



Impact of atrium design on lighting in shopping malls: Prestige Mall, Istanbul

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Abstract

Shopping spaces, serving not only as centers of commerce but also as key areas promoting social interaction, are environments where users spend significant amounts of time. In such spaces, the limited capacity of buildings to utilize natural daylight poses challenges in terms of energy efficiency and design. To address this issue, atrium designs, which effectively bring daylight into interiors, are increasingly favored in large-scale structures like shopping malls. Atriums enhance visual comfort and reduce energy consumption by allowing natural light to penetrate deeply into interior spaces.

This study analyzes the impact of the atrium design of the Prestige Mall shopping center in Istanbul on energy consumption for both natural and electric lighting, using the DIALux Evo software. In this context, variations in indoor illuminance levels during summer and winter periods were compared. The research tests the hypothesis that an efficiently designed atrium can minimize electric lighting demand and improve overall energy performance. The influence of daylight on lighting consumption during the summer period was calculated, while both daylight and electric lighting effects were evaluated during the winter period. The findings reveal that a well-designed atrium has the potential to significantly reduce energy consumption. Consequently, the study highlights the potential of atrium designs to enhance energy efficiency in shopping malls and underscores their importance in sustainable architecture and energy management.

Highlights

- The atrium opening contributed to uniform lighting levels by reducing daylight inequality between the floors.
- Energy consumption data revealed that atrium design reduced artificial lighting demand through increased daylight contribution.
- Analyses indicated that the atrium can serve as a functional design element by lowering artificial lighting loads.

Keywords

Architectural lighting; Shopping mall lighting; Prestige Mall; DIALux Evo

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Alışveriş merkezlerinde atrium tasarımının aydınlatma üzerindeki etkisi: Prestige Mall, İstanbul

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Öz

Alışveriş mekânları, ticaretin yanı sıra sosyal etkileşimi teşvik eden önemli alanlar olarak, kullanıcıların uzun süre geçirdiği ortamlardır. Bu tür mekânlarda, yapıların gün ışığından yararlanma kapasitesinin sınırlı olması, önemli bir tasarım ve enerji yönetimi sorunu yaratmaktadır. Bu sorunun çözümü olarak, gün ışığından etkin şekilde faydalanmayı sağlayan atrium tasarımları, alışveriş merkezleri gibi büyük ölçekli yapılarda giderek daha fazla tercih edilmektedir. Atrium, doğal ışığın yapının iç mekanlarına derinlemesine girmesini sağlayarak görsel konforu artırmakta ve enerji tüketiminin azaltılmasına katkı sağlamaktadır.

Bu çalışmada, İstanbul'da bulunan Prestige Mall alışveriş merkezinin atrium tasarımının doğal ve yapay aydınlatmaya bağlı enerji tüketimi üzerindeki etkisi, DIALux Evo yazılımı kullanılarak analiz edilmiştir. Bu kapsamda, yaz ve kış dönemlerinde iç mekân aydınlık düzeylerindeki değişimler karşılaştırılmıştır. Araştırmada, etkin biçimde tasarlanmış bir atriumun yapay aydınlatma gereksinimini azaltarak yapının genel enerji performansını iyileştireceği hipotezi test edilmiştir. Yaz döneminde gün ışığının aydınlatma enerjisi tüketimi üzerindeki etkisi değerlendirilirken, kış döneminde ise gün ışığı ve yapay aydınlatmanın birlikte oluşturduğu etkiler incelenmiştir. Elde edilen bulgular, iyi tasarlanmış bir atriumun enerji tüketimini önemli ölçüde azaltma potansiyeline sahip olduğunu ortaya koymuştur. Sonuç olarak çalışma, atrium tasarımlarının alışveriş merkezlerinde enerji verimliliğinin artırılmasına katkı sağlayabileceğini göstermekte ve sürdürülebilir mimarlık ile enerji yönetimi açısından önemini vurgulamaktadır.

Öne Çıkanlar

- Atrium açıklığı, katlar arasında gün ışığı eşitsizliğini azaltarak homojen aydınlatma düzeylerine katkı sağlamıştır.
- Enerji tüketim verileri, atrium tasarımının doğal ışık katkısıyla yapay aydınlatma ihtiyacını azalttığını göstermektedir.
- Analizler, atriumun yapay aydınlatma yükünü azaltan işlevsel bir tasarım ögesi olarak kullanılabileceğini ortaya koymuştur.

Anahtar Sözcükler

Mimari aydınlatma; Alışveriş merkezi aydınlatması; Prestige Mall, DIALux Evo

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THE EVOLUTION AND REQUIREMENTS OF SHOPPING ACTIVITIES

Shopping, originally a fundamental activity aimed at meeting basic needs throughout history, has evolved to encompass the acquisition of various goods and services required for sustaining modern life. Over time, the form and content of shopping have changed, reflecting in spatial organizations as well. This activity, persisting since the dawn of human history, has fostered the development of unique shopping cultures and spaces. Historically, shopping spaces emerged in settlements along trade routes and appeared as open, semi-open, or enclosed areas (Çetin, 2009). Today, these spaces are redefined as “shopping malls.”

Shopping malls are complex structures designed to offer users a comfortable and secure environment to meet their needs for food, entertainment, relaxation, shopping, and cultural activities. They generally consist of enclosed or semi-open spaces (Beddington, 1991). In Turkey, shopping malls are defined by the "Regulation on Shopping Centers (2016)" as commercial buildings containing at least one large store and a total of at least 30 retail units with a sales area of 5,000 square meters. These spaces are notable not only for their commercial functions but also for the security, comfort, and aesthetic features they provide to users. In this context, the functional and aesthetic success of shopping mall designs significantly enhances user experience.

However, shopping malls are known for their substantial energy consumption due to their large-scale enclosed spaces and the need for extensive lighting. In these structures, where natural light is often limited, artificial lighting systems are frequently used throughout the day, resulting in increased energy consumption (Onaygil et al., 2005). According to data from the North American Energy Agency, lighting systems account for 46% of electricity consumption in commercial buildings (Onaygil, 1995). In Turkey, shopping malls are classified as the second highest energy-consuming commercial buildings after accommodation services, with an annual energy consumption of 105,743 tons of oil equivalent (TOE) (Ministry of Energy and Natural Resources, 2023). Electricity constitutes 85% of this consumption, underscoring the need to evaluate shopping malls in terms of energy efficiency. Custom lighting designs are essential to minimize energy use while ensuring that users feel secure and perform their required actions effectively.

