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The Effect of Vertical Skylights Designed in Buildings on Daylight Illumination

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Graphical/Tabular Abstract (Grafik Özet)

In the study, the size, location and height of vertical skylights, which are important factors in daylight lighting, are observed over the effect of lighting frames according to floors, through current regulatory rules and lighting standards. It has been observed that vertical skylights are more efficient in low-rise buildings, while in multi-storey buildings, it is efficient at the top floor levels, and the consumption of efficiency is observed as you go down to the lower floors. / Çalışmada bitişik nizam yapıların günışığı aydınlatmasında önemli bir faktör olan düşey ışıklıkların büyüklükleri, konumu ve yüksekliklerinin katlara göre aydınlanma düzeylerinin etkisi güncel yönetmelik kuralları ve aydınlatma standartları üzerinden incelenmiştir. Az katlı yapılarda düşey ışıklıkların daha verimli olduğu, çok katlılarda ise en üst kat düzeylerinde verimli olup alt katlara inildikçe verimin azaldığı gözlemlenmiştir.

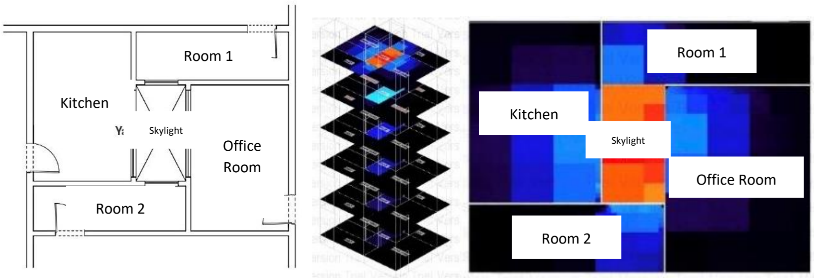

Figure A*: Simulation inputs and outputs /****Şekil A:****. Simülasyon girdi ve çıktıları*

Highlights (Önemli noktalar)

- *Düşey ışıklıkların büyüklükleri kadar kaç katlı bir yapıya hizmet ettikleri de önemlidir/ The size of the vertical skylights is as important as how many floors they serve..*
- *Kat sayısı arttıkça yalnızca ışıklıkların büyüklüğünün artması yeterli olmamaktadır/As the number of floors increases, it is not sufficient to increase the size of the skylights alone.*
- *Işıklıklar tek katlı bir yapıda verimli, ancak çok katlı yapılarda üst katlardan alt katlara inildikçe verimi azalmaktadır/ Skylights are efficient in a single-storey structure, but in multi-storey structures, their efficiency decreases as you go from the upper floors to the lower floors.*

Aim (Amaç): *It is the measurement of the efficiency of the vertical skylights according to the floors, where the spaces that do not have a window to the façade in adjacent buildings benefit from daylight lighting / Bitişik nizam yapılarda cepheye penceresi olmayan mekanların günışığı aydınlatmasından faydalandığı düşey ışıklıkların katlara göre veriminin ölçülmesidir.*

Originality (Özgünlük): *Addressing the skylight rules within the scope of the current zoning law shows that the result of the study can guide the current rules / Günümüzde geçerli imar kanunu kapsamındaki ışıklık kurallarının ele alınması çalışmanın sonucunun güncel kurallara yön verebileceğini göstermektedir.*

Results (Bulgular): *Skylights are efficient in a single-storey structure, but in multi-storey structures, their efficiency decreases as you go from the upper floors to the lower floors / Işıklıklar tek katlı bir yapıda verimli, ancak çok katlı yapılarda üst katlardan alt katlara inildikçe verimi azalmaktadır.*

Conclusion (Sonuç): *In order for the skylights to reach the lower floors efficiently, they should be covered with reflective surfaces and the size of the windows opening to the skylights should be taken into consideration / Işıklıkların günışığını alt katlara verimli ulaştırabilmesi için yansıtıcı yüzeylerle kaplanması, ışıklıklara açılan pencere büyüklüklerinin göz önünde bulundurulması gerekmektedir.*

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The Effect of Vertical Skylights Designed in Buildings on Daylight Illumination

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The fact that lighting plays an important role in the energy consumed by buildings, which have a large share in the total energy consumption in the world, requires more work to be done on daylight, which reduces the need for artificial lighting, saves energy in buildings and increases indoor comfort as well. Whether the current energy resources will exist in the future and the extent of the damage to the ecosystem as a result of the deterioration of the natural balance are discussed and discussed from different perspectives. At this point, with the thought of efficient use of energy, studies are carried out to reduce energy consumption and ensure sustainability in the field of lighting. In the building sector, which has a significant share in energy consumption, energy efficient design and sustainable architecture, which aims to use renewable energy sources and reduce energy consumption, are supported by planning and design criteria.

