

MASTER THESIS

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A Master's Thesis

**THE IMPACTS OF URBAN ARCHITECTURE IN ISTANBUL
ON INDOOR DAYLIGHT AVAILABILITY**

***DIE AUSWIRKUNGEN DER URBANEN ARCHITEKTUR IN ISTANBUL AUF DIE
VERFÜGBARKEIT VON TAGESLICHT IN INNENRÄUMEN***

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To my grandparents.

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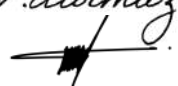
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ABSTRACT

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The lack of urban architecture and unplanned urbanization is still the biggest problem in Turkey. Although there have been laws concerning urbanization and urban transformation, these are applied without any design approach regardless of indoor daylight. One of the places with the most effects from this issue is Istanbul. That is because Istanbul is the most overcrowded city in Turkey and urban problems are inevitable. The problems in urban architecture also affect the quality of the interior spaces. The question is, what are the impacts of urban architecture in this region on indoor daylight availability? This master thesis aims to study the situation of current urban architecture in Istanbul; Beyoğlu, and 4. Levent districts, urban architecture are unsettled regarding indoor daylight availability. The buildings in Beyoğlu and 4. Levent have different heights, proximity, window sizes, and typology from each other. Due to these, almost all of them have different levels of daylight availability. The key points from literature reviews about urban architecture and indoor daylighting are analyzed. The buildings in Beyoğlu and 4. Levent are simulated with Climate Studio in terms of the building types, proximity, and certain features. The next step is to create a guide list to form a new Turkish daylight standard by

considering urban architecture, daylight, and individual building architecture. Consequently, the guide list helps to solve the problem of indoor daylight availability in unplanned urbanization. It highlights the importance of daylight for interior spaces in new urban transformations as well.

Keywords: *Urban architecture; unplanned urbanization; daylight availability; building typology; indoor daylight.*

ABSTRAKT

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Der Mangel an urbaner Architektur und die ungeplante städtebauliche Entwicklung sind immer noch das größte Problem in der Türkei. Obwohl es Gesetze zum Städtebau und zur urbanen Transformation gab, werden diese ohne jeglichen Designansatz unabhängig vom Tageslicht in Innenräumen angewendet. Einer der Orte mit den meisten Auswirkungen dieses Problems ist Istanbul. Das liegt daran, dass Istanbul die am stärksten bevölkerte Stadt in der Türkei ist und städtische Probleme unvermeidlich sind. Die Probleme der Stadtarchitektur wirken sich auch auf die Qualität der Innenräume aus. Die Frage ist, welche Auswirkungen die städtische Architektur in dieser Region auf die Verfügbarkeit von Tageslicht in Innenräumen hat. Ziel dieser Masterarbeit ist es, die Situation der aktuellen urbanen Architektur in Istanbul zu untersuchen; Beyoğlu und 4. in den Stadtteilen Levent ist die Stadtarchitektur in Bezug auf die Verfügbarkeit von Tageslicht in Innenräumen ungelöst. Die Gebäude in Beyoğlu und 4. Levent haben unterschiedliche Höhen, Abstände, Fenstergrößen und Typologien. Aus diesem Grund verfügen fast alle Wohnräume über unterschiedliche Tageslichtverfügbarkeiten. Die wichtigsten Punkte aus Literaturrecherchen über urbane Architektur und

Innenraum-Tageslicht werden analysiert. Die Gebäude in Beyoğlu und 4.Levent werden mit Climate Studio in Bezug auf die Gebäudetypen, die Abstände und bestimmte Merkmale simuliert. Der nächste Schritt ist die Erstellung einer Leitlinie zur Bildung eines neuen türkischen Tageslichtstandards unter Berücksichtigung von Stadtarchitektur, Tageslicht und individueller Gebäudearchitektur. Folglich hilft die Leitfadenliste, das Problem der Tageslichtverfügbarkeit bei ungeplanten Urbanisierungen zu lösen. Sie betont die Bedeutung von Tageslicht für Innenräume auch in neuen urbanen Transformationen.

Schlüsselwörter: *Stadtarchitektur; ungeplante Urbanisierung; Verfügbarkeit von Tageslicht; Gebäudetypologie; Tageslicht im Innenbereich.*

ACKNOWLEDGEMENT

Firstly, I would like to express my deepest gratitude to my supervisor Prof.Dr.-Ing. Thomas Römhild and Prof.Dr.-Ing. Jan Blieske for their wise supervision, understanding, and valuable support. I would never be able to finish my thesis without their guidance. It is an honor for me to be able to work with and learn from such successful academicians.

Secondly, I would like to express my love and gratitude to my parents; Ömer and Arzu. I can not ignore their sacrifices to get me to where I am now. I am grateful for always encouraging me to pursue my dreams. I would not come to this day without their love and support.

I thank my partner Taha Alper Ünal for showing me his endless love, motivation, and tireless support. I am grateful that he believed in me more than myself. This academic achievement would not have been possible without him.

Moreover, I would like to thank Matthias Grüner and Christopher Mayer-Berg from Lumen³. During this process, they always helped me and shared their supports.

Finally, I would like to thank my classmates; Ariunjargal Gantulga, Aleksandra Fedorenko, Melissa Ann Liu, Sıla Yılmaz, Himani Rajenkumar Shah and Mehtap Koç for their unforgettable friendships. I am pleased that they are more of a family than a group of friends and have made this time unique.

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LIST OF ABBREVIATIONS

3D	Three -Dimensional
AAI	Annual Average Illuminance
AD	Annual Sunlight Exposure
CEN	European Committee for Standardization
CS	Climate Studio
CM	Centimeter
DA	Daylight Autonomy
DF	Daylight Factor
DFA	Average Daylight Factor
DGI	Daylight Glare Index
EN	European Standard
EPBD	The Energy Performance of Buildings Directive
H	Hour
IES	Illuminating Engineering Society
M	Meter
RQ	Research Question
sDA	Spatial Daylight Autonomy
sDG	Spatial Disturbing Glare
UDI	Useful Daylight Index
UGR	Unified Glare Rating
V	Variant

LIST OF SYMBOLS

°	Degree
%	Percentage
C	Celsius
D_T	Target Daylight Factor
D_{TM}	Minimum Target Daylight Factor
d	Room depth
DF	Daylight Factor
ERC	Externally Reflected Component
HW	Window height from ground level
IRC	Internally Reflected Component
lx	Lux: Illuminance
m ²	Square meter
RB	Average reflection from the surfaces in the back of the room
SC	Sky Component
w	Room width

CHAPTER 1



INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1. Problem Statement

In recent years, indoor daylight and urban architecture have become interested in indoor quality. Multiple standards and research have provided adequate daylight availability for interior spaces. One of the essential aspects of improving indoor quality is natural lighting. In locations with intense urbanization, indoor daylight availability is impacted by building typology, building proximity, and height. This study reveals the consequences of urban architecture in Istanbul on indoor daylight availability. It aimed to accumulate positive and adverse results and develop a solution and daylight guidelines for interiors in Istanbul. These guidelines may shape the new daylight standard for Turkey in the case of Istanbul.

1.2. Aim of the Study

This research investigates the daylight availability of indoor spaces under different conditions. It targets to achieve this goal by comparing the results of simulations created by considering several points from building design to urban design. This thesis's main objective is to highlight the significance of urban architecture's impact on indoor natural lighting. Thus, it is determined by comparing the factors and causes due to urban architecture.

As a development, it is expected to show the guidelines for adequate daylight for interiors by comparing the literature review and simulations.

1.3. Structure of the Thesis

This thesis consists of multiple sections to achieve its purpose and search it in depth. Chapter 1 explains the study's problem and aims for a solution using structural components. In Chapter 2, the literature review is on urban architecture in Istanbul, indoor daylight, physical parameters of sunlight, and daylight availability for interiors. Chapter 3 represents the study's methodology in terms of research questions and hypotheses. The district examples, 4.Levent and Beyoğlu, from Istanbul, and the settings for Climate Studio (CS) are demonstrated and simulated to verify the aim of the thesis. Then, Chapter 4 compares results from two different research methods, which are simulation findings and discussion. The effects are studied and discussed in depth, they conclude and frame the new design guidelines for interior daylight availability. This section emphasizes the valuable points and suggestions for future analysis of interior daylight availability in terms of urban architecture as well as the new Turkish daylight standards. Lastly, Chapter 5 accomplishes the thesis's goal by summarizing the study's main structure.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1. Urban Architecture in Istanbul

It is conceivable to see diverse urban architectures according to regions throughout Turkey. Regardless, urban architecture and components have disappeared due to the excess unplanned construction in big cities. The city which is most affected by this unplanned urbanization is Istanbul (Unsal, 2007). Istanbul is the most renowned city in Turkey, with a population of approximately 16 million (TÜİK, 2022). Moreover, in terms of architecture and art, Istanbul hosts many ancient civilizations and their historical and different types of architectural elements. Several structures from the Byzantine, Ottoman, and Republic periods enrich the urban architecture of Istanbul (Karakuyu, Tezer & Balık, 2010). These architectural structures are crucial evidence of the history of Istanbul.

After the Second World War, the curiosity for big cities rose with the effects of industrialization (Arslan, 2011). This situation has caused people in the village to migrate to big cities to obtain work facilities and social opportunities (Figure 1). Due to this migration, the increasing number of buildings, including unauthorized structures, has led to unplanned urbanization (Yazman & Öztürk, 2009). Today, there are diverse types of buildings, such as residences, slums, skyscrapers, and apartments (Niğde Ömer Halisdemir University (OHU), 2017).

However, countless concerns arise as these structures are not built under urban design quality. Urbanization started in the 1950s has been replaced by urban transformation (Arslan, 2011). Urban transformation projects are continuing for the deteriorated urban architecture to improve urban architecture in Istanbul (CSB, 2019).



Figure 1. The Map of the Population Distribution in Istanbul (IBB, n.d.)

2.1.1. Unplanned Urbanization in Istanbul

One of the primary reasons for the unplanned urbanization in Istanbul is the high human population per square meter. This unplanned urbanization influences the silhouette of Istanbul and its urban architecture (Özdemir, 2018). These unplanned structures, created by the great migrations from the villages to the cities in the 1950s, are becoming the most prominent problem in Istanbul (Bozdoğan, n.d.). According to the State Institute of Statistics data, the number of cities with a population over 100,000 was two in 1927 and five in 1950 (TÜİK, 2022). After 1950, the way for unplanned urbanization was paved with the amnesty and zoning law for the buildings built without permission in Istanbul (Yazman & Öztürk, 2009) (Figure 2).

The number of buildings in big cities has expanded with the population, and unplanned urbanization has occurred. Urban transformation laws and projects have persisted since 2000 (Yolcu, 2021). According to Turkish Governmental data, 140 thousand independent units in Istanbul's 39 neighbourhoods are undergoing urban transformation and building alterations (Başer, 2021). In order to encourage people in big cities, many supports such as rent assistance, tax support, and fee exemption are provided for urban transformation (CSB, 2019). The most crucial point here is that those big cities should be restored under urban design and landscape architecture to realize urban transformation successfully.

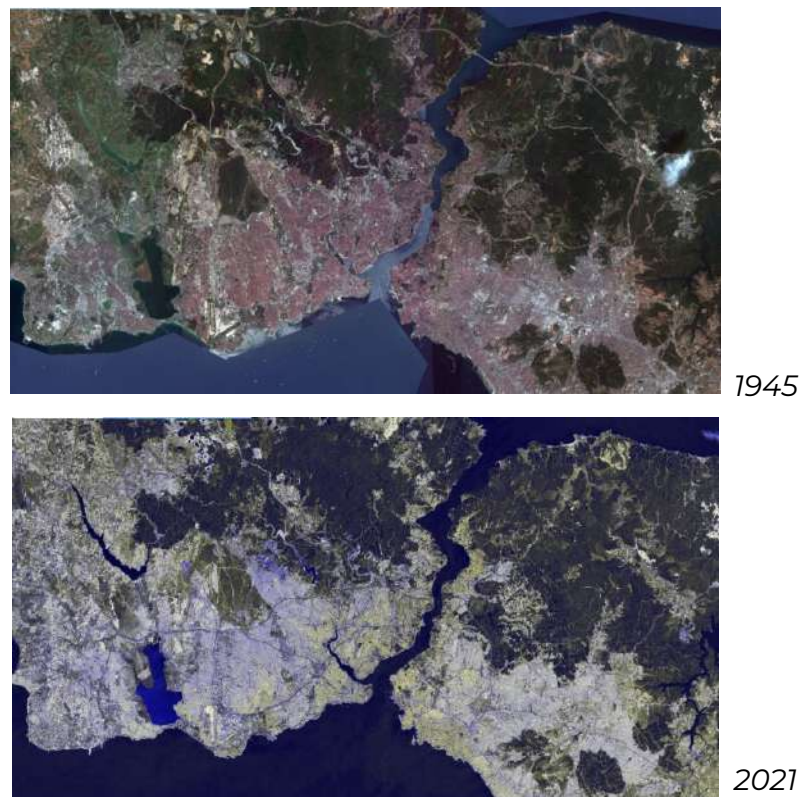


Figure 2. The Comparison between 1945 and 2021 in terms of the Population Distribution in Istanbul (IBB, n.d.)

2.1.2. Building Typology in Istanbul

Due to its comprehensive recorded background and high inhabitants, Istanbul has multiple building typologies. The most influential structures that impact Istanbul silhouette are apartments and skyscrapers (Erşen, 2016). Istanbul is the municipality with the most skyscrapers in Europe, according to information from an American-based organization regarding tall buildings and environment dated February 2022 (*IHA*, 2022). Istanbul contributes the largest to this, with 48 skyscrapers (*IHA*, 2022). In addition to apartments and skyscrapers, it is possible to see detached houses, mass housing, terrace houses, row houses, and historically colored wooden apartments (OHU, 2017).

2.2. Indoor Daylight

With the increasing awareness of the vision of sustainability, the essence of indoor natural lighting is augmenting day by day. Many studies provide essential knowledge about the positive aspects of daylight on human health and the environment (Majeed, Mustafa & Husein, 2019). According to studies, daylight is significant in keeping the circadian system in order (Mardaljevic, Andersen, Roy & Christoffersen, 2011). This rhythm regulates the human body's 24-hour mental, physical and behavioral cycle (Mardaljevic, Andersen, Roy & Christoffersen, n.d.). One of the most noteworthy things that assist this is sunlight. It is apparent that the effects of daylight on human health are inevitable (Lam, 1986). Therefore, providing indoor daylight has come to an important point. Indoor lighting varies according to the location of the building, topography, and climate (Ruck et al, 2000). In addition, building characteristics also affect bringing daylight indoors. The openings of the building, the size and direction of these openings, interior materials (reflective

or matt, dark or light colors), and even the facade materials of neighboring buildings also affect indoor daylight (Lam, 1986). Moreover, many standards have been launched and continue to be enhanced to provide sufficient daylight for indoor spaces. The most current and the first combination of daylight and design of these standards is the CEN daylight standard: EN 17037 (Jakobiak, 2021). This standard provides not only high daylight capacity but also daylight quality. Therefore, it offers four different daylight suggestions. These are daylight provision, view out from the building aperture, sunlight, and the prevention and minimization of the glare (Estonian Center for Standardization and Accreditation, 2021).

2.2.1. What is Indoor Daylight Availability?

Daylight availability is a norm that suggests the level of daylight indoors. The illuminance unit (lux) is used to estimate the usability of indoor daylight (Skowranek, 2017). In order to measure daylight availability for an interior, the weather file of the area where the space is located should be used (VELUX, n.d.). These files must contain the main elements that constitute the climatic conditions, such as precipitation, humidity, and wind, especially the solar radiation at different altitudes of the region (CS, 2022). When the models are used for calculation, it is taken as one year for annual calculations or 12 months separated (CS, 2022).

Many auxiliary metrics are used when calculating daylight availability. The first and most widely used of these is the *daylight factor*. It indicates the amount of daylight available indoors (Majeed, Mustafa & Husein, 2019). At the end of the calculations, it displays

the result as a percentage (%). It is possible to see the daylight distribution by shifting on the false color option in many daylight calculation programs (CS, 2022). According to calculations and norms, if an interior has a daylight factor of 2% or more, it has sufficient daylight (VELUX, n.d.). It means that artificial lighting may be used in addition to daylight for results below this value. In this case, the interior is not sustainable and does not fulfill the daylight availability rules. One of the biggest goals in improving indoor daylight availability is minimizing daytime energy use (Murdoch, 1977).

Another metric is the *daylight autonomy* (DA) which indicates the percentage of total daylight received by this interior during the period of use (CS, 2022). This aims to illuminate interior spaces used at certain times adequately. It aims to ensure that people receive sufficient daylight without being deprived of daylight during the time they spend indoors (Zhang, Du & Sharples 2017). From 100 lux to 500 lux for interior illumination are considered well lit (Mardaljevic, Andersen, Roy & Christoffersen, 2011). However, for Daylight Autonomy to be sufficient, it needs to receive light in these 100 lux averages for more than half of the day (VELUX, n.d.).

Rather than DA, *Useful Daylight Illuminance* (UDI) may be considered for calculation results. It is designated as excessive illumination because more than 3,000 lux of interior space would overheat, disrupting thermal comfort and causing glare (CS, 2022). According to UDI, values from 100 lux to 3,000 lux are given instead of 300 lux being shown as the previous limit (Mardaljevic, Andersen, Roy & Christoffersen, 2011).

In conclusion, computer-assisted programs are the easiest way to calculate these metrics. A work plane is generally needed even if the features change depending on the program type. It is necessary to install this work plane at 75 cm above the ground (CS, 2022). It is necessary to exclude unused areas from the calculation, limiting the area to 50 cm on the edges (VELUX, n.d.). Calculation programs such as Dialux, Relux, and climate studio perform this calculation automatically. However, this calculation may be calculated with the formula easily.

The DF is obtained by dividing the illuminance level of any indoor lux level and the outdoor level, then multiplying it by 100 (Skowranek, 2017). Namely;

$$DF = D_T = \frac{\text{Indoor lux level} \times 100}{\text{Outdoor lux level}}$$

$$DF = D_{TM} = \frac{\text{Min. Indoor lux level} \times 100}{\text{Outdoor lux level}}$$

One of the critical points to remember here is that the daylight factor is calculated based on an overcast sky (EVS, 2021).

2.2.2. Visual Comfort

Indoor comfort is a non-negligible topic in the interior architecture field. One of the most prominent reasons for this is that the time spent indoors is longer than outdoors. There are many fundamental points to make the interior comfortable. These are acoustic, thermal, air, and visual comfort (Deutsche Gesellschaft für nachhaltiges Bauen (DGNB), 2020). Providing these comforts helps occupants to spend a healthy time indoors.

On the other hand, visual comfort is not only related to natural light, but also visual comfort requirements should be provided in artificial light (Chartered Institution Of Building Services Engineers, 2002). Visual comfort is generally calculated according to the lux level practical, the purpose of the interior, the amount of glare, and the visual relation with the exterior. (DGNB, 2020) The illumination level varies according to the work purposes, the place used, and the people (Ruck et al, 2000). The light levels may change according to the tasks, such as offices, and the appropriate illuminance level in residences may differ from the public areas. (Arpacioğlu, 2012). The reason for this is the distinction in the purpose of use of the interior. The IES establishes illuminance standards for indoor spaces. Considering these standards, daylight availability is calculated, and indoor lighting is improved according to the acquired situation (Table 1). For example, working areas need higher lighting levels, while rest areas need less lighting than working areas (Fadzil, Nedhal, Abdullah & Harun, 2013).

Some of the standards conducted to provide visual comfort in artificial light are as follows;

Task	Illuminance (Lux)	Example of application
Lighting for infrequent used area	20	Minimum service illumination
	50	Interior walkway and car park
	100	Hotel bedroom
	150	Entrance and exit
Lighting for working interiors	200	Infrequent reading and writing
	150	Restroom
	100	Bedroom
	150 - 300	Kitchen
Localized lighting to exacting task	500	Proofreading
	1000	Exacting drawings

*Table 1. Recommended Average Illuminance Levels for Interior Spaces
(Fadzil, Nedhal, Abdullah & Harun, 2013)*

Visual comfort should be provided not solely for artificial light but also natural lighting. In that case, the daylight factor is of great essence. This is due situations where DF is acceptable to supply visual comfort. However, another issue to consider here is the light glare percentage. In the possibility of some light angle, the eye cannot endure problematic light, which leads to glare (Rea & Illuminating Engineering Society of North America (IESNA), 2000) . In this circumstance, it is almost impossible to provide visual comfort where there is glare (Table 2). According to IES Standards, UGR matters above 19 cause uncomfortable lighting due to glare (Arpacioğlu, 2012).

Glare Condition	Daylight Glare Index (DGI)
Unnoticeable	16
	18
Acceptable	20
	22
Uncomfortable	24
	26
Intolerable	28

*Table 2. DGI Levels for Interior Spaces
(IES, 1989, as cited in Arpacioğlu,2012)*

As an outcome, many metrics are used to provide visual comfort. These metrics should complete the demanded standards. In the overview of the information given above, the illumination level should be sufficient according to the qualities of the work: the distribution of the amount of illumination, the absence of glare, and the provision of sufficient and extreme light contrasts are the main criteria. If these metrics are provided, there is no reason why visual comfort cannot be achieved.

2.3. Physical Parameters of Indoor Daylight

Some factors influence indoor daylight availability, and these factors are integral to consider. These cover many conditions, including the area's climate, the building's location, and the interior's characteristics (Kutlu, 2019). Here, interior architecture and architecture carry a great responsibility. Even a tiny material difference may affect indoor daylight. This is because the outer shell of the building affects the spaces, which are the inner core. Unfortunately, in terms of daylight, this is not constantly praised. Hence, critical factors like the building facades, openings, sizes, characteristics of the openings, materials, and furniture in the interior are considered (Lam, 1986). These elements are examined in detail as sub-headings.

2.3.1 Building Design

Architecture may influence daylight just as daylight concerns architecture. Appreciation of the light, the architectural structure may be perceived differently, or the architecture may be supported by the light (Ruck et al, 2000). These are the positive effects that light has added to the architecture.

On the other hand, architecture correspondingly simulates daylight (Ander, 2016). Based on these outcomes, architectural daylight may lose its importance in cases where the planned and design process is insufficient.