Lighting is a fundamental element that directly influences the functionality and aesthetic perception of a space. In large-scale structures like shopping malls, lighting design should be approached not only from an energy efficiency perspective but also to optimize user comfort and visual perception (BS EN 12464-1, 2011). Steffy (2008) emphasized in his foundational approaches to architectural lighting design that the lighting requirements of a space should be tailored to the activities

performed there, the architectural layout, and the characteristics of the user profile. His work introduced lighting equipment and detailed the strategies for their design and application. Similarly, Çetin (2009) examined the role of lighting in enhancing user comfort and visual performance in shopping malls. His research highlighted that uneven illuminance levels on display surfaces, especially on vertical surfaces, affect product perception. Therefore, a balanced integration of natural and artificial lighting is essential in lighting design.

Additionally, the impact of lighting design on energy consumption is a significant area of research. Uyan (2010), in his study on the sustainability of illuminance levels in buildings, encouraged the use of simulation programs in designing building lighting systems. Simulations were shown to be effective tools for evaluating system performance, predicting energy consumption, and meeting visual comfort requirements during the design process. Aşcıoğlu (2014) stated that good lighting design should not only meet necessary illuminance levels but also address parameters such as visual comfort, performance, and security. His research highlighted the positive effects of LED fixtures on energy efficiency and user satisfaction, supporting these findings with simulations showing that LED technology provides high illuminance levels while consuming less power. These studies demonstrate the importance of lighting design in shopping malls for both energy efficiency and user satisfaction. Energy-efficient solutions that combine natural and artificial light sources are critical for ensuring visual comfort and supporting sustainable environmental policies.

In recent years, design strategies integrating natural light into interiors have gained prominence in shopping malls to enhance energy efficiency and optimize user experience. Atrium designs, incorporating large gallery voids and transparent roof surfaces, are considered effective methods to increase the use of natural light in shopping malls. Atriums facilitate the transmission of daylight from upper to lower floors, contributing to improved illuminance levels in corridors, retail spaces, and common areas. These designs not only reduce energy consumption but also enhance user comfort and reinforce the architectural aesthetics of the space (Boyce et al., 2022). However, during hours when natural light is insufficient, artificial lighting systems play a critical role in maintaining necessary visual comfort conditions sustainably (BS EN 12464-1, 2011). The balanced integration of natural and artificial lighting in atrium designs significantly contributes to achieving energy efficiency and user satisfaction goals.

MATERIALS AND METHODS

In this study, the criteria established to ensure visual comfort conditions in the general circulation areas of shopping centers, such as corridors and shared spaces, were examined in detail. The primary aim was to comprehensively analyze the impact of the atrium design at the Prestige Mall Shopping Center, located in Bahçeşehir, Istanbul, on the lighting load of the corridor areas located on the lower floors. The integration of natural and artificial lighting systems in the atrium was evaluated in terms of energy efficiency and visual comfort. Seasonal variations were examined by separately calculating the lighting loads of the atrium during the summer and winter periods.

Within the scope of the study, the compliance of the shopping mall interior lighting design with national and international standards was evaluated in detail to enhance user comfort and improve

energy efficiency. The standards used in lighting design were based on ensuring the efficient execution of visual activities and preventing poor lighting conditions (Boyce et al., 2022). In this context, international standards such as EN 12464-1 and CIE 200, as well as applicable lighting regulations in Turkey, were referenced.

The research methodology involved modeling the architectural plan and section diagrams of the selected building in 3D using the DIALux Evo simulation program. This modeling allowed for a detailed analysis of the impact of atrium design on natural and artificial lighting systems. Parameters such as the atrium's width, the dimensions of transparent surfaces on the roof, and their placement were used to evaluate how natural light penetrates different layers of the building. The simulations provided extensive data for determining the lighting load of lower floors, calculating energy consumption, and analyzing visual comfort levels.

In the study, the impact of atrium design on indoor illuminance levels was assessed by comparing these levels to the minimum lighting standards applicable to shopping mall interiors. Table 1 summarizes the minimum lighting levels used in this study. The simulation results yielded significant findings regarding the dual objectives of improving visual comfort for users and reducing energy consumption.

Table 1. Minimum lighting levels for shopping centers (TS EN 12464-1 Standards).

Shopping Center Sections	Minimum LUX
Stores (general)	300
Shops and Showrooms	500
Supermarkets	750
Restaurants	200
Self-Service Facilities (Buffets)	300
Coridors	150
Toilets	100

The DIALux Evo simulation program was utilized to analyze the effects on energy consumption and lighting levels, highlighting the potential contributions of atrium design to energy efficiency and its role in supporting a sustainable environment. Considering the different lighting needs during the summer and winter periods, improvements in atrium design were identified, and recommendations were developed. The findings demonstrated that optimizing atrium design could be a widely applicable strategy in shopping mall designs to achieve energy efficiency goals.

This study aims to demonstrate that atrium design in shopping malls should not only be considered an architectural feature but also a strategic tool for enhancing visual comfort and increasing energy efficiency.

CORRIDOR LIGHTING AND THE SIGNIFICANCE OF ATRIUMS IN SHOPPING CENTERS

Shopping centers are designed according to specific criteria to attract users and encourage them to spend more time within these spaces. Their appeal is not only linked to their central and accessible locations but also to the infrastructure and transportation facilities that support their commercial functionality. Additionally, their compatibility with the surrounding environment enhances their value in terms of sustainability and user satisfaction.

In the interior design of shopping centers, corridors play a critical role as both the primary circulation areas and the spaces connecting store entrances. The perceptibility and functionality of corridors are crucial for users to navigate the space comfortably, perceive storefronts effectively, and have a positive overall experience (Wakefield & Blodgett, 1996). At this point, the concept of spatial legibility becomes relevant. Legibility refers to the ease with which users can locate entrances and exits, stairways and elevator connections, restrooms, and emergency exits. To enhance spatial legibility, elements such as pathways, signage, colors, material selection, form composition, and lighting design are of vital importance (Çetin, 2009; Terece & Berkin, 2019).