In this study, the efficiency of skylights, which is one of the lighting methods with daylight, was investigated in accordance with the criteria specified in the relevant zoning legislation and the daylight standard in buildings. The effect of skylights on visual comfort and daylight performance in residential interiors that do not receive direct sunlight was analyzed with 3 different scenarios on spaces in different directions and floors with the help of the Design Builder simulation program. As a result of the analysis, it was concluded that the size of the spaces illuminated by the skylight, the length of the facade where the skylight is located, the floor where the space is located and its direction significantly affect the level of illumination. In line with the findings obtained in the study, it has been observed that the minimum skylight values given in the Planned Areas Zoning Regulation in force today do not provide sufficient daylight illumination, especially in the spaces on the ground floor. For this reason, solutions have been proposed to reach the level of visual comfort in spaces.

Binalarda Tasarlanan Düşey Işıklıkların Günışığı Aydınlatmasına Etkisi

Makale Bilgisi

Araştırma makalesi
Başvuru: 15/03/2023
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Öz

Dünyadaki toplam enerji tüketiminde büyük bir paya sahip olan binaların, tükettiği enerjide aydınlatmanın önemli rol oynaması, yapay aydınlatma ihtiyacını azaltarak, binalarda enerji tasarrufu sağlayan ve bunların yanı sıra iç mekân konforunu arttıran günışığı ile ilgili daha çok çalışmanın yapılmasını gerektirmektedir. Günümüzde sahip olunan enerji kaynaklarının gelecekte var olup olmayacağı, doğal dengenin bozulması sonucu ekosistemin göreceği zararın boyutu farklı bakış açıları ile ele alınmakta ve tartışılmaktadır. Bu noktada enerjinin verimli kullanımı düşüncesiyle aydınlatma alanında da enerji tüketimini azaltmaya ve sürdürülebilirliği sağlamaya yönelik çalışmalar yapılmaktadır. Enerji tüketiminde önemli bir paya sahip olan yapı sektöründe ise yenilenebilir enerji kaynaklarını kullanmayı ve enerji tüketimini azaltmayı hedefleyen enerji etkin tasarım ve sürdürülebilir mimarlık anlayışı, planlama ve tasarım kriterleri ile desteklenmektedir. Bu çalışmada günışığı ile aydınlatma yöntemlerinden birisi olan ışıklıkların ilgili imar mevzuatı ile binalarda günışığı standardında belirtilen ölçütler doğrultusundaki verimliliğinin araştırılmıştır. Doğrudan günışığı almayan konut iç mekânlarındaki ışıklıkların, görsel konfor ve günışığı performansına etkisi Design Builder simülasyon programı yardımıyla farklı yön ve katlardaki mekânlar üzerinde 3 farklı senaryo ile analiz edilmiştir. Yapılan analiz sonucunda ışıklık ile aydınlatılan mekânların büyüklüğü, ışıklığın bulunduğu cephenin uzunluğu, mekânın bulunduğu kat ile yönünün aydınlık düzeyini etkilediği sonucuna varılmıştır. Çalışmada elde edilen bulgular doğrultusunda, günümüzde yürürlükte olan Planlı Alanlar İmar Yönetmeliği'nde verilen minimum ışıklık değerlerinin özellikle zemin kattaki mekânlarda yeterli günışığı aydınlanması sağlamadığı görülmüştür. Bu sebeple mekânlarda görsel konfor düzeyine ulaşmak için çözüm önerileri getirilmiştir.

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1. INTRODUCTION (GİRİŞ)

Rapid population growth and urbanization have led to an increase in energy demand and a concomitant depletion of energy resources. As a result, the concept of sustainability, defined as handing over to future generations through efficient use of existing energy resources, has emerged and studies have been initiated to protect energy resources and reduce energy consumption in all sectors. In the building sector, which accounts for about 40% of total energy consumption, this situation has found far-reaching effects, and approaches such as sustainable architecture and energy-efficient design have emerged [1]. If we examine the energy consumption in buildings, which account for a significant amount of energy consumption, we find that the energy consumption due to lighting is about 28% [2]. For this reason, it is important to conduct lighting-specific studies to reduce the energy consumption caused by artificial lighting in terms of sustainable architecture and energy-efficient design. At this point, daylight, which is the most basic energy source, plays the most effective role for lighting. While the effects of daylight on people and the quality of the indoor environment are shared in the studies, the importance of daylight-efficient design is increasing. This is because it is well known that increased use of daylight not only provides sustainability and energy efficiency in buildings, but also increases the performance and visual comfort of individuals. [3, 4, 5]. Nowadays, in order to design sustainable and energy efficient buildings, many programs have been developed to calculate the energy and daylighting performance of buildings, energy consumption, and the daylighting percentage of spaces. In this way, one can get an idea of the energy efficiency of the buildings before they are put into service. In this study, the effect of skylights, which are one of the methods of incorporating daylight into buildings, on indoor visual comfort and daylight performance was investigated. In this context, the concept of lighting in sustainable architecture and energy-efficient design is discussed, and the effects of daylight on space are discussed. The zoning ordinance was evaluated against daylighting standards in buildings by measuring the amount of daylight and the performance provided to spaces using the variables of the number of stories of skylights with the minimum values of the zoning ordinance. The DesignBuilder program was used in the study for this evaluation, and suggestions for adequate daylighting and visual comfort were made as a result of the study.

