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Research Article

The Effect of Cantilevers on Interior Lighting: Case of Denizli Merkezefendi Library

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Abstract

Libraries are buildings where important sources of information are located, serving to make information accessible, to encourage access to information and to increase the general level of knowledge of the society. In the design of these spaces where users spend long hours for research, reading and study, adequate and qualified lighting is a very important and important issue in terms of reader comfort and protection of books. In modern library buildings, in individual, group and collective study areas with rich space options, the lighting of the spaces according to the nature of the study plays a supporting role in visual comfort and function. On the other hand, the correct use of light can sometimes be interrupted by some mass facade movements that increase the aesthetic appearance in the design of architectural buildings and may negatively affect the visual comfort in the building. In this study, the effect of aesthetic and functional façade movements on natural lighting in buildings is investigated. In the field study part of the study, Denizli Merkezefendi Municipality Central Library, one of the examples of modern library buildings, is discussed. As a study methodology, literature research on natural and electric lighting design in libraries was conducted, and lighting criteria in buildings were analyzed. Dialux program was used for data analysis and lighting simulation of the building. As a result of the examinations made on this model, the natural lighting effects in the building were analyzed through Denizli Merkezefendi Municipality Central Library and recommendations were made. In the conclusion part of the study, it is shown that cantilever masses can have direct and indirect negative effects on providing the required illumination level for the function in the interior space in terms of the determined criteria.

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1. Introduction

Libraries are spaces that are used for research and study for long hours during the day, and in some cases, they are used repeatedly due to their function in the process. In the past, libraries were only places suitable for reading and research, but in the current era, with the increasing population and developing information technologies, developments in the field of culture and education, libraries have become complex places where the information acquired can be processed, shared and discussed individually and / or in groups (Sema, 2022, pp. 263-283). According to Watson (2017), 21st century library buildings are defined as social spaces that can be used individually and in groups, where people interact and have technological infrastructure. On the other hand, libraries contribute to the economic and socio-cultural development of societies, support education, enable the transfer of information between generations, and on the other hand, try to keep up with the changes caused by current technological developments (Al Şensoy & Sarı, 2020, pp. 285-310). Today, technological equipment, digital materials and resources are of great importance for each individual to effectively learn and teach. With the evolution of these needs in accordance with the age, architectural spaces have been transformed and library buildings have become environments where not only information is acquired but also shared and discussed (Freeman, 2005, pp. 1-10). Today, a new generation of libraries inspires as a revitalized, dynamic learning resource, a hub for intellectual community and scientific entrepreneurship.

Planning new library spaces is closely linked to creating spaces where people can interact with the collections, information technologies and services they need. Those who design libraries and provide activities/services are also potential users of the library. Therefore, the user is at the center of every process in the design of the library (Mcdonald, 1996, pp. 13-42). Human needs and activities, which are factors in the architectural and interior design of libraries, can be considered as the main input of the process. These buildings are designed by taking into account the psychological needs of users and employees, but it is also necessary to avoid elements that will negatively affect people's working performance. One of the important physical parameters affecting the working performance of users in libraries is lighting. Since the first library buildings were constructed, lighting has been recognised as one of the important and decisive design elements of library architecture. According to Kandişer (2003), the choice of lighting system for a library is a very complex situation, because the lighting system should be able to respond to many completely different purposes. Providing the reading function in a comfortable environment affects the interior appearance of the space and the exterior appearance of the building, so the right lighting decisions must be made. The use of an artificial lighting system integrated with a natural lighting system is more suitable for multi-user buildings such as libraries (Thompson, 1989).

In this context, the effect of the form and architectural elements of the space in library buildings on the efficiency of the lighting system and user comfort cannot be ignored. In particular, architectural elements such as cantilevered overhangs can significantly affect the distribution of natural and artificial lighting in the space. Overhangs can be used in buildings to control the amount of daylight entering (Othman et al., 2024, pp.570-571). The amount of light and solar heat entering a building depends on the width, reflectivity, and geometry of the overhangs, reducing the cooling requirements of the building (Sghiouri et al., 2018, pp. 17). According to Lee et al. (2018), overhangs may unintentionally increase lighting energy consumption because they may cause working sessions to require more artificial lighting. As a result, the effects of cantilever overhangs on lighting should be designed in a balanced way, taking into account user needs and the function of the space. With proper lighting planning, the positive effects of these elements can be increased and their negative effects can be minimized.

