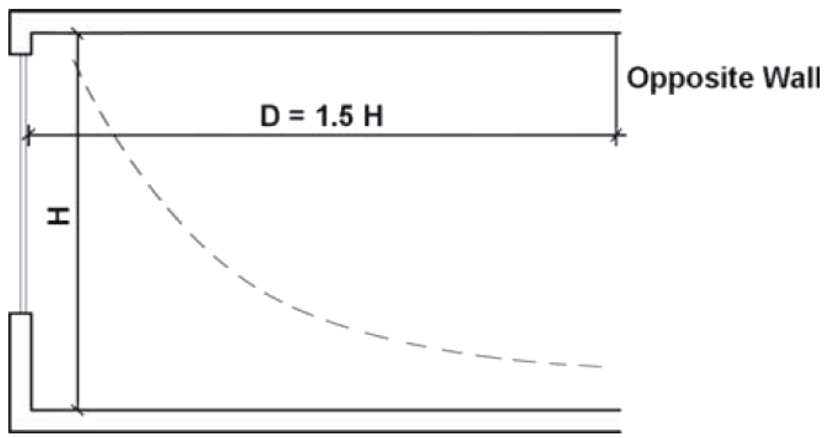


Figure 2.8: The effective depth (D) of daylight penetration from a side window as factor to window height. (Source: Boubekri, 2008)

A single side window may cause high discomfort glare because of the contrast between the brightness of the window and the darker background surrounding the window aperture. A more balanced daylight distribution may be obtained by bringing daylight from two different side walls, resulting in a deeper, more balanced daylight distribution and a reduction in glare (Boubekri, 2008).

2.7.2 Clerestory Window

A clerestory is usually contained in a part of the buildings that rises clear of the roof. It is also a side window but one that is placed high in the wall. Generally, it does not provide views towards the exterior but permits a deeper penetration of daylight into the room than a standard side window (Figure 2.9) while giving little glare discomfort to the occupants of the room.

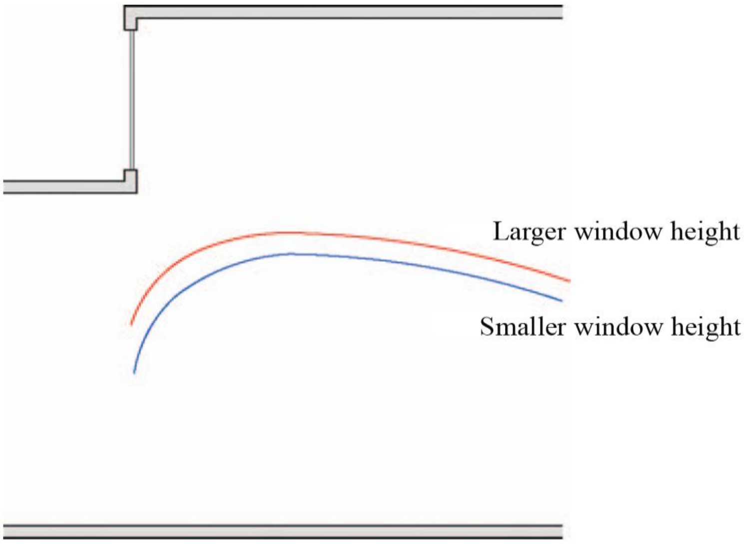


Figure 2.9: Daylight penetration pattern with a clerestory window. (Source: Boubekri, 2008; cited from Sharmin, 2011)

Similar to a standard side window, a south-facing clerestory will produce higher daylight illumination than one that faces north (Sharmin, 2011). East- and west-facing clerestories present the same problems as east and west windows: difficult shading and potentially high heat gains; however, sunlight penetration in the case of clerestories may not be as problematic as with standard side windows because the aperture is outside the field of view. The depth of the daylight zone depends on the mounting height of the clerestory (distance from the floor to the bottom of the aperture) and the width and length of the clerestory itself. The higher the mounting height, the deeper the daylight zone (Boubekri, 2008).

2.7.3 Combined side-systems

Combined side-systems that include a side window and a clerestory will provide a more balanced distribution of daylight than does a typical side window or a clerestory window alone. Since daylight levels are additive, the daylight distribution from the side window with that from a clerestory window can be combined (Figure 2.10) (Sharmin, 2011).

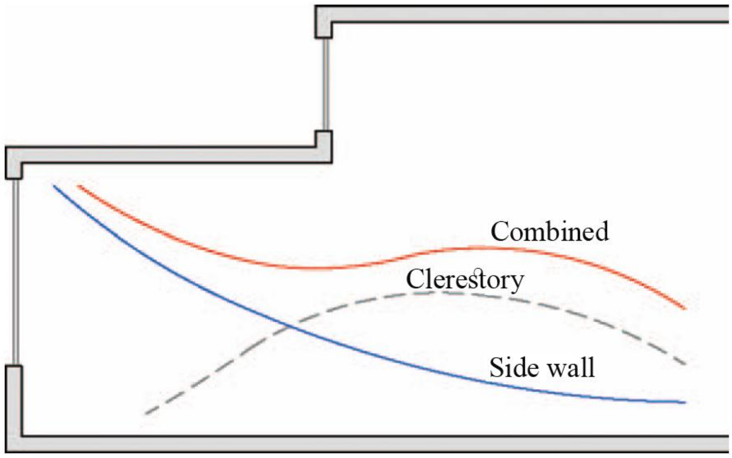


Figure 2.10: Daylight penetration resulting from the combination of a vertical clerestory and a side window. (Source: Boubekri, 2008; cited from Sharmin, 2011)

2.7.4 Light-shelf systems

A light-shelf is a device designed to capture daylight, particularly sunlight, and redirect it towards the back of the room by reflecting it off the ceiling (Figure 2.11, 2.12 and 2.13). As a result, this strategy can lead to a more even distribution of light throughout the room than is found in a room with only a side window (Boubekri, 2008).

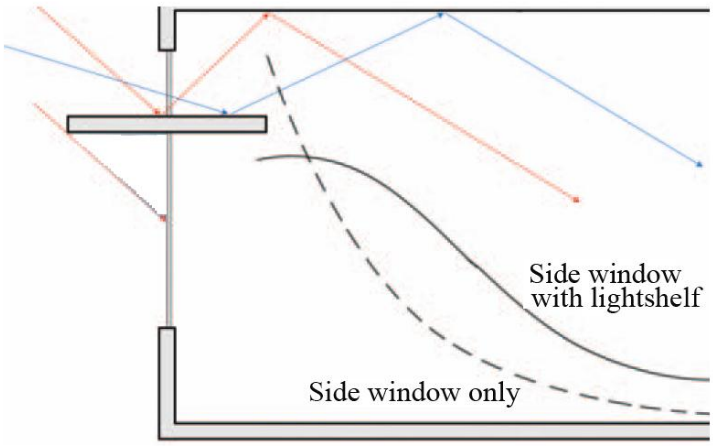


Figure 2.11: Daylight penetration from a combined light-shelf system. (Source: Boubekri, 2008)

A light-shelf divides the window into a lower part that mainly serves the role of providing a view and an upper window that serves to redirect the daylight towards the back of the room away from the window plane. As a by-product, a light-shelf can also provide shade from direct sunlight and reduce glare from the sky (Sharmin, 2011).

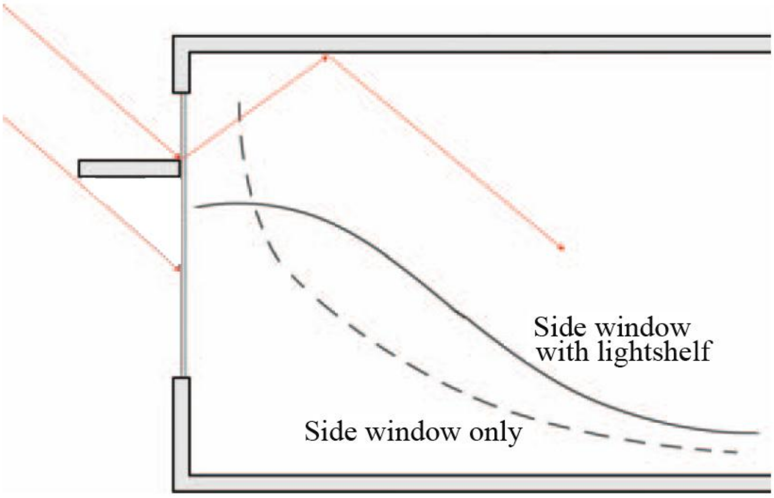


Figure 2.12: Daylight penetration in a room with an exterior light-shelf. (Source: Boubekri, 2008; cited from Sharmin, 2011)

A light-shelf works best under sunlight conditions. The upper surface of the shelf is made of a highly reflective material to maximize reflection; it should not, however, be made of a specular (highly polished) surface, in order to prevent glare and shiny spots on the ceiling. Semi-specular surface materials are recommended.

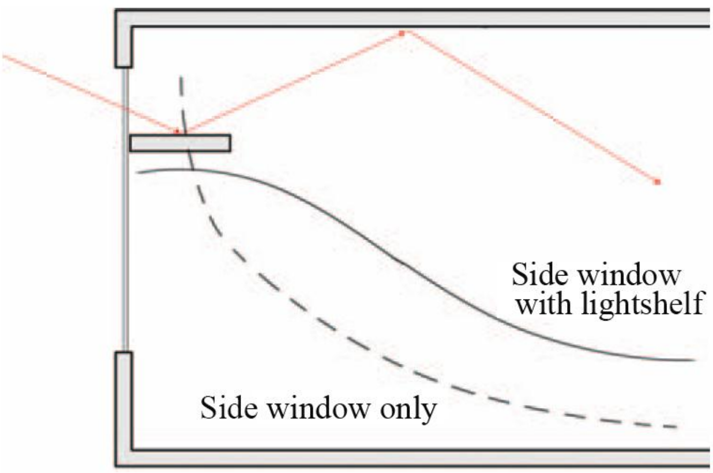


Figure 2.13: A comparison of daylight penetrations from a standard window and one with an interior light-shelf. (Source: Boubekri, 2008; cited from Sharmin, 2011).

The design of a light-shelf should be integrated with the fenestration of the building and planned during the early design stages. Its size and depth depend on window size and façade orientation. A light-shelf may be combined (Figure 2.11), exterior only (Figure 2.12), or interior only (Figure 2.13). Exterior light-shelves are more effective in providing shade than interior ones but reflect less light towards the back of the room (Boubekri, 2008).

2.7.5 Louvre systems

Louver systems are designed to capture sunlight falling in the front of the room and redirect it towards the back, thereby increasing daylight levels in the back of the room and reducing them in the front (Figure 2.14). Similar to the light-shelf system, the louver system works optimally under sunlight conditions.

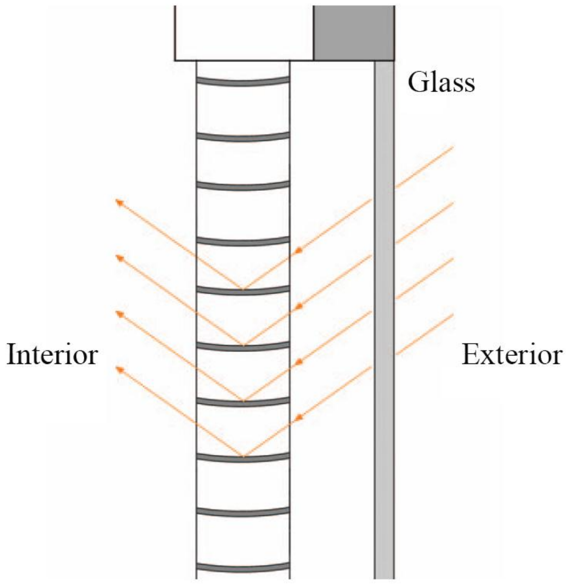


Figure 2.14: Light-redirecting louver system. (Source: Boubekri, 2008)

Louvers can be designed to be static or dynamic. In the latter case they are automatically controlled to follow the sun’s movement in the sky. On a daily and seasonal basis, automated louvers tend to perform better than static ones but require calibration and algorithms that need adjustment depending on the illumination needs of the building as well as the heating and cooling requirements in order to admit the right amount of sunlight (Boubekri, 2008).

2.7.6 Shading systems

Figure 2.15 shows some horizontal and vertical shading systems suitable for fenestration design.

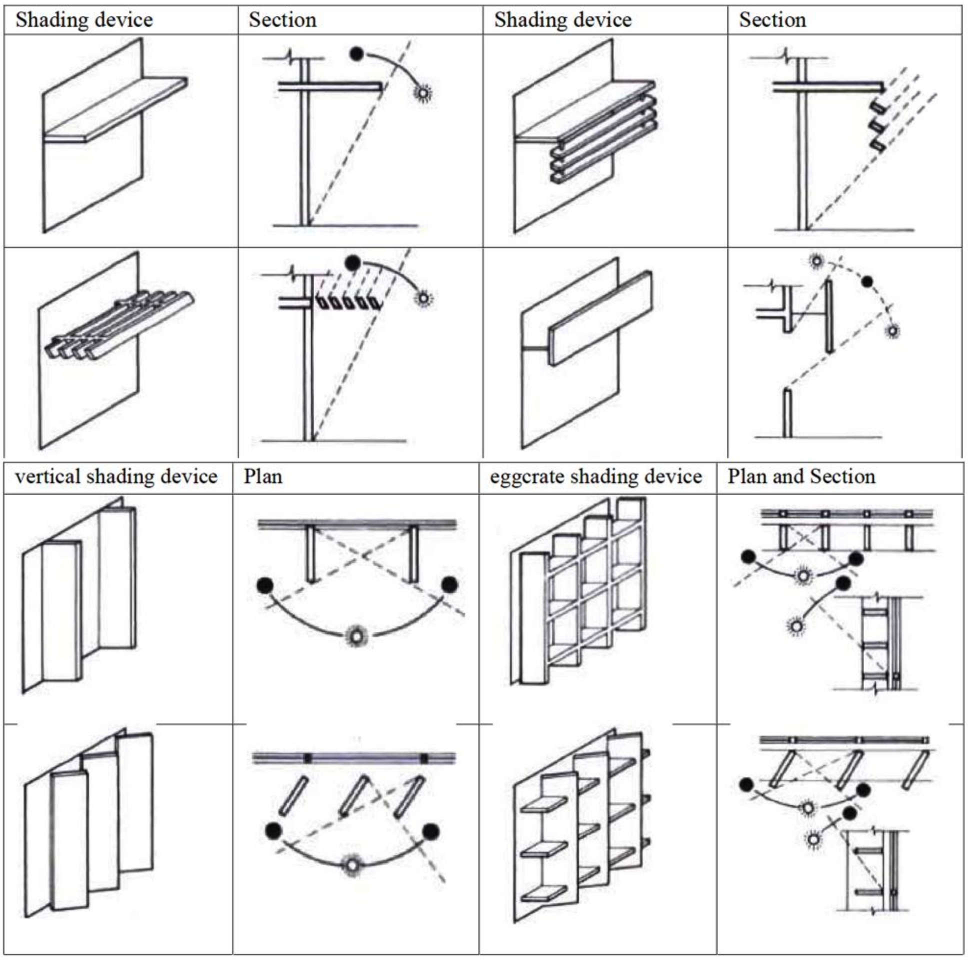


Figure 2.15: Horizontal and vertical Shading system. (Source: S. G. B.P., 2009; cited from Trisha, 2015)

Shading devices can be an integral part of shading the envelope. It is the most readily applicable and flexible method of controlling cooling loads. It can be applied in different climate types in which the sun's influence is significant, and for most of the modern buildings, irrespective of latitude (EC, 2000). Shading the glass, affects the quantity of incident solar radiation. Thus it influences both thermal, as well as, luminous performance (Trisha, 2015). East- and west-facing windows are best shaded with vertical devices, but these shades are usually harder to incorporate into a building, and limit views from the window (Robertson, 2002).

2.8 Illumination Standards for Architecture design studios

This section presents different international and Bangladeshi local standards on illumination condition of Architecture design studios.

2.8.1 International standard

Study shows that, buildings e.g. office, school and industry use 40% of the total consumed energy for lighting (Lechner, 2001). Local authorities of different countries are trying to address legislation focusing on standards of proper lighting to reduce the energy consumption. Daylighting standards vary from one country to another (Julian, 1998), based on the requirements of different aspects necessary for a building design such as quality of indoor illumination inside a room, windows and their sizes. The most frequently used legislation that relates to daylighting is the requirement for specific window sizes for various types of spaces (Boubekri, 2008). When it comes to the standards for daylight in schools, most conventional codes prescribe minimum or maximum levels for window properties or allow the designer to meet performance goals (Sharmin, 2011).

The codes in European countries go as far as to prescribe a minimum window size and daylight factor as well as ensuring that the windows are positioned in such a way to provide a view for the occupants, and to reduce the brightness to the interior (which can cause glare) (Ruck, 2000). In England, the British Code BR 8206 recommends that windows be, at a minimum, 20% of the external window wall for rooms measuring less than 8 meters in depth and 35% of the external wall for rooms deeper than 14 meters (DOA, 1971). For institutional buildings, classroom window size was specified as 20% of the area of the window wall (Wotton, 1981). In the United States, the Building Official Code Administrators (BOCA) specifies that every room or space intended for human occupancy should have an exterior glazing area of not less than 8% of the total floor area. Where natural light for rooms and spaces is provided through an adjacent room, the opening within the wall separating these two spaces must be no less than 8% of the total floor area of the room (BOCA, 1990). In Japan, regulations for the size of windows apply only to buildings with continuous occupancy such as houses, schools, or hospitals (Koga, 1998). According to Koga and

Nakamura, article 28 of the Japanese building code stipulates that habitable rooms in continuous occupancy buildings should have window sizes no less than 14% or l/7th of the total floor area of the building and between 20% and 40% of the floor area in other types of buildings (Koga, 1998).

The Illuminating Engineering Society of North America (IESNA) has recommended a design procedure which incorporates four steps: defining visual tasks in the proposed design, selection of illuminance category, determining the amount of lighting required, and establishing a target illuminance value for design (IESNA, 2000). It has established a set of minimum recommended illuminance levels for a variety of visual tasks and space functions. In 1979, IESNA established nine illuminance categories. Those have later been reduced to seven categories and organized into three sets of visual tasks with a set of minimum recommended illuminance levels (IESNA, 2000). Table 2.1 presents the IESNA recommended target light levels for three sets of visual tasks.

Table 2.1: Three sets of visual tasks and their recommended illuminances established by IESNA (Source: IESNA, 2000; cited from Iqbal, 2015).

Categories			**Illumination**
Orientation and simple visual task	A	Public spaces	30 lux (or 3fc)
	B	Simple orientation for short visit	50 lux (or 5 fc)
	C	Working space where simple visual task are performed	100 lux (or 10 fc)
Common visual task	A	Performance of visual task of high contrast and large size	300 lux (or 30 fc)
	B	Performance of visual task of high contrast and medium size	500 lux (or 50 fc)
	C	Performance of visual task of low contrast or small size	1000 lux (or 100 fc)
Special visual task	A	Performance of visual task near threshold	3000-10,000 lux (or 300-1000 fc)

2.8.2 Local standard

The 'Bangladesh National Building Code 2006' (BNBC) is a national level legally binding document which forms the basis for standards of design, construction and maintenance of buildings in the country. For the capital city of Dhaka, the ‘Rajdhani Unnayan Kartripakhya’ (RAJUK) is the planning authority which specifies regulations set forth in a document titled ‘Bangladesh Gadget 2008’, regarding different types of buildings based on the BNBC (Sharmin, 2011). Exterior window area, in a room used for residential or commercial purposes, shall not be less than 15 percent of the floor area for proper daylighting and natural ventilation (BG, 2008). On the other hand, Bangladesh National Building Code 2006 (BNBC) follows a set of minimum recommended illuminance levels for a variety of visual tasks and space functions for educational buildings (Table 2.2). The guidelines for consideration of the brightness ratio in design studios are illustrated in Table 2.3.

Table 2.2: Recommended values of illumination for Educational Building (BNBC, 2006; cited from Sharmin, 2011).

Area of Activity	**Illumination** [lux]
Class and Lecture Rooms	
Desks	300
Black boards	250
Art Rooms	400
Assembly Halls	
Examination	300
Corridors	70
Stairs	100

Table 2.3: Recommended brightness ratio at table top between task, adjacent source and surroundings (BNBC, 2006, Section 3.2.1).

Recommendation	**Requirement**	**Reference**
Recommended brightness	100cd/m^2	(BNBC 2006:3.2.1,p.11207)
Brightness ration: for high task of work brightness	3 to 1	(BNBC 2006:3.2.1,p.11207)
Maximum ratio between work area and any remote area	10 to 1	(BNBC 2006:3.2.1,p.11207)
Overall average illumination level	150 lux	(BNBC 2006: Table 1.3.2)

In a study on the preference of daylight illumination in Architecture design studios in a tropical city i. e. Dhaka, Shimu (2015) shows that, the students of Architecture in Dhaka prefer to work in the studio at illumination level between 200 lux to 500 lux. In the experiment, author selected ten drafting tables according to ten different lighting levels and 50 students voted for each lighting level conforming to the preference level. Table 2.4 shows the illumination level and student's preference level, where preference levels were considered as: inadequate, little less, adequate, little more and excessive with the representing value of -2, -1, 0, +1 and +2.

Table 2.4: Illumination level and student's preference level (50 students) (Shimu, 2015).

Illumination Level Range [Lux]	**-2**	**-1**	**0**	**1**	**2**
0 < 100	42	8	0	0	0
100 < 200	38	10	2	0	0
200 < 300	**0**	**8**	**42**	**0**	**0**
300 < 400	**0**	**2**	**48**	**0**	**0**
400 < 500	**0**	**0**	**38**	**10**	**2**
500 < 600	0	0	30	15	5
600 < 700	0	0	28	17	5
700 < 800	0	0	25	15	10
800 < 900	0	0	10	18	22
900 < 1000	0	0	0	15	35

2.8.3 Daylight factor-based standards

Commonwealth Association of Architects recommended a minimum Daylight Factor (DF) of 2% in 75% of all spaces occupied for critical visual tasks (CSIR, 2006; Ahmed, 2011). DF-based legislation does not target a specific daylight illuminance level in a room because of constantly changing outdoor conditions; rather, it is based on a percentage of whatever daylight is available outside and therefore is more practical than illuminance-based legislation. An example of such legislation can be found in a few countries (Boubekri, 2008). In France, the Cahier des Recommendations Techniques de Construction (Ministere d'Education) recommends a minimum OF in classrooms of 1.5% under overcast sky conditions (MDE, 1977). Table 2.5 summarizes the important codes and standards for lighting in classrooms that have been developed over the years. The chronology suggests that daylighting regulations and standards have evolved more quickly since the early 1980s (Sharmin, 2011).

Table 2.5: Chronology of important codes and standards (Source: Jackson, 2006).

Code	Year	Country	Recommendations for Daylighting in Classrooms (Wu & Ng, 2003, pp.111)
The London Building Act	1894	Britain	One-fifth the floor space for vertical lights in classrooms. Recommended illuminances in classrooms is 91 Lux.
British Standards Codes of Practice	1945	Britain	Minimum 2% daylight sky factor in classrooms, and 5% sky factor where possible.
IES Lighting code	1955	Britain	The level of maintained illuminance and the daylighting factor In classrooms should not be less than 100 Lux and 2%, respectively.
Statutory Instrument	1959	Britain	2% minimum daylight factor in any area normally used as teaching accommodation (Boyce, 1981).
CIBS Lighting Code	1977	Britain	Minimum illuminance on the working plane should not be less than 300 Lux.
The Education (School Premises) Regulations	1981	Britain	Daylight illuminance of not less than 300 Lux, for it to be adequate for the task. With a combination of artificial and natural lighting a minimum of 350 Lux should be achieved.
Building Code of Australia	1990	Australia	Windows must be provided with a total area that is not less than 10 percent of the floor area of the room (Osterhaus and Donn, 1998, pp. 3).
Australian Standard 1680.1	1990	Australia & New Zealand	Maximum glare index value of 19. Standard. Where it is possible to provide daylight through the working hours, should provide no less than 200 Lux (Standards Australia, 1990, pp. 37 & 60)
Guidelines for Environmental Design in School	1997	Britain	School premises should have a minimum of 300 Lux on the working plane. Whenever possible, a daylight in School factor of 4-5% should be reached in a daylit space.

2.8.4 Design illumination level for Architecture design studios

The comparison between different international and national standards on illumination level in Architecture design studios is presented in Table 2.6.

Table 2.6: Comparison between national and international standards on illumination level in Architecture design studios.

Standards	**International Standards (IESNA, 2000)**	**Local Standards (BNBC, 2006)**
Minimum illumination level at work plane (lux)	300	300
Maximum illumination level at work plane (lux)	500	-

For this research, the preferred illumination level at design studio (for drafting, drawing, model making, presentation) work plane is considered as 300 lux (BNBC, 2000) and the illumination level on work plane should not exceed 500 lux (Sharmin, 2011).

2.9 Factors Affecting Human Thermal Comfort

The variables that affect heat dissipation from the body (thus also thermal comfort) can be grouped into three sets as shown in Table 2.7 (Auliciems, 2007).

Table 2.7: Factors affecting thermal comfort (Shajahan, 2012)

Personal	**Environmental**	**Contributing factors**
Metabolic rate	Air Temperature	Food and drink
Clothing	Relative Humidity	Acclimatization
	Wind Speed	Body shape
	Radiation	Subcutaneous fat
		Age and gender state of health

Six factors should be taken into consideration when designing for thermal comfort shown in Figure 2.16 (Faludi, 2016).

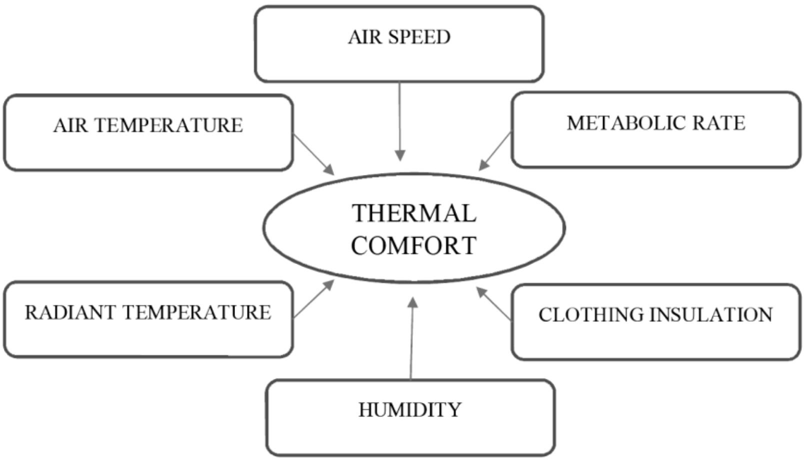


Figure 2.16: Factors governing thermal comfort.

2.9.1 Metabolic rate

According to American Society of Heating, Refregerating and Air-Conditioning Engineers (ASHRAE) (2004), Metabolic rate is defined in a medical dictionary as, Metabolism per unit time especially as estimated by food consumption, energy release as heat, or oxygen used in metabolic processes. Thermal comfort is related to the body's thermoregulatory system where the heat exchanges between the human body and its surrounding maintain deep body temperature at 37°C and skin temperature within the range of 28°C to 34°C (Mallick, 1994). The skin temperature of humans should always be at a lower temperature than the deep body, and the environment temperature should be below the skin temperature, in order to allow adequate heat dissipation (Tariq, 2014).

Thermal comfort is calculated as a heat transfer energy balance. Heat transfer through radiation, convection, and conduction are balanced against the occupant's metabolic rate. The heat transfer occurs between the environment and the human body, which has an area of approximately 19 ft^2 (1.81 m^2). If the heat leaving the occupant is greater than the heat entering the occupant, the thermal perception is "cold." If the heat entering the occupant is greater than the heat leaving the occupant, the thermal perception is "warm" or "hot" (Karanen, 2016). In warm climates, when thermal discomfort due to heat is felt with the increase of metabolic rate, requirement of lower skin temperature is increased (Givani, 1989; Ahmed, 1995). Table 2.8 shows some typical metabolic rates, which can be expressed as power density per unit body surface area (W/m²), as the power itself for an average person (W) or in a unit devised for thermal comfort studies, called the met, 1 met = 58.2 W/m², the basal metabolism (Tariq, 2014).

Table 2.8: Metabolic rates at different activities (Shajahan, 2012).

Activity	met	w/m^2	W (av)
Sleeping	0.7	40	70
Reclining, lying in bed	0.8	46	80
Seated, at rest	1.0	58	100
Standing, sedentary work	1.2	70	120
Very light work (shopping, cooking, light industry)	1.6	93	160
Medium light work (house~, machine tool ~)	2.0	116	200
Steady medium work (jackhammer, social dancing)	3.0	175	300
Heavy work (sawing, planning by hand, tennis) till	6.0	350	600
Very heavy work (squash, furnace work) up to	7.0	410	700

Temperature sensations depend mainly on the activity of thermo-receptors in the skin, whereas thermal comfort or discomfort, reflects a general state of the thermoregulatory system (Hensel, 1981). Age, gender, body composition, and acclimatization status can influence body temperature and energy expenditure (Tariq, 2014; Someren, 2002). In this research, metabolic rate of the students in architecture design studios was considered as 1.2 (Table 2.8).

2.9.2 Clothing insulation

Clothing has judged as one of the most powerful means of behavioral thermoregulation to attain comfort or neutrality (Parsons, 2003). Even the clothing adjustment was also found functional as a personal thermal comfort moderator and if combined with adaptive actions taken by the occupants it had a greater effect in reducing energy consumption in residential buildings (Newsham, 1997). Based on numerous research findings, International Organization of Standardization (ISO) have standardized estimation of the thermal insulation and evaporative resistance of clothing ensembles (ISO 9920 1995) (Shajahan, 2012) (Figure 2.17). Table 2.9 gives the clo-values of various pieces of garments.

Figure 2.17: Insulation of clothing in clo units (Source: Shajahan, 2012)

Table 2.9: Insulating value of clothing elements (Based on ASHRAE, 1985; cited from Auliciems, 2007).

Man		**clo**	**Woman**		**clo**
Underwear	Singlets	0.06	Underwear	Bra+panties	0.05
	T-shirt	0.09		Half slip	0.13
	Briefs	0.05		Full slip	0.19
	Long, upper	0.35		Long, upper	0.35
	Long, lower	0.35		Long, lower	0.35
Shirt	Light, short sleeve	0.14	Blouse	Light	0.20
	Light, long sleeve	0.22		Heavy	0.29
	Heavy, short sleeve	0.25	Dress	Light	0.22
	Heavy, long sleeve	0.29		Heavy	0.70
Vest	Light	0.15	Skirt	Light	0.10
	Heavy	0.29		Heavy	0.22
Trousers	Light	0.26	Slacks	Light	0.26
	Heavy	0.32		Heavy	0.44
Pullover	Light	0.20	Pullover	Light	0.17
	Heavy	0.37		Heavy	0.37
Jacket	Light	0.22	Jacket	Light	0.17
	Heavy	0.49		Heavy	0.37
Socks	Ankle length	0.04	Stockings	Any length	0.01
	Knee length	0.10		Panty-hose	0.01
Footwear	Sandals	0.02	Footwear	Sandals	0.02
	Shoes	0.04		Shoes	0.04
	Boots	0.08		Boots	0.08

In hot humid environmental conditions, the thin clothing enhances evaporative heat loss by acting as a mesh and also allowing wind action directly to the skin (Ahmed, 1995). Unit clo is the insulating value of a normal business suit, with cotton underwear; shorts with short-sleeved shirts would be about 0.25 clo, heavy winter suit with overcoat around 2 clo. Light summer cloth having a clo value of 0.35-0.5 is common in tropical environments (Auliciems, 2007).

2.9.3 Air temperature

Air temperature is one of the most important environmental factors, measured by the dry bulb temperature (DBT in degree Celsius). It is the main criterion of human comfort. This will determine the convective heat dissipation, together with any air movement. In the presence of air movement, the surface resistance of the body (or clothing) is much reduced (Mridha, 2002; Shajahan, 2012).

2.9.4 Wind speed

Wind speed is measured by its velocity (v, in m/s) and it also affects the evaporation of moisture from the skin, thus the evaporative cooling effect. In naturally ventilated buildings, natural wind is needed to serve at least two purposes. Firstly, it is required in providing fresh air for healthier indoor environmental conditions. Secondly, it assists in providing thermal comfort for the occupants.

When the temperature and humidity is relatively more difficult to modify, indoor air motion (wind) plays an important role by creating direct physiological cooling. Some researchers explored the potential of wind driven natural ventilation to create indoors thermal comfort (Ahmed, 1987; Chandra, 1987; Ernest, 1991). Natural ventilation is found not only to effectively contribute to the occupant’s thermal comfort but also to reduce overall cooling load and thus save energy (Ernest, 1991; Aynsley, 1999). Comfort zone indicates the influence of airflow in increasing the tolerance to higher relative humidity (Mallick, 1994; Ahmed, 1995).

Under everyday conditions, the average subjective reactions to various velocities are shown in Table 2.10 (Auliciems, 2007). These human responses depend on the air temperature. Under hot conditions, 1 m/s is pleasant and indoor air velocities up to 1.5 m/s are acceptable (Auliciems, 2007; Tariq, 2014).

Table 2.10: The average subjective reactions to various wind speed (Auliciems, 2007).

Speed (m/s)	Subjective Reactions
< 0.25	Unnoticed
0.25-0.50	Pleasant
0.50-1.00	Awareness of air movement
1.00-1.50	Draughty
> 1.50	Annoyingly Draughty

2.9.5 Humidity

Humidity of the air also affects evaporation rate as moisture content of the air is related to wetness of skin, which in turns affect comfort sensation (Mallick, 1994). This can be expressed by relative humidity (RH, %), absolute humidity or moisture content (AH, g/kg), or vapor pressure (p, in kPa).

In temperate climates (with moderate air temperatures of 15-25°C), humidity has little effect on thermal sensations for occupants under steady state conditions (i.e. when a person's stays in the same space for a long time), an increase of 10% in relative humidity will have the same effect as a mere 0.3°C rise in the air temperature (Goulding, 1992).

Under transient conditions (when a person moves from indoors to outdoors or from one space to another with a different humidity), the thermal effect of the change in humidity can be 2-3 times greater (Jitkhajornwanich, 1998). However, such tolerance can't be maintained in those situations, where high ambient temperature is associated with the higher range of relative humidity (Ahmed, 1995).

Studies show that an increase of 10% in relative humidity will have the same effect as 0.3°C rise in air temperature (Goulding, 1992). Moreover, a high level of humidity in the air increases temperature perception of humans, above the actual air temperature (Tariq, 2014) (Table 2.11).

Table 2.11: Impact of relative humidity on sensed temperature (Heinen, 1994).

Relative Humidity (%)	**Air Temperature (°C)**						
	21.1	**23.9**	**26.7**	**29.4**	**32.2**	**35.0**	**37.8**
0	17.8	20.6	22.8	25.6	28.3	30.6	32.8
10	18.3	21.1	23.9	26.7	29.4	32.2	35.0
20	18.9	22.2	25.0	27.8	30.6	33.9	37.2
30	19.4	22.8	25.6	28.9	32.2	35.6	40.0
40	20.0	23.3	26.1	30.0	33.9	38.3	43.3
50	20.6	23.9	27.2	31.1	35.6	41.7	
60	21.1	24.4	27.8	32.2	37.8	45.6	
70	21.1	25.0	29.4	33.9	41.1		
80	21.7	25.6	30.0	36.1	45.0		
90	21.7	26.1	31.1	38.9			
100	22.2	26.7	32.8	42.2			
	←— **Sensed Temperature (°C)** —→						

2.10 Impact of Windows on Thermal Comfort

Windows are the weakest point in a building, regarding energy efficiency and thermal resistance. Window should not emit all energy out or welcome heat onto the buildings, by inserting more glass panes and inert gases between the panes to obtain the greatest thermal resistance possible (Karanen, 2016).

Formula to measure total thermal resistance of a window:

$$R_{tot} = R_{conv1} + R_{glass} + R_{conv2} = R_i + \frac{L}{kA} + R_o$$

Where R_{tot} is the total thermal resistance, R_{conv} is the convection resistance, R_{glass} is the resistance for the glass. R_i is the inner convection resistance, L is the thickness of the glass, k is the conductivity for glass, A is the area and R_o is the outer convection resistance (Figure 2.18).

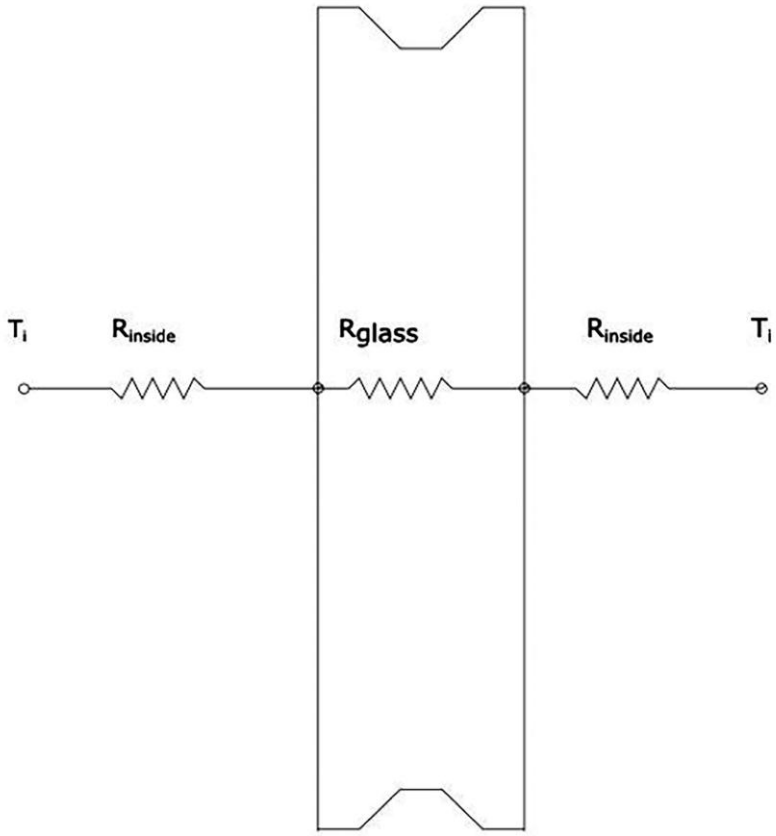


Figure 2.18: Illustrated Thermal resistance in a single pane window (Karanen, 2016)

The windows impact on the thermal comfort zone is dependent on the time of the year. In the summer energy passes through the window more as thermal radiation from the sun, the thermal radiation is not restricted by the U-value of the window. A single pane window's inside surface temperature is not affected from the heat flux due to radiation during the warmer nor colder periods (Huizenga, 2006).

A window influences thermal comfort in three ways (Figure 2.19) as following (Huizenga, 2006).

- Solar radiation
- Long-wave radiation from the warm or cold interior glass surface.
- Induced air motion (convective drafts) caused by a difference between the glass surface temperature and the adjacent air temperature.

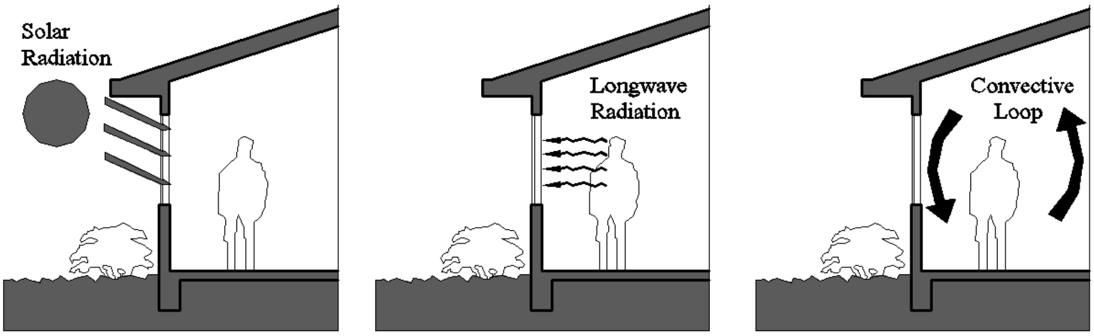


Figure 2. 19: Window impacts on thermal comfort: solar radiation, long-wave radiation, convective drafts (Huizenga, 2006).

The inside surface temperature of a window is heavily influenced by exterior conditions and this temperature can significantly affect the radiant heat exchange between an occupant and the environment. If this heat exchange becomes greater than or less than the acceptable range, discomfort will result. Mean Radiant Temperature (MRT), defined as the uniform temperature of an imaginary enclosure in which the net radiation heat exchange between the occupant and the enclosure equals the net radiation heat exchange in the actual environment, is commonly used to simplify the characterization of the radiant environment.

In temperate region e.g. United Kingdom (UK) or the Netherlands, on a cold day the inside surface temperature can easily drop below 15°F (-9°C) for a clear single pane window and below 40°F (4°C) for a clear, double pane window. If the occupant is sitting sufficiently near the window, MRT could drop to 55°F (13°C) for the single pane case and 62°F (17°C) for the double pane case. Based on ASHRAE Standard 55, even the use of the double pane window could result in discomfort. In addition to the MRT effect, a cold inside glass surface can induce a downward draft that increases air movement, contributing to further discomfort (Huizenga, 2006).

2.11 Thermal Standards for Architecture design studios

There are no standard values for air temperature, relative humidity and wind speed in naturally ventilated buildings prescribed by Government of Bangladesh (GoB) (BNBC/BG), though a limited number of thermal studies have been carried out in tropical countries of warm humid region, particularly for naturally ventilated buildings such as Singapore, Thailand, Indonesia, Bangladesh, Pakistan, Lybia and Brazil (Tariq, 2014).

To predict the comfort zone in the climate of Bangladesh, Ahmed (1987) proposed adaption of Humphreys and Nicol's (1970) 'neutral' temperature model, which was found to be better fitted for the local context of Dhaka division. After that, comfort condition for residential housing in Dhaka was identified (Figure 2.20), based on the analysis of air temperature, radiant temperature, air velocity and relative humidity values by Mallick (1994), using the Bedford scale (Bedford, 1936) and ASHRAE scale (ASHRAE, 1966).

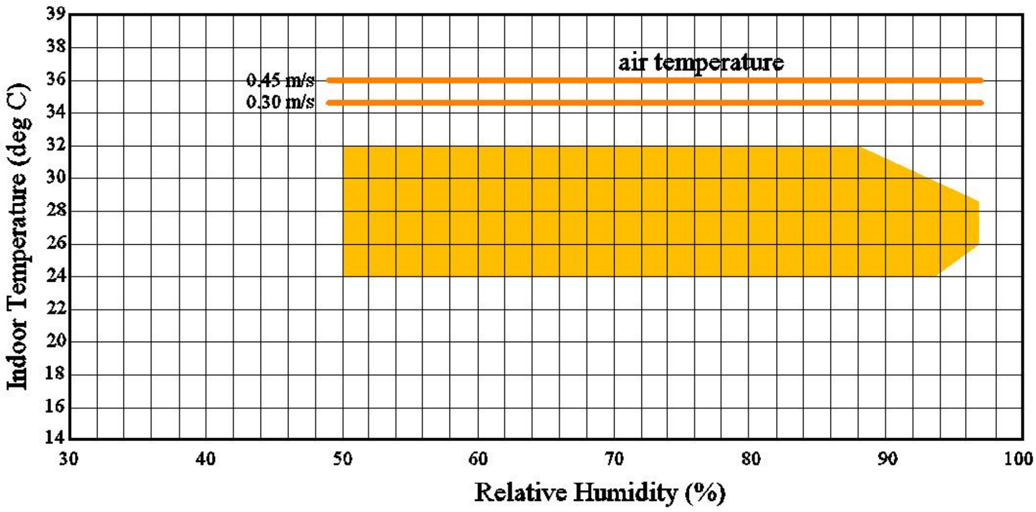


Figure 2.20: Summer comfort zone for urban housing of Dhaka, Bangladesh (Source: Mallick,1994; cited from Tariq, 2014)

According to this study, for people wearing normal summer clothing, engaged in normal household activity, the indoor air temperature for comfort, with no air movement, lies within the range of 24 °C and 32 °C with a relative humidity range of 50% - 95%. The study also found that with air flow, people will tolerate relatively higher humidity i.e. up to 95%, little or slow air movement (up to 0.15 m/s), makes very little difference to comfort temperatures.

The mean comfort temperature for this range is 28.9°C. For higher velocities of 0.3 m/s to 0.45 m/s, the upper and lower limits of comfort temperature increase between 2-3°C, allowing the mean comfort temperature to increase to 31.2°C. Moreover, people feel comfortable above 34°C with the introduction of air flow of 0.30 m/s, with the tolerance temperature as high as 36°C, when the air flow rises to 0.45 m/s (Tariq, 2014).

In the study of Shajahan (2011), an investigation of indoor thermal comfort range for rural houses of Dhaka region, a neutral temperature (NT) of 31.50°C was found with no air movement and comfort range is 29°C to 34°C.

Later, field investigation based research for a detailed understanding of perception of thermal environments by students, inside naturally ventilated classroom and design studios of Dhaka was carried by Tariq (2014). During warm periods in Dhaka, the ‘neutral temperature’ in classroom was found to be 30.20 ºC and acceptable temperature range was 29.89 ºC to 30.54 ºC.

Range of relative humidity levels was 65% to 68% and the identified ‘neutral’ relative humidity was 66.5% (Tariq, 2014).

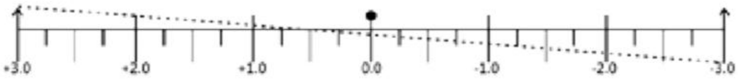
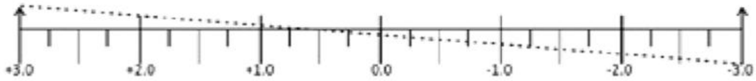
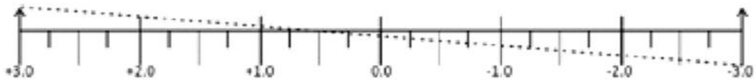
2.12 Thermal Comfort Indices

The most widely used comfort indices based on the empirical-numerical model was proposed by Fanger (1972) is called predicted mean vote (PMV). PMV predicts the mean value of the votes of a large group of persons on a thermal sensation scale that has seven points (Butera, 1998).

There are two main scales that use the same number of points but with different semantic, the ASHRAE thermal scale (ASHRAE, 1966) and the Bedford’s comfort scale (Bedford, 1936). ASHRAE scale is as follows: -3: cold; -2: cool; -1: slightly cool; 0: neutral; 1: slightly warm; 2: warm; and 3: hot. The Bedford’s scale is as follows: -3: much too cool; -2: too cool; -1: comfortably cool; 0: comfortable; 1: comfortably warm; 2: too warm; and 3: much too warm (Shajahan, 2012) (Table 2.12).

The *PMV index* has been accepted as an international standard since the 1980’s ISO standard 7730 (ISO, 1995), and in ASHRAE 55-1992 (ASHRAE, 1992) and consequently a large amount of researchers has taken this index as reference for their studies (Tariq, 2014).

Table 2.12: Scales used in thermal comfort evaluation (Tariq, 2014).

Parameter	Scales used in subjective evaluation	Scale
Thermal Sensation Vote (TSV)	very hot, hot, slightly cool, neutral, slightly hot, cold, very cold 	ASHRAE Scale
Comfort Sensation	very uncomfortable, just right, very uncomfortable 	General Comfort Scale
Thermal Preference	extreme hot, much warmer, slightly warmer, no change, slightly cooler, much cooler, extreme hot 	Mclntyre Scale

2.13 Measuring PMV-PPD

To measure the percentage of dissatisfied occupants in architecture design studios, PMV-PPD index could be used.

2.13.1 Predicted Mean Vote [PMV]

PMV was adopted as an ISO standard after developed by Fanger (Shajahan, 2012). It predicts the average vote of a large group of people on a seven-point thermal sensation scale where:

- +3 = hot
- +2 = warm
- +1 = slightly warm
- 0 = neutral
- -1 = slightly cool
- -2 = cool
- -3 = cold

The ASHRAE Standard 55-1992 Comfort Zone represents a predicted mean vote of between -0.5 and +0.5 for buildings as satisfactory range (Charles, 2003). Result starts to go for negative as the predicted mean vote moves away from zero in either direction. The index includes the combination and interdependencies of the following factors of thermal comfort: metabolic activity (met), clothing insulation (clo), air temperature, mean radiant temperature, air movement and humidity (ASW, 2016).

2.13.2 Predicted Percentage of Dissatisfied [PPD]

Fanger (1972) extended his concept to allow estimation of the predicted percent of dissatisfied people (PPD) (Charles, 2003). It predicts the percentage of occupants that will be dissatisfied with the thermal conditions.

It is a function of PMV, given that as PMV moves further from zero in either direction, PPD increases (Figure 2.21). The maximum number of people dissatisfied with their comfort conditions is 100% and, as it is impossible to satisfy all of the people all of the time, the recommended acceptable PPD range for thermal comfort from ASHRAE 55 guidance is less than 10% persons dissatisfied for an interior space (ASW, 2016). However, it is well known that different people will have a different perception of the climate produced in a building, and that any given climate is unlikely to be considered satisfactory by all. It is considered that satisfying minimum 80% of occupants is adequate, therefore, PPD of less than 20% is acceptable (Ahmed, 2012).

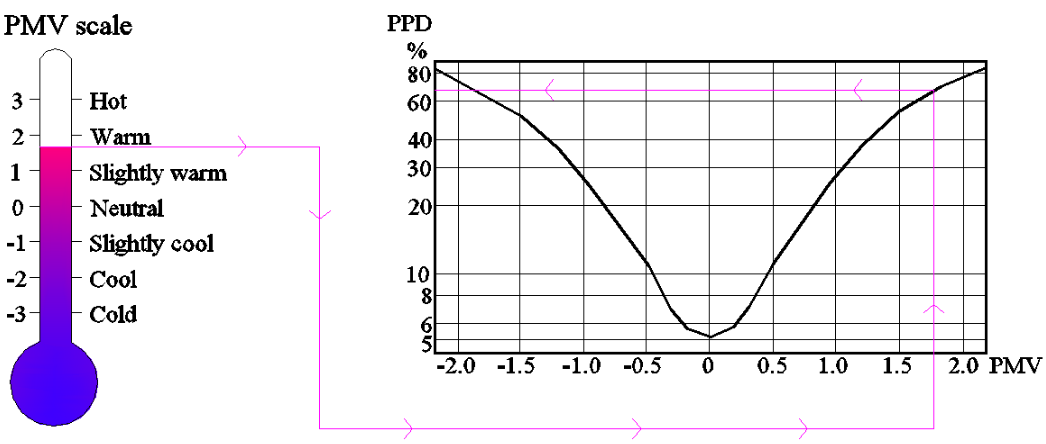


Figure 2.21: Measuring PMV-PPD (Charles, 2003)

PMV-PPD can be measured by giving the inputs of metabolic activity (met), clothing insulation (clo), air temperature, mean radiant temperature, air movement and humidity in PMV-PPD spreadsheet (Silva, 2013) (Figure 2.22).

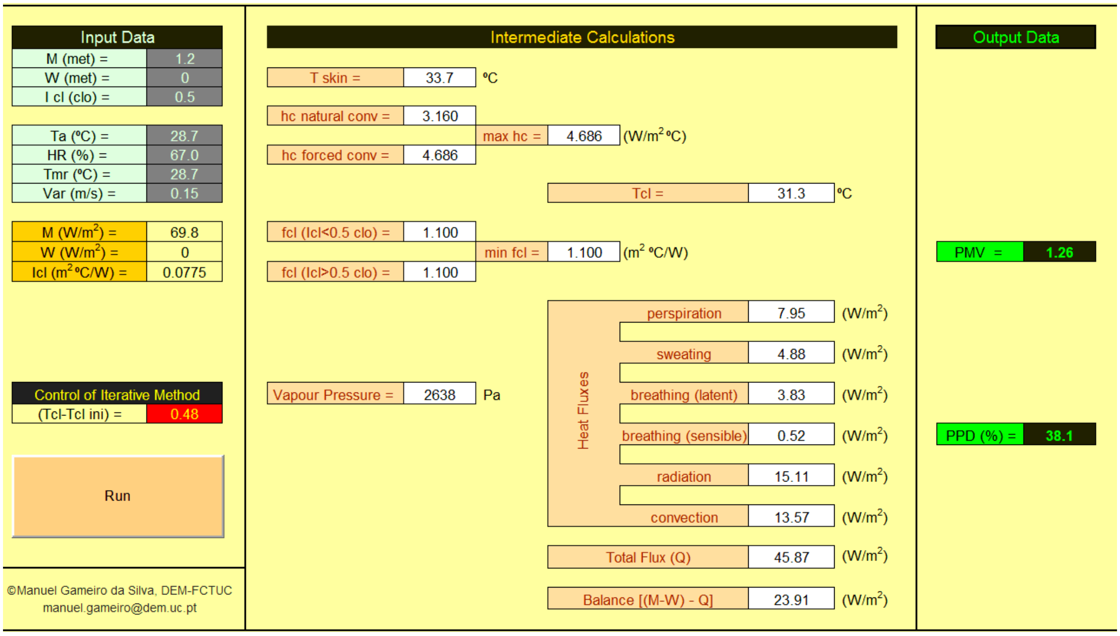


Figure 2.22: Spreadsheet for the calculation of PMV and PPD (Source: ISO 7730- Fanger's Method)

2.14 Critical Findings from Literature Review

In this section, key findings from literature review is briefly previewed.

- Penetration distance of daylighting into a room depends upon window size and location on the wall (Robertson, 2002). Moreover, the appropriate proportion of window to external wall reduces cooling loads and increase thermal comfort considering solar radiation during the summer period (Alibaba, 2016).
- The uniformity ratio between the daylight level in the front and back of a room becomes larger as the room becomes deeper and should not exceed a ratio of 10:1 (A.G.S., 2000).
- The preferred illumination level in architecture design studios is 300 lux (IESNA, 2000) and the illumination level on work plane should not exceed 500 lux (Sharmin, 2011).
- During warm periods in Dhaka, the 'neutral temperature' in classroom/design studio is 30.20 ºC and acceptable temperature range is 29.89 ºC to 30.54 ºC.

Range of relative humidity levels was 65% to 68% and the identified 'neutral' relative humidity was 66.5% (Tariq, 2014). Light summer cloth having a clo value of 0.35-0.5 is common in tropical environments (Auliciems, 2007).

- Different people will have a different perception of the climate produced in a building, and that any given climate is unlikely to be considered satisfactory by all. Therefore, it is considered that satisfying 80% of occupants is good, so a PPD of less than 20% is good (Ahmed, 2012).

2.15 Summery

This chapter has achieved the first objective by mapping a chain of consequences of the potentiality of window design as strategy for daylighting and thermal comfort in architecture design studios. Within the scope of this thesis, benefits of daylighting, factors influencing daylighting and thermal comfort, standard illumination and thermal level for architecture design studios have been discussed in this chapter, based on previous research and published sources. The findings of the chapter helped to select issues on which steps for the field survey and simulation study has been developed in Chapter 3.

3. CHAPTER THREE: METHODOLOGY

Preamble

Methodology

Summery

CHAPTER 3 METHODOLOGY

3.1 Preamble

The outcomes of the literature review have been discussed in Chapter 2 as the basic information required, based on which field investigation and simulation study could be conducted. This chapter explains the detailed steps of the methodology of simulation exercise done during this research. The impact of windows for daylighting in design studios on students' thermal satisfaction, considering the conflicts of luminous and thermal issues, can precisely be evaluated by simulation study. It is difficult to isolate the effects of one single aspect, and its variations due to simultaneous influences of many different conditions. Simulation allows study of the effect of changes in one aspect, keeping other factors constant. By using advance lighting and thermal simulation tools, i.e. DAYSIM and EneryPlus^{TM}, the amount of useful daylight inclusion and thermal comfort conditions have been identified, by assigning simulation parameters, derived from both field and literature study.

The findings of this Chapter aid to evaluate the performance of different window configurations, found in architecture design studios located at different universities in Dhaka. In addition to that, this chapter includes the method of simulation tool selection, case room selection, and selection of different parameters for the case academic building. Chapter 4 will compare the annual CBDM simulation results of different window configurations in terms of some daylight and thermal variables, e.g. Daylight Factor (DF), Daylight Autonomy (DA), Useful Daylight Index (UDI), Maximum Daylight Autonomy (DA_{max}), Continuous Daylight Autonomy (DA_{con}) and PMV-PPD based on the recommended methodology developed in this chapter.

3.2 Methodology

Simulation study was chosen in this research to identify the most feasible window configuration that can help to improve energy efficiency of design studio. Figure 3.1 shows the flow diagram of the methodology for the simulation process of this research.

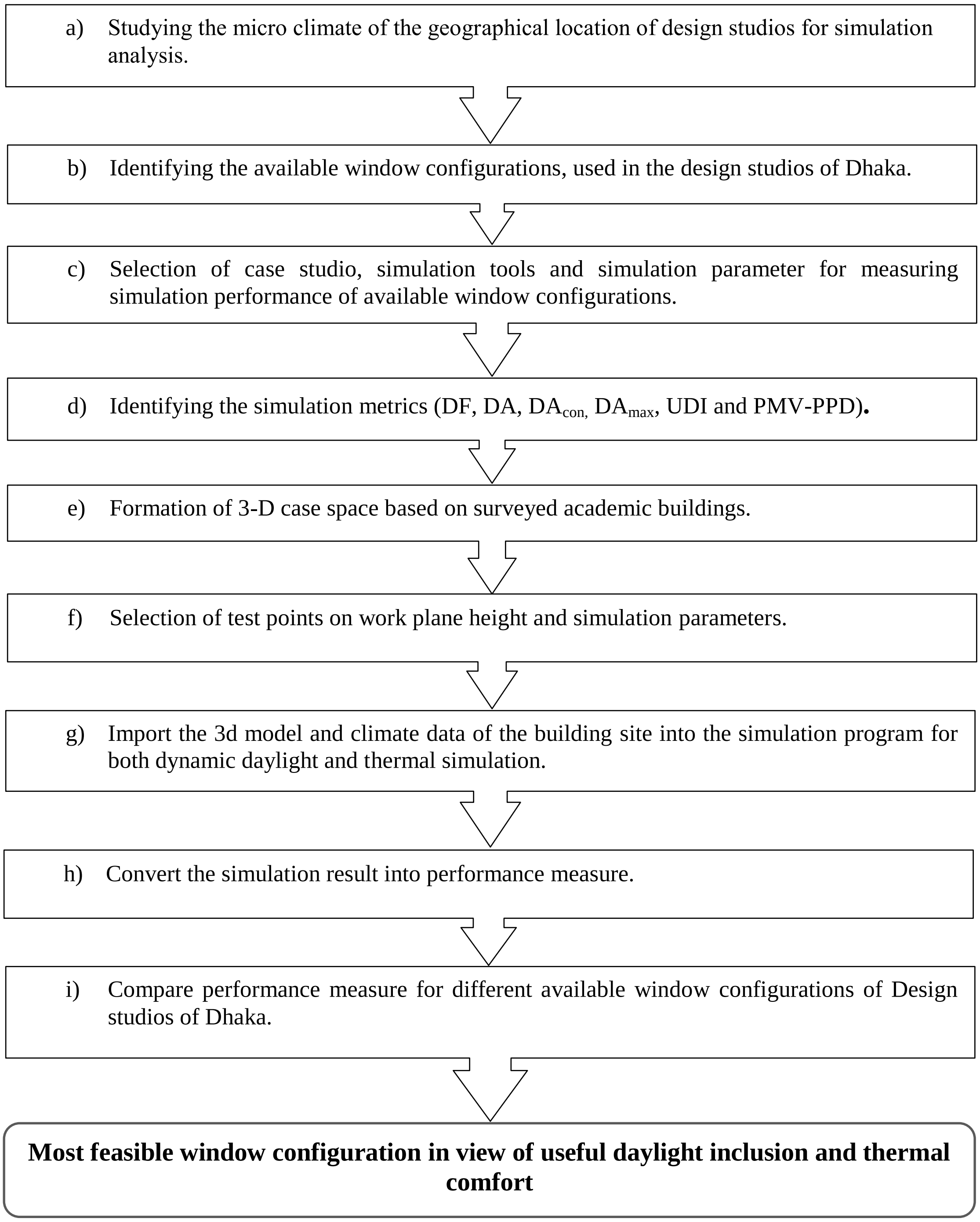


Figure 3.1: Flow diagram of the simulation process of the research. (after, Iqbal, 2015)

At first, the micro climate of the geographical location of design studios for simulation analysis was thoroughly studied. Field investigation was done to identify the available windows, which are used in design studios in the context of Dhaka.

Then, study was done to select the case design studio space and simulation tools for measuring the performance of the available window configurations with respect to daylighting and thermal conditions. The virtual 3D- case studio was formed based on the field investigation data of the case academic building with the selected simulation software tools.

Finally, the selection of the test points and core test points were done and a measuring criteria was developed for the performance evaluation process.

3.2.1 Climate of Bangladesh

Bangladesh has a subtropical monsoon climate and is regarded as one of the largest deltas in the world with a flat and low lying landscape (Ahsan, 2017). Meteorologically, the climate of Bangladesh is classified into four distinct seasons: winter, pre-monsoon, monsoon and post- monsoon (Ahmed, 1995): The winter is cool and dry; the pre-monsoon is hot and dry; the monsoon and post-monsoon seasons are hot and wet. Statistics show that, the winter months, December to February, are characterized by infrequent rains, cold northerly winds, mean temperatures of 2l°C with a mean maximum temperature below 26°C.

The pre-monsoon period covers the months March, April and May, and is characterized by occasional thunderstorms, and an average maximum temperature of 34°C. The monsoon is the longest season, covering the months- June to September, a period with torrential rains, with the average relative humidity above 80%, and an average temperature of 31°C. The post-monsoon season ranges between the months October and November. It is also regarded as a transitional period, with infrequent rains and average temperatures below 30°C (Trisha, 2015).

3.2.2 Microclimate of Dhaka

Dhaka lies between longitude 90^o20' E and 90^o30' E and between latitudes 23^o40' N and 23^o55' N at the southern extremity of the Pleistocene Terrace of the Madhupur (Mridha, 2002).

The climate of Dhaka region is tropical and greatly influenced by the presence of Himalayan mountain range and Tibet plateau in the north and the Bay of Bengal in the south (Mridha, 2002). Its climatic characteristics differ from other city region of the country due to its dense physical development and location (Ahmed, 1995). Dhaka has a distinctive monsoonal season, with an annual average temperature of 25.7°C (78.3°F) and monthly means varying between 18.4°C (65°F) in January and 28.4°C (83°F) in June.

In composite climates e.g. Dhaka, where both overcast conditions and clear blue skies during the course of each year are observed (Figure 3.2), designers face difficulties while designing considering it. The ways and means of tackling the two conditions are quite contrasting to each other (Ahmed, 1987).