1.1. Literature Review (Literatür araştırması)

Arpacıoğlu et al [6] and Arpacıoğlu [7], who studied the effects of daylight on visual comfort and space, concluded that daylight is a factor that increases space quality and comfort. However, in a study that examined the effects of daylight on psychological comfort [8], psychological comfort was found to be related to lighting prescriptions. The effects of daylight on work comfort are also frequently the subject of research. In a study that measured the effect of daylight illuminance on the stress levels of hospital employees [9], employees with daylight illuminance levels below the average illuminance (700 lx) but above the average had medium and high stress levels, while above the average illuminance (1000-1500 lx) this ratio was found to decrease. In addition, daylighting, which contributes positively to the reduction of electrical energy consumption, has also been the subject of numerous studies on energy efficient and effective design [10, 11, 12]. The literature includes studies that address energy-efficient lighting systems [13] and sustainable lighting designs for educational buildings [14]. Studies on luminaires, which are the direct subject of the study, are also common in the literature. In addition to the studies that simulate and measure the daylight levels provided by the types of skylights for the space [15], there are also studies that determine the optimal size, height/width ratio, and reflectance ratios of these skylights [16]. In addition, there are also studies that show the positive contribution of the skylight in reducing the energy consumption for lighting and developing cost-effective solutions. The effect of a skylight element on energy and daylight performance has been investigated with different design criteria [17]. In another study, it was suggested to use skylights with a 4-10% skylight opening, which can increase daylighting without affecting energy consumption [18]. In a study investigating the direct effect of skylight type on energy consumption, it was found that the energy consumption of a commercial building can be reduced by 0.8% to 14% and the lighting energy consumption can be reduced by 30% by using different skylight configurations [19]. In another study investigating the study of the energy and economic performance of skylights in different climates showed that in areas with mild climates, identical buildings in four different cities (Caribou, Maine, Miami, Florida) can save more energy and costs than in regions with severe winters [20]. Various studies in the literature have used different simulation programs that have evaluated the different impacts of skylights. There are studies that use program extensions such as the Lightscape program or Honeybee-Ladybug, an extension of the

Grasshopper program, and Lightools, an extension of the Solidworks program, for the effects of different design factors on the daylight values of skylights [15, 16, 17, 21]. The Design builder program, based on EnergyPlus, is used for the effects of skylight on energy and daylight performance [19]. Programs such as Dialux and Radiance have been used for pure illuminance measurements [22, 10]. In the literature search, no study was found that investigated the effect of a standard size skylight, which was created in accordance with zoning regulations for planned areas, under the climatic conditions of Turkey on different floors of the houses. In this study, the daylight comfort conditions in residential houses are evaluated using DesignBuilder simulation program.

1.2. Methodology

In this study, which aims to investigate the effect of vertical skylights in buildings on indoor visual comfort and daylighting performance, the dimensions of the skylight space and the created floor plan areas were kept stable and the number of floors was set as a variable. In determining the size of the skylight space, the limits of the zoning ordinance [23] were taken into account. TS EN for the necessary criterion of the target illuminance at the place of measurement, the standard 17037 Daylighting in Buildings [24] was used. In the corresponding standard, the daylight factor method is specified as minimum 300 lx, average 500 lx, high 750 lx in the daylight power limitation for horizontal openings (skylights). In this study, two different floor plan types were created in accordance with the limits of the zoning ordinance and tested with three different scenarios (Figure 1).

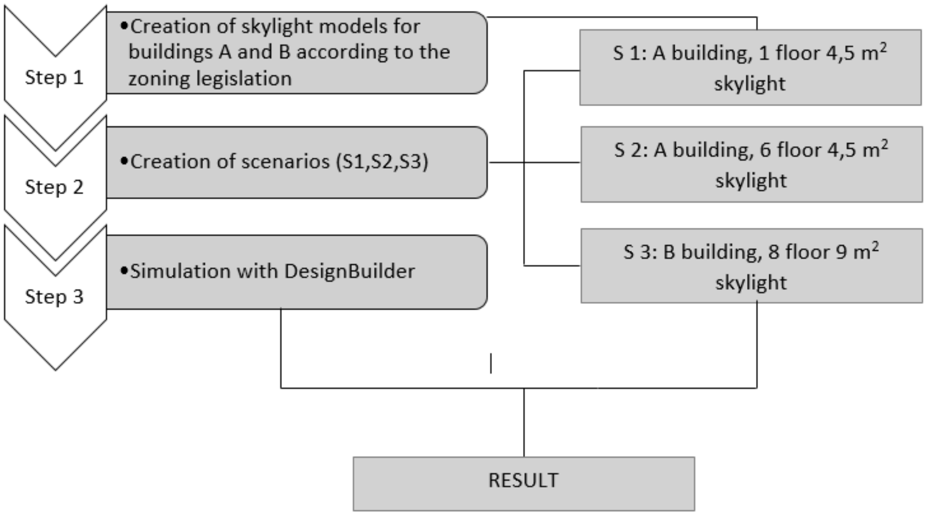


Figure 1. The method of the study (Çalışmanın yöntemi)

In the study, the skylights and surrounding spaces were modeled using Design Builder, the number of stories was increased while the skylight remained the same for Building A, and the effect of skylight size on the maximum story height for Building B was investigated. In the simulation with Design Builder, the daylight level and performance in the rooms in the single-story building were measured in the first scenario. In the second scenario, the daylight level and performance were calculated on the first floor of the 6-story building, which is the building code limit. In the third scenario, the daylight level and performance in the first floor spaces of the 8-story building were calculated by increasing the size of the skylights.