The hypothesis of this study is that the positive visual impact created by the cantilever masses on the building has negative functional effects on the spaces under the cantilever. The aim of this research is to investigate the effect of natural and artificial lighting in the library and to investigate the effect of the existing cantilever mass on natural lighting in such buildings. In this research, analyses were made on the example of Merkezefendi Municipality Central Library, which is located in Denizli and is intended to become an important social-cultural center in Denizli. The parameters that make up the analyzes were determined as the main criteria, primarily the cantilever projection distance, cantilever mass direction and building material. In line with these criteria, models of the building in Dialux program were created and simulations were made with different scenarios. At this point, the potential effects of the visual and spatial effect of the cantilever mass were discussed in the study by considering possible scenarios in case the cantilever is designed in different sizes and different directions.

2. Lightings and Visual Comfort Factors in Libraries

The basic actions in modern libraries can be listed as reading, writing, searching for publications on the shelves, borrowing/lending publications, etc. In libraries, it is important to create suitable environmental conditions for users to perform their actions efficiently in terms of efficient use of space. Light acts as the basic physical element of the act of seeing in a space. Providing visual comfort is realized by designing the lighting in accordance with the required quantity and quality. As in every area, there are two types of lighting in library spaces: natural and artificial. The variables affecting natural lighting are illuminance, daylight factor, luminance spread, prevention of glare, shading, directing lighting and the colour of light (Erlalelitepe & Aral & Kazanasmaz, 2011, pp. 39-51). The aforementioned visual comfort conditions are taken under control with various lighting arrangements. When these arrangements are made in accordance with the space and intended use of the space, they prevent distraction and increase productivity. The characteristics of various materials in libraries also affect the lighting design. Lighting arrangements that take into account the different needs of these materials allow users to access them comfortably and improve the library experience (Ünver, 2011, pp.127-138).

However, the characteristics of various materials in libraries influence and shape the lighting design. Different types of materials such as visual, audio, microfilm and electronic materials play an important role in determining lighting arrangements (Feyyaz, 2013, pp. 23-24). If lighting arrangements are listed;

- *Light Sources:* Natural or electric light sources to be used in lighting design. Along with daylight, various types such as fluorescent lamps, LEDs, halogen lamps can be counted under this heading. The power, color temperature and distribution of light sources affect lighting arrangements.

- *Lighting Equipment:* Equipment such as luminaires, reflectors, lighting control devices to be used in lighting design are determined. This equipment is selected in accordance with specific lighting needs and the characteristics of the space.
- *Surface Materials:* Surface materials of the space such as walls, floors and ceilings are taken into consideration when making lighting arrangements. These materials have a significant effect on the reflection, absorption and diffusion of light.
- *Area of Use and Function:* The intended use and function of the space are taken into consideration when determining lighting arrangements. For example, different lighting arrangements may be required for an office, a home, a store or an art gallery.
- *Energy Efficiency and Sustainability:* Energy efficiency and environmental sustainability play an important role in lighting design. For this reason, energy-efficient lighting systems are preferred and necessary measures are taken to prevent light pollution.

By combining these materials and factors in the building, an appropriate and effective lighting arrangement can be created. In libraries, various activities such as searching for books, studying, reading books, and collaborating in audio halls are carried out, and all of these activities are based on the functions provided by lighting (Baltacıoğlu, 2022, pp. 90-91). Stated in his study that good lighting is necessary for users to use libraries effectively and that not only electric light but also natural light affects the efficiency of users, the quality of the space, and as a result, the time the user will spend in that space. In this respect, it can be said that utilizing daylight in the space is an important part of the design.

As with the lighting requirements of every physical space, libraries also need to consume energy resources (electric lighting) in cases where natural (daylight) lighting is insufficient. However, since this study investigates the effect of cantilevers on the utilization of daylight, the issue of electric lighting in libraries is briefly touched upon and natural lighting is mainly emphasized. Since the first emergence of library buildings, it can be said that lighting has been one of the most important design elements shaping library architecture. Vitruvius (90-20 BC), one of the ancient architects, gave information about library buildings in his work De Architectura. In order to get maximum efficiency from daylight, he mentioned the necessities such as library buildings having skylights, wall windows facing east, etc.