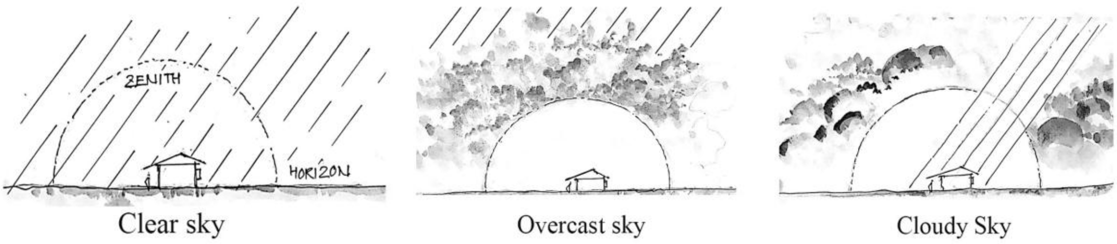


Figure 3.2: Various Sky Conditions (Source: Hossain, 2011)

Generally, the cool dry season is short while the summer is long and wet. April is the hottest month with average maximum temperature that varies from 25.9ºC to 30.7ºC and January is the coldest month with average temperature ranging from 16.2ºC to 19.8ºC.

Although overheating is the major problem of Dhaka City, it is due to some associated factors. For example, it is observed that from March to May there is high air temperature associated with high solar radiation (Figure 3.2). From June to October, conditions with high humidity are associated with high air temperature. Therefore, from March to May, minimizing the impact of solar radiation can potentially moderate the overheated condition, whereas from June to October maximizing wind flow can contribute to minimize the over-heating situation.

Figure 3.3 shows the Hourly solar radiation averaged by month for TRYs, Dhaka.

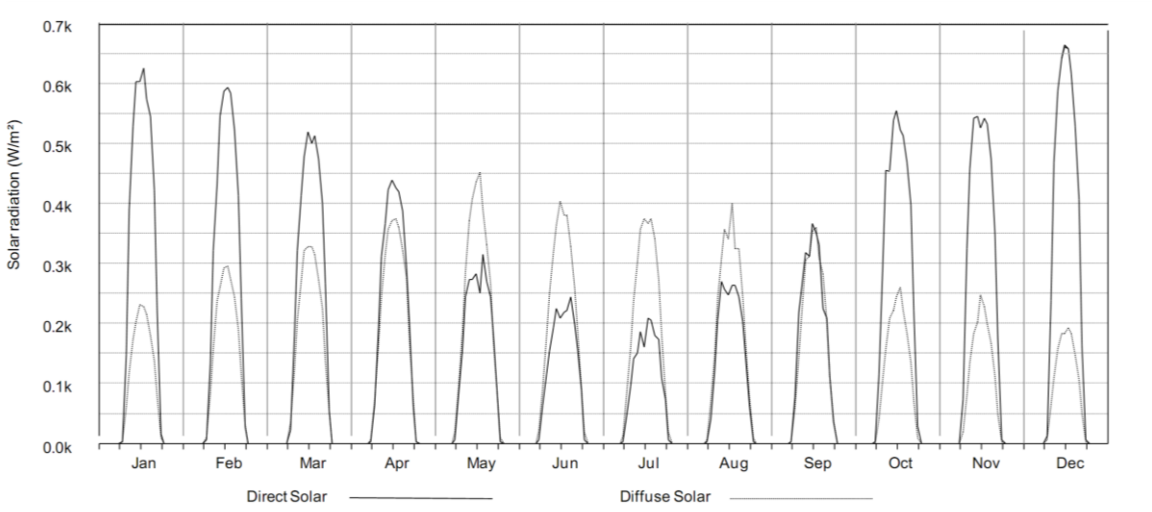


Figure 3.3: Hourly solar radiation averaged by month for TRYs, Dhaka (source: U.S. Department of Energy, 2008).

Table 3.1 shows the overall climatic condition of Dhaka related with thermal environment. The luminous environment of the city is related to the duration of sunshine hours and sky condition, two major climatic factors determining the quality and quantity of daylight. These two are discussed separately below.

Table 3.1: Climate data of Dhaka of the year- 2016 (Data source: Bangladesh Meteorological Department, Dhaka- 2017).

Climatic period	**Hot-dry**	**Warm -humid**	**Warm -humid**	**Cool-dry**
Month Climatic Factors	Mar-may	Jun-Sep (Monsoon)	Oct-Nov (Post-Monsoon)	Dec-Feb (Winter)
Air temperature (^{o}c)				
a .Maximum	39.0°C	36.1°C	36.0°C	34.0°C
b. Minimum	18.2°C	22.8°C	14.9°C	10.0°C
c. Average	26.8°C	28.6°C	25.8°C	20.1°C
RH (%)	68.33	79.00	73.50	67.67
Rainfall (mm)	107.33	231.50	50.50	5.33
Sunshine hours	6.8	4.4	6.3	5.2
Cloud cover (octa)	4	6.3	3	1.3
Wind speed	3.0	2.4	2.25	2.4
Wind direction	S	S, E	W, NE	W

a) Sun shine hours

Daylight availability of any location is influenced by latitude and weather patterns. In the cool dry period Dhaka has more than 8 hours of sunshine per day. But during monsoon months (warm-humid season) this comes down to 4 hours per day due to cloud cover. It is after June and July that this once again increases steadily (Joarder, 2007). The atmospheric condition during the month of July to November period is cloudy. Thus, the diffused component of the daylight is considerably high. The variation in sunshine hours during July to November is wide (Joarder, 2007). Figure 3.4 shows the Monthly Average Cloud Cover with respect to Monthly Average Sunshine Hours for Dhaka city for year 2016, while Figure 3.5 shows the sun path diagram of Dhaka, Bangladesh. Appendix B presents the detailed meteorological data of Dhaka region, collected from Dhaka Meteorological Department, Agargaon, Dhaka.

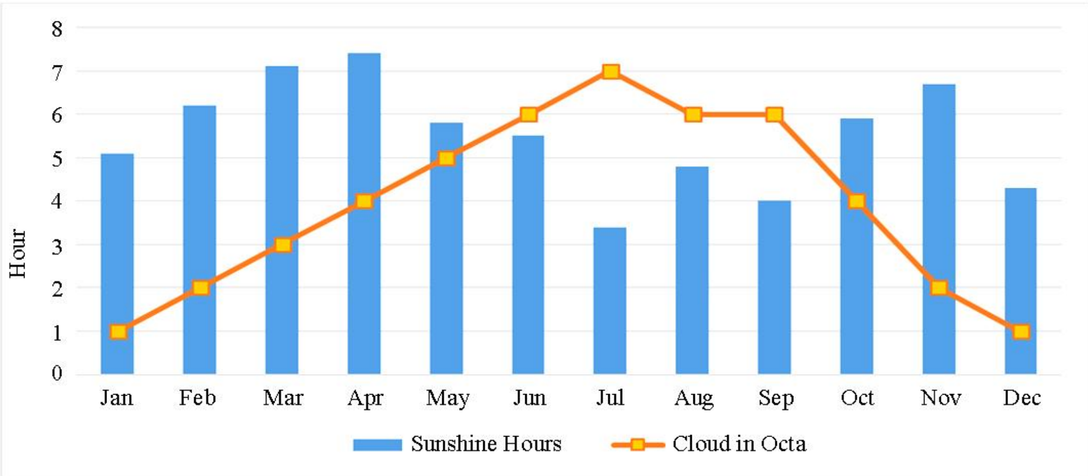


Figure 3.4: Monthly average cloud cover and Sun shine hours in Dhaka, year 2016 (Data source: Bangladesh Meteorological Department, Dhaka- 2017)

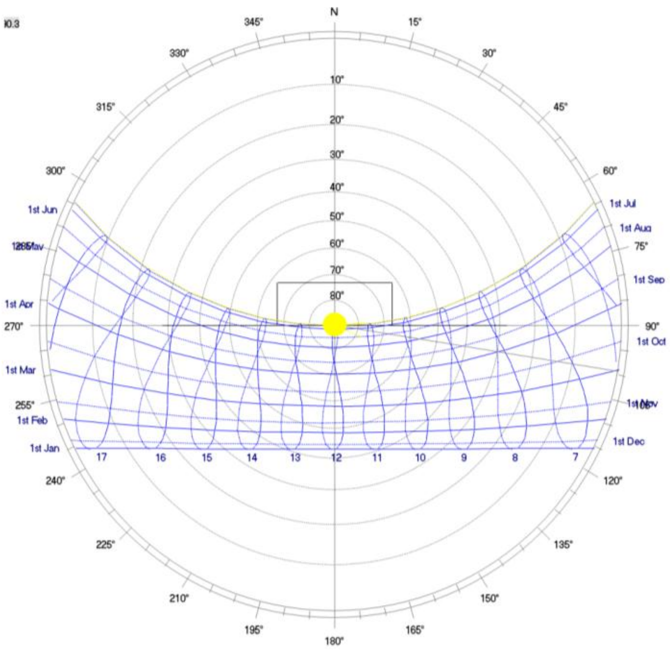


Figure 3.5: The sun path diagram of Dhaka, Bangladesh (Source: SUNTOOL - Solar Position Calculator, 1998; cited from Iqbal, 2015).

b) Sky condition

Direct sunlight is intense and varies substantially as the sun's position changes throughout the day (up to 1,00,000 lux). Daylight from a clear sky can be 10% to 25 % of the intensity of direct sunlight (10000-25000 lux). Daylight under partly cloudy conditions can be highly variable; daylight under full overcast conditions can be 5% to 10% of sun conditions (5000- 10000 lux) (AGS, 2000; Joarder, 2007). In context of Dhaka the sky remains clear and overcast in different parts of various seasons. During summer (Hot Dry) the sky remains both clear (sunny with sun) and overcast. Table 3.2 shows sky condition with respect to cloud cover over a year round.

Table 3.2: Sky condition over a year round (Data source: Bangladesh Meteorological Department, Dhaka- 2005; cited from Iqbal, 2015).

Type of sky	Pre-monsoon (March-May)	Monsoon (Jun-Sept)	Post-Monsoon (Oct-Nov)	Cool Dry (Dec-Feb)	Total (day)
Clear sky	62	38	39	77	215
Overcast sky	30	84	22	14	150
Total sky	92	122	61	90	365

During the warm-humid (March-November) period the sky remains considerably overcast. During monsoon (June-September) which is one third of the whole year the sky remains significantly overcast. And during the winter (December-February) the sky mostly remains clear. While during the rest of the year, both clear and overcast conditions are observed (Joarder, 2007). By statistical evaluation of long-term illumination records as 'design sky' illumination value can be established for a particular location. Suggested values for 'design sky' in the different latitudes are given in Table 3.3.

Published data on outdoor design sky illuminance specifies a value of approximately 10,000-12,000 lux for Dhaka latitudes (Hossain, 201; Evans, 1980). In warm-humid climatic context with special reference to Dhaka, shows that eight-hour daylit time frame, an average of about 16,500 lux can be considered as outdoor design sky illuminance (Khan, 2005; cited from Joarder, 2007).

Table 3.3: Illumination from a design sky on a horizontal unobstructed surface on different latitude and solar altitude (Evans, 1980; Hossain, 2011).

Suggested values for overcast sky	lux (lumen/m^2)
Latitude 50-60^0	5,000
Latitude 40-50^0	5,000-6,000
Latitude 30-40^0	5,000- 8,000
Latitude 20-30^0	8,000-10,000
Latitude 10-20^0	10,000-15,000
Suggested values for overcast sky	
All latitude	5,000
Solar altitude 15^0	14,000
Solar altitude 30^0	36,000
Solar altitude 45^0	58,000
Solar altitude 60^0	75,000
Solar altitude 75^0	83,000
Solar altitude 90^0	94,000 to 110,000

c) Air temperature

According to Bangladesh Meteorological Department (BMD), the temperature profile of Dhaka based on meteorological data recorded from 1960 to 1980 exhibits relatively higher monthly maximum average temperature in March, April and May i.e. pre-monsoon period (Tariq, 2014) than in other seasons, reaching the highest average at 37.8°C in April (Figure 3.6).

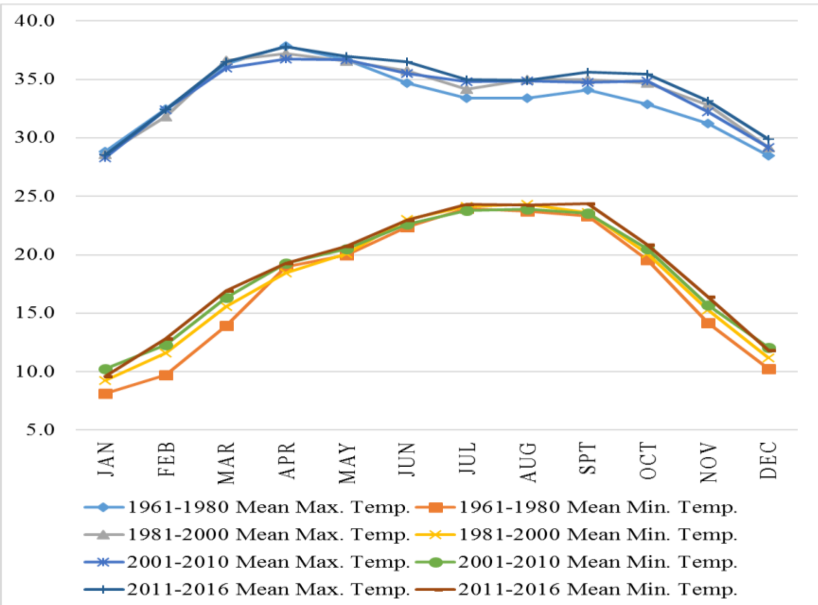


Figure 3.6: Monthly mean maximum and minimum air temperature profile for the year 1961-1980, 1981-2000, 2001-2010 and 2011-2016 (Data source: B. M. D., 2017)

In general, the pre-monsoon period shows the highest annual temperatures, especially in April (Tariq, 2014). In the study of thermal environment in residential areas of metropolitan Dhaka, Roy (2010) suggested that clear sky, dry weather, higher solar altitude angle, higher solar intensity and higher duration of sun-shine hour have given April the status of 'hottest month' in this region. On the other hand, from 1961 to 2016, it is evident that, the 'coldest month' in Dhaka region is January. In 2016, the hottest day was 24th April (39.0°C) and the coldest day was 27th January (10.0°C) (BMD, 2017).

d) Relative Humidity

Relative humidity is consistently highest in the monsoon and comparatively low in the winter seasons (Figure 3.7). According to the investigation done by Hossain and Nooruddin (1993), the relative humidity in adjacent rural areas of Dhaka city is higher and it generally decreases towards city centre (Tariq, 2014). Another study indicates that, with 50% impervious cover, run off increases 200% compared with rural conditions, concluding that urban humidity near the surface decreases, due to the rapid run-off (Schellen, 2010).

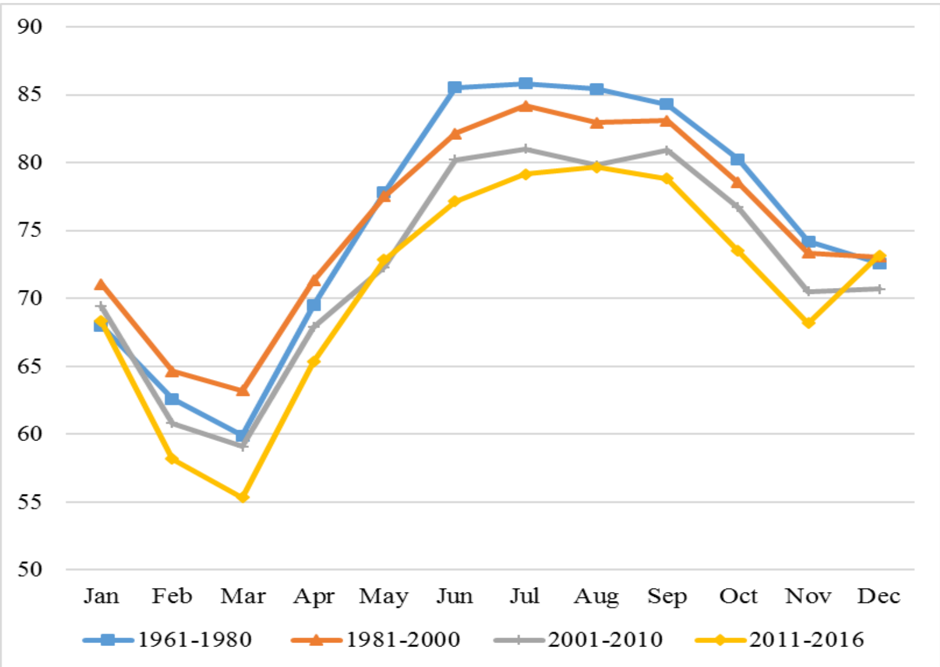


Figure 3.7: Monthly relative humidity profile for the year 1961-1980, 1981-2000, 2001-2010 and 2011-2016 (Data source: B. M. D., 2017)

e) Wind speed

The meteorological data (1961-2016), based on measurements in open locations, shows that prevailing wind speed in Dhaka is comparatively high in the pre-monsoon (March-April) and monsoon period (June to September) (Figure 3.8).

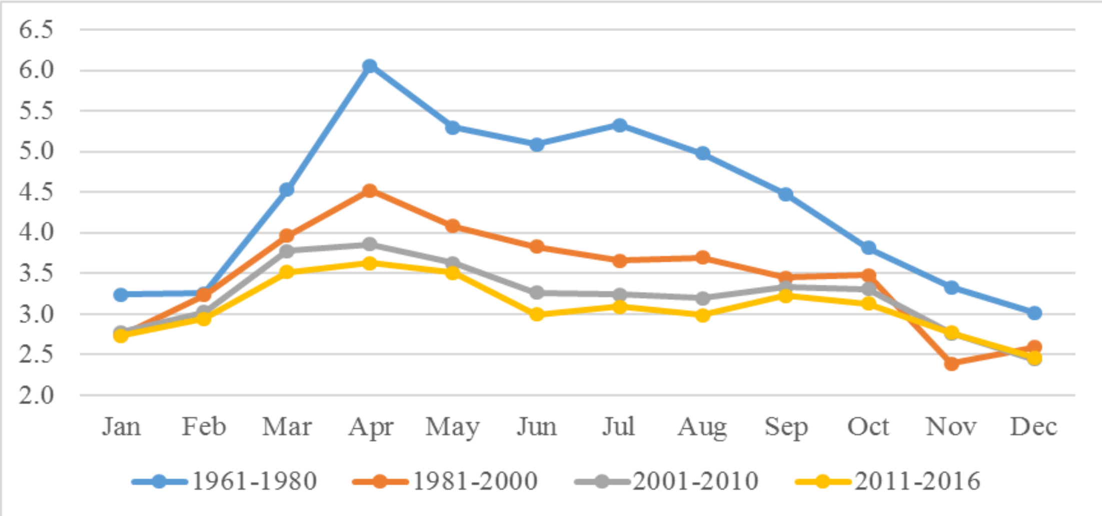


Figure 3.8: Monthly prevailing Wind Speed profile for the year 1961-1980, 1981-2000, 2001-2010 and 2011-2016 (Data source: B. M. D., 2017)

3.2.3 Field investigation

Daylighting and thermal comfort analysis were carried out through a study of selected architecture design studios and different window configurations of Dhaka. The process of selection is described in the following sections.

a) Selection of Design studios for field survey

In Bangladesh, there are 22 universities with an Architecture department and among these universities, 14 are located in the capital city of Dhaka (UGC, 2015). Table 3.4 presents the list of universities of Dhaka which have an architecture department.

The table shows that there are seven universities which have 'Designed' architecture design studios (which were designed for studio purpose) and other seven universities have studios which were not primarily designed for studio purpose and were later renovated and/or converted into architecture design studios.

Table 3.4: List of Universities in Dhaka with Architecture Department.

No.	Name of the Universities	Design Status
01	Bangladesh University of Engineering and Technology (BUET)	Designed
02	Ahsanullah University of Science and Technology (AUST)	Designed
03	University of Asia Pacific, Bangladesh (UAP)	Designed
04	BRAC University (BRACU)	Renovated
05	American International University, Bangladesh (AIUB)	Renovated
06	North South University (NSU)	Designed
07	Stamford University	Renovated
08	State University of Bangladesh (SUB)	Designed
09	Bangladesh University (BU)	Renovated
10	Primeasia University (PU)	Renovated
11	Daffodil International University (DIU)	Renovated
12	South East University (SEU)	Designed
13	Sonargaon University (SU)	Renovated
14	Military Institute of Science and Technology (MIST)	Designed

Though it is expected that the 'Designed' studios will have better design and will perform better as a studio than those which were renovated later (Sharmin, 2011), performance of designed and renovated window configurations may differ from the result of overall studio design performance. Therefore, in this study, both designed and renovated studios were considered to evaluate the daylight and thermal performance.

b) Present situation of architecture design studios

Existing studios of different architecture departments located at 14 universities (Table 3.4) were considered for pilot survey to understand the physical characteristics of the windows.

Table 3.5 shows the window configurations which are used in design studios in Architecture departments located at different universities.

Table 3.5: Window configurations, used in design studios in Dhaka

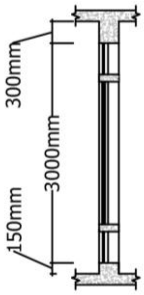
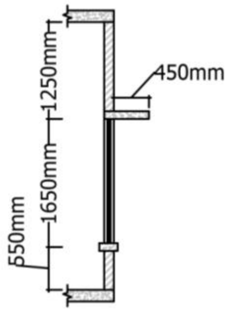
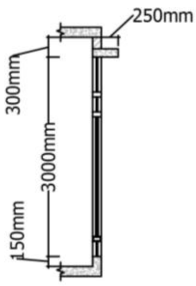
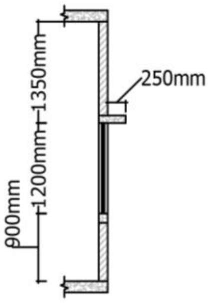
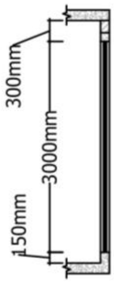
University name	Section of typical window configurations	Interior view of the studios
BUET		
AUST		
UAP		
BRACU		
AIUB		

Table 3.5 *continued*

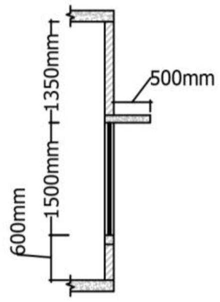
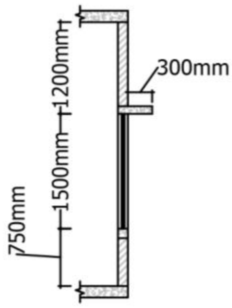
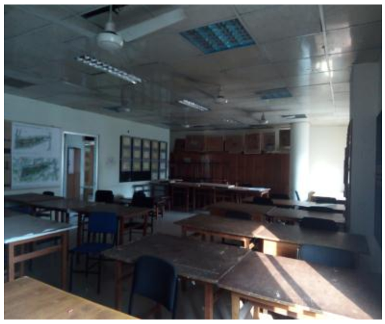
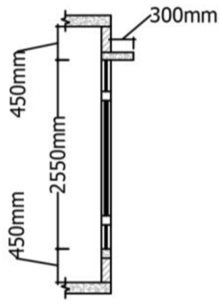
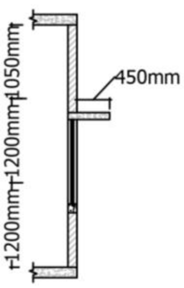
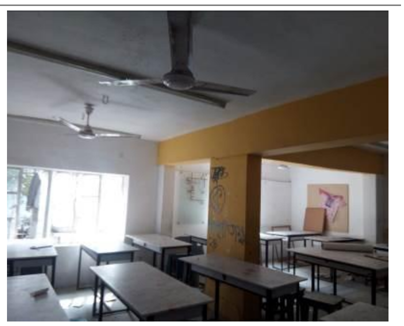
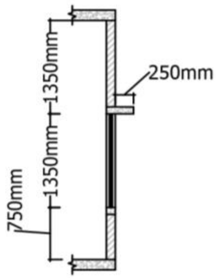
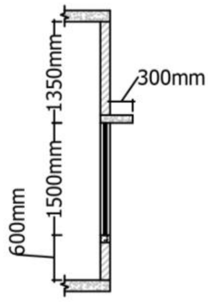
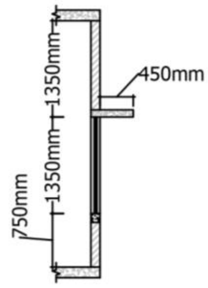
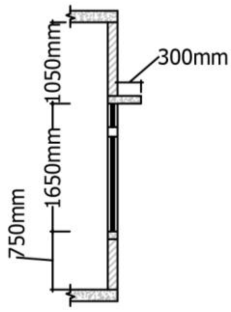
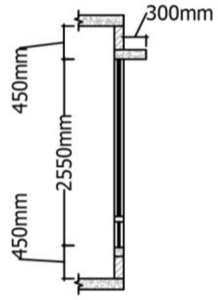
University name	Section of typical window configurations	Interior view of the studios
NSU		
STAMFORD		
SUB		
BU		
PU		

***Table 3.5** continued*

University name	Section of typical window configurations	Interior view of the studios
DIU		
SEU		
SU		
MIST		

c) Different window categories

The window configurations on south façade, found in field survey were organized in four categories: Segregated Viewing Windows (SVW); Segregated Full Height Windows (SFW); Continuous Viewing Windows (CVW), and Continuous Full Height Windows (CFW). (Figure 3.9).

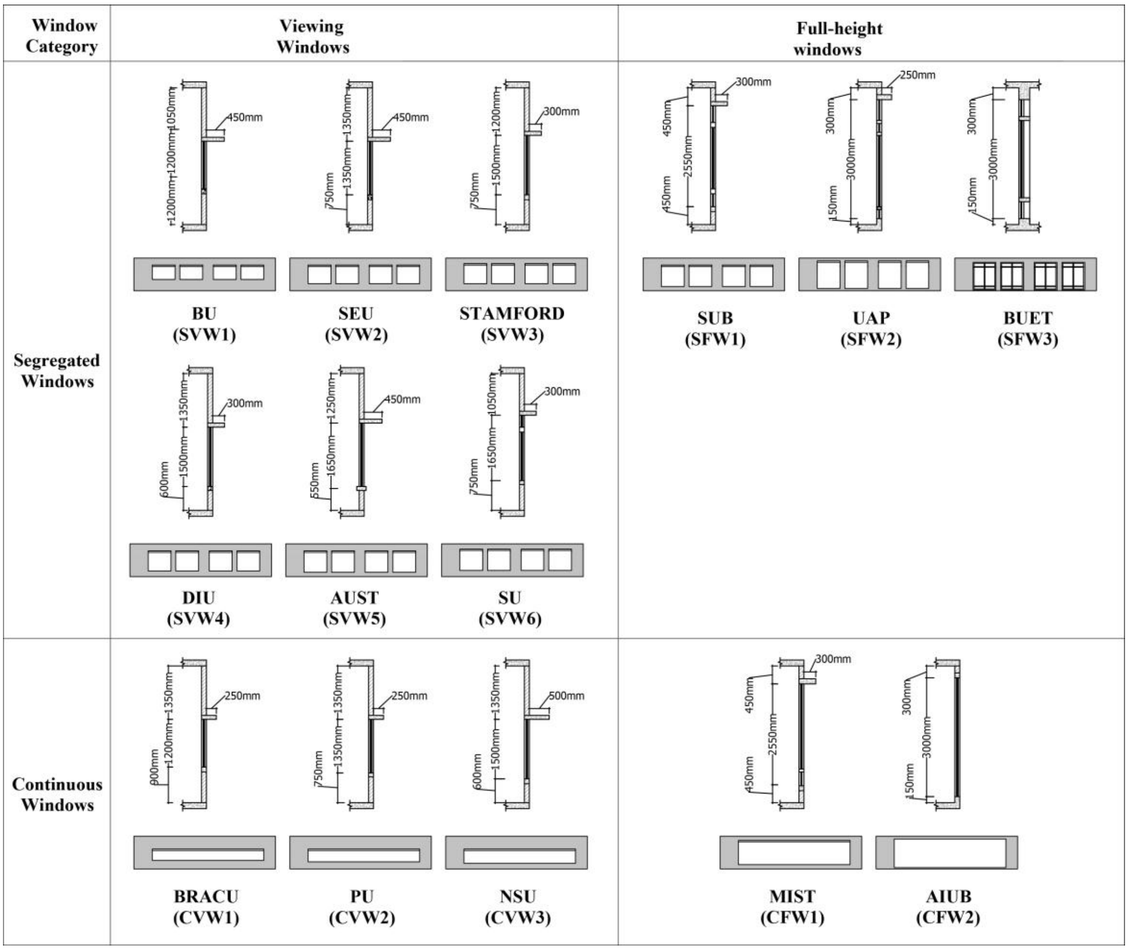


Figure 3.9: Window categories, found in field survey

Floor to ceiling heights of the studios in most of the universities were found as more than 3000mm. Therefore, lintel level of maximum 2400mm was considered as viewing windows.

d) Daylighting and thermal conditions of the selected studios

In order to get a picture of current daylighting and thermal condition, studios were selected from pilot survey for conducting quantitative survey by measuring daylight levels and PMV-PPD.

Considering the limited time frame, in this study, the survey was carried out on the 14 design studios from 14 universities in the period between the months of December 2016 and January 2017 at 12:30 pm. Under overcast condition, daylighting levels and indoor thermal conditions (AT, RH and WS) were measured at several points (Appendix-C). Outputs of thermal simulations were placed on spreadsheet to calculate

PMV-PPD (Table 3.6). Figure 3.10 and 3.11 show comparison of daylighting and thermal performance for surveyed design studios in Dhaka.

Table 3.6: comparison of daylighting and thermal performance for surveyed design studios in Dhaka.

Category of Windows	**Code of Windows**	**Name of the University**	**Highest Daylight Level** [lux]	**Lowest Daylight Level** [lux]	**Air Temperature** [°c]	**Relative Humidity** [%]	**Wind Speed** [m/s]	**Predicted Mean Vote (PMV)**	**Predicted Percentage of Dissatisfied (PPD)** [%]
SVW	SVW1	BU	**3520**	**68**	22.1	39	0.18	(-) 1.13	**31.8 ≈ 32**
	SVW2	SEU	**1500**	**500**	21.5	27	0.05	(-) 1.10	**30.5 ≈ 31**
	SVW3	STAMFORD	**1824**	**10**	20.8	33	0.07	(-) 1.28	**39.2 ≈ 39**
	SVW4	DIU	**346**	**71**	21.1	37	0.16	(-) 1.16	**33.5 ≈ 34**
	SVW5	AUST	**1860**	**95**	21.5	32	0.04	(-) 1.07	**29.2 ≈ 29**
	SVW6	SU	**2420**	**466**	21.0	43	0.11	(-) 1.18	**34.3 ≈ 34**
SFW	SFW1	SUB	**1440**	**126**	21.4	32	0.13	(-) 1.21	**35.7 ≈ 36**
	SFW2	UAP	**780**	**73**	21.8	40	0.13	(-) 1.05	**28.1 ≈ 28**
	SFW3	BUET	**2090**	**30**	21.0	29	0.06	(-) 1.21	**37.2 ≈ 37**
CVW	CVW1	BRACU	**102**	**11**	20.7	35	0.00	(-) 1.30	**40.2 ≈ 40**
	CVW2	PU	**5600**	**420**	20.9	21	0.08	(-) 1.31	**41.0 ≈ 41**
	CVW3	NSU	**5730**	**37**	21.3	30	0.13	(-) 1.25	**37.8 ≈ 38**
CFW	CFW1	MIST	**6250**	**155**	21.8	32	0.02	(-) 0.98	**25.2 ≈ 25**
	CFW2	AIUB	**8690**	**119**	22.1	23	0.00	(-) 0.94	**23.7 ≈ 24**

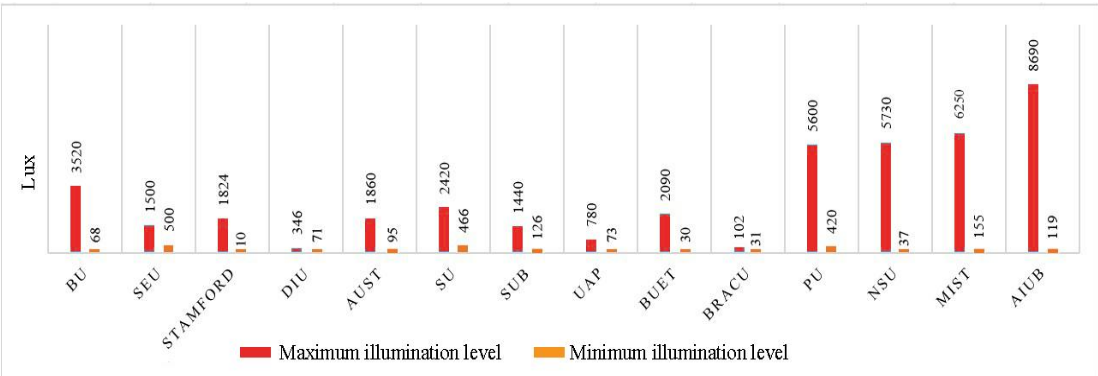


Figure 3.10: Maximum and Minimum Daylight Levels, measured in selected studios

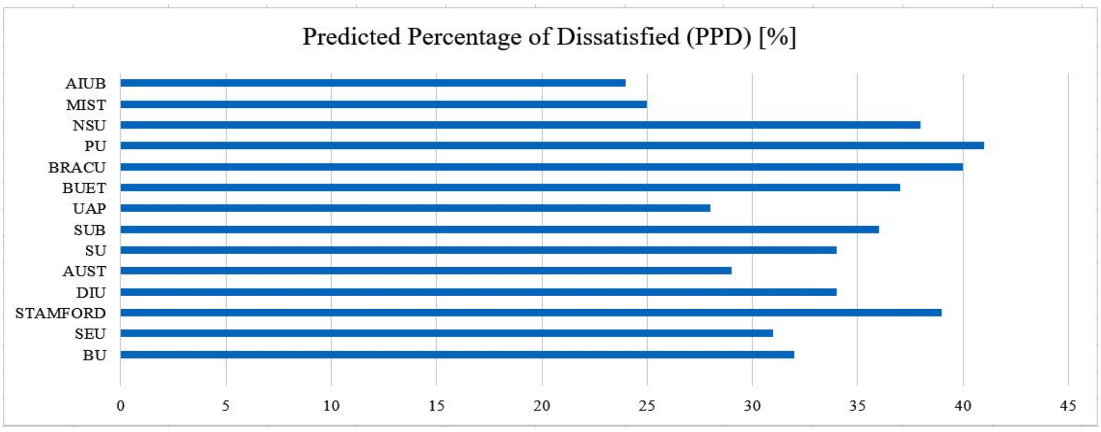


Figure 3.11: Predicted Percentage of Dissatisfied, measured by indoor thermal conditions in selected studios

According to field investigation, highest daylight levels in fourteen design studios of the universities were found considerably high, uniquely in MIST and AIUB. These were 6250 lux and 8690 lux respectively. It can be observed that, node points near south window provided the maximum values, which created over-lit condition at the window side desks (Appendix- C). In contrast, the values plummeted inversely with the distance from the window in the room. Minimum illumination values were found lower than the required illumination level, which were unable to provide useful daylight in the deep of the studio. On the other hand, satisfying minimum 80% of occupants is adequate in terms of PMV, therefore, in the field survey, thermal comfort conditions in the architecture design studios were found discontented.

Portable digital light meter: Dr. Meter Digital Light Meter Model: LX1330B, Extech 445703 Hygro-Thermometer and Handyman thermo-anemometer model no: TE1313 (Appendix-E) were used for field measurement and a portable stand was used to locate the measuring cell at a constant height (0.75 meter from the floor level) for each reading. In the compilation procedure, data sheets were designed to record the measurements for each surveyed studios.

e) Observations from field investigation

The observations from the field survey are summarized below:

- Maximum illumination levels in the design studios were much higher than the recommended maximum illumination level (500 lux), while minimum values were well below than the illumination threshold (300 lux).

- The standard of uniformity ratio between the daylight levels in the front and back are not maintained in most of the studios.
- Except for the places near south openings, daylight inclusion in the studio is very poor, specially at the rare part. Therefore, studios are dependent completely on artificial lighting.
- Large windows at south façade allow excessive daylighting, which cause glare in some design studios. Use of curtains during daytime is a common practice in some studios.
- Windows, having higher WWR provide excessive direct solar radiation which creates discomfort to the occupants in the design studios.

3.2.4 Selection of the case studio for simulation analysis

For simulation study, design studios were short listed on the basis of some selection criteria and among them, one design studio was selected as case studio to analyse the daylighting and thermal performance of window configurations in. As the choice of the case studio was based on the primary criteria it has to be 'designed' studio, a check was done to see that other criteria that are relevant in this study have been covered in the selection process (Sharmin, 2011).

a) Location of the building would be in the urban context of Dhaka.
b) The studio must be located on designed and planned campus.
c) Year of completion of the building /studios should be within 10 years (i.e. 2005-2015).
d) The studio should have the provision of window openings on exterior walls at south.
e) The activity pattern and internal layout of the case studio should represent current practice of the architecture design studios of Bangladesh.

Primarily, three studios of three different universities were selected as case studio based on the above criteria (Table 3.7). The investigation covered a broad area through a physical observation about the physical characteristics of the design studios located at south portion of the buildings.

Table 3.7: Primary selection of the studios as case studio for simulation study

Case no.	Name of the University	Studio No.	Floor area of the space	Student capacity	window openings	Location
02	AUST	3C01 (2nd Floor)	132 m^2	40	South	Tejgaon, Dhaka.
03	NSU	901 (9th Floor)	99 m^2	30	South	Basundhara, Dhaka.
04	MIST	703 (7th Floor)	95 m^2	30	South, East	Mirpur D.O.H.S., Dhaka.

Table 3.8, 3.9 and 3.10 present data and plan of the shortlisted studios. Discussions of this section are restricted to only that extent, based on which, one of the design studio among the three university buildings could be selected as case studio considering shape of the room, provision of direct sunlight penetration on south facade, depth of the studio, elongation of the direction of studio arrangements and other relevant features. Items such as building surroundings, interior materials, finishes, and functions were excluded in the discussions, as these parameters were fixed in simulation study only for the selected case studio.

Table 3.8: Field survey data of case 01: AUST

Name of the University	Shape of the room	Obstacle to Direct sunlight	Provision of effective windows	Depth (m)	Floor area	Direction of studio arrangement
AUST	Regular	Corridor on North	S-N	9.2	137 sq.m	E-W direction
Plan of the design studio				**Existing condition (without electric lighting)**		

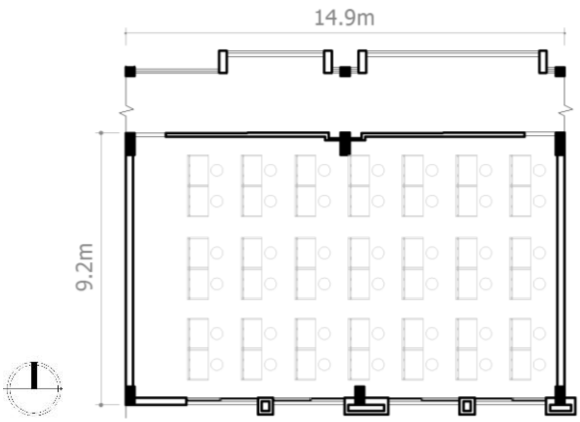


Table 3.9: Field survey data of case 02: NSU

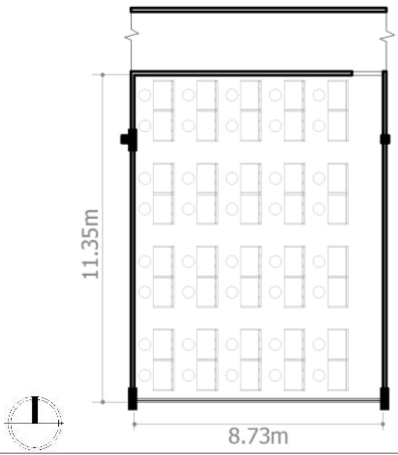
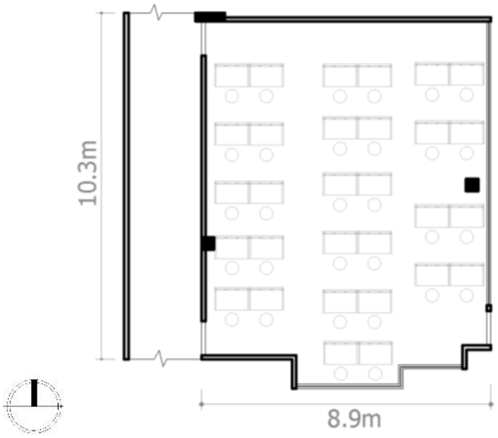
<table>
<tr><th>Name of the University</th><th>Shape of the room</th><th>Obstacle to Direct sunlight</th><th>Provision of effective windows</th><th>Depth (m)</th><th>Floor area</th><th>Direction of studio arrangement</th></tr>
<tr><td>NSU</td><td>Regular</td><td>Corridor on North</td><td>South</td><td>11.35</td><td>99 sq.m</td><td>E-W direction</td></tr>
<tr><td colspan="4">Plan of the design studio</td><td colspan="3">Existing condition (without electric lighting)</td></tr>
<tr><td colspan="4">
</td><td colspan="3"></td></tr>
</table>

Table 3.10: Field survey data of case 03: MIST

<table>
<tr><th>Name of the University</th><th>Shape of the room</th><th>Obstacle to Direct sunlight</th><th>Provision of effective windows</th><th>Depth (m)</th><th>Floor area</th><th>Direction of studio arrangement</th></tr>
<tr><td>MIST</td><td>Irregular</td><td>Corridor on North</td><td>S-E</td><td>10.3</td><td>95 sq.m</td><td>N-S direction</td></tr>
<tr><td colspan="4">Plan of the design studio</td><td colspan="3">Existing condition (without electric lighting)</td></tr>
<tr><td colspan="4">
</td><td colspan="3"></td></tr>
</table>

Considering the above information of the surveyed buildings, the design studio designated for first year first semester students located on the second floor in the Department of Architecture, Ahsanullah University of Science and Technology (AUST) was chosen as case studio for the reason that, the university satisfies most of the criteria considered for selecting the case studio for simulation study mentioned above i.e. shape of the room, obstacle to the direct sunlight, provision of effective windows.

Figure 3.12: Google view of AUST (left panel), View of AUST from front road (right panel)

Permanent campus building of AUST is an example of contemporary Architecture, which was built in the year of 2008. AUST is a 10 storied building, located in Tejgaon industrial area, Dhaka in a compact urban setting (Figure 3.12, 3.13 and 3.14).

Figure 3.13: Panoramic view of AUST premise (Source: Begum, 2016)

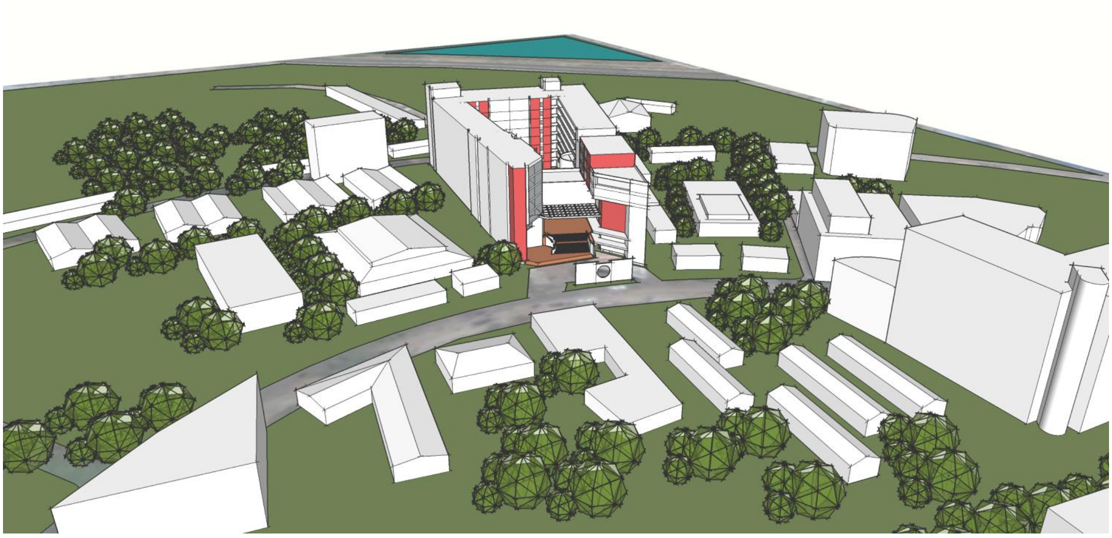


Figure 3.14: Surrounding context of AUST (Begum, 2016)

The building has an eight-meter-wide road on the west and some single-storied semi-pacca establishments on the north. Two storied milk factory building 10.5 m from the southern edge of the academic building provides a proper setback in sense of daylight provision specially from south (Figure 3.13 and Figure 3.14). Among 4 main blocks in the academic building, architecture department is placed at the south block from 1st to 5th floor. The selected design studio, located on 2nd floor (Figure 3.15 and Figure 3.16), is one of the typical studios with rectangular plan and has a vast opportunity of daylight inclusion.

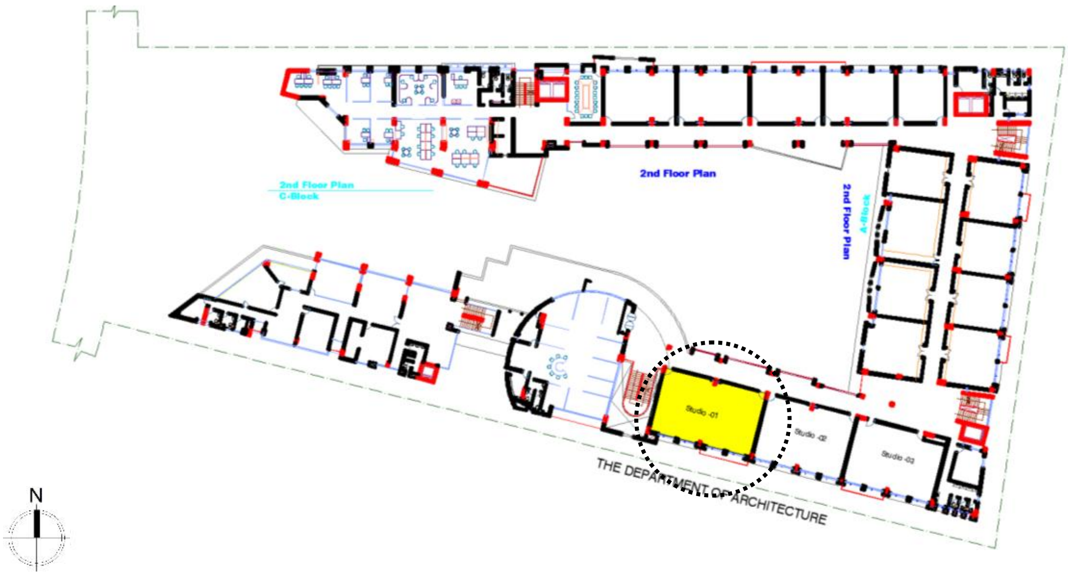


Figure 3.15: 2nd floor plan of AUST showing the case studio (Circled)

Figure 3.16: 2nd floor view (Circled) of AUST architecture department.

3.2.5 Selection of daylighting simulation tools

There are a large number of simulation tools available concerning lighting and thermal simulation in buildings. Dubois *et al.* reviewed the existing computer tools widely used by architects today, covering a total of 56 computer programs which were classified into three categories: CAAD (computer-aided architectural design) tools, Visualization tools, and simulation tools (Kanters, 2014). For the evaluation of the daylighting concept, a suitable simulation tool was required, which (Joarder, 2011)

- has high prediction capability for indoor daylight distribution;
- can model simple to complex geometry with surrounding environments; and
- can provide climate based daylight metrics as output (e.g. DA and UDI).

RADIANCE, a backward ray tracing software package for lighting simulation, was validated for accurate prediction of the distribution of indoor daylight environments by many researchers, for example, Ibarra (2009) and Reinhart (2001). Though RADIANCE can predict light levels for complex geometry accurately, RADIANCE does not have any built-in graphical interface to generate physical model, however, it is possible to use other software as modelling interface for RADIENCE, e.g. AUTOCAD and ECOTECT (Iqbal, 2015).

In this research, the initial simulation model of the case studio was constructed by ECOTECT V5.20 simulation program to analyse the lighting performance of available window configurations. Among the RADIENCE based ray tracer, a limited number of software are able to calculate climate based metrics as final output, such as 3D SOLAR, GENELUX, LIGHTSWITCH WIZARD, S.P.O.T, LIGHT SOLVE and DAYSIM.

For daylight simulation analysis, DAYSIM 2.1.P4 (Appendix-E) was selected which also satisfied the above mentioned three criteria. DF, DA, UDI>2000, DA_{max} above 5% and illumination on a specific point can be calculated by using DAYSIM simulation program. DAYSIM uses RADIANCE (backward) raytracer combined with a daylight coefficient approach (Tregenza, 1983). DAYSIM considers Perez all weather sky luminance models (Perez, 1990; 1993) and can provide more than 365 x 24 = 8760 hours' data for each sensor point. DAYSIM have been validated comprehensively and successfully for daylighting analysis (Reinhart, 2006).

3.2.6 Selection of thermal simulation tools

EnergyPlus™ (Energy+) Version 7.2.0, developed by U.S. Department of Energy with the OpenStudio Plug-in 1.0.1 integrated with Google Sketch-Up 8 have been used for this simulation study. Building Energy Software Tool Directory provides information on 405 building software tools for evaluating energy efficiency, renewable energy, and sustainability in buildings.

a) EnergyPlus™

EnergyPlus™ (Energy+) is an energy analysis and thermal load simulation program based on a user's description of a building from the perspective of the building's physical make-up and associated architectural, mechanical and other systems. EnergyPlus™ is a stand-alone simulation program without a 'user friendly' graphical interface. This program reads input and writes output as text (.idf files). Each version of EnergyPlus™ is tested extensively before release. EnergyPlus™ models heating, cooling, lighting, ventilation, other energy flows, and water use (Chowdhury, 2014) are shown in Figure 3.17.

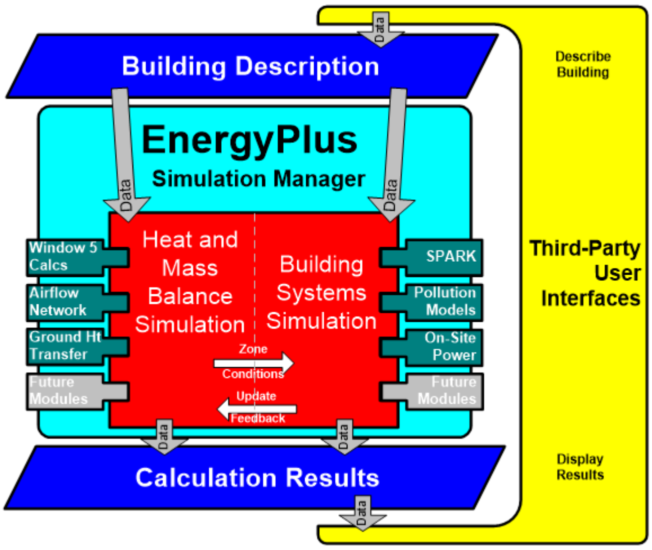


Figure 3.17: Structure of EnergyPlus™ (Source: U.S. Department of Energy,USA, 2013)

EnergyPlus™ includes many innovative simulation capabilities: time-steps less than an hour, modular systems and plant integrated with heat balance-based zone simulation, multi zone air flow, thermal comfort, water use, natural ventilation, and photovoltaic systems. Weather data is available for over 2,000 locations in a file format that can be read by EnergyPlus™ provided by U.S. Department of Energy (DOE, USA).

The EnergyPlus™ test results are compared to the results of all programs that completed and reported test results, including ANSI/ASHRAE Standard 140-2011, ESP, BLAST-3-193, DOE2.1D, SRES/SUN, SERIRES, S3PAS, TRNSYS and TASE. Although not part of the original set of results, results for later versions of BLAST and DOE2 have also been added for completeness --BLAST-3.0-334 and DOE2.1E.

b) OpenStudio

OpenStudio Plug-in for Google Sketch up 8 is another front end to EnergyPlus™ that was created by the National Renewable Energy Laboratory for the U.S. Department of Energy, that allows users to create and edit the building geometry for the EnergyPlus™ input files. The Sketch up Plug-in allows users to quickly create geometry for EnergyPlus™ with Sketch up functionality including drawing tools, integration with Google Earth, Building Maker, and Photo Match. System Outliner lets to create and edit HVAC systems (Chowdhury, 2014).

3.2.7 Metrics for simulation performance evaluation

Criteria were chosen which determine whether the daylight situation and thermal condition at a sensor is 'adequate' at a particular point in time. Several criteria have been suggested as following. Appendix-A provides the detailed lighting terminology.

a) For daylight simulation performance evaluation

1. **DF** is the ratio of internal light level to external light level and is defined as follows: DF = (Ei / Eo) x 100%

Where, E_i = illuminance due to daylight at a point on the indoor working plane
E_o = simultaneous outdoor illuminance on a horizontal plane from an unobstructed hemisphere of overcast sky.

In order to calculate E_i, one must establish the amount of light received from the outside to the inside of a building. Average daylight factors are divided into the following categories.

a) Below 2% – Not adequately lit – artificial lighting will be required.
b) Between 2% and 5% – Adequately lit but artificial lighting may be in use for part of the time.
c) Above 5% – Well lit – artificial lighting generally not required except at dawn and dusk – but glare and solar gain may cause problems.

2. **DA [%],** a percentage of annual daytime hours that a given point in a space is above a specified illumination level. For this research, DA threshold was assumed as 300 lux. If arrival time is 8:00 AM and departure time is 5:00 pm, it means 9 hour of a day x 365 days = 3285 luminous hours round the year.

3. **UDI [%]** is hourly time values based upon three illumination ranges, 0-100 lux, 100-2000 lux, and over 2000 lux (Nabil, 2006). Below 100 lux is not considered as visible light and working light. It provides full credit only to values between 100 lux and 2,000 lux. This range is regarded as useful daylight illumination range. Horizontal illumination values outside 2,000 lux

range are not useful. 2000 lux is the upper threshold, above which daylight is not wanted due to potential glare or overheating. So, less value of UDI<2000 means good indoor luminous environment.

4. **DA $_{max}$ [%]** is an illuminance-based glare analysis metrics. The idea is to calculate DA $_{max}$ using an illuminance threshold which is 10 times the design illuminance. For example, if 300 lux is the threshold then over 300 x 10= 3000 lux will be counted as DA $_{max}$ value. DA $_{max}$ must not exceed 1%, for more than 5% of a critical working plane area (Iqbal, 2015).

5. **Continuous Daylight Autonomy [DA_{con}],** proposed by Rogers (2006), is another set of metrics that resulted from research on classrooms. In contrast to earlier definitions of daylight autonomy, partial credit is attributed to time steps when the daylight illuminance lies below the minimum Illuminance level. For example, in the case where minimum 300 lux are required and 260 lux are provided by daylight at a given time step, a partial credit of 260 Lux/300 Lux = 0.87 is given for that time step.

b) For thermal simulation performance evaluation

1. **Zone Mean Air Temperature [ºC],** is the average temperature of the air temperatures at the system timestep. The zone heat balance represents a "well stirred" model for a zone, therefore, there is only one mean air temperature to represent the air temperature for the zone. EnergyPlus™ has the ability to provide the average air temperature data per minute for a specific day for architecture design studio.

2. **Zone Mean Radiant Temperature [ºC],** of a space is a measure of the combined effects of temperatures of surfaces within that space. Specifically, it is the surface area × emissivity weighted average of the zone inside surface temperatures, where emissivity is the thermal absorbance of the inside material layer of each surface.

3. **Zone Air Relative Humidity [%],** represents the air relative humidity after the correct step for each zone. The relative humidity uses the Zone Air Temperature, the Zone Air Humidity Ratio and the Outside Barometric Pressure for calculation.

4. **Zone Outdoor Wind speed [m/s],** calculates at the work plane height above floor level of the zone centroid.

3.2.8 Simulation parameters

a) Design conditions for daylight and thermal simulations

For dynamic daylight and static thermal simulation, design conditions for the modelling were set as shown in Table 3.12.

Table 3.11: Design conditions for daylight and thermal simulation

Sl. No.	Factors	Findings
1	Illumination threshold	300 Lux (IESNA, 2000)
2	Neutral air temperature	30.2^{o}c (Tariq, 2014)
3	Neutral relative humidity	66.5% (Tariq, 2014)
4	Air velocity	0.50 m/s (Tariq, 2014)
5	Clothing insulation	0.50 clo (Tariq, 2014)
6	Metabolic rate	1.2 (Tariq, 2014)
7	Air change rate	4 (1/hr) (ASHRAE, 2000)

b) Time basis for daylight and thermal simulations

Calculation of hourly illumination was done for the whole year at 160 intersecting grid points for dynamic daylight simulation. Each point provides 8760 (365 x 24) illumination data, considering 24 hours of the day and 3285 (365 x 09) data considering 09 hours of daylight time from 8:00 AM to 5:00 PM in 6 days a week. For thermal simulation, whole room were considered where each point gives data for the hottest day (April 24, 2016) from 8:00 AM to 5:00 PM in 6 days a week. Table 3.11 shows the parameters, considered for dynamic daylight metrics and thermal metrics (Iqbal, 2015).

Table 3.12: Daylighting and thermal simulation parameters

Parameters	Specifications
Location	Dhaka, Bangladesh
Longitude	90.40°N
Latitude	23.80°E
Sky illuminance design	16,500 Lux (Khan, 2005)
Time zone	+6 GMT
Hours of operation	6 days a week, 8:00 AM to 5:00 PM
Simulation time	8:00 AM to 5:00 PM
Building construction type	ASHRAE 90.1 non Res.
Room air distribution model	General cross ventilation
Natural ventilation	Simple
Occupancy	40 persons
Date	For dynamic daylight metrics: whole year
	For thermal simulation: Hottest day- April 24, 2016
Sky illumination model	Perez all possible sky model round the year (Appendix-A).
Unit of dimension	SI, metric (m, cm, mm)
	Photometric dimension: SI (lux, cd/m2)
Daylight properties of sky window glaze portion	Transmission: 90%
	Pollution factor: 0.70
	Framing factor: 0.90
	Maintenance factor: 0.85

c) Climate database for daylight and thermal simulations

Hourly weather data 'BGD_Dhaka.419230_SWERE.epw, originated from the US Department of Energy for Dhaka/Tejgaon was used to give input in DAYSIM and EnergyPlus™. For preparing thermal simulation settings, data of April 24, 2016 were modified based on the information gathered from the Bangladesh meteorological department, Agargaon, Dhaka (discussed in Chapter 2).

d) Dynamic daylight simulation engine parameters

DAYSIM uses the same Raytracer used to generate RADIANCE rendering. As DAYSIM calculate illuminances at discrete sensors, the simulation parameters needed to be modified slightly. Higher parameter settings will result in longer process time. Therefore, the art is to use parameters that are "sufficiently high but not too high" (Joarder, 2011). Table 3.13 summarizes the non-default RADIANCE simulation parameters for the simulation analysis for complex geometry. Appendix-A provides the definition of terms used in Table 3.13.

Table 3.13: Utilized simulation parameters in DAYSIM (Reinhart, 2006)

Ambient bounces	Ambient division	Ambient sampling	Ambient accuracy	Ambient Resolution	Specular threshold	Direct sampling
5	1000	20	0.01	300	0.15	0.0

e) Thermal simulation engine parameters

Before starting the simulations, a set of parameters were set for EnergyPlus™ and OpenStudio plug in modelling which are the followings (Table 3.14):

Table 3.14: Thermal simulation engine parameters (after Chowdhury, 2014)

Parameters	Specifications
Simulation engine	EnergyPlus™
Version identifier	7.2.0
Run simulation for weather file run periods	Yes
Run simulation for sizing periods	Yes
Terrain	City
Loads convergence tolerance value	0.4
Temperature convergence tolerance value	0.4
Solar distribution	Full interior and exterior
Calculation method	Average over days in frequency
Calculation frequency	20
Sky diffuse modelling algorithm	Detailed sky modelling
Algorithm	TARP & DOE-2
Number of time steps per hour	60

3.2.9 3-D model of the case studio for daylight simulation

For daylight simulation, the case studio was modelled in ECOTECT V5.5 (discussed in 3.2.5). The studio is a rectangular room of 137 m^2 (14.9m x 9.2m), designed for 40 students which consists of window openings on south façade and doors on north façade (Figure 3.18). A corridor runs through the floor in front of the room. There are four windows of 3.78 m^2 (1.8m x 2.1m) each in the studio (Figure 3.19). The bottom level of the window was at 600mm and the top level was at 2700mm.

Figure 3.18: Interior view of the case studio

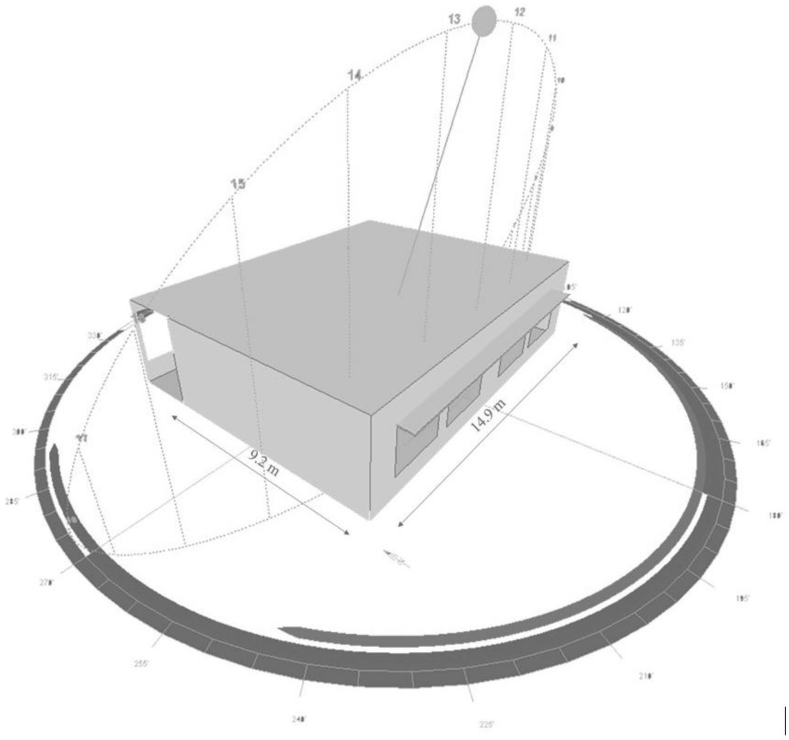


Figure 3.19: 3-dimensional exterior view of the case studio with sun path diagram of Dhaka (ECOTECT)

All indoor and outdoor conditions were kept constant, as found in the physical survey, i.e. window size, sill height, work plane height and different material reflectance. The interior space was modelled as vacant, devoid of any partitions or furniture, to avoid the effects of such surfaces, which may block and reflect daylight and may hide the actual difference of the impacts of the different window configurations being assessed. Table 3.15 shows the modelling parameters for simulation study.