2.MATERIALS AND METHODS (MATERYAL VE METOD)

2.1. Daylight and Visual Comfort (Günışığı ve Görsel Konfor)

Daylight, which affects both the physiological and psychological health of people and work performance, is the most important element that increases the quality of space and provides visual comfort. It is a phenomenon that maintains its importance as it reduces energy consumption in buildings and affects sustainability. One of the most important effects of daylight on human health is that it is an effective stimulant for the human visual system and the circadian cycle, that is, the biological alternation or rhythm of behavior. A lack of daylight leads to psychological problems such as depression, nervous fatigue, eyestrain or mood swings, as well as physiological problems such as insomnia, excessive sleep, disruption of the circadian cycle, increase in the risk of diabetes and some cancers [25]. In one study, daylight was found to be the fourth most important factor among the nine factors affecting human healthafter sleep, ventilation, and nutrition [26]. Another study states that about 15% of the world's population suffers from seasonal mood changes that are due to sunlight [27]. However, it is also known that daylight enhances human performance and increases motivation and productivity. In many studies, it has been found that a cloudy day or poor lighting conditions affect people's energy levels and reduce their work performance. In one of these studies, it was concluded that daylight, when used effectively and properly, can improve mental functions by 10 to 25%, including memory and work speed, and increase productivity by up to 15% [28]. The proper and effective use of daylight plays an important role in reducing energy consumption and ensuring sustainability on a global scale. This is because buildings account for about 40% of the total energy consumption in the world. In Turkey, this share is 45%. While 20% of the total electrical energy consumed is used for lighting purposes, this percentage is 56% in buildings [29]. By using daylight, the need for artificial lighting can be reduced, and energy costs can be lowered by reducing the amount of energy consumed. In addition to the physical and mental effects of daylight on people, it enhances the quality of space and provides visual comfort. Visual comfort is a subjective assessment of how well the eye sees and correctly perceives objects, their color, shape and texture, in short, the quality of light. To ensure visual comfort at work, there should be conditions such as the provision of the required level of lighting, the absence of glare and dazzle, and the choice of a color suitable for the function. In summary, the proper and effective use of daylight enables people to increase their energy level and motivation and, accordingly, increase their performance, be physically and mentally healthy, and reduce energy consumption by reducing the need for artificial lighting. The fact that lighting accounts for a significant proportion of energy consumption in homes has led to this study being conducted specifically for homes. Thus, the study was accompanied by a simulation program and spatial lighting analyzes to investigate the specific effects of daylight use on spaces.

2.2. Case Study: Measuring the Effect of Vertical Lights on Indoor Daylight Performance (Alan Çalışması: Düşey Işıklıkların İç Ortam Günışığı Performansına Etkisinin Ölçülmesi)

In this part of the study, the vertical skylights, which are one of the methods of integrating daylight into the building, are considered as the problem of building facades, that is, skylights and so on. Istanbul, which is a temperate climate region where these methods are commonly used and the population and building density is high, is discussed. In this direction, a partial apartment plan was prepared, keeping the dimensions of the rooms stable and setting the number of floors as variable. Accordingly, the daylight illuminance levels entering the rooms through the skylight were calculated. In the area of skylights and data analysis by floor, the data obtained in the study were included and the data were analyzed according to the standard TS EN 17037 Daylight in Buildings.

5.1. Indoor Skylight Criteria (İç Ortam Işıklık Kriterleri)

The boundaries of the indoor skylight space are defined by the zoning ordinance. According to the zoning ordinance, skylight defines "the spaces covered with transparent building materials created to illuminate the main staircase or landing of the building or the games without facade". In this study, the limits of skylights in the zoning ordinance were considered. According to the values in Article 32 of the relevant ordinance, skylights in buildings with 1 to 6 floors have a narrow side of at least 1.50 m and an area of 4.50 m2. It should be 9.00 m2. In addition, according to the regulation, a maximum of four games can benefit from a skylight with minimum size per floor. For this reason, in the study, the floor numbers 1 and 6 were set as the minimum and maximum floor distances for the 4.5 m2 skylight, while the area for the 9 m2 skylight was set at 8 floors and the analyzes were performed for these floor numbers. In the floor plan design, four rooms were created to benefit from the skylight. The windows in the skylight room were selected in accordance with the Regulation on the Energy Performance of Buildings and the standards of the Turkish Standards Institute. The EnergyPlus-based simulation program Design Builder, which was used in the study, made it possible to draw various conclusions by performing analyzes between building design alternatives using performance and function-based comparison methods [30]. In the DesignBuilder program, the analysis results can be obtained by entering data such as location and climate data of the building, zoning of areas within the building, activity of the zones and user profile, selection of wall, floor and roof materials, and thermal transmittance coefficients.