Corridor lighting is a design element in shopping centers that must simultaneously meet aesthetic, functional, and energy efficiency goals. Adequate lighting ensures visual comfort for users while strengthening spatial perception (Cuttle, 2003). Proper lighting allows users to clearly perceive storefronts and surrounding areas, thereby enhancing the shopping experience. Furthermore, given that shopping centers cater to a wide range of user demographics, a lighting design that accommodates different age groups and visual needs is essential (Boyce et al., 2022).

In this context, atrium designs in shopping centers stand out as innovative solutions that merge architectural aesthetics with energy efficiency goals. These structures effectively transmit natural light from upper to lower levels, reducing energy consumption and positively impacting visual comfort and spatial perception for users. The influence of atriums on lighting design represents an approach that enhances user experience while supporting sustainability objectives (EN 12464-1:2021; Boyce et al., 2022).

Spaces illuminated with natural light create a warm and inviting atmosphere through dynamic light levels, making it easier for users to navigate. Atriums play a significant role in illuminating large corridors and shared spaces. Research shows that natural light improves spatial perception, enabling visitors to better perceive storefronts and surrounding areas (Boubekri, 2014). This contributes to making the circulation areas in shopping centers more functional and user-friendly.

Atriums not only influence how users perceive and interact with the space but also contribute to the overall satisfaction and commercial success of the venue (Wakefield & Blodgett, 1996). İldeş's (2019) study, which examined the impact of comfort conditions on employees in shopping centers, highlighted that atrium design in the studied example provided thermal comfort and adequate lighting levels. This led to increased user dwell time and overall satisfaction. These findings underscore that atrium designs are not merely aesthetic preferences but functional components that support energy efficiency and enhance user experience.

ARCHITECTURAL LIGHTING ANALYSIS OF PRESTIGE MALL SHOPPING CENTER

This section presents a case study of the Prestige Mall Shopping Center located in Bahçeşehir, Istanbul, focusing on the impact of atrium design on the lighting load of corridor areas on the lower floors. This analysis aims to understand the effects of natural light on spatial perception, visual comfort, and energy consumption, highlighting the importance of atrium usage in shopping center designs from both architectural and sustainability perspectives.

The study first examines the location, architectural features, and relationship with the surrounding environment of the shopping center. The existing lighting conditions of the building are then evaluated in two different scenarios based on summer and winter periods. Based on the collected data, the advantages and areas for improvement regarding the building's energy consumption, use of natural light, and visual comfort are identified.

Location and Introduction of The Building

Prestige Mall Shopping Center was designed as a boutique mall and opened in 2007 in the Bahçeşehir district of Istanbul. The building is constructed in a rectangular form with three floors, covering a total usable area of 25,000 m² and featuring 55 stores to serve visitors. The mall stands out for its strong relationship with its surroundings, located at the end of a recreational pond area and positioned along the edge of a green space. This strategic placement reflects the adoption of an architectural approach in harmony with the environment.

The façade design of the building is shaped by frame structures that strongly emphasize both horizontal and vertical movements. This framing system enhances the visual perception of the structure and provides perceptual coherence through the reflective effect of glass elements on the building's surface. The façade primarily features transparent surfaces, with approximately 30% of the building envelope designed with transparent materials. These transparent surfaces not only facilitate the entry of natural daylight into the interior but also contribute to the aesthetic appearance of the building when viewed from the outside.

The design of Prestige Mall includes a large atrium integrated into the roof. This atrium contributes to natural lighting by allowing direct sunlight into the interior space. The atrium significantly meets the lighting needs of the upper floors through natural means, making it an important strategy for reducing the building's energy consumption. However, the limited natural light in the corridor areas on the lower floors increases the need for electric lighting. This situation stands out as a direct factor affecting the lighting load of the building.

Prestige Mall, as a product of an architecture harmonious with its surroundings, creates a visual unity with the green areas and the pond around it, offering an atmosphere that allows users to enjoy their time in the space. Additionally, considering the energy efficiency and aesthetic contributions of the transparent surfaces in the building envelope, developing strategies to utilize natural light more efficiently could further enhance the building's energy performance. Information summarizing the location and architectural features of Prestige Mall Shopping Center is presented in Figure 1-2.

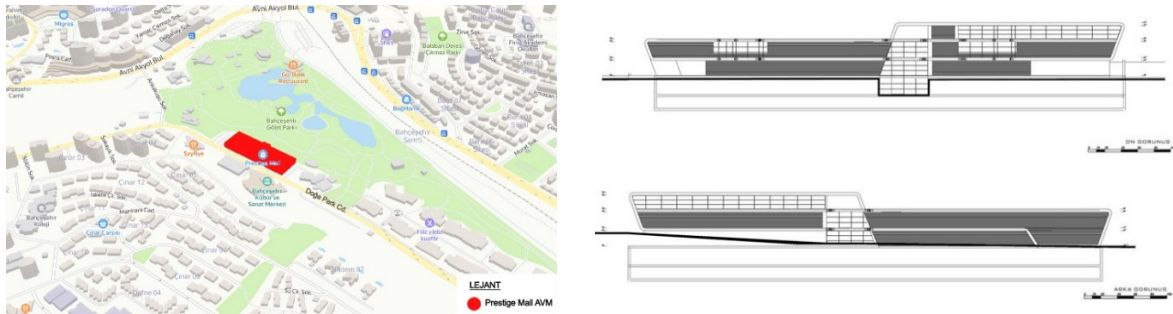


Figure 1. (A) Location (B) Appearance Drawings of Prestige Mall Shopping Center (ARKIV, n.d.)



Figure 2. Front Facade Images of Prestige Mall Shopping Center (ARKIV, n.d.)

Current Lighting Conditions of The Building

The building's current lighting system is presented separately for each floor plan in Figures 3, 4, and 5. The building's lighting is provided through a combination of natural light and electric lighting systems. A wide atrium design was created using transparent surfaces in the ceiling of the corridor volume, allowing natural light to enter the interior. This atrium design integrated into the roof was specifically designed to maximize the use of natural light during daylight hours.