Table 3.15: Modelling parameters for daylight and thermal simulation

Sl.	Parameters	Specification
1	Studio floor dimension	14.9m x 9.2m
2	Total floor area	137 m^2
3	Window to floor area ratio	0.11%
4	Window size	3.78m^2
5	Number of windows	4 nos.
7	Work plane height	0.75m
8	Window top level	2.2m
9	Window bottom height	0.55m
10	Ceiling	Height: 3.45m, Concrete, White painted
11	Average work plane height of studio table	0.75m
12	Floor	600mm x 600mm glazed tiles
13	Wall	North and East: Yellow, painted Particle board South: White painted on plaster West: White painted on Particle board
14	Window glazing	Single panel of glass with aluminum frame
15	Roof material	Concrete, white painted.

- ***Material Properties for daylight and thermal simulation***

For dynamic daylight and thermal simulation, material properties of the model were set according to the condition found in the field survey (Table 3.16).

Table 3.16: Material properties of the case studio used for simulation study

Building element	Material description	Material properties
Ceiling	Concrete slab with plaster	70% diffuse reflectance
Walls	North: Brick with plaster either side plus Particle board	40% diffuse reflectance
	East: Brick with plaster either side plus Particle board	40% diffuse reflectance
	South: Brick with plaster either side	50% diffuse reflectance
	West: Brick with plaster either side plus Particle board with glossy white topping	50% diffuse reflectance
Floor	Concrete slab on ground plus ceramic tiles	30% diffuse reflectance
Window	Single glazed low-e aluminium frame	90% visual transmittance
Mullions	Aluminium	50% diffuse reflectance

3.2.10 Test sensor points in 3-D space

With the reference of the furniture arrangements (drafting table), entire floor of the case studio was divided into 160 sensor points for simulation purpose (Figure 3.20). These sensor points were set into the work plane height at 0.75m from the floor level, representing the average height of the drafting table.

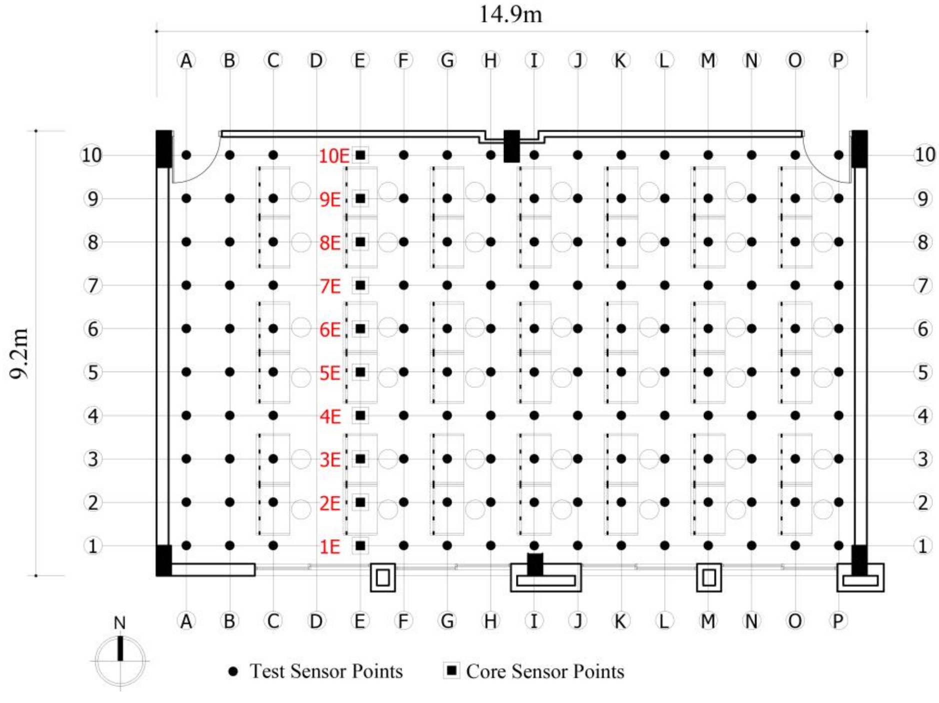


Figure 3.20: 3-D case studio showing the sensor points.

Intersection points in the plan were coded according to the letter and number system shown in the Figure 3.20 and Table 3.17. A total of 16 test sensor axis lines were placed in XX' direction and 10 in YY' direction, in an equal distance of 900mm from center to center.

Table 3.17: Intersection points for simulation study

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
1	1A	1B	1C	1D	**1E**	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P
2	2A	2B	2C	2D	**2E**	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P
3	3A	3B	3C	3D	**3E**	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P
4	4A	4B	4C	4D	**4E**	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
5	5A	5B	5C	5D	**5E**	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P
6	6A	6B	6C	6D	**6E**	6F	6G	6H	6I	6J	6K	6L	6M	6N	6O	6P
7	7A	7B	7C	7D	**7E**	7F	7G	7H	7I	7J	7K	7L	7M	7N	7O	7P
8	8A	8B	8C	8D	**8E**	8F	8G	8H	8I	8J	8K	8L	8M	8N	8O	8P
9	9A	9B	9C	9D	**9E**	9F	9G	9H	9I	9J	9K	9L	9M	9N	9O	9P
10	10A	10B	10C	10D	**10E**	10F	10G	10H	10I	10J	10K	10L	10M	10N	10O	10P
Visible node : 160																
Core sensor points: 1E, 2E, 3E, 4E, 5E, 6E, 7E, 8E, 9E, 10E.																

For dynamic daylight simulation which considers all possible sky models throughout the year, ten points on the EE axis were selected as core sensor points (Figure 3.21). The calculations consider both daylight factor (DF) and dynamic metric concepts under overcast sky conditions when there is no direct sunlight.

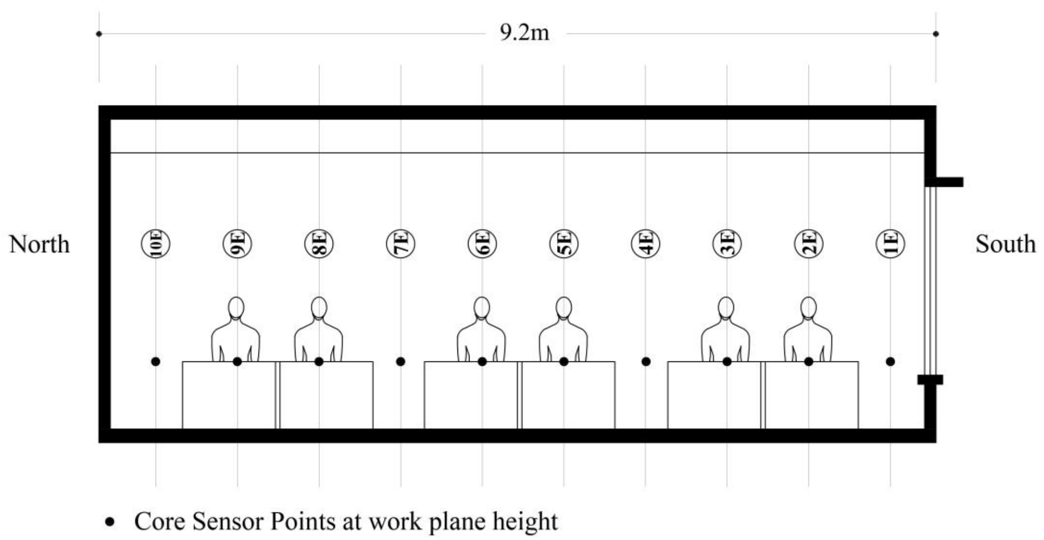


Figure 3.21: Cross section of the case studio showing core sensor points.

For thermal simulation on 24th April (hottest day, 2016), average value of whole case studio was considered to evaluate the performance of available window configurations in design studios in Dhaka. Considering human thermal comfort in a room, hottest day and coldest day are the extreme conditions in a year. The most dominant factor for comfort/discomfort in winter is the outdoor air temperature, while solar radiation is for summer (Huizenga, 2006). Therefore, hottest day was considered for analyzing the impact of windows for daylighting on thermal comfort in this research. Finally, the overall illumination level and thermal comfort condition for the configurations have been evaluated according to the following criteria:

For daylight simulation:

- Annual average illumination level on the core sensor points.
- Overall uniformity ratio of the test points data.
- Annual average illumination based glare index ratio (DA_{max}) on the test points
- DF, DA, UDI and DA_{con} value of the 10 core sensor points.

For thermal simulation:

- PMV and PPD values of the room by calculating simulation results of Air temperature, Mean radiant temperature, Relative humidity and Wind speed.

3.3 Summary

This Chapter explains the methodology for simulation study and selection criteria of case architecture design studio. The detail simulation study of available window configurations placed in case studio with respect to daylighting and thermal condition, is analysed and presented in the next Chapter 4.

4. CHAPTER FOUR: SIMULATION STUDY AND RESULTS

Preamble

Performance evaluation of window configurations

Dynamic daylight simulation findings for available window configurations

Static thermal comfort simulation findings for available window configurations

Comparative analysis to propose the most feasible window category

Summery

CHAPTER 4 SIMULATION STUDY AND RESULTS

4.1 Preamble

This chapter contains the descriptions and outputs of simulation exercise based on the outputs of previous chapter. Chapter 2 reviewed the basic information required as the basis of simulation study and Chapter 3 described the methodology of simulation study. This chapter consists of three major parts. The first part presents the results of dynamic metrics which considers all possible sky models in a year analysed by DAYSIM dynamic annual CBDM method. The second part describes the outcomes of thermal simulation. Finally, the third part elaborates the comparative analysis between the window configurations according to daylight and thermal simulation. The strategies based on the activities and key findings have been presented in concluding Chapter 5.

4.2 Performance evaluation of window configurations

Performance metrics can be used for comparative studies to guide building design or to benchmark a building against a pool of other buildings. Performance metrics range from being rather specific, e.g. it can be used to benchmark a window configuration for Architecture design studios in Bangladesh against a pool of available window configuration types used in the designed or renovated studios. These metrics usually combines several individual sub metrics into a single overall rating, stipulating a pass or fail criteria for each sub metric (Reinhart et al. 2006).

To start with, case studio with selected window configurations under four window categories i.e. segregated viewing windows, segregated full height windows, continuous viewing windows, and continuous full height windows (Section 3.2.9) was modelled in ECOTECT V5.0 and transported to DAYSIM V2.1.P4 simulation software to analyze dynamic performance of present daylighting situation.

The studio with 14 window configurations (Table 4.1) was also modelled in Sketch up 8- OpenStudio software to find out the thermal performance of the window configurations for hottest day by EnergyPlus 7.2.0. All the outdoor and indoor conditions and parameters were kept constant as found in field investigation and described in previous Chapter 3. Work plane height was kept at 0.75m height. Grid layout was set into the work plane height as illustrated on Section 3.2.10.

Table 4.1: Window configurations with dimensions.

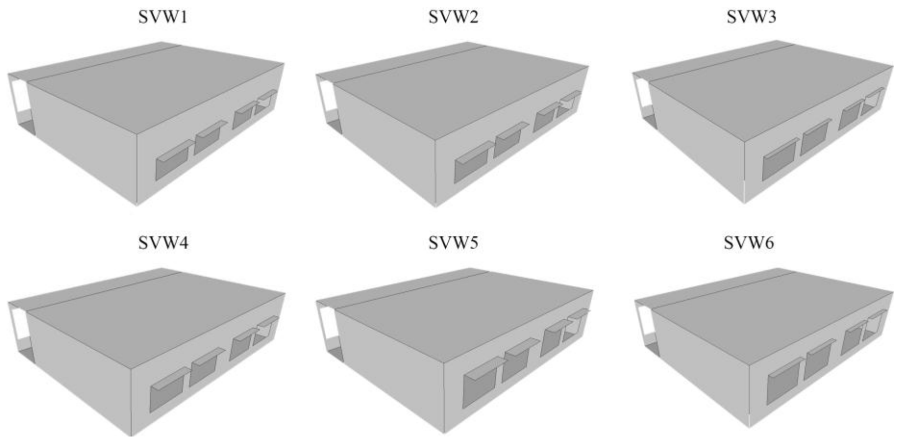
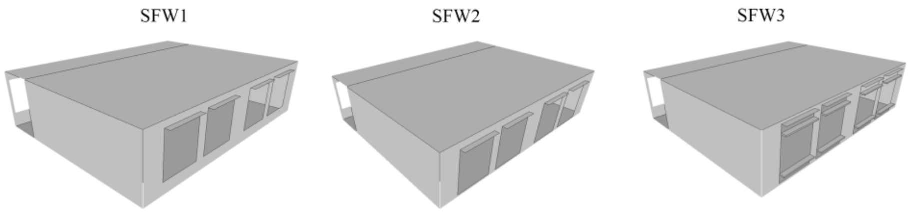
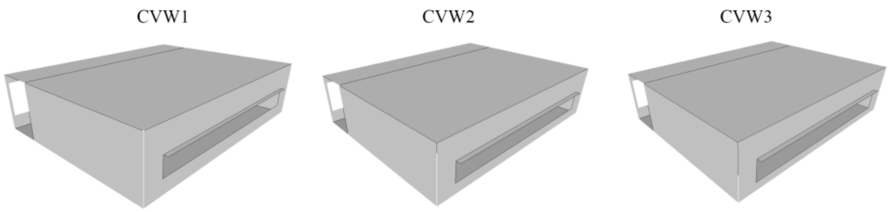
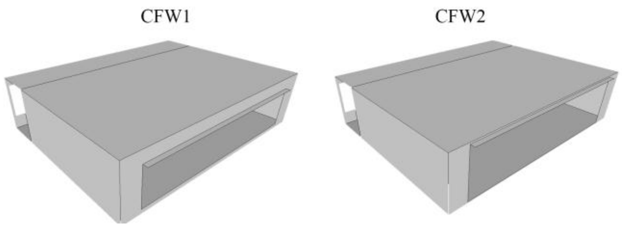
Category of Windows	Code	Window dimension	Shading dimension	Window wall ratio (WWR) [%]
Segregated Viewing Windows	SVW1	4 no. 2400mm x 1200mm	4 no. 2400mm x 450mm	22.4
	SVW2	4 no. 2400mm x 1350mm	4 no. 2400mm x 450mm	25.2
	SVW3	4 no. 2400mm x 1500mm	4 no. 2400mm x 300mm	28.0
	SVW4	4 no. 2400mm x 1500mm	4 no. 2400mm x 300mm	28.0
	SVW5	4 no. 2400mm x 1650mm	4 no. 2400mm x 450mm	30.8
	SVW6	4 no. 2400mm x 1650mm	4 no. 2400mm x 300mm	30.8
Segregated Full-height Windows	SFW1	4 no. 2400mm x 2550mm	4 no. 2400mm x 300mm	47.6
	SFW2	4 no. 2400mm x 3000mm	4 no. 2400mm x 250mm	56.0
	SFW3	4 no. 2400mm x 3000mm	4 no. 2400mm x 125mm	56.0
Continuous Viewing Windows	CVW1	1 no. 12000mm x 1200mm	1 no. 12000mm x 250mm	28.0
	CVW2	1 no. 12000mm x 1350mm	1 no. 12000mm x 250mm	31.5
	CVW3	1 no. 12000mm x 1500mm	1 no. 12000mm x 500mm	35.0
Continuous Full-height Windows	CFW1	1 no. 12000mm x 2550mm	1 no. 12000mm x 300mm	59.5
	CFW2	1 no. 12000mm x 3000mm	1 no. 12000mm x 50mm	70.0

South façade of the case studio with fourteen configurations of windows were coded as SVW1 to SVW6 for segregated viewing windows; SFW1 to SFW3 for segregated full-height windows; CVW1 to CVW3 for continuous viewing windows; and lastly, CFW1 and CFW2 for continuous full-height windows (Table 4.1) and simulated in two metrics: Dynamic metrics for daylighting; and, PMV-PPD model analysis considering indoor thermal conditions.

4.3 Dynamic daylight simulation findings for available window configurations

Summary results of annual dynamic metric simulations are shown in this Section, considering core work plane sensor approach (described in Section 3.2.10), which was introduced by Reinhart (2006). Table 4.2 shows the ECOTECT modelling of the case studio with studied window configurations, found in field survey. Appendix-F presents the detailed dynamic daylight simulation data.

Table 4.2: ECOTECT modelling of case studio with selected window configurations.

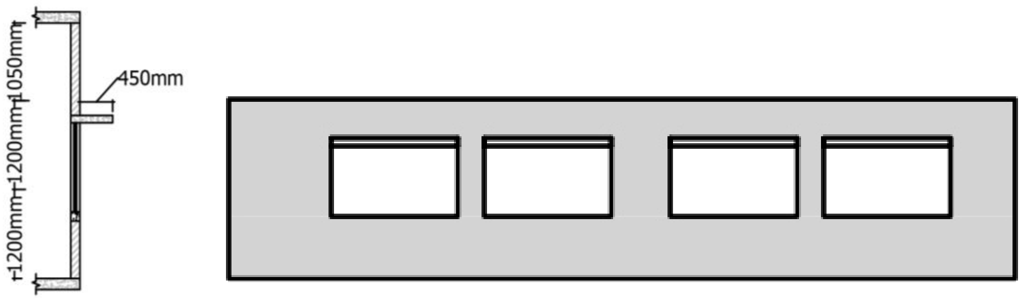
Types of Windows	ECOTECT modelling
Segregated Viewing Windows	
Segregated Full-height Windows	
Continuous Viewing Windows	
Continuous Full-height Windows	

4.3.1 Dynamic daylight simulation of SVW1

Annual CBDM simulation result of case studio with segregated viewing windows-SVW1 on south façade is presented in Table 4.3. It was observed from the Table that core sensor point 1E yielded highest DA of 97% with highest 8.8 DF. Lowest 79% DA with lowest 1.3 DF were found at 9E sensor point. 5E and 6E sensor points yielded the best UDI value among other sensor points with highest 96% $UDI_{100-2000}$ and lowest 0% $UDI_{>2000}$ metric value. 1E sensor point provided the worst UDI value among other sensor points with lowest 23% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 76%.

Table 4.3: Annual CBDM simulation result of segregated viewing windows-SVW1 on south façade.

Segregated Viewing Windows (SVW1)



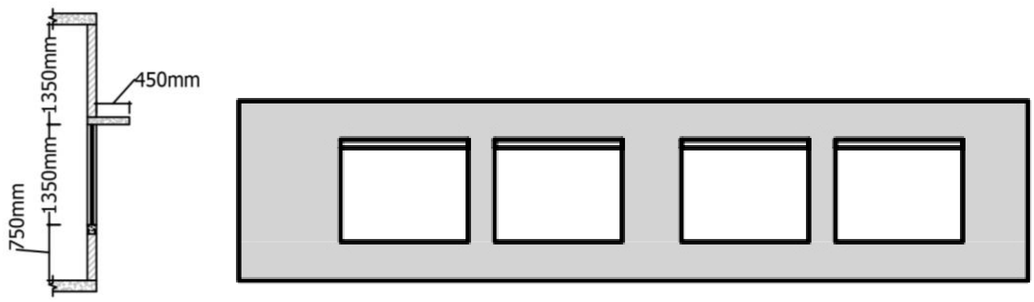
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	8.8	5.3	3.3	2.4	2	1.7	1.5	1.4	1.3	1.4
Daylight autonomy [DA] [%]	97	96	93	90	88	85	83	79	79	81
Continuous DA mean [DA_{con}] [%]	99	98	97	95	94	93	92	91	91	91
Maximum DA mean [DA_{max}] [%]	52	22	0	0	0	0	0	0	0	0
UDI<100 [%]	1	1	2	3	3	4	5	6	6	5
UDI 100-2000[%]	23	47	80	93	96	96	95	94	94	95
UDI> 2000 [%]	76	52	18	4	0	0	0	0	0	0

4.3.2 Dynamic daylight simulation of SVW2

Annual CBDM simulation result of case studio with segregated viewing windows-SVW2 on south façade is presented in Table 4.4. It was observed from the Table that core sensor point 1E yielded highest DA of 98% with highest 11.1 DF. Lowest 84% DA with lowest 1.4 DF was found at 8E sensor point, while 9E provided the lowest DF of 1.6. 7E to 10E sensor points yielded the best UDI value among other sensor points with highest 96% $UDI_{100-2000}$ and lowest 0% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 17% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 82%.

Table 4.4: Annual CBDM simulation result of segregated viewing windows-SVW2 on south façade.

Segregated Viewing Windows (SVW2)



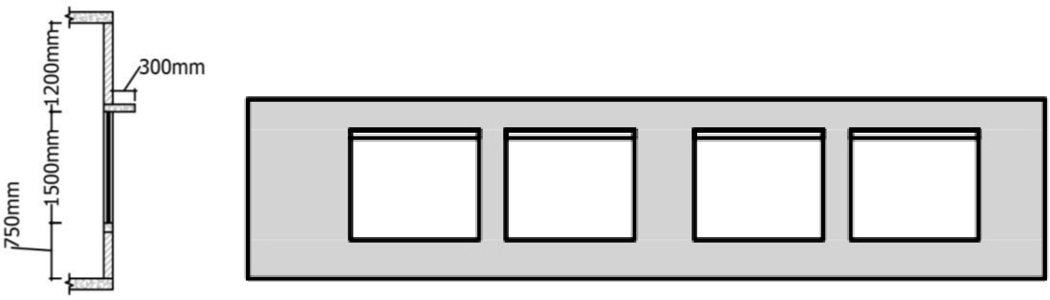
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	11.1	6.8	4.1	3.1	2.5	2.2	1.9	1.7	1.6	1.7
Daylight autonomy [DA] [%]	98	97	95	92	90	88	87	84	85	86
Continuous DA mean [DA_{con}] [%]	99	98	97	96	95	95	94	93	93	93
Maximum DA mean [DA_{max}] [%]	66	38	10	1	0	0	0	0	0	0
UDI<100 [%]	1	1	2	2	3	3	4	4	4	4
UDI 100-2000[%]	17	34	64	81	90	94	96	96	96	96
UDI> 2000 [%]	82	64	34	17	8	3	0	0	0	0

4.3.3 Dynamic daylight simulation of SVW3

Annual CBDM simulation result of case studio with segregated viewing windows-SVW3 on south façade is presented in Table 4.5. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 14.3 DF. Lowest 87% DA with lowest 1.9 DF were found at 9E sensor point. On the other hand, 9E sensor point yielded the best UDI value among all sensor points with highest 96% $UDI_{100\text{-}2000}$ and lowest 0% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 13% $UDI_{100\text{-}2000}$ and highest $UDI_{>2000}$ of 86%.

Table 4.5: Annual CBDM simulation result of segregated viewing windows-SVW3 on south façade.

Segregated Viewing Windows (SVW3)



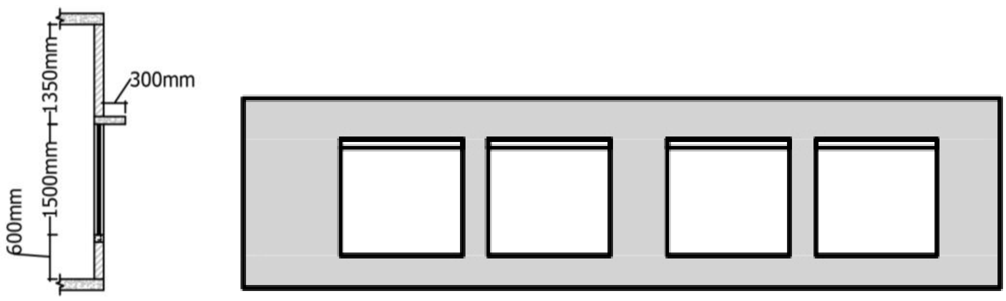
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	14.3	8.9	5.7	4	3.2	2.6	2.3	2.1	1.9	2
Daylight autonomy [DA] [%]	99	98	96	95	92	90	89	88	87	88
Continuous DA mean [DA_{con}] [%]	99	99	98	97	97	96	95	94	94	94
Maximum DA mean [DA_{max}] [%]	77	55	26	12	3	0	0	0	0	0
UDI<100 [%]	1	1	1	2	2	3	3	3	3	3
UDI 100-2000[%]	13	24	44	65	78	85	91	94	96	95
UDI> 2000 [%]	86	75	55	33	20	12	7	3	0	1

4.3.4 Dynamic daylight simulation of SVW4

Annual CBDM simulation result of case studio with segregated viewing windows-SVW4 on south façade is presented in Table 4.6. It was observed from the Table that core sensor point 1E yielded highest DA of 98% with highest 11.9 DF. Lowest 87% DA with lowest 1.9 DF were found at 10E sensor point. 8E, 9E and 10E sensor points yielded the best UDI value among all sensor points with highest 96% $UDI_{100\text{-}2000}$ and lowest 0% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 15% $UDI_{100\text{-}2000}$ and highest $UDI_{>2000}$ of 83%.

Table 4.6: Annual CBDM simulation result of segregated viewing windows-SVW4 on south façade.

Segregated Viewing Windows (SVW4)



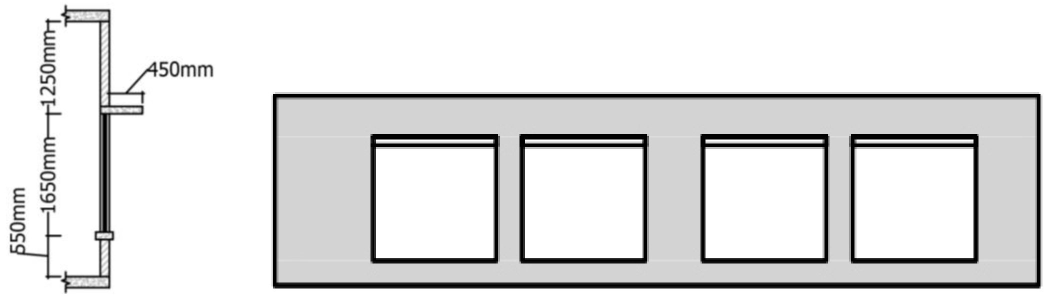
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	11.9	7.7	5.1	3.8	2.9	2.5	2.1	2	1.9	1.9
Daylight autonomy [DA] [%]	98	97	96	94	91	90	88	88	88	87
Continuous DA mean [DA_{con}] [%]	99	98	98	97	96	95	94	94	94	94
Maximum DA mean [DA_{max}] [%]	70	48	21	8	0	0	0	0	0	0
UDI<100 [%]	1	1	2	2	2	3	3	4	3	4
UDI 100-2000[%]	15	30	49	69	83	89	94	96	96	96
UDI> 2000 [%]	83	69	49	29	14	8	2	0	0	0

4.3.5 Dynamic daylight simulation of SVW5

Annual CBDM simulation result of case studio with segregated viewing windows-SVW5 on south façade is presented in Table 4.7. It was observed from the Table that core sensor point 1E yielded highest DA of 98% with highest 12.8 DF. Lowest 90% DA with lowest 2.4 DF were found at 9E and 10E sensor points. On the other hand, 10E sensor point yielded the best UDI value among other sensor points with highest 93% $UDI_{100-2000}$ and lowest 4% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 14% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 85%.

Table 4.7: Annual CBDM simulation result of segregated viewing windows-SVW5 on south façade.

Segregated Viewing Windows (SVW5)



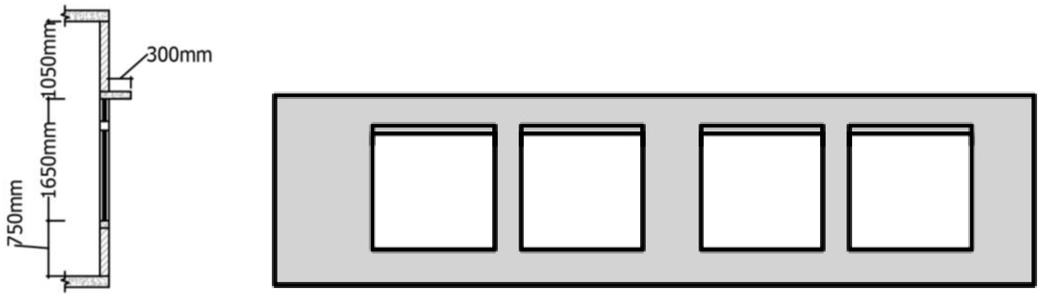
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	12.8	9.2	6.4	4.6	3.7	3.2	2.8	2.6	2.4	2.4
Daylight autonomy [DA] [%]	98	98	97	95	94	93	91	90	90	90
Continuous DA mean [DA $_{con}$] [%]	99	99	98	98	97	97	96	96	95	95
Maximum DA mean [DA $_{max}$] [%]	73	58	35	17	6	1	0	0	0	0
UDI<100 [%]	1	1	1	2	2	2	2	3	3	3
UDI 100-2000[%]	14	22	38	55	72	79	86	90	92	93
UDI> 2000 [%]	85	77	60	43	26	19	12	8	5	4

4.3.6 Dynamic daylight simulation of SVW6

Annual CBDM simulation result of case studio with segregated viewing windows-SVW6 on south façade is presented in Table 4.8. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 15.1 DF. Lowest 90% DA with lowest 2.5 DF were found at 9E sensor point. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 88% $UDI_{100-2000}$ and lowest 9% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 12% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 87%.

Table 4.8: Annual CBDM simulation result of segregated viewing windows-SVW6 on south façade.

Segregated Viewing Windows (SVW6)



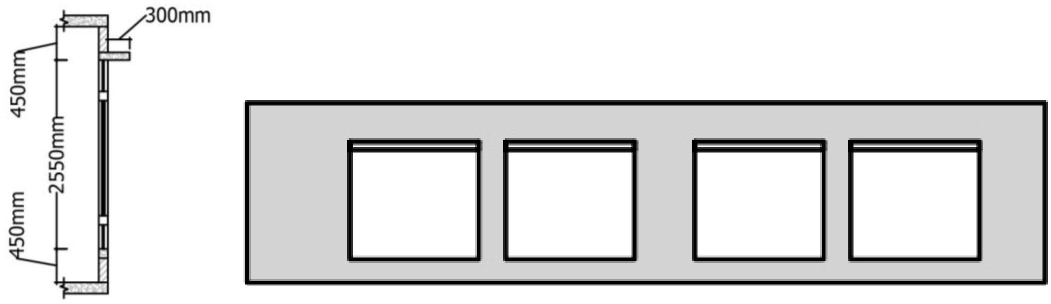
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	15.1	10.5	7	5.1	4	3.5	3	2.7	2.5	2.6
Daylight autonomy [DA] [%]	99	98	97	96	95	93	91	91	90	91
Continuous DA mean [DA_{con}] [%]	99	99	98	98	97	97	96	96	95	96
Maximum DA mean [DA_{max}] [%]	78	64	41	23	12	5	1	0	0	0
UDI<100 [%]	1	1	1	2	2	2	2	3	3	3
UDI 100-2000[%]	12	18	35	48	65	74	81	85	88	88
UDI> 2000 [%]	87	81	64	50	33	24	16	12	9	10

4.3.7 Dynamic daylight simulation of SFW1

Annual CBDM simulation result of case studio with segregated viewing windows-SFW1 on south façade is presented in Table 4.9. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 18.5 DF. Lowest 95% DA with lowest 4.1 DF were found at 8E to 10E sensor points. On the other hand, 8E and 9E sensor points yielded the best UDI value among other sensor points with highest 62% $UDI_{100-2000}$ and lowest 36% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 10% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 90%.

Table 4.9: Annual CBDM simulation result of segregated full-height windows-SFW1 on south façade.

Segregated Full-height Windows (SFW1)



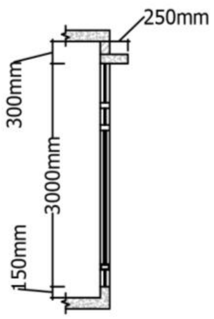
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	18.5	15.4	10.8	8	6.6	5.4	4.5	4.1	4.1	4.1
Daylight autonomy [DA] [%]	99	98	98	97	97	96	95	95	95	95
Continuous DA mean [DA_{con}] [%]	99	99	99	98	98	98	98	97	97	97
Maximum DA mean [DA_{max}] [%]	83	77	64	50	39	27	17	14	13	13
UDI<100 [%]	1	1	1	1	1	1	2	2	2	2
UDI 100-2000[%]	10	11	18	29	36	43	57	62	62	62
UDI> 2000 [%]	90	88	81	70	63	55	42	36	36	37

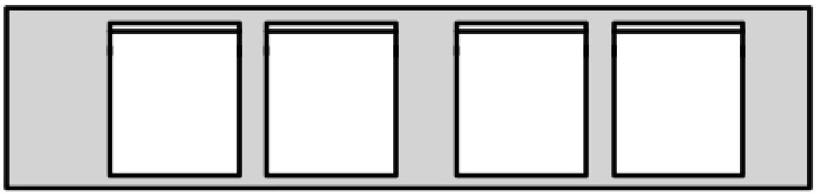
4.3.8 Dynamic daylight simulation of SFW2

Annual CBDM simulation result of case studio with segregated viewing windows-SFW2 on south façade is presented in Table 4.10. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 19.4 DF. Lowest 95% DA with lowest 4.4 DF were found at 9E and 10E sensor points. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 57% $UDI_{100-2000}$ and lowest 42% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 9% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 90%.

Table 4.10: Annual CBDM simulation result of segregated full-height windows-SFW2 on south façade.

Segregated Full-height Windows (SFW2)





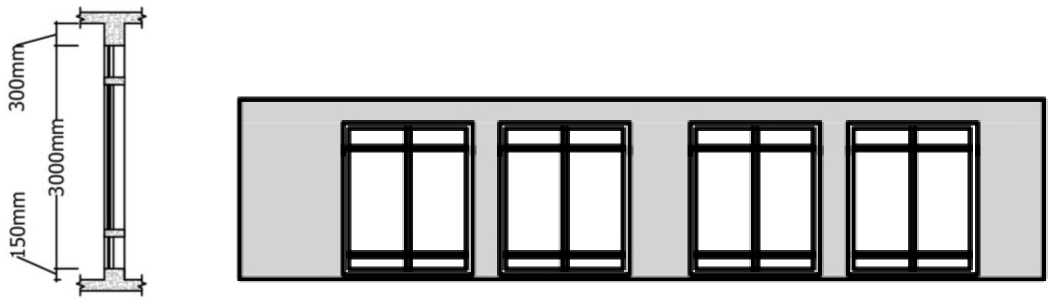
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	19.4	15.9	11.2	8.6	6.9	5.8	5.2	4.6	4.4	4.4
Daylight autonomy [DA] [%]	99	98	98	97	97	96	96	95	95	95
Continuous DA mean [DA_{con}] [%]	99	99	99	99	98	98	98	98	98	98
Maximum DA mean [DA_{max}] [%]	84	78	65	55	42	31	24	18	16	16
UDI<100 [%]	1	1	1	1	1	1	2	2	2	2
UDI 100-2000[%]	9	11	17	26	35	41	47	53	57	55
UDI> 2000 [%]	90	88	83	73	64	58	52	46	42	43

4.3.9 Dynamic daylight simulation of SFW3

Annual CBDM simulation result of case studio with segregated viewing windows-SFW3 on south façade is presented in Table 4.11. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 18.9 DF. Lowest 96% DA with lowest 4.5 DF were found at 10E sensor point. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 53% $UDI_{100-2000}$ and lowest 45% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 9% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 90%.

Table 4.11: Annual CBDM simulation result of segregated full-height windows-SFW3 on south façade.

Segregated Full-height Windows (SFW3)



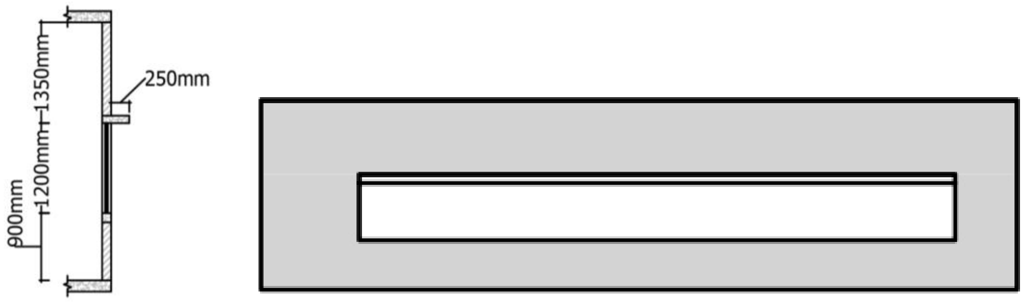
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	18.9	15.1	11.5	8.9	7.3	6	5.1	4.8	4.6	4.5
Daylight autonomy [DA] [%]	99	98	98	98	97	97	96	96	96	96
Continuous DA mean [DA_{con}] [%]	99	99	99	99	98	98	98	98	98	98
Maximum DA mean [DA_{max}] [%]	84	78	66	57	46	35	24	19	17	17
UDI<100 [%]	1	1	1	1	1	1	1	2	2	2
UDI 100-2000[%]	9	11	16	25	32	38	47	52	53	53
UDI> 2000 [%]	90	88	83	74	66	61	52	47	45	46

4.3.10 Dynamic daylight simulation of CVW1

Annual CBDM simulation result of case studio with segregated viewing windows-CVW1 on south façade is presented in Table 4.12. It was observed from the Table that core sensor point 1E yielded highest DA of 98% with highest 19.2 DF. Lowest 88% DA with lowest 2.1 DF were found at 9E sensor point. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 94% $UDI_{100\text{-}2000}$ and lowest 2% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 10% $UDI_{100\text{-}2000}$ and highest $UDI_{>2000}$ of 89%.

Table 4.12: Annual CBDM simulation result of continuous viewing windows-CVW1 on south façade.

Continuous Viewing Windows (CVW1)



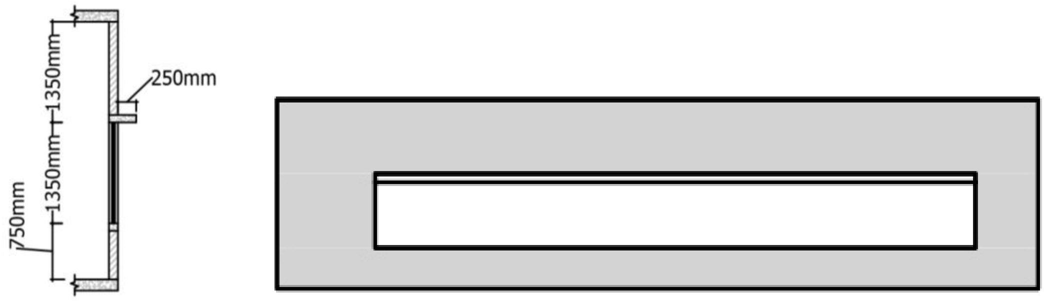
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	19.2	10	5.7	4	3.3	2.8	2.5	2.2	2.1	2.2
Daylight autonomy [DA] [%]	98	98	96	95	93	91	90	89	88	89
Continuous DA mean [DA_{con}] [%]	99	99	98	97	97	96	95	95	94	95
Maximum DA mean [DA_{max}] [%]	81	61	27	12	4	0	0	0	0	0
UDI<100 [%]	1	1	1	2	2	3	3	3	3	3
UDI 100-2000[%]	10	19	42	65	77	84	88	93	94	94
UDI> 2000 [%]	89	80	56	34	21	14	9	4	2	3

4.3.11 Dynamic daylight simulation of CVW2

Annual CBDM simulation result of case studio with segregated viewing windows-CVW2 on south façade is presented in Table 4.13. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 20.7 DF. Lowest 89% DA with lowest 2.3 DF were found at 9E sensor point. On the other hand, 9E and 10E sensor points yielded the best UDI value among other sensor points with highest 92% $UDI_{100\text{-}2000}$ and lowest 5% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 9% $UDI_{100\text{-}2000}$ and highest $UDI_{>2000}$ of 91%.

Table 4.13: Annual CBDM simulation result of continuous viewing windows-CVW2 on south façade.

Continuous Viewing Windows (CVW2)



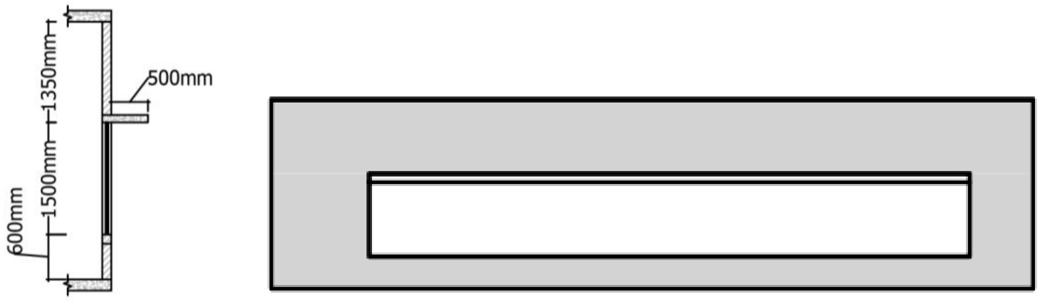
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	20.7	9.8	6	4.4	3.6	3	2.6	2.5	2.3	2.4
Daylight autonomy [DA] [%]	99	98	96	95	94	91	90	90	89	90
Continuous DA mean [DA_{con}] [%]	99	99	98	98	97	96	96	95	95	95
Maximum DA mean [DA_{max}] [%]	85	60	30	16	7	1	0	0	0	0
UDI<100 [%]	1	1	1	2	2	2	3	3	3	3
UDI 100-2000[%]	9	19	41	59	72	82	87	90	92	92
UDI> 2000 [%]	91	80	58	39	26	16	11	7	5	5

4.3.12 Dynamic daylight simulation of CVW3

Annual CBDM simulation result of case studio with segregated viewing windows-CVW3 on south façade is presented in Table 4.14. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 20.9 DF. Lowest 90% DA with lowest 2.6 DF were found at 9E sensor point. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 89% $UDI_{100-2000}$ and lowest 8% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 8% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 91%.

Table 4.14: Annual CBDM simulation result of continuous viewing windows-CVW3 on south façade.

Continuous Viewing Windows (CVW3)



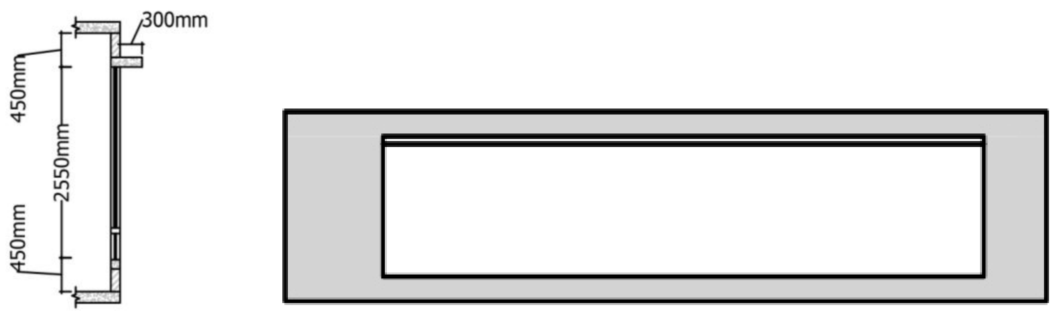
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	20.9	10.1	6.3	4.5	3.8	3.3	3	2.8	2.6	2.7
Daylight autonomy [DA] [%]	99	98	97	95	94	93	91	91	90	91
Continuous DA mean [DA_{con}] [%]	99	99	98	98	97	97	96	96	95	96
Maximum DA mean [DA_{max}] [%]	85	63	35	17	10	4	1	0	0	0
UDI<100 [%]	1	1	1	2	2	2	2	2	3	3
UDI 100-2000[%]	8	18	37	56	67	77	82	85	89	88
UDI> 2000 [%]	91	81	62	42	32	21	16	12	8	10

4.3.13 Dynamic daylight simulation of CFW1

Annual CBDM simulation result of case studio with segregated viewing windows-CFW1 on south façade is presented in Table 4.15. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 27.3 DF. Lowest 96% DA with lowest 4.7 DF were found at 9E sensor point. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 51% $UDI_{100-2000}$ and lowest 48% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 6% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 93%.

Table 4.15: Annual CBDM simulation result of continuous full-height windows-CFW1 on south façade.

Continuous Full-height Windows (CFW1)



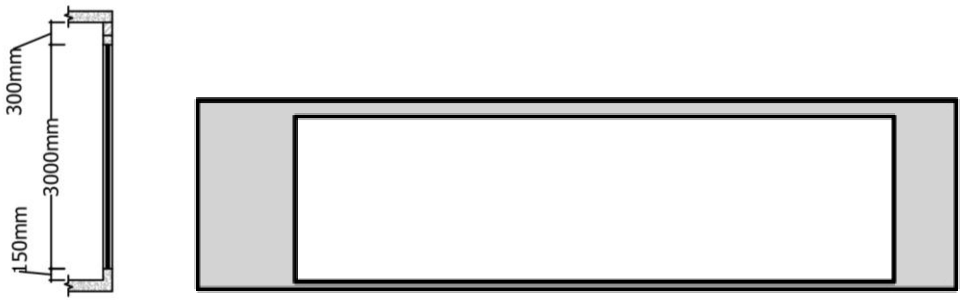
Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	27.3	17.3	11.8	9	7.2	6.2	5.3	5.1	4.7	4.8
Daylight autonomy [DA] [%]	99	98	98	98	97	97	96	96	96	96
Continuous DA mean [DA_{con}] [%]	99	99	99	99	98	98	98	98	98	98
Maximum DA mean [DA_{max}] [%]	89	82	69	58	46	36	25	22	19	19
UDI<100 [%]	1	1	1	1	1	1	1	2	2	2
UDI 100-2000[%]	6	10	15	24	32	38	45	47	51	49
UDI> 2000 [%]	93	89	84	75	66	61	54	51	48	49

4.3.14 Dynamic daylight simulation of CFW2

Annual CBDM simulation result of case studio with segregated viewing windows-CFW2 on south façade is presented in Table 4.16. It was observed from the Table that core sensor point 1E yielded highest DA of 99% with highest 30.8 DF. Lowest 97% DA with lowest 6.6 DF were found at 9E and 10E sensor points. On the other hand, 9E sensor point yielded the best UDI value among other sensor points with highest 34% $UDI_{100-2000}$ and lowest 65% $UDI_{>2000}$. 1E sensor point provided the worst UDI value among other sensor points with lowest 5% $UDI_{100-2000}$ and highest $UDI_{>2000}$ of 94%.

Table 4.16: Annual CBDM simulation result of continuous full-height windows-CFW2 on south façade.

Continuous Full-height Windows (CFW2)



Core points	**1E**	**2E**	**3E**	**4E**	**5E**	**6E**	**7E**	**8E**	**9E**	**10E**
Daylighting factor [DF] [%]	30.8	22.6	16.4	12.8	10.3	8.7	7.4	6.8	6.6	6.6
Daylight autonomy [DA] [%]	99	99	98	98	98	98	97	97	97	97
Continuous DA mean [DA_{con}] [%]	99	99	99	99	99	99	98	98	98	98
Maximum DA mean [DA_{max}] [%]	90	87	81	72	64	58	49	43	41	41
UDI<100 [%]	1	1	1	1	1	1	1	1	1	1
UDI 100-2000[%]	5	8	11	14	18	24	30	33	34	33
UDI> 2000 [%]	94	91	89	85	81	75	69	65	65	66

4.3.15 Comparison of Dynamic Daylight Simulation Results

Table 4.17 presents the summary results of dynamic daylighting performance process for architecture design studios provided with fourteen window configurations of four categories. According to DA and DA_{con}, continuous full height windows is superior to the other three window categories. However, it scored considerably lower in DA_{max}, $UDI_{100\text{-}2000}$ and $UDI_{>2000}$ metrics. $UDI_{100\text{-}2000}$ shows that, viewing windows provided with lintel height of 2100mm-2400mm effectively produce larger amount of useful daylight into the studio compared to the full height windows. Increase of lintel height i.e. full height windows, indicates excessive daylighting through large openings which may create glare, particularly in the workspace near windows. On the other hand, $UDI_{>2000}$ of minimum 60 percentage and DA_{max} of minimum 40 percentage suggest that, the case space for both segregated full height and continuous full height windows is over daylit.

Table 4.17: Summery result of annual CBDM simulation for available window configurations for architecture design studios.

Category of Windows	Code of Windows	DF (%)	DA (%)	DA_{con} (%)	DA_{max} (%)	$UDI_{<100}$ (%)	$UDI_{100\text{-}200}$ (%)	$UDI_{>2000}$ (%)
SVW	SVW1	2.9	87	94	7	4	81	15
	SVW2	3.7	90	95	12	3	76	21
	SVW3	4.7	92	96	17	2	69	29
	SVW4	4.2	92	96	15	3	72	25
	SVW5	5.0	94	97	19	2	64	34
	SVW6	5.6	94	97	19	2	59	39
SFW	SFW1	8.2	97	98	40	1	39	60
	SFW2	8.6	97	98	43	1	35	64
	SFW3	8.7	97	98	44	1	34	65
CVW	CVW1	5.4	93	96	19	2	67	31
	CVW2	5.7	93	97	20	2	64	34
	CVW3	6	94	97	22	2	61	38
CFW	CFW1	9.9	97	98	47	1	32	67
	CFW2	12.9	98	99	63	1	21	78

Figure 4.1, 4.2, 4.3, 4.4 and 4.5 show comparison of performance for different window configurations with respect to different dynamic metrics.

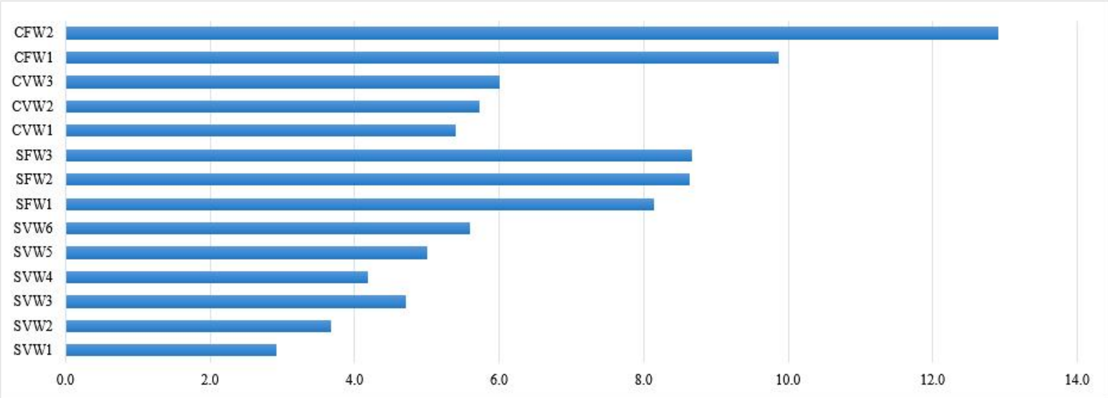


Figure 4.1: DF performance analysis for available window configurations of architecture design studios.

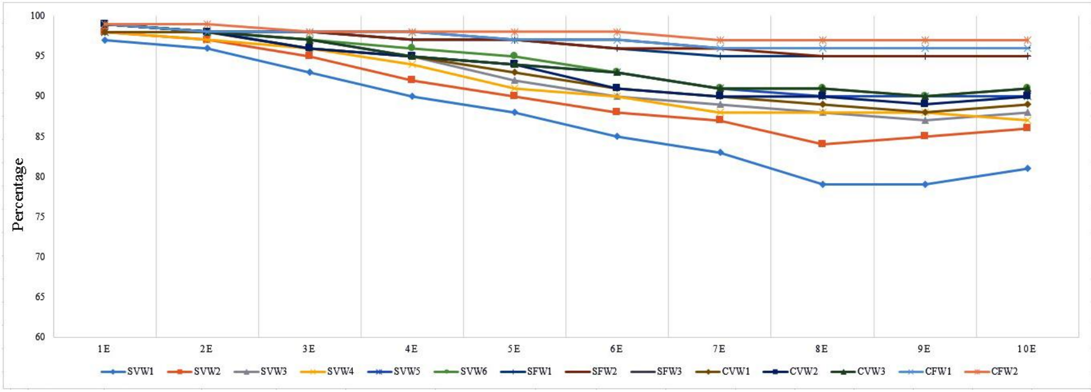


Figure 4.2: DA performance analysis for available window configurations of architecture design studios.

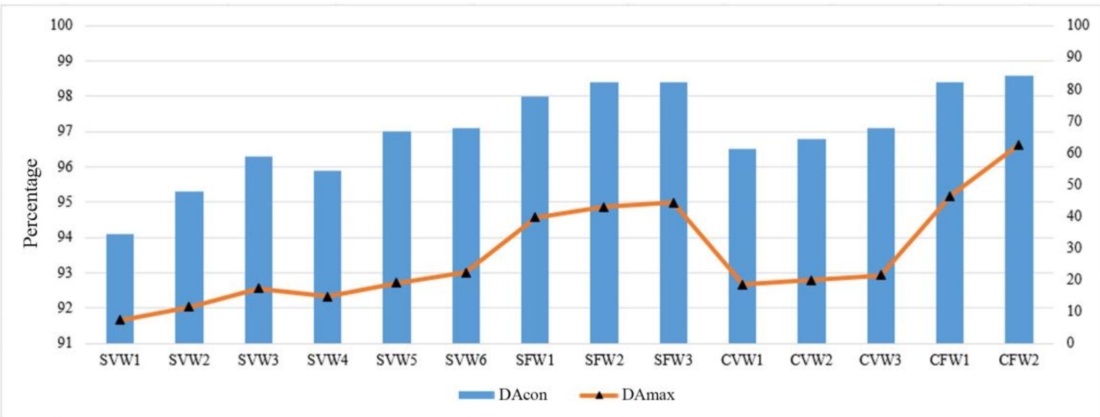


Figure 4.3: DA_{con} and DA_{max} performance analysis for available window configurations of architecture design studios.

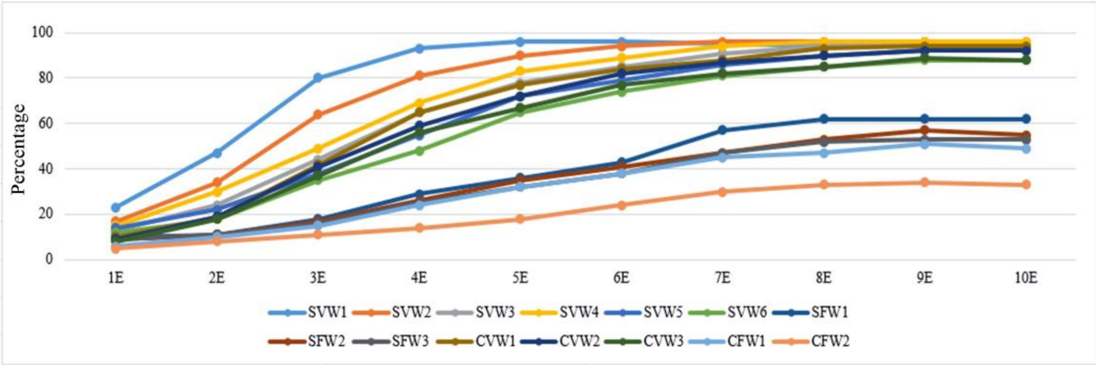


Figure 4.4: $UDI_{100\text{-}2000}$ performance analysis for available window configurations of architecture design studios.

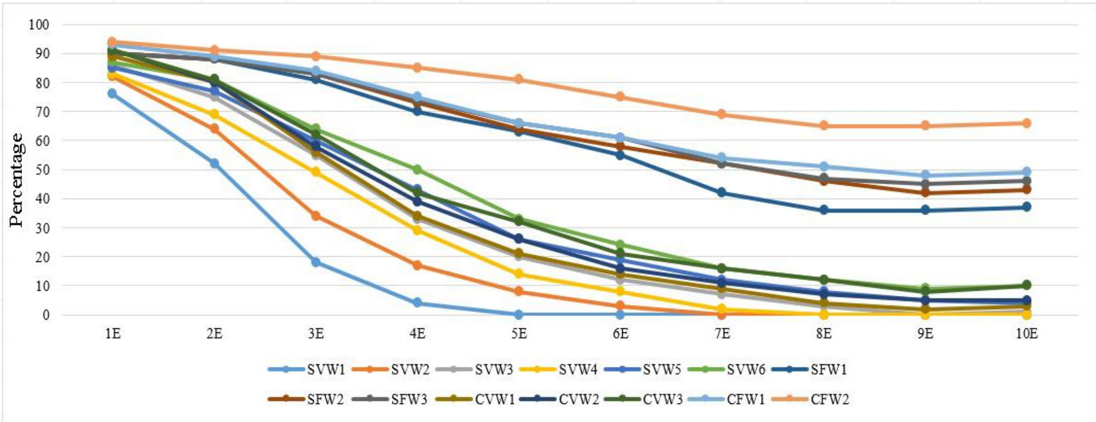


Figure 4.5: $UDI_{>2000}$ performance analysis for available window configurations of design studios.

4.3.16 Ratings of Dynamic Daylight Simulation Results

Rating between the fourteen available window configurations of four categories is easier to interpret using the dynamic metrics except UDI<100 and DF; as UDI<100 metric was identical almost for selected window configurations and DF considers only overcast sky (Reinhart et al. 2006).

From 1^{st} to 14^{th} place, rating points were considered as 13 point to 0 point respectively (Reinhart et al., 2006). Rating was done considering the dynamic metric e.g. DA, DA_{con}, DA_{max}, $UDI_{100\text{-}2000}$ and UDI>2000 range values and mean value of core sensor points for each available window configurations of architecture design studios in Dhaka (Table 5.18).

Table 4.18: Rating points distribution for different dynamic metrics of fourteen window configurations

Category of Windows	**Code of Windows**	**DA (%)**	**DA_{con} (%)**	**DA_{max} (%)**	**$UDI_{100-200}$ (%)**	**$UDI_{>2000}$ (%)**	**Ranking with rating points**	**Average rating points of category**	**Place**
SVW	SVW1	0	0	13	13	13	**3rd (39)**	**38.33**	**1st**
	SVW2	1	1	12	12	12	**4th (38)**		
	SVW3	3	4	10	10	10	**5th (37)**		
	SVW4	3	4	11	11	11	**2nd (40)**		
	SVW5	8	8	9	8	8	**1st (41)**		
	SVW6	8	8	9	5	5	**9th (35)**		
SFW	SFW1	12	12	4	4	4	**7th (36)**	**33**	**3rd**
	SFW2	12	12	3	3	3	**11th (33)**		
	SFW3	12	12	2	2	2	**12th (30)**		
CVW	CVW1	5	4	9	9	9	**6th (36)**	**34.67**	**2nd**
	CVW2	5	8	6	8	8	**8th (35)**		
	CVW3	8	8	5	6	6	**10th (33)**		
CFW	CFW1	12	12	1	1	1	**13th (27)**	**26.5**	**4th**
	CFW2	13	13	0	0	0	**14th (26)**		

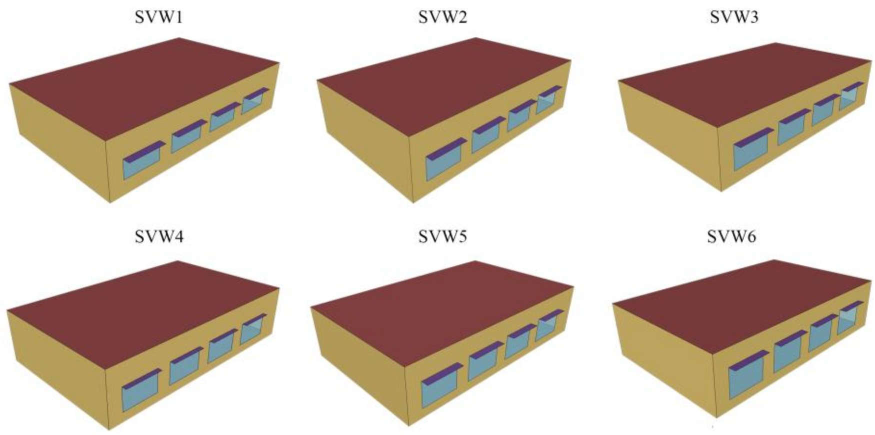
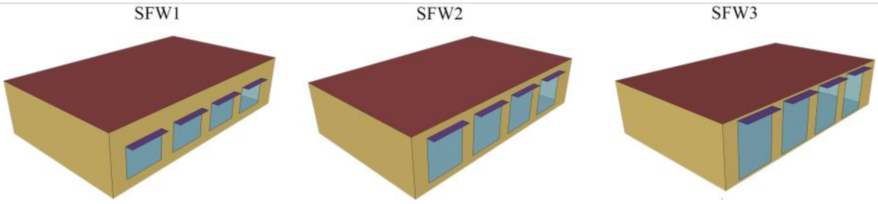
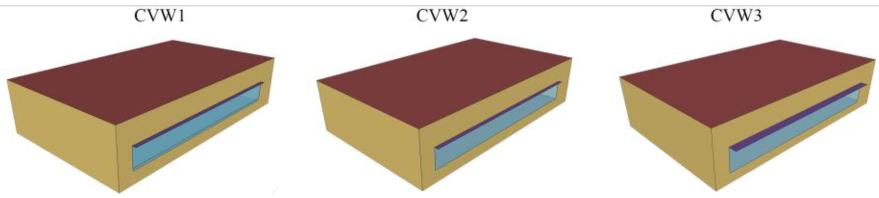
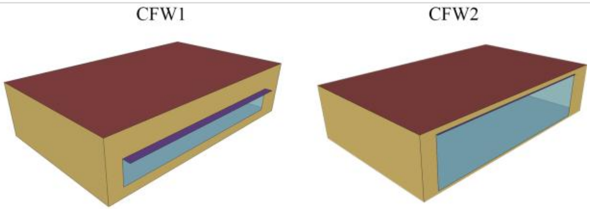
Considering most of the dynamic daylight metrics and sub metrics, window configurations of segregated viewing windows were found as higher in rank to the other window configurations (Table 4.18). Continuous full height windows perform poor for the reason of creating over daylit condition in the interior of case studio. After summing all the rating points achieved by the available window configurations, Segregated viewing windows was found as superior with rating points range of 35 to 41 and average of 38.33, to other window configurations. On the other hand, continuous full-height windows ware found as lowest as it achieved the rating points range of 26-27 and average of 26.5 points.

According to the dynamic daylight simulation, SVW5 was rated as the most feasible window configuration, while segregated viewing windows yielded the highest position among the four window categories for architecture design studios in Dhaka.

4.4 Thermal simulation findings for available window categories

Summary results of thermal metric simulations are shown in this Section, considering the whole interior space of case studio. Table 4.19 shows the Sketch up-OpenStudio modelling of the case studio with studied window configurations, found in field survey. Appendix-G shows the thermal simulation findings of the case studio.