5.2. Simulation with Designbuilder of Skylights in the Interior (İç ortam Düşey Işıklıkların DesignBuilder ile Simülasyonu)

As an example for the study, a partial apartment floor plan with a floor height of 3.5 m is designed, consisting of four rooms that can receive daylight only through the skylight (Figure 2 and Figure 3). To better analyze the value differences in the study, scenarios with building A with 1 and 6 floors and the scenario with floor plan B with 8 floors are discussed (Figure 4). There are also differences in the size of the space between buildings A and B due to the size of the skylights. Since the size of the space does not change in this case, Scenarios 1 and 2 are comparable for Building A, and Building B is evaluated on its own. In addition, the preferred materials and the thickness, density, and thermal conductivity values of the materials were entered into the DesignBuilder program for analysis. It was found that natural gas and radiator heating systems as heating systems and natural ventilation without mechanical solutions for cooling provide thermal comfort. For the comfort zone of the modeled building, 18-22°C was chosen for heating comfort and 28-34°C for cooling comfort.

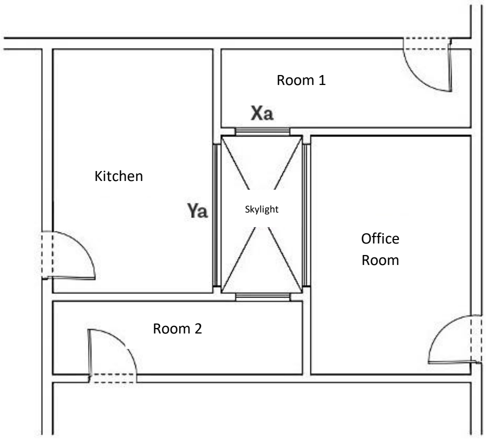


Figure 2. Partial plan sketch of building A (A Binasının Kısmi Planı)

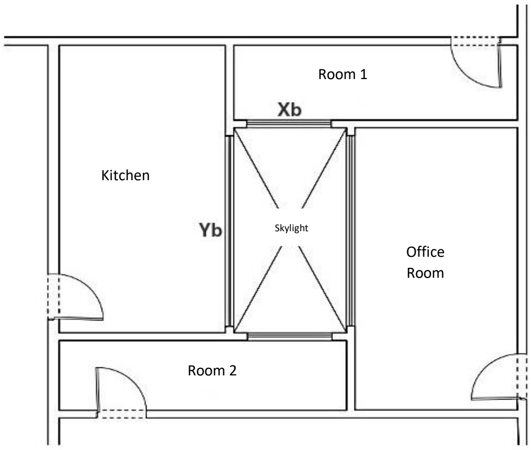


Figure 3. Partial plan sketch of building B (B Binasının Kısmi Planı

The direction for each space, the size of the space, and the window size used are given in Table 1. The floor height has been determined as 3.50 m in buildings A and B for each space.

Table 1. Information about spaces in scenarios (Senaryodaki Odalar Hakkındaki Bilgiler)

District	Direction of light	Scenerio 1		Scenerio 2		Scenerio 3	
		Space Size	Window Size	Space Size	Window Size	Space Size	Window Size
Kitchen	East	15,5m²	270x200cm	15,5m²	270x200cm	19,0m²	430x200cm
Room	South	7,8m²	130x200cm	7,8m²	130x200cm	8,0m²	180x200cm
Office	West	15,5m²	270x200cm	15,5m²	270x200cm	19,0m²	430x200cm
Room	North	7,8m²	130x200cm	7,8m²	130x200cm	8,0m²	180x200cm

In addition, the spaces where floor heights and skylight spaces are evaluated in the section for Buildings A and B are shown in Figure 4.

The results of the analyzes performed based on the above information are discussed in the next section.

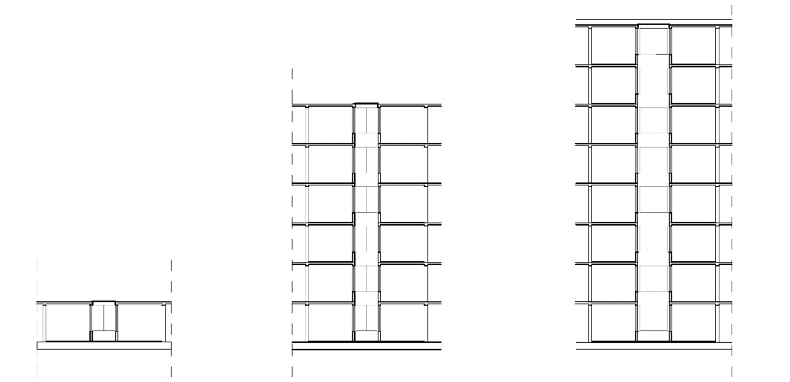


Figure 4. The sections of building A and building B (A binası ve B binasının bölümleri)

3.RESULTS (BULGULAR)

In the analyzes performed, the distribution of illuminance levels in the floor plan of Scenario 1 in Building A is shown according to the color scale in Figure 5. From this it can be seen that the illuminance of daylight supplied to the rooms from the skylight, about half of the volume of each room, meets the relevant standard (Figure 5). It can be seen that the illuminance in front of the windows of the building reaches up to 920 lux, which is the maximum value of daylight illuminance.