The color temperature of natural light entering from the roof was visually assessed to ensure compatibility with the installed electric lighting elements. The electric lighting system consists of spot LED fixtures (ERD3395B_FAD870F, 5000 K, CRI 82) and linear LED fixtures (LL217X PSU ELP3 EM 1, 3000 K, CRI 80). Visual observations and interior photographs indicated that during midday under clear sky conditions, the average perceived color temperature of daylight was approximately 5500 K. to ensure aesthetic harmony and minimize visual discomfort, the arrangement and selection of artificial lighting were made so that the overall lighting environment—including both natural and electric light—approximates a balanced visual effect. This “adjustment” refers to the strategic positioning and selection of electric fixtures rather than altering the daylight itself, which naturally varies throughout the day and year. Before the adjustment, certain areas experienced a mismatch between the cooler daylight and the warmer artificial light, particularly on floors where electric lighting dominates. After this adjustment, the

combined visual effect provides a more uniform perception of color temperature across the interior space, enhancing both visual comfort and aesthetic coherence. Spot LED fixtures are used in each floor plan, and in addition, linear LED fixtures have been added in the basement to meet the required light levels. Upon examining the interior layout, it can be observed that light-toned, highly reflective plastic-based materials are used for the ceilings, while dark-toned, low-reflectivity colors are preferred for the walls, and wood materials are incorporated to add movement in some areas.

It was observed that the atrium design allows for effective use of natural light in the upper floors, but this effect is limited on the lower floors. The upper floors, by receiving natural light from the roof, can reduce the lighting needs during certain times of the day, while the lower floors cannot benefit sufficiently from natural light, making electric lighting more prominent in these areas. In this context, the natural light used in the upper floors reduces energy consumption, but due to the high need for electric lighting in the lower floors, it has a limited effect on energy efficiency. The use of electric lighting on the lower floors leads to visually observed lighting deficiencies, particularly due to insufficient illumination of corridors and some fixtures being out of order. The insufficient lighting levels can clearly be observed in the photos taken from the corner points in Figures 3 and 4.

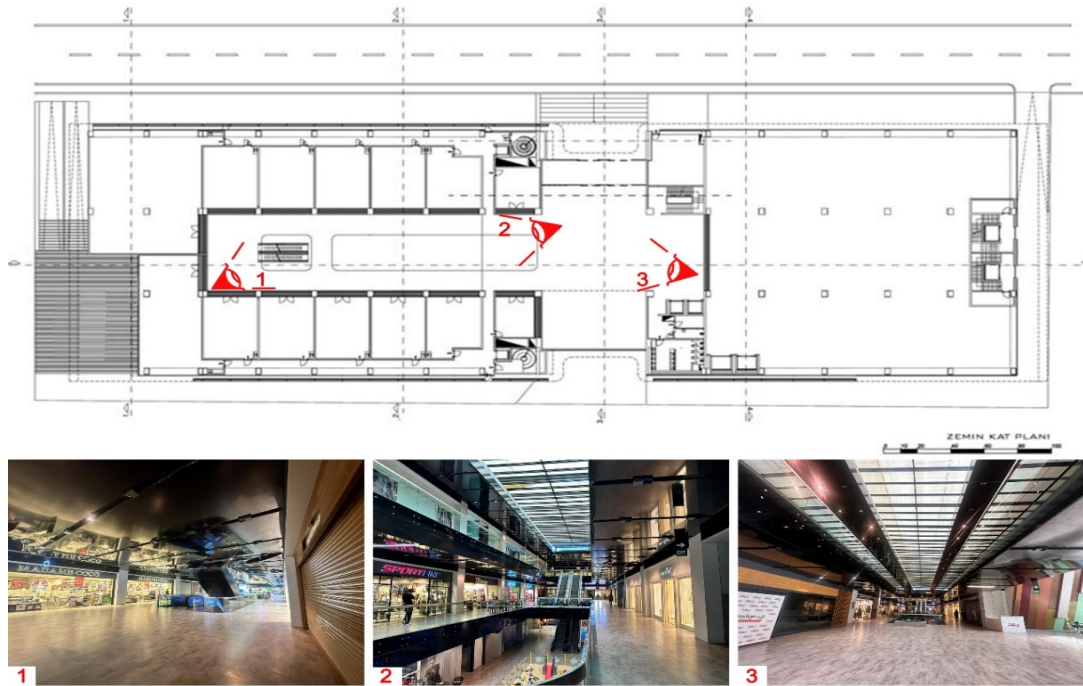


Figure 3. Ground floor plan and current lighting conditions

In the shopping center corridors, in addition to fixture use, the light reflected from store windows is also important. Spot LED fixtures and linear LED fixtures used along the corridor are placed to provide adequate lighting in specific areas. However, the light reflected from store windows also plays a significant role in illuminating the space. However, due to some stores not being actively used and some fixtures being out of service, the light emitted from the store windows is also

insufficient, and lighting deficiencies are noticeable in the interior of the building. This situation can be clearly observed in Figure 4 (3).



Figure 4. Basement Floor Plan and Current Lighting Conditions (Ertas, 2024)

The noticeable lighting deficiency in the interior of the building is not only related to the arrangement and number of lighting elements but also linked to the surface colors and reflectivity properties of the space (Veitch & Galasiu, 2012). The walls and inactive store windows in the building's interior feature dark-colored, low-reflectivity materials, while high-reflectivity materials are preferred for the ceilings. However, the use of black as a ceiling finish has hindered the adequate reflection of light, causing the space to be perceived as darker. This design choice has reduced the overall light level of the space and limited the light distribution. It is considered that lighting improvements should be made to reduce this effect. For example, by using lighter ceiling colors and reflective surfaces, the perception of brightness in the space could be enhanced. Additionally, the efficiency of the existing lighting elements should be reviewed, and the fixtures should be optimized to provide more effective and even light distribution.