Table 4.19: Sketch up-OpenStudio modelling of case studio with fourteen window configurations

Category of Windows	Sketch up-OpenStudio modelling
Segregated Viewing Windows	
Segregated Full-height Windows	
Continuous Viewing Windows	
Continuous Full-height Windows	

4.4.1 Comparison of Thermal Comfort Simulation Results

Table 4.20 presents the summary results of thermal performance process for architecture design studios provided with window configurations of four categories. Indoor air temperature gradually rose with increase of window size during the class time. Viewing windows provided the temperature range of 28.0°C to 28.9°C, while full-height windows provided increased temperature range of 29.0°C to 29.5°C. Maximum air temperature was found as 29.5°C for continuous full-height windows, which is in comfortability range. On the other hand, relative humidity decreased according to window size changes. Using viewing windows provide the sensation of higher relative humidity range of 62.6% to 64.2%, while continuous windows had lower humidity range of 60.2% to 62%. According to the average subjective reaction to wind speed (Section 2.10.4) in the studio, simulated results showed that, wind speed remained unnoticed with changes of window size.

Table 4.20: Summery result of thermal simulation for available window configurations for architecture design studios.

Category of Windows	**Code of Windows**	**Hottest day (24th April, 2016)**			
		Air Temperature [°C]	**Mean Radiant Temperature [°C]**	**Relative Humidity [%]**	**Wind Speed [m/s]**
SVW	SVW1	28.0	27.2	64.1	0.23
	SVW2	28.1	27.4	64.2	0.25
	SVW3	28.3	27.5	63.6	0.20
	SVW4	28.7	27.9	62.6	0.28
	SVW5	28.3	27.5	63	0.27
	SVW6	28.4	27.7	63.0	0.21
SFW	SFW1	29.0	28.5	62	0.24
	SFW2	29.2	29.0	60.7	0.22
	SFW3	29.3	29.0	60.7	0.21
CVW	CVW1	28.6	27.9	63.2	0.24
	CVW2	28.9	27.9	63.1	0.22
	CVW3	28.8	27.9	63.1	0.23
CFW	CFW1	29.5	29.2	60.2	0.24
	CFW2	29.5	29.8	60.2	0.25

Figure 4.6, 4.7, 4.8 and 4.9 show comparison of performance for different window configurations with respect to different thermal metrics.

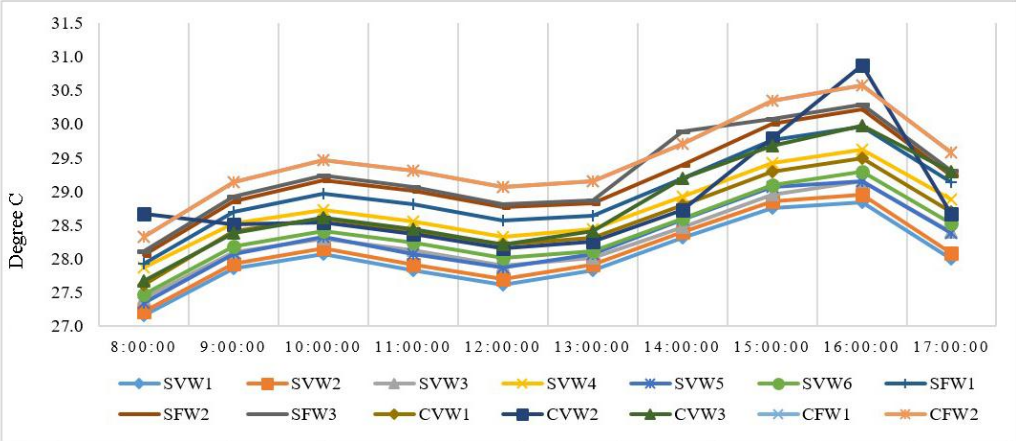


Figure 4.6: Air temperature analysis for available window configurations of architecture design studios.

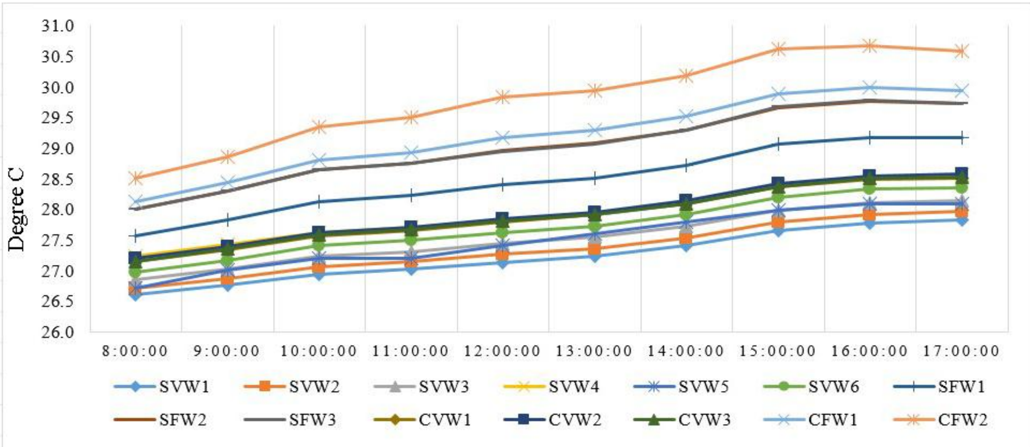


Figure 4.7: Mean radiant temperature analysis for available window configurations of design studios.

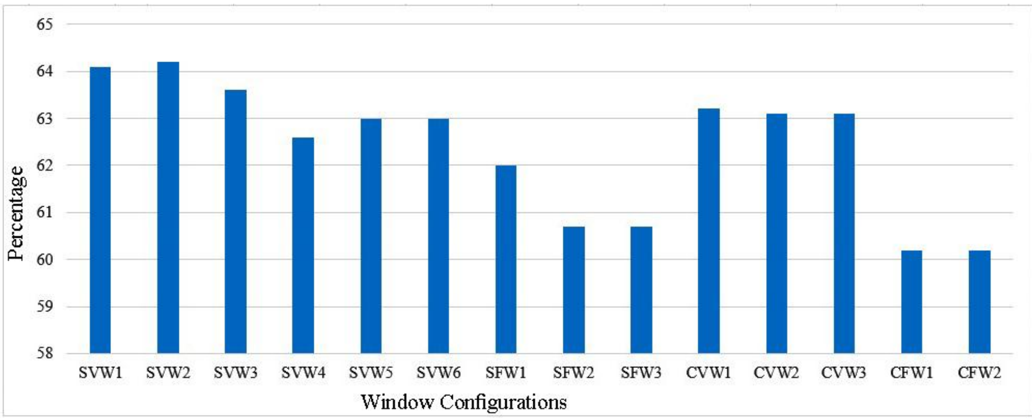


Figure 4.8: Relative humidity analysis for available window configurations of design studios.

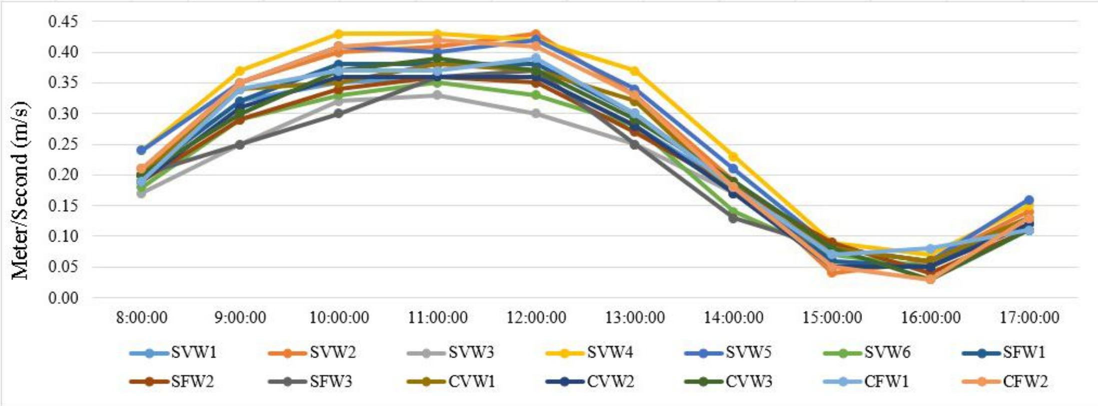


Figure 4.9: Wind speed analysis for available window configurations of architecture design studios.

4.4.2 PMV-PPD Results

To measure the occupant's reaction towards the thermal conditions in case studio provided by available window configurations, PPD, developed by Fanger (1970) was adopted in this research, which is a part of PMV (discussed in section 2.14). Results of thermal simulation (air temperature, mean radiant temperature, relative humidity, and wind speed) were placed on spreadsheet to calculate PMV-PPD.

Table 4.21: PMV-PPD result of thermal simulation for available window configurations for architecture design studios.

Category of Windows	**Code of Windows**	**Hottest day (24th April, 2016)**	
		Predicted Mean Vote (PMV)	**Predicted Percentage of Dissatisfied (PPD) [%]**
SVW	SVW1	(+) 0.80	18.3 ≈ 18
	SVW2	(+) 0.82	19.3 ≈ 19
	SVW3	(+) 0.93	23.2 ≈ 23
	SVW4	(+) 0.98	25.3 ≈ 25
	SVW5	(+) 0.85	20.3 ≈ 20
	SVW6	(+) 0.96	24.5 ≈ 25
SFW	SFW1	(+) 1.16	33.2 ≈ 33
	SFW2	(+) 1.27	38.9 ≈ 39
	SFW3	(+) 1.30	40.0 ≈ 40
CVW	CVW1	(+) 1.00	26.1 ≈ 26
	CVW2	(+) 1.08	29.8 ≈ 30
	CVW3	(+) 1.05	28.4 ≈ 28
CFW	CFW1	(+) 1.34	42.5 ≈ 43
	CFW2	(+) 1.42	46.3 ≈ 46

According to PMV result presented in Table 4.21, case studio by providing viewing windows was found to be ‘neutral’ to ‘slightly warm’ by having PMV range from +0.80 to +1.08. However, continuous full-height windows created the studio ‘slightly warm’ to ‘warm’ having PMV range of +1.16 to +1.42, which failed to satisfy more than 40% occupants. The mean value of segregated viewing windows was found better than the other three categories. Therefore, more students would be satisfied in respect to thermal sensation in the architecture design studios, if the studio is provided with segregated viewing windows.

4.4.3 Ratings of thermal Simulation Results

In this section, rating between the fourteen available window configurations of four categories simulated results is discussed. From 1st to 14th place rating points were considered as 13 point to 0 point respectively.

Table 4.22: Rating points distribution for PPD of fourteen window configurations.

Category of Windows	Code of Windows	Hottest day (24th April, 2016)			
		Rating points for PPD	Ranking with rating points	Average rating points of category	Place
SVW	SVW1	13	**1st (13)**	**10.5**	**1st**
	SVW2	12	**2nd (12)**		
	SVW3	10	**4th (10)**		
	SVW4	8	**6th (8)**		
	SVW5	11	**3rd (11)**		
	SVW6	9	**5th (9)**		
SFW	SFW1	4	**10th (4)**	**3**	**3rd**
	SFW2	3	**11th (3)**		
	SFW3	2	**12th (2)**		
CVW	CVW1	7	**7th (7)**	**6**	**2nd**
	CVW2	5	**9th (5)**		
	CVW3	6	**8th (6)**		
CFW	CFW1	1	**13th (1)**	**0.5**	**4th**
	CFW2	0	**14th (0)**		

Rating was done by PPD results considering the thermal metrics e.g. air temperature, mean radiant temperature, relative humidity, and wind speed for the case studio for each available window configurations of architecture design studios in Dhaka (Table 4.22). After summing the rating points achieved by the available window configurations, windows of segregated viewing windows were found as superior with rating points range of 8 to 13 and average point of 10.5, to other window configurations. As the recommended acceptable PPD range for thermal comfort are less than 20% persons dissatisfied for an interior space, most of the window configurations of the viewing and full-height window categories failed to achieve the acceptable range. On the other hand, windows of continuous full-height windows category were found as lowest as it achieved the rating points range of 0-1 and average point of 0.5, as created thermal discomfort to a maximum number of occupants by allowing excessive solar radiation by large openings in the interior of Architecture design studios.

Considering the thermal simulation, SVW1 was rated as the most feasible window configuration, while segregated viewing windows yielded the first position among the selected the window categories for architecture design studios in Dhaka.

4.5 Comparative study to identify the most feasible window configuration

Dynamic daylight and thermal simulation ranking was varied for fourteen available window configurations of window categories.

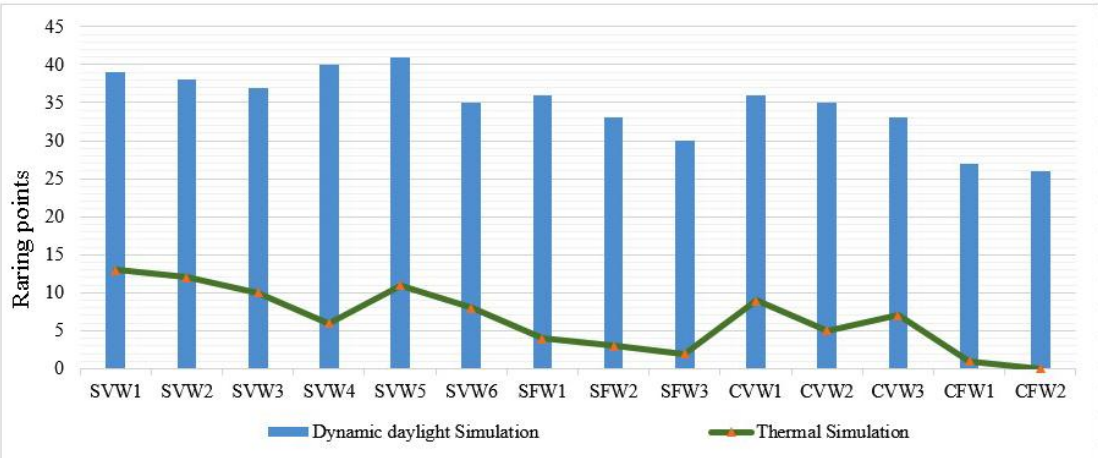


Figure 4.10: Rating points achieved from dynamic daylight and thermal simulation by the available window configurations.

Figure 4.10 shows the rating points achieved from dynamic daylight and thermal simulation by the configurations. As the research was focused on the impact of daylighting windows on thermal comfort, ranking of thermal simulation was given priority over dynamic daylight simulation. Table 4.23 presents the combined result of dynamic daylight and thermal simulation based on ranking to determine the most feasible window configuration among studied architecture design studios in Dhaka.

Table 4.23: Most feasible window configuration among studied architecture design studio in Dhaka.

Category of Windows	Code of Windows	Ranking in Dynamic Daylight Simulation	Ranking in Thermal Simulation	Combined ranking with placement	Average ranking points of category	Place
SVW	SVW1	3	1	**4 (1st)**	**8**	**1st**
	SVW2	4	2	**6 (3rd)**		
	SVW3	5	4	**9 (4th)**		
	SVW4	2	8	**10 (5th)**		
	SVW5	1	3	**4 (2nd)**		
	SVW6	9	6	**15 (7th)**		
SFW	SFW1	7	10	**17 (10th)**	**21**	**3rd**
	SFW2	11	11	**22 (11th)**		
	SFW3	12	12	**24 (12th)**		
CVW	CVW1	6	5	**11 (6th)**	**15**	**2nd**
	CVW2	8	9	**17 (8th)**		
	CVW3	10	7	**17 (9th)**		
CFW	CFW1	13	13	**26 (13th)**	**27**	**4th**
	CFW2	14	14	**28 (14th)**		

After summing the rankings achieved by the fourteen available window configurations of four categories, performance metrics ranked SVW1 as the most feasible window configuration of architecture design studio in Dhaka, while segregated viewing windows yielded the first position among the selected the window categories (Figure 4.11).

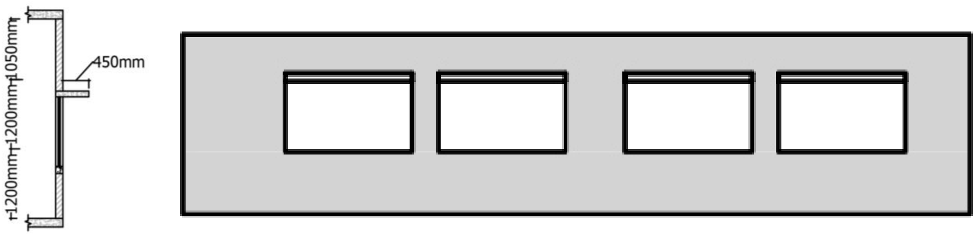


Figure 4.11: Cross section and elevation of the most feasible window configuration.

4.6 Comparative study to propose the most feasible window category among 4 types

At first, dynamic daylight simulation of fourteen available window configurations of four categories was conducted on south façade of case studio (described in Section 4.3.16). Later, thermal simulation was conducted on the configurations considering PMV-PPD metrics (described in Section 4.4.3). Figure 4.12 shows the average rating points achieved from dynamic daylight and thermal simulation by the available window configurations. Table 4.24 presents the combined result of dynamic daylight and thermal simulation to determine the most feasible window category for architecture design studio in Dhaka.

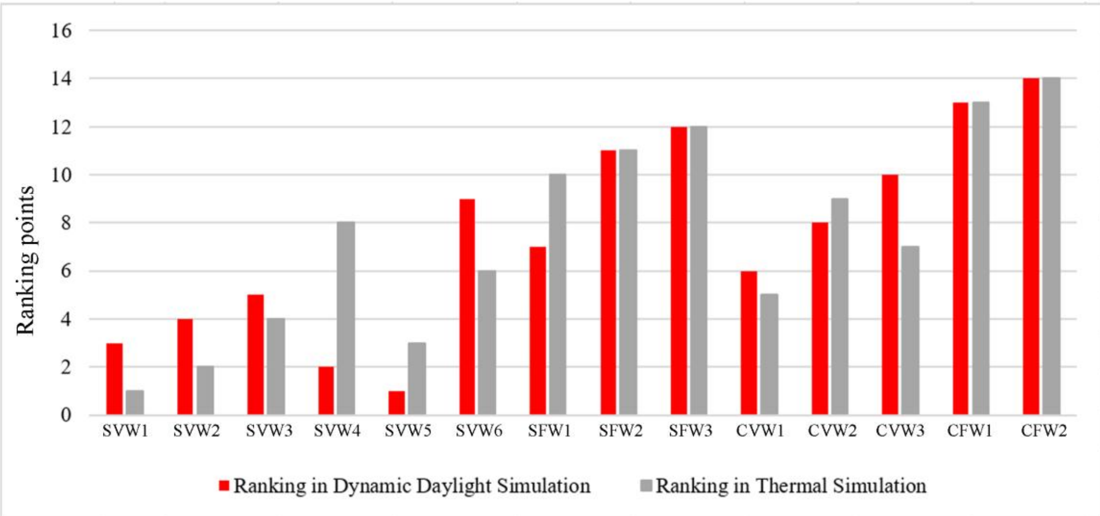


Figure 4.12: Average rating points achieved from dynamic daylight and thermal simulation by the available window categories.

Table 4.24: Most feasible window category for architecture design studio in Dhaka.

	1st place	**2nd place**	**3rd place**	**4th place**
Dynamic Daylight Simulation	SVW	CVW	SFW	CFW
Thermal Simulation	SVW	CVW	SFW	CFW
Combined Simulation Result	**SVW**	**CVW**	**SFW**	**CFW**
Full name	Segregated Viewing Windows	Continuous Viewing Window	Segregated Full-height Windows	Continuous Full-height Windows

According to both dynamic daylight and thermal simulation, segregated viewing window was found to be the most feasible window category for architecture design studios in Dhaka.

4.7 Segregated Viewing windows

Fourteen window configurations under four categories were found during field survey among architecture design studios located in Dhaka and placed on the existing window location of the case studios at south façade for analysis. The configurations were simulated by annual CBDM simulation tool and thermal simulation tool and segregated viewing windows was found as the best in daylighting and thermal performance for architecture design studios in the climatic context of Dhaka.

4.7.1 Window-to-wall ratio

Windows under segregated viewing windows category had the lowest window-to-wall ratio (WWR) among the studied window configurations for simulation study, presented in Table 5.1. In the act of glare increases proportionately with the size of windows, window configurations of segregated windows category having smaller WWRs (22%-31%) got the highest points considering $UDI_{100-200}$ and $UDI_{>2000}$ (Section 5.3.16 and Table 5.18). Among window configurations, SVW1 (22.4%) had the highest values in these sections and SVW5 (30.8%) placed first in overall dynamic daylight simulation analysis. On the other hand, continuous full-height windows, having larger WWRs (60%-70%) provided poor daylighting and placed last in the ranking pool.

Segregated viewing windows also provided lower indoor air temperature and mean radiant temperature discussed in section 5.4.1 considering the hottest day in the year. Though value differences in air temperature, wind speed pool were not high, continuous full-height windows got the lowest points in respect to PPD. Designing large windows can allow more daylight to enter and create a balance between the lighting and thermal systems (Fasi, 2015), but high levels of solar radiation during the summer period increase indoor temperature. Occupants were therefore more satisfied with small segregated windows than the large continuous windows.

4.7.2 Window bottom-top level height

Bottom and top level of the window configurations performed an important role in the simulation analysis. Ahmed (2014) described narrow windows at sufficient height as better daylighting rather than wider windows at lower levels. As the workplane height was at 750mm, segregated viewing windows provided more useful daylight during 8am to 5pm than the other window configurations.

Opening from the floor level to workplane height does not contribute to overall illumination level of the studio and increases room air temperature by allowing more solar radiation during summer time. Configurations of full-height window category thus had poor ratings in PMV index. Having bottom level at 1200mm, Window configurations SVW1 and CVW1 achieved highest points and found to be superior in individual viewing window categories. On the other hand, window configurations of segregated viewing windows category with lintel height at 2100mm to 2400mm performed better and yielded the highest ranking points in dynamic daylight and thermal comfort simulation results.

4.7.3 Shading devices

According to dynamic daylight and thermal simulation study, segregated viewing window category with horizontal shading of 450mm at south façade was found to be most effective in architecture design studios in climatic context of Dhaka. It is evident from the analysis that, same size of windows with different shading created difference in annual daylight and thermal simulation results. Window configuration- SFW2 with 250mm shading performed better than SFW3 of segregated full-height windows category. As horizontal shading at south façade can allow the low winter sun to enter, while shading the high sun during summer period, with minimum obstruction of view (Trisha, 2015), glare from excessive solar radiation was protected by overhang shading of segregated viewing windows. Therefore, shading can be used with viewing windows to satisfy the daylighting and thermal aspects in architecture design studios in Dhaka.

4.8 Data Validation

4.8.1 Existing daylight illumination condition of the case studio

To validate the dynamic daylight simulation results of case studio, illumination level was measured physically on the work plane height of the case studio floor under overcast sky condition.

Table 4.25: Existing daylight illumination level of case studio measured with Lux meter under overcast condition.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	415	439	326	279	238	199	194	225	289	220
B	2992	1264	648	439	281	259	198	268	284	186
C	3853	1520	735	466	320	230	180	182	174	109
D	3465	1444	809	456	345	317	248	239	212	186
***E**	2552	1389	805	465	350	258	175	172	130	122
F	3644	1608	852	595	397	308	236	185	209	191
G	3657	1539	823	511	399	275	222	195	211	192
H	968	744	543	391	295	286	221	158	174	162
I	1046	793	537	314	277	196	185	145	109	121
J	3586	1399	735	462	298	195	169	106	103	98
K	3697	1662	852	578	401	291	216	207	170	148
L	2088	1328	714	519	329	286	227	210	175	139
M	3681	1473	821	506	392	236	224	156	192	161
N	3888	1557	783	514	338	237	250	178	173	164
O	2659	1009	561	313	262	174	151	149	161	119
P	348	406	317	269	240	224	197	208	265	244
Maximum: 3888 lux and minimum: 98 lux										
Visible node : 160, Average value of overall plane: 633 lux										
***Core sensor points for simulation: 1E, 2E, 3E , 4E, 5E, 6E, 7E, 8E, 9E, 10E**										

Lux readings were taken by Dr. Meter Digital Light Meter Model: LX1330B (Appendix-D) on the 160 sensor points position as described in Section 4.2.6 on 4th September, 2016 at 12:30 PM. South window side sensor points showed higher value than the rare work plane sensor points (Table 4.25). Rare zone sensor points showed illumination level between 98 lux to 244 lux, while the illumination threshold is 300 lux (IESNA, 2000). Average illumination level of all 160 sensor points was found as 633 lux. On the other hand, illumination level at the window side sensor points was far more than the illumination level, since the illumination range is 300 lux-500 lux (Sharmin, 2011).

4.8.2 Comparison between measured daylight illumination and simulation findings

Physical measurement of the actual daylight level in the existing condition of case studio were compared with the illumination values generated by RADIANCE dynamic metric simulation tool at 12:30 PM on 4th September, 2016 according to climate data collected from Bangladesh Meteorological Department. To validate the daylighting level outcome of existing and simulation findings, deviation at core sensor point values were compared (Table 4.26).

Table 4.26: Comparison between existing illumination level and simulated illumination level of the case studio.

Core sensor points	Daylight Illumination level [lux] (Field Survey)	Daylight Illumination level [lux] RADIANCE Output	**Deviation**	**Percentage [%]**
1E	2552	2296	256	11.11
2E	1389	1558	-169	12.17
3E	805	896	-91	11.13
4E	465	539	-74	15.91
5E	350	335	15	4.48
6E	258	305	-47	18.22
7E	175	263	-88	50.29
8E	172	175	-3	1.74
9E	130	124	-6	4.84
10E	122	103	19	18.45
Average of 10 core sensor points	642	659	-17	2.65
Average of 160 sensor points	**633**	**654**	**-21**	**3.32**

The average illumination value of core sensor points found in survey was 642 lux. On the other hand, average illumination value of core sensor points found in RADIANCE dynamic metric simulation tool was 659 lux. Therefore, according to Table 5.29, there is a deviation of -17 lux between actual condition and simulation tool results, which was approximately 2.65% (<5%) deviation of actual condition.

4.8.3 Existing thermal condition of the case room

Factors affecting thermal comfort (Air temperature, Relative humidity, Wind speed), were measured physically on the work plane height occupied by 40 students in the case studio under overcast sky condition. Relative humidity readings were taken by Extech 445703 Hygro-Thermometer and air temperature- wind speed readings were taken by Handyman thermo-anemometer model no: TE1313 (Appendix-D) on the 160 sensor points position as described in Section 4.2.6 on 4th September, 2016 at 12:30 PM. Then, results of thermal condition were placed on spreadsheet to calculate PMV-PPD. Metabolic rate and clothing insulation were considered as 1.2 and 0.5 clo for architecture design studio (Tariq, 2014). Table 4.27 presents the average air temperature, relative humidity, wind speed and PMV-PPD values measured by thermal meters. Detail readings of air temperature, relative humidity and wind speed are provided in Appendix-H.

Table 4.27: Existing overall thermal condition of case studio measured by meters.

	Air Temperature **[^{o}C]**	Relative Humidity **[%]**	Wind Speed **[m/s]**	**PMV (Field Survey)**	**PPD (Field Survey) [%]**
Average of 160 sensor points	28.3	67	0.11	(+) 1.21	35.6

According to the field survey, PMV was found to be 1.21. Therefore, 36% students were dissatisfied with existing thermal condition in case studio.

4.8.4 Simulated thermal condition of the case room

To validate the physical measurement of actual thermal condition, existing condition of case studio were compared with the thermal variable values generated by EnergyPlus^{TM} static thermal simulation at 12:30 PM on 25th June, 2016 according to climate data collected from Bangladesh Meteorological Department. Table 4.28 presents the simulated values of average air temperature, relative humidity, wind speed and PMV-PPD.

Table 4.28: Existing overall thermal condition of case studio generated by EnergyPlus™.

	Air Temperature [°C]	Mean Radiant Temperature [°C]	Relative Humidity [%]	Wind Speed [m/s]	**PMV (Field Survey)**	**PPD (Field Survey) [%]**
Average of 160 sensor points	28.8	28.0	68.5	0.19	(+) 1.15	33.1 ≈ 33

According to the simulation study, PMV was found to be 1.15. Therefore, 33% students were dissatisfied with existing thermal condition in case studio.

4.8.5 Comparison between existing and simulation findings: Thermal condition

To validate the outcome of existing thermal condition and thermal simulation findings, deviation was compared (Table 4.29).

Table 4.29: Comparison between existing PPD value and simulated PPD value of the case studio.

	PPD **(Field Survey) [%]**	PPD **EnergyPlus™ analysis [%]**	**Deviation [%]**
Average of 160 sensor points	35.6	33.1	2.50

The deviation between actual thermal condition and simulation tool results was found to be approximately 2.50%, which is below 5%.

4.9 Summary

This chapter achieved two objectives by focusing on the simulation studies to find out the effectiveness of different window configurations to enhance daylight inclusion and their impact on indoor thermal conditions in architecture design studio with respect to the achieved daylight.

The second objective of this research has been achieved by establishing a window category among a pool of window configurations as a possible option for incorporation of suitable daylight in the interior of architecture design studio in Dhaka. Segregated viewing window (SVW) was found as most feasible window category for architecture design studio among the studied configurations in climatic context of Bangladesh, which can provide uniform illumination level for the studio throughout the year.

The third objective has been achieved by evaluating the thermal simulation performance of the window configurations, which were previously analysed for daylighting. Segregated viewing window was found to be the most effective window category with respect to the daylight inclusion and thermal comfort in the architecture design studio in Dhaka. Based on the observation made by simulation studies, it can be stated that, by careful selection of window configurations and little changes in window size and location, sufficient daylight can be efficiently included and thermal comfort can be ensured in architecture design studio.

This chapter leads to the presentation of the achievement of the research objectives in next chapter 5 with some indicative recommendations and suggestions for future work.

5. CHAPTER FIVE: RECOMMENDATION AND CONCLUSION

Preamble

Achievement of the objectives

Recommendations

Suggestion for future research

CHAPTER 5 RECOMMENDATION AND CONCLUSION

5.1 Preamble

In this thesis, Chapter 1 introduced the research, while Chapter 2 focused on the literature of this research and provided a clear understanding of window configurations and different national and international standards. Detailed steps of Methodology for simulation study with field survey were discussed in Chapter 3 to select the parameters of simulation model. In Chapter 4, fourteen window configurations under four window categories available in architecture design studios located at Dhaka, found during field survey were evaluated through dynamic daylight and thermal simulation to find out the available most feasible window configuration. This Chapter summarizes the research, mentioning the achievement of the objectives which was mentioned in Chapter 1 and will recommend some indicative suggestions that could be considered to improve the luminous environment and predicted comfort level in architecture design studios. It concludes with highlighting areas of further research.

5.2 Achievement of the objectives

The achievement of the objectives of this research, developed in Chapter 1 (Section 1.3) are discussed in this section as following.

5.2.1 Role of windows for efficient daylighting and thermal comfort

In this research, the first objective was to identify the necessities of appropriate window design for efficient daylighting and thermal comfort in architecture design studios in Dhaka. To achieve this objective, literature review on windows and standards and field investigation on existing architecture design studios were conducted. Literature showed that, the distance that adequate daylighting will penetrate into a room depends upon window size and location on the wall (Robertson, 2002) and the correct proportion of window to external wall reduces cooling loads and increase thermal comfort considering solar radiation during the summer period (Alibaba, 2016). Moreover, observations from the field investigation showed that, the standard of uniformity ratio between the daylight levels in the front and back are not maintained in most of the studios due to improper window size and location (discussed in Section 3.2.3.5). This is the reason why an appropriate window design could be effective for daylighting and thermal comfort in the interior space of architecture design studios.

5.2.2 Effectiveness of different window configurations to enhance daylighting

To enhance useful daylight penetration, second objective of the research was to analyse the effectiveness of different window configurations under different window categories and find out an effective window category for architecture design studios in the climatic context of Dhaka. In order to achieve this objective, field survey was conducted at fourteen universities in Dhaka to find out different available window configurations for dynamic daylighting simulation study. Different simulation parameters and criteria were set and dynamic simulation performance metric were conducted on the window configurations under four window categories for architecture design studios to identify the most feasible window category. Segregated viewing windows category was found as the most feasible for the studios (Table 5.1) from the dynamic daylighting performance metrics rating system.

Segregated Viewing Windows Category

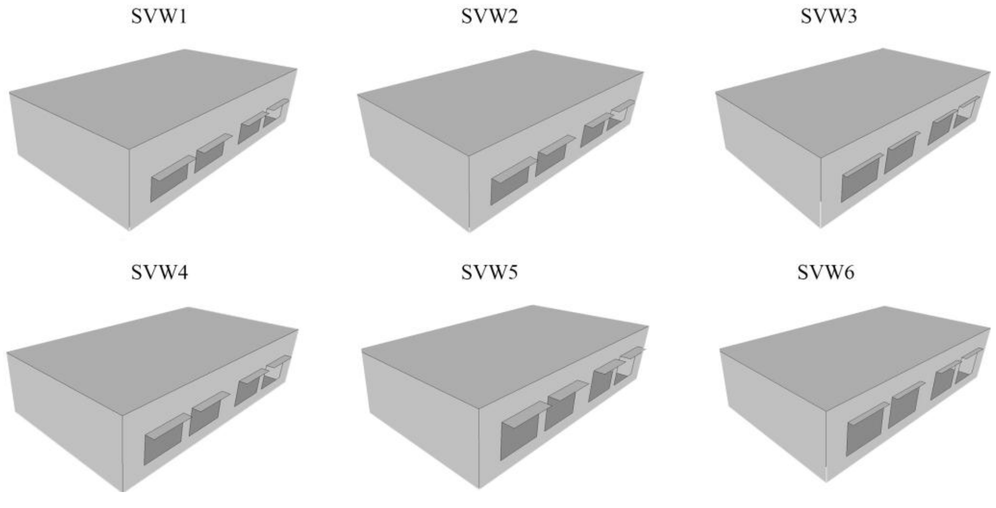


Figure 5.1: 'Segregated Viewing windows' as the most feasible window category among studied architecture design studios in Dhaka.

5.2.3 Impact of different window configurations on indoor thermal conditions

The third objective was to investigate the impact of different window configurations on indoor thermal conditions with respect to achieved daylight and find out the most feasible window category to ensure proper daylighting and thermal comfort in architecture design studios in Dhaka.

To achieve this objective, thermal simulation study was conducted with the available window configurations under four categories and results of both dynamic daylighting and thermal simulation were combined. Segregated Viewing Window (SVW1) (Figure 5.2) was found to be the best window configuration among the studied configurations with respect to occupant's thermal satisfaction, while segregated viewing window category was found as the most feasible category in architecture design studios in Dhaka.

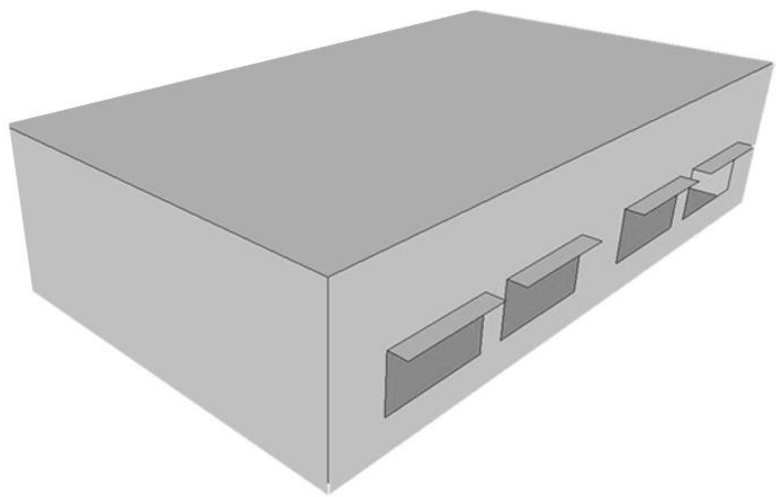


Figure 5.2: SVW1 as the most feasible window configuration among studied architecture design studios in Dhaka.

Simulation results also revealed that, windows having smaller WWR (22%-31%) perform better than windows having larger WWR (60%-70%) considering thermal comfort during summer period, while horizontal shading of 450mm on south facing segregated viewing windows is most effective, round the year.

5.3 Recommendations

The following specific as well as some general recommendations are drawn from this research for window designing of architecture design studios in order to improve the luminous environment and thermal conditions by integrating appropriate window design, in climatic context of Dhaka.

- Use segregated windows rather than continuous windows for architecture design studios, as it was found in this research as the most feasible window category among available fourteen window configurations for useful daylight illumination and thermal comfort in the studios.
- Place the window head level higher to result deep daylight penetration and more even illumination in the room. Start glazing area of the window at work plane height since lower glazing does not contribute to the overall illumination level on the worktop.
- To satisfy both daylighting and thermal conditions in the studios, position window bottom level at 1200mm which will result even illumination on the workplane height and avoid unwanted heat in the room.
- 450mm horizontal shading device performs better with south facing segregated viewing windows to improve daylight penetration and to avoid overheating in architecture design studios.
- Use windows of lower WWR of 22%-31% rather than windows of higher WWR of 60%-70% to avoid glare and overheating during summer period.
- Design the internal layout and table arrangement considering the segregated viewing windows alignment, so that each row can be illuminated adequately.

5.4 Suggestions for further research

Some of the most important areas that need to be explored in future with special reference to daylighting and thermal comfort in architecture design studios are following.

- This study is based only on the performance of window configurations available in buildings during the survey, discussed in section 3.2.3.c. Change of the parameters, or relationship among different geometrical elements of these configurations, may yield variation in the results generated in the simulation studies. Further research could be conducted to identify a suitable window configuration, which may be better than the existing 14 options.

- The study concentrates only on architecture design studios. Investigations of different building types need to be conducted before generalized application.
- Simulation studies of daylighting and thermal conditions were based on the climatic context of Dhaka. Analysis in different case locations may yield different result. However, this research can be generalized for architecture design studios in similar climates and cultures, in Bangladesh and else around the world.
- Adapting contextual comfort levels of daylight and the total visual environment for architecture students in the studio needed to be studied.
- More analyses can be done to the effect of windows for daylighting on overall energy savings.
- Impact of daylighting and thermal comfort strategies on ventilation aspects need to be explored.
- More research is needed to fix predicted percentage of dissatisfied in respect to thermal conditions.
- Performance of different glare control measures with window configurations for architecture design studios can be examined.

It is expected that, the research will contribute to further research on daylighting and thermal comfort by helping architects and designers to investigate other aspects as described above for appropriate daylight distribution and thermal satisfaction in architecture studios.

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APPENDICES

Appendix A: Key terms and concepts

Appendix B: Meteorological data of Dhaka

Appendix C: Existing daylight and thermal conditions of the design studios

Appendix D: Specification of daylighting and thermal measuring tools

Appendix E: Simulation software

Appendix F: Detail DAYSIM simulation results

Appendix G: Thermal simulation findings of the case studio

Appendix H: Existing thermal condition of the case room for validation

Appendix A: Key terms and concepts

LIGHTING TERMINOLOGY

DA (Daylight Autonomy) – is the percentage of the occupied times of the year when the minimum illuminance requirement at the sensor is met by daylight alone.

DA_{con} (Continuous Daylight Autonomy) – is the percentage of the minimum illuminance requirement met by daylight alone at the sensor during the full occupied times of the year. The metric acknowledges that even a partial contribution of daylight to illuminate a space is still beneficial. For e.g. if the design illuminance is 300 lux on core work plane sensor, and 180 lux are provided by daylight alone at one sensor point during the whole office hours of the year; a partial credit of 180lux/300lux=0.6 (60%) is given to that sensor point.

DA_{max} (Maximum Daylight Autonomy) – is the percentage of the occupied hours when the daylight level is 10 times higher than design illumination; represents the likely appearance of glare.

Daylight factor (DF) – is the ratio of the daylight illuminance at an interior point to the unshaded, external horizontal illuminance of the building under a CIE overcast sky condition.

Diffuse radiation – is the total amount of radiation falling on a horizontal surface from all parts of the sky apart from the direct sun.

Direct radiation – is the radiation arriving at the earth's surface with the sun's beam.

Global radiation – is the total of direct solar radiation and diffuse sky radiation received by a horizontal surface of unit area.

Illuminance – is the quantitative expression for the luminous flux incident on unit area of a surface. A more familiar term would be "lighting level". Illuminance is expressed in lux (lx). One lux equals one lumen per square meter (lm/m^2). In Imperial units the unit is the foot-candle which equals lumen per square foot (lm/ft^2).Other units are – metrecandle, phot, nox.

UDI (Useful daylight illuminance) – try to find out when daylight levels are 'useful' for the user and when they are not. Based on occupants' preferences in daylit RMGs, UDI results in three metrics, i.e. the percentages of the occupied times of the year when daylight is useful (100- 2000lux), too dark (<100 lux), or too bright (> 2000 lux).

LIGHTING METHODS

Ambient accuracy (aa) – value is approximately equal the error from indirect illuminance interpolation. A value of zero implies no interpolation.

Ambient bounces (ab) – is the maximum number of diffuse bounces computed by the indirect calculation. A value of zero implies no indirect calculation.

Ambient division (ad) – The error in the Monte Carlo calculation of indirect illuminance will be inversely proportional to the square root of the number of ambient divisions. A value of zero implies no indirect illumination.

Ambient resolution (ar) – determine the maximum density of ambient values used in interpolation. Error will start to increase on surfaces spaced closer than the scene size divided by the ambient resolution. The maximum ambient value density is the scene size times the ambient accuracy divided by the ambient resolution.

A**mbient sampling (as)** – are applied only to the ambient divisions which show a significant change.

Backward raytracing – simulates individual rays from the points of interest to light source or other objects backwardly with respect to a given viewpoint (Figure A.1). It is possible to simulate different basic surfaces (e.g. 100% specular surfaces, lambertian surfaces, transparent surfaces and translucent surfaces) and a random mixture of these basic surfaces under raytracing.

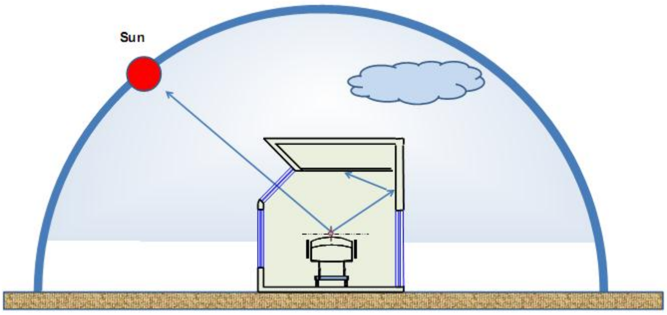


Figure A.1: Backward raytracing simulates individual rays from the points of interest to light source or other objects backwardly (after, Reinhart, 2006).

DAYSIM simulation – calculates the performance metrics considering the impact of local climate and generates a time series indoor annual illuminance profile at points of interest in a building. DAYSIM requires two steps to calculate the annual amount of daylight in a building. Daylight coefficients are calculated first considering the available daylight surrounding the building. After that, the daylight coefficients are combined with the specified climate data of building site. Based on generated illumination profile, DAYSIM derives several dynamic, climate-based daylight performance matrices, such as Daylight Autonomy (DA), Useful Daylight Index (UDI), Continuous Daylight Autonomy (DAcon) and Maximum Daylight Autonomy (DAmax). Figure A.2 shows the process of daylight simulation under DAYSIM. More details on the simulation algorithm used by DAYSIM can be found under Reinhart (2006).

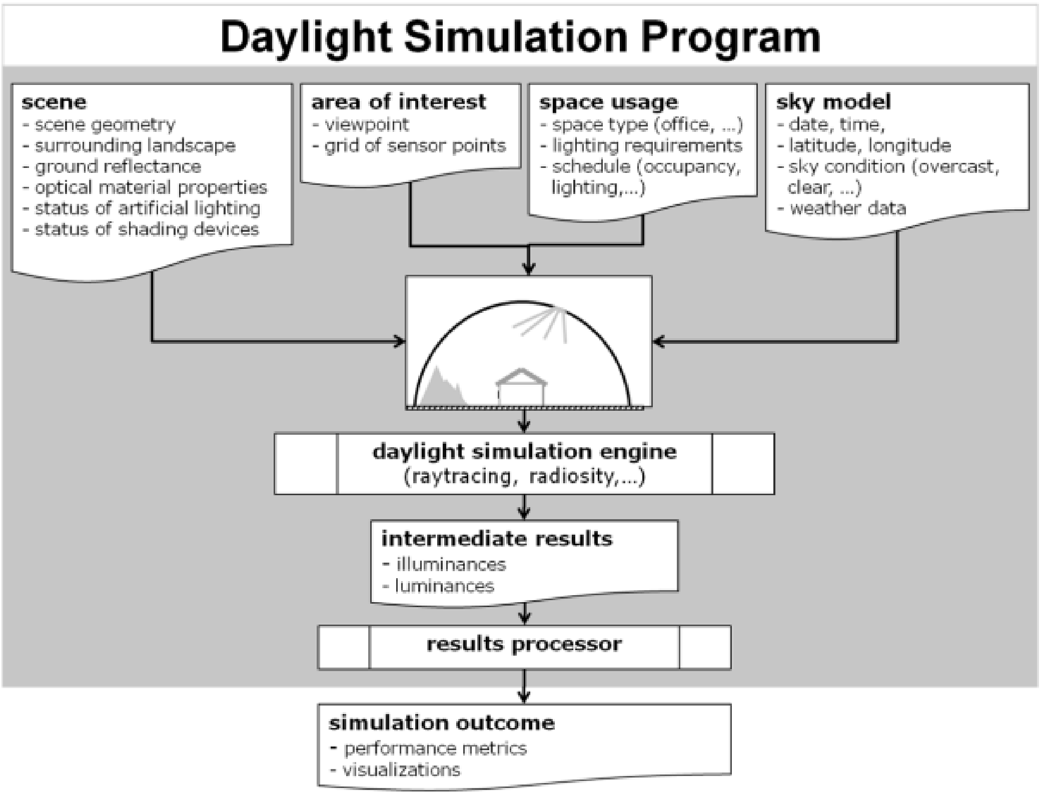


Figure A.2: The process of daylight simulation in DAYSIM (Reinhart, 2006).

DAYSIM uses **Perez all weather sky luminance model**. Perez sky model was developed in early nineties by Richard Perez et al. (1990; 1993). To investigate the performance of a building under all possible sky conditions that may occur in a year, DAYSIM first imports hourly direct and diffuse irradiances from a climate file and if required, a stochastic autocorrelation model is used to convert the time series down to five-minute time series of direct and diffuse irradiances from one hour. Then, these irradiances are converted into illuminance and a series of sky luminous distributions of the celestial hemisphere. The sky luminous distribution for a given sky condition varies with date, time, site and direct and diffuse irradiance values, and influence the relative intensity of light back-scattered from the earth surface, the width of the circumsolar region, the relative intensity of the circumsolar region, the luminance gradient near the horizon, and darkening or brightening of the horizon. Figure A.3 shows the background steps of using Perez sky model in DAYSIM.

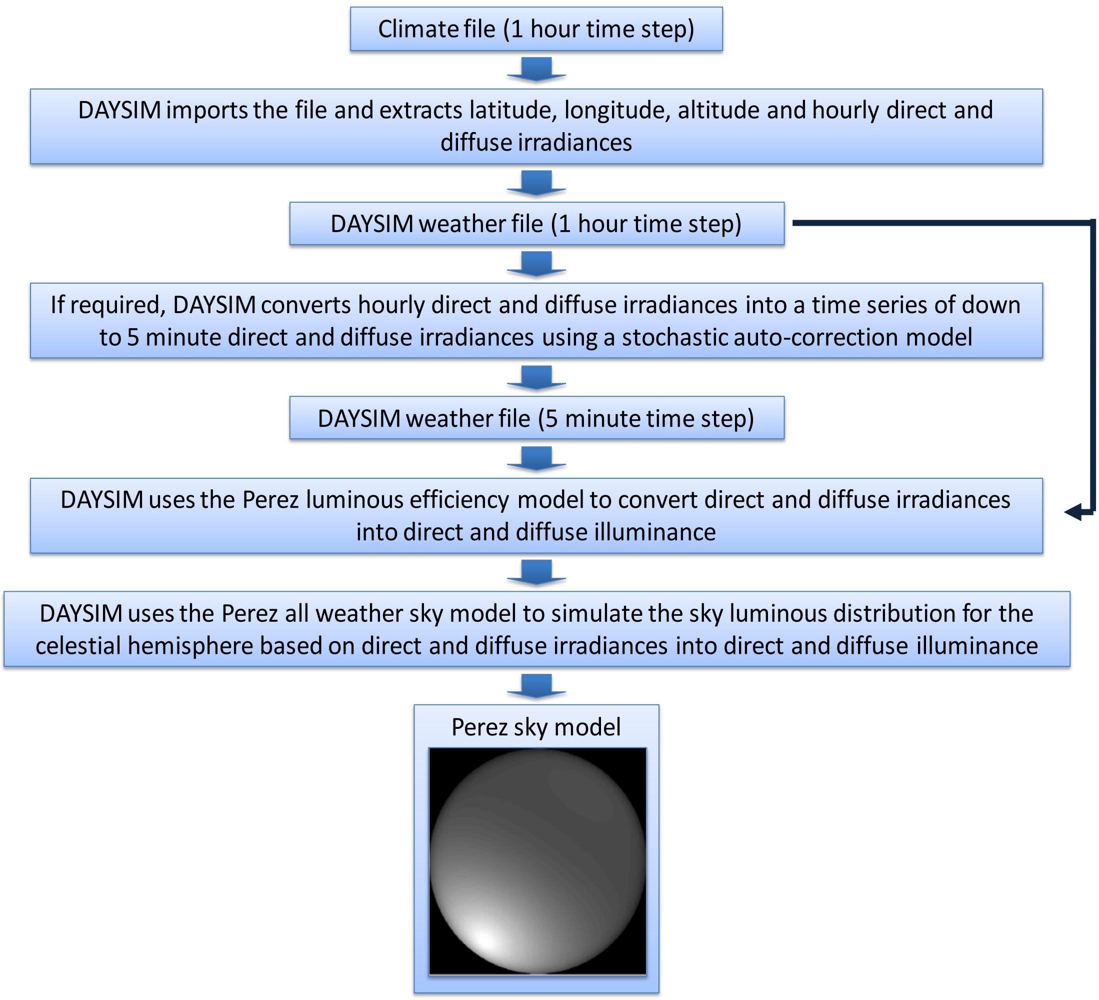


Figure A.3: The use of the Perez sky model in DAYSIM (Joarder, 2011).

Appendix B: Meteorological data of Dhaka

B1: Monthly average cloud cover in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1961	2	3	3	3	4	6	6	6	6	4	2	1
1962	1	2	1	3	5	7	6	6	5	4	1	1
1963	1	1	1	4	5	6	7	6	5	4	1	2
1964	1	2	2	5	4	6	7	6	6	5	2	1
1965	1	2	2	3	5	7	6	7	6	4	1	3
1966	*	0	0	3	3	7	6	6	5	3	2	2
1967	2	1	3	3	5	5	6	6	6	3	1	2
1968	1	2	2	4	5	6	6	6	5	4	3	1
1969	1	1	3	3	4	6	6	6	5	3	2	2
1970	2	2	3	3	4	6	6	6	6	4	2	0
1972	1	2	2	4	5	6	6	7	5	3	2	1
1973	0	2	2	4	6	6	*	7	7	4	3	1
1975	1	2	1	3	5	6	7	6	6	4	3	1
1976	1	1	2	4	5	6	7	6	5	3	3	1
1977	1	2	3	5	6	7	7	6	5	3	3	1
1978	1	2	2	3	6	6	6	6	6	4	2	1
1979	1	2	2	3	3	6	6	6	5	3	2	1
1980	1	2	3	4	4	6	6	5	5	4	2	1
1981	2	1	4	4	5	5	7	6	5	2	1	2
1982	0	2	2	4	3	6	6	6	5	2	2	1
1983	2	2	3	4	4	6	6	6	6	4	2	1
1984	1	2	2	3	5	7	6	6	5	4	1	1
1985	2	1	3	4	5	6	6	6	6	3	2	1
1986	1	2	1	5	4	6	7	6	6	3	2	2
1987	1	1	3	4	3	5	7	6	6	3	3	1
1988	1	2	3	4	6	6	6	7	6	4	2	1
1989	0	1	2	3	5	6	6	6	6	4	1	1
1990	0	3	4	4	5	6	7	6	6	4	3	2
1991	2	1	2	4	6	6	6	6	6	4	2	2
1992	1	2	1	3	4	5	7	6	5	3	3	1
1993	1	2	2	4	5	6	6	7	6	4	1	1
1994	1	1	3	3	4	6	6	6	5	3	3	1
1995	2	2	2	3	5	6	6	6	6	4	3	1
1996	1	1	2	3	5	5	6	6	5	3	1	1
1997	2	2	2	4	4	6	6	6	6	2	2	3
1998	3	2	3	4	5	5	7	6	5	4	3	0
1999	1	1	1	3	5	6	7	7	6	5	2	1
2000	1	3	3	4	5	6	6	6	6	4	1	1
2001	1	1	2	3	5	6	6	6	6	5	3	1
2002	2	1	3	5	6	7	7	7	6	4	3	1
2003	1	2	3	4	5	7	6	6	6	5	1	2
2004	2	1	3	5	5	6	7	6	6	3	1	1
2005	2	2	3	4	5	5	6	7	6	5	1	1
2006	1	1	2	4	5	7	7	6	6	4	3	0
2007	1	2	1	4	4	6	7	6	6	4	2	1
2008	2	2	4	3	5	6	7	6	6	4	1	2
2009	0	1	2	3	5	6	7	7	6	3	2	1
2010	1	1	3	5	5	6	6	6	6	4	1	2
2011	1	1	3	3	5	6	6	7	6	3	1	1
2012	2	1	2	4	4	6	7	6	6	4	2	1
2013	0	1	2	3	6	6	6	6	6	5	1	1
2014	1	1	2	2	5	6	6	6	5	3	1	2
2015	2	1	2	5	5	6	7	6	5	3	1	2
2016	1	2	3	4	5	6	7	6	6	4	2	1

B2: Monthly average sunshine hours in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	8.5	7.7	8.4	8.9	8.2	4.1	5.8	5.1	5.8	7.3	9.1	9.2	**7.4**
1962	9.4	9.2	10	8.5	8.5	4.1	6.7	4.1	6.3	7	9.9	9.3	**7.8**
1963	9.4	9.9	9.2	8.5	8.1	4.9	5.2	6.3	6.6	7.4	9.6	9.2	**7.9**
1964	8.7	8.9	8.5	*	8.3	5.6	4.6	6.5	5.9 *	*	8.9	9.4	**7.6**
1965	8	8.9	9.5	9.3	9.1	4.2	5.5	4.7	5.7	8.1	9.9	7.7	**7.6**
1966	8.1	9.6	8.5	9.2	8.8	3.8	5.9	5.5	5.7	7.8	8	8.3	**7.5**
1967	8	9	7.9	8.7	9.1	6.8	6	5.7	4.8	8	9.8	8.6	**7.8**
1968	8.3	8.4	7.9	8.1	8.1	4	5.7	5.5	6	6.7	8.3	8.5	**7.2**
1969	9.2	8.6	7.9	8.2	9.7	4.8	5.4	5.3	6.3	8.2	8.9	8.8	**7.6**
1970	9	9.8	8.9	8.8	8.9	5.6	4.5	6.4	5.8	7.2	9	10.2	**7.9**
1972	8.4	10	11	*	*	*	*	*	*	*	*	*	**9.9**
1973	*	*	*	*	*	*	*	*	*	*	7.8	9.9	**8.9**
1975	9.9	9.3	9	9.2	6.8	5.2	6.3	6.8	5.7	7.7	7.6	9.3	**7.8**
1976	9.8	10.7	9	10	8.2	5.7	2.6	5.7	6.1	7.6	8.5	9.8	**7.8**
1977	9.6	9.6	9.6	10.2	8.7	7.3	4.2	7.1	5.4	6.5	8.4	9.6	**8.1**
1978	9.5	9.5	10.1	10	8.4	4.6	5.8	5.7	8.5	9.2	7.8	8.9	**8.2**
1979	7.5	8.3	9.6	7.8	7.6	4.7	5.1	6.2	7.2	7.8	7.1	8.1	**7.3**
1980	8.9	9	7.5	7.9	5.7	4.1	4.2	6.3	5.1	7.5	8.4	8.6	**7**
1981	7.7	8.8	8.6	8.6	*	4.6	4.5	5.4	5.2	8.4	7	8.1	**7**
1982	8.1	8.4	8.2	8.8	7	4.4	4	5.8	5.7	6.7	9.2	7.6	**7**
1983	6.9	7.8	6.7	7.1	7.8	6.5	3	6.1	4.9	8.6	8.6	7.1	**6.8**
1984	7.6	7	7.1	7.3	8.2	4.2	5.2	5.7	5.8	8.1	7.8	7.5	**6.8**
1985	7.2	8	7.8	7.3	7.9	5.9	*	5.6	4.8	6.4	*	7.9	**6.9**
1986	7.6	7.9	8.6	8.7	6.2	3.5	4.2	4.3	5.3	6.2	9.5	8.3	**6.8**
1987	7.8	8.6	8.2	7.4	6.3	4.4	4.1	6.1	6	8.7	8.2	8	**7**
1988	7.5	8.9	9.1	8.5	8.5	10.3	*	5.8	4.4	7.3	7.6	8.1	**7.9**
1989	8.7	8.8	8.6	7.5	9	6.5	3.1	4.9	5.5	8.3	7.8	8.3	**7.3**
1990	8.1	8.1	8.2	7.6	6.7	4.5	4.6	3.9	6	8.3	7.7	7.4	**6.8**
1991	8.4	8.9	8.4	8.7	6.9	6	4.7	6.9	4.2	6.1	8.5	7.3	**7.1**
1992	*	*	*	*	7.1	6.1	4	4.9	5.7	6.4	7.2	7.5	**6.2**
1993	6.3	7.4	7.8	7.8	6.2	5.4	4.1	3.6	4.8	5.8	7.4	7.5	**6.2**
1994	6.9	7.6	7.3	7.4	7.2	4.6	5.4	5.4	6.2	7.1	6.1	7.3	**6.6**
1995	7.2	6.2	7.7	8.5	6.6	4.7	4.2	4.6	3.9	7.1	6.8	7.1	**6.3**
1996	7.5	8.9	9	7	7.7	4.5	3.9	3.8	5.4	7.8	8.6	6.6	**6.8**
1997	5.2	7.5	7.7	7.3	7.6	5.6	4.1	4.8	4.6	8.5	6.2	5.6	**6.3**
1998	4	6.1	8.1	7.3	5.8	6.8	2.8	3.7	4.3	5.8	7.4	7.8	**5.9**
1999	8.3	7.5	7.2	8.4	5.5	5	3.9	3.8	3.8	5.2	8.3	7.4	**6.2**
2000	6.1	5.8	8.5	8.5	5.2	4.6	5	4.8	4.6	5.8	8.3	8.2	**6.3**
2001	7.9	7.2	8.7	8.6	6.1	3.5	4.6	5.1	4.6	5.6	6.4	7.2	**6.3**
2002	7.4	8.8	7.8	8.2	5.6	2.5	1.8	4.3	5.5	6.7	6.6	6.3	**6**
2003	5.2	7.4	7.2	8	7.4	2.1	5	5.7	3.7	4.7	8.3	5.9	**5.9**
2004	5.3	7.6	7.6	6.5	7.8	2.9	3.8	5.6	2.7	6.6	7.8	6.7	**6**
2005	6.3	7.9	7	8.4	7.8	3.2	4.1	3.5	4.8	4.6	6.6	7	**6**
2006	5.3	6.1	7.3	7.8	6.5	2.2	4.8	6.2	5.1	5.1	6	5.5	**5.7**
2007	5.7	5.7	8.2	6.4	7.8	4.7	3.3	4.9	3	5.2	5.7	5.5	**5.6**
2008	4.7	6.6	5.9	8.5	7.7	4.2	3.1	4	4.4	5.8	7.9	3.9	**5.6**
2009	5.7	8.7	7.3	8.3	6.8	5.9	4.7	3.9	4.1	6.2	6.7	4.8	**6.1**
2010	5.7	6.7	8.3	7.3	6.7	3.7	4.9	4.4	3.8	5.8	6.2	6.2	**5.9**
2011	4.9	7.5	7	6.8	5.5	3.5	4.1	2.5	5.1	6.1	6	4.4	**5.3**
2012	4.6	7.1	7.6	7.1	6.2	2.9	3.9	3.8	4	6	5.6	3	**5.2**
2013	4.5	7	7.9	6.5	3.6	4.8	4.4	3.3	3.6	4.5	7	4.1	**5.2**
2014	4.2	6.3	8.6	8.6	6.7	3.3	3.9	3.2	4.8	5.8	5.2	2.8	**5.3**
2015	4.4	5.4	8.5	6.4	6.4	4.7	2.5	3.4	4.2	6.1	6.2	4.6	**5.3**
2016	5.1	6.2	7.1	7.4	5.8	5.5	3.4	4.8	4	5.9	6.7	4.3	**5.5**