Daylight should be seen as one of the indispensable factors of urban architecture. Buildings should be in the design phase and urban designs from the beginning (Köster, 2004). Numerous prismatic or transparent technologies and lighting systems may be selected to improve indoor daylighting (Ruck et al, 2000). Nevertheless, while these designs strengthen daylight availability, the indoor temperature should be controlled in terms of thermal comfort. Regarding indoor daylight availability, the two most influential parameters to consider in structure design are constructing orientation and geometry (Kutlu, 2019). These two factors directly involve indoor daylight availability.

The first factor, the orientation of a building, varies according to the longitude and latitude (Lam, 1986). This factor brings climate and weather conditions with it—the path and the angle of the sun, which the sun's rays also reach, changes. Therefore, building orientation should be done according to the climatic conditions of the place where the building is located and the sun path (Köster, 2004). As shown in Figure 3, desired daylight time varies according to the time and seasons of the building and its location. Unfortunately, in some cases, daylight intake is limited by the direction of the building, regardless of the building's facade (Ander, 2016).

In a situation where the direction of the building is west, the desired DF may remain below 5% even if the building openings are increased (Figure 3). Turkey is located in the northern hemisphere (Dewdney & Yapp, 2022). For this explanation, the most used areas (such as the living room, kitchen, and bedroom) are expected to be located on the south facade (Kışmıroğlu, 2010). Accordingly, it is preferable to make an interior distribution, as shown in Figure 3.

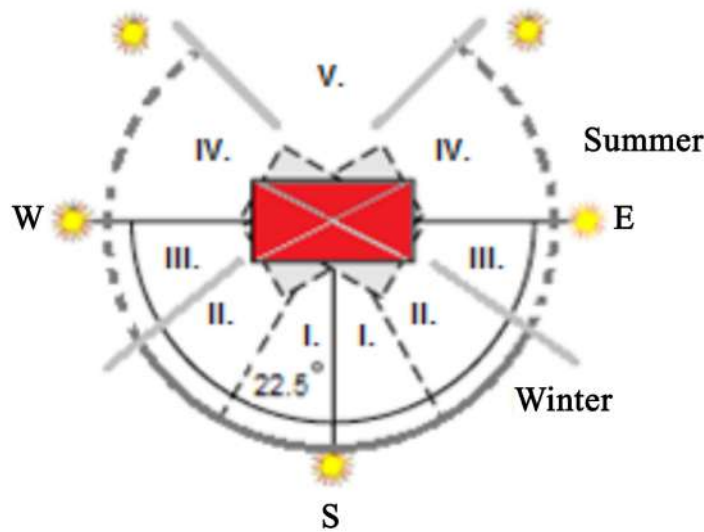


Figure 3. The Preferred Building Positions for Daylight (Kutlu, 2019)

Another critical aspect is the geometry of the building. Although a building's compact geometry is essential for thermal comfort, this may occasionally negatively affect daylight availability (Majeed et al., 2019). However, on the other hand, a building that has multiple exterior facades may not have the desired daylight sufficiency for the interior. One of the critical measures is the room's depth (DGNB, 2020). In addition, the floor of the room to the size of the window should be associated.

To get proper daylight availability, the connection between the room and the window should ensure these criteria (Arpacioğlu, Çalışkan, Şahin & Ödevci, 2020);

$$\frac{d}{w} + \frac{d}{HW} \leq \frac{2}{(1-RB)}$$

d = room depth

w = room width

HW= window height from ground level,

RB= average reflection from the surfaces in the back of the room

As a consequence of this part, room depth may be simulated based on the formula given above. Unfortunately, the final value of the result does not provide the daylight factor. To represent this, a simple room with a height of 3 meters, a length of 6 meters, a width of 6 meters, that is 36 m², has a daylight span of 3 m². While a zone that may get satisfactory daylight should have a DF above 2%, this place was below this limit with 1.6% (Figure 4). This means that artificial light is required concurrently with daylight.

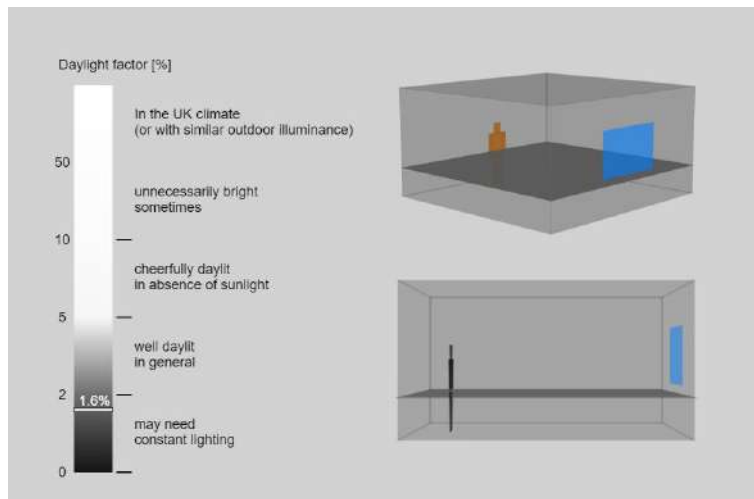


Figure 4. The Basic DF Calculation Method (University of Bath: Department of Architecture and Civil Engineer, n.d. ,and *by author*)

2.3.2. Material and Reflections

The wall of the room, floor, and ceiling are additional elements for perceiving daylight indoors. Daylight from windows or skylights hits all room surfaces, illuminating the room (Rea & IESNA, 2000). Unlike direct sunlight, these are indirect lights. The point to be considered here is the materials used in the room (Society of Light and Lighting (SLL) & Chartered Institution of Building Services Engineers (CIBSE), 2002). Glossy or semi-gloss surfaces reflect light.

On the contrary, matte surfaces absorb light more than glossy surfaces (Figure 5). The matter of such materials is excellent not only for interior items but also for facades of buildings (Marsh, 2010). In cases where there are no neighboring buildings or the neighboring buildings do not affect the main building, the sun arrives directly through the windows (Lam, 1986). Regardless, in cases where there are surrounding structures, the sun's rays may reflect and reach the interior of the actual room, depending on the

facade materials of the buildings (Danks, Good & Sinclair, 2016). In this issue, the rays reflected from the surrounding buildings may potentially cause glare (Lam, 1986). Therefore, exterior cladding should be done by considering the indoor daylighting conditions of the surrounding buildings.

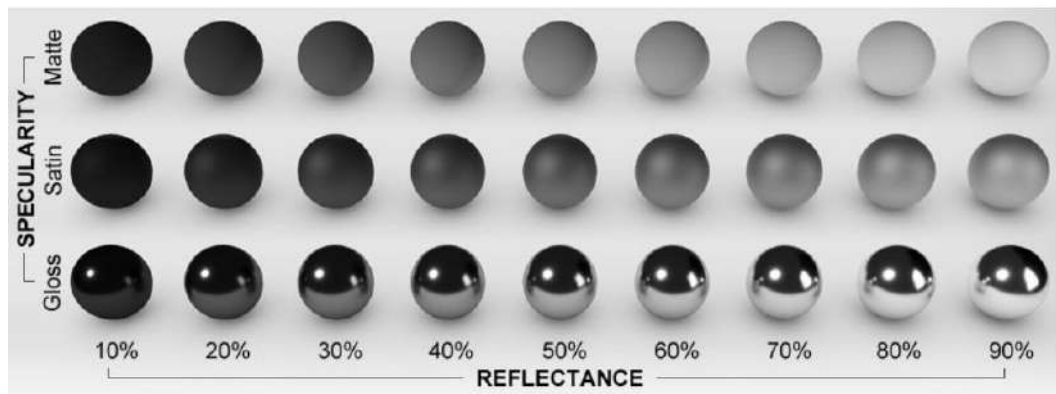


Figure 5. The Reflectance Values for Different Material Properties
(Marsh, 2010)

Along with the material, another additional element is color. Colors may counter in different light conditions. It may be perceived differently depending on the color of the light (McCann, Parraman & Rizzi 2014). The link between light and color is dependable, and there is no color without light (Kavasoğulları, 2021). However, it is necessary to comprehend the use of color exceptionally for designers and architects (Imamguloyev, 2021).

If dark colors are preferred on the room's surfaces, these colors absorb the sunlight (Paktaş, 2018). Thus, dark colors are not recommended for areas with a problem getting sunlight (Table 3). In the situation of limited daylight, using dark colors may restrict the daylight even more. On the other hand, bright colors help reflect light (Paktaş, 2018).

Colors	Light reflectance value
Very white	85%
Very black	7%
Light gray	60%
Dark gray	35%
Light red	35%
Red	18%
Purple	10%
Light green	60%
Dark green	30%
Light blue	50%
Dark Blue	20%
Dark brown	25%
Yellow	68%

*Table 3. The Table for Color Properties in terms of Light Reflectance Value
(Imamguluyev, 2021)*

2.3.3. Aperture Features

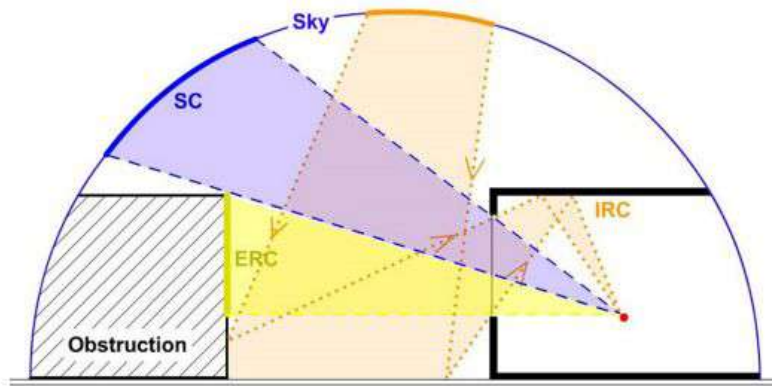
Building openings are one of the most prominent means of providing daylight to the interior. Windows not only provide illumination to the interior but also a visual interaction with the outside (Rea & IESNA, 2000). Although the openings used on the facades do not have standard dimensions, their shape, size, and direction may alter according to the building design approach (Ruck et al, 2000). Openings may be on the side, up, or even on corners. Depending on the direction and shape of the opening, the amount of daylight availability for indoors may also change (Ander, 2016). For this, the importance of the surrounding buildings is predictable. The silhouettes of buildings may obstruct openings and change in daylight. Regarding the eye level of building occupants, the size and position of windows, window frames, and other facade features should be carefully examined (Ruck et al, 2000). Side daylight, upper daylight, or different daylight systems such as a light

shelf and solar tunnel may be utilized in buildings (Lam, 1986).

According to the above research results, building openings affect indoor daylight availability (Rea & IESNA, 2000). Consequently, it is of great importance to provide the correct building opening. The shape, size, and material of the opening of the building impact the quality of daylight (Skowranek, 2017).

2.3.4. Obstructions

Urban architecture is a crucial factor in the quality of life. This affects the quality of the streets, buildings, and interiors (Danks, Good & Sinclair, 2016). Indoor daylight quality also changes according to the location of the buildings and the surrounding structures (Zhang, Du & Sharples, 2017). Indoors' view of a green zone is pleasingly satisfying and allows daylight into the interior (Lam, 1986). In this case, it is related to the size of the tree and whether the green area is visually blocked or not. Concerning the obstacles on a construction site, it notifies a designer about the daylight prospect of the building's facades, allowing him or her to shape the structure and apportion floor spaces under daylight availability (Ruck et al, 2000).



SC= Sky Component

ERC= Externally Reflected Component

IRC= Internally Reflected Component

Figure 6. The Components of Daylight Factor (DF)

(Arpacioğlu, 2010 as cited in Arpacioğlu, Çalışkan, Şahin & Ödevci, 2020).

In indoor daylight, it is not merely the effects of surrounding buildings. In addition, roads, green areas, and other structures in the surrounding area also have an influence. Depending on the material of the existing building, the effect on indoor daylight varies. As stated in the chapter on sunlight, the reflectance of materials changes in the clear and overcast sky (Lam, 1986). While this sometimes benefits the dimmed interior, glare is challenging to control and is therefore paramount to the design process. Depending on the reflectivity of the exterior materials of adjacent buildings, the daylight penetrating the interior may also vary (Danks, Good & Sinclair, 2016) (Figure 6). Trees may form shadows for low floors in buildings facing green areas, although they provide visual contact with the outside. Daylight reflects off adjacent buildings, ground, and buildings (Lam, 1986).

As the literature review described above shows, indoor daylight availability and quality may be overshadowed by building and urban architecture. From the exterior of the building to the interior design, even the geometry and material structure of the surrounding buildings can cause negative consequences. In order to increase or enhance indoor daylight efficiency, the best solution is to consider indoor daylight before forming urban structures. Thus, interior quality and visual comfort may be achieved.

CHAPTER 3

METHODOLOGY

CHAPTER 3

METHODOLOGY

3.1. Research Questions and Hypotheses

There are one main and three sub-research questions in order to bring the research to the desired and planned point. In that case, the research questions are as follows:

RQ: Can urban architecture be part of the factors on indoor daylight standard for buildings in Istanbul to strengthen indoor daylight availability?

Sub-RQ1: Do buildings that have different typologies have different impacts on indoor daylight availability?

Sub-RQ2: Are the differences between building apertures, floors, and the proximity of buildings to each other interconnected in terms of daylight availability?

In response to these research questions, the following hypotheses are formulated:

H0: There is no connection between urban architecture and indoor daylight availability.

H1: The indoor daylight efficiency of the buildings in the unplanned urbanization region is insufficient, and the buildings affect the indoor daylight availability of each other.

H2: The proximity of neighboring or independent buildings affects the indoor daylight qualities of each other.

H3: While skyscrapers affect the indoor daylight of low-rise buildings in the regions where they are located, low-rise buildings affect each other's daylight due to their proximity to each other and the elevation difference.

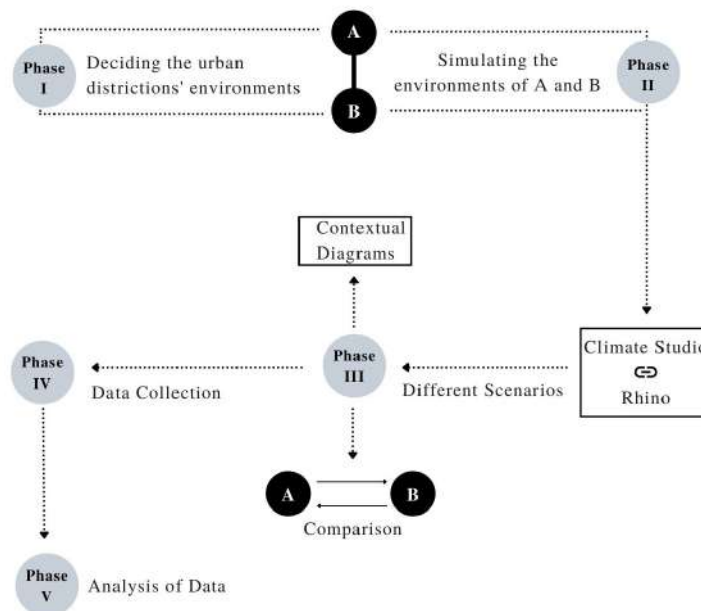


Figure 7. The Procedure Map of the Study (by author, 2022)

3.2. Sample and Settings

In order to establish indoor daylight standards in buildings for Istanbul, two different locations have been determined (Figure 8). These locations will be simulated with the aid of Climate Studio, the results will be compared with EN 17037, and a new indoor daylight standard will be created accordingly. While these standards ensure the proper and efficient use of daylight in future building and urban designs, solutions will be presented for existing building structures to fulfill these standards. The reason for choosing two locations in Istanbul is the increasing population density in Istanbul and the problems caused by unplanned urbanization to compare different cases. 4. Levent/Kağıthane and Galata/ Beyoğlu regions were preferred due to different building typologies and heights.



Figure 8. Selected Locations in Istanbul for the Study (by author, 2022)

Beyoğlu is a district on the shore of Haliç. The most famous area of this district is Galata (See Appendix A). It generally contains greenery and gardens, but the construction has also risen with the increased migration from the countryside to the cities.

The symbol of this district is Galata Tower. *Galata Tower* is a landmark with an excellent historical reputation and was used as a fire watchtower in the past. It is possible to reach this structure, which has many tourist visits, from 4 streets. The only street where the whole silhouette of the tower can be seen is the Büyük Hendek Caddesi. *Küçük Hendek Caddesi*, which is selected for this study, is located in the back street (Figure 9). This street has many apartments and cafes. It is located in the so-called modern buildings and traditional Istanbul houses in this neighborhood.



*Figure 9. Plan and Side View from Sample A with Selected Room
(by author, 2022)*

The building, no 18, located in the street, is the only triangular bay window building around Galata. The bay windows' most important feature is covering the living room and making a unique area for the household. One of the causes for the triangular bay window is to receive daylight efficiently, while on the other hand, it was designed to keep the distance according to the level of the adjacent buildings (Figure 10).

Even if this building is thought to provide daylight quality, the environmental circumstances of the building prevent this. This building will be referred to as *sample A* throughout the simulation trials.

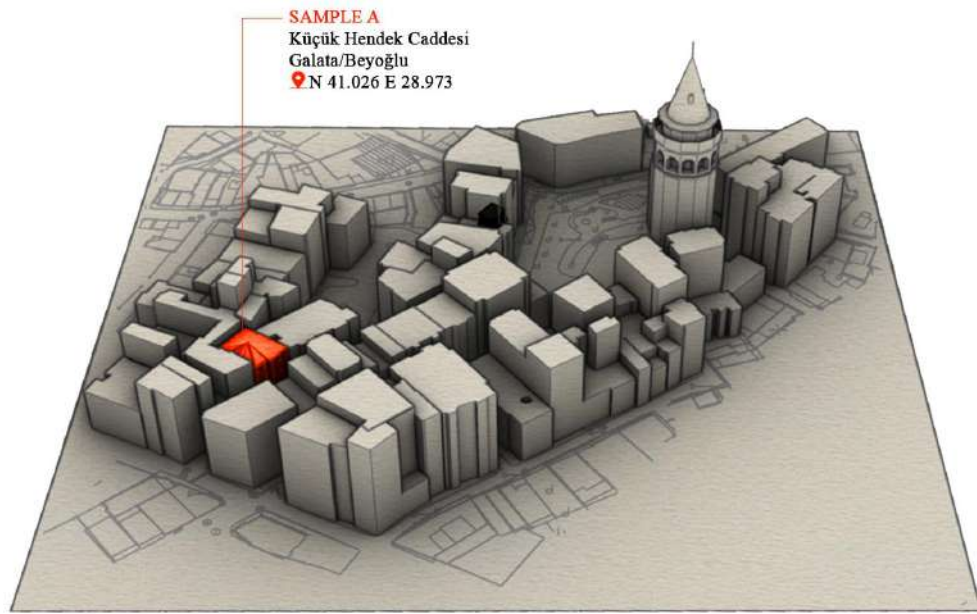


Figure 10. 3D Map of Galata, Beyoğlu (by author, 2022)

4. Levent district, the other experimental area, is known as the skyscraper area of Istanbul (Figure 11). It is because this incorporates the most well-known and most high skyscrapers. Sapphire Shopping Center is one of the tallest skyscrapers in Istanbul and is located in this region. NidaKule, which stands out with its crystal form, is also located in this region (See Appendix A). Apart from the skyscrapers, this area has many high-rise office towers and shopping centers. Nonetheless, besides these skyscrapers, there are many low-rise apartments here. Moreover, unfortunately, these apartments are overshadowed by skyscrapers.



*Figure 11. Plan and Side View from Sample B with Selected Room
(by author, 2022)*

One of the neighborhoods most impacted by this situation is *Atalar Caddesi*. This quarter of Nida Kule, on the west side, consists of buildings of diverse sizes (Figure 12). The upper floors of these buildings are houses; the lower floors of restaurants and markets are reserved for the public. Buildings with conjoined building typology have various heights and widths. This makes it challenging to bring daylight to indoors. In addition to the skyscrapers, the neighboring buildings may not be able to benefit from daylight adequately due to the high floor heights. Apartment no 4, the lowest-story building on this street, was preferred for the simulation. This building will be called *sample B* in the simulation.

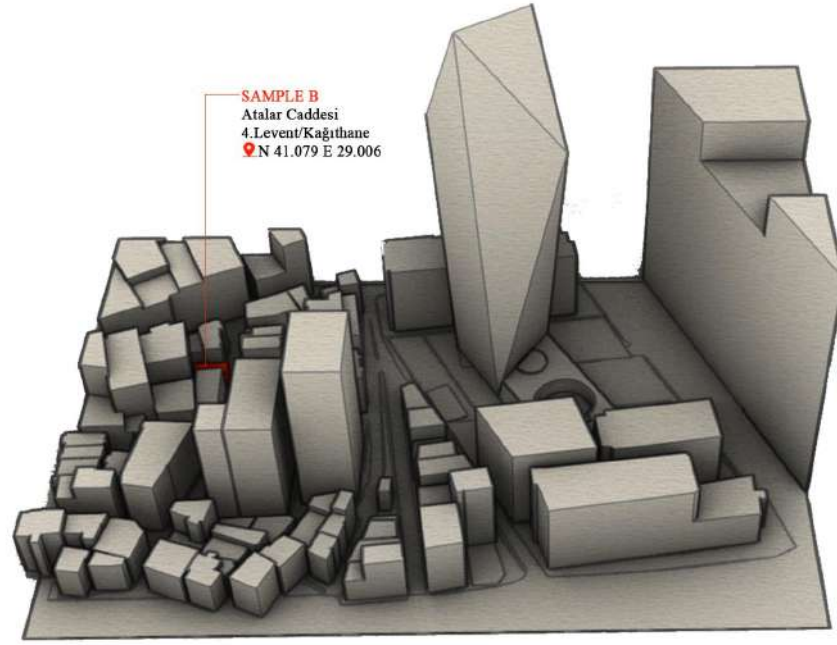


Figure 12. 3D Map of 4.Levent, Kağıthane (by author, 2022)

Consequently, these two districts are preferred because they are in different provinces and have, unlike urban architectures. The living rooms of samples A and B will be considered while simulating the calculation. The living room is of tremendous significance in terms of Turkish family tradition. Especially when looking at the residential areas in Istanbul, it is witnessed that the houses do not have a garden. That is why families spend most of their time together in their living room. The living room culture has an attractive tradition for Turkish family. Then, the living room simulations of the A and B samples are compared according to their building locations, building closeness, types, and usage times. Thus, solutions that should be in indoor daylight and conveyed to the existing situation are studied.