Since the early 18th century, developments in science and technology, changing and evolving needs have enabled new planning in library buildings as in many architectural buildings. Lighting has become one of the most important design criteria in new generation library buildings. It can be said that it is imperative to make the best use of daylight today due to the lack of a light source that has all the properties of daylight (the healthiest light source) and the cost of energy.

In the natural lighting design of the building, the location and dimensions of the daylight openings should be carefully planned in line with the climatic-geographical location, (local) light and heat values, taking into account the functions of the spaces. According to the research conducted and published by Edward T. Dean in 2005 within the scope of the project called Library designs; daylight openings should meet (control) the following four elements.

- *Solar control:* To reduce any increase in heat load and to control direct glare.
- *Glare control:* To create and maintain comfortable brightness distribution, including no direct bright sky image in the normal direction of the image.
- *Variation control:* Avoiding inadequate local light levels that any user would perceive.
- *Control of Contrasts:* Reducing the difference in intensity between main light and fill light to create a balanced illumination in the space (Edward, 2005, pp.11-12)

According to the TS-EN 17037 Standard in force in Turkey, the criteria for daylight illumination,

a. Ensuring daylight illumination
b. Establishing a visual connection with the external environment
c. Exposure to sunlight
d. Protection against glare

as the most important criteria. Information on these criteria, gathered under four headings, is briefly given below;

2.1. Daylight provision

According to TS-EN 17037, the need for illuminance in spaces should generally be met by daylight. The minimum, medium and high average levels recommended for daylight illuminance are ≥300 lx, ≥500 lx and ≥750 lx respectively. It is desirable to achieve the preferred illuminance level in at least 50% of the reference plane of the space. These values may vary depending on the characteristics of the space and the window. The zone or zones where the recommended illuminance level is achieved can be of different shapes and sizes, and schematic drawings of these are given in Figure 1.

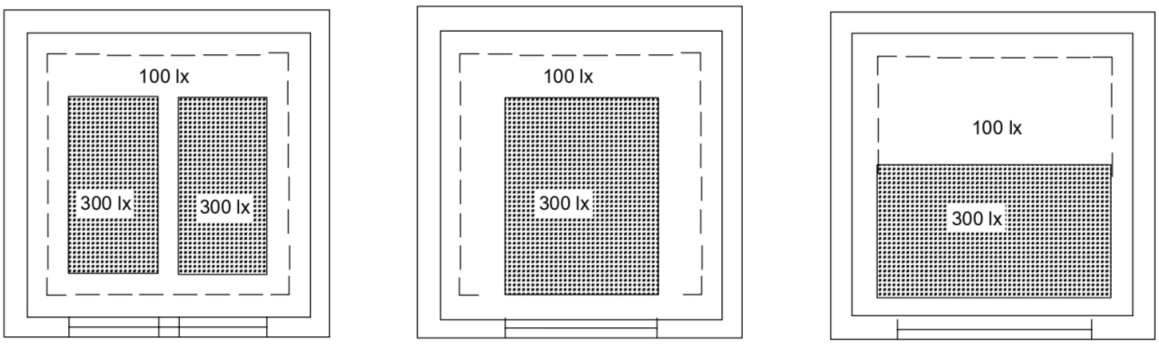

Figure 1. Schematic drawings of the location of the region where at least 300 lx illuminance level is provided in the reference plane (D. Öztürk, 2018, pp. 556-571).

In the predominantly occupied area or areas of the space, for example, the illuminance level of at least 300 lx should be maintained throughout the year for more than 2190 hours ((365×12)/2=2190), which is half of the total daylight hours in a year. Under the condition that the targeted illuminance level is ≥300 lx, the illuminance level in ≥95% of the reference plane should be ≥100 lx for ≥2190 hours per year (Zahmacıoğlu, 2019, pp. 9-10).

In libraries, the ideal daylight level should generally be between 300 and 500 lux. This value provides adequate illumination for reading and studying and reduces eye strain. However, these standards may vary depending on library design and location. Standards have been set in the field of lighting to create a healthy working environment. The European Committee for Standardization (CEN) has set the appropriate value for libraries at 500 lux. This value is recommended to support users to work comfortably and efficiently (Feyyaz, 2013, pp. 72-73).