The natural lighting strategies used in the building contribute to reducing energy consumption, but the high demand for electric lighting on the lower floors indicates that the full potential of natural light has not been realized. This situation highlights the need for optimizing electric lighting effectively on the lower floors, in addition to the atrium design, to further improve the building's energy efficiency. The study continues to examine the effects of natural light usage on energy

performance, and measurements using lighting analysis programs will be addressed in later stages of the study for a more detailed evaluation.

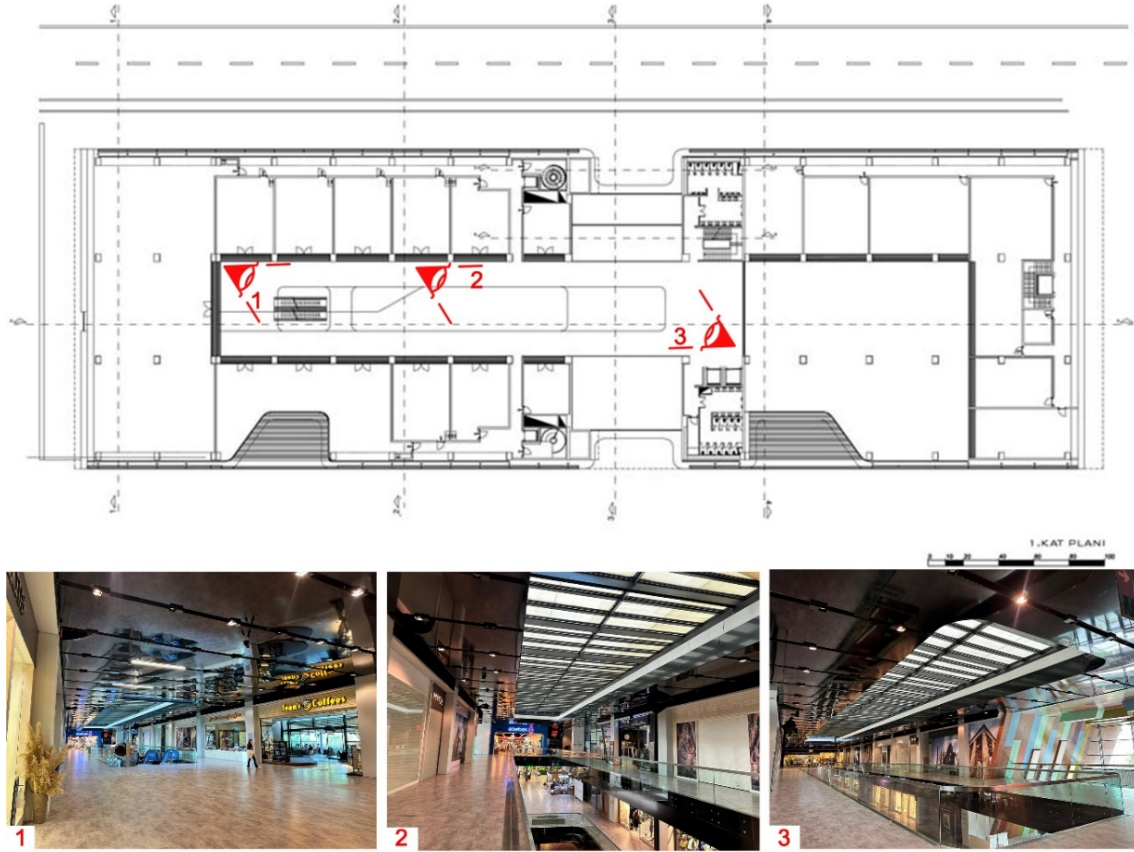


Figure 5. First Floor Plan and Current Lighting Conditions (Ertaş, 2024)

Lighting Analysis of Prestige Mall Shopping Center: Natural and Artificial

The evaluation of the effects of lighting design on annual energy consumption can be approached more comprehensively not only through the examination of individual user profiles and usage scenarios but also by accurately analyzing the contribution of natural light. However, the inability to assess the impact of natural light through manual calculations has led to the development of specialized software tools like DIALux and RELUX. These software programs allow the analysis of energy-saving potential by integrating natural and electric lighting. Indeed, daylight integration can reduce energy use by more than a third compared to current levels (Hemmerling et al., 2023). This situation has made the investigation of daylight contributions a critical element in lighting design.

In this study, the energy consumption related to the impact of daylight in the Prestige Mall shopping center in Istanbul was analyzed using DIALux Evo software. First, the interior of the building was modeled at a 1:1 scale, and the lighting levels of the main circulation areas were examined. During the modeling process, elements such as floor heights, wall thicknesses and depths, atrium openings, the locations of gallery spaces, and the number and placement of electric

lighting fixtures were carefully integrated into the program. Additionally, the color and reflectivity properties of the materials used in the building were considered in the detailed modeling.

The building has three floors with walkable spaces and 786 m² of corridor/circulation space per floor. These areas were modeled by floor, and the effect of daylight on the lighting levels of each floor was analyzed separately (Figure 6). The existing LED fixtures were modeled in accordance with the minimum lighting requirements specified for shopping centers in the EN 12464-1 standards. The effect of natural light on the spatial lighting during daylight hours in outdoor conditions was analyzed for both summer and winter periods. A comprehensive comparison was made, including electric lighting, to better understand the effect of natural light during winter hours.