Before the CS calculations, the properties of samples A and B are discussed. These factors may impact the calculation results, which are shown in the setting table below.

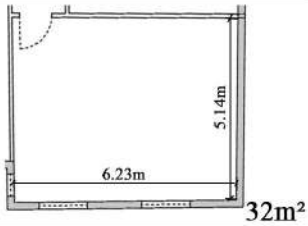
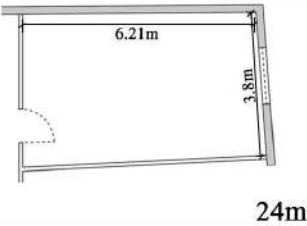
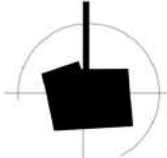
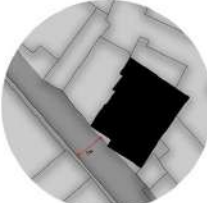
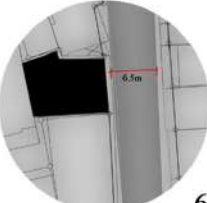
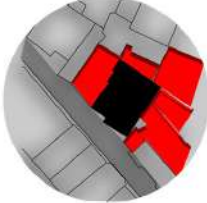
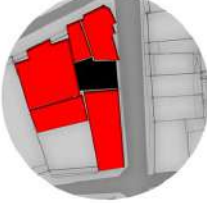
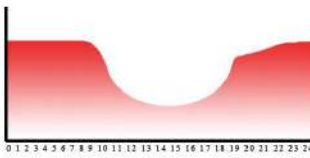
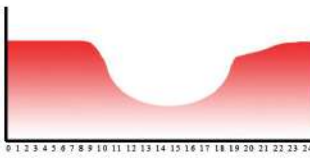
	SAMPLE A	SAMPLE B
DIMENSIONS		
LOCATION	 WSW Facade	 E Facade
ROAD DISTANCE	 3m	 6.5m
ADJACENT BUILDINGS		
THE TIME OF USE		

Table 4. The Settings for Sample A and B (by author, 2022)

Sample A, in Galata, is a 32-square meter living room with three windows. The height of the area is approximately 3 meters (Table 4). Two of the windows face south west, and one faces northwest. All 3 of the windows are located in the bay window of the room. On the other hand, sample B in the 4. Levent is smaller than sample A, 24 square meters. Although the room depths are nearly the same, one window facing east in sample B.

When compared in terms of locations, sample B receives more morning sun, and sample A is expected to receive more evening sun during the day. Both of them have only one main facade for apertures (Table 4). The other three facades are shared with neighboring buildings. Since the A sample is located in Galata, in the historic street, the street width of the B sample is two times bigger than that of sample A, while the street width is 3 meters. Comparing the distances of its open facades to the buildings opposite, this is expected that the B sample will receive more light.

Samples A and B contain six adjacent buildings of different heights, sizes, and even typologies. Sample A, the adjacent buildings are the same height. Nevertheless, Sample B is the lowest among the adjacent buildings.

Since samples A and B are residential buildings, the living area was chosen as the calculation area. It was created considering that the usage time of the living room decreases from 9 a.m. to 7 p.m.. During the period, it is determined that the room is not occupied all the time (Table 4).

The adjustments made according to location, direction, and building characteristics are similar in both examples (Table 4). Each of these adjustments will be included in the calculation by being specified in the CS calculations.

When the interior features are considered, the most critical factor will involve the reflection or absorption of light on the finishing materials. Hence, the same materials were used to control the reflectivity levels for both samples. When the reflectance values of the materials are examined, the ceiling material is the most reflective with 89.4%. Increasing the reflectivity of the ceiling aims to construct the room brighter by reflecting the sun rays taken inside. In addition, wood and light gray tones paintings are prevalent throughout the room (Table 5). The reflectance value given to the surrounding buildings is 64.3%. It further demonstrates the influence of the surrounding buildings on the interior.

Layer	Objects	Material	Rvis	Tvis
Floor	1	 Wooden Parquet floor	%19,8	%0,0
Ceiling	1	 White painted ceiling	%89,4	%0,0
Wall	1	 Grey Painted wall	%45,8	%0,0
Windows	1	 Clear	%8,4	%87,7
Door	1	 Light Brown Wooden Doors	%41,9	%0,0
Window frames	3	 Wooden Frame	%13,3	%0,0
Buildings	146	 Exterior wall	%64,3	%0,0

Table 5. The Properties of Selected Materials (based on CS, 2022)

The following data is used to set the simulation environment accurately. These data were created by accepting the average of Istanbul's location and weather conditions. There are different conditions of design requirements, and they are:

TUR_IB_Istanbul-Ataturk.170600_TM Yx.2004-2018

Koepfen climate Zone: Temperate, Dry Hot Summer (Csa)

ASHRAE climate zone: Warm (3)

Average annual temperature: 11 °C

Annual total solar radiation: 1.640 kWh/m²

Heating Design Conditions

Coldest month: January

Coldest week: 12/15 - 12/21

Typical winter week: 1/20 - 1/26

Annual HDD for 18 °C is: 1.509

Design temperature 0.04%: -10 °C

Cooling Design Conditions

Hottest month: August

Hottest week: 7/27 - 8/ 2

Typical summer week: 7/ 6 - 7/12

Annual CDD for 10 °C is: 2.555

Design temperature 99.6%: 31,7 °C

Four diverse periods of 12 months; are depend on the winter solstice, summer solstice, vernal equinox, and autumnal equinox. These periods provide comparative data due to different sun angles and climatic conditions. The calculations are based on certain times of the year. The summer solstice is when the sun's rays hit the earth at the steepest angle. In contrast, the winter solstice is when the sun is at its lowest position (Figure 13). In the equinoxes, there are differences in daylight availability due to the equal day and night (Table 6). The situations in question for Istanbul are as follows:

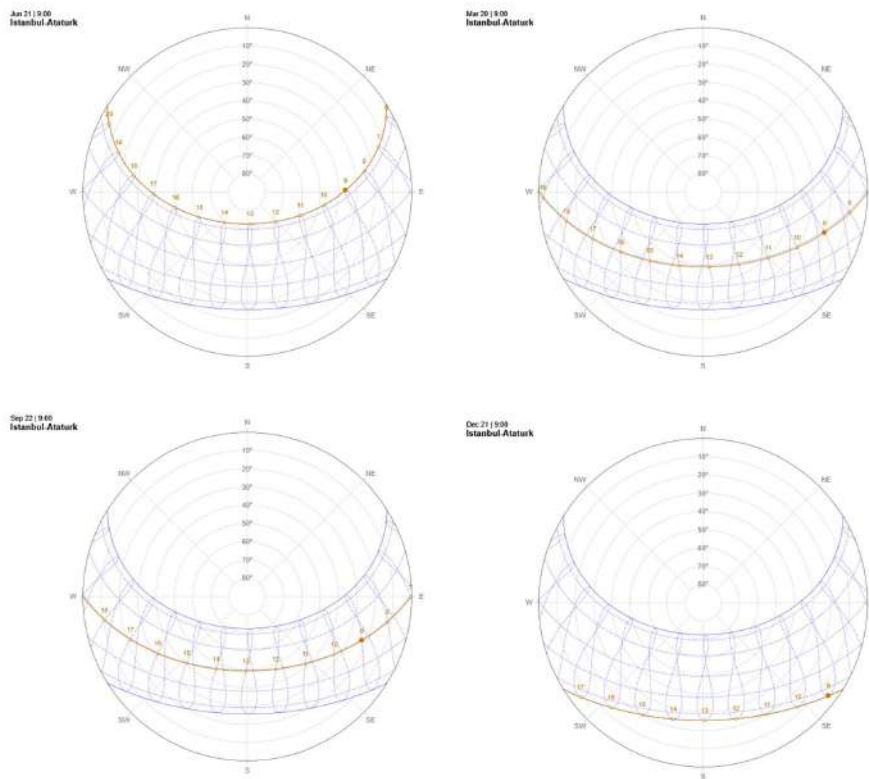


Figure 13. The Sun Path for Winter Solstice, Summer Solstice, Vernal Equinox and Autumnal Equinox (based on CS, 2022)

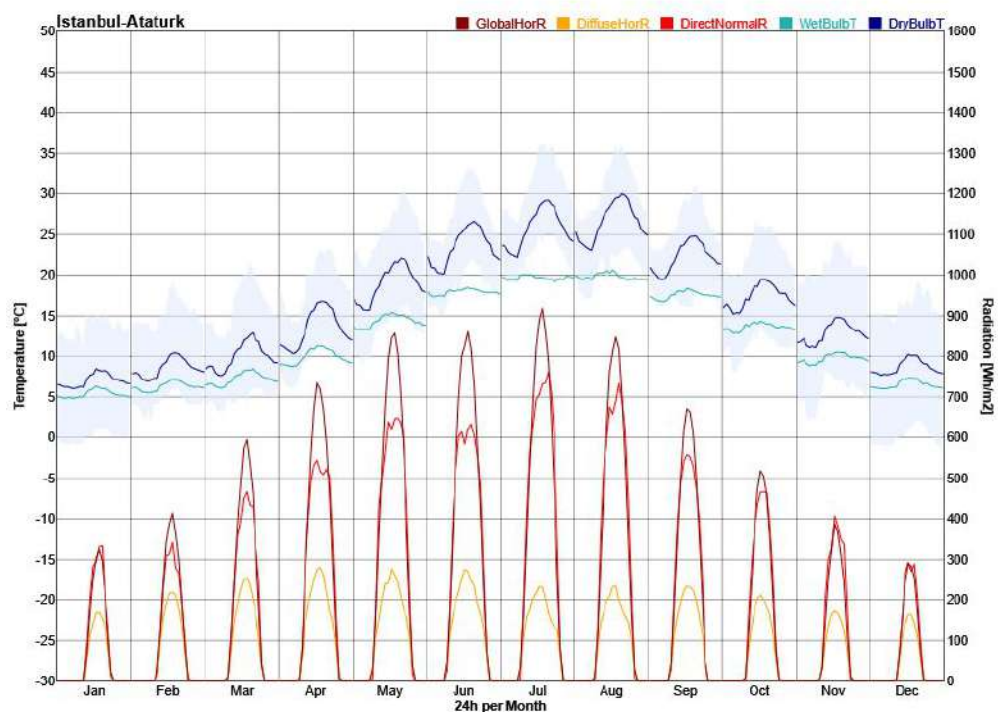


Table 6. The Radiation Graph for 24h per Month(based on CS, 2022)

3.3. Experimental Simulation

3D models of samples, A and B are prepared for Climate Studio calculations after their plans are drawn on the rhino. Climate Studio was adjusted according to the settings determined above. The working plane should be set at 0.75 meters. For sample A, the 2nd floor was considered for calculation, whereas the upper floor for sample B. First, site analysis should be done, and models with shadows should be created for the shadow and sun path situation. The diagrams' results should be output. As the first step of the calculations, sun path and shadow analysis are taken. During this analysis, it will be apparent how these shadows obscure these main buildings. The shadow and sun path analysis is a crucial part of calculating precisely.

3.4. Instrument and Data Collections

Data from Istanbul Municipality and drawings from the Ministry of Environment and Urbanization delivered technical details and drawings throughout the methodology section. In order to simulate the acquired data, the site plans of samples A and B were made three-dimensional by Rhino and associated with the Climate Studio interface. Although there are many computer programs in this way, the purpose of using climate studio is that it contains numerous matters and norms and may readily present results. CS was preferred in order to give valid and actual results of the research. CS is a daylight calculation program, and it is possible to obtain accurate results using the weather data entered into it. CS includes sub-evaluation tags such as site analysis, point-in-time illuminance, annual glare, viewpoint, daylight availability, and EN 17037 (Figure 14). In this project, this program was preferred because the EN 17037 standard is of great importance for daylight availability and should be checked.

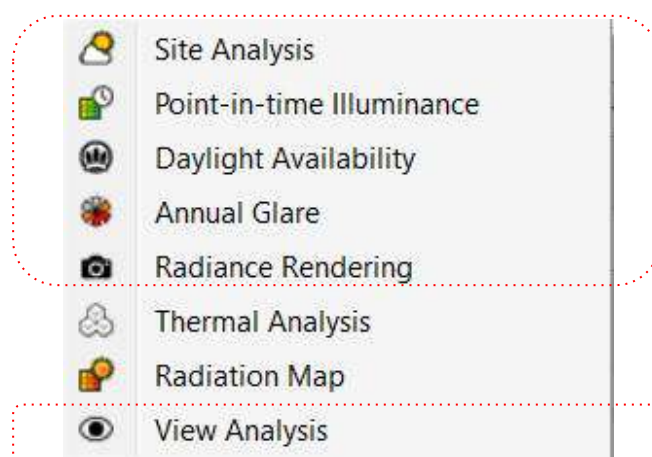


Figure 14. The Sub-evaluation Tags (based on CS, 2022).

After calculating the standards assigned from the settings, samples A and B were calculated according to 4 different months. The data's variability and the distinction between them were compared, and initial outcomes statements were prepared from the calculations. For each calculation, the false colored plans and value results are taken in the plan view.

The state of the obtained results, re-calculations, and adjustments were made to improve the conditions of samples A and B. The circumstances where these new calculations should be in the future building designs and the situation that the current situations may get more useful daylight are evaluated.

CHAPTER 4



RESULTS

CHAPTER 4

RESULTS

Galata and 4. Levent was simulated based on Istanbul's weather data. Samples with the same height but different environmental factors, A and B, were modeled, and calculations have resulted. The calculations checked compliance with the daylight standard for different lighting values and EN 17037. The calculations completed in the methodology section and the results obtained from the experimental simulations are concluded and compared in detail—the locations selected from two different districts of Istanbul, Galata and 4. Levent of the obtained results and different versions varied from these results will be summarized under various sub-tags, and information will be given. The collection of results forms a new and usable daylight standard for Istanbul.

4.1. Simulation Findings

This section provides the results of samples A and B under diverse categories. The visuals and data of the outcomes acquired are listed in categorical order.

4.1.1. Site Analysis

The site analysis for Galata and 4. Levent, which are for Sample A and Sample B, are documented below under separated periods, and the results are given:

Sample A

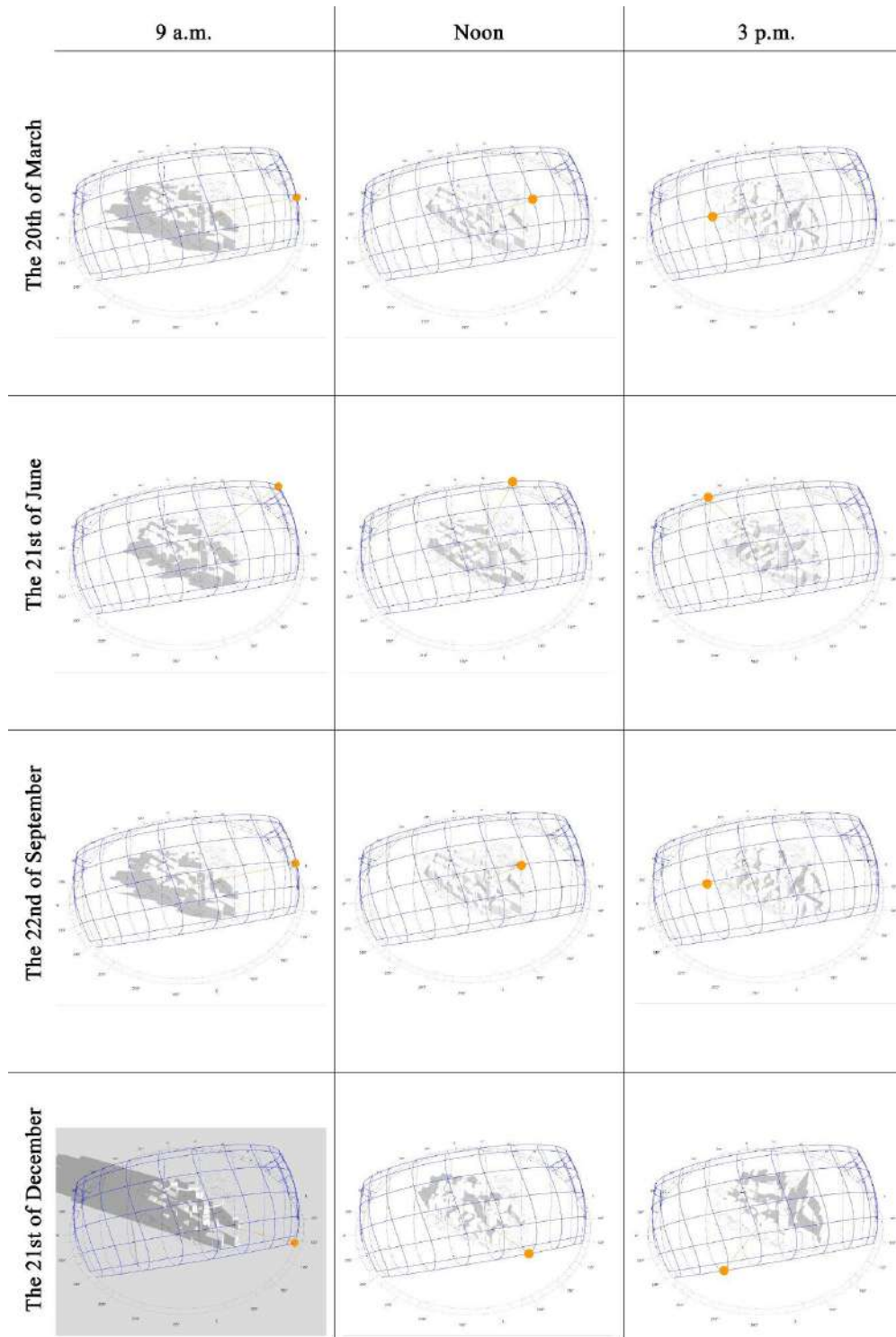


Table 7. The Shadow Analysis of Sample A (by author).

Sample B

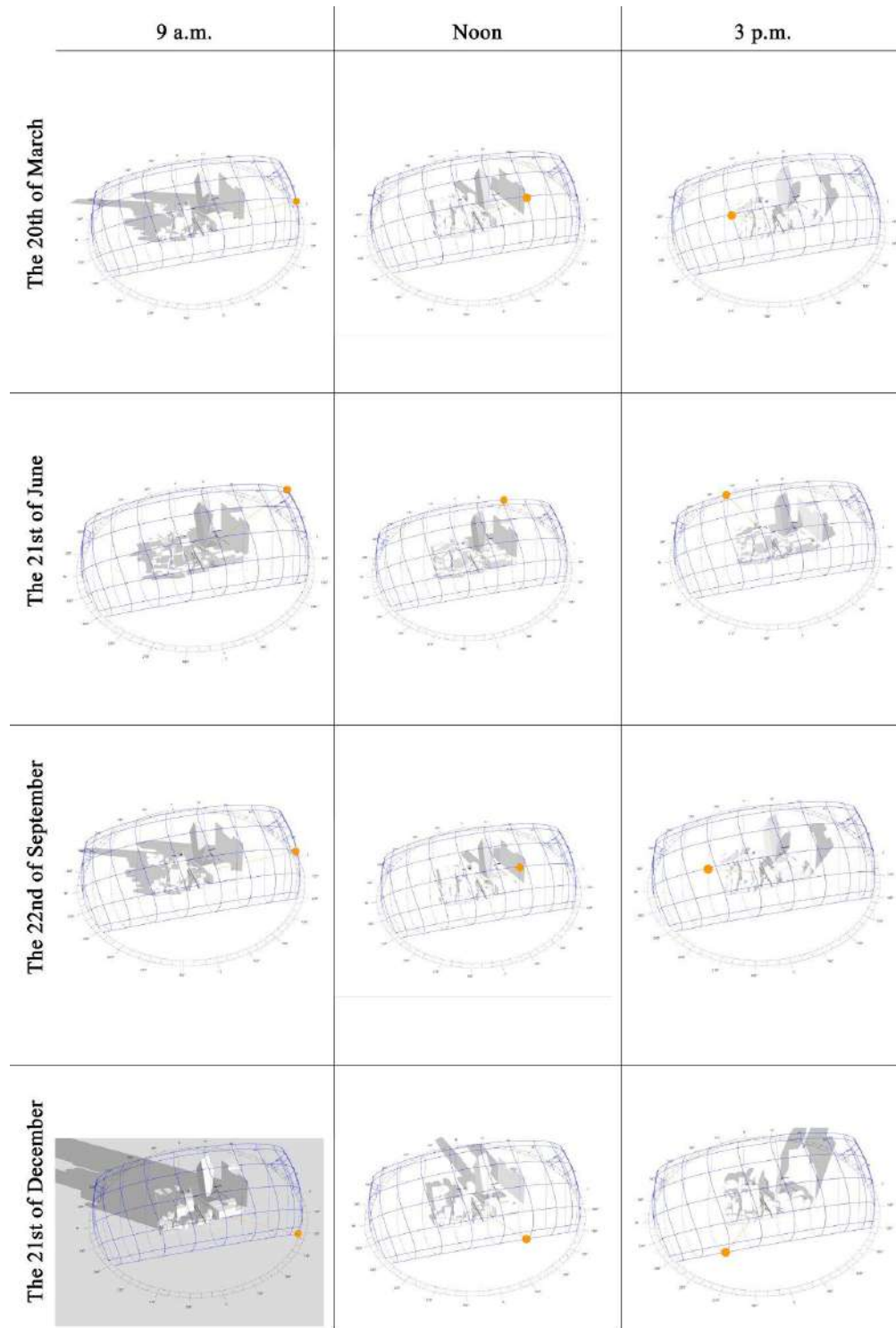


Table 7. The Shadow Analysis of Sample B (by author, 2022).