2.2. View out

The quality of the image entering the person's visual field depends on factors such as its position within the space, window size, the number of visible layers and the content of the perceived environment. According to the TS-EN 17037 standard, an assessment is made in terms of the quality of the external environment and visual connection;

- horizontal viewing angle depending on window width
- distance of external obstacles from the structure and
- number of visible layers

It was proposed to be done according to three different variables, and three degrees were determined for each variable: minimum, medium and high. The recommended grades are given in Table 1.

Table 1. Recommended grades for visual connection with the external environment (TS-EN 17037).

Variables	Degree of Visual Connectivity with Respect to a Given Point		
	Minimum	**Medium**	**High**
Horizontal viewing angle depending on window width	≥ 14°	≥ 28°	≥ 54°
Distance of external obstacles from the structure	≥ 6 m	≥ 20 m	≥ 50 m
Layers that must be visible from at least 75% of the area used -sky -landscape -floor	Included landscape layer	Included at least two layers	All layer included

The plan and cross-section of the space can be used to determine the number of layers entering the visual field and the width of the image, i.e. the horizontal viewing angle. According to TS-EN 17037, depending on the user's position (sitting at a height of 1.20 m, standing at a height of 1.70 m), the outdoor image seen through the window is evaluated on 3 layers (sky, natural or artificial landscape/landscape, ground). Among these layers, the clear and cloudy sky layer to be included in the study is given below (Figure 2).

Figure 2. Example of Visible Layers (Adobe Stock-1, 2024; Adobe Stock-2, 2024).

In library design, external views are taken into account through factors such as the positioning of windows and optimizing the view (Figure 3). This ensures that users can see the natural surroundings and relax while indoors (Table 2).

Table 2. Recommended degrees of insolation (TS-EN 17037).

Insolation degree	**Insolation duration**
Minimal exposure to sunlight	1.5 hours
Moderate exposure to sunlight	3 hours
High levels of sun exposure	> 4 hours

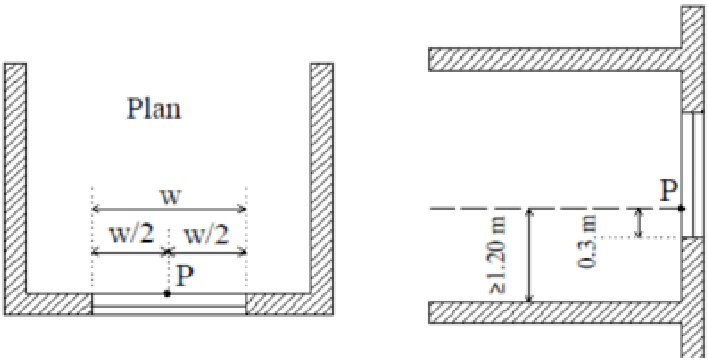

Figure 3. Reference point where insolation is evaluated (TS-EN 17037).

Clear and cloudy day data in the region where the building is located will be examined, and the data obtained will play a critical role in optimising lighting performance and increasing user comfort.

2.3. Exposure to sunlight

Exposure to sunlight, exposure to direct sunlight, is beneficial for human health. The positive effects of exposure to sunlight include vitamin D synthesis, promoting bone health, regulating circadian rhythm and reducing stress by increasing serotonin levels. exposure to sunlight is particularly important for individuals with mobility limitations (Zahmacıoğlu, 2019, pp. 4-5). In addition, the penetration of sunlight indoors can reduce the need for heating during the winter months. In summer, solar control systems can be used against the risk of excessive heat and glare. In daylight-based standards, March 21 is chosen as a reference for assessing insolation and it is recommended that the space should receive at least 1.5 hours of sunlight during that day. Assuming clear skies, three different levels of insolation are recommended: minimum, medium and high (Table 2). As shown in Figure 3, the reference point (P) considered in the evaluation of insolation on March 21 is defined as the center of the window width (w), on the interior wall, at a height of at least 1.20 m above the floor and 0.30 m above the parapet height, if any.

2.4. Protection against glare

Highly illuminated surfaces in the visual field cause glare to the human eye. Direct sunlight entering the space through a window can cause glare. Daylight glare is assessed by the 'daylight glare probability (DGP, daylight glare probability)'. Daylight glare probability (DGP) is an approach to assessing the proportion of people who are uncomfortable, taking into account the level of vertical illuminance at eye level and the high illuminance sources that cause glare. The recommended daylight glare probability thresholds (DGP) for three levels of glare protection: minimum, medium and high are given in Table 3. The time during the year that the predominantly occupied area of a space is used is defined as the reference occupancy period. This period is assumed to be 8:00-18:00 hours five working days a week throughout the year. Daylight glare probability thresholds are allowed to be exceeded for a maximum of 5% of the reference period. If the thresholds are exceeded, measures such as sunbreakers, blinds, etc. can be taken as solar control systems in windows (Yağmur & Ünver, 2015, pp 16-19).