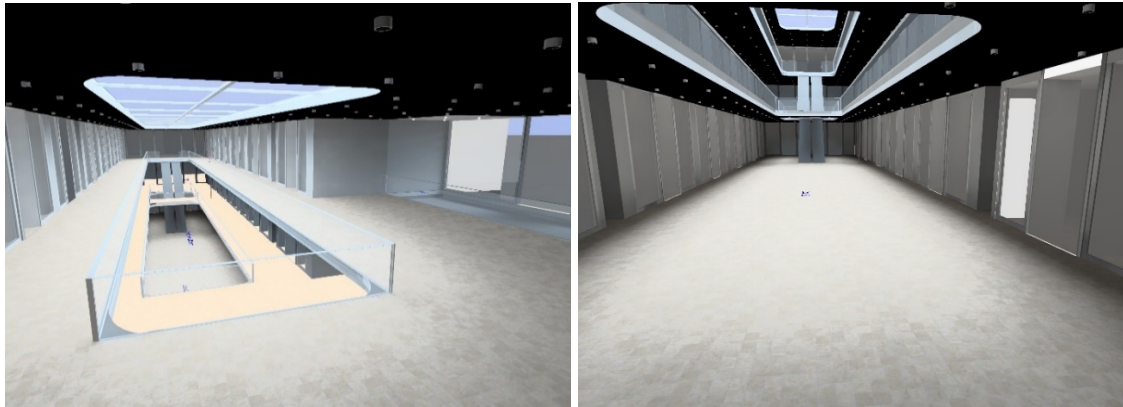


Figure 6. (A) 1st Floor and (B) Basement Floor 3D Modeling

The results obtained revealed the impact of the atrium design on the interior lighting levels. The effect of the atrium on each floor varies depending on the size of the gallery openings and the floor heights. The light distribution and technical data of the LED fixtures integrated with natural light are shown in detail in Figure 7. This study provides valuable data for improving the energy efficiency of such structures by analyzing the effects of natural and electric lighting on energy consumption and visual comfort.

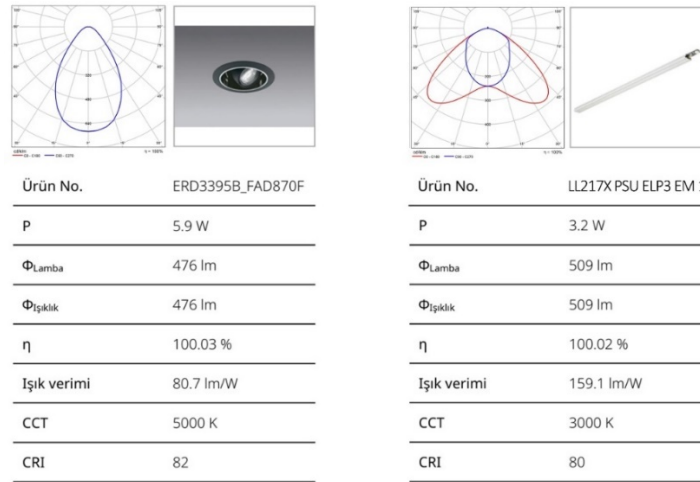


Figure 7. Luminous Intensity Distribution and Fixture Data for Spot and LED Fixtures

When examining the use of natural light on a floor-by-floor basis, it was observed that daylight was effectively provided due to the width of the atrium. On the upper floor, since a large portion of the illumination level was achieved by natural light, fewer artificial lighting fixtures were required. In contrast, on the ground and basement floors, the narrowing of the atrium opening resulted in reduced daylight penetration. Therefore, a greater number of luminaires were installed on these levels to maintain uniform lighting. In the basement, linear LED fixtures with higher luminous output were employed to ensure sufficient illuminance, as listed in Table 2.

The light distribution characteristics and technical data of these LED fixtures, including parameters such as luminous efficacy, correlated color temperature (CCT), and color rendering index (CRI), are presented in Figure 7. These details illustrate how the artificial lighting system was designed to complement the natural daylight contribution throughout different floors.

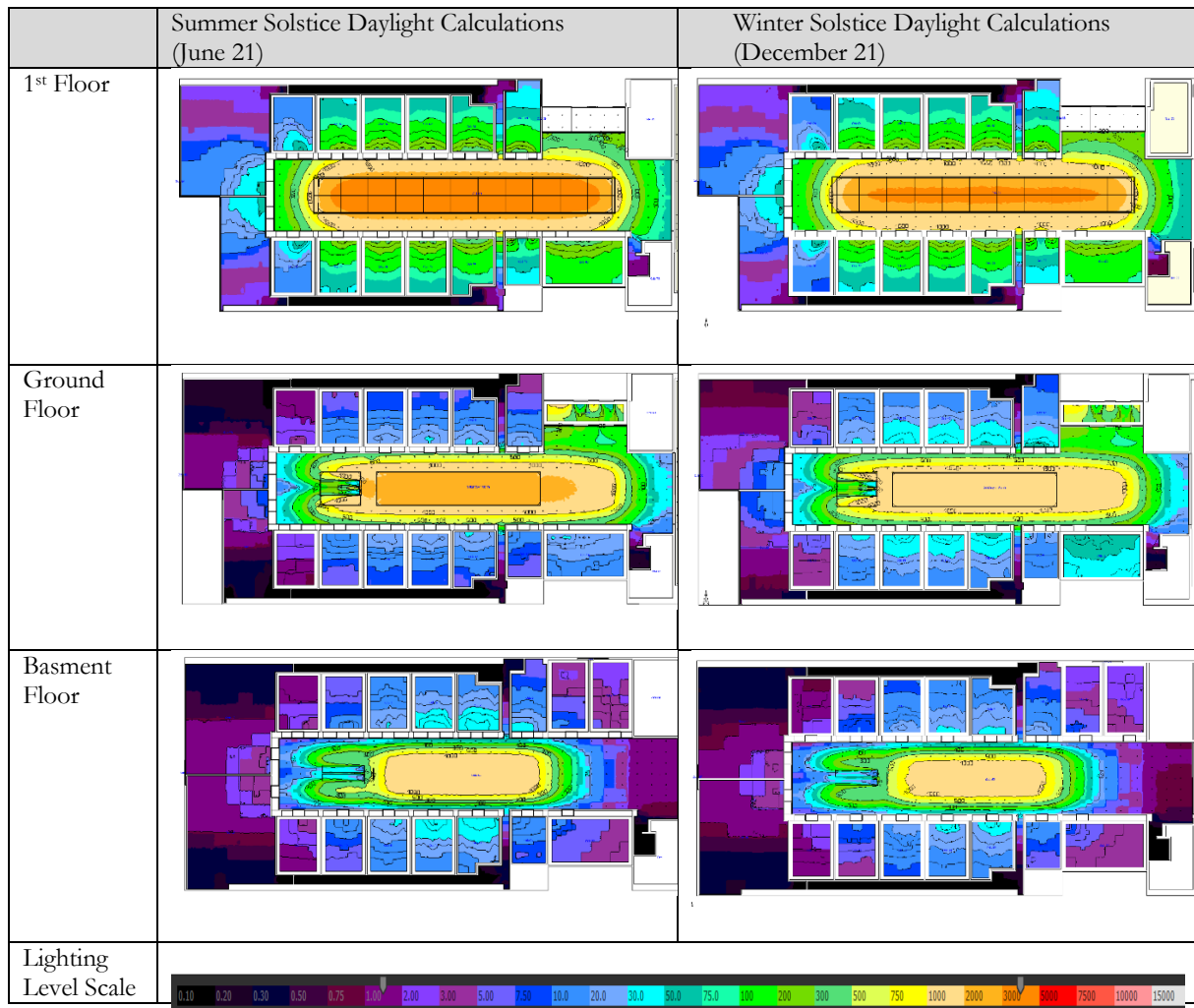
Table 2. List of light sources by floor.