4.1.2. Point-in-Time Illuminance

Clear Sky: Sample A

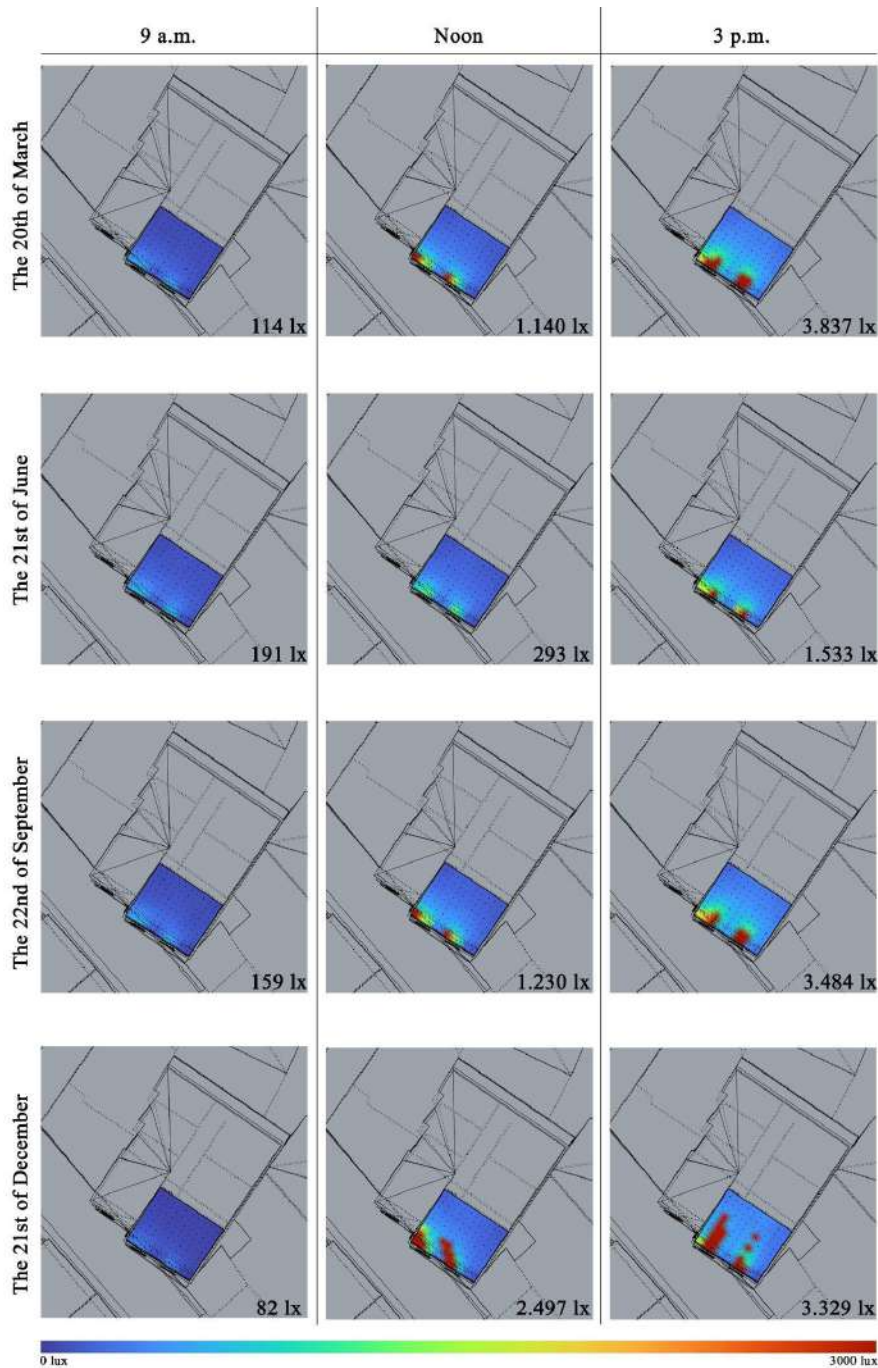


Table 9. The Point-in-Illuminance Analysis of Sample A under Clear Sky Condition (by author, 2022).

Intermediate Sky: Sample A

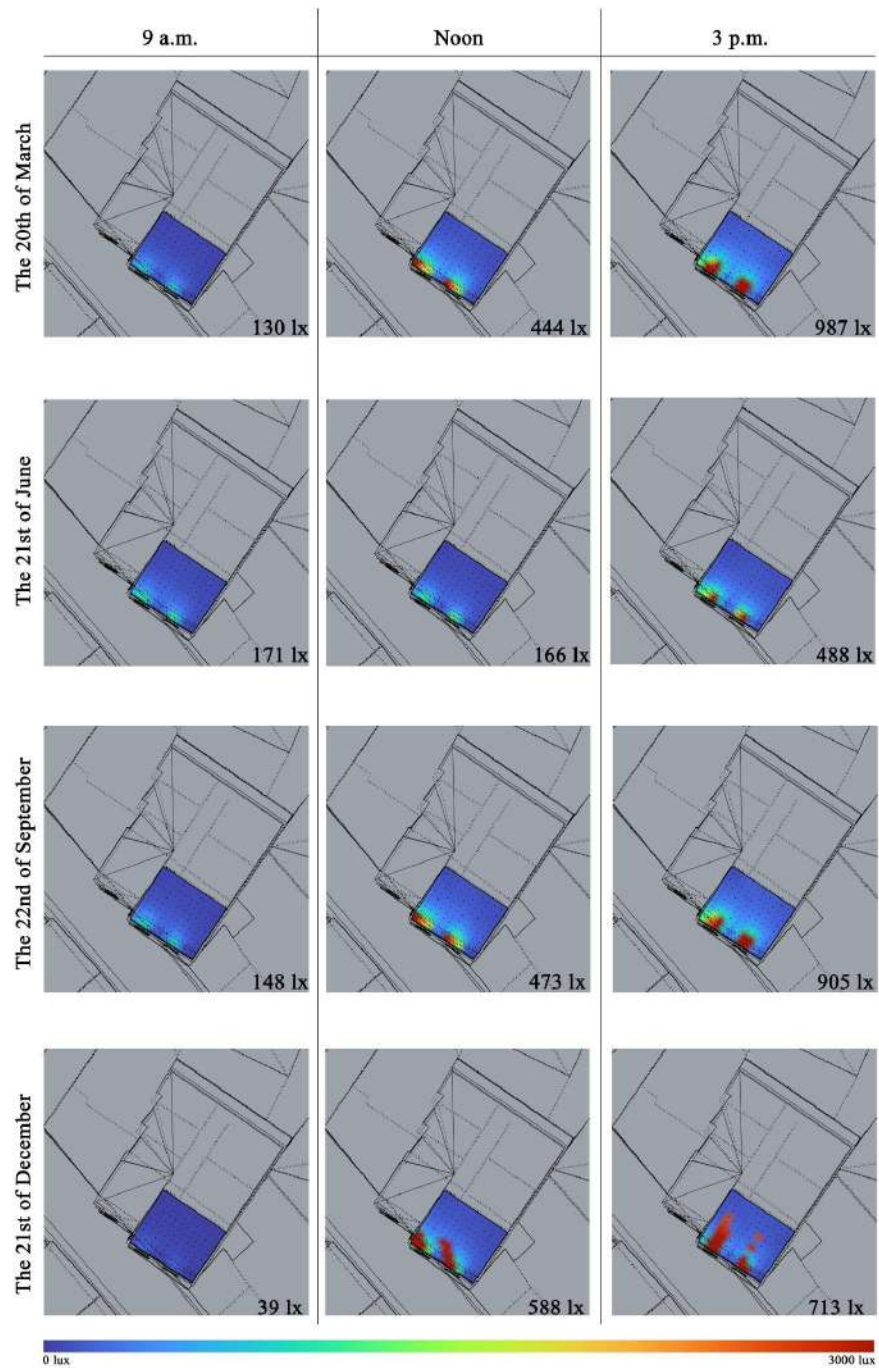


Table 10. The Point-in-Illuminance Analysis of Sample A under Intermediate Sky Condition (by author, 2022).

Overcast Sky: Sample A

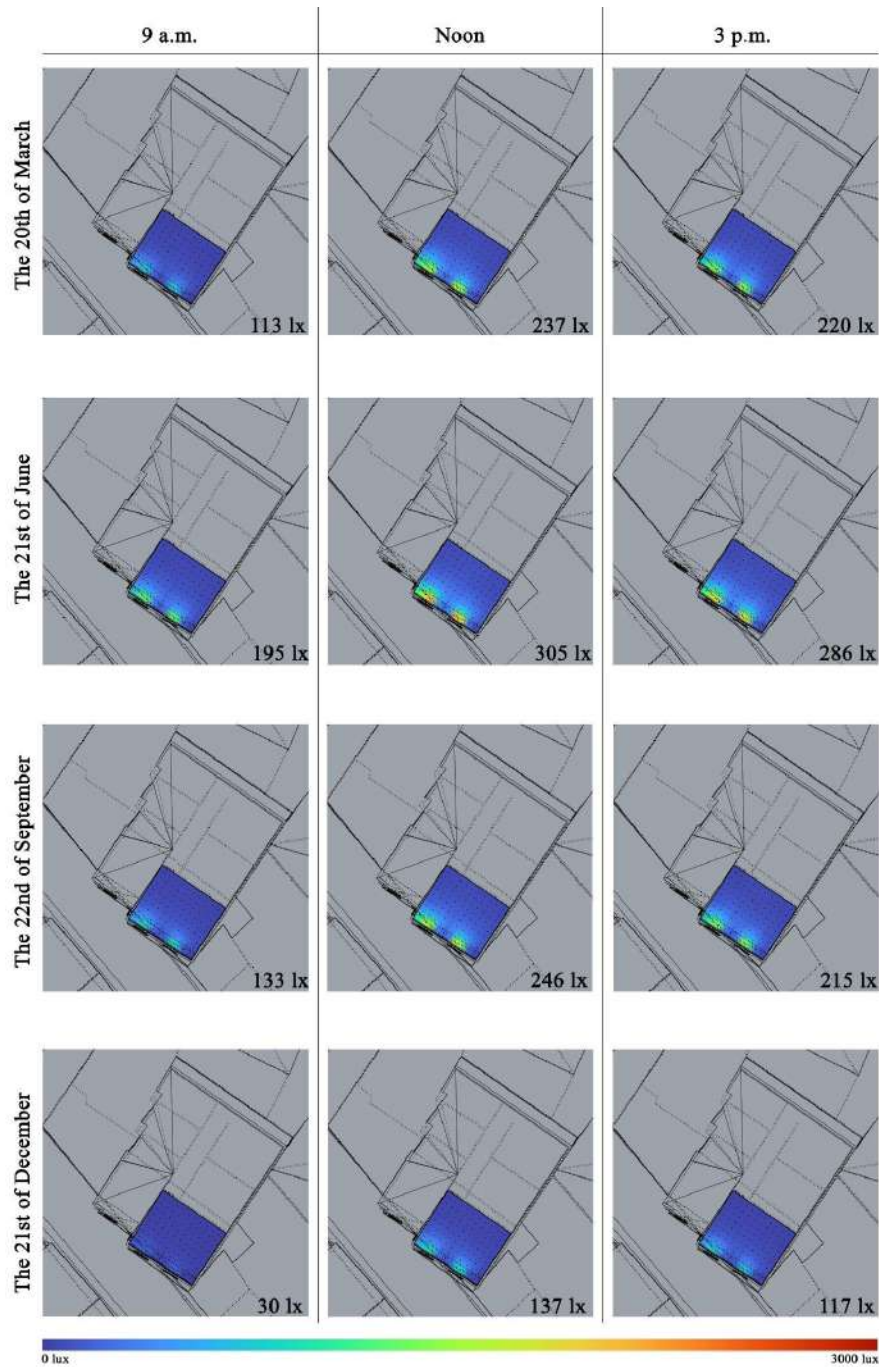


Table 11. The Point-in-Illuminance Analysis of Sample A under Overcast Sky Condition (by author, 2022).

Clear Sky: Sample B

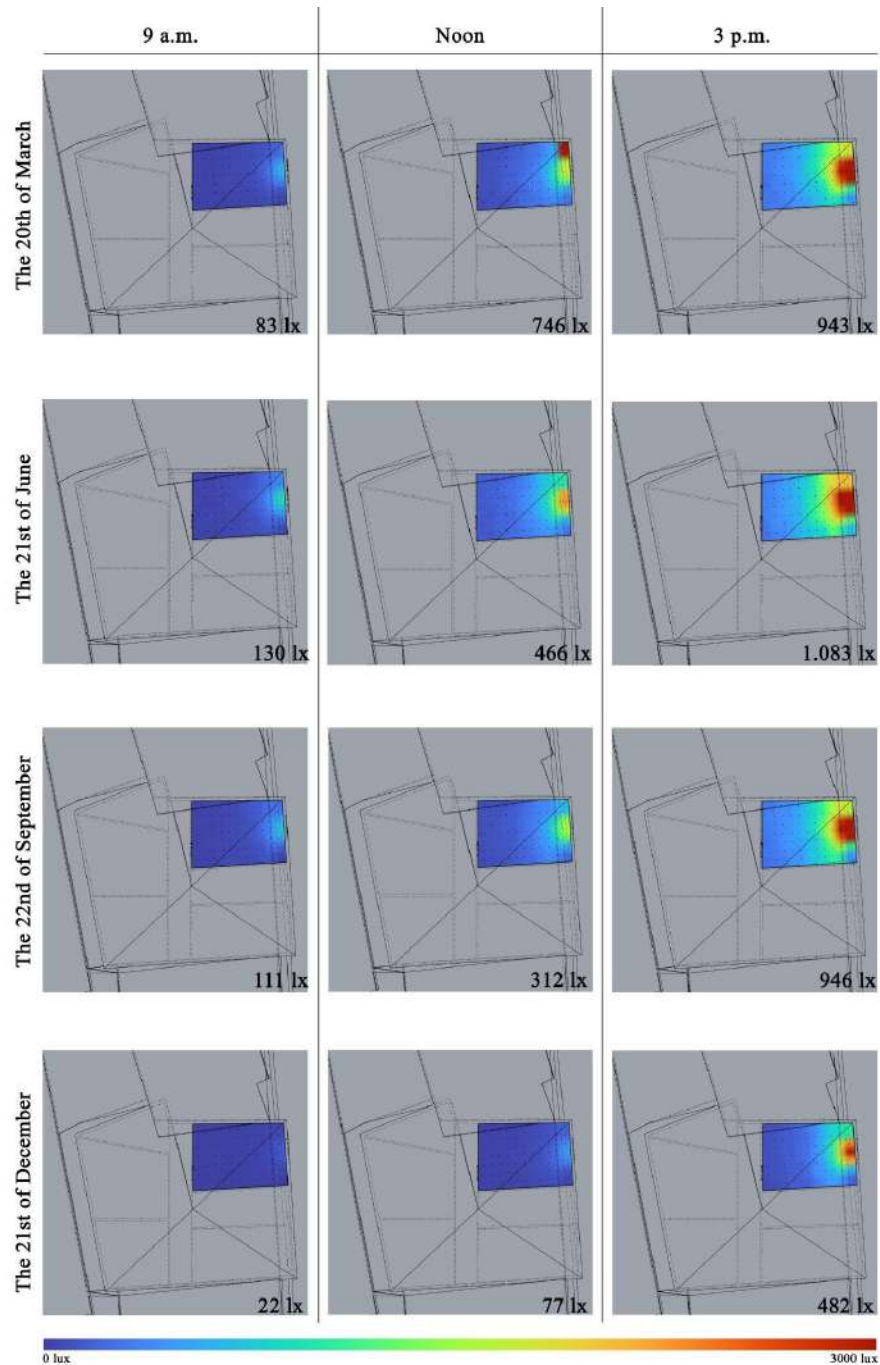


Table 12. The Point-in-Illuminance Analysis of Sample B under Clear Sky

Condition (by author, 2022).

Intermediate Sky: Sample B

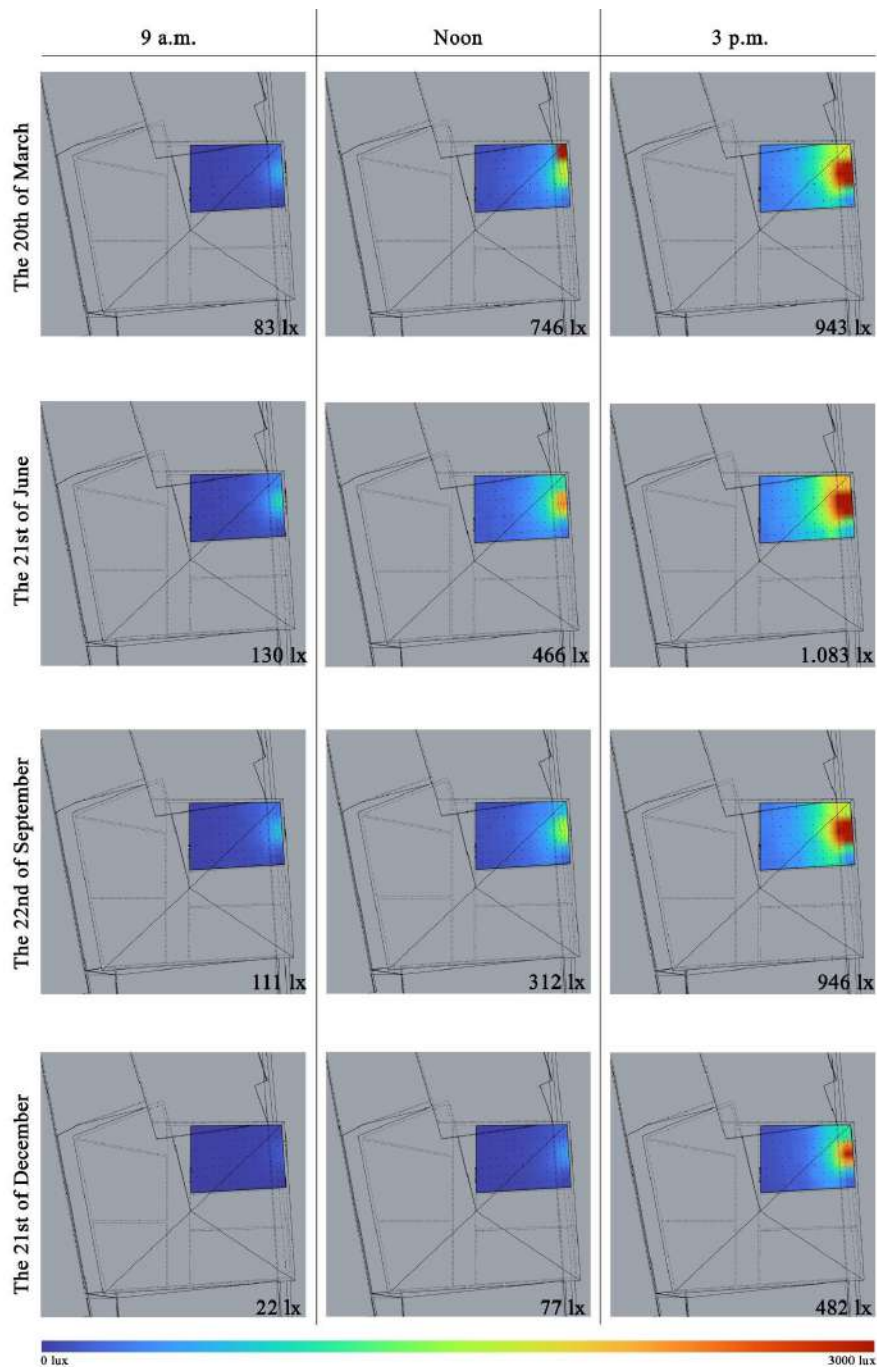


Table 13. The Point-in-Illuminance Analysis of Sample B under
Intermediate Sky Condition (by author, 2022).

Overcast Sky: Sample B

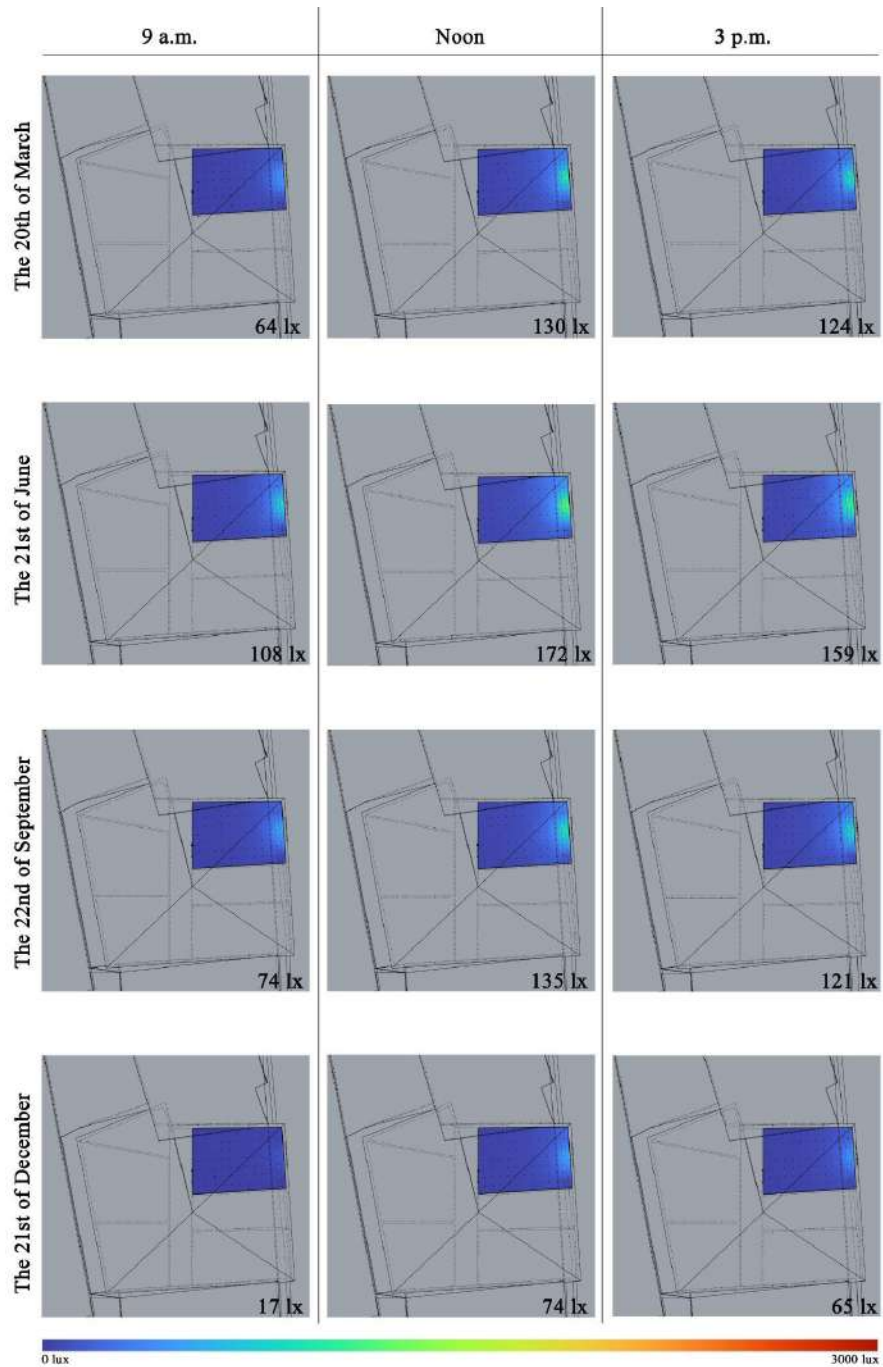


Table 14. The Point-in-Illuminance Analysis of Sample B under Overcast

Sky Condition (by author, 2022).