B3: Monthly and yearly maximum air temperature in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	29.2	31.7	36.3	40.6	36.6	35.1	34.3	32.8	33.6	32.6	30.6	31	**40.6**
1962	29.3	31.6	40.6	39.4	35.9	35	35.1	32.7	33.6	32.5	31.1	28	**40.6**
1963	28.1	33.1	35.9	37.9	34.9	34.7	32.2	32.7	34.9	33.2	31.1	28.2	**37.9**
1964	29.9	34.7	36.7	36.7	36.7	34.9	32.6	32.8	34.3	32.9	30.6	28.3	**36.7**
1965	28.6	31.6	35.8	42	38.3	34.2	32.4	33.4	33.3	32.9	32.6	28.9	**42**
1966	*	*	*	39.8	39.8	35.6	32.8	32.8	34.1	31.9	30.5	27.2	*****
1967	27.2	33.6	34.9	37.7	36.1	35.4	32.8	33.9	32.7	33.3	29.9	28.3	**37.7**
1968	27.2	31.6	36.9	37.7	36.9	33.1	33.3	34.2	35.3	32.8	31.2	29.4	**37.7**
1969	28.3	35.1	35.8	37.2	37.1	34.2	32.8	33.3	34.4	32.8	32.2	27.8	**37.2**
1970	27.8	32.3	37.2	36.9	37.2	34.4	34.2	34.2	33.3	32.9	30.9	27.8	**37.2**
1972	26.7	31.6	29.7	32.1	35.3	32.8	33.3	32.7	33.8	32.8	30.2	*	*****
1973	30.5	31.7	36.7	36.8	36.1	35.2	35.6	32.4	34.6	33.8	31.1	30.9	**36.8**
1975	31.2	33.6	36.3	39.4	33.3	33.5	*	32.9	36.7	33.2	30.6	26.7	*****
1976	27.2	31.9	37.2	37.6	36.7	34.9	32.2	34.4	33.4	33.2	30.2	26.8	**37.6**
1977	29.2	32.8	37	38.9	39.8	33.9	32.4	32.8	33.9	33.1	32.4	28.7	**39.8**
1978	27.4	32.3	35.6	33.3	34.7	33.8	33.6	34.4	35	32.2	31.9	29.4	**35.6**
1979	34.2	33	36.1	37.2	35.3	33.3	32.9	33.8	33.6	33.4	32.9	29.8	**37.2**
1980	28.3	31.1	37.2	38.9	40.6	38.3	33.9	35.1	34.2	32.7	31.8	27.2	**40.6**
1981	28.9	32.2	37.9	38.9	35.4	36.7	32.8	33.6	33.6	32.5	31.7	28.9	**38.9**
1982	27.8	32.9	34	35.4	35	35.9	33.3	36.5	35	33.4	33.1	29	**36.5**
1983	30.1	30.3	36.1	37	38.3	36.6	34.8	33.2	34.8	34.4	32.1	27.2	**38.3**
1984	28.1	31.7	36.2	37.7	36.4	35.6	34.4	33.6	33.1	33.6	32.8	28.8	**37.7**
1985	27.2	33	38	37.6	35.8	35.8	32.5	35.4	34.5	34	31.8	30	**38**
1986	29.4	32.4	37.1	35.8	35.1	35	34.3	34.7	35	35.5	33.3	30.6	**37.1**
1987	30	32.3	39.5	38	37.2	36.8	34.5	36	34.5	33.9	33.1	29	**39.5**
1988	29.8	35	39	39.5	38	37	34.1	34.7	34.6	35.1	33	29.2	**39.5**
1989	29.2	32.8	37	39	36.2	36.8	35.2	34.1	36	35.1	33	29.3	**39**
1990	27.9	32.6	37.2	38.4	39.4	36.5	34.1	35.5	35.3	35.4	33.4	30	**39.4**
1991	28.2	30.4	34.6	34.5	35.4	34.2	32.7	35.3	34.8	34	32.8	28.6	**35.4**
1992	28	33	36.8	37.2	34.2	34	35	36.2	34.5	37	30.2	29.3	**37.2**
1993	27.4	28	36.6	39.2	36.2	35.8	33.8	35.2	35	34.6	33.5	27.8	**39.2**
1994	28.6	32	34.6	37	35	34.3	33.2	33.3	35.3	33.6	30.8	29.1	**37**
1995	29.1	31	35.2	37.6	36.1	34.8	34	34.1	35	34.5	33	29.8	**37.6**
1996	29.2	30.8	38.8	39	38	36.6	33.5	34.7	35.6	34.6	34.2	28.6	**39**
1997	29.2	32	37.6	38.4	36.5	35.5	34.1	35.5	37.5	35.4	33.7	30.3	**38.4**
1998	27.6	31.3	35.6	34.7	36.2	35.5	34.4	37.5	34	34	33.7	29	**37.5**
1999	27.3	30.8	34.8	35.7	37.5	35.8	34.1	34.6	36.2	35.7	33.6	30.3	**37.5**
2000	29.4	35.7	39.6	37.6	37.5	36.6	35.6	34	34.6	34.6	32.4	29.7	**39.6**
2001	28.7	28.2	34	35.1	36.6	35.2	35.2	35	34.4	34.9	32.5	27.3	**36.6**
2002	28	31.4	35.8	37.5	35	33.8	34	34	34.2	34.8	32	28.4	**37.5**
2003	28.2	33.5	35.5	34.3	35.4	34.4	35.2	34.1	35	34.2	32	29.5	**35.5**
2004	27.5	31.6	34	36.2	36.3	36.7	35.3	35.1	34.2	34	32.1	29.2	**36.7**
2005	27.5	32.8	35.7	35.2	38.1	35.2	34.5	34.6	34	34.5	31.1	29.4	**38.1**
2006	28.5	32.1	35.6	37	36.4	36.6	33.7	34	35.1	34.6	31.4	29	**37**
2007	28.2	35.9	38.5	37.1	36.8	35	35.6	35.2	35.7	34.7	32.6	30.1	**38.5**
2008	28.8	30.8	36.7	35.9	37.5	35.9	34.8	35.9	34.9	35.6	31.8	28.2	**37.5**
2009	29	30.6	34.6	36.9	36.7	35.4	34	36	34.8	34.8	32.3	29	**36.9**
2010	28.1	33.9	36	39.6	37.8	36.5	35.7	34.3	35.3	35.8	33.9	29	**39.6**
2011	29	31.2	37.3	37.9	36.9	35.8	35.1	35.1	34	35.7	33.2	29.7	**37.9**
2012	27.8	31	34.5	35.8	35.3	36	35.4	35	36.2	34.5	32.4	30	**36.2**
2013	28.5	33	37.3	37.1	36.2	36.7	34.3	34.5	36.5	34.4	32.4	28.5	**37.3**
2014	28.1	32.4	36	37	37.1	36.4	34.6	35	35.7	35.2	32.1	30.5	**37.1**
2015	28.5	30.4	38	40.2	38	37	35.8	34.4	34.8	36	33.8	29.2	**40.2**
2016	29.9	32.2	36.4	35.5	36.4	36.5	35.5	34.7	36.5	35.5	32.9	30.3	**36.5**

B4: Monthly and yearly minimum air temperature in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	8.8	7.2	15.5	18.6	20	23.2	21.7	21.1	24.2	20.5	10.6	6.7	**6.7**
1962	6.1	9.7	13.1	20.3	18.3	22.2	22.8	23.3	23.1	18.9	12.8	7.8	**6.1**
1963	7.6	11.7	13.6	17.5	20.3	23.6	25	25	23.9	19.8	15	10.8	**7.6**
1964	5.6	9.2	14.7	18.1	20.3	22.2	23.2	24.4	21.9	21.7	15.8	8.9	**5.6**
1965	7.2	10.1	12.8	17.8	21.1	21.1	23.9	21	24.4	20.4	15	11.7	**7.2**
1966	7.2	10.1	12.8	20.6	22.1	23.1	23.9	24.4	23.1	19.6	14.2	11.1	**11.1**
1967	9.4	8.6	14.7	18.3	21.1	21.9	24.4	23.9	21.4	17.2	12.8	10	**8.6**
1968	8.3	7.2	16.1	15.6	19.9	22.8	25	24.4	24.1	21.1	16.2	6.7	**6.7**
1969	7.2	9.4	15	17.2	20.6	22.6	25	23.6	23.9	17.8	11.9	10.6	**7.2**
1970	8.3	9.7	16.7	20.1	20.2	22.5	23.2	23.3	24.4	21.1	13.1	9.6	**8.3**
1972	10.6	8.9	14.7	22.2	18.4	24.2	23.9	22.7	22.8	19.7	12.2	19.7	**8.9**
1973	7.5	7.3	12.1	17.8	20.1	21.1	24	22.8	23.6	19.9	15	9	**7.3**
1975	8.9	13.2	14.4	20.7	19.3	22.8	24	24.4	22.8	19.9	15.4	12.1	**8.9**
1976	8.9	11.7	13.8	20.2	20	21.2	23.6	23.7	22.6	10.4	13.3	9.3	**8.9**
1977	9.8	13.6	12.8	18.7	18.9	20.4	23.7	23.6	23.3	20.3	15.8	8.4	**8.4**
1978	8.2	7.8	14.4	18.5	18.6	20.6	24.1	24.5	23.9	19.9	16.4	10.8	**7.8**
1979	6.4	9.9	11.8	18.3	20	21.7	24.3	24.4	22.8	22.5	11.6	9.3	**6.4**
1980	9.4	11.1	11.7	20	21.4	23.9	24.4	24.7	23.3	21.4	18.4	10	**9.4**
1981	9.2	8.6	14.6	20.1	19.4	23.9	25	25.3	23.3	19.6	13.3	11.6	**8.6**
1982	10.6	10	15	17.2	14.7	23.6	24.4	24.8	23.4	18.9	13.7	10	**10**
1983	8.9	10.6	15	18.3	19.4	22.1	22.9	24.3	23	18.9	12.8	11.1	**8.9**
1984	10	7.8	15.8	17.9	20.7	21.9	23.9	23.1	24.3	18.7	16.2	9.4	**7.8**
1985	9.6	11.5	14.2	18.2	18.9	22.9	23.3	23.6	22.2	23.2	15.7	11.2	**9.6**
1986	11.6	12.3	17.1	18.2	19.6	22.8	23.4	24.8	23.8	19.7	15.9	11.9	**11.6**
1987	10.6	12.8	16.1	18.3	20.7	22.7	23.9	25.1	21.4	20.6	15.3	11.7	**10.6**
1988	8.8	12.8	16.2	18.9	18.9	24.4	24.2	22.6	23.3	19.6	15.8	12.1	**8.8**
1989	9.6	11.7	16.9	18.9	21.7	22.7	25	24.9	24.4	20.9	15.6	13.1	**9.6**
1990	6.8	11.6	14.6	20.6	21.1	22.1	24.4	25.3	24.4	19.8	15.6	11	**6.8**
1991	10.7	15	15	15.5	20.9	23.5	25	24.7	24	20	15.7	13.2	**10.7**
1992	10	14.2	18.4	19	20	22.8	24.6	24.6	23.4	21.6	15.4	10.3	**10**
1993	10.8	13	17.8	20.2	19	23	24	24.3	23.6	19	15	9.7	**9.7**
1994	7.2	11.4	13.7	19	19.8	23.1	23	24.6	24.2	19.2	15.5	10.6	**7.2**
1995	9	11.5	14	18	20.5	23.2	25	24	23	20	15	9.9	**9**
1996	6.5	10.2	14.5	17.7	22.8	23.1	23.6	23.2	24.5	19.2	14.6	11.3	**6.5**
1997	9	11	15.4	19	21.5	21.5	24.5	24.2	24.5	20.6	13.6	11.1	**9**
1998	7.8	9	17.2	17	21.1	22.4	24.4	25	22.5	19	15.8	10.6	**7.8**
1999	7.8	10.6	13.5	17.7	20.8	24.7	24.8	24.6	24.9	21.5	16.2	11.4	**7.8**
2000	9.4	11.5	15.2	21.2	20.6	24.3	24.3	24.7	24.3	22	15.1	11	**9.4**
2001	10	13.2	15.4	18	19.5	23.8	24	23.6	23	19.3	16.8	13.4	**10**
2002	9.8	12.4	16.6	20.9	19.9	24	24	22.5	21.5	19.7	15.5	12.6	**9.8**
2003	11.2	11.5	15.8	16.6	19.4	22	22.8	23.3	22	18.3	17.5	11.7	**11.2**
2004	8.1	14.2	13.5	17.8	19.6	22.5	23.4	24.2	23.5	23	14	13.2	**8.1**
2005	10.7	10.4	16.3	18.5	20.2	22.4	21.5	24.8	22.7	21.5	15.8	11.5	**10.4**
2006	11.4	11.5	19	19.6	19.7	22.5	24	24.3	23.8	20.8	16	12.2	**11.4**
2007	10.4	15.4	16.3	20.2	20.4	22.3	24.6	22.7	23.8	21.8	13.3	12.6	**10.4**
2008	9.6	12.6	15	18.1	22.5	22	23.4	24.2	24.5	19.5	16.8	11.3	**9.6**
2009	10.5	10.8	16.5	19.6	20.3	22.5	24.6	23.6	24.4	18	16.3	13	**10.5**
2010	11.1	12.2	15.8	20.4	21.6	22.6	24.4	24.3	24.5	20.6	15.2	11.4	**11.1**
2011	9.6	12	18.4	20.8	21.3	23.2	25.3	25	24.8	21.5	16.6	11	**9.6**
2012	8.2	13	16	20.2	21.3	23.2	23.9	24.5	23.7	22	17.2	11	**8.2**
2013	10.5	12.2	18.3	19	20.5	23.2	25.2	24.4	24.9	20.3	14.8	9.6	**9.6**
2014	7.2	14	16.7	19.8	20	22	24.5	24.5	24.2	20.1	16	11.8	**7.2**
2015	10.3	11.6	16	18.9	21.1	23.2	24	24.3	24.2	19.5	15.4	12.3	**10.3**
2016	11.4	12.8	15	19.5	20.1	23.2	23.6	23.8	24	20.3	17.5	11.5	**11.4**

B5: Monthly average dry-bulb temperature in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1961	18.8	19	26.9	28.4	28.7	27.7	28.2	28.1	27.8	26.7	21.7	16.5
1962	16.7	21	26.3	28.4	27.8	27.9	28.7	27.9	28.4	26.3	22	18.3
1963	17.2	22.5	25.9	27.1	27	28.1	28.4	28.4	28.5	26.5	22.4	19.2
1964	17.2	21.4	26.9	27.4	28.1	28.1	27.4	28.4	28.2	27.1	23.3	19.4
1965	18.4	20.6	24.7	28.2	28.9	28	27.7	27.6	27.7	26.7	23	19.4
1966	*	*	*	29.4	30	28	28.4	28.1	27.7	25.7	23.7	19
1967	18.6	22	24.1	27.4	28.7	28.5	28.4	28.1	27.5	26.3	21.7	19.5
1968	18	20.9	25.7	27.9	28.3	27.2	28.3	28.4	28.8	26.6	23.3	19
1969	17.9	21.6	26.4	28.2	29.3	28.3	28.4	27.6	28.6	26.8	23.1	19.4
1970	18	21.8	26	28.5	29.5	28.5	28.4	28.4	28.1	26.5	22.9	18.8
1972	18.5	20.9	22.2	27.9	28.2	28.3	28.2	27.3	28.6	27.6	23.6	*
1973	18.4	19	26.2	27.2	29.3	28.6	28.6	27.6	28.5	27	23.5	19.7
1975	19	22.7	25.1	29	27	28.3	*	28.2	27.8	26.9	22.8	19
1976	18.3	21.6	26.3	28.8	28.2	28.6	27.3	28.3	27.5	27.2	22.4	18.3
1977	18.8	21.9	26.7	28.6	27.6	27.6	27.9	27.6	28.2	26.7	24.4	18.5
1978	17.7	21.1	27	26	26.7	27.4	28.1	28.7	28.4	26.7	24.3	19.5
1979	17.7	21.1	25.6	27.1	27.1	27.9	28.1	28.8	28	27.5	23.9	19.2
1980	19	20.4	26.1	29	30.3	29	28.7	28.6	28.3	27.3	25.3	19.5
1981	18	21.2	26.5	30.1	27.7	28.5	28.4	28.7	28.5	26.7	23.7	20.7
1982	19.3	21.5	24.8	26.5	27.8	29.4	28.1	29.2	28.5	27.9	24	19.7
1983	19.5	21.4	25	27.2	29.5	28.2	28.9	28.2	28.6	27.1	22.3	19
1984	18	20.3	25.7	27.1	27.8	29.1	29	28.4	28.2	26.9	24.5	19.3
1985	18.5	20.7	27.2	28.8	27.8	28.2	28.2	28.4	28.1	28.1	23.6	20
1986	19.7	22.1	27.5	28.5	27.9	28.7	27.9	28.9	28.3	27.7	23.7	20.8
1987	19.4	22.3	27.3	27.5	28.3	29.4	28.5	29.3	27.7	26.7	24	20.4
1988	19.1	22.7	26.3	27.9	29.7	29.9	28.3	28.9	29	27.9	24.6	20.6
1989	19.8	22.7	26.1	29	28.7	28.5	28.8	29	29.5	27.8	24.5	21
1990	17.7	21.8	26.5	29.7	29.5	29.1	28.8	29.6	28.4	27.5	23.9	19.2
1991	19.3	22.3	23.9	27.2	28.3	29.2	28.2	29.2	28.5	26.6	25.3	20.9
1992	18.8	23.1	26.9	28.7	27.4	28.4	29.1	28.9	27.9	27.3	23.4	19.6
1993	18.5	20.6	27.1	29.8	28.5	29.5	28.5	28.9	28.8	27.4	23.7	18.5
1994	17.8	22.4	24.7	27.6	27.4	28.7	28.6	28.4	28.3	27.2	23.7	19.8
1995	19.1	20.3	26.3	27.9	29.1	29	29.2	29	28.8	27.3	23.5	19
1996	17.7	21.2	26.1	29.9	30.1	29.3	28.6	29.1	28.6	27.6	23.9	19
1997	18.3	22	27.4	28.9	29.6	28.3	28.9	28.3	29.1	26.9	23.4	19.7
1998	17.6	20.8	26.7	25.9	28.9	29	28.7	29.2	27.9	26.5	24	19
1999	17.1	21.7	24.4	27.4	29.1	30.7	28.8	28.9	28.7	28.5	25	20.4
2000	18.8	23.3	27.7	30.6	28.6	29	28.5	28.5	28.2	27.6	23.8	20.9
2001	18.7	20.8	25.5	27.9	28	29.1	29	29.1	28.6	27.5	24.5	20.1
2002	18.4	22.6	26.6	29.1	27.7	28	28.8	29.5	28.7	27.6	24.5	19.8
2003	19.7	22.6	26.2	27.6	27.8	28.3	28.5	28.6	28.9	27.4	24	20.3
2004	16.2	22.1	24.4	28.9	29.5	28.4	29.3	29.4	28.5	27.8	24	20.5
2005	18.2	21.8	27.1	27.8	30.4	28.5	28.6	29.1	27.7	26.9	23.4	21
2006	19	23.4	26.9	29	28.6	29.7	28.6	29	28.9	27	23.9	20.9
2007	18.9	24.9	27.4	28.6	29.1	29.1	29.2	29.1	28.5	27.9	24.3	20.6
2008	18	21.5	25.4	28.1	30	28.7	28.2	29.1	28.7	27.1	23.9	19.8
2009	19	20.3	26.6	29.2	29.3	28.7	28.5	28.8	28.9	27.1	23.7	20.4
2010	19.7	23.3	27	30.1	29.1	30.2	29	28.9	28.8	27.6	24.6	20
2011	17.6	22.3	28.2	30.4	29.7	29.3	29.7	29.5	28.9	28.3	24.9	20.1
2012	17.3	22.5	26.4	28	28.4	29.1	29.2	28.5	29.1	28.1	23.9	19.3
2013	18.9	22.1	27.1	28.1	30.1	29.7	29.1	29.2	29	27.9	23.5	18.4
2014	17.6	22.8	27.5	29	28	30.1	29.3	28.7	28.9	27.2	23.8	20.2
2015	18.3	21	26.5	30.7	30.2	29.6	29.5	28.8	29.2	27.7	24.3	19
2016	19.1	22.4	26.3	27.9	29.7	29.3	28.4	29.2	29	27.7	24.5	20.4

B6: Monthly and yearly average relative humidity in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	29.2	31.7	36.3	40.6	36.6	35.1	34.3	32.8	33.6	32.6	30.6	31	**40.6**
1962	29.3	31.6	40.6	39.4	35.9	35	35.1	32.7	33.6	32.5	31.1	28	**40.6**
1963	28.1	33.1	35.9	37.9	34.9	34.7	32.2	32.7	34.9	33.2	31.1	28.2	**37.9**
1964	29.9	34.7	36.7	36.7	36.7	34.9	32.6	32.8	34.3	32.9	30.6	28.3	**36.7**
1965	28.6	31.6	35.8	42	38.3	34.2	32.4	33.4	33.3	32.9	32.6	28.9	**42**
1966	*	*	*	39.8	39.8	35.6	32.8	32.8	34.1	31.9	30.5	27.2	*****
1967	27.2	33.6	34.9	37.7	36.1	35.4	32.8	33.9	32.7	33.3	29.9	28.3	**37.7**
1968	27.2	31.6	36.9	37.7	36.9	33.1	33.3	34.2	35.3	32.8	31.2	29.4	**37.7**
1969	28.3	35.1	35.8	37.2	37.1	34.2	32.8	33.3	34.4	32.8	32.2	27.8	**37.2**
1970	27.8	32.3	37.2	36.9	37.2	34.4	34.2	34.2	33.3	32.9	30.9	27.8	**37.2**
1972	26.7	31.6	29.7	32.1	35.3	32.8	33.3	32.7	33.8	32.8	30.2	*	*****
1973	30.5	31.7	36.7	36.8	36.1	35.2	35.6	32.4	34.6	33.8	31.1	30.9	**36.8**
1975	31.2	33.6	36.3	39.4	33.3	33.5	*	32.9	36.7	33.2	30.6	26.7	*****
1976	27.2	31.9	37.2	37.6	36.7	34.9	32.2	34.4	33.4	33.2	30.2	26.8	**37.6**
1977	29.2	32.8	37	38.9	39.8	33.9	32.4	32.8	33.9	33.1	32.4	28.7	**39.8**
1978	27.4	32.3	35.6	33.3	34.7	33.8	33.6	34.4	35	32.2	31.9	29.4	**35.6**
1979	34.2	33	36.1	37.2	35.3	33.3	32.9	33.8	33.6	33.4	32.9	29.8	**37.2**
1980	28.3	31.1	37.2	38.9	40.6	38.3	33.9	35.1	34.2	32.7	31.8	27.2	**40.6**
1981	28.9	32.2	37.9	38.9	35.4	36.7	32.8	33.6	33.6	32.5	31.7	28.9	**38.9**
1982	27.8	32.9	34	35.4	35	35.9	33.3	36.5	35	33.4	33.1	29	**36.5**
1983	30.1	30.3	36.1	37	38.3	36.6	34.8	33.2	34.8	34.4	32.1	27.2	**38.3**
1984	28.1	31.7	36.2	37.7	36.4	35.6	34.4	33.6	33.1	33.6	32.8	28.8	**37.7**
1985	27.2	33	38	37.6	35.8	35.8	32.5	35.4	34.5	34	31.8	30	**38**
1986	29.4	32.4	37.1	35.8	35.1	35	34.3	34.7	35	35.5	33.3	30.6	**37.1**
1987	30	32.3	39.5	38	37.2	36.8	34.5	36	34.5	33.9	33.1	29	**39.5**
1988	29.8	35	39	39.5	38	37	34.1	34.7	34.6	35.1	33	29.2	**39.5**
1989	29.2	32.8	37	39	36.2	36.8	35.2	34.1	36	35.1	33	29.3	**39**
1990	27.9	32.6	37.2	38.4	39.4	36.5	34.1	35.5	35.3	35.4	33.4	30	**39.4**
1991	28.2	30.4	34.6	34.5	35.4	34.2	32.7	35.3	34.8	34	32.8	28.6	**35.4**
1992	28	33	36.8	37.2	34.2	34	35	36.2	34.5	37	30.2	29.3	**37.2**
1993	27.4	28	36.6	39.2	36.2	35.8	33.8	35.2	35	34.6	33.5	27.8	**39.2**
1994	28.6	32	34.6	37	35	34.3	33.2	33.3	35.3	33.6	30.8	29.1	**37**
1995	29.1	31	35.2	37.6	36.1	34.8	34	34.1	35	34.5	33	29.8	**37.6**
1996	29.2	30.8	38.8	39	38	36.6	33.5	34.7	35.6	34.6	34.2	28.6	**39**
1997	29.2	32	37.6	38.4	36.5	35.5	34.1	35.5	37.5	35.4	33.7	30.3	**38.4**
1998	27.6	31.3	35.6	34.7	36.2	35.5	34.4	37.5	34	34	33.7	29	**37.5**
1999	27.3	30.8	34.8	35.7	37.5	35.8	34.1	34.6	36.2	35.7	33.6	30.3	**37.5**
2000	29.4	35.7	39.6	37.6	37.5	36.6	35.6	34	34.6	34.6	32.4	29.7	**39.6**
2001	28.7	28.2	34	35.1	36.6	35.2	35.2	35	34.4	34.9	32.5	27.3	**36.6**
2002	28	31.4	35.8	37.5	35	33.8	34	34	34.2	34.8	32	28.4	**37.5**
2003	28.2	33.5	35.5	34.3	35.4	34.4	35.2	34.1	35	34.2	32	29.5	**35.5**
2004	27.5	31.6	34	36.2	36.3	36.7	35.3	35.1	34.2	34	32.1	29.2	**36.7**
2005	27.5	32.8	35.7	35.2	38.1	35.2	34.5	34.6	34	34.5	31.1	29.4	**38.1**
2006	28.5	32.1	35.6	37	36.4	36.6	33.7	34	35.1	34.6	31.4	29	**37**
2007	28.2	35.9	38.5	37.1	36.8	35	35.6	35.2	35.7	34.7	32.6	30.1	**38.5**
2008	28.8	30.8	36.7	35.9	37.5	35.9	34.8	35.9	34.9	35.6	31.8	28.2	**37.5**
2009	29	30.6	34.6	36.9	36.7	35.4	34	36	34.8	34.8	32.3	29	**36.9**
2010	28.1	33.9	36	39.6	37.8	36.5	35.7	34.3	35.3	35.8	33.9	29	**39.6**
2011	29	31.2	37.3	37.9	36.9	35.8	35.1	35.1	34	35.7	33.2	29.7	**37.9**
2012	27.8	31	34.5	35.8	35.3	36	35.4	35	36.2	34.5	32.4	30	**36.2**
2013	28.5	33	37.3	37.1	36.2	36.7	34.3	34.5	36.5	34.4	32.4	28.5	**37.3**
2014	28.1	32.4	36	37	37.1	36.4	34.6	35	35.7	35.2	32.1	30.5	**37.1**
2015	28.5	30.4	38	40.2	38	37	35.8	34.4	34.8	36	33.8	29.2	**40.2**
2016	29.9	32.2	36.4	35.5	36.4	36.5	35.5	34.7	36.5	35.5	32.9	30.3	**36.5**

B7: Monthly and yearly average rainfall in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1961	*	12	20	205	219	856	296	288	221	52	0	0	*
1962	0	15	6	166	205	191	355	273	395	180	0	0	**1786**
1963	0	0	51	98	219	621	404	186	200	182	7	3	**1971**
1964	9	42	18	296	236	354	629	155	269	283	*	0	*
1965	0	*	22	55	305	442	304	480	300	50	131	*	*
1966	*	*	*	34	127	270	291	306	496	261	14	15	*
1967	23	12	168	185	216	241	363	504	266	74	1	0	**2053**
1968	0	5	121	*	194	590	480	212	128	69	74	0	*
1969	0	1	65	86	95	249	198	540	201	103	2	0	**1540**
1970	16	8	23	45	192	276	496	280	200	427	32	0	**1995**
1972	3	28	*	*	344	339	550	540	*	118	*	*	*
1973	0	11	12	248	340	353	249	380	*	105	0	0	*
1975	*	21	32	131	621	414	*	238	348	128	64	86	*
1976	1	29	13	98	317	235	559	307	329	232	25	0	**2145**
1977	0	7	117	34	459	627	346	361	165	114	8	0	**2238**
1978	0	66	71	255	381	252	306	92	131	273	10	24	**1861**
1979	0	20	18	194	454	529	320	426	192	98	0	0	**2251**
1980	3	13	6	17	114	258	267	525	382	146	55	51	**1837**
1981	3	32	54	147	414	323	380	269	296	300	0	0	**2218**
1982	10	42	109	274	272	168	356	188	320	82	9	35	**1865**
1983	0	15	81	104	154	514	136	346	258	146	51	0	**1805**
1984	*	61	138	318	348	300	179	437	322	253	*	18	*
1985	13	1	5	124	707	637	694	311	478	58	0	0	**3028**
1986	8	1	195	176	300	399	262	317	306	79	0	10	**2053**
1987	22	0	23	247	191	304	443	171	687	237	172	3	**2500**
1988	4	0	33	230	109	316	526	462	363	104	7	33	**2187**
1989	0	44	74	282	513	580	255	169	196	213	153	3	**2482**
1990	0	32	0	85	228	319	347	59	305	240	0	12	**1627**
1991	0	36	151	154	202	229	567	227	247	181	103	6	**2103**
1992	27	8	46	53	529	320	318	345	692	392	14	106	**2850**
1993	1	47	0	25	153	132	386	182	158	83	2	0	**1169**
1994	0	52	88	113	556	504	421	432	417	217	19	0	**2819**
1995	13	54	115	201	254	266	153	246	169	55	14	0	**1540**
1996	8	31	0	88	264	237	354	360	205	91	112	1	**1751**
1997	0	21	54	199	208	343	257	361	244	357	0	0	**2044**
1998	2	7	82	133	151	249	549	230	440	30	1	22	**1896**
1999	49	4	83	178	405	89	521	552	246	100	83	0	**2310**
2000	0	0	0	21	428	348	553	282	361	368	13	0	**2374**
2001	13	44	172	189	608	165	197	359	216	278	0	0	**2241**
2002	0	1	33	46	402	386	202	205	209	177	18	0	**1679**
2003	22	4	51	111	272	373	446	272	156	52	116	0	**1875**
2004	0	25	96	123	140	473	191	202	264	134	0	45	**1693**
2005	0	0	9	167	162	476	295	191	839	208	0	0	**2347**
2006	1	3	155	91	291	259	542	361	514	417	3	0	**2637**
2007	0	0	0	181	185	326	331	167	663	61	5	0	**1919**
2008	0	30	11	163	185	628	753	505	179	320	111	0	**2885**
2009	23	56	45	91	205	577	563	319	279	227	0	0	**2385**
2010	1	1	43	14	168	170	676	482	298	74	4	0	**1931**
2011	0	48	22	37	177	308	167	340	169	174	0	81	**1523**
2012	0	0	20	123	235	314	356	409	207	112	0	0	**1776**
2013	10	1	37	269	137	175	226	282	81	38	68	5	**1329**
2014	0	8	26	32	378	325	302	212	138	131	0	4	**1556**
2015	0	12	10	80	147	342	212	391	156	49	0	0	**1399**
2016	3	17	4	166	185	375	623	395	346	51	0	1	**2166**

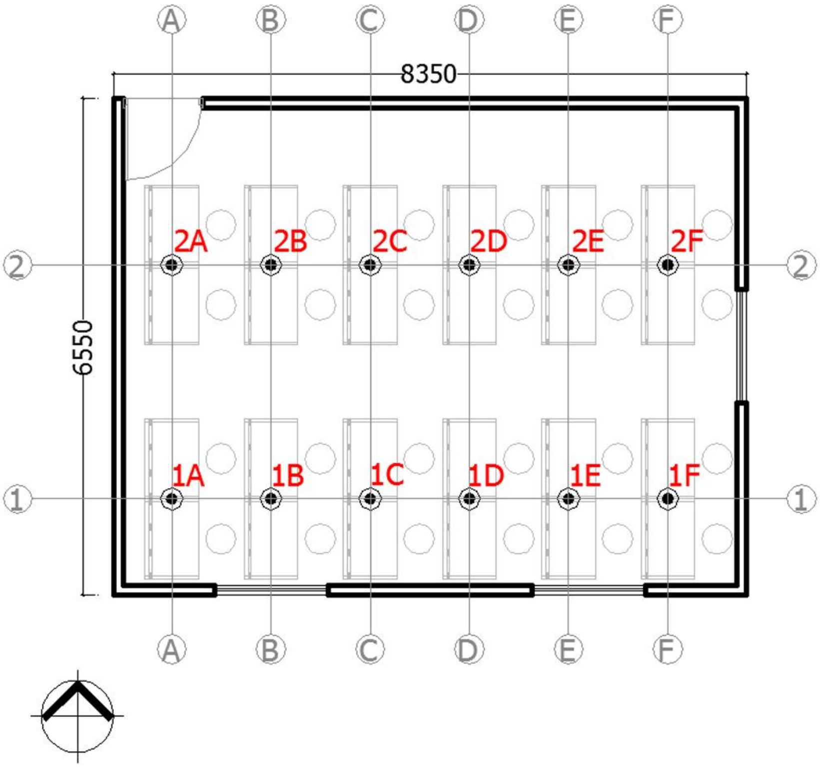
B8: Monthly and yearly prevailing wind speed in Dhaka (BMD, 2017)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1961	2.9	3.1	5.6	5.1	7.6	6.4	8	7.7	6.1	3.4	2.9	3.6
1962	4.6	4.1	5	8.4	5.3	5.8	6.4	5.2	7.6	2.3	2.3	3.7
1963	2.6	3.7	4.1	4.8	5.2	5.7	5.9	4.4	4.7	6.1	2.8	3.4
1964	3.2	3.4	5.3	8.3	4.8	5.3	4.5	5.7	6	5	4.1	3.6
1965	3.6	4	5.4	6.7	6.3	5.2	5.8	5.7	4.6	3.3	3.7	3.3
1966	4.6	0	0	8.5	5.8	9.1	5.3	4.5	3.8	6.3	3	2.8
1967	3.3	3.2	3.9	6.5	6.6	5.2	4.9	5	4.5	2	3.4	2.6
1968	3.1	3	4.4	5.4	4.8	4.1	4.6	4.5	3.7	2.9	3.2	3
1969	3.4	2.9	4.8	5.1	4.1	4.5	5	4.4	5.6	3	2.4	2.9
1970	3.3	3.1	5	5.8	6.4	4.7	4.4	4.5	3.6	3.6	3.5	2.9
1972	3.3	3.4	3.5	3.5	3	4.8	4.9	4.3	3.8	3.8	2.5	2.9
1973	3	3.3	5.5	6	6	4.4	7.2	4.8	3.4	4.5	3.1	3.1
1975	2.9	3.3	3.5	4.8	4.5	3.3	8.2	4	3.8	2.2	6.5	3
1976	2.8	3.5	4.2	6.5	5.1	3.8	3.8	4.7	3.7	3.4	2.8	2.6
1977	2.8	3.8	5.5	5.8	5	5.1	5.4	5	4.5	2.9	2.9	2
1978	2.9	3.8	4.6	7.5	5.6	5.6	4.4	5.6	5.3	4.2	3.8	2.2
1979	3.4	4.3	5.5	4.7	5	5.2	4.1	5.5	3	4	3.1	3.7
1980	3.2	3	5	4.3	4.8	4.5	3.9	5.5	3.2	3.7	5.2	3.4
1981	2.7	2.9	5.2	7.4	4.7	4	4.5	3.6	4.2	5.9	2	2.6
1982	3.3	3.5	5.1	4.9	4.3	3.8	4.1	2.7	3.7	3.2	2.9	2.7
1983	2.8	3.3	2.8	6.3	5.8	4.8	4.7	4.9	4	2.2	2.3	2.9
1984	3.3	5.2	6.1	5.1	3.7	4.7	4.7	4.8	4.2	3.9	2.9	3.6
1985	3.9	3.3	4.1	5.7	4.2	5	4.1	4.7	3.6	3.5	2.6	2.9
1986	2.5	4.1	4.9	4.6	4.3	4	3.5	5	3.3	7.4	3	3.1
1987	2.3	3	4.7	5.9	3.5	3.4	4.2	3.9	5.7	2.6	2	3
1988	3.2	3.3	4.4	5.3	4.9	4.4	4.2	4	3.6	3.4	2.7	2.4
1989	2.5	3	4.9	5.3	6.2	4.2	4.4	4.4	3.8	3.6	2.4	2.8
1990	3.5	4.5	3.5	6.4	6.1	4.9	4.2	3.7	4.3	3.6	2.6	2.9
1991	2.6	3.5	6.3	6.5	3.8	4.8	4.4	4.2	4.7	7.5	2.6	3
1992	3.2	4	3.3	4.6	6.2	3.9	4.5	4	4.3	3.1	2.3	4.2
1993	3.7	4.2	4.7	5.8	4.4	4.1	3.9	5.2	3.6	3.8	2.5	2.8
1994	3	3.7	4.6	3.5	3.7	3.9	3.4	3.4	3.1	3.6	2.5	2.7
1995	3.2	3	4.4	3.9	4	4.2	3.8	3.8	3.7	2.6	2.1	2.2
1996	2.8	2.6	2.9	3.1	3.4	3.7	3.8	3.9	3.7	2.4	2.3	2.2
1997	2.3	2.7	3	2.9	2.7	2.6	2	1.8	1.5	3.3	1.4	1.4
1998	1.5	1.8	2.4	2.3	2.2	2.4	2.2	2.9	2	1.4	2	1.7
1999	1.5	1.7	2.7	2.5	3.1	2.8	2	1.9	2.1	2.7	3.6	2
2000	2.1	2.2	2.2	2.5	2.5	2.5	2.6	2.3	1.9	2.4	1.6	1.7
2001	1.6	2	2.3	3.3	2.6	2.5	2.4	2.4	2.2	3.3	1.5	1.6
2002	2.2	1.8	3.6	4.1	3.4	3.2	3.9	2.5	3	2.6	1.7	2
2003	2.5	2.5	3.9	4.1	3.5	2.8	2.7	2.8	3	2	6.5	2.4
2004	3.1	3.5	3.8	5.1	4.9	4.1	4.1	4.3	4.3	3.3	2.8	3.1
2005	3.5	3.9	5.6	5.9	5.5	3.6	4.3	4.1	6.3	4.2	3.2	3.3
2006	4.1	4.3	4.6	4.5	4.4	4.4	4.6	3.5	4.6	4.8	3.4	3.7
2007	3	3.6	5	3.8	3.8	2.1	2.2	4.5	5.4	2.3	2.1	2.4
2008	2.9	3.1	4.2	3.8	3.5	3.1	3.1	3.1	3.2	4.1	5.5	2.9
2009	3.6	3.2	3.8	3.4	3.4	3.3	3.4	2.8	2.8	9.6	2.5	3.3
2010	3.3	4.1	4	4.1	3.8	3.1	4.3	2.8	4.2	2.3	2.8	2.4
2011	2.9	3.3	3.8	4.1	3.7	3	2.4	2.2	2.6	2	2.9	2.4
2012	2.2	2.4	3.8	2.4	3	2.7	2.4	2.4	2.6	2	2.3	2.1
2013	2.4	3	2.5	2.6	2.5	3	2.7	2.5	2.2	2	2.2	2.3
2014	2.3	2.2	2.6	2.8	3.2	2.3	2.7	2.7	2.2	2.9	2.1	2.3
2015	2.5	2.5	2.4	2.2	2.8	2.1	2.4	2.4	2.1	2.1	2.1	2.2
2016	2.2	2.4	2.2	2.5	2.3	2.6	2.4	2.7	3	1.9	2.5	2.1

Appendix C: Existing daylight and thermal conditions of the design studios

C1: Bangladesh University (SVW1)

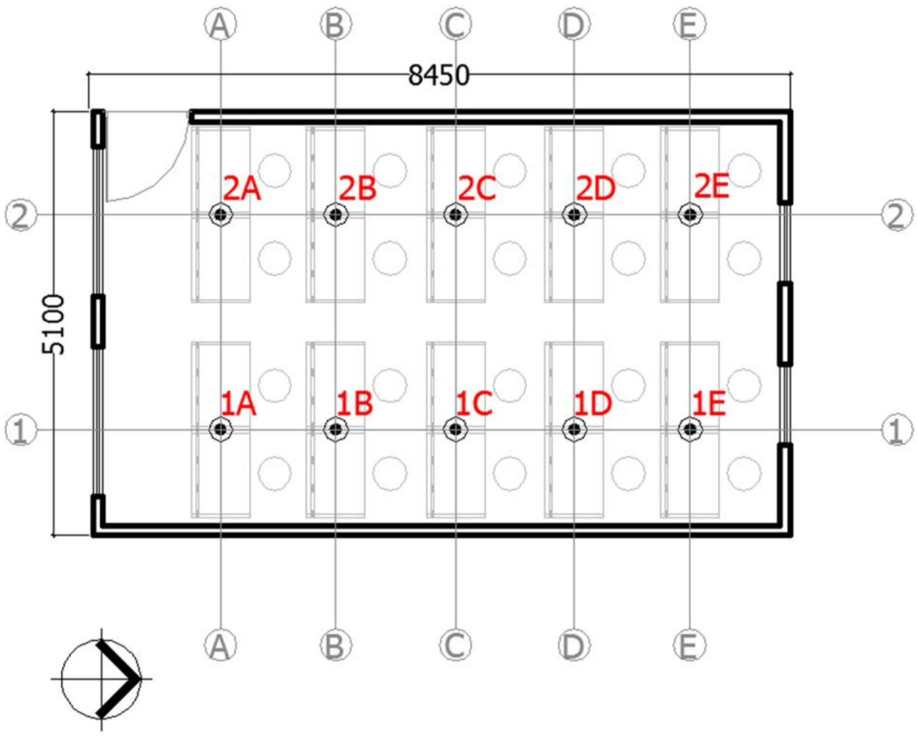
Bangladesh University (SVW1)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [^{o}c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	1590	22.5	38	0.2
1B	**3520**	22.1	38	0.3
1C	362	21.5	38	0.1
1D	227	21.1	38	0.1
1E	479	21.3	38	0.3
1F	476	23.1	39	0.1
2A	96	20.5	39	0.1
2B	90	21.2	39	0.2
2C	101	22.3	39	0.2
2D	91	22.2	39	0.3
2E	74	23.9	39	0.1
2F	**68**	23.8	39	0.2
Average	**598**	**22.1**	**39**	**0.18**

C2: Southeast University (SVW2)

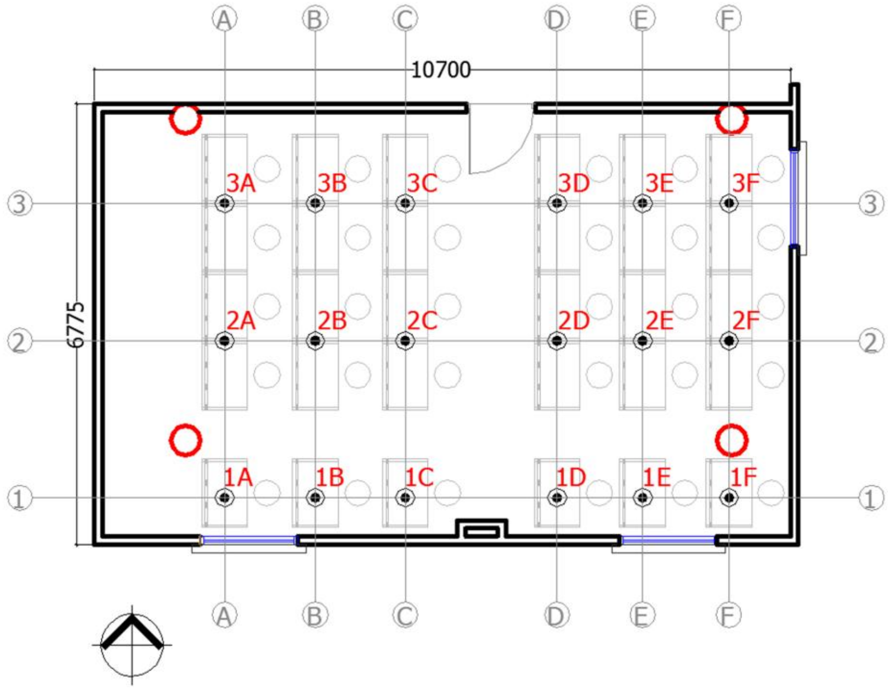
Southeast University (SVW2)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [^{o}c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	**1500**	21.3	26	0.2
1B	1500	21.8	27	0.0
1C	1500	22.5	27	0.0
1D	1000	21.5	28	0.1
1E	700	20.8	27	0.0
2A	1500	20.7	26	0.2
2B	1500	20.1	26	0.0
2C	1000	21.3	26	0.0
2D	700	21.9	27	0.0
2E	**500**	23.1	27	0.0
Average	**1140**	**21.5**	**27**	**0.05**

C3: Stamford University (SVW3)

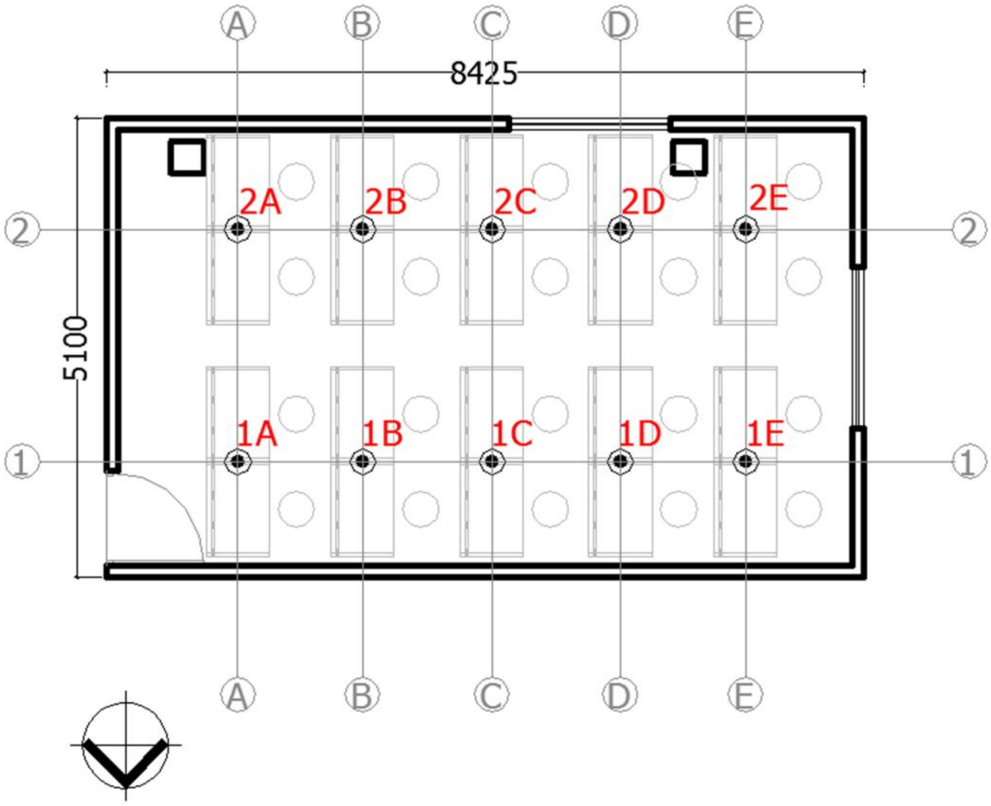
Stamford University (SVW3)



Node points	Daylight Levels [Lux]	Air Temperature [°c]	Relative Humidity [%]	Wind Speed [m/s]
1A	1280	21.8	32	0.1
1B	620	20.1	32	0.1
1C	160	21.1	33	0.1
1D	78	20.5	33	0.3
1E	625	20.3	33	0.1
1F	**1824**	20.4	33	0.1
2A	47.4	20.5	33	0.0
2B	13.5	20	33	0.1
2C	13.9	20.5	33	0.1
2D	**10**	20.3	33	0.0
2E	20.4	21.5	33	0.0
2F	60.3	20.3	33	0.1
3A	28.1	20.8	33	0.1
3B	12.4	21.1	33	0.1
3C	11.2	21.2	33	0.0
3D	43.3	21.1	33	0.0
3E	70.9	20.9	33	0.0
3F	52	21.1	34	0.0
Average	**276**	**20.8**	**33**	**0.07**

C4: Daffodil International University (SVW4)

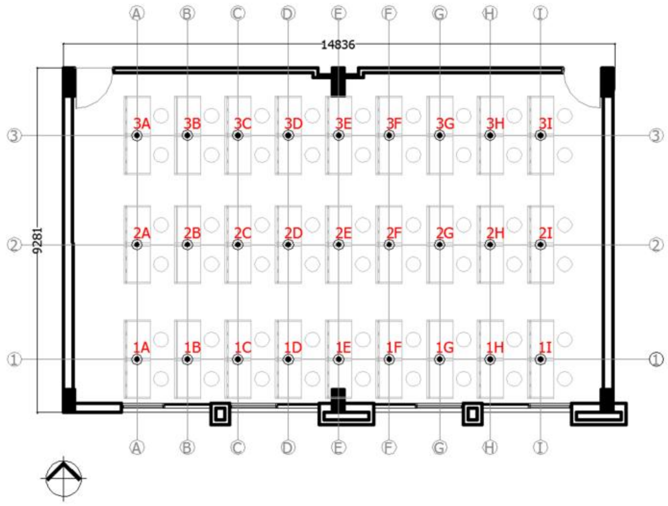
Daffodil International University (SVW4)



Node points	Daylight Levels [Lux]	Air Temperature [^{o}c]	Relative Humidity [%]	Wind Speed [m/s]
1A	89.3	21	38	0.0
1B	110	20.8	38	0.1
1C	105.3	21.1	37	0.3
1D	115.7	20.8	37	0.1
1E	199.9	21	37	0.1
2A	**71**	21.1	36	0.1
2B	288.3	21.2	36	0.3
2C	**346**	21.1	36	0.1
2D	320	21.5	37	0.2
2E	193.5	21.1	37	0.3
Average	**184**	**21.1**	**37**	**0.16**

C5: Ahsanullah University of Science and Technology (SVW5)

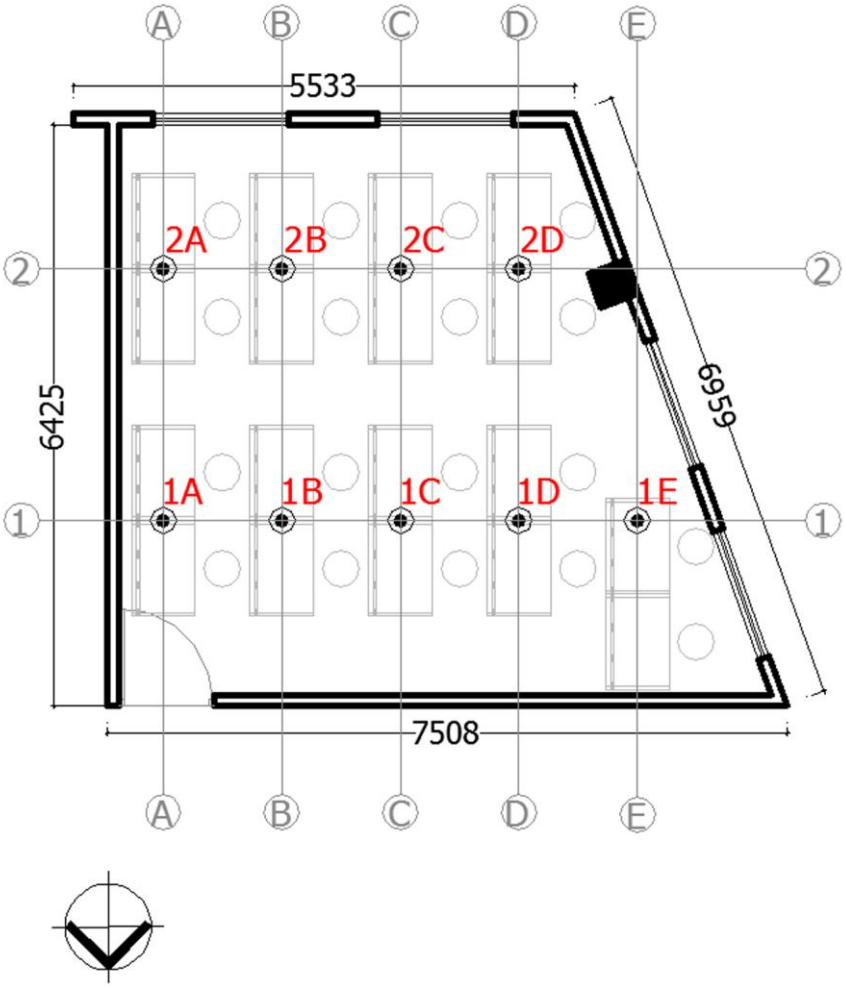
Ahsanullah University of Science and Technology (SVW5)



Node points	Daylight Levels [Lux]	Air Temperature [°c]	Relative Humidity [%]	Wind Speed [m/s]
1A	1340	21.8	32	0.0
1B	1440	22.1	32	0.1
1C	1290	21.9	32	0.1
1D	1300	21.5	32	0.1
1E	1080	21.5	32	0.2
1F	**1860**	21.3	32	0.1
1G	1780	21.2	33	0.0
1H	1730	20.5	33	0.0
1I	1390	20.9	33	0.1
2A	380	21.9	33	0.0
2B	560	21.5	33	0.1
2C	500	21.5	33	0.0
2D	460	21.3	34	0.0
2E	360	22.1	34	0.1
2F	640	22.3	34	0.0
2G	600	21.9	34	0.0
2H	370	20.5	34	0.1
2I	490	21.1	34	0.0
3A	**95**	21.3	32	0.0
3B	108	22.2	31	0.0
3C	220	21.1	31	0.0
3D	110	20.2	31	0.0
3E	170	20.5	30	0.0
3F	130	21.1	30	0.0
3G	150	21.9	30	0.0
3H	150	22.1	30	0.1
3I	140	22.2	30	0.0
Average	**698**	**21.5**	**32**	**0.04**

C6: Sonargaon University (SVW6)

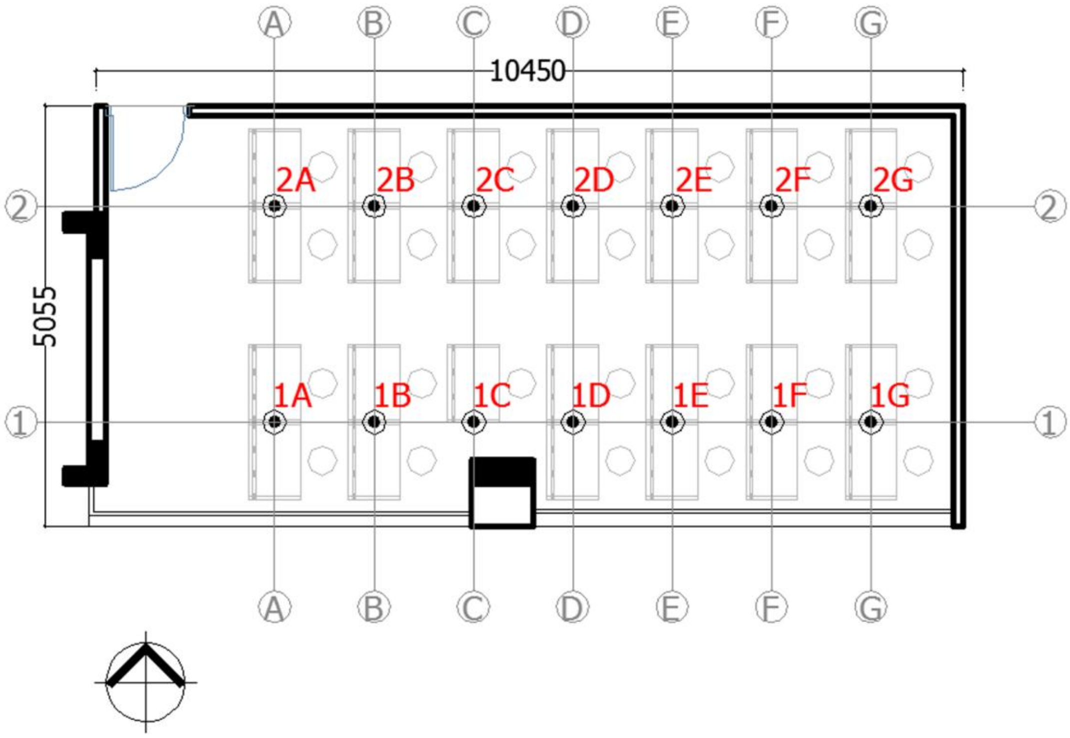
Sonargaon University (SVW6)



Node points	Daylight Levels [Lux]	Air Temperature [°c]	Relative Humidity [%]	Wind Speed [m/s]
1A	**466**	20.2	40	0.1
1B	501	20.5	42	0.1
1C	539	21.1	44	0.0
1D	899	21.1	44	0.0
1E	913	21.5	44	0.0
2A	**2420**	20.8	43	0.3
2B	875	21.1	43	0.1
2C	1520	21.3	43	0.2
2D	1352	21.5	43	0.2
Average	**1054**	**21.0**	**43**	**0.11**

C7: State University of Bangladesh (SFW1)

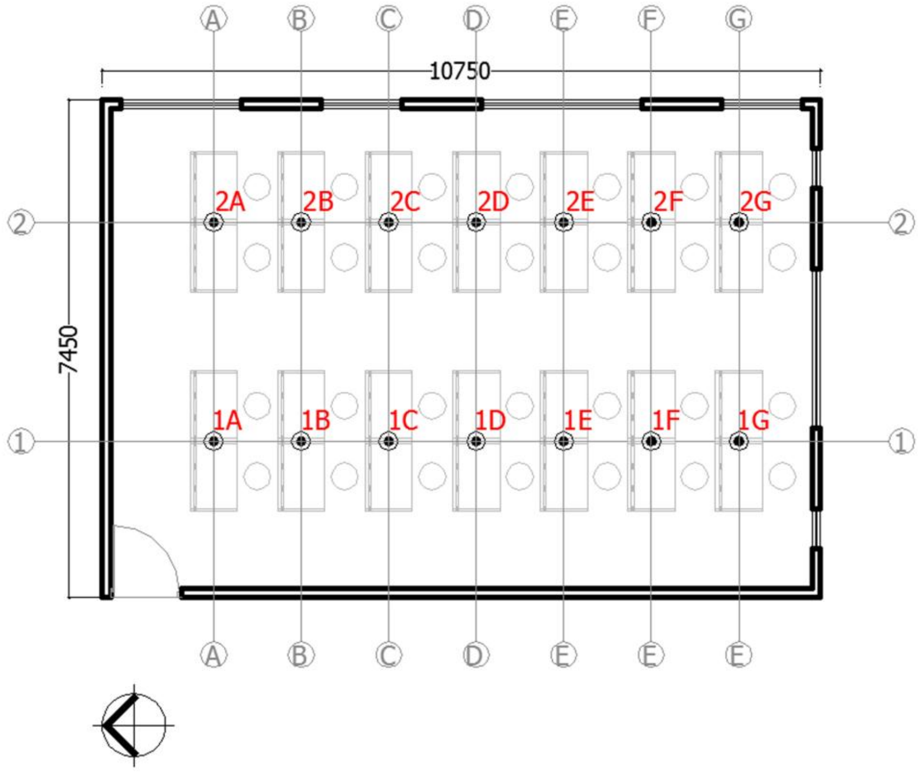
State University of Bangladesh (SFW1)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [°c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	637.5	21.5	35	0.1
1B	**1440**	21.5	34	0.3
1C	1220	21.4	34	0.1
1D	**126**	21.1	32	0.2
1E	545.45	22.1	32	0.3
1F	888.31	21.8	32	0.4
1G	521.3	21.7	32	0.3
2A	194	21.5	30	0.0
2B	233.2	20.8	30	0.0
2C	212.5	21.3	30	0.0
2D	212.3	21.2	31	0.0
2E	198.9	21.5	31	0.1
2F	177.7	21.5	31	0.0
2G	223.2	21.1	31	0.0
Average	**488**	**21.4**	**32**	**0.13**

C8: University of Asia Pacific (SFW2)

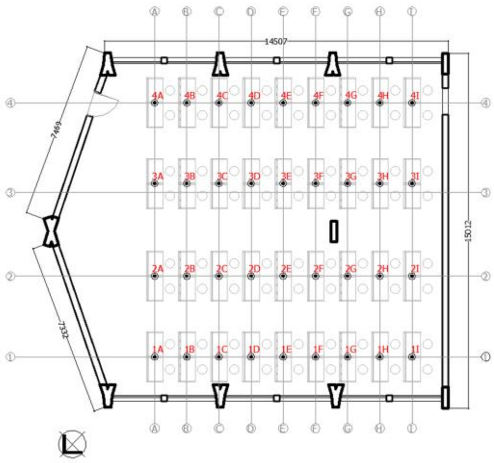
University of Asia Pacific (SFW2)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [^{o}c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	**73**	21.9	39	0.1
1B	79	21.2	39	0.2
1C	89.1	21.1	40	0.2
1D	105.1	21.6	40	0.2
1E	105.3	21.9	40	0.1
1F	162	22.1	40	0.2
1G	175.3	20.8	40	0.1
2A	100	21.5	39	0.1
2B	194	21.8	39	0.0
2C	105	22.1	39	0.2
2D	358	22.1	40	0.2
2E	263	22.5	40	0.1
2F	240	22.1	40	0.0
2G	**780**	22.1	40	0.1
Average	**202**	**21.8**	**40**	**0.13**

C9: Bangladesh University of Engineering and Technology (SFW3)

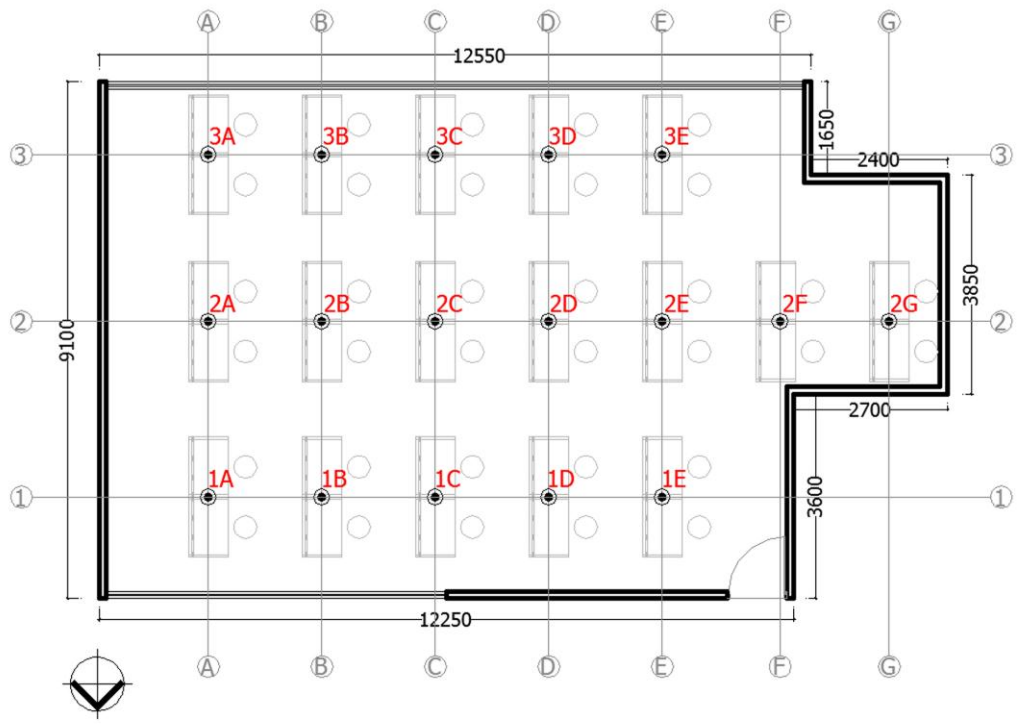
Bangladesh University of Engineering and Technology (SFW3)



Node points	Daylight Levels [Lux]	Air Temperature [^{o}c]	Relative Humidity [%]	Wind Speed [m/s]
1A	47	22.1	29	0.0
1B	79	22.1	29	0.0
1C	135	22.2	29	0.1
1D	114	21.9	29	0.0
1E	109	22.1	29	0.1
1F	104	21.7	29	0.1
1G	40	21.7	29	0.0
1H	113	21.3	29	0.0
1I	134	21.1	29	0.0
2A	48	21.1	29	0.0
2B	44	21.3	29	0.1
2C	45	20.5	29	0.1
2D	67	20.5	29	0.2
2E	**30**	19.8	29	0.2
2F	92	20.5	29	0.0
2G	49	20.5	29	0.0
2H	71	20.8	29	0.1
2I	48	20.4	29	0.0
3A	112	19.8	29	0.0
3B	77	21.5	29	0.0
3C	320	21.8	29	0.2
3D	188	21.5	29	0.0
3E	120	22.1	29	0.0
3F	141	21.7	29	0.0
3G	130	21.8	29	0.1
3H	265	21.5	29	0.1
3I	341	22.2	29	0.1
4A	533	21.5	29	0.1
4B	1414	21.1	29	0.1
4C	1213	20.5	29	0.1
4D	777	20.5	29	0.1
4E	830	20.5	29	0.0
4F	925	20.1	29	0.0
4G	1461	19.1	29	0.0
4H	**2090**	19.2	29	0.1
4I	813	19.3	29	0.1
Average	**364**	**21.0**	**29**	**0.06**