List of Light Sources by Floor								
1st.Floor	Adt.	Üretici	Ürün No.	Ürün adı	R_{UG}	P	Φ	Işık verimi
	147	Endo Lighting	ERD3395 B_FAD870 F	Adjustable Downlight	24	5.9 W	476 lm	80.7 lm/W
Ground Floor	Adt.	Üretici	Ürün No.	Ürün adı	R_{UG}	P	Φ	Işık verimi
	151	Endo Lighting	ERD3395 B_FAD870 F	Adjustable Downlight	23	5.9 W	476 lm	80.7 lm/W

Basement Floor	Adt.	Üretici	Ürün No.	Ürün adı	R _{UG}	P	Φ	Işık verimi
	151	Endo Lighting	ERD3395 B_FAD870 F	Adjustable Downlight	23	5.9 W	476 lm	80.7 lm/W
	1	Philips	LL217X PSU ELP3 EM 1 xLED80S/830 VWB		18	3.2 W	509 lm	159.1 lm/W

The natural daylight calculations for the summer and winter periods, showing false colour representations of the floor plans, are presented in Table 3. In these analyses, no artificial lighting is active for either period. The calculations are based on the summer solstice (June 21) for the summer period and the winter solstice (December 21) for the winter period. Daylight calculations focus on the midday hours (12:00–14:00), when natural light through the atrium reaches its maximum, allowing artificial lighting to be used minimally. A clear sky type is selected, as this best illustrates the atrium's daylighting potential.

Table 3. Incorrect color representations of natural lighting usage for summer and winter periods.



The floor plans with false colour representations for the summer and winter periods provide critical data for analyzing the seasonal variations of natural lighting within the building. In these plans, color scales represent different light levels; blue tones indicate low light levels, while red tones represent high light levels. According to EN 12464-1 standards, the minimum lighting level required for corridor areas is 150 lx, which corresponds to the green color.

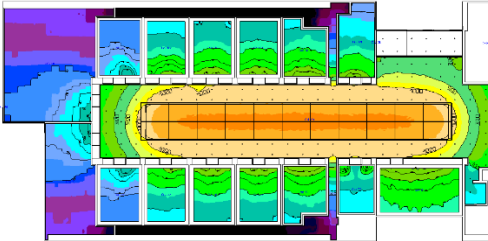
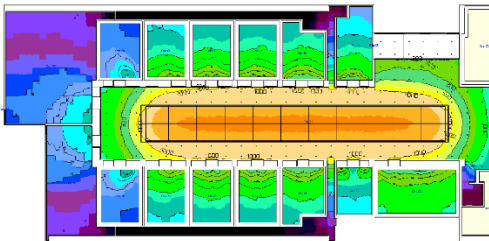
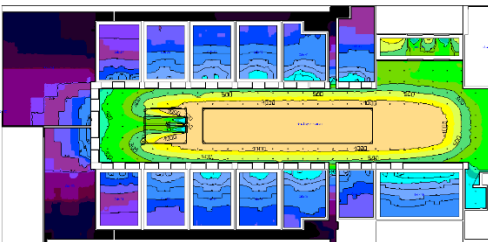
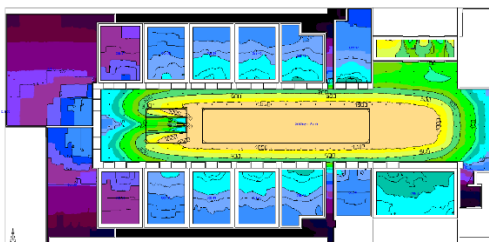
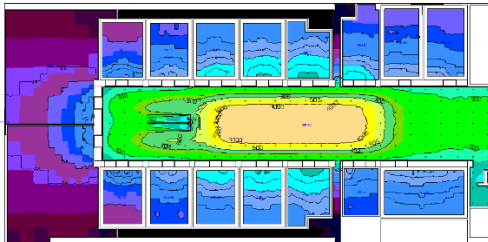
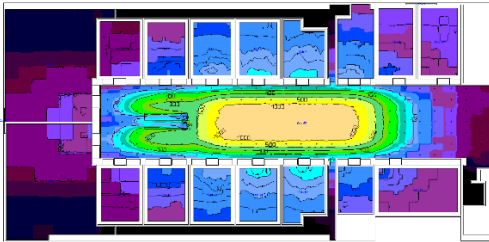
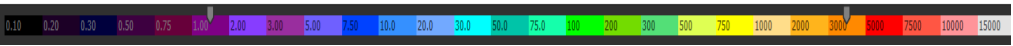
In the summer plan, due to sunlight entering at a more direct angle and longer daylight hours, higher and more homogeneous illuminance levels are observed, particularly in areas under the atrium (as shown in Table 3 and the corresponding colour-coded graphs). Illuminance uniformity, assessed by the ratio of minimum to average illuminance, is higher in these areas, confirming the observed homogeneity (Kruisselbrink et al., 2018). This reduces the need for electric lighting, thus positively affecting energy savings. In the winter period, however, with sunlight coming at a shallower angle and shorter daylight hours, illuminance levels drop significantly, especially on lower floors and areas farther from the atrium.

For the summer period, when comparing the highest and lowest daylight levels, the light level at the center of the atrium on the 1st floor is 3603 lx, which drops to a minimum of 78 lx towards the corners, where the required lighting levels are not met. For the ground floor, the maximum light level at the center of the atrium is 2194 lx, while the minimum level is 18 lx. In the basement, this ratio drops even further, with a maximum light level of 1529 lx and a minimum of 0.80 lx.