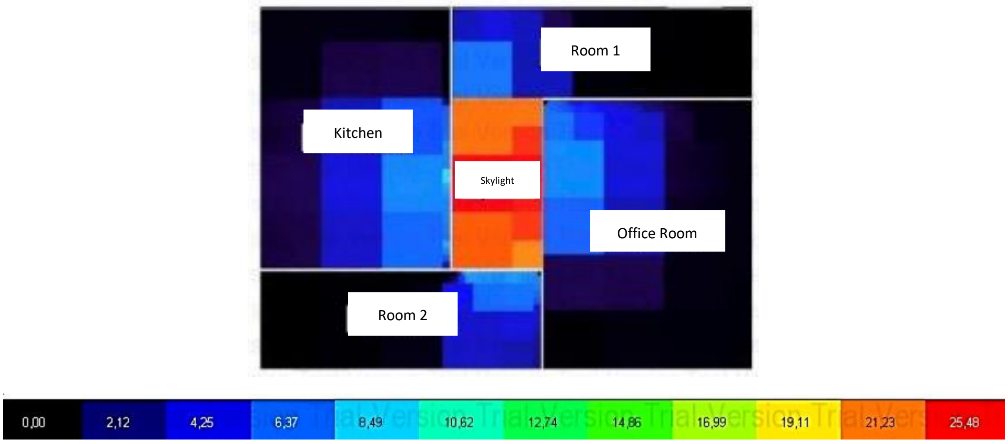


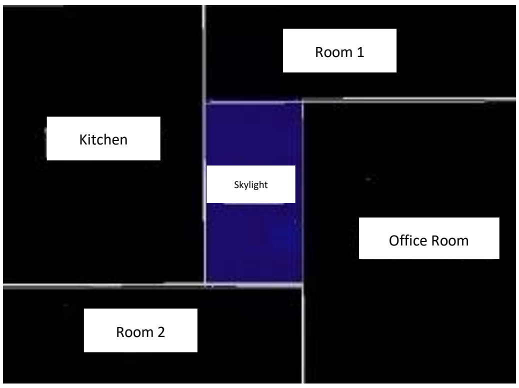
Figure 5. Building A scenario 1, daylight analysis in plan (Senaryo 1, A binasının günışığı aydınlatma analizi)

On the other hand, as the spaces move away from the skylight, areas where the minimum illuminance level decreases to approximately 5 lux were observed, and it was observed that in scenario 1, although the building was a single storey, sufficient illumination level could not be provided on the ground floor. This situation is especially related to direction, depth of space and window area. In the planning, the kitchen and room 2 are located on the north and derivative facades, while the office room and room 1 are located on the south and derivative facades. On the other hand, since the spaces can only be illuminated from the window opened in the skylight, this evaluation will be based on the direction in which the illumination can be provided. However, there is a 1x2 size difference between the window sizes of the kitchen and room 2 (Table 2). The difference between the minimum illuminance levels of the kitchen and room 2 can be said to be related to the presence of areas farther away from the skylight, since the m2 of the kitchen is larger than that of room 2. Similarly, there is the same relationship between office room and room 1.

Table 2. Simulation outputs for building A scenario 1 (A binası için simülasyon çıktıları)

District	Minimum Daylight Level (%)	Maksimum Daylight Level (%)	Minimum Illuminance Level (lux)	Maksimum Illuminance Level (lux)
Kitchen	0,047	7,762	4,68	775,95
Room 2	0,116	5,906	11,62	591,09
Skylight	20,111	25,021	2011,18	2502,16
Office Room	0,083	6,234	8,26	623,30
Room 1	0,137	9,210	13,73	920,89

When the results of Scenario 2 in building A are examined, it has been determined that the daylight illuminance level on the ground floor in the 6-storey building is well below the values given in the standard, and there are dark spots with values of 0.26 lx, 0.10 lx and 0.14 lx, where daylight does not reach in the areas far from the skylight (Fig. 6 and Table 3). In the color scale of the simulation outputs given in Figure 6, the dark parts where the light cannot reach show that the relevant standard cannot be achieved in all of the spaces.