C10: BRAC University (CVW1)

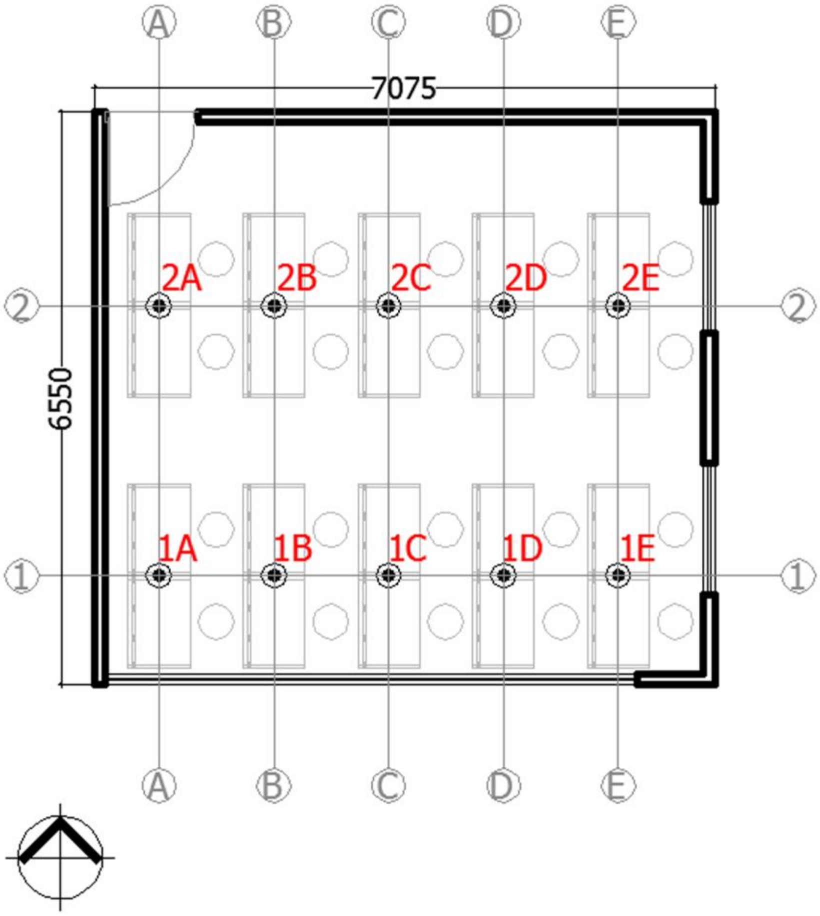
BRAC University (CVW1)



Node points	Daylight Levels [Lux]	Air Temperature [^{o}c]	Relative Humidity [%]	Wind Speed [m/s]
1A	21.5	20.2	35	0.0
1B	18.4	20.2	35	0.0
1C	15.2	20.5	35	0.0
1D	11.5	20.8	35	0.0
1E	**11**	21.1	36	0.0
2A	16.1	20.5	36	0.0
2B	18.3	20.8	36	0.0
2C	20.4	20.1	36	0.0
2D	29.4	19.8	35	0.0
2E	20.5	20.1	35	0.0
2F	36.1	20.5	35	0.0
2G	16.3	20.5	36	0.0
3A	41	20.9	35	0.0
3B	94	21.1	35	0.0
3C	**102**	21.1	35	0.0
3D	40	21.5	35	0.0
3E	80	21.5	35	0.0
Average	**35**	**20.7**	**35**	**0.00**

C11: Primeasia University (CVW2)

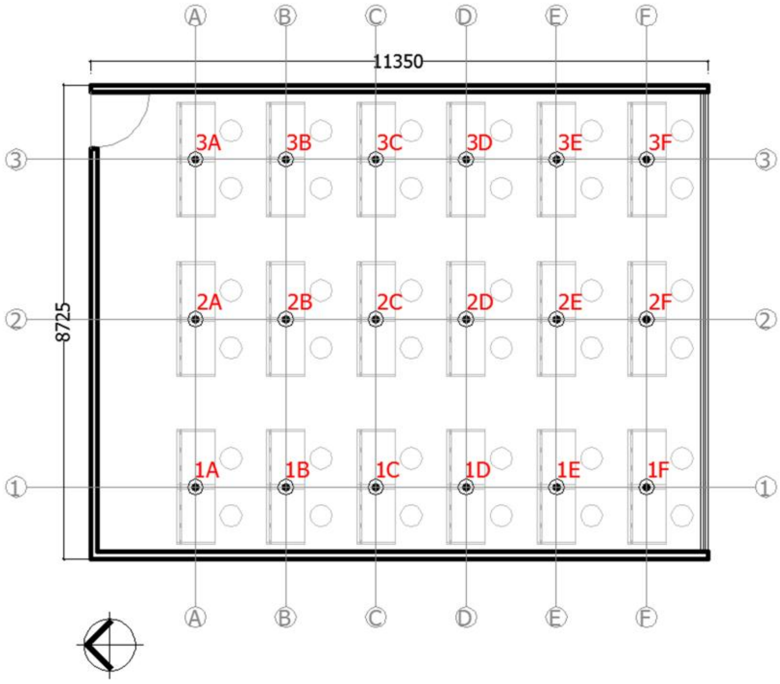
Primeasia University (CVW2)



Node points	Daylight Levels [Lux]	Air Temperature [°c]	Relative Humidity [%]	Wind Speed [m/s]
1A	**5600**	20.1	20	0.1
1B	3560	20.5	20	0.2
1C	3680	20.5	20	0.1
1D	4150	20.9	20	0.1
1E	2560	21.5	20	0.1
2A	436	21.5	21	0.0
2B	**420**	21.1	21	0.1
2C	482	21.3	21	0.0
2D	530	20.5	21	0.1
2E	814	20.8	21	0.0
Average	**2223**	**20.9**	**21**	**0.08**

C12: Northsouth University (CVW3)

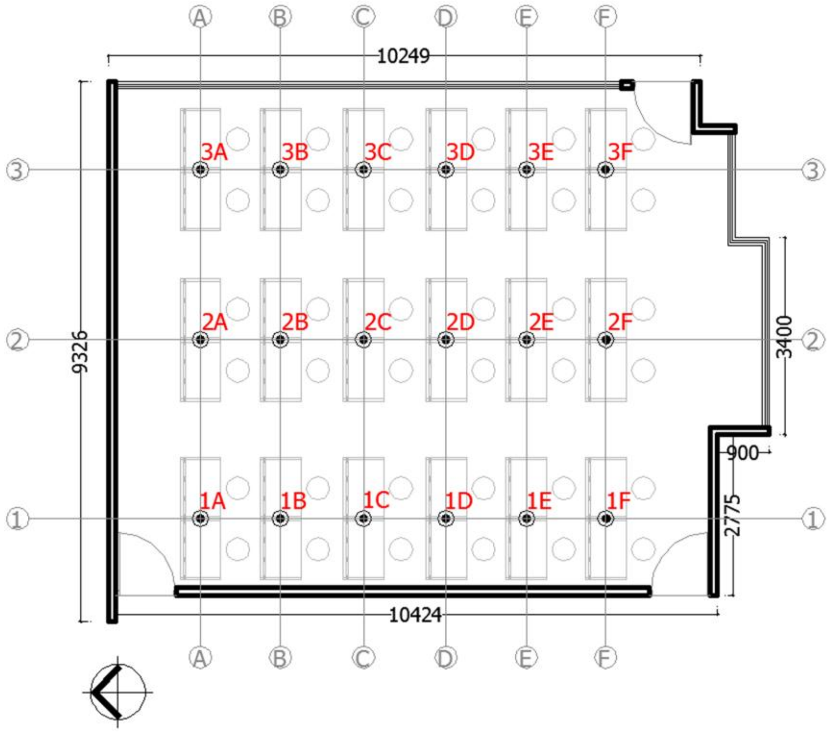
Northsouth University (CVW3)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [^{o}c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	**37**	20.8	30	0.2
1B	64	20.5	30	0.2
1C	158	21.1	30	0.0
1D	255	21.1	30	0.2
1E	743	21.5	30	0.1
1F	1380	21.7	30	0.2
2A	69	21.5	30	0.0
2B	121	20.8	30	0.2
2C	212	20.1	30	0.0
2D	490	20.1	30	0.2
2E	909	20.5	30	0.1
2F	3250	20.6	30	0.2
3A	100	20.6	30	0.0
3B	121	22.1	30	0.2
3C	193	22.8	30	0.1
3D	401	22.5	30	0.0
3E	663	22.1	30	0.1
3F	**5730**	22.1	30	0.3
Average	**828**	**21.3**	**30**	**0.13**

C13: Military Institute of Science and Technology (CFW1)

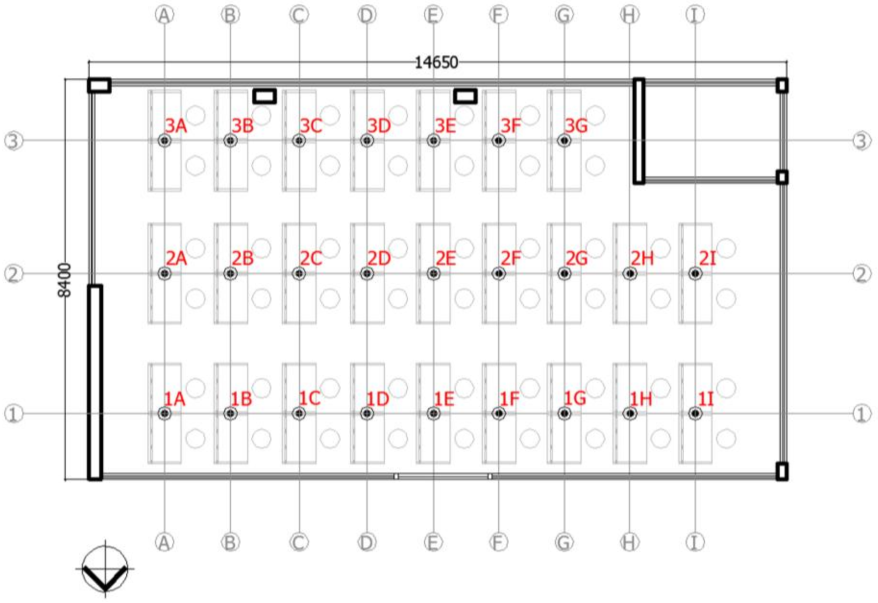
Military Institute of Science and Technology (CFW1)



Node points	Daylight Levels [Lux]	Air Temperature [°c]	Relative Humidity [%]	Wind Speed [m/s]
1A	214	20.5	32	0.1
1B	179	20.5	32	0.0
1C	325	21.1	32	0.0
1D	205	21.5	32	0.0
1E	211	22.2	32	0.0
1F	**155**	22.5	32	0.0
2A	224	23.1	32	0.0
2B	280	22.1	32	0.0
2C	219	22.1	32	0.0
2D	280	22.3	32	0.0
2E	450	21.5	32	0.0
2F	**6250**	21.3	32	0.0
3A	1474	21.5	31	0.2
3B	645	21.9	31	0.0
3C	441	22.5	31	0.0
3D	922	22.9	32	0.0
3E	570	22.1	31	0.0
3F	2202	21.5	32	0.0
Average	**819**	**21.8**	**32**	**0.02**

C14: American International University of Bangladesh (CFW2)

American International University of Bangladesh (CFW2)



Node points	**Daylight Levels** [Lux]	**Air Temperature** [^{o}c]	**Relative Humidity** [%]	**Wind Speed** [m/s]
1A	178	22.5	25	0.0
1B	125	22.1	25	0.0
1C	**119**	22.1	24	0.0
1D	161	22.8	24	0.0
1E	144	21.8	24	0.0
1F	182	21.1	24	0.0
1G	178	21.1	24	0.0
1H	1227	21.5	24	0.0
1I	4510	21.3	23	0.0
2A	405	20.5	22	0.0
2B	676	20.5	22	0.0
2C	398	20.8	22	0.0
2D	222	20.9	22	0.0
2E	470	21.9	22	0.0
2F	296	21.5	22	0.0
2G	259	22.2	22	0.0
2H	733	22.5	22	0.0
2I	1482	22.5	22	0.0
3A	6830	23.1	22	0.0
3B	7960	23.5	22	0.0
3C	**8690**	22.9	22	0.0
3D	4440	23.1	22	0.0
3E	9250	23.1	22	0.0
3F	8190	23.1	22	0.0
3G	8350	23.3	22	0.0
Average	**2619**	**22.1**	**23**	**0.00**

Appendix D: Specification of daylighting and thermal measuring tools

Dr.Meter® DM-LX1330B

– Please Note: It is Dr.Meter® brand, not generic light meter.
– The Digital Light meters are used in the fields of cinematography and scenic design, in order to determine the optimum light level for a scene. They are used in the general field of lighting, where they can help to reduce the amount of waste light used in the home, light pollution outdoors, and plant growing to ensure proper light levels.

Specifications
– Display: 3-1/2 digit 18mm LCD
– Power: 9V battery
– Ranges: 0.1-200/2,000/20,000/200,000 Lux
– Accuracy: ±3% ±10 digits (0-20,000 lux) / ±5% ±10 digits (over 20,000 Lux)
– Repeatability: ±2%
– Temperature Characteristic: ±0.1%C
– Photo detector type: Silicon Photo Diode with Filter
– Operating temperature: 32-104 degrees F (0-40 degrees C)
– Sampling rate: 2-3 times per second
– Battery life: 200 hours (estimate)
– Dimensions: 149 x 71 x 41 mm
– Photo Detector Dimensions: 100 x 60 x 28 mm

Package Content
– 1 x Dr.Meter 1330B Light Meter
– 1 x Carrying case
– 1 x 9V battery
– 1 x User manual

EXTECH INSTRUMENTS

Experience the Extech Advantage

PRODUCT DATASHEET

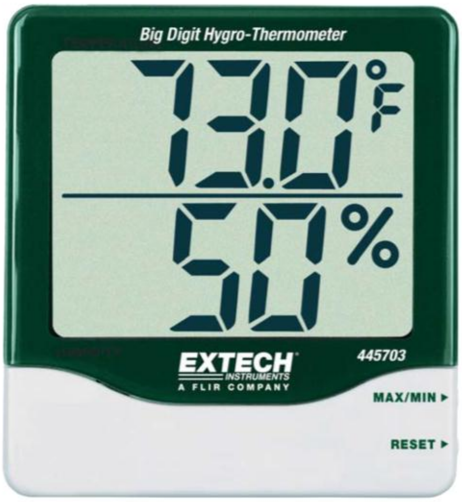
Big Digit Hygro-Thermometer

Large 1" Digits on Dual LCD

Display Humidity and Temperature

Features:

- 1" digits displayed on Large LCD (3.1 x 2.4"/80 x 62mm) provide simultaneous measurements of humidity and temperature
- Memory with reset function stores maximum and minimum measurements
- Measuring range:
  Temperature 14 to 140°F (-10 to 60°C)
  Humidity 10% to 99% RH
- Accurate to 5% RH, 1°C, and 1.8°F (@ 0 to 50°C/32 to 122°F)
- °C/°F switchable temperature measurements
- Low battery indication
- Dimensions: 4.3 x 3.9 x 0.78" (110 x 100 x 20mm)
- Weight 6oz (169g)
- Complete with built-in tilt stand, wall mounting bracket, and 1.5V AAA battery



Applications:

- Use in factories, greenhouses and offices to maintain proper temperature and humidity conditions and to record extremes during the day.

Specifications:	Range
Humidity range	10 to 99%RH
Basic RH accuracy	± 5% (25 to 80%)
Temperature range	14 to 140°F (-10 to 60°C)
Basic Temperature Accuracy	+/-1.8F/1°C (14 to 122°F)
Dimensions	4.3 x 3.9 x 0.78"(109 x 99 x 20mm)
Weight	6oz (169g)

Ordering Information:

445703 ....Big Digit Hygro Thermometer

CE

www.extech.com

Specifications subject to change without notice.

4/11/13 - R1

HandyMAN TEK1313 Thermo-Anemometer

HandyMAN

Specification

Wind Velocity (Meter Per Second)

- Range: 0.0 – 45.0
- Threshold: 0.3
- Resolution: 0.1
- Accuracy: ±3% ±0.1

Wind Velocity (Knots)

- Range: 0.0 – 88.0
- Threshold: 0.6
- Resolution: 0.1
- Accuracy: ±3% ±0.1

Wind Velocity (Km Per Hour)

- Range: 0.0 – 140.0
- Threshold: 1.0
- Resolution: 0.1
- Accuracy: ±3% ±0.1

Range of Temperature °C

- Range: 0 to 60
- Accuracy: ±2°C
- Resolution: 0.1

Range of Temperature°F

- Range: 32 to 140
- Accuracy: ±4°F
- Resolution: 0.1

General

- Bearing: Sapphire jewel bearing
- Temperature Sensor: K-Type thermocouple
- Operating Temperature: 0 ~ 50°C (32 ~ 122°F)
- Operating Humidity: Less than 80% RH
- Battery Type: 9V
- Battery Life: 50 hours (for 300mA-hrs battery)
- Dimension (Meter) : 150 x 72 x 35mm
- Dimension (Vane) : 66 x 132 x 29.2mm
- Weight: 350g (including battery)

Appendix E: Simulation Software

E1: About DAYSIM software

DAYSIM version 2.1

At the most fundamental level DAYSIM offers an efficient way to calculate the annual amount of daylight available in and around buildings. To do so DAYSIM combines a daylight coefficient approach with the Perez all weather sky model and the RADIANCE backward ray-tracer. The resulting time series of illuminance, radiances or irradiances at user defined sensors points can be used for a number of purposes:

- to derive climate-based daylighting metrics
- to calculate annual electric lighting use for different lighting controls based on available daylight

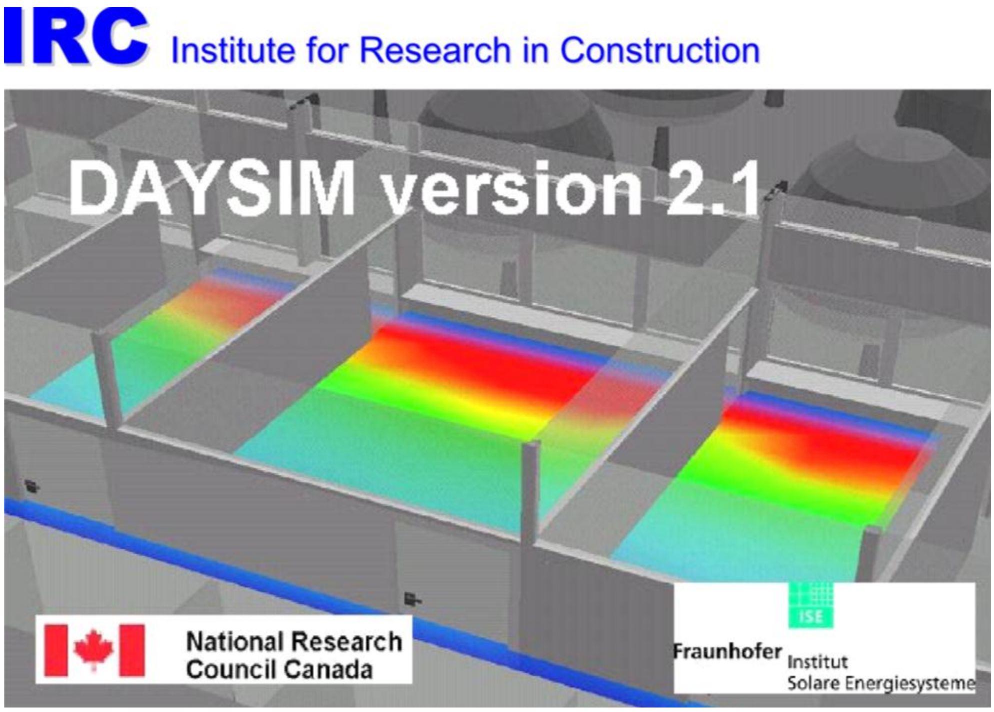


Figure E.1: Interface of DAYSIM simulation software

Climate-based Daylighting Metrics**: Over** the past decade a new family of daylighting metrics to describe and evaluate daylight in spaces has been developed. These metrics summarize the daylight availability over the year and throughout a space. Two prominent daylighting metrics which are calculated by DAYSIM are Daylight Autonomy and Useful Daylight Illuminance. Daylight Autonomy is now being a recommend metrics by the Illuminating Engineering Society of North America (IESNA).

Electric Lighting Use: DAYSIM uses an occupant behaviour model called Lighswitch to model called Light switch to predict based on annual illuminance profiles and occupancy schedules how occupants in a spaces are going to manually operate electric lighting controls and shading systems (see below). The model thus predicts overall electric lighting energy use in a space. DAYSIM also outputs an Internal Gains schedule as can be used by energy simulation programs such as EnergyPlus^{TM} and eQuest to conduct an integrated thermal lighting analysis of a space.

Dynamic Shading: DAYSIM can also model spaces with multiple dynamic shading systems such as venetian blinds, roller shades and electro chromic glazings. In spaces with dynamic shading systems DAYSIM automatically generates multiple annual illuminance profiles each with the shading system(s) in a static position throughout the year. In a post-processing step it then uses the Light witch model to predict in which state the shading systems is going to be.

Glare Analysis: DAYSIM uses the daylight glare probability metric to predict discomfort glare from daylight for different viewpoint in a scene through the year. Similarly, as for the annual illuminance profiles DAYSIM generates annual daylight glare probability profiles for different shading device settings that in a post-process are then used to predict the setting of a dynamic shading system throughout the year.

E2: About EnergyPlus™ software

EnergyPlus™ version 7.2.0

EnergyPlus™ has its roots in both the BLAST and DOE-2 programs. BLAST (Building Loads Analysis and System Thermodynamics) and DOE-2 were both developed and released in the late 1970s and early 1980s as energy and load simulation tools. Their intended audience is a design engineer or architect that wishes to size appropriate HVAC equipment, develop retrofit studies for life cycling cost analyses, optimize energy performance, etc. Born out of concerns driven by the energy crisis of the early 1970s and recognition that building energy consumption is a major component of the American energy usage statistics, the two programs attempted to solve the same problem from two slightly different perspectives. Both programs had their merits and shortcomings, their supporters and detractors, and solid user bases both nationally and internationally.

Like its parent programs, EnergyPlus™ 7.2 is an energy analysis and thermal load simulation program. Based on a user's description of a building from the perspective of the building's physical make-up, associated mechanical systems, etc., EnergyPlus™ will calculate the heating and cooling loads necessary to maintain thermal control set points, conditions throughout a secondary HVAC system and coil loads, and the energy consumption of primary plant equipment as well as many other simulation details that are necessary to verify that the simulation is performing as the actual building would. Many of the simulation characteristics have been inherited from the legacy programs of BLAST and DOE-2. Below is list of some of the features of the first release of EnergyPlus™. While this list is not exhaustive, it is intended to give the reader and idea of the rigor and applicability of EnergyPlus™ to various simulation situations.

- **Integrated, simultaneous solution** where the building response and the primary and secondary systems are tightly coupled (iteration performed when necessary).

- **Sub-hourly, user-definable time steps** for the interaction between the thermal zones and the environment; variable time steps for interactions between the thermal zones and the HVAC systems (automatically varied to ensure solution stability).
- **ASCII text based weather, input, and output files** that include hourly or sub-hourly environmental conditions, and standard and user definable reports, respectively.
- **Heat balance based solution** technique for building thermal loads that allows for simultaneous calculation of radiant and convective effects at both in the interior and exterior surface during each time step.
- **Transient heat conduction** through building elements such as walls, roofs, floors, etc. using conduction transfer functions.
- **Improved ground heat transfer modeling** through links to three-dimensional finite difference ground models and simplified analytical techniques.
- **Combined heat and mass transfer** model that accounts for moisture adsorption/desorption either as a layer-by-layer integration into the conduction transfer functions or as an effective moisture penetration depth model (EMPD).
- **Thermal comfort models** based on activity, inside dry bulb, humidity, etc.
- **Anisotropic sky model** for improved calculation of diffuse solar on tilted surfaces.
- **Advanced fenestration calculations** including controllable window blinds, electrochromic glazing, layer-by-layer heat balances that allow proper assignment of solar energy absorbed by window panes, and a performance library for numerous commercially available windows.
- **Loop based configurable HVAC systems** (conventional and radiant) that allow users to model typical systems and slightly modified systems without recompiling the program source code.

Atmospheric pollution calculations that predict CO_2, SO_x, NO_x, CO, particulate matter, and hydrocarbon production for both on site and remote energy conversion.

Appendix F: Detail DAYSIM simulation results

F1: Detail DAYSIM result of SVW1

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	2.2	88	94	2	3	89	8	92	3992541
1B	0.750	11.1	98	99	61	1	22	77	0	20570356
1C	0.750	14.7	98	99	77	1	12	87	0	28303636
1D	0.750	13.3	98	99	70	1	14	85	0	26345482
1E	**0.750**	8.8	97	99	52	1	23	76	0	15720938
1F	0.750	15.1	98	99	77	1	12	87	0	27620580
1G	0.750	14.3	98	99	71	1	14	85	0	26600968
1H	0.750	3.6	94	97	6	2	73	25	89	6186317
1I	0.750	4.4	94	97	17	2	61	37	66	8524853
1J	0.750	14.4	98	99	74	1	13	86	0	27453004
1K	0.750	14.7	98	99	76	1	12	87	0	27482936
1L	0.750	7.3	97	98	47	1	29	69	34	13364039
1M	0.750	13.8	98	99	71	1	14	85	0	25710314
1N	0.750	14.7	98	99	76	1	12	87	0	27612948
1O	0.750	9.6	98	99	51	1	29	69	0	16773054
1P	0.750	1.9	87	94	0	4	95	1	93	3278681
2A	0.750	2.8	91	96	2	2	81	16	94	4874679
2B	0.750	4.5	94	97	13	2	61	37	91	6923886
2C	0.750	5.8	96	98	25	1	43	56	63	8722695
2D	0.750	5.4	96	98	21	1	47	52	81	8218797
2E	**0.750**	5.3	96	98	22	1	47	52	83	8224868
2F	0.750	5.8	96	98	28	1	43	55	40	9898704
2G	0.750	5.3	96	98	19	2	52	46	76	7889511
2H	0.750	3.6	95	97	3	2	72	26	97	5987202
2I	0.750	3.9	95	97	8	2	69	30	97	6276150
2J	0.750	5.4	96	98	22	1	49	50	59	8553105
2K	0.750	5.9	96	98	27	1	43	56	53	9226806
2L	0.750	5.0	96	98	20	1	49	50	92	7938242
2M	0.750	5.5	96	98	23	1	46	53	71	8473764
2N	0.750	5.6	96	98	21	2	50	48	69	8199508
2O	0.750	4.3	95	97	11	2	66	33	95	6631400
2P	0.750	2.7	92	96	1	3	87	11	96	4573866
3A	0.750	2.5	90	95	0	3	88	9	96	4208886
3B	0.750	2.8	91	96	0	2	86	11	96	4531458
3C	0.750	3.2	92	96	0	2	82	16	97	5063587
3D	0.750	3.3	93	97	1	2	78	20	97	5307697
3E	**0.750**	3.3	93	97	0	2	80	18	97	5218571
3F	0.750	3.4	94	97	1	2	79	19	97	5380483
3G	0.750	3.2	93	97	0	2	82	16	97	5011438
3H	0.750	3.0	93	97	1	2	81	17	96	5004655
3I	0.750	2.9	93	96	0	2	84	14	96	4805483
3J	0.750	3.2	93	97	0	2	82	16	97	5007165
3K	0.750	3.4	94	97	1	2	78	20	97	5397861
3L	0.750	3.2	93	97	0	2	81	17	97	5067125
3M	0.750	3.2	94	97	0	2	80	18	97	5185379
3N	0.750	3.2	94	97	0	2	81	17	97	5038176
3O	0.750	2.7	92	96	0	3	88	10	96	4348856
3P	0.750	2.3	90	95	0	3	94	3	95	3817102
4A	0.750	2.2	88	95	0	3	94	3	95	3656754
4B	0.750	2.3	89	95	0	3	93	4	95	3650899
4C	0.750	2.4	89	95	0	3	94	4	95	3757226
4D	0.750	2.4	89	95	0	3	93	4	96	3802496
4E	**0.750**	2.4	90	95	0	3	93	4	96	3884101
4F	0.750	2.5	90	95	0	3	92	5	96	3975220
4G	0.750	2.4	89	95	0	3	94	3	95	3844889
4H	0.750	2.4	90	95	0	3	94	3	95	3857477
4I	0.750	2.3	89	95	0	3	95	2	95	3720041
4J	0.750	2.5	90	96	0	3	93	5	96	3971532
4K	0.750	2.4	90	95	0	3	93	4	95	3870244
4L	0.750	2.5	91	96	0	3	93	4	96	3969173
4M	0.750	2.3	89	95	0	3	94	3	95	3743977
4N	0.750	2.3	89	95	0	3	95	2	95	3645370
4O	0.750	2.1	87	94	0	4	96	0	94	3307183
4P	0.750	2.1	89	95	0	3	96	0	94	3434463
5A	0.750	1.8	86	93	0	4	96	0	93	2928645
5B	0.750	1.9	86	93	0	4	96	0	94	3019231
5C	0.750	1.9	87	94	0	4	96	0	94	3158176
5D	0.750	2.0	87	94	0	4	96	0	94	3228637
5E	**0.750**	2.0	88	94	0	3	96	0	94	3255687
5F	0.750	2.0	88	94	0	4	96	0	94	3227392
5G	0.750	2.0	87	94	0	4	96	0	94	3207469
5H	0.750	2.0	87	94	0	4	96	0	94	3178337
5I	0.750	2.0	88	94	0	4	96	0	94	3219953
5J	0.750	2.0	88	94	0	4	96	0	94	3205402
5K	0.750	1.9	87	94	0	4	96	0	94	3131065
5L	0.750	2.0	87	94	0	4	96	0	94	3209262
5M	0.750	1.9	86	94	0	4	96	0	94	3068721
5N	0.750	1.8	85	93	0	4	96	0	93	2905376

Table F1: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	1.8	86	94	0	4	96	0	93	2961355
5P	0.750	1.8	86	94	0	4	96	0	93	2891116
6A	0.750	1.6	84	92	0	4	96	0	92	2608826
6B	0.750	1.6	83	92	0	5	95	0	92	2536584
6C	0.750	1.7	85	93	0	4	96	0	93	2702043
6D	0.750	1.8	86	93	0	4	96	0	93	2814235
6E	**0.750**	1.7	85	93	0	4	96	0	93	2772050
6F	0.750	1.7	85	93	0	4	96	0	93	2744722
6G	0.750	1.7	86	93	0	4	96	0	93	2830041
6H	0.750	1.7	85	93	0	4	96	0	93	2742570
6I	0.750	1.7	85	93	0	4	96	0	93	2736503
6J	0.750	1.7	85	93	0	4	96	0	93	2767486
6K	0.750	1.7	84	93	0	4	96	0	93	2679660
6L	0.750	1.6	83	92	0	4	96	0	92	2589942
6M	0.750	1.6	83	92	0	4	96	0	92	2573894
6N	0.750	1.6	83	92	0	4	96	0	92	2546437
6O	0.750	1.5	83	92	0	4	96	0	92	2486951
6P	0.750	1.5	83	93	0	4	96	0	92	2527643
7A	0.750	1.5	83	92	0	5	95	0	92	2450779
7B	0.750	1.5	83	92	0	5	95	0	92	2445291
7C	0.750	1.4	80	91	0	5	95	0	91	2296588
7D	0.750	1.6	82	92	0	5	95	0	92	2463396
7E	**0.750**	1.5	83	92	0	5	95	0	92	2482205
7F	0.750	1.6	84	93	0	4	96	0	92	2578777
7G	0.750	1.5	83	92	0	5	95	0	92	2476572
7H	0.750	1.5	82	92	0	5	95	0	92	2386646
7I	0.750	1.6	84	92	0	4	96	0	92	2565188
7J	0.750	1.6	83	92	0	4	96	0	92	2520851
7K	0.750	1.4	80	91	0	5	95	0	90	2288048
7L	0.750	1.4	81	91	0	5	95	0	90	2317157
7M	0.750	1.5	82	92	0	5	95	0	91	2430410
7N	0.750	1.3	78	91	0	5	95	0	88	2159391
7O	0.750	1.3	77	90	0	5	95	0	87	2091267
7P	0.750	1.3	81	91	0	5	95	0	89	2221535
8A	0.750	1.5	83	92	0	5	95	0	92	2343824
8B	0.750	1.5	80	91	0	6	94	0	91	2221293
8C	0.750	1.6	82	92	0	5	95	0	92	2364027
8D	0.750	1.3	78	90	0	6	94	0	89	2108227
8E	**0.750**	1.4	79	91	0	6	94	0	90	2181208
8F	0.750	1.3	79	90	0	6	94	0	89	2135415
8G	0.750	1.4	80	91	0	5	95	0	90	2233165
8H	0.750	1.3	77	90	0	6	94	0	89	2131755
8I	0.750	1.5	83	92	0	5	95	0	92	2425866
8J	0.750	1.4	80	91	0	5	95	0	90	2251480
8K	0.750	1.3	77	90	0	5	95	0	89	2089850
8L	0.750	1.3	75	90	0	5	95	0	87	2038883
8M	0.750	1.3	77	90	0	5	95	0	88	2073199
8N	0.750	1.2	72	89	0	6	94	0	85	1919742
8O	0.750	1.2	75	90	0	5	95	0	86	1988876
8P	0.750	1.2	77	90	0	5	95	0	86	1983165
9A	0.750	1.4	81	91	0	5	95	0	91	2219973
9B	0.750	1.6	82	92	0	5	95	0	92	2296525
9C	0.750	1.3	75	90	0	6	94	0	88	2015390
9D	0.750	1.4	79	91	0	6	94	0	90	2133727
9E	**0.750**	1.3	79	91	0	6	94	0	90	2139365
9F	0.750	1.4	81	91	0	5	95	0	91	2269286
9G	0.750	1.4	81	91	0	5	95	0	91	2264384
9H	0.750	1.3	77	90	0	6	94	0	89	2102185
9I	0.750	1.4	81	92	0	5	95	0	91	2294928
9J	0.750	1.4	80	91	0	5	95	0	90	2203274
9K	0.750	1.3	79	91	0	5	95	0	89	2128700
9L	0.750	1.2	74	89	0	6	94	0	87	1973982
9M	0.750	1.2	73	89	0	6	94	0	86	1913670
9N	0.750	1.2	72	89	0	6	94	0	85	1880197
9O	0.750	1.1	71	89	0	6	94	0	85	1843669
9P	0.750	1.1	72	89	0	6	94	0	84	1830968
10A	0.750	1.3	79	91	0	6	94	0	90	2088268
10B	0.750	1.4	80	91	0	6	94	0	90	2156263
10C	0.750	1.3	79	91	0	5	95	0	90	2149677
10D	0.750	1.3	80	91	0	5	95	0	90	2160733
10E	**0.750**	1.4	81	91	0	5	95	0	91	2215150
10F	0.750	1.4	82	92	0	5	95	0	91	2299028
10G	0.750	1.4	82	92	0	5	95	0	91	2273018
10H	0.750	1.4	83	92	0	5	95	0	92	2363650
10I	0.750	1.4	81	92	0	5	95	0	91	2264931
10J	0.750	1.3	80	91	0	5	95	0	90	2197789
10K	0.750	1.4	82	92	0	5	95	0	91	2282928
10L	0.750	1.3	80	91	0	5	95	0	89	2155668
10M	0.750	1.3	79	91	0	5	95	0	89	2089907
10N	0.750	1.2	75	90	0	5	95	0	86	1932724

F2: Detail DAYSIM result of SVW2

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	2.8	91	95	3	2	80	18	92	4946528
1B	0.750	13.4	98	99	69	1	18	81	0	27917124
1C	0.750	18.1	98	99	82	1	10	89	0	38422464
1D	0.750	15.7	98	99	75	1	12	87	0	33266810
1E	**0.750**	11.1	98	99	66	1	17	82	0	22340368
1F	0.750	18.1	98	99	82	1	10	89	0	37993240
1G	0.750	17.0	98	99	77	1	12	87	0	35203456
1H	0.750	4.7	95	98	17	2	55	43	74	9063405
1I	0.750	5.7	96	98	27	1	46	52	47	12046256
1J	0.750	17.6	98	99	79	1	10	89	0	37012564
1K	0.750	18.0	99	99	81	1	10	89	0	38123884
1L	0.750	9.8	98	99	62	1	19	80	0	19796858
1M	0.750	16.4	98	99	76	1	11	88	0	34667940
1N	0.750	18.1	99	99	82	1	10	89	0	38025756
1O	0.750	11.8	98	99	59	1	22	77	0	23496020
1P	0.750	2.4	90	96	0	3	87	10	95	4252957
2A	0.750	3.7	93	97	15	2	69	29	79	7012576
2B	0.750	5.7	96	98	24	2	48	51	49	9166222
2C	0.750	7.7	97	98	43	1	33	66	12	11330385
2D	0.750	7.0	97	98	40	1	34	65	16	11419819
2E	**0.750**	6.8	97	98	38	1	34	64	17	11229355
2F	0.750	7.4	97	98	42	1	34	65	10	12214855
2G	0.750	6.9	97	98	35	1	36	62	34	10536562
2H	0.750	4.8	96	98	23	1	51	48	72	8584586
2I	0.750	5.1	96	98	25	1	47	51	61	8993150
2J	0.750	7.0	97	98	38	1	36	62	23	10855599
2K	0.750	7.5	97	98	43	1	32	66	13	11529663
2L	0.750	6.7	97	98	39	1	34	65	21	11160467
2M	0.750	7.4	97	98	43	1	33	66	8	11876199
2N	0.750	7.3	97	98	38	1	35	63	19	11602458
2O	0.750	5.6	96	98	22	2	50	48	58	8733147
2P	0.750	3.4	94	97	8	2	74	24	89	6147162
3A	0.750	3.0	92	96	3	2	80	18	97	5164880
3B1	0.750	3.6	93	97	8	2	73	25	96	5860808
3C	0.750	4.0	94	97	10	2	67	31	97	6353423
3D	0.750	4.2	95	97	13	2	61	38	97	6855972
3E	**0.750**	4.1	95	97	10	2	64	34	98	6596851
3F	0.750	4.4	95	98	15	2	59	40	94	7153917
3G	0.750	4.0	95	97	10	2	66	32	98	6454601
3H	0.750	3.7	95	97	6	2	69	29	97	6100372
3I	0.750	3.7	95	97	6	2	70	29	98	6176560
3J	0.750	3.9	95	97	10	2	67	31	97	6436396
3K	0.750	4.4	95	98	15	2	58	40	94	7182371
3L	0.750	4.4	95	98	14	2	60	38	96	6957590
3M	0.750	4.2	95	97	12	2	65	34	97	6696143
3N	0.750	4.1	95	97	10	2	68	30	98	6423489
3O	0.750	3.4	94	97	4	2	76	22	97	5551252
3P	0.750	3.1	93	97	1	2	80	18	97	5106569
4A	0.750	2.6	91	96	0	3	86	11	96	4464571
4B	0.750	2.8	91	96	0	3	85	12	96	4582946
4C	0.750	2.9	91	96	0	2	85	13	96	4635299
4D	0.750	3.2	92	96	1	2	80	18	97	5171373
4E	**0.750**	3.1	92	96	1	2	81	17	97	4978071
4F	0.750	3.1	93	96	1	2	81	17	97	5030958
4G	0.750	3.0	93	96	0	2	81	17	97	4963722
4H	0.750	3.0	92	96	0	2	81	17	97	4971991
4I	0.750	3.1	93	97	0	2	80	18	97	5050725
4J	0.750	3.0	92	96	0	2	82	16	96	4858063
4K	0.750	3.0	93	96	0	2	81	16	97	4898121
4L	0.750	3.1	93	97	0	2	80	18	97	5001964
4M	0.750	3.1	93	97	0	2	80	17	97	4984392
4N	0.750	2.8	92	96	0	3	85	12	96	4476158
4O	0.750	2.6	91	96	0	3	87	10	96	4273048
4P	0.750	2.5	91	96	0	3	88	9	96	4237572
5A	0.750	2.2	88	95	0	3	93	4	95	3699807
5B	0.750	2.3	89	95	0	3	92	5	95	3764875
5C	0.750	2.4	89	95	0	3	91	6	95	3898088
5D	0.750	2.4	89	95	0	3	92	6	95	3890043
5E	**0.750**	2.5	90	95	0	3	90	8	96	4130076
5F	0.750	2.5	90	95	0	3	90	8	96	4091205
5G	0.750	2.5	90	95	0	3	90	7	96	4112230
5H	0.750	2.5	90	95	0	3	90	7	96	4096837
5I	0.750	2.5	90	96	0	3	89	8	96	4141586
5J	0.750	2.5	90	96	0	3	89	8	96	4150760
5K	0.750	2.5	90	96	0	3	90	7	96	4075407
5L	0.750	2.5	90	95	0	3	90	7	96	4006623
5M	0.750	2.3	89	95	0	3	92	5	95	3790253
5N	0.750	2.4	89	95	0	3	91	6	95	3866763

Table F2: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	2.1	88	95	0	3	95	2	94	3550443
5P	0.750	2.1	89	95	0	3	95	2	94	3589618
6A	0.750	2.0	88	94	0	3	96	1	95	3364108
6B	0.750	2.1	88	94	0	3	95	2	95	3451293
6C	0.750	2.1	88	94	0	3	95	2	95	3410079
6D	0.750	2.2	88	94	0	3	95	2	95	3488031
6E	**0.750**	2.2	88	95	0	3	94	3	95	3615891
6F	0.750	2.2	89	95	0	3	94	3	95	3624119
6G	0.750	2.2	88	95	0	3	94	2	95	3595091
6H	0.750	2.1	88	95	0	3	95	2	95	3513742
6I	0.750	2.2	89	95	0	3	94	3	95	3607208
6J	0.750	2.1	88	95	0	3	95	2	95	3482297
6K	0.750	2.1	88	95	0	3	95	2	95	3534334
6L	0.750	2.1	88	95	0	3	95	2	95	3523787
6M	0.750	2.0	88	95	0	4	96	0	94	3379756
6N	0.750	2.0	87	94	0	4	96	0	94	3279679
6O	0.750	1.9	87	94	0	4	96	0	94	3215722
6P	0.750	1.9	88	95	0	4	96	0	94	3222699
7A	0.750	1.9	86	94	0	4	96	0	94	3072646
7B	0.750	1.8	86	93	0	4	96	0	93	2965625
7C	0.750	1.8	86	93	0	4	96	0	93	2887771
7D	0.750	1.9	86	93	0	4	96	0	93	3024743
7E	**0.750**	1.9	87	94	0	4	96	0	94	3172328
7F	0.750	1.8	86	93	0	4	96	0	93	3029869
7G	0.750	1.9	86	94	0	4	96	0	93	3057034
7H	0.750	2.0	88	94	0	4	96	0	94	3287034
7I	0.750	1.9	87	94	0	4	96	0	94	3182798
7J	0.750	1.9	87	94	0	4	96	0	94	3248563
7K	0.750	1.8	86	94	0	4	96	0	93	3033789
7L	0.750	1.9	87	94	0	4	96	0	94	3143451
7M	0.750	1.8	86	94	0	4	96	0	93	2962436
7N	0.750	1.7	85	93	0	4	96	0	93	2864187
7O	0.750	1.7	85	93	0	4	96	0	93	2818131
7P	0.750	1.7	85	94	0	4	96	0	93	2860800
8A	0.750	1.8	86	93	0	4	96	0	93	2870232
8B	0.750	1.8	86	93	0	4	96	0	93	2833722
8C	0.750	1.8	86	93	0	4	96	0	93	2877004
8D	0.750	1.7	85	93	0	4	96	0	93	2831451
8E	**0.750**	1.7	84	93	0	4	96	0	93	2741688
8F	0.750	1.7	85	93	0	4	96	0	93	2794626
8G	0.750	1.7	85	93	0	4	96	0	93	2815723
8H	0.750	1.6	84	92	0	4	96	0	92	2659979
8I	0.750	1.8	86	94	0	4	96	0	93	2974924
8J	0.750	1.7	85	93	0	4	96	0	93	2795543
8K	0.750	1.7	85	93	0	4	96	0	93	2764706
8L	0.750	1.6	83	92	0	4	96	0	92	2579852
8M	0.750	1.6	83	92	0	4	96	0	92	2590356
8N	0.750	1.5	82	92	0	5	95	0	91	2471992
8O	0.750	1.5	83	92	0	4	96	0	92	2562853
8P	0.750	1.5	83	92	0	5	95	0	91	2473363
9A	0.750	1.8	86	93	0	4	96	0	93	2799750
9B	0.750	1.7	85	93	0	4	96	0	93	2734395
9C	0.750	1.7	84	93	0	4	96	0	93	2669095
9D	0.750	1.6	85	93	0	4	96	0	92	2681333
9E	**0.750**	1.6	85	93	0	4	96	0	92	2668938
9F	0.750	1.6	84	92	0	4	95	0	92	2668802
9G	0.750	1.7	85	93	0	4	96	0	93	2762677
9H	0.750	1.6	84	93	0	4	96	0	93	2673660
9I	0.750	1.6	84	93	0	4	96	0	92	2642762
9J	0.750	1.6	83	92	0	4	96	0	92	2581650
9K	0.750	1.6	83	92	0	4	96	0	92	2608163
9L	0.750	1.6	83	92	0	4	96	0	92	2577899
9M	0.750	1.5	83	92	0	4	96	0	92	2563094
9N	0.750	1.4	81	92	0	5	95	0	91	2374780
9O	0.750	1.4	81	92	0	5	95	0	91	2359663
9P	0.750	1.4	81	92	0	5	95	0	90	2317656
10A	0.750	1.6	85	93	0	4	96	0	92	2662281
10B	0.750	1.7	85	93	0	4	96	0	93	2678057
10C	0.750	1.7	85	93	0	4	96	0	93	2757291
10D	0.750	1.6	85	93	0	4	96	0	93	2703932
10E	**0.750**	1.7	86	93	0	4	96	0	93	2807662
10F	0.750	1.7	85	93	0	4	96	0	93	2777200
10G	0.750	1.7	85	93	0	4	96	0	93	2755250
10H	0.750	1.7	86	93	0	4	96	0	93	2880855
10I	0.750	1.7	86	93	0	4	96	0	93	2860070
10J	0.750	1.7	86	93	0	4	96	0	93	2842360
10K	0.750	1.7	86	93	0	4	96	0	93	2822013
10L	0.750	1.6	85	93	0	4	96	0	93	2744588

F3: Detail DAYSIM result of SVW3

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.7	93	97	16	2	64	34	79	7085231
1B	0.750	16.5	98	99	74	1	14	85	0	34650860
1C	0.750	22.3	99	99	85	1	8	91	0	47351648
1D	0.750	19.4	98	99	82	1	10	89	0	40773016
1E	**0.750**	14.3	99	99	77	1	13	86	0	29202400
1F	0.750	22.2	99	99	85	1	8	91	0	46666956
1G	0.750	20.9	99	99	82	1	10	89	0	43233916
1H	0.750	6.2	96	98	35	1	40	59	46	12246104
1I	0.750	7.5	97	98	43	1	30	69	5	16821388
1J	0.750	20.9	98	99	84	1	9	90	0	44712024
1K	0.750	22.0	99	99	85	1	8	91	0	46384336
1L	0.750	12.6	98	99	72	1	14	85	0	26208668
1M	0.750	20.3	99	99	83	1	9	90	0	43397128
1N	0.750	21.9	99	99	85	1	8	91	0	46391024
1O	0.750	14.6	98	99	66	1	17	82	0	29618700
1P	0.750	3.2	93	97	8	2	72	26	92	5992818
2A	0.750	4.6	94	98	22	2	54	44	56	9586578
2B	0.750	7.5	97	98	40	1	34	65	12	15229078
2C	0.750	9.6	98	99	56	1	25	74	0	19166928
2D	0.750	9.1	98	99	55	1	25	74	0	17598368
2E	**0.750**	8.9	98	99	55	1	24	75	0	17224312
2F	0.750	9.8	98	99	57	1	23	75	0	19933268
2G	0.750	8.9	97	98	50	1	29	70	0	17684276
2H	0.750	6.2	96	98	35	1	37	62	28	12492142
2I	0.750	6.7	97	98	40	1	34	65	17	13646398
2J	0.750	9.1	98	99	53	1	26	73	0	18304518
2K	0.750	9.8	98	99	58	1	22	77	0	18999068
2L	0.750	8.9	98	99	55	1	24	75	0	17003272
2M	0.750	9.5	98	99	58	1	22	77	0	18412592
2N	0.750	9.7	98	99	52	1	26	73	0	19120680
2O	0.750	7.0	97	98	34	1	40	58	34	13916611
2P	0.750	4.4	95	97	18	2	58	40	74	8623374
3A	0.750	4.0	94	97	14	2	64	35	86	6804586
3B1	0.750	4.7	95	98	19	2	56	42	70	7625025
3C	0.750	5.4	96	98	24	2	49	50	56	8503719
3D	0.750	5.6	96	98	27	1	44	55	47	8974603
3E	**0.750**	5.7	96	98	26	1	44	55	50	8972567
3F	0.750	5.5	96	98	26	1	45	53	56	8846719
3G	0.750	5.3	96	98	26	1	46	53	58	8665156
3H	0.750	4.9	96	98	23	1	51	48	77	8053481
3I	0.750	4.8	96	98	20	2	53	46	79	7866353
3J	0.750	5.5	96	98	25	1	46	52	58	8770275
3K	0.750	5.7	96	98	28	1	44	55	50	9118489
3L	0.750	5.3	96	98	24	2	50	49	61	8382859
3M	0.750	5.6	96	98	25	1	48	51	54	8785997
3N	0.750	5.3	96	98	23	2	52	47	62	8301697
3O	0.750	4.3	95	97	15	2	63	35	86	6990161
3P	0.750	3.7	94	97	10	2	70	28	96	6281172
4A	0.750	3.3	92	96	6	2	76	22	97	5579055
4B	0.750	3.5	93	97	8	2	73	25	97	5834411
4C	0.750	3.7	94	97	9	2	71	27	97	6097326
4D	0.750	3.8	94	97	10	2	69	29	97	6286259
4E	**0.750**	4.0	95	97	12	2	65	33	95	6606957
4F	0.750	3.9	94	97	11	2	68	30	96	6373427
4G	0.750	3.8	95	97	10	2	69	29	97	6296334
4H	0.750	3.7	94	97	9	2	69	29	97	6198578
4I	0.750	3.6	94	97	8	2	71	27	97	6061524
4J	0.750	3.9	95	97	11	2	67	31	96	6531936
4K	0.750	4.1	95	97	13	2	65	34	94	6708201
4L	0.750	4.2	95	97	14	2	63	35	93	6849862
4M	0.750	3.9	95	97	11	2	68	30	97	6386359
4N	0.750	3.7	94	97	8	2	72	26	97	5978608
4O	0.750	3.3	94	97	4	2	76	22	97	5408466
4P	0.750	3.2	94	97	3	2	76	22	97	5428196
5A	0.750	2.8	91	96	1	3	83	15	96	4747155
5B	0.750	2.9	91	96	2	2	82	16	96	4872352
5C	0.750	3.0	91	96	2	2	81	17	96	4935331
5D	0.750	3.1	92	96	3	2	80	18	97	5107721
5E	**0.750**	3.2	92	97	3	2	78	20	97	5311511
5F	0.750	3.1	92	96	3	2	78	19	97	5217857
5G	0.750	3.1	92	96	2	2	78	20	97	5157349
5H	0.750	3.3	93	97	3	2	76	22	97	5451065
5I	0.750	3.1	93	96	2	2	78	20	97	5150039
5J	0.750	3.1	92	96	2	2	79	19	97	5107061
5K	0.750	3.1	93	97	2	2	78	20	97	5195087
5L	0.750	3.2	93	97	3	2	77	21	97	5328855
5M	0.750	3.0	92	96	1	2	80	18	97	4889934
5N	0.750	2.9	92	96	1	2	81	17	96	4868038

Table F3: *Continued*

TEST POINTS	**H**	**DF [%]**	**DA [%]**	**DA_{con} [%]**	**DA_{max} [%]**	**$UDI_{<100}$ [%]**	**$UDI_{100-2000}$ [%]**	**$UDI_{>2000}$ [%]**	**DSP [%]**	**annual light exposure [lux]**
5O	0.750	2.8	92	96	0	3	83	15	96	4614728
5P	0.750	2.8	92	96	0	2	82	15	96	4662561
6A	0.750	2.4	90	95	0	3	89	8	96	4125504
6B	0.750	2.5	90	95	0	3	88	9	96	4179538
6C	0.750	2.6	90	95	0	3	86	11	96	4344910
6D	0.750	2.7	91	96	0	3	84	13	96	4528083
6E	**0.750**	2.6	90	96	0	3	85	12	96	4387135
6F	0.750	2.7	91	96	0	3	84	14	96	4576723
6G	0.750	2.6	90	96	0	3	85	12	96	4395155
6H	0.750	2.6	90	96	0	3	85	12	96	4364292
6I	0.750	2.7	91	96	0	3	84	13	96	4436896
6J	0.750	2.7	91	96	0	2	83	14	96	4594023
6K	0.750	2.5	90	96	0	3	86	11	96	4249207
6L	0.750	2.5	90	96	0	3	87	11	96	4236934
6M	0.750	2.5	90	96	0	3	87	10	96	4170602
6N	0.750	2.5	91	96	0	3	87	11	96	4247310
6O	0.750	2.4	90	95	0	3	89	8	95	3969122
6P	0.750	2.3	91	96	0	3	91	6	95	3945589
7A	0.750	2.2	89	95	0	3	93	4	95	3696326
7B	0.750	2.2	88	95	0	3	93	4	95	3685385
7C	0.750	2.2	88	94	0	3	92	4	95	3645427
7D	0.750	2.4	89	95	0	3	91	6	95	3922196
7E	**0.750**	2.3	89	95	0	3	91	7	95	3929575
7F	0.750	2.4	89	95	0	3	90	7	96	3961014
7G	0.750	2.4	89	95	0	3	90	7	96	3960495
7H	0.750	2.4	89	95	0	3	90	7	96	4022700
7I	0.750	2.4	90	95	0	3	90	7	96	4035678
7J	0.750	2.2	89	95	0	3	92	5	95	3765976
7K	0.750	2.3	89	95	0	3	91	6	95	3881928
7L	0.750	2.2	89	95	0	3	92	5	95	3734178
7M	0.750	2.2	88	95	0	3	93	4	95	3638215
7N	0.750	2.2	89	95	0	3	93	4	95	3674352
7O	0.750	2.1	88	95	0	3	95	2	94	3542244
7P	0.750	2.0	89	95	0	3	96	1	94	3489495
8A	0.750	2.1	88	94	0	3	96	1	95	3396083
8B	0.750	2.1	87	94	0	3	95	1	94	3363979
8C	0.750	2.2	88	94	0	3	94	3	95	3587381
8D	0.750	2.0	88	94	0	3	95	2	94	3363875
8E	**0.750**	2.1	88	94	0	3	94	3	95	3583817
8F	0.750	2.2	89	95	0	3	93	4	95	3691113
8G	0.750	2.1	88	94	0	3	94	2	94	3489897
8H	0.750	2.2	89	95	0	3	93	4	95	3718828
8I	0.750	2.0	88	94	0	3	94	2	94	3441552
8J	0.750	2.1	88	95	0	3	94	3	95	3597398
8K	0.750	2.1	88	95	0	3	94	3	95	3563368
8L	0.750	2.0	88	94	0	3	95	1	94	3402533
8M	0.750	2.0	87	94	0	4	96	1	94	3314280
8N	0.750	2.0	87	94	0	4	96	0	94	3324538
8O	0.750	1.9	87	94	0	4	96	0	94	3180930
8P	0.750	1.8	87	94	0	4	96	0	94	3149199
9A	0.750	1.9	87	94	0	4	96	0	94	3234078
9B	0.750	2.2	88	94	0	3	96	0	95	3453873
9C	0.750	2.1	88	94	0	3	96	0	94	3383455
9D	0.750	2.0	87	94	0	4	96	1	94	3295645
9E	**0.750**	1.9	87	94	0	3	96	0	94	3265091
9F	0.750	2.0	88	94	0	3	95	2	94	3393594
9G	0.750	2.1	88	94	0	3	94	2	95	3526487
9H	0.750	2.0	88	94	0	4	95	2	94	3391450
9I	0.750	2.0	88	94	0	3	95	1	94	3391004
9J	0.750	1.9	87	94	0	4	96	1	94	3267732
9K	0.750	1.9	87	94	0	4	96	0	94	3227232
9L	0.750	1.9	87	94	0	4	96	0	94	3199029
9M	0.750	1.9	87	94	0	4	96	0	94	3181034
9N	0.750	1.8	86	94	0	4	96	0	93	3059830
9O	0.750	1.8	86	94	0	4	96	0	93	3024509
9P	0.750	1.7	85	93	0	4	96	0	93	2881143
10A	0.750	1.9	87	94	0	3	97	0	94	3217427
10B	0.750	1.9	87	94	0	4	96	0	94	3182111
10C	0.750	2.0	88	94	0	3	96	0	94	3326807
10D	0.750	2.0	88	94	0	3	96	1	94	3362007
10E	**0.750**	2.0	88	94	0	3	95	1	94	3373810
10F	0.750	2.1	88	95	0	3	94	2	95	3533509
10G	0.750	2.1	88	95	0	3	95	2	95	3517275
10H	0.750	2.1	89	95	0	3	95	2	95	3541919
10I	0.750	2.1	89	95	0	3	94	3	95	3628491
10J	0.750	2.1	89	95	0	3	95	2	95	3583097
10K	0.750	2.0	88	95	0	3	96	1	94	3425224
10L	0.750	2.0	88	95	0	3	96	0	94	3355955

F4: Detail DAYSIM result of SVW4

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.1	92	96	7	2	74	24	92	5610865
1B	0.750	14.6	98	99	72	1	16	83	0	29327952
1C	0.750	19.3	99	99	83	1	9	90	0	39877652
1D	0.750	17.0	98	99	79	1	11	88	0	34929120
1E	**0.750**	11.9	98	99	70	1	15	83	0	23392220
1F	0.750	19.7	98	99	83	1	9	90	0	40492588
1G	0.750	18.4	98	99	80	1	11	88	0	36817828
1H	0.750	5.2	96	98	23	2	48	50	70	9895703
1I	0.750	6.2	96	98	32	1	39	59	34	12975637
1J	0.750	19.0	98	99	81	1	10	89	0	38638692
1K	0.750	19.4	99	99	83	1	9	90	0	40078660
1L	0.750	10.9	98	99	67	1	16	83	0	21244260
1M	0.750	18.4	98	99	80	1	10	89	0	37835192
1N	0.750	19.7	99	99	83	1	9	90	0	39740212
1O	0.750	12.8	98	99	62	1	19	79	0	24668994
1P	0.750	2.9	92	96	1	2	80	18	96	5011697
2A	0.750	4.2	94	97	19	2	60	39	66	8868963
2B	0.750	6.6	96	98	33	1	38	60	29	11453500
2C	0.750	8.4	97	98	48	1	30	69	0	13937521
2D	0.750	8.2	97	99	51	1	28	71	0	14121918
2E	**0.750**	7.7	97	98	48	1	30	69	0	14251544
2F	0.750	8.7	97	99	51	1	28	71	0	14828368
2G	0.750	8.0	97	98	45	1	31	67	12	14103715
2H	0.750	5.7	96	98	30	1	41	58	44	10669383
2I	0.750	5.6	96	98	31	1	41	58	44	10815739
2J	0.750	8.3	97	98	48	1	29	69	0	13558793
2K	0.750	8.7	97	98	51	1	28	71	0	13775566
2L	0.750	7.9	97	98	49	1	29	70	0	14475273
2M	0.750	8.2	97	99	51	1	28	71	0	14142706
2N	0.750	8.4	97	98	46	1	31	68	0	13805556
2O	0.750	6.5	96	98	30	1	44	55	44	10800358
2P	0.750	3.9	95	97	13	2	66	33	77	7825918
3A	0.750	3.7	93	97	11	2	68	30	96	6278535
3B1	0.750	4.3	94	97	14	2	62	37	87	6956087
3C	0.750	4.8	96	98	18	2	54	44	78	7633885
3D	0.750	5.0	96	98	20	2	51	47	76	7902865
3E	**0.750**	5.1	96	98	21	2	49	49	75	8090202
3F	0.750	5.0	96	98	21	1	50	48	75	8014841
3G	0.750	4.8	96	98	20	2	53	45	81	7746847
3H	0.750	4.4	95	98	17	1	56	43	94	7297324
3I	0.750	4.4	95	98	15	2	58	41	94	7233657
3J	0.750	4.7	96	98	19	2	54	44	83	7650637
3K	0.750	5.0	96	98	21	1	52	47	79	7928179
3L	0.750	5.1	96	98	21	2	52	47	74	7982105
3M	0.750	5.1	96	98	21	1	52	46	77	7952459
3N	0.750	4.6	95	98	16	2	59	40	86	7306649
3O	0.750	4.2	95	97	12	2	66	33	94	6665543
3P	0.750	3.6	94	97	8	2	72	26	97	6010841
4A	0.750	3.0	92	96	2	2	81	17	97	5110176
4B	0.750	3.2	92	96	4	2	79	19	97	5250723
4C	0.750	3.4	93	97	5	2	76	22	97	5569424
4D	0.750	3.5	93	97	5	2	75	23	97	5648101
4E	**0.750**	3.8	94	97	8	2	69	29	98	6208985
4F	0.750	3.6	94	97	6	2	73	25	97	5876664
4G	0.750	3.5	94	97	4	2	74	24	97	5684153
4H	0.750	3.5	94	97	4	2	74	24	97	5724747
4I	0.750	3.6	95	97	5	2	72	26	97	5942814
4J	0.750	3.6	95	97	6	2	72	26	97	5949082
4K	0.750	3.8	95	97	7	2	70	28	98	6150007
4L	0.750	3.7	95	97	7	2	72	26	98	5969236
4M	0.750	3.5	94	97	4	2	74	24	97	5666785
4N	0.750	3.3	94	97	2	2	77	22	97	5377062
4O	0.750	3.1	93	97	1	2	79	19	97	5094518
4P	0.750	2.9	93	96	0	2	82	16	96	4880409
5A	0.750	2.6	90	95	0	3	87	10	96	4368572
5B	0.750	2.6	90	95	0	3	87	11	96	4362031
5C	0.750	2.8	91	96	0	3	85	12	96	4532424
5D	0.750	2.8	91	96	0	2	84	14	96	4677410
5E	**0.750**	2.9	91	96	0	2	83	14	96	4742707
5F	0.750	2.9	91	96	0	2	82	15	96	4790410
5G	0.750	3.0	92	96	0	2	82	16	96	4868354
5H	0.750	2.9	92	96	0	2	82	16	96	4771593
5I	0.750	2.8	91	96	0	3	84	14	96	4594896
5J	0.750	3.0	92	96	0	2	82	16	96	4875670
5K	0.750	2.9	92	96	0	2	82	15	96	4787506
5L	0.750	2.9	92	96	0	2	82	16	96	4779468
5M	0.750	2.8	92	96	0	3	85	13	96	4502286
5N	0.750	2.7	91	96	0	3	86	11	96	4378320