3D models of samples A and B were added to Rhino. Calculations were considered by using the weather data recorded for Istanbul with the service of Climate Studio. First, the location's solar path data was used for field analyses. These data displayed the buildings and areas impacted by the sun and the shadows created by the surrounding buildings. The shadow model of sample A in Galata in four periods from solstices and equinoxes is shown (Table 7). Accordingly, sample A stayed under the shadow of the surrounding buildings for almost all daytime.

On the other hand, site analysis of sample B shows almost the same situation. The finding which may be seen from the shadows of the buildings is that urban architecture influences the daylight requirement of the building regardless of the location and building structure (Table 8).

The information acquired in site analysis and point-in-illuminance data were also calculated. This calculation seeks to see the amount of daylight availability for indoors during various months and different day duration. While making this calculation, different sky conditions were experienced. To illustrate this, sample A has the highest value in clear sky conditions at 3.837 lux in March, while it has the highest value in June with 305 lux in the overcast sky (Table 9 & 11). Conversely, sample B has the highest value at 1.083 lux in the clear sky at 3 p.m. in June and 172 lux in the overcast sky at noon in June (Table 12 & 14). When the intermediate sky conditions of samples A and B are examined, it is apparent that sample B has fewer daylight values than sample A (Table 10 & 13). According to the calculation results above, both samples are insufficient in terms of sunlight in some conditions.

4.1.3. Daylight Availability

Sample A

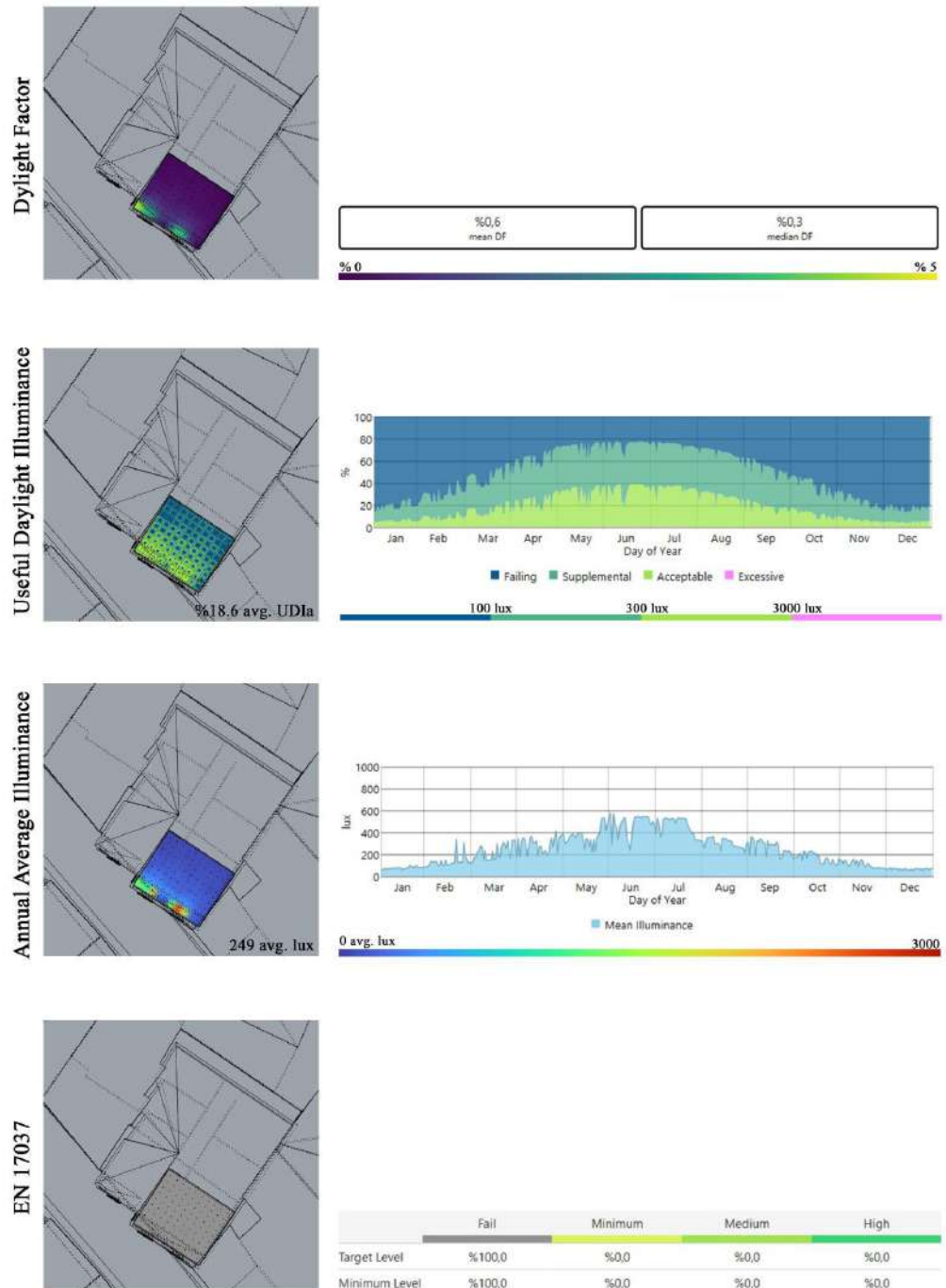


Figure 15. The Daylight Availability Analysis of Sample A (by author, 2022).

Sample B

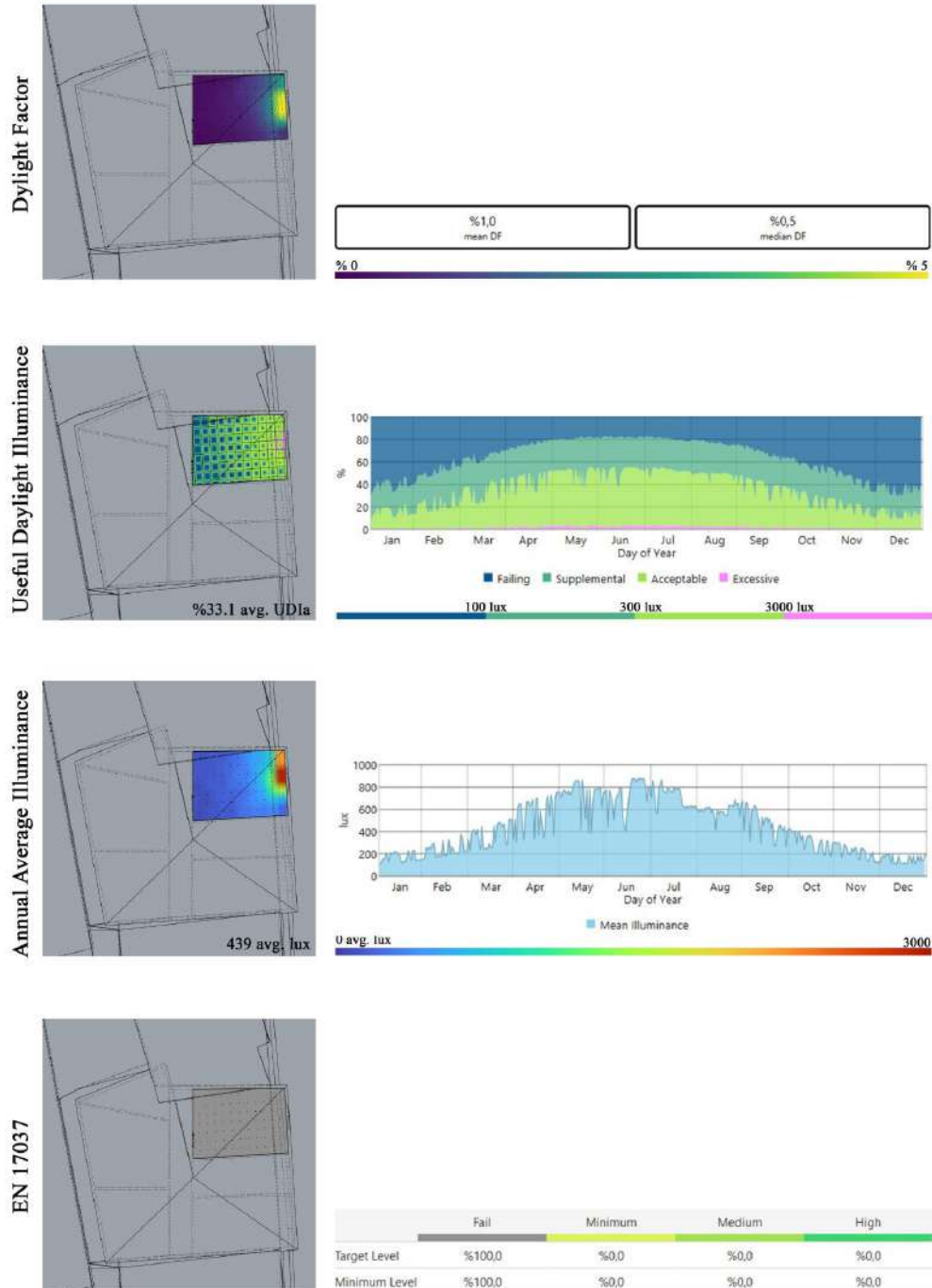
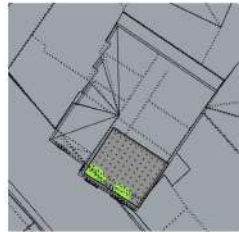


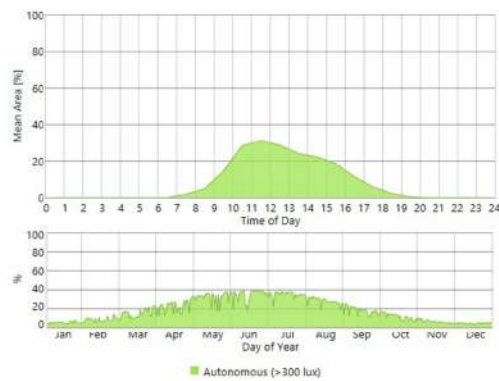
Figure 16. The Daylight Availability Analysis of Sample B (by author, 2022).

Daylight Autonomy

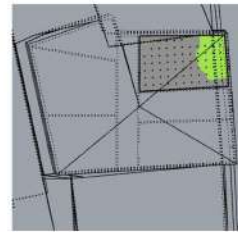
Sample A



%18,73 sDA_{300/50%}



Sample B



%25,71 sDA_{300/50%}

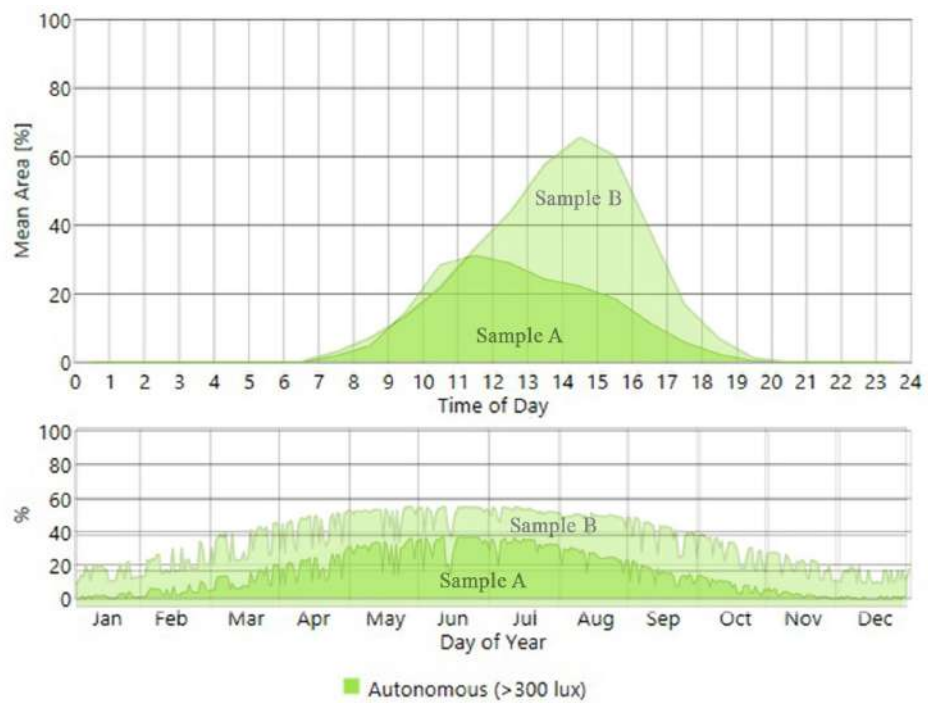


Figure 17. The Daylight Autonomy Analysis of Sample A & B
(by author, 2022).

4.1.4. Annual Sunlight Exposure

	Sample A		Sample B
<i>January</i>	1.56 h	<i>January</i>	0.65 h
<i>February</i>	1.7 h	<i>February</i>	0.92 h
<i>March</i>	2.01 h	<i>March</i>	1.33 h
<i>April</i>	2.59 h	<i>April</i>	1.93 h
<i>May</i>	2.91 h	<i>May</i>	2.53 h
<i>June</i>	3.31 h	<i>June</i>	3.08 h
<i>July</i>	3.23 h	<i>July</i>	2.86 h
<i>August</i>	3.34 h	<i>August</i>	2.53 h
<i>September</i>	3.25 h	<i>September</i>	1.94 h
<i>October</i>	2.42 h	<i>October</i>	1.21 h
<i>November</i>	1.66 h	<i>November</i>	0.75 h
<i>December</i>	1.1 h	<i>December</i>	0.56 h

Table 15. The Annual Sun Exposure Analysis of Sample A & B
(by author, 2022).

The table above indicates the estimated annual sun exposure of samples A and B according to their location and the direction their facades are facing. In that case, sample A, Galata, has 2.43 sun hours per day, whereas sample B, 4. Levent, has 1.69 sun hours per day. It is obvious that the main facade of sample B is not proper for sun exposure.

Six different calculation types and lighting norms were used to view the indoor daylight availability data. According to these calculations, sample A remains below the required limit with 0.6% DF in terms of DF value. The desired value in DF should be a minimum of 2.0% or more (Figure 15). Sample B cannot correspond to this value with 1.0% DF (Figure 16). Moreover, calculations made in terms of the efficiency of the sunlight operated, the UDI_a values demonstrate that daylight illuminates only the window areas of the room on an annual basis.

Nevertheless, daylight cannot reach the back of the rooms of the two samples adequately. The AAI calculation shows sample B has 439 average lux, while sample A has 249 average lux. It shows that the direction of the building, its location, and environmental components' effect on daylight availability are unpredictable (Figure 15 & 16). Ultimately, calculations of EN 17037 were made to see if they comply with European daylight standards, and two samples failed.

When samples A and B are examined in terms of glare, it is seen that glare is low because there is not enough light, and glare does not disturb in the current situation (Figure 18 & 19). However, if the surrounding tall buildings and their exterior cladding are made of a reflective material, glare may occur due to ERC from the surrounding buildings. In this case, it may be challenging to control glare, but eclectic designs (such as curtains and blinds) may be preferred.

4.1.5. Annual Glare

Sample A

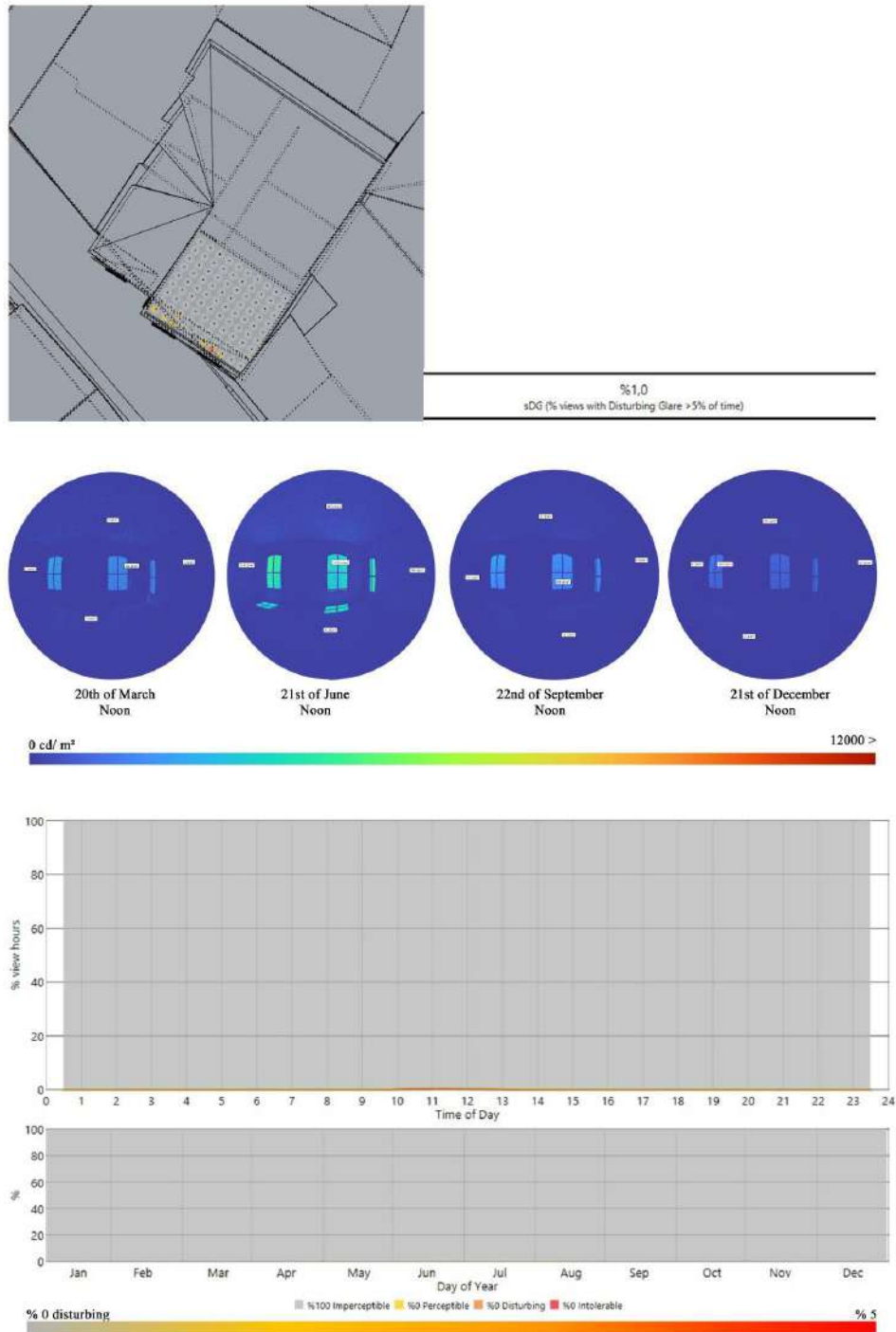


Figure 18. The Annual Glare Analysis of Sample A (by author, 2022).

Sample B

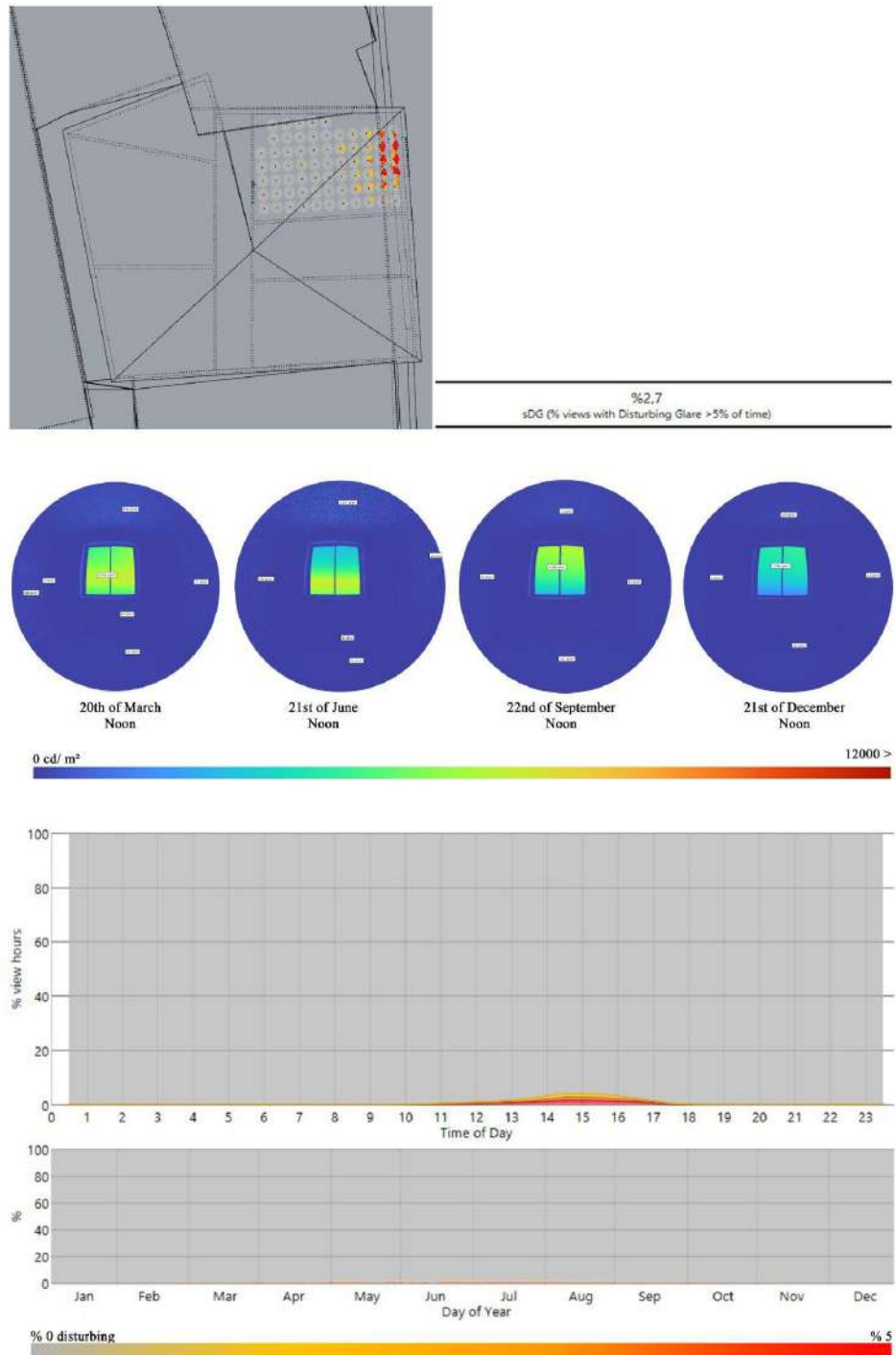


Figure 18. The Annual Glare Analysis of Sample B (by author, 2022).