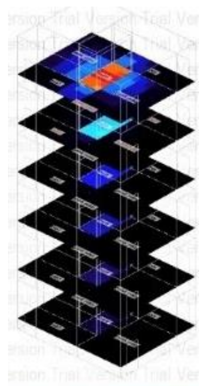


Figure 6. Building A scenario 2 daylight analysis in plan (Senaryo 2 için A Binasının plandaki Günışığı Analizi)

Figure 7. Building A scenario 2 daylight analysis in section (Senaryo 2 için A Binasının Kesitteki Günışığı Analizi)

The fact that all the data of scenario 1 and scenario 2 are stable and only the number of floors are different explains the difference in illuminance values in building A and building B. In the 1st scenario, the ground floor of the single-storey building has an illuminance level of 920 lx above the standard value. It is known that it can show its effect at a maximum depth of 6m. The same situation can be seen vertically, with a height difference of 17.5 m (3.5 m x 5 floors) between the top floor and the ground floor of the surface where the light can be received. In this case, it is seen that the illuminance levels at every point of the spaces remain below the relevant standard, regardless of which direction they are located.

Table 3. *Simulation results for building A scenario 2 (A senaryosu 2 oluşturmak için simülasyon sonuçları)*

District	Minimum Daylight Level (%)	Maksimum Daylight Level (%)	Minimum Illuminance Level (lux)	Maksimum Illuminance Level (lux)
Kitchen	0,003	0,189	0,26	17,88
Room 2	0,001	0,122	0,10	11,52
Skylight	2,166	2,578	204,97	243,98
Office Room	0,002	0,108	0,21	10,27
Room 1	0,001	0,307	0,10	29,12

The simulation outputs of the illuminance levels in the 8-storey building, which is considered as Scenario 3 in the study for the building B, are given in Figure 7 and Figure 8. Accordingly, it has been observed that the daylight illuminance levels provided to the spaces from the 9.00 m2 skylight on the ground floor are 348 lx. This value is almost the minimum value of the standard. As in the other 2 scenarios, it is seen that there are dark spots where daylight does not reach in the 3rd scenario.

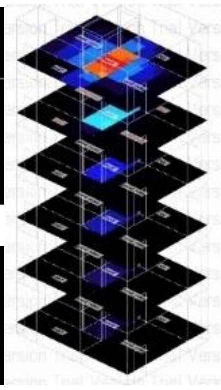


Figure 8. Daylight analysis in plan B building (B planı binasında gün ışığı analizi) **Figure 9.** Daylight analysis in section B building (B bölümündeki binada gün ışığı analizi)

Building B has a skylight twice the size of Building A and has 8 stories. While the window heights of the rooms arranged around the 9 m2 skylight are the same, the window widths are about 1.5 times larger than those of Building A. In this case, although the illuminance to be extracted is greater, the number of floors increases, so the height distance required to reach the illuminance also increases (3.5 m x 8). It can be seen that the maximum illuminance levels on the first floor of building B have values close to the limit of the daylighting standard (329-348 lux) or below the standard (51-167 lux) (Figure 8 and Figure 9, Table 4).

Table 4. Simulation results of building B (B binasının simülasyon sonuçları)

District	Minimum Daylight Level (%)	Maksimum Daylight Level (%)	Minimum Illuminance Level (lux)	Maksimum Illuminance Level (lux)
Kitchen	0,005	0,055	4,76	51,88
Room 2	0,002	0,371	1,46	348,44
Skylight	2,077	3,033	1951,66	2849,96
Office Room	0,004	0,178	3,38	167,10
Room 1	0,001	0,350	1,13	329,10

However, if we look at the directions in which the rooms are located, we find that the kitchen and room 2, which can be illuminated from the east and north directions in building B, are more illuminated than the office room and room 1, which can be illuminated from the west and south directions. The diagram comparing the illuminance levels of all 3 scenarios is shown below (Figure 10). Although the rooms designed as kitchens and offices have the same dimensions and window areas, different results were obtained depending on the location of the rooms. It can be seen that for thestandard CIE (International Commission on Illumination) [31], when the sky is cloudy, the kitchen, which is illuminated from the east, has an illuminance 20% higher than the study, which is illuminated from the west.