For the winter period, when comparing the highest and lowest daylight levels, the light level at the center of the atrium on the 1st floor reaches 2864 lx, while in the corner points away from the atrium, it drops to 61 lx, which is insufficient. For the ground floor, the maximum light level in the center of the atrium is 1755 lx, while in the corners it drops to 21 lx, creating a darker environment. Finally, in the basement, the light level in the center of the atrium is 1220 lx, and in the corners away from the atrium, it drops to 0.62 lx.

Another significant change observed in the winter lighting use is the increase in energy consumption due to the replacement of natural light with electric light. The lighting analysis reveals that during winter, when daylight levels are low, the use of electric light increases to compensate for the insufficient light levels that natural light could not provide. This is particularly noticeable in areas like the basement and ground floors, which have lower light intake capacity. In these periods when natural light is limited, strategic placement and proper fixture selection become crucial to ensure the efficient use of energy provided by electric lighting. Table 4 compares the effects of natural and electric lighting use on light levels during the winter period.

Table 4. Incorrect color representations of natural and artificial lighting use for the winter period.

	Summer Solstice Daylight Calculations (June 21)	Winter Solstice Daylight Calculations 21 (December 21)
1.st Floor		
Ground Floor		
Basement Floor		
Lighting Level Scale		

Finally, in the winter period, when electric lighting is added, the comparison of the highest and lowest light levels in terms of light distribution ratios shows that, for the 1st floor, the light level in the center of the atrium reaches 3737 lx, while it drops to a minimum of 232 lx in the corners of the space as you move away from the atrium. However, the minimum required light level for the corridor's corner points is met. For the ground floor, the maximum light level in the center of the atrium is 2480 lx, and the minimum light level is 170 lx, which satisfies the minimum lighting requirements, indicating that an appropriate electric lighting design has been implemented. However, in the basement, the maximum light level drops further to 1202 lx, and the minimum light level decreases to 61 lx. Under these conditions, it was observed that the light levels in the corner points were insufficient, suggesting that the current lighting design needs to be revised or supported with additional fixtures.

According to the program reports, the average light levels for each floor were deemed sufficient. However, due to the uneven distribution of daylight effects across spaces, and the high illuminance values in certain areas, this resulted in higher light levels. Based on the analysis, it was observed that as one moves away from the gallery openings, the light levels rapidly decrease and become insufficient. This situation could lead to significant differences in light levels within the interior, potentially causing glare issues. In this context, it is necessary to support the corner points with electric lighting, particularly on the ground and basement floors.

Another potential negative impact of natural lighting use is the constant change in shadow effects due to the movement of daylight. In the building, significant shadow effects caused by daylight were observed, particularly in the vertical circulation areas on the left side of the plan. Special designs may be required to achieve the desired light levels in these areas. Seasonal differences highlight the need for strategic adjustments in the building's lighting design to make more efficient use of natural light.

EVALUATION AND CONCLUSION

This study analyzes the effects of natural and artificial light usage on energy consumption and visual comfort by examining the existing lighting conditions of the Prestige Mall shopping center in Istanbul. The lighting strategies applied within the interior of the building are discussed in the context of atrium design, the characteristics of the lighting fixtures used, and lighting efficiency.

Prestige Mall stands out as a building that integrates both natural and electric lighting systems. Especially on the upper floors, the wide atrium design integrated into the roof enables effective use of natural light, reducing energy consumption. However, while the upper floors can use natural light more efficiently, the limited benefits of natural daylight in the corner areas indicate that the light levels are not evenly distributed throughout the building. The lower floors (ground and basement levels), on the other hand, require more electric lighting. Factors such as the limited natural light in corner areas and malfunctioning electric light fixtures in certain stores negatively impact the light levels in the interior. Additionally, due to the use of dark-colored ceilings and low-reflectivity materials, light deficiencies were observed in the space. This underscores the need for a lighting design that strikes a balance between aesthetic integrity and visual comfort.

Lighting analysis using DIALux Evo software clearly demonstrates the impact of natural light on the light levels within the space during both summer and winter periods. During the summer, the intensive use of natural light in areas under the atrium significantly reduces the need for electric lighting. In winter, as daylight decreases and sunlight enters at a steeper angle, especially on the lower floors, the need for electric lighting increases. This, in turn, raises energy consumption and leads to potential losses in energy efficiency. These seasonal differences highlight the need for strategic adjustments in the building's lighting design to allow more efficient use of natural light. In particular, during the winter months, using light shelves or reflective surfaces away from the atrium can help natural light penetrate deeper into the space. Additionally, optimizing the atrium design and reorganizing the electric lighting systems to adapt to seasonal changes would be an important step toward improving energy efficiency and visual comfort.

To increase energy efficiency and promote natural light usage on the lower floors, a review of the current lighting design is necessary. At this point, based on previous studies in the literature for this purpose; Increasing the size of transparent surfaces on the roof and making improvements to the arrangement of glass surfaces could elevate the light levels on the lower floors, reducing the need for electric lighting (Veitch & Galasiu, 2012). Furthermore, replacing dark surfaces with lighter tones and choosing materials with high reflectivity can improve the overall brightness perception of the space.

In conclusion, this study highlights the impact of integrating natural and electric lighting on energy consumption and visual comfort while emphasizing the importance of atrium design. However, the limited use of natural light on the lower floors and the increased need for electric lighting negatively impact energy efficiency. Future research should delve into the potential of different lighting strategies, material selections, and simulation software to optimize energy performance. Particularly, flexible and efficient lighting solutions should be developed by considering seasonal and spatial differences.

With the right design strategies, increasing the use of natural light can both reduce energy consumption and enhance visual comfort. Additionally, more comprehensive analyses using simulation software could provide new design suggestions that not only optimize energy consumption but also increase user satisfaction. Improving visual comfort for users will enhance the overall shopping experience, contributing significantly to sustainable architectural practices and energy management.

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Author Contribution Statement | Yazar Katkı Beyanı

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AUTHOR 2: (a) Idea, (d) Supervision, (g) Analyses, Interpretation, (i) Critical Review

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