Table F4: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	2.5	91	96	0	3	88	9	96	4159395
5P	0.750	2.5	91	96	0	3	89	9	96	4205221
6A	0.750	2.3	89	95	0	3	92	5	95	3785266
6B	0.750	2.4	90	95	0	3	91	6	95	3960403
6C	0.750	2.4	89	95	0	3	91	6	96	3943630
6D	0.750	2.4	90	95	0	3	90	7	96	4033981
6E	**0.750**	2.5	90	95	0	3	89	8	96	4109795
6F	0.750	2.4	90	95	0	3	90	7	96	4052274
6G	0.750	2.5	90	96	0	3	89	9	96	4155414
6H	0.750	2.4	90	95	0	3	90	7	96	4067321
6I	0.750	2.4	90	95	0	3	90	7	96	4027687
6J	0.750	2.5	91	96	0	3	88	9	96	4219097
6K	0.750	2.4	90	95	0	3	90	7	95	3983035
6L	0.750	2.4	90	95	0	3	91	6	96	3960468
6M	0.750	2.4	90	95	0	3	91	6	96	3952218
6N	0.750	2.3	89	95	0	3	93	4	95	3787637
6O	0.750	2.2	89	95	0	3	94	3	95	3663537
6P	0.750	2.2	90	95	0	3	95	2	95	3667374
7A	0.750	2.0	88	94	0	3	96	1	95	3440858
7B	0.750	2.1	88	94	0	3	95	2	95	3481152
7C	0.750	2.2	89	95	0	3	94	3	95	3584267
7D	0.750	2.3	89	95	0	3	94	3	95	3711622
7E	**0.750**	2.1	88	94	0	3	94	2	95	3496996
7F	0.750	2.3	89	95	0	3	93	4	95	3755261
7G	0.750	2.2	89	95	0	3	94	3	95	3644295
7H	0.750	2.2	89	95	0	3	94	3	95	3682572
7I	0.750	2.2	88	95	0	3	94	3	95	3596850
7J	0.750	2.2	89	95	0	3	94	3	95	3665718
7K	0.750	2.2	89	95	0	3	94	3	95	3610521
7L	0.750	2.1	88	95	0	3	95	2	95	3517650
7M	0.750	2.1	88	95	0	3	95	1	94	3412421
7N	0.750	2.0	87	94	0	3	96	0	94	3327246
7O	0.750	1.9	87	94	0	4	96	0	94	3198519
7P	0.750	1.9	88	95	0	4	96	0	94	3274290
8A	0.750	2.0	88	94	0	3	97	0	94	3330389
8B	0.750	2.1	88	94	0	3	97	0	94	3317739
8C	0.750	1.9	86	93	0	4	96	0	94	3057310
8D	0.750	2.2	88	94	0	3	96	0	95	3446498
8E	**0.750**	2.0	88	94	0	4	96	0	94	3279692
8F	0.750	2.1	88	94	0	3	96	1	95	3433543
8G	0.750	2.0	88	94	0	3	96	1	94	3406293
8H	0.750	2.0	88	94	0	3	96	1	94	3407062
8I	0.750	2.0	88	94	0	3	96	1	94	3354309
8J	0.750	2.0	88	95	0	3	96	1	94	3413690
8K	0.750	2.0	88	94	0	4	96	0	94	3319945
8L	0.750	1.9	87	94	0	4	96	0	94	3163741
8M	0.750	1.8	86	94	0	4	96	0	93	3003987
8N	0.750	1.8	86	94	0	4	96	0	93	3023970
8O	0.750	1.7	85	93	0	4	96	0	93	2892556
8P	0.750	1.8	86	94	0	4	96	0	93	2964201
9A	0.750	1.9	87	94	0	4	96	0	94	3136051
9B	0.750	2.1	88	94	0	3	97	0	95	3268748
9C	0.750	1.8	86	93	0	4	96	0	94	2997051
9D	0.750	1.9	87	94	0	4	96	0	94	3128172
9E	**0.750**	1.9	88	94	0	3	96	0	94	3217042
9F	0.750	1.9	88	94	0	4	96	0	94	3208862
9G	0.750	2.0	88	94	0	3	96	0	94	3313326
9H	0.750	2.0	88	94	0	4	96	0	94	3255429
9I	0.750	1.9	88	94	0	4	96	0	94	3205229
9J	0.750	1.9	87	94	0	4	96	0	94	3221193
9K	0.750	1.8	86	94	0	4	96	0	93	3036572
9L	0.750	1.8	85	93	0	4	96	0	93	2909664
9M	0.750	1.7	85	93	0	4	96	0	93	2866297
9N	0.750	1.7	85	93	0	4	96	0	93	2856488
9O	0.750	1.7	85	93	0	4	96	0	93	2798203
9P	0.750	1.6	85	93	0	4	96	0	93	2740457
10A	0.750	1.9	87	94	0	4	96	0	94	3094545
10B	0.750	1.9	87	94	0	4	96	0	94	3050526
10C	0.750	1.8	86	94	0	4	96	0	94	3045759
10D	0.750	1.9	88	94	0	3	97	0	94	3193624
10E	**0.750**	1.9	87	94	0	4	96	0	94	3151378
10F	0.750	2.0	88	94	0	3	96	0	94	3309978
10G	0.750	2.0	88	94	0	3	97	0	94	3324457
10H	0.750	2.0	88	94	0	3	97	0	94	3358431
10I	0.750	2.0	88	95	0	3	96	0	94	3386150
10J	0.750	2.0	88	95	0	3	96	0	94	3325595
10K	0.750	1.9	87	94	0	4	96	0	94	3195764
10L	0.750	1.9	87	94	0	4	96	0	94	3103357

F5: Detail DAYSIM result of SVW5

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.7	93	97	14	2	66	32	89	6574906
1B	0.750	15.4	98	99	73	1	15	85	0	30366602
1C	0.750	20.7	99	99	85	1	9	90	0	41858964
1D	0.750	18.0	98	99	81	1	11	88	0	36270712
1E	**0.750**	12.8	98	99	73	1	14	85	0	24652684
1F	0.750	20.7	99	99	84	1	9	90	0	41755768
1G	0.750	19.5	98	99	81	1	10	89	0	38528032
1H	0.750	6.0	96	98	31	1	42	57	55	10991254
1I	0.750	6.9	97	98	39	1	33	66	20	13908332
1J	0.750	20.0	98	99	83	1	9	90	0	40328352
1K	0.750	20.4	99	99	84	1	9	90	0	41311280
1L	0.750	11.5	98	99	69	1	15	84	0	22157020
1M	0.750	19.2	99	99	82	1	9	90	0	39464780
1N	0.750	20.8	99	99	84	1	9	90	0	41559200
1O	0.750	13.6	98	99	64	1	18	81	0	25753668
1P	0.750	3.4	94	97	6	2	72	26	97	5860425
2A	0.750	5.1	95	98	24	1	48	51	53	10102232
2B	0.750	7.8	97	98	45	1	30	69	3	16359257
2C	0.750	10.5	98	99	61	1	22	77	0	20372556
2D	0.750	10.1	98	99	62	1	19	80	0	18968128
2E	**0.750**	9.2	98	99	58	1	22	77	0	17612434
2F	0.750	10.3	98	99	61	1	21	78	0	20653972
2G	0.750	9.4	98	99	53	1	25	74	0	18387178
2H	0.750	6.8	97	98	42	1	32	66	17	13338439
2I	0.750	7.0	97	98	45	1	31	68	14	14120945
2J	0.750	9.4	98	99	56	1	25	74	0	18640780
2K	0.750	10.6	98	99	62	1	19	80	0	20203698
2L	0.750	9.4	98	99	58	1	21	78	0	17590634
2M	0.750	10.0	98	99	61	1	19	79	0	19026362
2N	0.750	10.1	98	99	56	1	22	76	0	19709092
2O	0.750	7.5	97	98	40	1	37	62	27	14570547
2P	0.750	4.8	96	98	18	2	52	47	72	9127280
3A	0.750	4.5	95	97	18	2	56	43	75	7547253
3B1	0.750	5.3	96	98	23	2	47	51	58	8504517
3C	0.750	6.1	96	98	29	1	41	58	45	9394807
3D	0.750	6.5	97	98	35	1	37	62	31	9999443
3E	**0.750**	6.4	97	98	35	1	38	60	30	10244796
3F	0.750	6.5	97	98	36	1	36	63	35	10125780
3G	0.750	6.0	96	98	31	1	40	59	46	9491512
3H	0.750	5.4	96	98	26	1	44	55	66	8727814
3I	0.750	5.6	96	98	28	1	43	55	51	9296258
3J	0.750	6.2	96	98	32	1	39	59	45	9644319
3K	0.750	6.5	97	98	36	1	37	62	35	10127134
3L	0.750	6.1	96	98	30	1	41	58	39	9744926
3M	0.750	6.1	96	98	30	1	42	56	46	9399816
3N	0.750	5.9	96	98	26	1	46	53	51	9098806
3O	0.750	5.0	96	98	19	2	52	46	73	7912402
3P	0.750	4.3	95	97	15	2	59	39	88	7128258
4A	0.750	3.8	94	97	12	2	66	32	93	6457855
4B	0.750	4.0	94	97	12	2	64	35	93	6595910
4C	0.750	4.5	95	98	15	2	57	41	88	7235039
4D	0.750	4.6	95	98	16	2	56	42	89	7321378
4E	**0.750**	4.6	95	98	17	2	55	43	87	7447193
4F	0.750	4.7	95	98	18	2	54	44	85	7537530
4G	0.750	4.6	95	98	17	2	55	43	91	7416527
4H	0.750	4.4	95	98	17	2	56	43	93	7334748
4I	0.750	4.4	95	98	17	2	56	42	93	7329711
4J	0.750	4.6	95	98	18	2	54	45	87	7592382
4K	0.750	4.5	95	98	16	2	57	41	89	7315178
4L	0.750	4.6	95	98	17	2	56	42	87	7411418
4M	0.750	4.5	95	98	15	2	59	39	91	7122238
4N	0.750	4.5	95	98	15	2	60	39	89	7083432
4O	0.750	3.9	95	97	9	2	68	30	97	6324313
4P	0.750	3.8	95	97	10	2	68	30	97	6387987
5A	0.750	3.3	93	97	4	2	78	20	97	5469769
5B	0.750	3.4	93	97	5	2	76	22	97	5571137
5C	0.750	3.5	93	97	5	2	74	24	97	5715551
5D	0.750	3.6	94	97	6	2	72	26	97	5928082
5E	**0.750**	3.7	94	97	6	2	72	26	97	5913413
5F	0.750	3.8	94	97	6	2	70	28	98	6031358
5G	0.750	3.5	94	97	5	2	73	25	97	5800403
5H	0.750	3.6	94	97	5	2	72	26	97	5917837
5I	0.750	3.6	94	97	5	2	71	27	97	5937884
5J	0.750	3.8	95	97	7	2	69	29	98	6117716
5K	0.750	3.9	95	97	9	2	68	30	98	6296702
5L	0.750	3.6	94	97	5	2	74	24	97	5736369
5M	0.750	3.6	94	97	5	2	74	24	97	5748527
5N	0.750	3.5	94	97	4	2	74	24	97	5660593

Table F5: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	3.2	94	97	1	2	78	20	97	5303963
5P	0.750	3.2	94	97	1	2	78	20	97	5322728
6A	0.750	2.9	91	96	0	2	84	14	96	4860745
6B	0.750	3.0	91	96	0	2	83	15	96	4901527
6C	0.750	3.0	91	96	0	2	83	15	96	4906769
6D	0.750	3.0	91	96	0	2	82	15	96	4941349
6E	**0.750**	3.1	92	96	1	2	80	17	97	5091244
6F	0.750	3.2	93	97	1	2	79	19	97	5279564
6G	0.750	3.2	93	97	1	2	79	19	97	5243143
6H	0.750	3.2	93	97	1	2	78	20	97	5257418
6I	0.750	3.2	93	97	1	2	79	19	97	5250391
6J	0.750	3.1	92	96	0	2	81	17	97	4982685
6K	0.750	3.2	93	97	1	2	79	19	97	5208830
6L	0.750	3.2	93	97	1	2	79	19	97	5151569
6M	0.750	3.0	93	96	0	2	82	16	97	4879627
6N	0.750	2.9	92	96	0	2	84	14	96	4644219
6O	0.750	2.8	92	96	0	2	85	12	96	4545405
6P	0.750	2.7	93	96	0	2	86	12	96	4557925
7A	0.750	2.6	90	96	0	3	89	8	96	4284168
7B	0.750	2.5	90	95	0	3	90	8	96	4202005
7C	0.750	2.6	90	96	0	3	88	9	96	4323750
7D	0.750	2.7	90	96	0	3	88	10	96	4348398
7E	**0.750**	2.8	91	96	0	2	86	12	96	4553107
7F	0.750	2.8	91	96	0	2	85	12	96	4590346
7G	0.750	2.7	91	96	0	3	86	12	96	4505536
7H	0.750	2.8	91	96	0	2	85	13	96	4590855
7I	0.750	2.8	91	96	0	2	85	12	96	4519498
7J	0.750	2.7	91	96	0	3	87	11	96	4414828
7K	0.750	2.7	91	96	0	3	87	11	96	4404856
7L	0.750	2.6	91	96	0	3	88	9	96	4302213
7M	0.750	2.6	91	96	0	3	88	10	96	4310246
7N	0.750	2.5	91	96	0	3	90	8	96	4116292
7O	0.750	2.4	91	96	0	3	92	5	96	3958770
7P	0.750	2.4	91	96	0	3	92	5	96	3997238
8A	0.750	2.4	90	95	0	3	94	4	95	3897572
8B	0.750	2.5	90	95	0	3	93	5	96	3997108
8C	0.750	2.5	90	95	0	3	91	6	96	4105754
8D	0.750	2.5	90	95	0	3	91	7	96	4130413
8E	**0.750**	2.6	90	96	0	3	90	8	96	4272771
8F	0.750	2.5	90	95	0	3	90	7	96	4141822
8G	0.750	2.6	91	96	0	3	89	8	96	4285170
8H	0.750	2.6	91	96	0	3	89	9	96	4320039
8I	0.750	2.5	90	96	0	3	91	6	96	4096973
8J	0.750	2.5	91	96	0	3	90	7	96	4173006
8K	0.750	2.5	91	96	0	3	91	7	96	4148351
8L	0.750	2.5	90	96	0	3	92	6	96	4045656
8M	0.750	2.4	90	96	0	3	92	5	96	3970283
8N	0.750	2.3	90	95	0	3	94	3	95	3844772
8O	0.750	2.2	90	95	0	3	95	2	95	3716679
8P	0.750	2.2	90	95	0	3	96	1	95	3697801
9A	0.750	2.4	90	95	0	3	94	3	96	3890896
9B	0.750	2.5	90	95	0	3	95	3	96	3869077
9C	0.750	2.3	90	95	0	3	94	3	95	3846824
9D	0.750	2.3	90	95	0	3	93	4	96	3884779
9E	**0.750**	2.4	90	95	0	3	92	5	96	4018979
9F	0.750	2.4	90	95	0	3	92	5	96	3990236
9G	0.750	2.5	90	96	0	3	92	6	96	4078758
9H	0.750	2.4	90	95	0	3	92	5	96	4009068
9I	0.750	2.4	90	96	0	3	92	5	96	4069664
9J	0.750	2.5	90	96	0	3	92	5	96	4079012
9K	0.750	2.4	90	96	0	3	93	4	96	3949388
9L	0.750	2.3	90	95	0	3	94	3	95	3778986
9M	0.750	2.3	90	95	0	3	95	2	95	3771018
9N	0.750	2.2	90	95	0	3	96	1	95	3650629
9O	0.750	2.1	89	95	0	3	96	0	95	3545502
9P	0.750	2.1	89	95	0	3	97	0	94	3445475
10A	0.750	2.3	89	95	0	3	95	2	95	3736934
10B	0.750	2.3	90	95	0	3	94	3	95	3829534
10C	0.750	2.4	90	95	0	3	93	4	96	3986596
10D	0.750	2.4	90	95	0	3	93	4	96	3982714
10E	**0.750**	2.4	90	95	0	3	93	4	96	3926823
10F	0.750	2.4	90	96	0	3	92	5	96	4072906
10G	0.750	2.5	91	96	0	3	90	7	96	4244177
10H	0.750	2.5	91	96	0	3	90	7	96	4256262
10I	0.750	2.4	91	96	0	3	92	5	96	4087869
10J	0.750	2.5	91	96	0	3	92	6	96	4138055
10K	0.750	2.4	91	96	0	3	93	5	96	4043913
10L	0.750	2.4	91	96	0	3	93	5	96	4042130

F6: Detail DAYSIM result of SVW6

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	4.3	94	97	21	1	55	43	66	8073538
1B	0.750	17.8	98	99	76	1	12	87	0	36249428
1C	0.750	23.5	99	99	86	1	8	91	0	48871352
1D	0.750	20.6	99	99	83	1	9	90	0	42176376
1E	**0.750**	15.1	99	99	78	1	12	87	0	30411852
1F	0.750	23.6	99	99	86	1	8	91	0	48499032
1G	0.750	21.7	99	99	83	1	9	90	0	44431588
1H	0.750	7.3	97	98	46	1	33	66	21	13802773
1I	0.750	8.5	97	99	50	1	25	74	0	18110480
1J	0.750	22.7	99	99	85	1	8	91	0	46759060
1K	0.750	23.3	99	99	86	1	8	91	0	47948472
1L	0.750	13.6	98	99	74	1	13	86	0	27571838
1M	0.750	21.5	99	99	85	1	9	91	0	44915092
1N	0.750	23.4	99	99	86	1	8	91	0	48139320
1O	0.750	15.6	98	99	68	1	16	83	0	30871384
1P	0.750	3.8	94	97	15	2	64	34	91	6941290
2A	0.750	5.8	96	98	31	1	42	57	34	11442289
2B	0.750	9.1	98	99	52	1	25	73	0	18268346
2C	0.750	11.5	98	99	64	1	19	80	0	21947838
2D	0.750	11.1	98	99	64	1	17	82	0	20295252
2E	**0.750**	10.5	98	99	64	1	18	81	0	19486782
2F	0.750	11.7	98	99	65	1	17	82	0	22539884
2G	0.750	10.8	98	99	62	1	19	80	0	20423448
2H	0.750	7.9	97	99	53	1	26	73	0	15209549
2I	0.750	8.1	97	99	52	1	25	74	0	15752223
2J	0.750	11.0	98	99	63	1	19	80	0	21008400
2K	0.750	11.9	98	99	65	1	16	83	0	21911128
2L	0.750	10.4	98	99	62	1	18	81	0	18964592
2M	0.750	11.2	98	99	64	1	17	82	0	20702580
2N	0.750	11.4	98	99	62	1	19	79	0	21490838
2O	0.750	8.7	97	98	48	1	32	67	3	16263916
2P	0.750	5.3	96	98	25	2	47	51	58	10020351
3A	0.750	5.0	95	98	23	2	50	48	52	8828693
3B1	0.750	5.8	96	98	28	1	43	55	42	9290025
3C	0.750	6.7	97	98	36	1	37	62	21	10880998
3D	0.750	6.8	97	98	39	1	36	63	17	11133530
3E	**0.750**	7.0	97	98	41	1	35	64	10	11574786
3F	0.750	7.1	97	98	42	1	33	65	13	11427774
3G	0.750	6.4	97	98	36	1	38	61	25	10640814
3H	0.750	5.9	96	98	33	1	40	59	24	10360361
3I	0.750	6.2	97	98	36	1	38	61	21	10761477
3J	0.750	6.7	97	98	39	1	35	63	18	10945544
3K	0.750	7.1	97	98	42	1	33	65	12	11537263
3L	0.750	7.1	97	98	43	1	34	64	9	11732892
3M	0.750	7.0	97	98	38	1	36	63	21	11027395
3N	0.750	6.5	97	98	34	1	41	58	32	10419910
3O	0.750	5.7	96	98	25	1	48	51	51	8966623
3P	0.750	4.7	95	98	19	2	54	45	67	8196556
4A	0.750	4.2	94	97	16	2	59	39	80	7227162
4B	0.750	4.5	95	98	18	2	57	42	74	7504286
4C	0.750	4.8	95	98	19	2	54	44	73	7719706
4D	0.750	5.0	96	98	20	2	51	47	69	7966316
4E	**0.750**	5.1	96	98	23	2	48	50	64	8258553
4F	0.750	5.2	96	98	24	1	48	51	62	8434901
4G	0.750	5.2	96	98	23	1	47	51	63	8457374
4H	0.750	5.0	96	98	25	1	47	51	66	8419708
4I	0.750	4.9	96	98	23	1	50	49	72	8182434
4J	0.750	5.0	96	98	23	1	51	48	68	8166092
4K	0.750	5.1	96	98	22	2	51	48	68	8171011
4L	0.750	5.0	96	98	22	2	51	47	70	8103203
4M	0.750	4.9	96	98	20	2	55	43	72	7796867
4N	0.750	4.7	95	98	19	2	57	41	76	7560528
4O	0.750	4.3	95	97	16	2	61	37	85	7109094
4P	0.750	4.0	95	97	14	2	65	34	91	6798263
5A	0.750	3.5	93	97	8	2	72	26	97	5931807
5B	0.750	3.5	93	97	7	2	73	25	97	5831092
5C	0.750	3.8	94	97	9	2	70	29	96	6192206
5D	0.750	3.9	94	97	11	2	67	31	96	6394542
5E	**0.750**	4.0	95	97	12	2	65	33	94	6582437
5F	0.750	4.1	95	97	13	2	64	34	93	6642764
5G	0.750	4.1	95	97	14	2	63	35	94	6736448
5H	0.750	4.0	95	97	12	2	64	34	96	6587541
5I	0.750	4.0	95	97	12	2	65	33	96	6548604
5J	0.750	4.0	95	97	11	2	66	32	96	6514338
5K	0.750	4.2	95	97	14	2	63	35	93	6781235
5L	0.750	3.9	95	97	11	2	68	30	96	6412440
5M	0.750	3.9	95	97	11	2	68	30	96	6356541
5N	0.750	3.7	94	97	8	2	71	27	97	6021383

Table F6: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	3.6	94	97	7	2	73	25	97	5901274
5P	0.750	3.4	94	97	4	2	74	24	97	5667552
6A	0.750	3.1	92	96	3	2	79	19	97	5211754
6B	0.750	3.0	91	96	3	2	80	17	97	5044065
6C	0.750	3.3	93	97	4	2	77	21	97	5448281
6D	0.750	3.4	93	97	4	2	77	21	97	5492643
6E	**0.750**	3.5	93	97	5	2	74	24	97	5699344
6F	0.750	3.4	93	97	5	2	74	23	97	5666780
6G	0.750	3.3	93	97	4	2	76	22	97	5484917
6H	0.750	3.4	93	97	5	2	75	23	97	5616752
6I	0.750	3.4	93	97	4	2	75	23	97	5601051
6J	0.750	3.3	93	97	4	2	76	22	97	5447618
6K	0.750	3.4	94	97	4	2	75	23	97	5574751
6L	0.750	3.3	94	97	4	2	75	23	97	5519397
6M	0.750	3.3	94	97	3	2	76	22	97	5396282
6N	0.750	3.0	93	97	1	2	79	19	97	5070382
6O	0.750	3.0	93	96	0	2	80	17	96	4916593
6P	0.750	2.9	93	96	0	2	80	17	96	4939089
7A	0.750	2.7	91	96	0	3	85	13	96	4603720
7B	0.750	2.8	91	96	0	3	85	13	96	4639679
7C	0.750	3.0	91	96	1	2	83	15	96	4857042
7D	0.750	2.9	91	96	0	2	83	14	96	4778686
7E	**0.750**	3.0	91	96	1	2	81	16	96	4905141
7F	0.750	2.9	92	96	1	2	81	17	96	4936774
7G	0.750	3.0	92	96	1	2	81	17	97	4990078
7H	0.750	2.9	92	96	1	2	81	17	96	4892036
7I	0.750	3.1	93	97	2	2	78	19	97	5174041
7J	0.750	3.0	93	96	1	2	80	18	96	4948350
7K	0.750	3.0	92	96	0	2	80	17	96	4929326
7L	0.750	2.8	92	96	0	2	83	15	96	4709450
7M	0.750	2.9	92	96	0	2	82	15	96	4754491
7N	0.750	2.7	92	96	0	3	85	13	96	4468706
7O	0.750	2.6	91	96	0	3	87	10	96	4304588
7P	0.750	2.6	92	96	0	3	87	11	96	4342599
8A	0.750	2.5	90	95	0	3	89	9	96	4265047
8B	0.750	2.8	91	96	0	3	87	10	96	4446351
8C	0.750	2.7	91	96	0	3	86	11	96	4453970
8D	0.750	2.8	91	96	0	3	86	12	96	4535061
8E	**0.750**	2.7	91	96	0	3	85	12	96	4528101
8F	0.750	2.7	91	96	0	3	85	13	96	4568387
8G	0.750	2.7	91	96	0	3	84	13	96	4573922
8H	0.750	2.7	91	96	0	3	85	12	96	4472848
8I	0.750	2.7	91	96	0	3	84	13	96	4530580
8J	0.750	2.7	91	96	0	3	85	13	96	4515487
8K	0.750	2.6	91	96	0	3	86	12	96	4390588
8L	0.750	2.6	91	96	0	3	86	11	96	4384379
8M	0.750	2.5	91	96	0	3	88	9	96	4224671
8N	0.750	2.4	91	96	0	3	89	8	96	4079703
8O	0.750	2.3	91	96	0	3	91	6	96	3961210
8P	0.750	2.4	91	96	0	3	91	6	96	4045025
9A	0.750	2.5	90	95	0	3	91	6	96	4122884
9B	0.750	2.6	90	95	0	3	90	7	96	4194431
9C	0.750	2.6	90	95	0	3	90	8	96	4228987
9D	0.750	2.5	90	95	0	3	89	8	96	4224281
9E	**0.750**	2.5	90	95	0	3	88	9	96	4238833
9F	0.750	2.5	90	96	0	3	88	10	96	4333789
9G	0.750	2.6	91	96	0	3	87	10	96	4352845
9H	0.750	2.5	90	96	0	3	89	9	96	4218144
9I	0.750	2.6	91	96	0	3	87	10	96	4333262
9J	0.750	2.6	91	96	0	3	87	10	96	4351484
9K	0.750	2.5	91	96	0	3	88	9	96	4259232
9L	0.750	2.5	91	96	0	3	89	8	96	4185017
9M	0.750	2.4	91	96	0	3	90	7	96	4053632
9N	0.750	2.3	91	96	0	3	92	5	95	3920294
9O	0.750	2.2	90	95	0	3	94	3	95	3804301
9P	0.750	2.2	90	95	0	3	95	2	95	3709880
10A	0.750	2.5	90	95	0	3	91	6	96	4118623
10B	0.750	2.6	91	96	0	3	90	7	96	4263790
10C	0.750	2.5	90	95	0	3	90	7	96	4191969
10D	0.750	2.5	90	96	0	3	89	8	96	4217480
10E	**0.750**	2.6	91	96	0	3	88	10	96	4367358
10F	0.750	2.6	91	96	0	3	87	11	96	4439980
10G	0.750	2.7	92	96	0	2	85	13	96	4579230
10H	0.750	2.6	91	96	0	3	86	11	96	4467097
10I	0.750	2.7	92	96	0	2	85	13	96	4598776
10J	0.750	2.6	92	96	0	2	86	12	96	4463640
10K	0.750	2.5	91	96	0	3	88	9	96	4277721
10L	0.750	2.6	92	96	0	3	88	10	96	4354303

F7: Detail DAYSIM result of SFW1

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	6.2	96	98	39	1	36	63	18	11226301
1B	0.750	20.7	99	99	79	1	10	89	0	40114576
1C	0.750	27.0	99	99	88	1	7	93	0	53110596
1D	0.750	23.9	99	99	86	1	8	91	0	46546752
1E	**0.750**	18.5	99	99	83	1	10	90	0	34779760
1F	0.750	26.9	99	99	88	1	7	92	0	52450040
1G	0.750	25.3	99	99	86	1	8	91	0	48739960
1H	0.750	9.5	98	99	59	1	22	77	0	17062720
1I	0.750	10.9	98	99	66	1	19	80	0	21578136
1J	0.750	25.8	99	99	87	1	7	92	0	51371724
1K	0.750	26.9	99	99	88	1	6	93	0	52252768
1L	0.750	16.9	98	99	81	1	11	88	0	31827512
1M	0.750	25.0	99	99	87	1	7	92	0	49208080
1N	0.750	26.7	99	99	88	1	6	93	0	52159648
1O	0.750	18.3	99	99	75	1	13	86	0	34478952
1P	0.750	5.7	96	98	33	2	44	55	45	9890494
2A	0.750	8.6	97	99	54	1	25	74	0	17598238
2B	0.750	13.0	98	99	70	1	18	81	0	27630008
2C	0.750	16.3	98	99	75	1	12	87	0	32789556
2D	0.750	15.8	98	99	77	1	11	88	0	31671544
2E	**0.750**	15.4	98	99	77	1	11	88	0	31519330
2F	0.750	16.6	98	99	77	1	11	88	0	34383792
2G	0.750	15.3	98	99	75	1	13	87	0	29922824
2H	0.750	11.7	98	99	69	1	15	84	0	24713716
2I	0.750	11.8	98	99	70	1	15	84	0	24345192
2J	0.750	15.4	98	99	75	1	12	87	0	32045742
2K	0.750	16.3	98	99	78	1	11	88	0	33296388
2L	0.750	15.7	98	99	77	1	11	88	0	31497782
2M	0.750	16.4	98	99	78	1	12	88	0	32565204
2N	0.750	16.1	98	99	74	1	13	86	0	32897580
2O	0.750	12.3	98	99	63	1	19	80	0	25252836
2P	0.750	8.1	97	98	50	1	30	68	3	15574193
3A	0.750	7.7	97	98	48	1	28	71	0	15523338
3B1	0.750	9.1	98	99	56	1	24	75	0	17969874
3C	0.750	10.3	98	99	62	1	22	77	0	19682320
3D	0.750	11.2	98	99	64	1	18	81	0	21229952
3E	**0.750**	10.8	98	99	64	1	18	81	0	21144234
3F	0.750	11.0	98	99	64	1	16	83	0	20779792
3G	0.750	10.4	98	99	62	1	19	80	0	19422836
3H	0.750	9.4	98	99	60	1	21	78	0	18328114
3I	0.750	9.7	98	99	61	1	20	79	0	19008884
3J	0.750	10.4	98	99	63	1	19	80	0	19660288
3K	0.750	11.3	98	99	65	1	17	82	0	22849860
3L	0.750	11.0	98	99	63	1	18	81	0	21186964
3M	0.750	10.8	98	99	62	1	19	79	0	20656946
3N	0.750	10.4	98	99	58	1	21	78	0	19452588
3O	0.750	8.9	98	99	52	1	28	71	0	16924120
3P	0.750	7.5	97	98	46	1	32	67	14	13427901
4A	0.750	6.5	97	98	39	1	34	65	21	11048301
4B	0.750	7.0	97	98	42	1	33	65	12	11823659
4C	0.750	7.4	97	98	45	1	32	67	2	12205751
4D	0.750	7.8	97	98	48	1	30	69	0	12736351
4E	**0.750**	8.0	97	98	50	1	29	70	0	12629214
4F	0.750	8.0	97	98	51	1	29	70	0	13503207
4G	0.750	7.7	97	98	50	1	31	68	0	13118258
4H	0.750	7.4	97	98	47	1	31	68	0	12551949
4I	0.750	7.8	97	98	50	1	29	70	0	12941253
4J	0.750	7.9	97	98	51	1	29	70	0	13488170
4K	0.750	8.1	97	98	51	1	30	69	0	13532934
4L	0.750	7.8	97	98	46	1	32	67	0	12265924
4M	0.750	7.7	97	98	45	1	32	67	4	12361579
4N	0.750	7.6	97	98	45	1	32	66	10	12233106
4O	0.750	6.8	97	98	39	1	37	62	26	11295366
4P	0.750	6.4	97	98	36	1	39	59	35	10589883
5A	0.750	5.4	96	98	28	1	43	56	45	9265811
5B	0.750	5.7	96	98	28	1	42	56	43	9338200
5C	0.750	6.0	96	98	33	1	39	59	33	9890600
5D	0.750	6.3	97	98	35	1	38	61	28	10245631
5E	**0.750**	6.6	97	98	39	1	36	63	20	10741837
5F	0.750	6.4	97	98	37	1	37	61	28	10412384
5G	0.750	6.1	97	98	35	1	38	61	30	10109340
5H	0.750	6.2	97	98	36	1	38	61	26	10218540
5I	0.750	6.4	97	98	36	1	37	61	27	10431519
5J	0.750	6.3	97	98	36	1	38	61	30	10249414
5K	0.750	6.4	96	98	35	1	38	61	29	10277295
5L	0.750	6.5	97	98	35	1	37	61	29	10419361
5M	0.750	6.2	96	98	33	1	41	58	36	9990873
5N	0.750	5.8	96	98	29	1	46	53	43	9369423

Table F7: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	5.5	96	98	26	2	47	52	49	9056816
5P	0.750	5.2	96	98	25	2	48	51	54	8835836
6A	0.750	4.6	95	98	19	2	52	46	71	7882241
6B	0.750	4.8	96	98	22	2	50	48	63	8214530
6C	0.750	5.1	96	98	24	1	47	51	57	8528693
6D	0.750	5.1	96	98	24	1	47	52	55	8566521
6E	**0.750**	5.4	96	98	27	1	43	55	48	9022230
6F	0.750	5.4	96	98	27	1	43	55	48	9034141
6G	0.750	5.3	96	98	27	1	45	53	51	8839146
6H	0.750	5.2	96	98	25	2	46	52	55	8682619
6I	0.750	5.2	96	98	25	2	47	51	55	8663682
6J	0.750	5.3	96	98	26	1	46	52	53	8869486
6K	0.750	5.5	96	98	27	1	46	52	48	9023974
6L	0.750	5.2	96	98	25	1	49	49	58	8605149
6M	0.750	5.0	96	98	23	2	51	47	63	8297841
6N	0.750	4.9	96	98	22	2	52	46	66	8159304
6O	0.750	4.7	96	98	20	2	55	44	71	7864690
6P	0.750	4.6	96	98	19	2	55	43	76	7673156
7A	0.750	4.1	95	97	14	2	59	39	88	7049694
7B	0.750	4.2	95	97	14	2	60	38	87	7080583
7C	0.750	4.8	96	98	18	2	53	45	76	7765754
7D	0.750	4.4	95	98	17	2	57	42	80	7413939
7E	**0.750**	4.5	95	98	17	2	57	42	79	7454103
7F	0.750	4.7	96	98	19	2	54	44	73	7763664
7G	0.750	4.7	96	98	20	2	53	46	72	7841666
7H	0.750	4.7	96	98	20	2	54	44	74	7778051
7I	0.750	4.5	95	98	18	2	56	42	79	7526007
7J	0.750	4.7	96	98	20	2	54	44	73	7811993
7K	0.750	4.7	96	98	20	2	55	44	74	7777160
7L	0.750	4.4	95	98	18	2	58	40	81	7396997
7M	0.750	4.3	95	98	17	2	59	39	84	7277879
7N	0.750	4.5	95	98	18	2	57	41	79	7520910
7O	0.750	4.1	95	97	13	2	63	35	92	6811933
7P	0.750	4.1	95	97	15	2	62	36	91	6993960
8A	0.750	4.0	95	97	11	2	63	36	95	6704435
8B	0.750	4.0	94	97	11	2	63	35	94	6705382
8C	0.750	4.0	95	97	11	2	64	34	93	6679617
8D	0.750	4.2	95	97	14	2	60	38	89	7000988
8E	**0.750**	4.1	95	97	14	2	62	36	90	6881817
8F	0.750	4.2	95	97	15	2	61	38	88	7037442
8G	0.750	4.3	95	98	16	2	58	40	85	7304787
8H	0.750	4.3	95	98	17	2	58	40	85	7289265
8I	0.750	4.3	95	98	17	2	58	40	86	7280914
8J	0.750	4.4	95	98	17	2	58	40	85	7271642
8K	0.750	4.3	95	98	16	2	60	39	87	7148440
8L	0.750	4.2	95	97	15	2	62	37	90	7001328
8M	0.750	4.1	95	97	13	2	63	35	93	6786984
8N	0.750	3.9	95	97	11	2	66	32	95	6538865
8O	0.750	3.8	95	97	10	2	68	30	97	6384970
8P	0.750	3.7	95	97	9	2	70	29	98	6249024
9A	0.750	3.7	94	97	8	2	68	30	97	6259029
9B	0.750	3.8	94	97	8	2	67	31	97	6329650
9C	0.750	3.8	94	97	9	2	67	31	97	6357380
9D	0.750	3.9	95	97	10	2	65	34	96	6577988
9E	**0.750**	4.1	95	97	13	2	62	36	93	6832302
9F	0.750	4.1	95	97	13	2	61	37	92	6958334
9G	0.750	3.9	95	97	12	2	64	35	95	6677640
9H	0.750	4.0	95	97	12	2	63	35	94	6718555
9I	0.750	4.1	95	97	14	2	62	36	92	6875780
9J	0.750	4.0	95	97	13	2	64	35	95	6732018
9K	0.750	4.1	95	97	13	2	63	35	93	6834592
9L	0.750	3.9	95	97	11	2	65	33	96	6601373
9M	0.750	3.9	95	97	11	2	67	32	96	6516186
9N	0.750	3.7	95	97	9	2	69	29	97	6276260
9O	0.750	3.7	95	97	8	2	70	28	97	6227362
9P	0.750	3.4	94	97	5	2	73	25	97	5821741
10A	0.750	3.7	94	97	8	2	69	29	98	6226914
10B	0.750	3.8	94	97	8	2	67	32	98	6385697
10C	0.750	3.7	95	97	9	2	67	31	97	6397486
10D	0.750	4.0	95	97	11	2	64	35	96	6716786
10E	**0.750**	4.1	95	97	13	2	62	37	92	6893989
10F	0.750	4.0	95	97	13	2	62	37	92	6900284
10G	0.750	4.2	95	98	14	2	60	38	91	7046152
10H	0.750	4.1	95	98	15	2	60	38	92	7055259
10I	0.750	4.1	95	98	14	2	60	38	93	7013853
10J	0.750	4.0	95	97	13	2	62	36	94	6866598
10K	0.750	3.9	95	97	12	2	64	34	96	6689098
10L	0.750	3.9	95	97	12	2	65	34	96	6663234

F8: Detail DAYSIM result of SFW2

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	6.9	96	98	46	1	31	68	1	12487619
1B	0.750	21.0	99	99	80	1	10	89	0	40868560
1C	0.750	27.3	99	99	88	1	6	93	0	53803656
1D	0.750	24.5	99	99	87	1	7	92	0	47564900
1E	**0.750**	19.4	99	99	84	1	9	90	0	36127988
1F	0.750	27.4	99	99	89	1	6	93	0	53516236
1G	0.750	25.5	99	99	86	1	7	92	0	49392764
1H	0.750	10.3	98	99	63	1	19	80	0	18442276
1I	0.750	11.6	98	99	69	1	17	83	0	22842716
1J	0.750	26.4	99	99	87	1	7	92	0	52400752
1K	0.750	27.1	99	99	88	1	6	93	0	52936308
1L	0.750	17.5	98	99	83	1	10	89	0	33022670
1M	0.750	25.3	99	99	87	1	7	92	0	50017912
1N	0.750	27.4	99	99	88	1	6	93	0	53306456
1O	0.750	19.0	99	99	78	1	12	87	0	35609336
1P	0.750	6.4	97	98	41	1	37	61	26	11228958
2A	0.750	9.2	98	99	59	1	23	76	0	18642698
2B	0.750	13.2	98	99	72	1	16	83	0	28246404
2C	0.750	16.6	98	99	76	1	12	87	0	33630280
2D	0.750	16.2	98	99	79	1	11	88	0	32575032
2E	**0.750**	15.9	98	99	78	1	11	88	0	32390924
2F	0.750	16.8	98	99	79	1	11	88	0	35197792
2G	0.750	15.4	98	99	75	1	13	86	0	30352764
2H	0.750	12.1	98	99	71	1	14	85	0	25492908
2I	0.750	12.2	98	99	72	1	14	85	0	25322824
2J	0.750	15.8	98	99	77	1	12	87	0	32847160
2K	0.750	17.1	98	99	80	1	11	88	0	34485568
2L	0.750	15.6	98	99	78	1	11	88	0	31803132
2M	0.750	16.2	98	99	79	1	11	88	0	32692520
2N	0.750	16.1	98	99	75	1	13	86	0	33238900
2O	0.750	12.7	98	99	65	1	17	82	0	26026888
2P	0.750	8.8	98	99	54	1	26	72	0	16738924
3A	0.750	8.1	97	99	52	1	25	74	0	16262636
3B1	0.750	9.6	98	99	60	1	23	76	0	18911592
3C	0.750	10.7	98	99	63	1	20	79	0	20472122
3D	0.750	11.0	98	99	64	1	18	81	0	21255076
3E	**0.750**	11.2	98	99	65	1	17	83	0	21909836
3F	0.750	11.3	98	99	66	1	16	83	0	21480376
3G	0.750	10.8	98	99	64	1	17	82	0	20211734
3H	0.750	9.9	98	99	62	1	19	80	0	19191330
3I	0.750	10.1	98	99	63	1	19	80	0	19565780
3J	0.750	11.2	98	99	65	1	17	82	0	20923864
3K	0.750	11.3	98	99	65	1	17	82	0	22937740
3L	0.750	11.4	98	99	64	1	17	82	0	21934868
3M	0.750	11.2	98	99	64	1	18	81	0	21436148
3N	0.750	10.6	98	99	59	1	21	78	0	19918556
3O	0.750	9.2	98	99	54	1	25	74	0	17478528
3P	0.750	8.0	97	98	50	1	29	70	0	14190924
4A	0.750	6.9	97	98	44	1	30	68	8	11799022
4B	0.750	7.5	97	98	47	1	30	69	0	12695218
4C	0.750	8.1	97	98	51	1	27	71	0	13376536
4D	0.750	8.3	97	98	53	1	27	71	0	13607545
4E	**0.750**	8.6	97	99	55	1	26	73	0	13622699
4F	0.750	8.4	97	99	54	1	27	72	0	14237706
4G	0.750	8.5	97	99	54	1	26	73	0	14360475
4H	0.750	8.0	97	99	52	1	28	71	0	13584869
4I	0.750	8.2	97	99	54	1	26	73	0	13705867
4J	0.750	8.3	97	99	53	1	27	72	0	14133933
4K	0.750	8.5	98	99	54	1	27	71	0	14234239
4L	0.750	8.5	98	99	52	1	28	71	0	13454358
4M	0.750	8.3	97	98	49	1	29	69	0	13271199
4N	0.750	7.9	97	98	47	1	31	68	0	12742845
4O	0.750	7.2	97	98	43	1	33	65	15	12013793
4P	0.750	6.6	97	98	40	1	36	63	27	11045049
5A	0.750	5.8	96	98	34	1	39	60	34	9980885
5B	0.750	6.1	97	98	35	1	38	60	32	10132548
5C	0.750	6.3	97	98	37	1	37	62	25	10499761
5D	0.750	6.6	97	98	40	1	36	63	17	10860704
5E	**0.750**	6.9	97	98	42	1	35	64	12	11233933
5F	0.750	6.8	97	98	40	1	36	62	18	10976376
5G	0.750	7.0	97	98	43	1	34	65	9	11440664
5H	0.750	6.9	97	98	43	1	34	65	11	11278299
5I	0.750	6.9	97	98	42	1	35	64	14	11309258
5J	0.750	7.0	97	98	43	1	34	65	12	11492035
5K	0.750	6.9	97	98	41	1	35	63	15	11155179
5L	0.750	6.8	97	98	40	1	35	63	20	11010616
5M	0.750	6.7	97	98	39	1	36	63	22	10904452
5N	0.750	6.3	96	98	35	1	40	58	31	10176930

***Table F8** Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	6.0	96	98	32	1	42	56	37	9873290
5P	0.750	5.7	96	98	30	1	42	56	43	9646645
6A	0.750	5.2	96	98	25	1	44	54	56	8854969
6B	0.750	5.3	96	98	25	1	45	53	55	8736618
6C	0.750	5.5	96	98	27	1	44	55	50	9034217
6D	0.750	5.6	96	98	30	1	41	57	42	9434836
6E	**0.750**	5.8	96	98	31	1	41	58	40	9596878
6F	0.750	5.9	96	98	32	1	41	58	38	9701393
6G	0.750	5.9	96	98	33	1	40	58	37	9781581
6H	0.750	5.9	96	98	32	1	40	58	37	9713243
6I	0.750	5.7	96	98	30	1	42	56	41	9422840
6J	0.750	5.8	96	98	30	1	42	57	39	9513628
6K	0.750	5.8	96	98	30	1	42	56	41	9461881
6L	0.750	5.7	96	98	29	2	45	54	44	9262327
6M	0.750	5.6	96	98	28	1	45	53	46	9182451
6N	0.750	5.4	96	98	26	2	48	51	50	8924075
6O	0.750	5.1	96	98	24	2	49	49	59	8506882
6P	0.750	5.0	96	98	23	2	49	49	61	8443976
7A	0.750	4.6	95	98	18	2	53	46	78	7726547
7B	0.750	4.8	96	98	20	1	51	47	71	7980147
7C	0.750	5.0	96	98	21	2	49	50	68	8171495
7D	0.750	5.0	96	98	22	2	49	50	64	8258418
7E	**0.750**	5.2	96	98	24	2	47	52	60	8534073
7F	0.750	5.2	96	98	24	1	46	52	58	8622225
7G	0.750	5.1	96	98	23	2	48	50	62	8436091
7H	0.750	5.1	96	98	23	2	48	50	62	8447878
7I	0.750	5.1	96	98	24	2	48	50	61	8500546
7J	0.750	5.2	96	98	24	2	48	50	60	8557216
7K	0.750	5.1	96	98	23	2	50	49	64	8355555
7L	0.750	5.0	96	98	23	2	50	48	64	8271746
7M	0.750	4.9	96	98	22	2	52	47	67	8131414
7N	0.750	4.8	96	98	21	2	54	45	72	7896062
7O	0.750	4.5	95	98	18	2	57	41	82	7478584
7P	0.750	4.4	95	98	18	2	58	41	86	7417949
8A	0.750	4.3	95	98	14	2	58	41	89	7178887
8B	0.750	4.4	95	98	15	2	57	42	87	7295385
8C	0.750	4.7	95	98	16	2	54	44	82	7554855
8D	0.750	4.5	95	98	17	2	55	43	80	7558167
8E	**0.750**	4.6	95	98	18	2	53	46	76	7768324
8F	0.750	4.8	96	98	20	2	51	48	72	7975224
8G	0.750	4.5	95	98	18	2	55	44	79	7621243
8H	0.750	4.8	96	98	21	2	51	47	72	8004605
8I	0.750	4.6	95	98	19	2	54	44	78	7667816
8J	0.750	4.6	96	98	19	2	54	44	78	7675874
8K	0.750	4.6	96	98	19	2	54	44	77	7696844
8L	0.750	4.6	95	98	19	2	56	43	80	7564780
8M	0.750	4.3	95	98	16	2	58	40	86	7250976
8N	0.750	4.3	95	97	15	2	60	39	89	7103323
8O	0.750	4.2	95	97	14	2	61	38	91	6997551
8P	0.750	4.1	95	97	14	2	61	37	93	6975830
9A	0.750	4.1	95	97	11	2	61	38	96	6850232
9B	0.750	4.3	95	97	13	2	60	39	92	7017010
9C	0.750	4.3	95	97	13	2	59	40	90	7116771
9D	0.750	4.3	95	98	14	2	58	40	89	7161662
9E	**0.750**	4.4	95	98	16	2	57	42	86	7375412
9F	0.750	4.5	95	98	17	2	55	44	83	7572137
9G	0.750	4.4	95	98	16	2	57	41	87	7322759
9H	0.750	4.5	95	98	17	2	56	43	83	7520474
9I	0.750	4.5	96	98	18	2	55	43	82	7553034
9J	0.750	4.6	96	98	19	2	54	44	79	7697520
9K	0.750	4.4	95	98	17	2	57	42	87	7342837
9L	0.750	4.3	95	98	16	2	58	40	89	7229240
9M	0.750	4.3	95	98	15	2	59	39	90	7132950
9N	0.750	4.0	95	97	12	2	63	36	96	6745060
9O	0.750	3.9	95	97	11	2	64	35	97	6637860
9P	0.750	3.9	95	97	11	2	65	33	97	6573835
10A	0.750	3.9	95	97	10	2	63	35	97	6649277
10B	0.750	4.2	95	98	13	2	58	40	93	7069117
10C	0.750	4.2	95	98	13	2	59	40	91	7110021
10D	0.750	4.3	95	98	14	2	57	41	89	7265241
10E	**0.750**	4.4	95	98	16	2	55	43	86	7442026
10F	0.750	4.5	96	98	17	2	54	44	84	7585819
10G	0.750	4.5	96	98	17	2	55	44	84	7561558
10H	0.750	4.6	96	98	18	2	53	45	82	7704337
10I	0.750	4.6	96	98	19	2	53	45	81	7721243
10J	0.750	4.5	96	98	18	2	55	44	83	7593255
10K	0.750	4.5	96	98	17	2	55	43	85	7513315
10L	0.750	4.3	95	98	16	2	58	41	90	7272515

F9: Detail DAYSIM result of SFW3

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	6.9	96	98	46	1	30	69	1	12372863
1B	0.750	20.9	99	99	80	1	9	90	0	40915328
1C	0.750	27.3	99	99	88	1	6	93	0	54111440
1D	0.750	24.2	99	99	86	1	7	92	0	47545336
1E	**0.750**	18.9	99	99	84	1	9	90	0	35931300
1F	0.750	27.2	99	99	88	1	6	93	0	53962612
1G	0.750	25.5	99	99	86	1	7	92	0	49658008
1H	0.750	10.1	98	99	64	1	19	80	0	18381272
1I	0.750	11.5	98	99	69	1	16	83	0	22927532
1J	0.750	26.0	99	99	87	1	7	92	0	51491224
1K	0.750	27.2	99	99	88	1	6	93	0	53461676
1L	0.750	17.5	98	99	83	1	10	89	0	33289858
1M	0.750	25.2	99	99	87	1	7	92	0	50199708
1N	0.750	27.1	99	99	88	1	6	93	0	53240544
1O	0.750	18.7	99	99	78	1	12	87	0	35465996
1P	0.750	6.4	97	98	42	1	37	62	24	11215758
2A	0.750	8.7	98	99	59	1	24	75	0	17004656
2B	0.750	12.8	98	99	72	1	16	83	0	24070132
2C	0.750	15.9	98	99	76	1	12	87	0	28930880
2D	0.750	15.5	98	99	78	1	11	88	0	27401942
2E	**0.750**	15.1	98	99	78	1	11	88	0	27111436
2F	0.750	16.8	98	99	80	1	11	88	0	31339230
2G	0.750	15.0	98	99	76	1	12	87	0	26646708
2H	0.750	11.7	98	99	70	1	15	85	0	21998564
2I	0.750	12.0	98	99	72	1	14	85	0	22707836
2J	0.750	15.0	98	99	76	1	12	87	0	28254812
2K	0.750	16.5	98	99	79	1	11	88	0	29182012
2L	0.750	15.2	98	99	78	1	11	88	0	27023452
2M	0.750	15.9	98	99	79	1	11	88	0	27884836
2N	0.750	15.7	98	99	76	1	13	86	0	28936912
2O	0.750	12.7	98	99	66	1	17	82	0	22648650
2P	0.750	8.6	97	99	54	1	26	73	0	15679150
3A	0.750	8.1	97	99	54	1	25	74	0	15100060
3B1	0.750	9.7	98	99	60	1	22	77	0	16236960
3C	0.750	10.9	98	99	64	1	19	80	0	17155596
3D	0.750	11.6	98	99	66	1	16	83	0	19818592
3E	**0.750**	11.5	98	99	66	1	16	83	0	20006280
3F	0.750	11.1	98	99	65	1	16	83	0	17442316
3G	0.750	10.9	98	99	65	1	17	82	0	18086510
3H	0.750	10.0	98	99	62	1	19	80	0	18185596
3I	0.750	10.3	98	99	63	1	18	81	0	18673920
3J	0.750	11.1	98	99	65	1	16	83	0	18415960
3K	0.750	11.5	98	99	66	1	16	83	0	19796004
3L	0.750	11.2	98	99	64	1	17	82	0	19563264
3M	0.750	11.3	98	99	65	1	17	82	0	19214344
3N	0.750	10.8	98	99	62	1	19	80	0	16745354
3O	0.750	9.5	98	99	55	1	23	75	0	15562963
3P	0.750	7.8	97	98	50	1	29	70	0	14014019
4A	0.750	7.1	97	98	46	1	30	69	6	11950508
4B	0.750	7.7	97	98	49	1	28	71	0	13493342
4C	0.750	8.4	97	98	53	1	27	72	0	13248944
4D	0.750	8.3	97	98	52	1	28	71	0	13042201
4E	**0.750**	8.9	98	99	57	1	25	74	0	14076454
4F	0.750	8.7	97	99	56	1	26	73	0	13806312
4G	0.750	8.7	98	99	56	1	25	74	0	13867860
4H	0.750	8.5	98	99	56	1	24	75	0	13821009
4I	0.750	8.3	97	99	54	1	27	72	0	13319962
4J	0.750	8.8	98	99	56	1	24	75	0	14010604
4K	0.750	8.7	98	99	55	1	26	73	0	13750395
4L	0.750	8.4	97	98	51	1	28	71	0	13188369
4M	0.750	8.5	97	99	51	1	28	71	0	13323667
4N	0.750	8.3	97	98	49	1	29	70	0	12977334
4O	0.750	7.5	97	98	46	1	32	67	8	12068389
4P	0.750	7.0	97	98	44	1	33	66	20	11634387
5A	0.750	6.2	97	98	38	1	36	63	28	10467266
5B	0.750	6.4	97	98	38	1	36	63	26	10517187
5C	0.750	6.6	97	98	41	1	35	64	19	10884134
5D	0.750	7.0	97	98	43	1	34	64	10	11299596
5E	**0.750**	7.3	97	98	46	1	32	66	1	11801551
5F	0.750	7.4	97	98	45	1	33	66	3	11728595
5G	0.750	7.3	97	98	47	1	32	67	0	11827874
5H	0.750	7.0	97	98	44	1	34	65	8	11406209
5I	0.750	6.8	97	98	42	1	35	63	16	11075126
5J	0.750	7.3	97	98	45	1	33	66	5	11705395
5K	0.750	7.2	97	98	44	1	34	65	7	11544705
5L	0.750	7.2	97	98	43	1	33	66	10	11546649
5M	0.750	6.8	97	98	40	1	35	64	19	11045945
5N	0.750	6.7	97	98	38	1	36	62	24	10722988

Table F9: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	6.3	97	98	35	1	39	59	34	10220966
5P	0.750	6.0	96	98	33	1	40	59	39	10073831
6A	0.750	5.3	96	98	26	1	44	55	56	8896448
6B	0.750	5.4	96	98	28	1	43	56	49	9129617
6C	0.750	5.6	96	98	30	1	42	57	46	9263250
6D	0.750	6.0	96	98	34	1	39	60	36	9856198
6E	**0.750**	6.0	97	98	35	1	38	61	34	9923949
6F	0.750	6.0	97	98	35	1	38	60	34	9907020
6G	0.750	6.1	97	98	36	1	38	61	31	10079159
6H	0.750	6.1	96	98	36	1	38	60	33	10051162
6I	0.750	6.0	96	98	34	1	39	59	36	9872984
6J	0.750	6.2	97	98	35	1	38	61	34	10138876
6K	0.750	6.0	97	98	34	1	39	60	37	9951647
6L	0.750	5.9	96	98	32	1	41	57	40	9651585
6M	0.750	5.7	96	98	29	1	44	55	46	9352996
6N	0.750	5.3	96	98	26	2	48	50	59	8734499
6O	0.750	5.4	96	98	27	2	45	53	54	9060722
6P	0.750	5.1	96	98	24	2	47	51	62	8590982
7A	0.750	4.6	96	98	18	1	52	47	79	7772868
7B	0.750	4.8	96	98	19	1	50	49	75	7948021
7C	0.750	5.2	96	98	24	1	45	53	64	8518043
7D	0.750	5.1	96	98	23	2	47	52	65	8399138
7E	**0.750**	5.1	96	98	24	1	47	52	64	8466468
7F	0.750	5.5	96	98	27	1	44	55	53	8966356
7G	0.750	5.3	96	98	25	1	45	53	59	8706943
7H	0.750	5.5	96	98	27	1	43	55	51	9008586
7I	0.750	5.1	96	98	24	2	47	51	63	8474550
7J	0.750	5.2	96	98	25	2	47	51	61	8633264
7K	0.750	5.3	96	98	25	2	48	51	59	8663052
7L	0.750	5.3	96	98	25	2	48	51	59	8639755
7M	0.750	5.2	96	98	24	2	49	50	63	8452272
7N	0.750	4.8	96	98	21	2	52	46	73	7974913
7O	0.750	4.8	96	98	20	2	53	45	76	7899648
7P	0.750	4.6	96	98	19	2	54	45	81	7730801
8A	0.750	4.5	95	98	16	2	53	45	87	7531510
8B	0.750	4.7	96	98	18	1	52	46	83	7714746
8C	0.750	4.6	95	98	16	2	53	45	86	7574823
8D	0.750	4.8	96	98	19	2	50	48	79	7848378
8E	**0.750**	4.8	96	98	19	2	52	47	77	7844423
8F	0.750	4.9	96	98	21	2	49	50	72	8137855
8G	0.750	4.8	96	98	19	2	51	47	78	7867207
8H	0.750	5.0	96	98	22	2	49	49	72	8182273
8I	0.750	4.9	96	98	21	2	51	48	75	8023690
8J	0.750	4.8	96	98	20	2	52	47	78	7917833
8K	0.750	4.6	96	98	19	2	53	45	81	7693376
8L	0.750	4.6	96	98	18	2	55	44	83	7568141
8M	0.750	4.7	96	98	19	2	54	44	82	7645474
8N	0.750	4.4	95	98	17	2	57	41	89	7364644
8O	0.750	4.3	95	98	15	2	58	40	91	7242244
8P	0.750	4.2	95	98	14	2	59	39	94	7058035
9A	0.750	4.2	95	97	12	2	59	40	96	6967698
9B	0.750	4.3	95	97	12	2	59	40	95	7005734
9C	0.750	4.5	95	98	15	2	56	43	90	7340011
9D	0.750	4.4	95	98	15	2	56	42	90	7289432
9E	**0.750**	4.6	96	98	17	2	53	45	86	7589343
9F	0.750	4.6	96	98	18	2	52	46	85	7702020
9G	0.750	4.6	96	98	18	2	54	45	85	7636086
9H	0.750	4.7	96	98	18	2	53	46	83	7726105
9I	0.750	4.6	96	98	19	2	53	46	83	7702545
9J	0.750	4.6	96	98	19	2	54	45	83	7663153
9K	0.750	4.5	95	98	17	2	56	43	88	7404536
9L	0.750	4.5	95	98	17	2	56	42	88	7425200
9M	0.750	4.2	95	98	14	2	59	39	94	7066172
9N	0.750	4.2	95	97	14	2	60	39	94	6989344
9O	0.750	4.1	95	97	12	2	61	37	96	6846569
9P	0.750	4.0	95	97	10	2	63	36	97	6684266
10A	0.750	4.1	95	97	11	2	60	38	97	6843258
10B	0.750	4.3	95	98	13	2	57	41	95	7115857
10C	0.750	4.6	96	98	15	2	52	46	88	7541887
10D	0.750	4.5	95	98	15	2	54	44	88	7445635
10E	**0.750**	4.5	96	98	17	2	53	46	86	7618428
10F	0.750	4.7	96	98	19	1	51	48	82	7826944
10G	0.750	4.7	96	98	19	1	50	48	81	7895861
10H	0.750	4.7	96	98	19	1	51	48	81	7886899
10I	0.750	4.6	96	98	19	2	52	46	84	7740629
10J	0.750	4.7	96	98	19	2	52	47	81	7874070
10K	0.750	4.7	96	98	19	2	52	46	82	7817858
10L	0.750	4.5	96	98	17	2	55	43	89	7461543