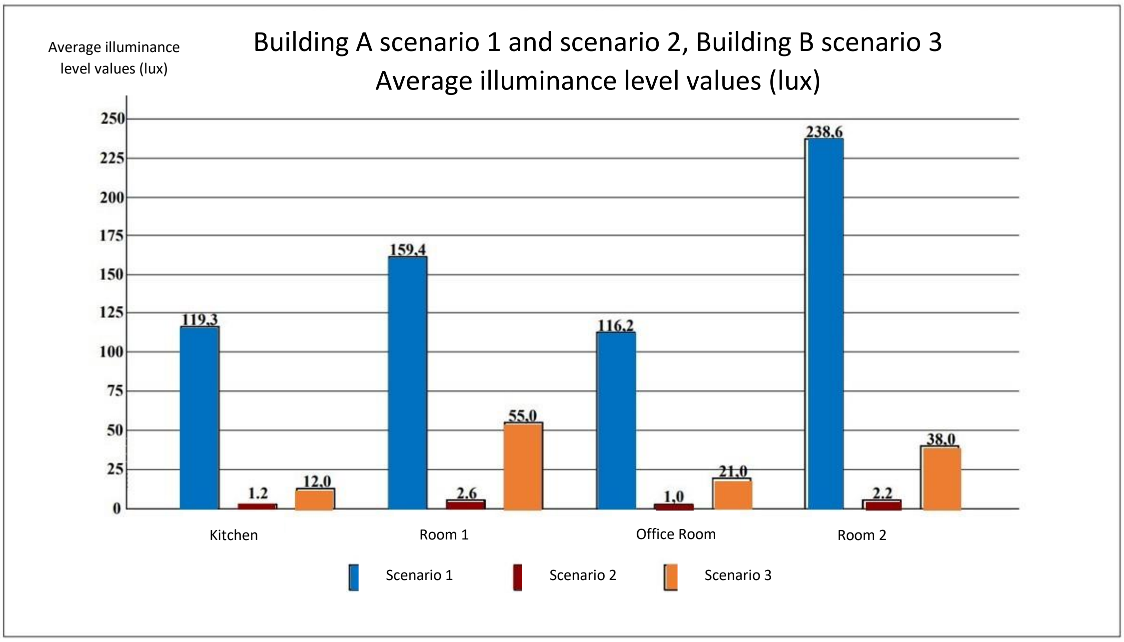


Figure 10. Average illuminance values for scenario 1 and scenario 2 for building A, scenario 3 for building B (A binası için senaryo 1 ve senaryo 2, B binası için senaryo 3 ortalama aydınlık değerleri)

Even between Room 1 and Room 2, which have the same room and window dimensions, Room 2 has 36% lower illuminance than Room 1. This situation can be related to the illumination of Room 2 from the north and the illumination of Room 1 from the south. In the analysis, in Building A, where 4.5 m^2 skylights were studied, there was a 96-98% decrease in average illuminance in first floor rooms when the number of floors was increased from a single floor to 6 floors, compared to Scenario 2 Scenario 1. Looking at the illumination values of the 9 m2 skylight in Scenario 3, we can see that the illumination values in the first floor of an 8-story building are higher than those of the 6-story building in Scenario 2 and that the skylight is twice as large.

4.CONCLUSIONS (SONUÇLAR)

Numerous studies show that a qualified lighting design that provides sufficient daylight increases human work performance, ensures the maintenance of the circadian cycle in a healthy way, and positively influences mental health. Visual comfort, reducing the use of artificial lighting, and lowering energy consumption and costs are directly related to the effective use of daylight. Therefore, improper and unqualified lighting design not only leads to various psychological and physiological health problems in humans, but also increases the energy consumption of buildings and brings cost and sustainability problems. In this study, the effect of skylight space, which is one of the methods of incorporating daylight into the building and is used as a solution in places with high building density where daylight cannot be provided directly, on indoor visual comfort and daylight performance was investigated. As a result of the study, it was found that the skylight space, for which limits are set in the zoning ordinance, cannot provide the required level of daylight in rooms as the number of floors increases. In addition, artificial lighting should be used in locations where daylight cannot be adequately used during the day. While this results in an increase in lighting costs, it also negatively impacts the expectation of sustainability. The conditions discussed in the study are the current conditions in the Planned Area Designation Ordinance. Therefore, these conditions are inadequate in terms of spatial requirements. Even in a single-story building, the skylight does not provide adequate lighting, while these spaces become meaningless, especially in multi-story buildings. In this case, where the skylight is insufficient, the first step should be to improve the skylight conditions required by the regulation. It is recommended to increase the size of the skylight, increase the ratio between the windows that can be opened and the skylight, and install reflective, light-reflective materials along the surface at the top of the skylight and inside. In this regard, in the studies included in the literature review, the use of skylights with 4-10% skylight opening that can increase daylight, the use of guiding and reflective elements in the skylight space, the use of translucent photovoltaic windows, etc. Methods are recommended. In this way, it will be possible to provide sufficient daylight illumination and visual comfort, as the daylight reaches the first floor.

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DECLARATION OF ETHICAL STANDARDS (ETİK STANDARTLARIN BEYANI)

The author of this article declares that the materials and methods they use in their work do not require ethical committee approval and/or legal-specific permission.

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AUTHORS' CONTRIBUTIONS (YAZARLARIN KATKILARI)

***Yaren Dilara ERDEM*:** She conducted the simulations, analyzed the results and performed the writing process.

Simülasyonları yapmış, sonuçlarını analiz etmiş ve makalenin yazım işlemini gerçekleştirmiştir.

***Şule YILMAZ ERTEN*:** She analyzed the simulation results and performed the writing process.

Simülasyon sonuçlarını analiz etmiş ve makalenin yazım işlemini gerçekleştirmiştir.

***Filiz UMAROĞULLARI*:** She performed the writing and controlling process.

Makalenin yazım ve kontrol işlemini gerçekleştirmiştir.

CONFLICT OF INTEREST (ÇIKAR ÇATIŞMASI)

There is no conflict of interest in this study.

Bu çalışmada herhangi bir çıkar çatışması yoktur.

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