4.1.6. View Analysis

Sample A

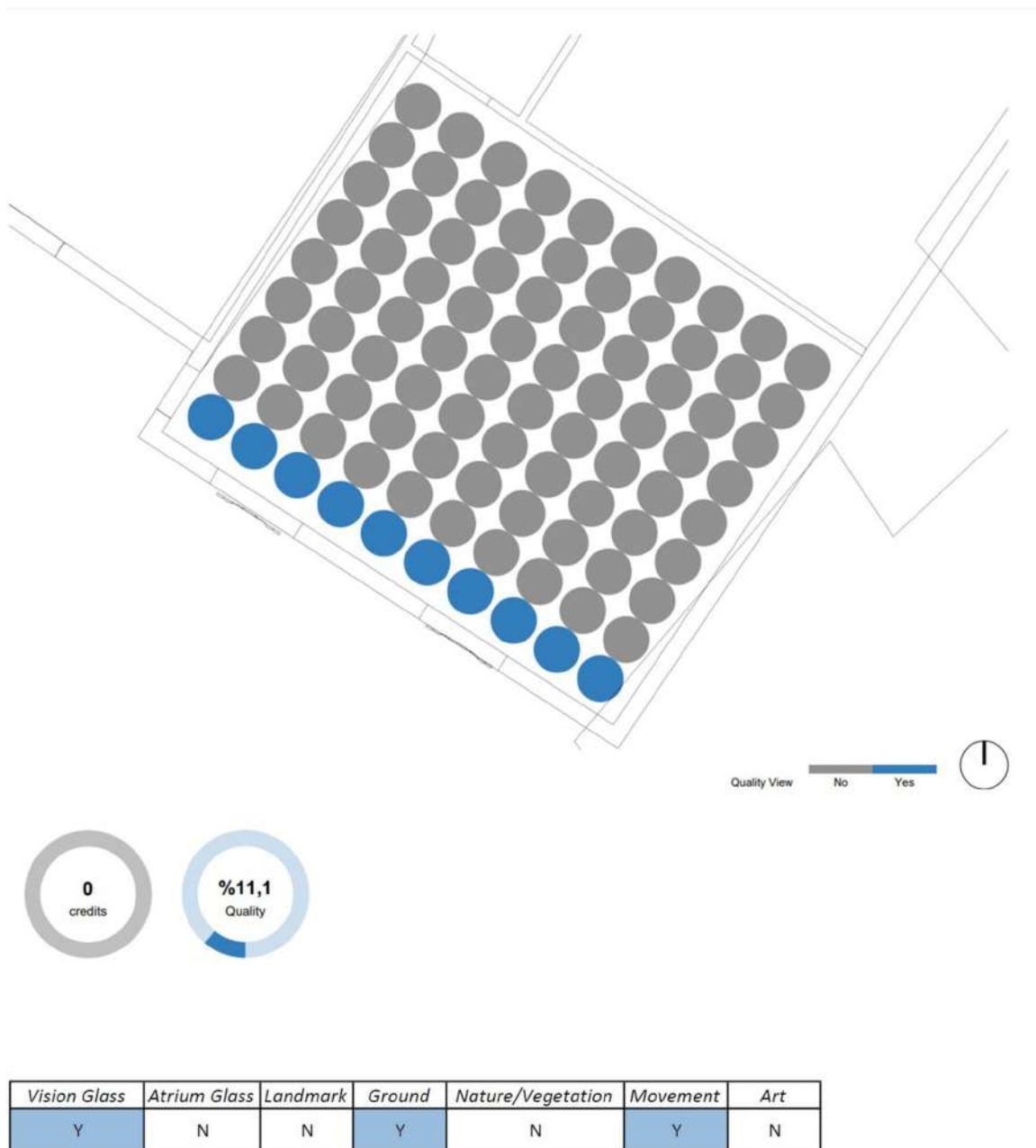
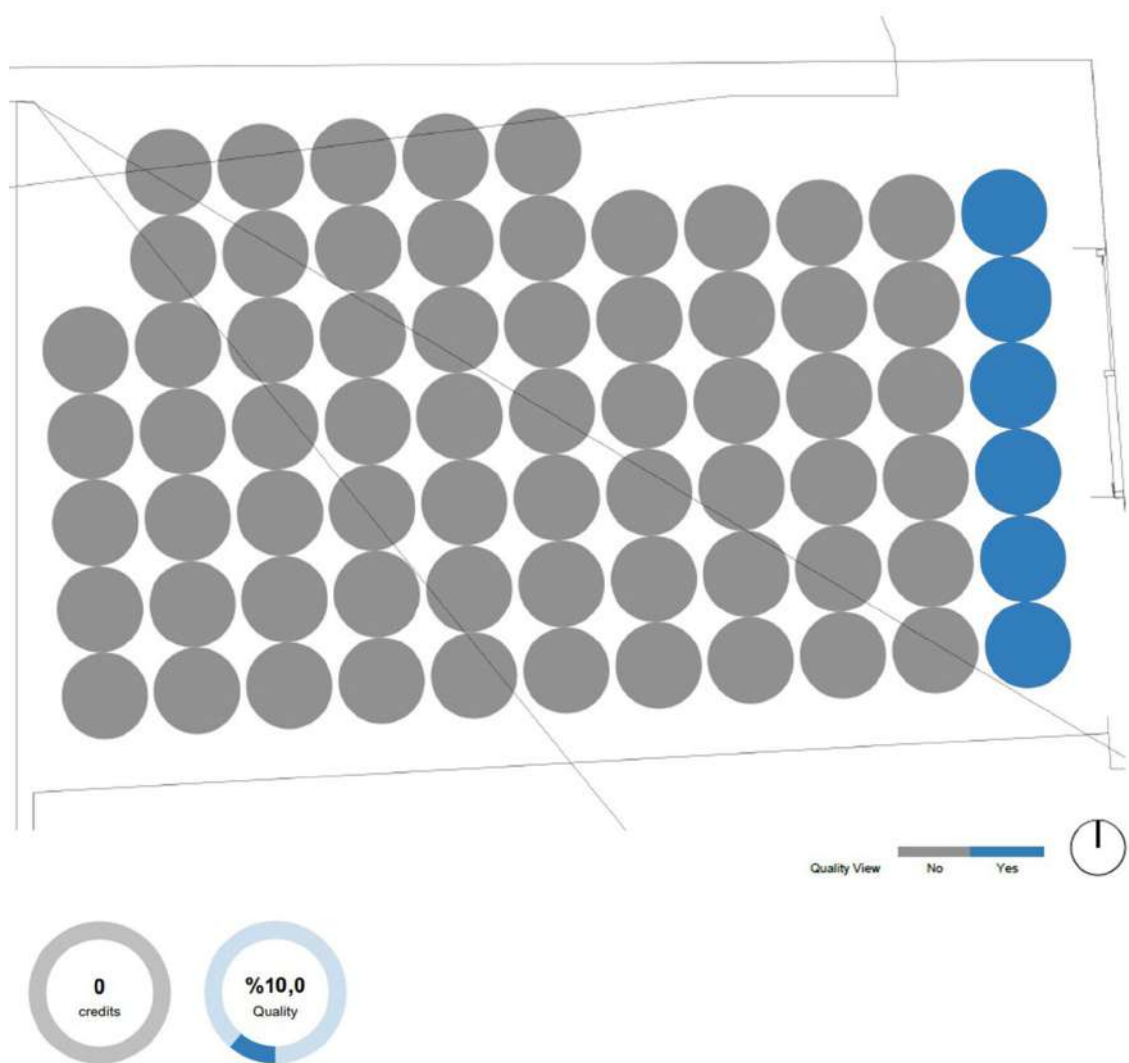


Figure 20. The View Analysis of Sample A (by author, 2022).

Sample B



Vision Glass	Atrium Glass	Landmark	Ground	Nature/Vegetation	Movement	Art
Y	N	N	Y	N	N	N

Figure 20. The View Analysis of Sample B (by author, 2022).

The view seen from the openings of the room is very important for the interior quality. The EN 17037 standard seeks to be strong not only in terms of daylight adequacy, but also in the connection of the interior with the outside. Visual links between interior and exterior are usually provided by side openings. In this case, it is expected that factors with different characteristics will be seen from these openings. A quality view, green space, landmark, action (road or pedestrian) if any, and 6 meters from the outside view are expected (Figure 20). Unfortunately, samples A and B cannot meet them due to narrow streets and high and adjacent buildings (Figure 21).

4.2. Discussion

In this part, the results of the comparison of two different samples compared in terms of daylight indoor efficiency and the new data created by these results are examined. These data are based on Istanbul location and national daylight standards. As stated in the conclusion sections, samples taken from two different locations in Istanbul revealed insufficient indoor daylight. The best way to improve indoor daylight efficiency is to design daylight with environmental considerations in architectural design for individual buildings and urban areas. However, the interiors of already existing buildings can be improved using light shelves or similar add-ons. In both cases, daylight conditions were investigated by improving and making different trials. It is aimed to create a guide list based on different results and initial situations that change according to this design.

4.2.1. Urban Architecture

According to the changes made by changing and improving the urban architecture of the examples above, indoor daylight availability are calculated below under different headings.

4.2.1.1. Street Distance

While the width of the street where the A sample is located is 3 meters and the street where the B sample is located is 4.5 meters, it cannot receive enough light (Figure 22 & 23). Accordingly, if the street is widened by 3 meters and 6 meters, it is aimed to receive more daylight in case the distance between it and the neighboring buildings increases.

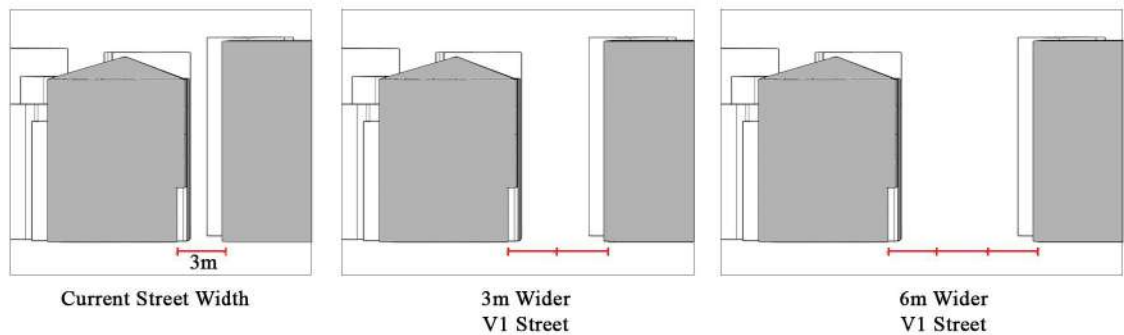


*Figure 22. The Street Distance Calculation Settings for Sample A
(by author, 2022).*

All the same calculations made for the existing states of the A and B samples were also made for the changed dimensions. Accordingly, when the conditions under different sky conditions are examined in terms of point-in illuminance, it is seen that

the daylight availability increases when 6 meters are added to the existing situation (Table 16,17,21 & 22).

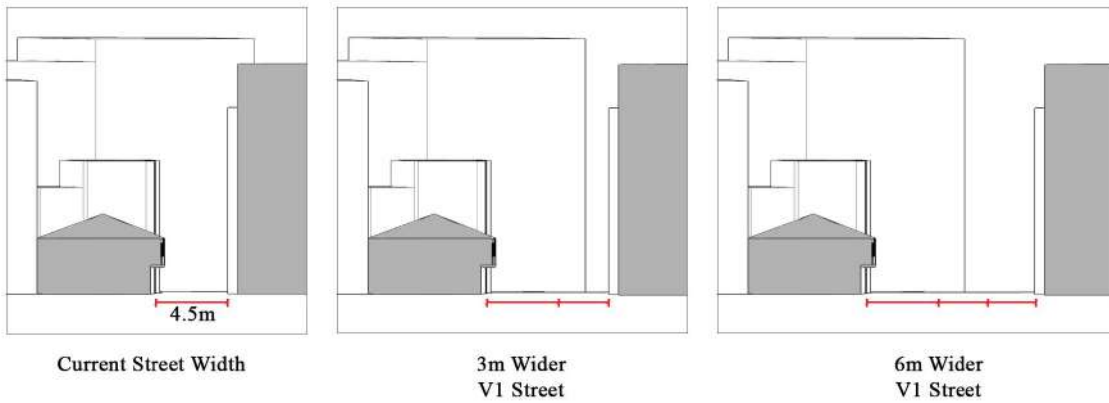


Figure 23. The Street Distance Calculation Settings for Sample B (by author, 2022).

According to their calculations in terms of daylight availability in both samples, they have almost reached the desired value of 2.0% in cases where the DF values are more than 6 meters (Figure 24 & 25). However, it still does not provide the desired 3-credit value in terms of view. Although they can see further thanks to the widening street, the quality of the landscape they see is still low and does not meet EN 17037.

Sample A (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	164 lx	1259 lx	271 lx
	21st of June	543 lx	660 lx	1638 lx
	22nd of September	332 lx	1334 lx	262 lx
	21st of December	41 lx	167 lx	102 lx
Inter. Sky	20th of March	105 lx	324 lx	172 lx
	21st of June	195 lx	197 lx	367 lx
	22nd of September	129 lx	335 lx	170 lx
	21st of December	21 lx	110 lx	85 lx
Overcast Sky	20th of March	75 lx	155 lx	142 lx
	21st of June	125 lx	196 lx	186 lx
	22nd of September	85 lx	156 lx	138 lx
	21st of December	19 lx	87 lx	64 lx

Table 16. The Point-in-Illuminance Analysis of Sample A for 3m Wider Street (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	404 lx	1526 lx	3976 lx
	21st of June	694 lx	884 lx	1930 lx
	22nd of September	449 lx	1618 lx	3392 lx
	21st of December	96 lx	2541 lx	203 lx
Inter. Sky	20th of March	174 lx	473 lx	881 lx
	21st of June	284 lx	282 lx	511 lx
	22nd of September	198 lx	496 lx	786 lx
	21st of December	42 lx	543 lx	174 lx
Overcast Sky	20th of March	123 lx	250 lx	241 lx
	21st of June	207 lx	328 lx	312 lx
	22nd of September	142 lx	261 lx	233 lx
	21st of December	32 lx	146 lx	123 lx

Table 17. The Point-in-Illuminance Analysis of Sample A for 6m Wider Street (by author, 2022).

According to the results of the calculations in case of widening the street: 3 meters widening in two examples is not sufficient. The main reason for this is that the surrounding buildings are tall and still block indoor daylight. Even if it is 6 meters wider, it fails the view analysis and does not meet the EN 17037 standard, although it receives sufficient daylight (Table 20 & 25). This means that simply having a wider street is not sufficient for indoor daylight quality. According to the conclusion to be drawn from this, it is expected that the quality and daylight intake will increase if the neighboring buildings are lower.

Sample A (Daylight Availability)

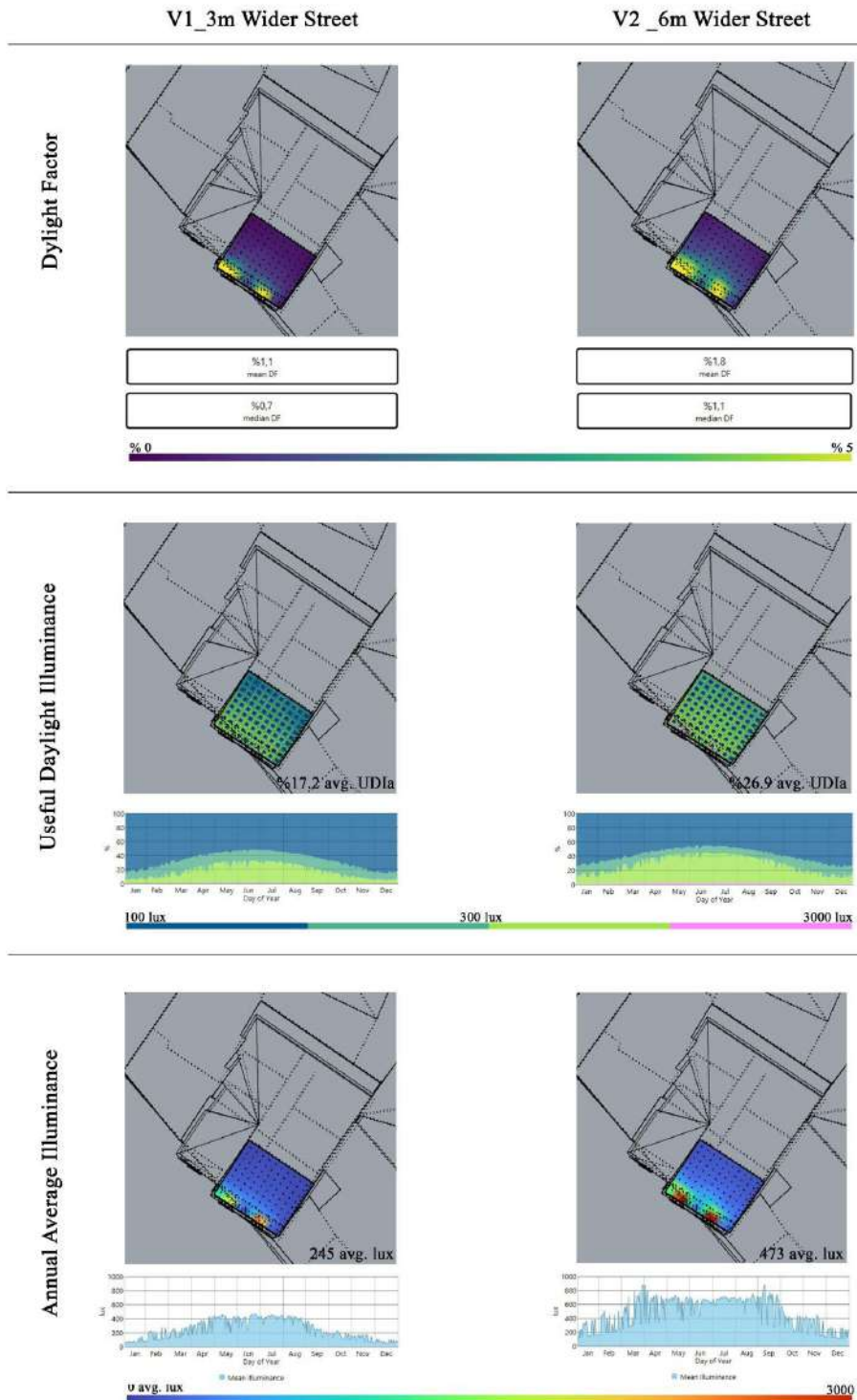


Figure 24. The Daylight Availability Analysis of Sample A for Street Distance (by author, 2022).

Sample A (Annual Glare-View Analysis- EN 17037)

	sDG	Glare
V1_3m Wider Street	1,90%	Imperceptible
V2_6m Wider Street	2,50%	Imperceptible

Table 18. The Annual Glare Analysis of Sample A for Street Distance (by author, 2022).

	Credits	Quality
V1_3m Wider Street	0	13%
V2_6m Wider Street	1	24%

V1_3m Wider Street						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	N	Y	N	Y	N

V2_6m Wider Street						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

Y: Yes
N: No

Table 19. The View Analysis of Sample A for Street Distance (by author, 2022)

	Fail	Minimum	Medium	High	
V1_3m Wider Street	100%				Target Level
	100%				Minimum Level
V2_6m Wider Street		100%			Target Level
		100%			Minimum Level

Table 20. The EN 17037 Analysis of Sample A for Street Distance (by author, 2022).

Sample B (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	112 lx	799 lx	905 lx
	21st of June	196 lx	659 lx	1073 lx
	22nd of September	141 lx	418 lx	918 lx
	21st of December	35 lx	118 lx	480 lx
Inter. Sky	20th of March	104 lx	275 lx	301 lx
	21st of June	190 lx	227 lx	306 lx
	22nd of September	120 lx	219 lx	291 lx
	21st of December	26 lx	115 lx	157 lx
Overcast Sky	20th of March	95 lx	198 lx	184 lx
	21st of June	160 lx	251 lx	241 lx
	22nd of September	106 lx	203 lx	179 lx
	21st of December	25 lx	113 lx	97 lx

Table 21. The Point-in-Illuminance Analysis of Sample B for 3m Wider Street (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	171 lx	1072 lx	801 lx
	21st of June	309 lx	892 lx	987 lx
	22nd of September	1896 lx	676 lx	776 lx
	21st of December	62 lx	233 lx	429 lx
Inter. Sky	20th of March	174 lx	396 lx	316 lx
	21st of June	330 lx	305 lx	313 lx
	22nd of September	455 lx	332 lx	312 lx
	21st of December	41 lx	185 lx	176 lx
Overcast Sky	20th of March	131 lx	271 lx	252 lx
	21st of June	226 lx	346 lx	322 lx
	22nd of September	148 lx	276 lx	243 lx
	21st of December	34 lx	153 lx	131 lx

Table 22. The Point-in-Illuminance Analysis of Sample B for 6m Wider Street (by author, 2022).