F10: Detail DAYSIM result of CVW1

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.2	92	96	9	2	73	24	92	5725134
1B	0.750	13.8	98	99	66	1	20	78	0	27823552
1C	0.750	19.0	98	99	80	1	10	89	0	38167144
1D	0.750	19.4	99	99	82	1	10	89	0	38523044
1E	**0.750**	19.2	98	99	81	1	10	89	0	38436872
1F	0.750	19.0	98	99	81	1	10	89	0	38208728
1G	0.750	19.4	98	99	82	1	10	89	0	38623428
1H	0.750	19.1	98	99	81	1	10	89	0	38185520
1I	0.750	19.3	98	99	81	1	10	89	0	38475792
1J	0.750	19.1	98	99	81	1	10	89	0	38270776
1K	0.750	19.2	98	99	81	1	10	89	0	38447760
1L	0.750	19.0	98	99	81	1	10	89	0	38051680
1M	0.750	19.1	98	99	81	1	10	89	0	38309512
1N	0.750	18.5	98	99	79	1	11	88	0	37235768
1O	0.750	12.4	98	99	58	1	24	75	0	23708208
1P	0.750	3.0	92	96	2	2	79	19	96	5091544
2A	0.750	4.3	94	97	19	2	59	39	66	8844795
2B	0.750	6.6	96	98	34	1	38	60	28	11552685
2C	0.750	9.0	98	99	53	1	26	73	0	15393821
2D	0.750	9.8	98	99	60	1	20	79	0	17012264
2E	**0.750**	10.0	98	99	61	1	19	80	0	17355692
2F	0.750	10.1	98	99	62	1	18	81	0	17532208
2G	0.750	10.1	98	99	62	1	18	81	0	17533068
2H	0.750	10.0	98	99	61	1	18	81	0	17445478
2I	0.750	10.1	98	99	61	1	18	81	0	17497412
2J	0.750	9.8	98	99	59	1	20	79	0	17029716
2K	0.750	10.1	98	99	61	1	18	81	0	17447332
2L	0.750	9.9	98	99	59	1	19	79	0	17144284
2M	0.750	9.6	98	99	58	1	21	78	0	16688135
2N	0.750	8.6	97	98	48	1	29	70	0	14638598
2O	0.750	6.2	96	98	28	1	45	53	45	10549434
2P	0.750	4.0	95	97	13	2	66	33	77	7853525
3A	0.750	3.7	93	97	13	2	67	31	91	6537903
3B1	0.750	4.3	94	97	15	2	61	37	82	7085885
3C	0.750	5.1	96	98	23	2	50	49	62	8246535
3D	0.750	5.5	96	98	25	1	45	54	55	8765026
3E	**0.750**	5.7	96	98	27	1	42	56	49	9111055
3F	0.750	5.8	96	98	30	1	41	58	46	9413352
3G	0.750	5.9	96	98	31	1	41	58	42	9511982
3H	0.750	6.0	96	98	31	1	39	59	39	9696917
3I	0.750	5.9	96	98	30	1	41	58	42	9510655
3J	0.750	5.9	96	98	30	1	41	58	43	9448530
3K	0.750	5.9	96	98	30	1	40	59	44	9510911
3L	0.750	5.8	96	98	27	1	43	56	49	9199906
3M	0.750	5.6	96	98	25	1	47	51	55	8822754
3N	0.750	4.9	96	98	20	2	55	43	75	7763978
3O	0.750	4.1	95	97	13	2	67	32	93	6613975
3P	0.750	3.6	94	97	9	2	72	26	97	6087957
4A	0.750	3.2	92	96	5	2	76	22	97	5500026
4B	0.750	3.3	92	96	5	2	77	21	97	5506117
4C	0.750	3.6	93	97	8	2	72	26	97	5972042
4D	0.750	4.1	95	97	12	2	64	34	95	6684971
4E	**0.750**	4.0	95	97	12	2	65	34	96	6597972
4F	0.750	4.2	95	97	14	2	62	37	92	6884442
4G	0.750	4.2	95	97	14	2	62	37	92	6886865
4H	0.750	4.4	95	98	16	2	59	40	90	7147275
4I	0.750	4.5	95	98	17	2	58	40	88	7240477
4J	0.750	4.3	95	97	14	2	62	37	93	6901554
4K	0.750	4.3	95	97	15	2	61	37	92	6963955
4L	0.750	4.2	95	97	13	2	65	33	95	6693204
4M	0.750	3.8	95	97	9	2	70	28	98	6186207
4N	0.750	3.6	94	97	7	2	73	25	97	5920469
4O	0.750	3.2	94	97	3	2	77	21	97	5331251
4P	0.750	3.1	93	97	2	2	79	19	97	5164188
5A	0.750	2.7	91	96	0	3	84	13	96	4626368
5B	0.750	2.8	91	96	1	3	84	14	96	4709341
5C	0.750	3.0	91	96	2	2	81	16	96	4940299
5D	0.750	3.1	92	96	3	2	79	18	97	5197818
5E	**0.750**	3.3	93	97	4	2	77	21	97	5418614
5F	0.750	3.5	94	97	6	2	74	24	97	5792025
5G	0.750	3.3	93	97	4	2	76	22	97	5509828
5H	0.750	3.5	94	97	6	2	74	24	97	5787201
5I	0.750	3.5	94	97	5	2	74	24	97	5757437
5J	0.750	3.5	94	97	5	2	74	24	97	5650610
5K	0.750	3.3	94	97	4	2	76	22	97	5496755
5L	0.750	3.2	93	97	2	2	78	20	97	5281172
5M	0.750	3.1	93	97	2	2	78	20	97	5184667
5N	0.750	2.8	92	96	0	2	82	16	96	4748404

Table F10: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	2.7	92	96	0	3	84	13	96	4514519
5P	0.750	2.6	92	96	0	3	86	11	96	4353936
6A	0.750	2.4	90	95	0	3	90	7	95	4075029
6B	0.750	2.3	89	95	0	3	90	7	95	3948860
6C	0.750	2.7	90	96	0	3	86	11	96	4397293
6D	0.750	2.6	90	95	0	3	86	11	96	4356921
6E	**0.750**	2.8	91	96	0	3	84	14	96	4603895
6F	0.750	2.8	91	96	0	2	83	14	96	4697399
6G	0.750	2.8	91	96	0	2	83	15	96	4695019
6H	0.750	2.8	91	96	0	2	83	15	96	4671639
6I	0.750	2.8	92	96	0	2	82	15	96	4741520
6J	0.750	2.8	92	96	0	2	83	15	96	4684121
6K	0.750	2.8	92	96	0	2	83	15	96	4686359
6L	0.750	2.7	91	96	0	3	85	13	96	4442656
6M	0.750	2.6	91	96	0	3	87	11	96	4264273
6N	0.750	2.4	90	96	0	3	89	9	96	4063131
6O	0.750	2.4	90	95	0	3	90	7	95	3951153
6P	0.750	2.3	91	96	0	3	91	6	95	3952110
7A	0.750	2.2	88	95	0	3	93	3	95	3671419
7B	0.750	2.2	89	95	0	3	92	5	95	3738723
7C	0.750	2.4	89	95	0	3	91	6	95	3916752
7D	0.750	2.3	89	95	0	3	91	6	95	3931464
7E	**0.750**	2.5	90	95	0	3	88	9	96	4232211
7F	0.750	2.5	90	95	0	3	89	9	96	4125641
7G	0.750	2.5	90	96	0	3	88	10	96	4269070
7H	0.750	2.6	91	96	0	3	87	10	96	4318889
7I	0.750	2.6	91	96	0	3	87	10	96	4297435
7J	0.750	2.5	91	96	0	3	88	9	96	4223672
7K	0.750	2.4	90	95	0	3	90	7	96	4007337
7L	0.750	2.4	90	95	0	3	91	6	95	3944511
7M	0.750	2.2	89	95	0	3	93	4	95	3705158
7N	0.750	2.1	88	95	0	3	94	2	94	3572691
7O	0.750	2.1	88	95	0	3	95	1	94	3458233
7P	0.750	2.0	89	95	0	3	96	1	94	3478194
8A	0.750	2.2	88	94	0	3	96	1	95	3509646
8B	0.750	2.1	88	94	0	3	95	1	95	3393700
8C	0.750	2.4	90	95	0	3	94	3	95	3806312
8D	0.750	2.3	89	95	0	3	94	3	95	3719002
8E	**0.750**	2.2	89	95	0	3	93	4	95	3722699
8F	0.750	2.2	88	95	0	3	94	3	95	3604000
8G	0.750	2.3	89	95	0	3	92	5	95	3839407
8H	0.750	2.3	89	95	0	3	92	5	95	3879977
8I	0.750	2.3	89	95	0	3	92	5	95	3825996
8J	0.750	2.2	89	95	0	3	93	4	95	3716982
8K	0.750	2.2	89	95	0	3	93	4	95	3725765
8L	0.750	2.1	88	95	0	3	94	2	95	3597876
8M	0.750	2.1	88	95	0	3	95	2	95	3542722
8N	0.750	1.9	87	94	0	4	96	0	94	3257453
8O	0.750	1.9	87	94	0	4	96	0	94	3204400
8P	0.750	1.9	87	94	0	4	96	0	94	3162463
9A	0.750	2.1	88	94	0	3	97	0	95	3379081
9B	0.750	2.1	88	94	0	3	96	1	95	3471102
9C	0.750	2.1	88	94	0	3	96	0	95	3357025
9D	0.750	2.1	88	94	0	3	95	2	95	3452545
9E	**0.750**	2.1	88	94	0	3	94	2	95	3543838
9F	0.750	2.1	88	95	0	3	94	3	95	3618218
9G	0.750	2.1	88	95	0	3	94	2	95	3548437
9H	0.750	2.1	88	94	0	3	95	2	95	3494778
9I	0.750	2.2	89	95	0	3	94	3	95	3681408
9J	0.750	2.1	88	95	0	3	94	2	95	3573672
9K	0.750	2.1	88	95	0	3	95	1	94	3449453
9L	0.750	2.1	88	95	0	3	96	1	95	3475426
9M	0.750	2.0	88	94	0	4	96	0	94	3281053
9N	0.750	1.9	87	94	0	4	96	0	94	3147750
9O	0.750	1.8	86	94	0	4	96	0	93	2953078
9P	0.750	1.8	86	94	0	4	96	0	93	3008749
10A	0.750	2.0	88	94	0	3	97	0	94	3314145
10B	0.750	2.1	89	95	0	3	96	1	95	3496145
10C	0.750	2.1	88	94	0	3	96	1	95	3476748
10D	0.750	2.1	88	94	0	3	96	1	95	3435968
10E	**0.750**	2.2	89	95	0	3	94	3	95	3671879
10F	0.750	2.2	89	95	0	3	94	4	95	3783834
10G	0.750	2.2	89	95	0	3	94	3	95	3686053
10H	0.750	2.3	90	95	0	3	93	4	95	3887573
10I	0.750	2.2	89	95	0	3	94	3	95	3711542
10J	0.750	2.3	90	95	0	3	93	4	95	3824588
10K	0.750	2.2	89	95	0	3	95	2	95	3678733
10L	0.750	2.1	88	95	0	3	96	1	95	3478650

F11: Detail DAYSIM result of CVW2

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.5	92	96	12	2	69	29	92	6216495
1B	0.750	15.3	98	99	73	1	15	84	0	30295286
1C	0.750	20.3	99	99	84	1	9	90	0	40770632
1D	0.750	20.4	99	99	85	1	9	90	0	40806616
1E	**0.750**	20.7	99	99	85	1	9	91	0	41052260
1F	0.750	20.8	99	99	85	1	8	91	0	41181540
1G	0.750	20.5	99	99	85	1	9	90	0	40828488
1H	0.750	20.8	99	99	85	1	8	91	0	41197924
1I	0.750	20.7	99	99	85	1	8	91	0	41071000
1J	0.750	20.6	99	99	85	1	8	91	0	40963612
1K	0.750	20.8	99	99	85	1	8	91	0	41107136
1L	0.750	20.7	99	99	85	1	8	91	0	41039872
1M	0.750	20.6	99	99	85	1	8	91	0	41012284
1N	0.750	20.2	99	99	83	1	9	90	0	40167016
1O	0.750	13.5	98	99	63	1	18	81	0	25487096
1P	0.750	3.1	93	97	4	2	76	22	97	5447231
2A	0.750	4.3	94	97	20	2	57	41	64	8977447
2B	0.750	6.8	96	98	35	1	37	61	25	11843875
2C	0.750	8.8	97	99	54	1	26	73	0	15323127
2D	0.750	9.6	98	99	60	1	20	79	0	16963940
2E	**0.750**	9.8	98	99	60	1	19	80	0	17191354
2F	0.750	10.1	98	99	63	1	18	81	0	17705572
2G	0.750	9.9	98	99	62	1	18	81	0	17450294
2H	0.750	10.1	98	99	63	1	18	81	0	17719864
2I	0.750	10.0	98	99	62	1	18	81	0	17582872
2J	0.750	10.1	98	99	62	1	18	81	0	17589544
2K	0.750	9.7	98	99	59	1	20	79	0	17080294
2L	0.750	9.7	98	99	59	1	19	79	0	17059346
2M	0.750	9.6	98	99	59	1	20	79	0	16828456
2N	0.750	8.7	97	99	50	1	27	71	0	14956136
2O	0.750	6.7	97	98	33	1	41	57	39	11277312
2P	0.750	4.2	95	97	16	2	62	37	76	8167574
3A	0.750	3.9	94	97	14	2	65	34	87	6724451
3B1	0.750	4.5	95	97	17	2	57	41	76	7434509
3C	0.750	5.1	96	98	22	2	49	49	61	8256785
3D	0.750	5.7	96	98	28	1	42	57	46	9193098
3E	**0.750**	6.0	96	98	30	1	41	58	39	9501114
3F	0.750	6.0	97	98	33	1	39	60	37	9800019
3G	0.750	6.3	97	98	35	1	36	62	31	10193054
3H	0.750	6.3	97	98	35	1	37	62	33	10109780
3I	0.750	6.1	96	98	33	1	38	60	36	9937758
3J	0.750	6.3	97	98	34	1	37	62	33	10106661
3K	0.750	6.1	97	98	32	1	39	60	38	9836585
3L	0.750	5.9	96	98	28	1	41	58	48	9337244
3M	0.750	5.6	96	98	26	1	47	52	52	8933404
3N	0.750	5.1	96	98	21	2	52	46	68	8088462
3O	0.750	4.4	95	97	16	2	61	37	85	7121999
3P	0.750	3.8	95	97	12	2	68	30	95	6516746
4A	0.750	3.4	93	97	7	2	74	24	97	5808968
4B	0.750	3.7	93	97	9	2	71	27	97	6107452
4C	0.750	4.0	94	97	11	2	66	32	95	6510625
4D	0.750	4.1	95	97	13	2	63	36	92	6737978
4E	**0.750**	4.4	95	98	16	2	59	39	87	7176022
4F	0.750	4.6	95	98	17	2	57	41	83	7399251
4G	0.750	4.4	95	98	16	2	58	40	85	7232037
4H	0.750	4.6	95	98	18	2	56	42	81	7476247
4I	0.750	4.6	95	98	18	2	55	43	81	7538591
4J	0.750	4.6	95	98	18	2	56	43	82	7497323
4K	0.750	4.4	95	98	16	2	59	39	88	7152026
4L	0.750	4.4	95	98	16	2	60	39	89	7141035
4M	0.750	4.0	95	97	12	2	66	33	95	6541791
4N	0.750	3.8	95	97	9	2	70	28	97	6207769
4O	0.750	3.4	94	97	5	2	74	24	97	5701181
4P	0.750	3.3	94	97	4	2	76	22	97	5531057
5A	0.750	3.0	92	96	2	2	81	17	97	5073054
5B	0.750	3.1	91	96	3	2	79	19	97	5146687
5C	0.750	3.2	92	96	3	2	78	19	97	5302254
5D	0.750	3.4	93	97	5	2	75	23	97	5614823
5E	**0.750**	3.6	94	97	7	2	72	26	97	5904267
5F	0.750	3.6	94	97	7	2	72	26	97	5970494
5G	0.750	3.6	94	97	7	2	72	26	97	5956189
5H	0.750	3.7	94	97	8	2	70	28	97	6113604
5I	0.750	3.8	95	97	9	2	69	29	97	6257197
5J	0.750	3.7	95	97	8	2	70	28	97	6132419
5K	0.750	3.5	94	97	6	2	73	25	97	5802618
5L	0.750	3.5	94	97	5	2	74	24	97	5734099
5M	0.750	3.3	94	97	3	2	76	22	97	5464286
5N	0.750	3.1	93	97	2	2	78	19	97	5105451

Table F11: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	2.9	93	96	0	2	81	17	96	4912740
5P	0.750	2.9	93	96	0	2	81	17	96	4897572
6A	0.750	2.7	91	96	0	3	86	11	96	4519223
6B	0.750	2.7	90	96	0	3	85	12	96	4509871
6C	0.750	2.8	91	96	0	2	84	13	96	4687030
6D	0.750	2.9	91	96	0	2	83	14	96	4783807
6E	**0.750**	3.0	91	96	1	2	82	16	96	4895227
6F	0.750	3.0	92	96	2	2	80	18	97	5014005
6G	0.750	3.1	92	96	2	2	80	18	97	5116922
6H	0.750	3.1	92	96	2	2	79	18	97	5114472
6I	0.750	3.1	93	97	2	2	79	19	97	5164533
6J	0.750	3.1	93	97	2	2	79	19	97	5115303
6K	0.750	3.0	93	97	1	2	79	18	97	5077043
6L	0.750	2.9	92	96	0	2	82	16	96	4827936
6M	0.750	2.8	92	96	0	2	83	14	96	4609892
6N	0.750	2.6	91	96	0	3	86	12	96	4412023
6O	0.750	2.6	92	96	0	3	87	10	96	4306632
6P	0.750	2.5	92	96	0	3	88	9	96	4269092
7A	0.750	2.4	90	95	0	3	91	6	96	4093861
7B	0.750	2.5	90	95	0	3	90	7	96	4095005
7C	0.750	2.6	90	95	0	3	89	9	96	4259235
7D	0.750	2.6	90	95	0	3	88	10	96	4284328
7E	**0.750**	2.6	90	96	0	3	87	11	96	4351387
7F	0.750	2.6	90	96	0	3	87	11	96	4371537
7G	0.750	2.8	91	96	0	3	84	13	96	4557047
7H	0.750	2.8	91	96	0	2	84	13	96	4593046
7I	0.750	2.7	91	96	0	3	85	12	96	4477347
7J	0.750	2.7	91	96	0	2	85	13	96	4520785
7K	0.750	2.7	91	96	0	3	86	12	96	4455509
7L	0.750	2.6	91	96	0	3	88	10	96	4255305
7M	0.750	2.5	91	96	0	3	89	9	96	4179294
7N	0.750	2.4	90	96	0	3	91	7	96	3981371
7O	0.750	2.3	90	95	0	3	93	4	95	3821804
7P	0.750	2.3	90	96	0	3	93	4	95	3895952
8A	0.750	2.3	89	95	0	3	93	4	95	3851977
8B	0.750	2.4	89	95	0	3	93	4	95	3827153
8C	0.750	2.4	90	95	0	3	92	5	96	3951438
8D	0.750	2.5	90	95	0	3	91	6	96	4033503
8E	**0.750**	2.5	90	95	0	3	90	7	96	4108652
8F	0.750	2.5	90	96	0	3	88	9	96	4230228
8G	0.750	2.5	90	95	0	3	89	8	96	4164617
8H	0.750	2.5	90	95	0	3	89	8	96	4162449
8I	0.750	2.5	90	96	0	3	89	8	96	4153823
8J	0.750	2.4	90	95	0	3	90	7	96	4064116
8K	0.750	2.5	90	96	0	3	90	7	96	4081989
8L	0.750	2.4	90	95	0	3	92	6	95	3940631
8M	0.750	2.3	89	95	0	3	93	4	95	3811563
8N	0.750	2.1	88	95	0	3	95	2	95	3563786
8O	0.750	2.1	88	95	0	3	96	1	94	3473948
8P	0.750	2.1	89	95	0	3	96	1	94	3478124
9A	0.750	2.2	89	95	0	3	95	2	95	3644891
9B	0.750	2.2	89	95	0	3	95	2	95	3667200
9C	0.750	2.2	89	95	0	3	94	2	95	3657900
9D	0.750	2.2	88	95	0	3	94	3	95	3625117
9E	**0.750**	2.3	89	95	0	3	92	5	95	3887950
9F	0.750	2.3	90	95	0	3	92	5	95	3951141
9G	0.750	2.4	90	95	0	3	91	6	96	4000281
9H	0.750	2.3	89	95	0	3	92	5	95	3894234
9I	0.750	2.5	90	96	0	3	91	7	96	4099223
9J	0.750	2.4	90	95	0	3	92	5	95	3934157
9K	0.750	2.3	90	95	0	3	93	4	95	3859617
9L	0.750	2.3	89	95	0	3	94	3	95	3792165
9M	0.750	2.1	88	95	0	3	96	1	94	3454135
9N	0.750	2.0	88	94	0	3	96	0	94	3335584
9O	0.750	2.0	88	95	0	3	96	0	94	3368239
9P	0.750	2.0	88	95	0	4	96	0	94	3300983
10A	0.750	2.2	89	95	0	3	95	2	95	3638534
10B	0.750	2.4	89	95	0	3	94	3	95	3793654
10C	0.750	2.2	89	95	0	3	94	3	95	3669506
10D	0.750	2.3	89	95	0	3	94	3	95	3764197
10E	**0.750**	2.4	90	95	0	3	92	5	96	3961111
10F	0.750	2.4	90	95	0	3	92	5	96	3973941
10G	0.750	2.5	90	96	0	3	90	7	96	4129249
10H	0.750	2.4	90	95	0	3	92	6	96	4007412
10I	0.750	2.4	90	96	0	3	91	6	96	4045177
10J	0.750	2.4	90	96	0	3	91	6	96	4089081
10K	0.750	2.4	91	96	0	3	91	6	96	4088307
10L	0.750	2.3	90	95	0	3	93	4	95	3871359

F12: Detail DAYSIM result of CVW3

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	3.9	93	97	16	2	63	36	83	6885178
1B	0.750	15.7	98	99	73	1	14	85	0	30861484
1C	0.750	20.6	99	99	85	1	9	90	0	41285136
1D	0.750	20.8	99	99	85	1	8	91	0	41442052
1E	**0.750**	20.9	99	99	85	1	8	91	0	41440520
1F	0.750	21.0	99	99	85	1	8	91	0	41602884
1G	0.750	20.9	99	99	85	1	8	91	0	41466872
1H	0.750	20.9	99	99	85	1	8	91	0	41527180
1I	0.750	20.7	99	99	85	1	8	91	0	41364092
1J	0.750	20.8	99	99	85	1	8	91	0	41455776
1K	0.750	21.0	99	99	85	1	8	91	0	41559392
1L	0.750	20.9	99	99	85	1	8	91	0	41434532
1M	0.750	20.9	99	99	85	1	8	91	0	41449320
1N	0.750	20.5	99	99	84	1	9	91	0	40765928
1O	0.750	13.8	98	99	64	1	17	81	0	26050024
1P	0.750	3.5	94	97	9	2	70	28	97	6128851
2A	0.750	4.8	95	98	23	2	51	47	56	9676057
2B	0.750	7.3	97	98	41	1	32	66	14	12691572
2C	0.750	9.2	98	99	56	1	24	75	0	15928284
2D	0.750	10.1	98	99	62	1	18	80	0	17682836
2E	**0.750**	10.1	98	99	63	1	18	81	0	17809224
2F	0.750	10.2	98	99	63	1	18	81	0	17827628
2G	0.750	10.6	98	99	64	1	17	82	0	18504170
2H	0.750	10.5	98	99	64	1	17	82	0	18409628
2I	0.750	10.5	98	99	64	1	17	82	0	18307764
2J	0.750	10.7	98	99	65	1	16	83	0	18546358
2K	0.750	10.4	98	99	63	1	17	82	0	18203818
2L	0.750	10.2	98	99	62	1	18	81	0	17818072
2M	0.750	10.0	98	99	60	1	19	80	0	17471016
2N	0.750	9.3	98	99	53	1	24	74	0	15825056
2O	0.750	6.9	97	98	35	1	40	59	33	11614076
2P	0.750	4.5	95	98	18	2	55	43	71	8760524
3A	0.750	4.2	94	97	17	2	58	40	79	7333576
3B1	0.750	4.9	95	98	21	2	52	47	63	8074492
3C	0.750	5.6	96	98	27	2	43	55	48	9032863
3D	0.750	5.9	96	98	31	1	40	58	39	9551403
3E	**0.750**	6.3	97	98	35	1	37	62	30	10096472
3F	0.750	6.5	97	98	37	1	36	63	27	10431791
3G	0.750	6.5	97	98	38	1	35	63	26	10522270
3H	0.750	6.5	97	98	38	1	35	64	26	10565162
3I	0.750	6.6	97	98	38	1	35	64	25	10619051
3J	0.750	6.5	97	98	38	1	35	63	25	10549457
3K	0.750	6.6	97	98	37	1	36	63	28	10494322
3L	0.750	6.3	97	98	32	1	39	60	37	9938845
3M	0.750	5.9	96	98	29	1	43	56	44	9451028
3N	0.750	5.5	96	98	24	2	49	49	55	8687118
3O	0.750	4.6	95	98	18	2	56	42	77	7581663
3P	0.750	4.0	95	97	14	2	64	35	91	6858873
4A	0.750	3.7	94	97	9	2	68	30	96	6269751
4B	0.750	3.9	94	97	11	2	65	33	92	6541718
4C	0.750	4.3	94	97	14	2	61	37	87	7005673
4D	0.750	4.5	95	98	16	2	58	40	83	7290960
4E	**0.750**	4.5	95	98	17	2	56	42	81	7465696
4F	0.750	4.8	96	98	19	2	53	45	73	7845820
4G	0.750	4.8	96	98	20	2	52	46	72	7902323
4H	0.750	5.0	96	98	22	2	50	49	68	8218301
4I	0.750	4.9	96	98	21	2	50	48	70	8100453
4J	0.750	4.9	96	98	21	2	52	47	71	7992795
4K	0.750	4.8	96	98	20	2	54	44	74	7801759
4L	0.750	4.7	96	98	19	2	55	43	78	7626361
4M	0.750	4.6	95	98	18	2	58	41	83	7394213
4N	0.750	4.1	95	97	13	2	64	34	93	6632817
4O	0.750	3.9	95	97	11	2	67	31	96	6450225
4P	0.750	3.5	94	97	7	2	72	26	97	6003740
5A	0.750	3.2	92	97	4	2	77	21	97	5523472
5B	0.750	3.4	93	97	6	2	75	23	97	5635485
5C	0.750	3.5	93	97	6	2	74	24	97	5767783
5D	0.750	3.8	94	97	9	2	68	30	97	6216041
5E	**0.750**	3.8	94	97	10	2	67	32	97	6352125
5F	0.750	4.1	95	97	13	2	62	36	92	6770091
5G	0.750	4.0	95	97	12	2	64	34	93	6588175
5H	0.750	4.0	95	97	12	2	64	34	93	6640575
5I	0.750	4.0	95	97	13	2	63	35	93	6706480
5J	0.750	4.0	95	97	12	2	65	33	94	6572523
5K	0.750	3.9	95	97	10	2	67	31	96	6356037
5L	0.750	3.8	95	97	9	2	69	29	97	6191693
5M	0.750	3.6	94	97	8	2	71	27	97	5986117
5N	0.750	3.4	94	97	4	2	75	23	97	5613437

Table F12: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	3.2	94	97	2	2	76	22	97	5378042
5P	0.750	3.2	94	97	2	2	77	21	97	5314971
6A	0.750	2.9	91	96	1	2	82	16	97	4949544
6B	0.750	3.0	91	96	2	2	81	17	97	5015896
6C	0.750	3.1	91	96	2	2	80	18	97	5104010
6D	0.750	3.2	92	96	3	2	78	19	97	5284611
6E	**0.750**	3.3	93	97	4	2	77	21	97	5450193
6F	0.750	3.4	93	97	4	2	75	23	97	5611730
6G	0.750	3.4	93	97	4	2	76	22	97	5540290
6H	0.750	3.5	94	97	5	2	74	24	97	5720284
6I	0.750	3.5	94	97	5	2	73	25	97	5783398
6J	0.750	3.4	94	97	5	2	74	24	97	5670229
6K	0.750	3.4	94	97	4	2	75	23	97	5535033
6L	0.750	3.2	93	97	2	2	77	21	97	5306117
6M	0.750	3.0	93	96	1	2	79	19	97	5039970
6N	0.750	3.0	93	96	0	2	81	17	96	4916123
6O	0.750	2.8	93	96	0	2	82	15	96	4770394
6P	0.750	2.8	93	96	0	2	84	14	96	4703686
7A	0.750	2.7	91	96	0	3	87	11	96	4503186
7B	0.750	2.8	91	96	0	3	86	12	96	4538068
7C	0.750	2.8	91	96	0	3	85	12	96	4598479
7D	0.750	3.0	91	96	0	2	83	15	96	4854267
7E	**0.750**	3.0	91	96	1	2	82	16	96	4891500
7F	0.750	3.0	91	96	1	2	82	16	96	4903668
7G	0.750	3.0	92	96	1	2	80	17	97	5032897
7H	0.750	3.1	93	97	2	2	79	19	97	5238978
7I	0.750	3.1	92	96	1	2	80	18	97	5062932
7J	0.750	3.0	92	96	1	2	81	17	97	4944282
7K	0.750	2.9	92	96	0	2	81	17	96	4892553
7L	0.750	2.9	92	96	0	2	83	15	96	4750543
7M	0.750	2.7	92	96	0	2	85	13	96	4544522
7N	0.750	2.6	91	96	0	3	87	10	96	4336898
7O	0.750	2.5	91	96	0	3	88	9	96	4221690
7P	0.750	2.5	92	96	0	3	89	9	96	4248543
8A	0.750	2.6	90	95	0	3	90	7	96	4238133
8B	0.750	2.8	91	96	0	3	89	8	96	4320135
8C	0.750	2.6	90	95	0	3	88	9	96	4277635
8D	0.750	2.6	90	96	0	3	87	10	96	4366389
8E	**0.750**	2.8	91	96	0	2	85	12	96	4621165
8F	0.750	2.7	91	96	0	3	85	12	96	4538081
8G	0.750	2.7	91	96	0	3	85	12	96	4508867
8H	0.750	2.8	91	96	0	2	84	13	96	4611726
8I	0.750	2.8	91	96	0	2	84	13	96	4624527
8J	0.750	2.7	91	96	0	3	85	12	96	4522416
8K	0.750	2.7	91	96	0	3	86	11	96	4401158
8L	0.750	2.6	91	96	0	3	87	10	96	4374196
8M	0.750	2.5	91	96	0	3	89	9	96	4206640
8N	0.750	2.4	90	95	0	3	92	5	96	3951458
8O	0.750	2.4	90	96	0	3	93	5	96	3938469
8P	0.750	2.3	91	96	0	3	94	3	95	3855894
9A	0.750	2.4	90	95	0	3	94	3	96	3927982
9B	0.750	2.7	90	96	0	3	91	6	96	4248611
9C	0.750	2.6	90	95	0	3	91	6	96	4110636
9D	0.750	2.6	90	95	0	3	90	8	96	4237483
9E	**0.750**	2.6	90	95	0	3	89	8	96	4245224
9F	0.750	2.6	90	96	0	3	88	9	96	4318313
9G	0.750	2.6	90	96	0	3	88	9	96	4308296
9H	0.750	2.7	91	96	0	3	87	10	96	4402698
9I	0.750	2.6	91	96	0	3	88	9	96	4300360
9J	0.750	2.6	91	96	0	3	88	10	96	4334036
9K	0.750	2.6	91	96	0	3	89	9	96	4273833
9L	0.750	2.5	90	96	0	3	90	7	96	4096212
9M	0.750	2.4	90	95	0	3	92	5	96	3940511
9N	0.750	2.3	89	95	0	3	94	3	95	3808799
9O	0.750	2.2	89	95	0	3	95	2	95	3682801
9P	0.750	2.2	90	95	0	3	95	2	95	3750076
10A	0.750	2.4	90	95	0	3	93	4	96	3953107
10B	0.750	2.6	90	95	0	3	92	6	96	4141769
10C	0.750	2.5	90	95	0	3	92	6	96	4056770
10D	0.750	2.6	90	96	0	3	89	8	96	4267728
10E	**0.750**	2.7	91	96	0	3	88	10	96	4408723
10F	0.750	2.6	91	96	0	3	88	10	96	4377235
10G	0.750	2.7	91	96	0	2	86	12	96	4547284
10H	0.750	2.8	92	96	0	2	85	13	96	4627916
10I	0.750	2.8	92	96	0	2	85	13	96	4597698
10J	0.750	2.7	91	96	0	2	87	11	96	4434160
10K	0.750	2.6	91	96	0	3	90	8	96	4245372
10L	0.750	2.5	91	96	0	3	90	8	96	4184240

F13: Detail DAYSIM result of CFW1

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	6.7	96	98	45	1	32	67	5	12179280
1B	0.750	20.3	99	99	79	1	10	89	0	40220556
1C	0.750	26.6	99	99	88	1	6	93	0	53377288
1D	0.750	27.3	99	99	89	1	6	93	0	54348760
1E	**0.750**	27.3	99	99	89	1	6	93	0	54400328
1F	0.750	27.4	99	99	89	1	6	93	0	54544008
1G	0.750	27.6	99	99	89	1	6	93	0	54810748
1H	0.750	27.6	99	99	89	1	6	93	0	54874600
1I	0.750	27.2	99	99	89	1	6	93	0	54499192
1J	0.750	27.4	99	99	89	1	6	93	0	54591464
1K	0.750	27.3	99	99	89	1	6	93	0	54497916
1L	0.750	27.3	99	99	89	1	6	93	0	54417012
1M	0.750	27.3	99	99	89	1	6	93	0	54203948
1N	0.750	26.7	99	99	88	1	6	93	0	52781512
1O	0.750	18.0	99	99	77	1	12	87	0	34704816
1P	0.750	6.2	97	98	39	1	39	59	29	10959171
2A	0.750	8.7	98	99	57	1	24	75	0	16940188
2B	0.750	12.6	98	99	71	1	17	82	0	23690364
2C	0.750	16.0	98	99	77	1	12	87	0	29618312
2D	0.750	17.5	99	99	82	1	10	89	0	31991684
2E	**0.750**	17.3	98	99	82	1	10	89	0	32426740
2F	0.750	17.8	99	99	83	1	10	90	0	33106232
2G	0.750	18.2	99	99	83	1	9	90	0	33610600
2H	0.750	18.0	99	99	84	1	9	90	0	33410084
2I	0.750	18.1	99	99	83	1	9	90	0	33514426
2J	0.750	18.0	99	99	83	1	9	90	0	33369192
2K	0.750	18.0	99	99	83	1	9	90	0	33273596
2L	0.750	17.7	99	99	82	1	10	89	0	32542708
2M	0.750	17.0	98	99	81	1	10	89	0	31036780
2N	0.750	15.6	98	99	76	1	13	86	0	28457292
2O	0.750	12.0	98	99	65	1	18	81	0	21838456
2P	0.750	8.3	97	99	53	1	27	71	0	15248253
3A	0.750	7.8	97	99	52	1	26	73	0	14809728
3B1	0.750	9.3	98	99	59	1	23	76	0	16219873
3C	0.750	10.6	98	99	64	1	19	79	0	17895798
3D	0.750	11.3	98	99	66	1	16	83	0	19613552
3E	**0.750**	11.8	98	99	69	1	15	84	0	20702224
3F	0.750	12.2	98	99	70	1	14	85	0	21345134
3G	0.750	12.6	98	99	71	1	13	86	0	21878060
3H	0.750	12.7	98	99	71	1	13	86	0	22038124
3I	0.750	12.4	98	99	70	1	14	85	0	21614320
3J	0.750	12.2	98	99	69	1	14	85	0	21331166
3K	0.750	12.4	98	99	70	1	14	85	0	21571796
3L	0.750	11.9	98	99	67	1	16	83	0	20565292
3M	0.750	11.2	98	99	65	1	17	82	0	19188340
3N	0.750	10.6	98	99	61	1	19	80	0	17296288
3O	0.750	9.0	98	99	53	1	25	74	0	15230951
3P	0.750	7.6	97	98	49	1	29	69	4	13870996
4A	0.750	6.8	97	98	44	1	30	69	9	11700891
4B	0.750	7.4	97	98	47	1	29	69	0	12183596
4C	0.750	8.2	97	98	53	1	27	72	0	13206036
4D	0.750	8.6	97	99	56	1	26	73	0	13751213
4E	**0.750**	9.0	98	99	58	1	24	75	0	14356148
4F	0.750	9.2	98	99	59	1	22	77	0	14789357
4G	0.750	9.5	98	99	60	1	21	78	0	15122572
4H	0.750	9.5	98	99	61	1	20	79	0	15210461
4I	0.750	9.5	98	99	60	1	20	79	0	15150684
4J	0.750	9.5	98	99	60	1	20	79	0	15144580
4K	0.750	9.1	98	99	58	1	23	76	0	14483167
4L	0.750	8.9	98	99	55	1	24	75	0	14151255
4M	0.750	8.6	97	99	52	1	27	72	0	13556743
4N	0.750	7.9	97	98	48	1	29	69	0	12702225
4O	0.750	7.2	97	98	44	1	33	66	14	11736137
4P	0.750	6.8	97	98	43	1	33	65	23	11403801
5A	0.750	6.1	97	98	38	1	36	62	29	10428149
5B	0.750	6.3	97	98	39	1	36	63	26	10552422
5C	0.750	6.7	97	98	41	1	34	64	17	11067595
5D	0.750	7.0	97	98	44	1	33	66	9	11528584
5E	**0.750**	7.2	97	98	46	1	32	66	3	11837635
5F	0.750	7.3	97	98	47	1	32	67	0	12027568
5G	0.750	7.6	97	98	50	1	30	69	0	12485581
5H	0.750	7.7	97	98	50	1	30	69	0	12557325
5I	0.750	7.6	97	98	49	1	31	68	0	12396806
5J	0.750	7.6	97	98	48	1	31	68	0	12402774
5K	0.750	7.5	97	98	47	1	32	67	0	12145075
5L	0.750	7.2	97	98	44	1	33	66	10	11677579
5M	0.750	6.8	97	98	41	1	35	64	19	11128686
5N	0.750	6.4	97	98	38	1	37	61	28	10532196

Table F13: *Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	6.1	96	98	35	1	40	59	35	10176998
5P	0.750	5.9	96	98	33	1	40	59	39	10023065
6A	0.750	5.4	96	98	28	1	42	57	52	9124100
6B	0.750	5.4	96	98	28	1	43	56	51	9054488
6C	0.750	5.7	96	98	30	1	41	58	46	9420732
6D	0.750	5.9	96	98	33	1	40	59	39	9780922
6E	**0.750**	6.2	97	98	36	1	38	61	32	10187341
6F	0.750	6.3	97	98	37	1	37	61	29	10381762
6G	0.750	6.5	97	98	39	1	37	62	25	10614813
6H	0.750	6.6	97	98	40	1	36	62	21	10776531
6I	0.750	6.3	97	98	37	1	38	61	29	10372067
6J	0.750	6.4	97	98	37	1	37	61	28	10426233
6K	0.750	6.2	96	98	35	1	38	60	33	10147117
6L	0.750	6.1	96	98	34	1	40	58	35	9912300
6M	0.750	5.8	96	98	30	1	43	55	44	9437033
6N	0.750	5.6	96	98	28	1	45	53	48	9177608
6O	0.750	5.4	96	98	26	2	46	52	54	8914910
6P	0.750	5.1	96	98	24	2	47	51	59	8626724
7A	0.750	4.9	96	98	21	1	47	52	71	8208545
7B	0.750	4.9	96	98	21	1	48	51	70	8188110
7C	0.750	5.3	96	98	24	1	45	53	61	8617049
7D	0.750	5.2	96	98	25	2	45	53	58	8679502
7E	**0.750**	5.3	96	98	25	1	45	54	56	8768414
7F	0.750	5.5	96	98	28	1	43	56	49	9141933
7G	0.750	5.7	96	98	31	1	42	57	44	9416821
7H	0.750	5.7	96	98	30	1	42	56	45	9367574
7I	0.750	5.6	96	98	29	1	42	56	46	9291927
7J	0.750	5.6	96	98	29	1	43	55	47	9229301
7K	0.750	5.5	96	98	28	2	44	54	49	9136642
7L	0.750	5.3	96	98	26	2	48	51	56	8751193
7M	0.750	5.2	96	98	25	1	48	50	60	8628186
7N	0.750	4.9	96	98	22	2	52	46	69	8068380
7O	0.750	4.7	96	98	21	2	54	45	76	7874236
7P	0.750	4.7	96	98	20	2	52	46	78	7927415
8A	0.750	4.6	96	98	17	1	52	46	84	7652101
8B	0.750	4.6	95	98	16	2	53	45	84	7568691
8C	0.750	4.7	96	98	18	2	51	47	79	7801751
8D	0.750	4.9	96	98	19	2	50	49	74	8023093
8E	**0.750**	5.1	96	98	22	2	47	51	66	8338295
8F	0.750	5.1	96	98	23	1	46	52	63	8465715
8G	0.750	5.1	96	98	23	1	47	52	64	8492894
8H	0.750	5.1	96	98	23	2	47	52	64	8500333
8I	0.750	5.1	96	98	23	2	48	50	64	8452489
8J	0.750	5.1	96	98	23	2	49	50	67	8366014
8K	0.750	5.0	96	98	22	2	50	48	69	8248697
8L	0.750	4.9	96	98	21	2	52	47	72	8049661
8M	0.750	4.7	96	98	20	2	53	45	78	7798228
8N	0.750	4.5	96	98	18	2	55	43	84	7581236
8O	0.750	4.5	95	98	17	2	56	42	87	7448226
8P	0.750	4.3	95	98	15	2	58	40	93	7193274
9A	0.750	4.4	95	98	14	2	55	43	92	7312226
9B	0.750	4.5	95	98	14	2	55	43	91	7312205
9C	0.750	4.6	95	98	16	2	53	45	87	7551096
9D	0.750	4.7	96	98	18	2	51	47	82	7759835
9E	**0.750**	4.7	96	98	19	2	51	48	78	7861102
9F	0.750	4.9	96	98	21	2	48	51	74	8199616
9G	0.750	4.9	96	98	20	2	50	49	74	8064960
9H	0.750	4.9	96	98	21	2	50	49	73	8119210
9I	0.750	4.9	96	98	21	2	50	49	73	8156542
9J	0.750	4.8	96	98	20	2	51	47	74	8015282
9K	0.750	4.7	96	98	19	2	53	46	79	7791486
9L	0.750	4.6	96	98	18	2	54	44	83	7614598
9M	0.750	4.4	95	98	16	2	56	42	88	7396282
9N	0.750	4.3	95	98	15	2	58	40	92	7159233
9O	0.750	4.2	95	97	13	2	59	39	95	6971081
9P	0.750	4.1	95	97	12	2	61	37	97	6848490
10A	0.750	4.3	95	98	13	2	57	41	95	7173465
10B	0.750	4.4	95	98	14	2	55	44	91	7370088
10C	0.750	4.5	95	98	15	2	54	45	88	7490628
10D	0.750	4.7	96	98	18	2	50	48	81	7839821
10E	**0.750**	4.8	96	98	19	2	49	49	77	7978612
10F	0.750	4.9	96	98	21	1	47	51	72	8240485
10G	0.750	4.9	96	98	21	1	47	51	71	8261433
10H	0.750	5.0	96	98	22	1	47	51	71	8327361
10I	0.750	5.0	96	98	22	2	48	50	73	8271486
10J	0.750	4.9	96	98	21	2	49	49	73	8225273
10K	0.750	4.8	96	98	20	2	51	47	77	8033018
10L	0.750	4.7	96	98	20	2	52	46	80	7905766

F14: Detail DAYSIM result of CFW2

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
1A	0.750	8.8	98	99	61	1	24	75	0	15739896
1B	0.750	23.1	99	99	83	1	9	90	0	44207648
1C	0.750	29.8	99	99	90	1	5	94	0	57551584
1D	0.750	30.7	99	99	90	1	5	94	0	58678816
1E	**0.750**	30.8	99	99	90	1	5	94	0	58969232
1F	0.750	30.9	99	99	90	1	5	94	0	59025912
1G	0.750	30.9	99	99	90	1	5	94	0	59128900
1H	0.750	30.9	99	99	90	1	5	94	0	59125128
1I	0.750	31.0	99	99	90	1	5	94	0	59191436
1J	0.750	31.0	99	99	90	1	5	94	0	59195440
1K	0.750	31.0	99	99	90	1	5	94	0	59074880
1L	0.750	30.8	99	99	90	1	5	94	0	58809928
1M	0.750	30.6	99	99	90	1	5	94	0	58472552
1N	0.750	29.6	99	99	89	1	5	94	0	56656928
1O	0.750	20.9	99	99	81	1	10	89	0	38640868
1P	0.750	8.3	97	99	54	1	27	72	0	14426038
2A	0.750	11.4	98	99	70	1	18	81	0	22471168
2B	0.750	16.1	98	99	77	1	12	87	0	32686124
2C	0.750	20.5	99	99	83	1	9	90	0	40780004
2D	0.750	21.8	99	99	86	1	8	91	0	43813564
2E	**0.750**	22.6	99	99	87	1	8	91	0	45240116
2F	0.750	23.1	99	99	87	1	7	92	0	45974096
2G	0.750	23.3	99	99	87	1	7	92	0	46252500
2H	0.750	23.3	99	99	87	1	7	92	0	46267896
2I	0.750	23.1	99	99	87	1	7	92	0	46013848
2J	0.750	23.0	99	99	87	1	7	92	0	45957248
2K	0.750	22.9	99	99	87	1	7	92	0	45730512
2L	0.750	22.8	99	99	86	1	7	92	0	45280272
2M	0.750	22.0	99	99	86	1	7	92	0	43553792
2N	0.750	20.2	99	99	82	1	9	90	0	39449960
2O	0.750	15.5	98	99	75	1	13	86	0	30284160
2P	0.750	11.2	98	99	66	1	17	82	0	20575248
3A	0.750	10.5	98	99	69	1	19	80	0	20867210
3B1	0.750	12.8	98	99	73	1	15	84	0	24352676
3C	0.750	14.5	98	99	75	1	13	87	0	27205828
3D	0.750	15.8	98	99	78	1	11	88	0	29699002
3E	**0.750**	16.4	98	99	81	1	11	89	0	30882258
3F	0.750	16.8	98	99	82	1	10	89	0	31566008
3G	0.750	17.1	98	99	83	1	10	89	0	31936260
3H	0.750	17.0	98	99	82	1	10	89	0	31812344
3I	0.750	17.3	98	99	83	1	10	90	0	32357928
3J	0.750	17.2	98	99	82	1	10	89	0	31823552
3K	0.750	16.7	98	99	82	1	10	89	0	31191958
3L	0.750	16.3	98	99	80	1	11	88	0	30482028
3M	0.750	15.7	98	99	78	1	12	87	0	29088480
3N	0.750	14.2	98	99	73	1	13	86	0	26136848
3O	0.750	12.3	98	99	68	1	16	83	0	22653618
3P	0.750	10.6	98	99	64	1	18	81	0	18720652
4A	0.750	9.7	98	99	65	1	21	78	0	16868228
4B	0.750	10.3	98	99	65	1	19	80	0	17370406
4C	0.750	11.2	98	99	67	1	17	82	0	18226926
4D	0.750	12.0	98	99	69	1	15	85	0	19278610
4E	**0.750**	12.8	98	99	72	1	14	85	0	20361432
4F	0.750	13.0	98	99	72	1	13	86	0	21068908
4G	0.750	13.1	98	99	73	1	13	86	0	21388396
4H	0.750	13.4	98	99	75	1	12	87	0	21735014
4I	0.750	13.5	98	99	75	1	13	87	0	21869902
4J	0.750	13.3	98	99	73	1	13	86	0	21508692
4K	0.750	12.9	98	99	71	1	14	85	0	20883140
4L	0.750	12.8	98	99	70	1	14	85	0	20013496
4M	0.750	12.0	98	99	69	1	15	84	0	18998014
4N	0.750	11.0	98	99	65	1	17	81	0	17689572
4O	0.750	10.0	98	99	60	1	20	79	0	16413571
4P	0.750	9.2	98	99	59	1	21	78	0	15828147
5A	0.750	8.3	98	99	57	1	24	75	0	14217396
5B	0.750	8.7	98	99	58	1	23	76	0	14491067
5C	0.750	9.2	98	99	60	1	23	76	0	15030158
5D	0.750	9.7	98	99	62	1	21	78	0	15790996
5E	**0.750**	10.3	98	99	64	1	18	81	0	16538962
5F	0.750	10.6	98	99	64	1	17	82	0	16940926
5G	0.750	10.5	98	99	64	1	17	82	0	16865210
5H	0.750	10.9	98	99	65	1	16	83	0	17357772
5I	0.750	10.5	98	99	64	1	17	82	0	16906662
5J	0.750	10.7	98	99	64	1	17	82	0	17008314
5K	0.750	10.3	98	99	63	1	18	81	0	16464833
5L	0.750	10.0	98	99	62	1	19	80	0	15993258
5M	0.750	9.7	98	99	59	1	20	79	0	15542515
5N	0.750	9.0	98	99	55	1	23	76	0	14520870

***Table F14:** Continued*

TEST POINTS	H	DF [%]	DA [%]	DA_{con} [%]	DA_{max} [%]	$UDI_{<100}$ [%]	$UDI_{100-2000}$ [%]	$UDI_{>2000}$ [%]	DSP [%]	annual light exposure [lux]
5O	0.750	8.5	98	99	53	1	24	74	0	13967115
5P	0.750	8.1	97	99	53	1	25	74	0	13647137
6A	0.750	7.4	97	98	50	1	27	72	0	12593040
6B	0.750	7.5	97	98	51	1	28	71	0	12719041
6C	0.750	7.9	97	98	53	1	27	72	0	13173654
6D	0.750	8.3	97	99	56	1	25	73	0	13726217
6E	**0.750**	8.7	98	99	58	1	24	75	0	14235432
6F	0.750	8.8	98	99	58	1	24	75	0	14416764
6G	0.750	8.9	98	99	58	1	23	76	0	14588303
6H	0.750	9.0	98	99	58	1	22	77	0	14576748
6I	0.750	9.1	98	99	58	1	22	77	0	14706606
6J	0.750	9.0	98	99	58	1	22	77	0	14561150
6K	0.750	8.8	98	99	56	1	23	76	0	14301285
6L	0.750	8.4	98	99	53	1	25	73	0	13742383
6M	0.750	8.2	97	99	51	1	27	72	0	13341213
6N	0.750	7.7	97	98	49	1	29	70	0	12738152
6O	0.750	7.5	97	98	48	1	30	69	4	12451907
6P	0.750	7.1	97	98	46	1	30	68	14	12023006
7A	0.750	6.7	97	98	44	1	31	68	16	11329182
7B	0.750	6.7	97	98	43	1	32	67	15	11233787
7C	0.750	7.0	97	98	45	1	32	67	8	11593070
7D	0.750	7.3	97	98	48	1	29	69	0	12156025
7E	**0.750**	7.4	97	98	49	1	30	69	0	12261888
7F	0.750	7.6	97	98	51	1	29	70	0	12562340
7G	0.750	7.8	97	98	51	1	28	71	0	12762518
7H	0.750	7.9	97	98	52	1	28	71	0	12899772
7I	0.750	7.9	97	98	51	1	28	71	0	12920744
7J	0.750	7.7	97	98	49	1	29	69	0	12661024
7K	0.750	7.6	97	98	48	1	30	69	0	12467142
7L	0.750	7.3	97	98	46	1	31	68	4	12097471
7M	0.750	7.2	97	98	44	1	32	67	10	11795512
7N	0.750	6.9	97	98	42	1	33	65	18	11368397
7O	0.750	6.6	97	98	40	1	35	64	24	10953944
7P	0.750	6.5	97	98	40	1	34	64	27	10911085
8A	0.750	6.1	97	98	38	1	35	64	33	10336387
8B	0.750	6.3	97	98	38	1	35	64	29	10534902
8C	0.750	6.7	97	98	41	1	33	66	21	10963570
8D	0.750	6.6	97	98	41	1	34	64	20	10949494
8E	**0.750**	6.8	97	98	43	1	33	65	13	11291884
8F	0.750	6.9	97	98	44	1	33	65	12	11430834
8G	0.750	7.0	97	98	44	1	33	66	10	11571137
8H	0.750	7.3	97	98	47	1	31	67	3	11937525
8I	0.750	7.1	97	98	44	1	33	66	9	11639623
8J	0.750	7.0	97	98	44	1	33	65	10	11570880
8K	0.750	6.9	97	98	43	1	34	65	14	11322172
8L	0.750	6.8	97	98	42	1	34	65	18	11208079
8M	0.750	6.5	97	98	39	1	36	63	26	10773920
8N	0.750	6.3	97	98	37	1	37	62	31	10398741
8O	0.750	6.0	97	98	35	1	38	61	37	10127974
8P	0.750	5.9	97	98	33	1	38	60	40	9936734
9A	0.750	6.0	97	98	36	1	36	63	39	10035166
9B	0.750	6.0	97	98	35	1	37	62	38	10065902
9C	0.750	6.2	97	98	37	1	36	63	33	10314215
9D	0.750	6.3	97	98	39	1	35	64	27	10589498
9E	**0.750**	6.6	97	98	41	1	34	65	20	10943342
9F	0.750	6.7	97	98	42	1	34	65	19	11079363
9G	0.750	6.8	97	98	42	1	34	65	16	11229043
9H	0.750	6.9	97	98	43	1	33	65	15	11366602
9I	0.750	6.8	97	98	43	1	34	65	15	11309486
9J	0.750	6.7	97	98	42	1	35	64	21	11040713
9K	0.750	6.5	97	98	40	1	35	64	23	10855225
9L	0.750	6.5	97	98	39	1	36	63	27	10694099
9M	0.750	6.2	97	98	36	1	37	62	32	10300419
9N	0.750	6.1	97	98	36	1	38	61	36	10138546
9O	0.750	5.7	96	98	31	1	41	58	45	9620418
9P	0.750	5.6	96	98	30	1	41	58	48	9473283
10A	0.750	5.8	97	98	34	1	37	62	43	9786441
10B	0.750	6.1	97	98	36	1	36	63	38	10128890
10C	0.750	6.1	97	98	37	1	35	63	33	10323195
10D	0.750	6.4	97	98	40	1	34	65	26	10716775
10E	**0.750**	6.6	97	98	41	1	33	66	20	10978826
10F	0.750	6.7	97	98	43	1	33	66	17	11218426
10G	0.750	6.9	97	98	44	1	32	67	14	11414387
10H	0.750	6.9	97	98	45	1	32	67	13	11536052
10I	0.750	6.8	97	98	44	1	33	66	15	11377561
10J	0.750	6.7	97	98	43	1	33	65	18	11237434
10K	0.750	6.7	97	98	42	1	33	66	18	11216819
10L	0.750	6.5	97	98	40	1	34	65	26	10856411

Appendix G: Thermal simulation findings of the case studio

Time Period (24th April)	Output Variables	SVW1	SVW2	SVW3	SVW4	SVW5	SVW6	SFW1	SFW2	SFW3	CVW1	CVW2	CVW3	CFW1	CFW2
08:00:00	A.T. [°c]	27.2	27.2	27.4	27.9	27.4	27.5	27.9	28.1	28.1	27.6	28.7	27.7	28.3	28.3
	M.R.T. [°c]	26.6	26.7	26.8	27.2	26.7	27.0	27.6	28.0	28.0	27.1	27.2	27.1	28.1	28.5
	R.H. [%]	66.6	66.4	66.4	64.9	66	66.0	65	64.1	64.1	66.1	66.0	66.1	63.7	63.7
	W.S. [m/s]	0.20	0.21	0.17	0.24	0.24	0.18	0.20	0.19	0.20	0.20	0.19	0.20	0.19	0.21
09:00:00	A.T. [°c]	27.9	27.9	28.1	28.5	28.1	28.2	28.7	28.9	28.9	28.4	28.5	28.4	29.1	29.1
	M.R.T. [°c]	26.8	26.9	27.0	27.4	27.0	27.2	27.8	28.3	28.3	27.3	27.4	27.4	28.4	28.9
	R.H. [%]	65.7	65.5	65.9	64.7	65	65.3	64	63.2	63.2	65.5	65.3	65.4	62.8	62.8
	W.S. [m/s]	0.32	0.35	0.25	0.37	0.35	0.29	0.32	0.29	0.25	0.34	0.31	0.30	0.34	0.35
10:00:00	A.T. [°c]	28.1	28.2	28.3	28.7	28.3	28.4	29.0	29.2	29.2	28.6	28.5	28.6	29.5	29.5
	M.R.T. [°c]	26.9	27.1	27.2	27.6	27.2	27.4	28.1	28.6	28.6	27.6	27.6	27.6	28.8	29.3
	R.H. [%]	66.6	68.2	65.9	65.0	66	65.3	64	63.0	62.9	65.5	65.4	65.5	62.4	62.4
	W.S. [m/s]	0.32	0.35	0.25	0.37	0.35	0.29	0.32	0.29	0.25	0.34	0.31	0.30	0.34	0.35
11:00:00	A.T. [°c]	27.8	27.9	28.1	28.6	28.1	28.2	28.8	29.0	29.1	28.4	28.4	28.4	29.3	29.3
	M.R.T. [°c]	27.0	27.1	27.3	27.7	27.2	27.5	28.2	28.8	28.8	27.7	27.7	27.7	28.9	29.5
	R.H. [%]	67.3	67.0	66.4	65.4	66	65.8	64	63.4	63.4	65.9	65.8	65.9	62.9	62.9
	W.S. [m/s]	0.36	0.41	0.33	0.43	0.40	0.35	0.38	0.36	0.36	0.38	0.36	0.39	0.37	0.42
12:00:00	A.T. [°c]	27.6	27.7	27.9	28.3	27.9	28.0	28.6	28.8	28.8	28.2	28.2	28.2	29.1	29.1
	M.R.T. [°c]	27.1	27.3	27.4	27.8	27.4	27.6	28.4	29.0	28.9	27.8	27.8	27.8	29.2	29.8
	R.H. [%]	67.1	66.7	66.2	65.2	66	65.6	64	63.2	63.3	65.7	65.6	65.7	62.7	62.7
	W.S. [m/s]	0.36	0.43	0.30	0.42	0.42	0.33	0.38	0.35	0.37	0.37	0.36	0.37	0.39	0.41

Table G: *continued*

Time Period (24th April)	Output Variables	SVW1	SVW2	SVW3	SVW4	SVW5	SVW6	SFW1	SFW2	SFW3	CVW1	CVW2	CVW3	CFW1	CFW2
13:00:00	A.T. [^{o}c]	27.8	27.9	28.0	28.4	28.1	28.1	28.6	28.8	28.9	28.3	28.3	28.4	29.2	29.2
	M.R.T. [^{o}c]	27.2	27.4	27.5	27.9	27.6	27.7	28.5	29.1	29.1	27.9	27.9	27.9	29.3	29.9
	R.H. [%]	65.4	65.1	65.2	64.1	64	64.6	63	62.4	62.4	64.7	64.6	64.7	61.8	61.8
	W.S. [m/s]	0.28	0.33	0.25	0.37	0.34	0.28	0.30	0.27	0.25	0.32	0.28	0.29	0.30	0.33
14:00:00	A.T. [^{o}c]	28.3	28.4	28.5	28.9	28.6	28.6	29.2	29.4	29.9	28.8	28.7	29.2	29.7	29.7
	M.R.T. [^{o}c]	27.4	27.5	27.7	28.1	27.8	27.9	28.7	29.3	29.3	28.1	28.1	28.1	29.5	30.2
	R.H. [%]	62.7	62.4	62.7	61.7	62	62.0	61	59.7	59.7	62.2	62.1	62.2	59.2	59.2
	W.S. [m/s]	0.18	0.19	0.17	0.23	0.21	0.14	0.18	0.18	0.13	0.17	0.17	0.19	0.18	0.18
15:00:00	A.T. [^{o}c]	28.8	28.9	29.0	29.4	29.1	29.1	29.8	30.0	30.1	29.3	29.8	29.7	30.4	30.4
	M.R.T. [^{o}c]	27.6	27.8	28.0	28.4	28.0	28.2	29.1	29.7	29.7	28.4	28.4	28.4	29.9	30.6
	R.H. [%]	59.8	61.5	59.6	58.9	59	59.0	57	56.4	56.4	59.1	59.0	59.1	55.8	55.8
	W.S. [m/s]	0.06	0.04	0.05	0.09	0.08	0.07	0.06	0.09	0.08	0.08	0.05	0.08	0.07	0.05
16:00:00	A.T. [^{o}c]	28.8	29.0	29.2	29.6	29.2	29.3	30.0	30.2	30.3	29.5	30.9	30.0	30.6	30.6
	M.R.T. [^{o}c]	27.8	27.9	28.1	28.5	28.1	28.3	29.2	29.8	29.8	28.5	28.5	28.5	30.0	30.7
	R.H. [%]	58.8	58.5	58.1	57.5	58	57.5	56	55.0	55.0	57.7	57.5	57.6	54.4	54.4
	W.S. [m/s]	0.05	0.06	0.05	0.07	0.06	0.05	0.05	0.04	0.06	0.06	0.05	0.03	0.08	0.03
17:00:00	A.T. [^{o}c]	28.0	28.1	28.4	28.9	28.4	28.5	29.1	29.2	29.3	28.7	28.7	29.3	29.6	29.6
	M.R.T. [^{o}c]	27.8	28.0	28.1	28.5	28.1	28.3	29.2	29.7	29.7	28.5	28.6	28.5	29.9	30.6
	R.H. [%]	60.9	60.6	59.9	59.0	60	59.2	58	57.0	57.0	59.4	59.3	59.4	56.5	56.5
	W.S. [m/s]	0.12	0.14	0.13	0.15	0.16	0.12	0.13	0.11	0.13	0.13	0.12	0.11	0.11	0.13

*** A.T..: Air Temperature, R.H.: Relative Humidity, W.S.: Wind Velocity.**

Appendix H: Existing thermal condition of the case room for validation

		1	2	3	4	5	6	7	8	9	10	Average
A	A.T. [°c]	29.3	28.8	28.6	28.6	28.5	28.5	27.8	27.6	27.1	27.2	**28.2**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.1	0	**0.14**
B	A.T. [°c]	29.3	28.7	28.6	28.5	28.4	28.4	28.3	28.2	28.1	27.9	**28.44**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.1	0.1	0	0.1	0	0.1	0.1	0	**0.09**
C	A.T. [°c]	30	28.5	28.7	28.5	28.4	27.9	27.8	27.5	28.2	28.1	**28.36**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**
D	A.T. [°c]	29.5	28.9	28.7	28.5	28.4	28.3	28.3	28.2	28.2	28.1	**28.51**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.2	0.1	0	0.1	0.1	0.1	0	0	**0.1**
E	A.T. [°c]	29.4	29.8	28.5	28.5	28.1	28	28.1	27.9	27.8	28.1	**28.42**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.2	0.1	0	0.1	0.1	0	0	0	**0.09**
F	A.T. [°c]	29.6	28.9	28.8	28.6	28.4	28.4	28.3	28.3	28.2	28.1	**28.56**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**
G	A.T. [°c]	29.5	28.9	28.7	28.3	28.4	28.3	28.3	28.3	28.2	28.1	**28.5**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0	0.1	0.1	**0.12**
H	A.T. [°c]	29.3	28.9	28.7	28.6	28.4	28.4	28.3	28.3	28.2	28.1	**28.52**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.3	0.2	0.2	0	0.1	0	0.1	0	0.1	0	**0.1**
I	A.T. [°c]	29.3	28.9	28.7	28.6	28.5	28.4	28.3	28.3	28.2	28.2	**28.54**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**
J	A.T. [°c]	29.6	29	28.8	28.6	28.4	28.4	28.3	28.2	28.2	28.2	**28.57**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.2	0.1	0	0.1	0.1	0.1	0	0	**0.1**
K	A.T. [°c]	29.6	29	28.5	28.3	28.2	28	27.9	27.8	27.6	27.5	**28.24**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1	**0.11**
L	A.T. [°c]	28.2	28.1	27.9	28	27.9	28	27.9	27.9	27.7	28.7	**28.03**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.3	0.2	0.2	0	0.1	0	0.1	0	0.1	0	**0.1**
M	A.T. [°c]	29.8	29.1	28.2	27.8	27.7	27.7	27.6	27.6	27.5	27.3	**28.03**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**
N	A.T. [°c]	29.7	28.8	28.1	28	27.9	27.8	27.5	27.2	27	27.3	**27.93**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**
O	A.T. [°c]	29.8	29.1	28.1	28.2	27.8	27.5	27.5	27.3	27.5	27.8	**28.06**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0	0.1	0.1	**0.11**
P	A.T. [°c]	29.8	29.1	28.5	28.4	28.2	28.2	28.1	27.9	28.1	27.5	**28.38**
	R.H. [%]	67	67	67	67	67	67	67	67	67	67	**67**
	W.S. [m/s]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0	0.1	0	**0.11**

*** A.T..: Air Temperature, R.H.: Relative Humidity, W.S.: Wind Velocity.**

Overall Thermal Condition (Average): Air Temperature (28.3 °c), Relative Humidity (67%), Wind Speed (0.11 m/s)