Sample B (Daylight Availability)

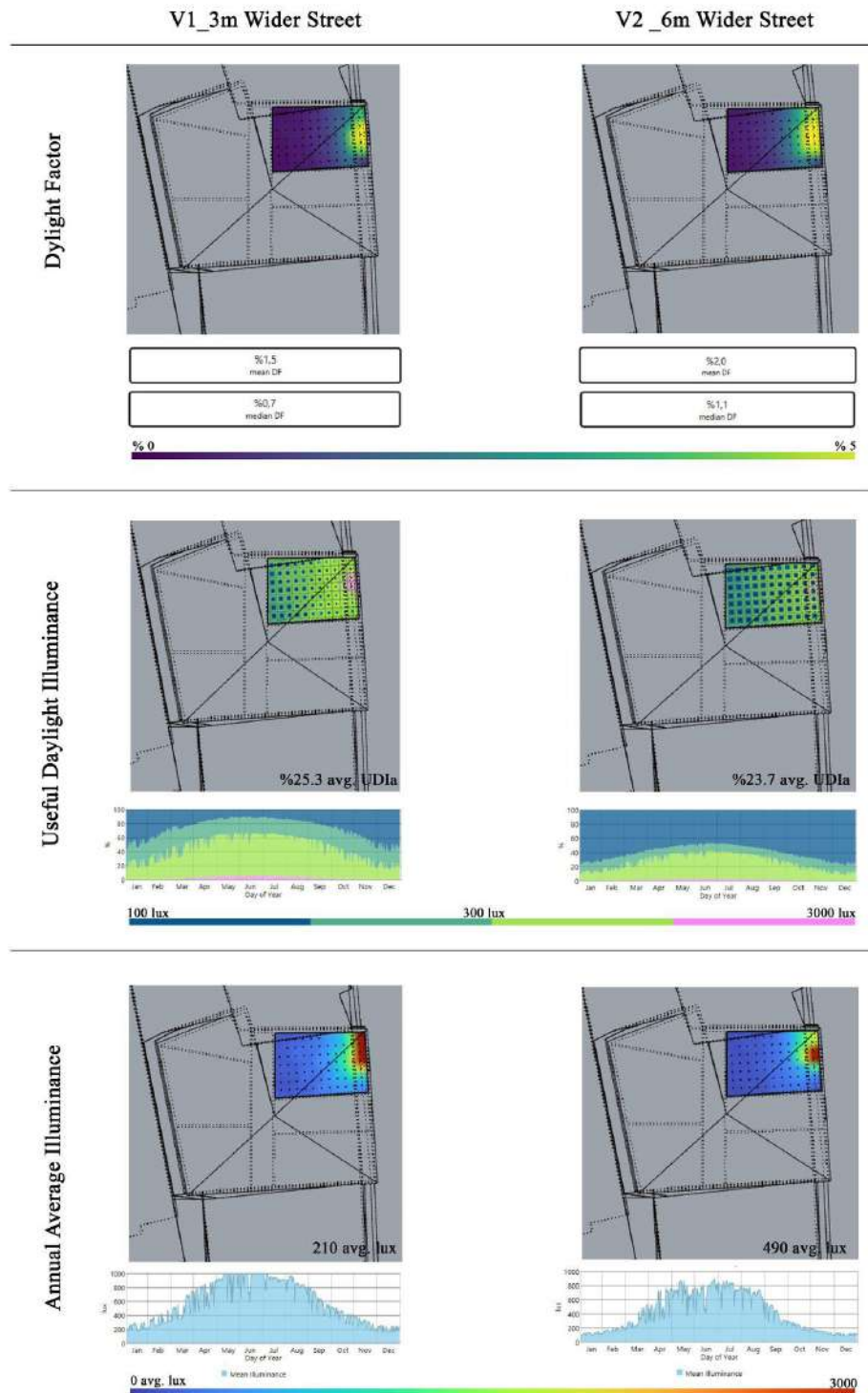


Figure 25. The Daylight Availability Analysis of Sample B for Street Distance (by author, 2022).

Sample B (Annual Glare-View Analysis- EN 17037)

	sDG	Glare
V1_3m Wider Street	4,50%	Imperceptible
V2_6m Wider Street	7,50%	Disturbing

Table 23. The Annual Glare Analysis of Sample B for Street Distance (by author, 2022).

	Credits	Quality
V1_3m Wider Street	0	18%
V2_6m Wider Street	1	35%

V1_3m Wider Street						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

V2_6m Wider Street						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

Y: Yes
N: No

Table 24. The View Analysis of Sample B for Street Distance (by author, 2022)

	Fail	Minimum	Medium	High	
V1_3m Wider Street	100%				Target Level
	100%				Minimum Level
V2_6m Wider Street		100%			Target Level
	100%				Minimum Level

Table 25. The EN 17037 Analysis of Sample B for Street Distance (by author, 2022).

4.2.1.2. The Heights of Surrounding Buildings

The detailed results of the calculations obtained by reducing only the height of the surrounding buildings, keeping the area where the samples are located, the width of the street they are located, the height and interior properties of the samples the same, are given below. According to these results, the highest values according to the street width and window size were obtained here.

This means that indoor daylight quality increases when building heights are interconnected. It is seen that not only the intake of daylight is increased, but also the quality between the exterior and interior spaces. According to the results, sample A has a DF value of 2.9%, while sample B has a value of 2.1%. This is 2 times the current DF values.

Sample A (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	541 lx	1852 lx	725 lx
	21st of June	990 lx	941 lx	934 lx
	22nd of September	566 lx	2846 lx	713 lx
	21st of December	153 lx	3773 lx	443 lx
Inter. Sky	20th of March	271 lx	694 lx	550 lx
	21st of June	444 lx	369 lx	480 lx
	22nd of September	305 lx	850 lx	546 lx
	21st of December	65 lx	848 lx	313 lx
Overcast Sky	20th of March	192 lx	393 lx	375 lx
	21st of June	327 lx	511 lx	483 lx
	22nd of September	216 lx	401 lx	358 lx
	21st of December	50 lx	228 lx	194 lx

Table 26. The Point-in-Illuminance Analysis of Sample A for the Less Height of Surrounding Buildings (by author, 2022).

Sample B (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	3742 lx	832 lx	248 lx
	21st of June	5366 lx	454 lx	290 lx
	22nd of September	2983 lx	380 lx	243 lx
	21st of December	347 lx	253 lx	159 lx
Inter. Sky	20th of March	794 lx	438 lx	201 lx
	21st of June	1279 lx	259 lx	160 lx
	22nd of September	728 lx	349 lx	192 lx
	21st of December	90 lx	237 lx	134 lx
Overcast Sky	20th of March	138 lx	282 lx	263 lx
	21st of June	235 lx	358 lx	346 lx
	22nd of September	155 lx	288 lx	257 lx
	21st of December	36 lx	162 lx	140 lx

Table 27. The Point-in-Illuminance Analysis of Sample B for the Less Height of Surrounding Buildings (by author, 2022).

The UDI of the A sample is higher than that of B and the daylight A sample does not leave any part of the room in darkness (Figure 26). Due to the larger room depth and small window of sample B, the rear sides are still insufficient in terms of UDI. Looking at the annual average lux values, it is seen that A receives more light than B. This means that window sizes become important when the height of the buildings is average or lower.

According to the test on building heights, in cases where the street width is narrow, the building heights should be lower. If the buildings are higher, the street width and the width between the buildings should be larger.

Sample A -B (Daylight Availability)

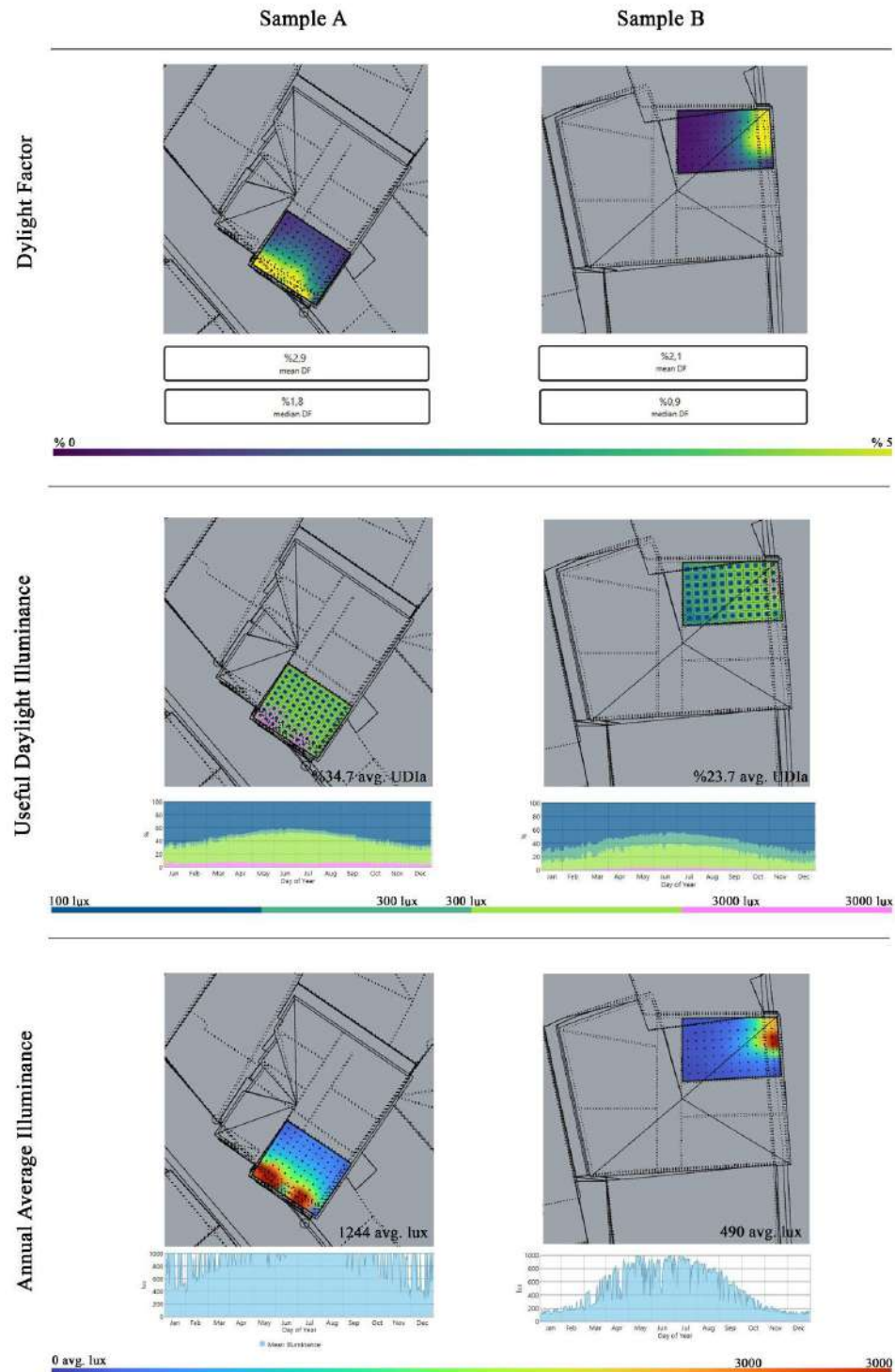


Figure 26. The Daylight Availability Analysis of Sample A and B for The Less Heights of Surrounding Buildings (by author, 2022).

Sample A -B (Annual Glare-View Analysis- EN 17037)

	sDG	Glare
Sample A	11,80%	Disturbing
Sample B	7,30%	Disturbing

Table 28. The Annual Glare Analysis of Sample A and B for The Less Heights of Surrounding Buildings (by author, 2022).

	Credits	Quality
Sample A	2	72%
Sample B	2	67%

Sample A						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	Y	Y	N

Sample B						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	Y	Y	N

Table 29. The View Analysis of Sample A and B for The Less Heights of Surrounding Buildings (by author, 2022).

	Fail	Minimum	Medium	High	
Sample A				100%	Target Level
			100%		Minimum Level
Sample B			100%		Target Level
		100%			Minimum Level

Table 30. The EN 17037 Analysis of Sample A and B for The Less Heights of Surrounding Buildings (by author, 2022).

The two sub-headings shown above emphasize the importance of urban architecture. Urban architecture is of great importance not only in terms of buildings and streets, but also in terms of interior quality. Considering the changed street widths of the A and B samples and the lower status of the surrounding buildings, it is seen how much the indoor daylight values have increased. This means that properly designed urban spaces and buildings can provide indoor daylight efficiency.

4.2.2. Individual Building Architecture

Window dimensions and features in building designs are as important as the importance of urban architecture. In this section, by keeping the environmental characteristics of the A and B samples the same, the cases where the window dimensions are changed and the solutions that can be made in cases where they cannot be changed are considered.

4.2.2.1. Window Sizes

According to the current situation of sample A, there is a bay window in the living area. The purpose of the bay windows is to provide more daylight to the interior, but this cannot be realized due to the environmental factors in which the A sample is located. It has a bay window surrounded by 3 windows, two of which face the main facade. The size of the windows is 1.5 meters by 1 meter (Figure 27). The width of the window in the corner of the bay window is half a meter. 0.5 meters. Based on the main dimensions, 3 different window combinations were created by adding 1 meter to each side. The purpose of this is to be able to identify the most efficient window.

Sample A

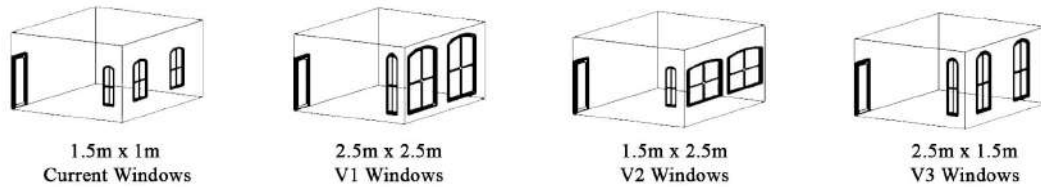


Figure 27. The Window Sizes Calculation Settings for Sample A (by author, 2022).

Comparing the calculations for sample A, the 2.5m by 2.5m window provides more daylight as expected (Figure 28). The window with the highest DF value with a DF of 2.7% is the window V1, which is 2.5 meters by 2.5 meters, while the window with the lowest DF value with 1.4% is the window V3 with a DF value of 2.5 meters by 1.5 meters. As can be seen when UDI values and false color schemes are compared, V1_2.5x2.5 is more homogeneous in daylight distribution (Figure 29). Since the height and width of the window, which is the V1 version, is high, it causes annoying glare with 11.30% depending on the amount of daylight it receives. However, unfortunately, increasing the size of the window does not meet the view analysis. This remains a shortcoming for EN 17037.

Sample B

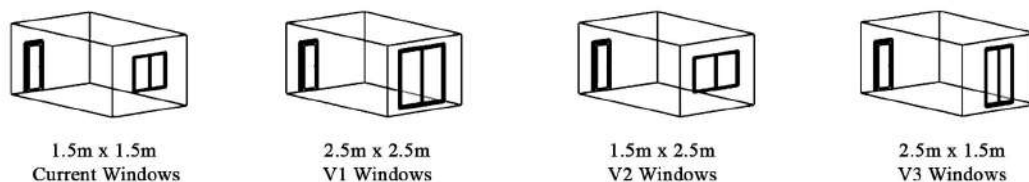


Figure 28. The Window Sizes Calculation Settings for Sample B (by author, 2022).

Sample B has a single window and this window is on the main facade. This window measures 1.5 meters by 1.5 meters. When the models and calculations created for the B sample are examined, it is the version with the highest values of 2.5 meters by 2.5 meters, like the A sample. The 2.5 x 2.5 window width, which is the V1 version, has a DF value of 2.2% (Figure 29). On the other hand, unlike sample B, in sample A, the V3 version has a minimum value of 2.5 meters by 1.5 meters (Figure 30). From the perspective of the UDI, it was still seen that the back of the room was not sufficiently exposed to the sun.

Examination of the daylight results of the windows of 3 different sizes for the two samples shows that the length and width of the window affect the daylight availability. By changing the window size, the quality of daylight availability can be increased, but the visual connection with the exterior may not improve. The reason for this may be the surrounding obstacles and in this case, the appearance analysis cannot be expected to give good results and the EN 17037 standard cannot be achieved (Table 35 & 41). In order to ensure the EN standard, everything must be provided as a whole (Table 36 & 42).

Sample A (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	462 lx	3997 lx	586 lx
	21st of June	980 lx	1675 lx	3796 lx
	22nd of September	593 lx	3946 lx	575 lx
	21st of December	91 lx	389 lx	208 lx
Inter. Sky	20th of March	226 lx	923 lx	373 lx
	21st of June	416 lx	500 lx	862 lx
	22nd of September	268 lx	909 lx	367 lx
	21st of December	50 lx	248 lx	184 lx
Overcast Sky	20th of March	175 lx	360 lx	342 lx
	21st of June	300 lx	460 lx	439 lx
	22nd of September	198 lx	371 lx	330 lx
	21st of December	46 lx	207 lx	176 lx

Table 31. The PII Analysis of Sample A for 2.5m x 2.5m Window Sizes (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	330 lx	3414 lx	433 lx
	21st of June	701 lx	1150 lx	3231 lx
	22nd of September	421 lx	3838 lx	423 lx
	21st of December	65 lx	292 lx	152 lx
Inter. Sky	20th of March	162 lx	733 lx	257 lx
	21st of June	294 lx	340 lx	677 lx
	22nd of September	192 lx	791 lx	254 lx
	21st of December	35 lx	175 lx	129 lx
Overcast Sky	20th of March	121 lx	249 lx	235 lx
	21st of June	207 lx	318 lx	303 lx
	22nd of September	135 lx	255 lx	227 lx
	21st of December	32 lx	143 lx	122 lx

Table 32. The PII Analysis of Sample A for 1.5m x 2.5m Window Sizes (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	248 lx	1157 lx	333 lx
	21st of June	527 lx	895 lx	2.107
	22nd of September	314 lx	2539 lx	325 lx
	21st of December	50 lx	212 lx	118 lx
Inter. Sky	20th of March	121 lx	409 lx	211 lx
	21st of June	229 lx	264 lx	480 lx
	22nd of September	147 lx	550 lx	202 lx
	21st of December	28 lx	134 lx	102 lx
Overcast Sky	20th of March	99 lx	204 lx	190 lx
	21st of June	166 lx	255 lx	243 lx
	22nd of September	109 lx	205 lx	183 lx
	21st of December	25 lx		89 lx

Table 33. The PII Analysis of Sample A for 2.5m x 1.5m Window Sizes (by author, 2022).

Sample A (Daylight Availability)

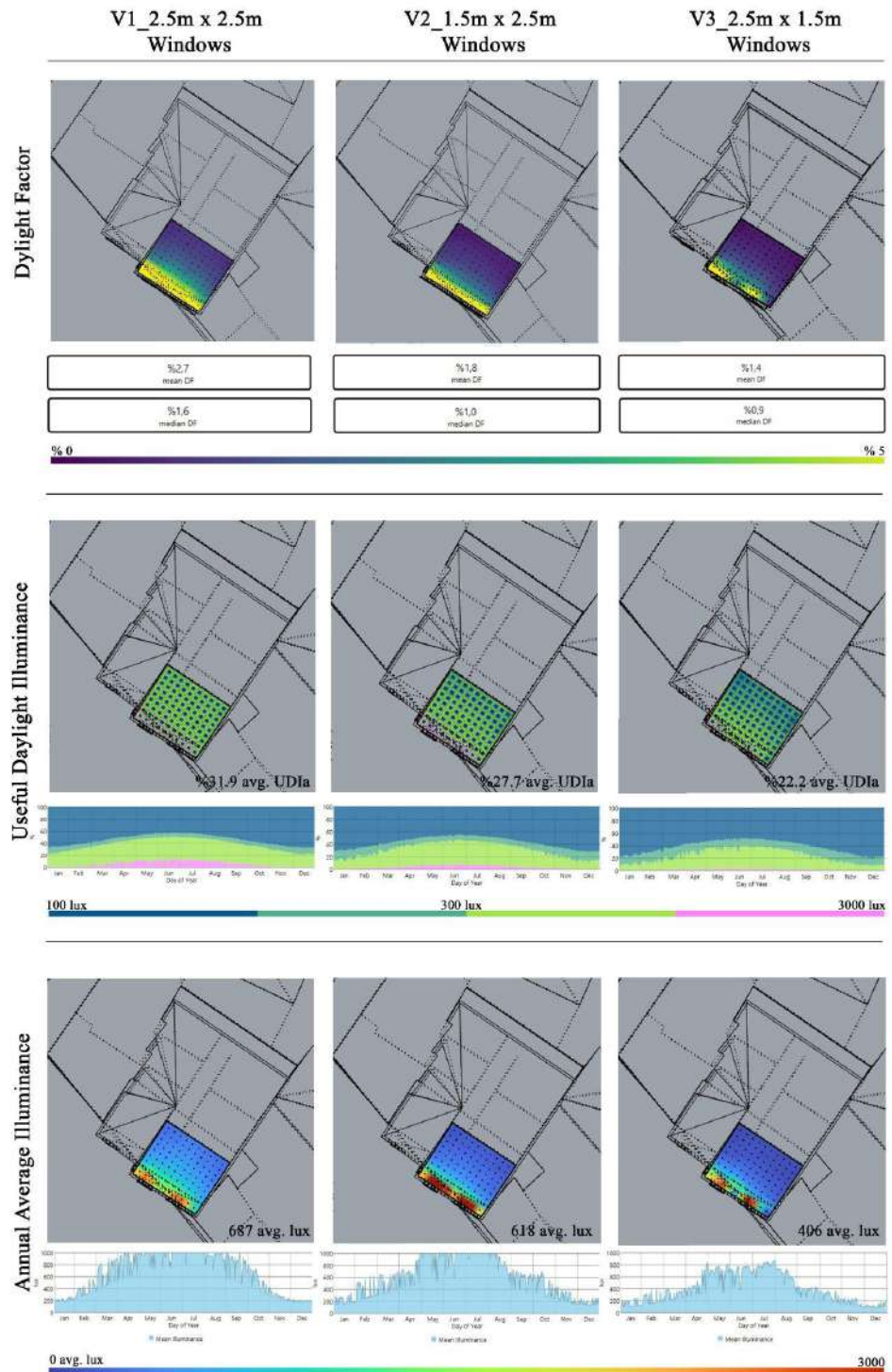


Figure 29. The Daylight Availability Analysis of Sample A for Window Sizes (by author, 2022).

Sample A (Annual Glare-View Analysis- EN 17037)

	sDG	Glare
V1_ 2.5m x 2.5m Windows	11,30%	Disturbing
V2_ 1.5m x 2.5m Windows	6,50%	Disturbing
V3_ 2.5m x 1.5m Windows	3,60%	Imperceptible

Table 34. The Annual Glare Analysis of Sample A for Window Sizes
(by author, 2022)

	Credits	Quality
V1_ 2.5m x 2.5m Windows	1	26%
V2_ 1.5m x 2.5m Windows	0	10%
V1_ 2.5m x 1.5m Windows	0	13%

V1_ 2.5m x 2.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

V2_ 1.5m x 2.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	N	Y	N	Y	N

V3_ 2.5m x 1.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

Y: Yes
N: No

Table 35. The View Analysis of Sample A for Window Sizes
(by author, 2022).

	Fail	Minimum	Medium	High	
V1_ 2.5m x 2.5m Windows		100%			Target Level
			100%		Minimum Level
V2_ 1.5m x 2.5m Windows	100%				Target Level
		100%			Minimum Level
V3_ 2.5m x 1.5m Windows		100%			Target Level
		100%			Minimum Level

Table 36. The EN 17037 Analysis of Sample A for Window Sizes
(by author, 2022).

Sample B (Point-in-time Illuminance)

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	195 lx	1558 lx	2042 lx
	21st of June	296 lx	1093 lx	2345 lx
	22nd of September	248 lx	736 lx	2100 lx
	21st of December	50 lx	175 lx	1073 lx
Inter. Sky	20th of March	145 lx	464 lx	589 lx
	21st of June	238 lx	344 lx	612 lx
	22nd of September	167 lx	343 lx	588 lx
	21st of December	37 lx	177 lx	304 lx
Overcast Sky	20th of March	145 lx	303 lx	283 lx
	21st of June	249 lx	386 lx	364 lx
	22nd of September	166 lx	311 lx	276 lx
	21st of December	39 lx	173 lx	149 lx

Table 37. The PII Analysis of Sample B for 2.5m x 2.5m Window Sizes (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	118 lx	879 lx	1231 lx
	21st of June	181 lx	674 lx	1419 lx
	22nd of September	154 lx	474 lx	1290 lx
	21st of December	30 lx	109 lx	651 lx
Inter. Sky	20th of March	88 lx	272 lx	357 lx
	21st of June	145 lx	211 lx	370 lx
	22nd of September	103 lx	212 lx	365 lx
	21st of December	23 lx	107 lx	183 lx
Overcast Sky	20th of March	89 lx	184 lx	173 lx
	21st of June	154 lx	232 lx	224 lx
	22nd of September	99 lx	184 lx	166 lx
	21st of December	23 lx	105 lx	90 lx

Table 38. The PII Analysis of Sample B for 1.5m x 2.5m Window Sizes (by author, 2022).

		9 a.m.	Noon	3 p.m.
Clear Sky	20th of March	152 lx	570 lx	1610 lx
	21st of June	228 lx	843 lx	1805 lx
	22nd of September	196 lx	579 lx	1661 lx
	21st of December	39 lx	136 lx	872 lx
Inter. Sky	20th of March	109 lx	258 lx	463 lx
	21st of June	186 lx	262 lx	466 lx
	22nd of September	129 lx	261 lx	467 lx
	21st of December	28 lx	134 lx	242 lx
Overcast Sky	20th of March	111 lx	229 lx	215 lx
	21st of June	188 lx	295 lx	279 lx
	22nd of September	127 lx	234 lx	210 lx
	21st of December	29 lx	131 lx	113 lx

Table 39. The PII Analysis of Sample B for 2.5m x 1.5m Window Sizes (by author, 2022).

Sample B (Daylight Availability)

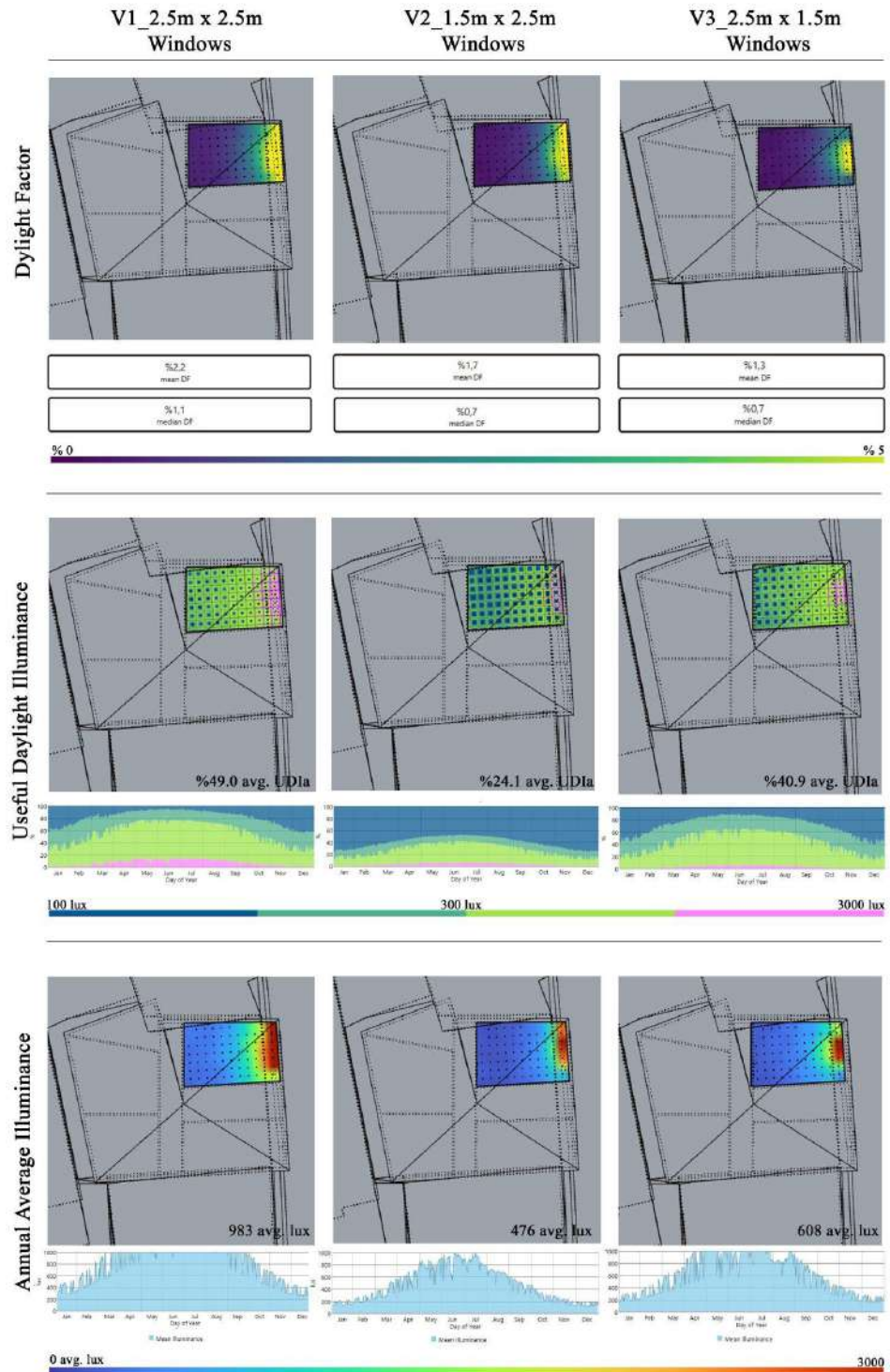


Figure 30. The Daylight Availability Analysis of Sample B for Window Sizes (by author, 2022).

Sample B (Annual Glare-View Analysis- EN 17037)

	sDG	Glare
V1_ 2.5m x 2.5m Windows	17,10%	Disturbing
V2_ 1.5m x 2.5m Windows	8,00%	Disturbing
V3_ 2.5m x 1.5m Windows	14,50%	Disturbing

Table 40. The Annual Glare Analysis of Sample B for Window Sizes (by author, 2022).

	Credits	Quality
V1_ 2.5m x 2.5m Windows	1	23%
V2_ 1.5m x 2.5m Windows	0	7%
V1_ 2.5m x 1.5m Windows	0	12%

V1_ 2.5m x 2.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

V2_ 1.5m x 2.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	N	Y	N	Y	N

V3_ 2.5m x 1.5m Windows						
Vision Glass	Atrium Glass	Landmark	Ground	Nature/ Vegetation	Movement	Art
Y	N	Y	Y	N	Y	N

Y: Yes
N: No

Table 41. The View Analysis of Sample B for Window Sizes (by author, 2022).

	Fail	Minimum	Medium	High	
V1 2.5m x 2.5m Windows		100%			Target Level
		100%			Minimum Level
V2 1.5m x 2.5m Windows	100%				Target Level
	100%				Minimum Level
V3 2.5m x 1.5m Windows	100%				Target Level
		100%			Minimum Level

Table 42. The EN 17037 Analysis of Sample B for Window Sizes (by author, 2022).

4.2.2.2. Daylight Systems

If the urban architectural situation is irregular and the building windows cannot be changed due to the building construction, daylight systems can be used. The most common of these are the use of light shelves, reflective blinds and external reflector. These three systems have negative aspects as well as their contribution to bringing the daylight indoors. In the case of a window, daylight enters the interior from above and extends inclined towards the back of the room (Figure 31).

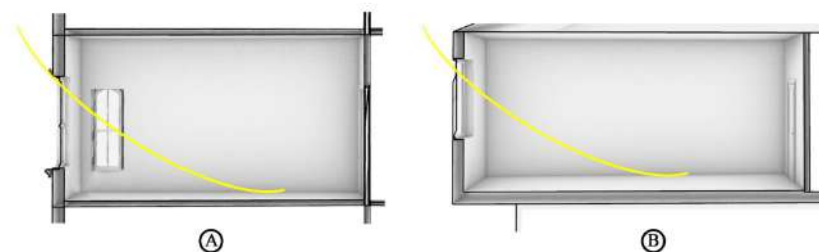


Figure 31. Light distribution from Windows for Sample A & B (by author, 2022).

Reflective Blinds

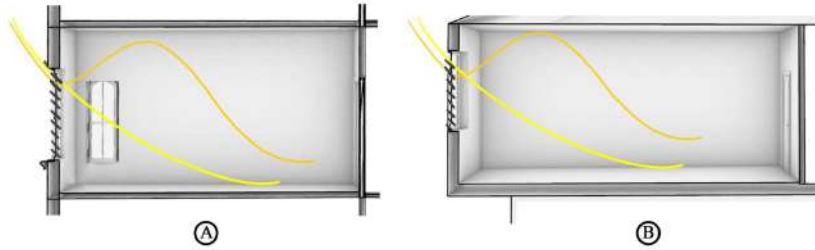


Figure 32. Light distribution from Reflective Blinds for Sample A & B (by author, 2022).

In the case of using reflective louvers, the louver can be made of reflective material and the louver shape can be selected according to the required reflection shape. These types of blinds are generally used to bring the light indoors in the winter, and to provide thermal relaxation of the house by removing the sunlight in the summer (Figure 32). However, one of the situations that should not be forgotten here is the connection with the outdoors. As explained above, seeing outside plays an important role for the indoor quality, and the visual connection with the outside is almost completely broken due to the use of such blinds and the closeness of the louver layers.

Interior Light Shelf

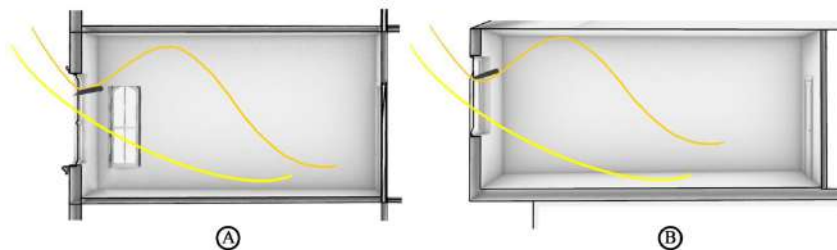


Figure 33. Light distribution from Interior Light Shelf for Sample A & B (by author, 2022).

Another option is to use the light shelf from the inside. Here, the purpose of using the inner light shelf instead of the outer light shelf is to allow the light to go deeper into the room (Figure 33). Since only one shelf is used, it does not block the eye level and does not affect the exterior design of the building.

External Reflector

External reflectors are more easily accessible than adjustability according to the position of the sun. However, there are some situations that should be considered when placing these external reflectors (Figure 34). One of them is the width and length of the reflector because it can affect the daylight of the lower stories. It is more likely to cause glare as the direction of the sun changes.

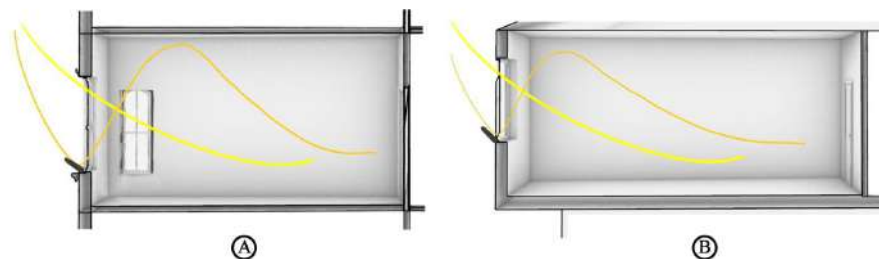


Figure 34. Light distribution from External Reflector for Sample A & B (by author, 2022).

All three different lighting systems given above have their positive and negative sides. However, within the scope of this thesis, a selection should be made considering the location of the A and B samples, their neighboring buildings and building designs. Considering these factors, it is recommended to choose an interior light shelf as it does not affect the building design from the outside, does not prevent eye level and can carry the light intake to the back of the room.

4.3. Daylight Guidelines for Istanbul

According to the above simulations and the results obtained from these simulations, daylight suggestions were created based on Istanbul (See Appendix B). Considering the EN 17037 daylight standards, additional suggestions for urban architecture and building design were added (EVS, 2021). The recommended daylight standard units and suggestions for Istanbul are as follows:

- Daylight
- Glare
- Sunlight
- View Connection
- Urban Architecture
- Individual Building Architecture

4.3.1. Daylight

Some factors should be unguardable when daylight is calculated to check daylight availability. It starts from the urban architecture to the interior area. For the urban part, the surrounding is vital to comprehend obstructions and reflections. Moreover, building design, transmittance, and reflectivity of the windows, their dimensions, and cantilevers in the building should have been considered.

The daylight factor changes according to the geographical location. Therefore, according to the calculations based in Istanbul, a minimum of 1,52% DF is required for 300 lux.

$$DF = \frac{300}{19.700} \times 100 = 1,52 D_T$$

$$DF = \frac{100}{19.700} \times 100 = 0,50 D_{TM}$$

Outdoor lux level in Istanbul: 19.700 lux (Overcast Sky)

- D_T (300 lx): 1,52
- D_{TM} (100 lx): 0,50

4.3.2. Glare

Especially for the facades facing east and west, glare should be controlled; in cases where the sun's angle decreases or increases, glare may be a significant concern. If technological devices such as computers and televisions are used, their placement should be determined according to the room's purpose and glare. If glare occurs and the values are more than desired, curtains or blinds may be preferred. Also, the properties of materials, reflectivity, and even transmittance of the item used are critical. Using opaque material minimizes glare but may also completely block the daylight.

The sDG matter should be below 5%, considering the interior's adequate daylight and the external reflections from the surrounding buildings.

Experimental Calculations and literature reviews also verify that the UGR value should remain below 19 in order not to create disturbing glare.

- sDG < 5%
- UGR < 19

4.3.3. Sunlight

Based on samples A and B, it is aimed to determine an average sun exposure time. The orientation of the main facade of the building is of great essence here. The south direction is the main facade for Istanbul's available sun exposure duration to form the norms. In this case, indoor is at least 1.5 hours, and the highest is 4.5 hours

	Minimum	Medium	High
Sunlight Exposure	1.5 h	3 h	4.5h

Based on EN 17037 (EVS, 2021)

4.3.4. View Connection

The window provides the most vital junction between indoors and outdoor. The outside can be seen as large as the opening of the building. That is why the characteristics of vertical openings are necessary. It should be seen at eye level at least 6 meters ahead of the window. Also, the narrower viewing angle limits the view; the more comprehensive the viewing angle, the more surroundings can be seen. Regardless, the quality of the view seen is also influential. outdoor vegetation,

sky, landmarks, and ground (pedestrian and road movements) should be observed. If all of these are provided, the EN 17037 standard may be completed to a considerable scope. It aims to transmit all these layers together and strengthen the external relation.

	Minimum	Medium
Horizontal sight angle	>14°	>28°
Outside Distance of the view	>6m	>20m

Based on EN 17037 (EVS, 2021)

- ☐ Sky
- ☐ Landscape (Vegetation)
- ☐ Ground (Pedestrian & Road Movements)
- ☐ Landmark

4.3.5. Urban Architecture

Urban architecture may influence each of the guidelines, which is explained in this part. The distances between the buildings should be considered so that they do not interfere with each other. Therefore, openings between buildings, color, and reflectivity of the material used on the exterior facade of the surrounding buildings should also be thought. For instance, 20% of cities should consist of green areas, not just buildings and roads. If the neighboring buildings of the main building are higher, the distance between the main building's facade and the opposite building

should be at least 6 meters wide. The suggested distributions of the urban architecture are listed below:

- ☐ %40 Buildings
- ☐ %25 Vegetation (Landscape)
- ☐ %25 Ground (Pedestrian & Road Movements)
- ☐ %5 Landmark (not required)
- ☐ % 5 Others

4.3.6. Individual Building Architecture

To design the building, the proportions and features of the rooms should also be considered in terms of daylight. Although sometimes large and deep rooms are in demand, such rooms may be insufficient in terms of daylight if they do not have sufficient openings. In cases where the room depth is more than 4 meters, light access to the back of the room may be problematic. At this point, the opening should be at least vertical and a minimum of 2.5 m x 1.5 m. It is recommended that main spaces face south to provide the best daylight reception. The characteristics of the exterior cladding of the surrounding buildings are as important as the interior's design and the finishing materials' characteristics. High-gloss materials may generate unwanted glare, while dark colors and matte materials may absorb light and destroy the room's existing daylight.

- ☐ Room Depth < 4 meters
- ☐ Min. Window Sizes: 2.5 m x 1.5 m
- ☐ Facade Direction: South
- ☐ Surface Materials: Light Colors, Semi-matte finishing

CHAPTER 5

CONCLUSION

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CONCLUSION

Turkey's most considerable concern is still a lack of urban architecture and unplanned urbanization. Although specific regulations govern urbanization and urban renewal, they are enforced without respect for design or interior daylighting. Istanbul is one area where this issue has an immense impact. It is because Istanbul is Turkey's most populated metropolitan city, and urban issues are unavoidable. The quality of interior spaces is also affected by imperfections in urban architecture.

This thesis pursued to enhance the interior spaces in Istanbul in terms of daylight quality and to design new urban architectures based on daylight standards. In the research process of the thesis, the general diagnosis of the sources underlines the essence of indoor daylight. The information extracted from the sources has been used throughout the thesis methodology. It enabled the analysis of location instances from two different districts of Istanbul through the CS program. Various calculations were made in terms of the environmental architecture of the locations and interiors. It brings them together to compare them to three-dimensional urban architecture and daylighting. According to these calculations, multifarious aspects of existing urban architecture (such as building proximity, building types, and heights) influence indoor daylighting.

The sample of Galata, A, is below the desired levels, despite the exterior design for daylighting. It means that there is insufficient daylight availability throughout the year. On the other hand, the B sample, which is the 4.Levent, is overshadowed by the plazas and skyscrapers around it. Even though the exterior cladding of the skyscrapers is made of glass and similar lightly reflective materials, the percentage of glare is also deficient.

The heights, proximity, opening proportions, and style of the buildings in the Beyoğlu and 4.Levent areas vary from each other. As an outcome of these aspects, practically all of them have uneven values of daylight availability. The critical topics from literature evaluations on urban design and interior daylighting were searched to prove this. On the other hand, by assisting Climate Studio, calculations replicate the buildings in Beyoğlu and 4.Levent in terms of building varieties, closeness, and specific features. The next phase is compiling a guidelist to establish a new daylight standard for Istanbul (See Appendix B). As a development, the guide list assists in solving the interior daylight availability problem in unplanned urbanization. It also emphasizes the relevance of daylight in future urban transformations for interior spaces.

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APPENDICES



A. PHOTOGRAPHS FROM GALATA AND 4.LEVENT



Photo 1. Ertürk, Y. (2021) The Streets of Beyoğlu. Archive



Photo 2. Ertürk, Y. (2021) The Street of Galata. Archive



Photo 3. Ertürk, Y. (2021) Galata, Beyoğlu. Archive



Photo 4. Ertürk, Y. (2021) Beyoğlu. Archive



Photo 6. Guerra, Fernando (2014). Soyak Kristal Kule | Finansbank Headquarters. Archive.



Photo 7. Morlok, Ben (2012). Modern Istanbul skyline at sunset. Archive.



Photo 8. Yılmaz, Merve (2022). 4.Levent/ Kağıthane, Night. Archive.



Photo 9. Yılmaz, Merve (2022). 4.Levent/ Kağıthane. Archive.

B. INTERIOR DAYLIGHT AVAILABILITY CHECKLIST

Interior Daylight Availability Checklist

Based on The Guidelines of Istanbul

Project: _____ Date: _____

Location: _____

	GUIDELINES	
1.	Daylight Factor is above 1.52 % for 300 lux and 2.53 % for 500 lux.	
2.	The sDG value is below 5% to avoid glare, and the UGR is less than 19.	
3.	The designated room receives at least 1.5 hours of sun.	
4.	Six meters out of the window is visible, and at least the sky, green space, and movement should be seen.	
5.	The horizontal sight angle should be at least 14 degrees.	
6.	Structures should occupy a maximum of 1.6 times as much as green areas.	
7.	The room depth is less than 4 meters.	
8.	Window dimension is a minimum of 2.5 meters to 1.5 meters.	
9.	The main facade faces south.	
10.	Light colors and semi-matt finishing materials are preferred for interior surfaces.	
11.	The surrounding buildings are not high from each other, and the exterior cladding is not of highly reflective material.	

☒ YES ☐ NO

Note: All urban architecture and individual building designs not mentioned above should be considered as extra.