Table 3. Recommended grades for sunshine duration (TS-EN 17037).

Degree of protection from glare	**DGPt**	**Maximum permissible exceedance rate during the period of use**
Minimal protection. Glare is perceptible and often uncomfortable	≤ 0.45	%5
Moderate protection. Glare is perceptible but mostly not annoying	≤ 0.40	%5
High level of protection. Glare is mostly imperceptible.	≤ 0.35	%5

For example, glare can be caused by reflected light from a computer screen, overhead lights, bright light sources such as light bulbs or bright windows, or even the reflection of a magazine with a glossy page (Edward, 2005, pp.11-12).

Torches, kindling, gas lamps and lanterns, which are used as a guide in places where natural lighting is not sufficient and more light is needed, have been replaced by electric lighting devices today (Dalkılıç & Halifeoğlu, 2003, pp. 3-4). With the invention and development of electrically powered lighting elements, a field of study has been formed and today lighting has become a branch that requires specialization. Correct and good lighting is very important for the success of a library in general and in its use. For this reason, especially in the design phase of library buildings, lighting should be handled by experts. However, the elements that make up the functional lighting design in libraries:

- Structural Features
- In-Building Lighting
- Visual Comfort
- Energy Efficiency
- Flexibility and Control

It is not only the provision of the appropriate light energy required, but also the direction of light to the eye, the brightness of the objects surrounding the visual field and the task object, and the light diffusing properties of the task object. According to the 'Light and Lighting' regulation of the Turkish Standards Institute published in 2013 (TS EN 12464-1: 2013), it is stated that the criteria for electric lighting may depend on the illuminance level (E; lm / m², lx), Luminance and Glare (R_{UGL}), Uniform spread of the illuminance level (U_o), the color of the illuminating light (color rendering index-R_a, color temperature-K) and the directional structure of light and shadow properties.

3. Possible Effects of the Use of Cantilever Mass in Architecture on Lighting

It is a natural process of planning to consider the effects of the façade fiction along with the planning of the architectural project. With some technical and mechanical limitations in planning, cantilever masses are frequently used in architecture to bring mobility to the façade fiction, to provide different dimensions in the floor area and shading. Some of the possible effects of cantilevered masses, which can have negative effects on the illumination of the space in some cases when designed with only architectural design in mind, are evaluated under the following subheadings.

Shadow Creation: A cantilever mass is a part of the building that projects outward from the building façade. When criteria such as direction, distance, etc. are not taken into consideration, the masses protruding from this structure can create a shadow effect at certain times of the day and prevent the passage of light to the interior spaces. This is important in terms of providing homogeneous illumination in the interior spaces and maintaining a stable light distribution throughout the day. Especially in tall buildings, if the cantilevers are not designed appropriately, they may adversely affect neighboring buildings or the environment. Shading is a factor to be considered in relation to environmental regulations and the placement of neighboring buildings.

Lighting Imbalance within the Space: Cantilever mass can cause lighting imbalances within the building. If natural light is focused or falls only in certain areas, it can create dim and dark areas in other areas. This can lead to visual comfort issues for indoor users and reduced work performance.

Energy Efficiency: The direction in which the cantilever masses are positioned in the building is very important. In terms of both direction and size, it can have positive or negative effects on the main mass when it is designed considering the effects it can create in the interior spaces. This may indirectly increase or decrease the amount of energy consumed in lighting and/or heating-cooling loads.

Aesthetic Effects: Cantilever masses may not look good architecturally when they are designed only to create extra space and not as an impressive or complementary element of the design. Especially if they are not carefully considered in terms of design and aesthetics, if they are not designed to show the limits of the structure or load-bearing elements, cantilever masses can have a negative effect on the building and can create a very rigid form.

In summary, it is important to be meticulous in the design and positioning of cantilever masses, taking into account the natural lighting factor. With proper design and planning, the aforementioned negative effects can be minimized or eliminated.

4. Examination of Merkezefendi Library as a Case

In the study, the Central Library of Central Municipality of Merkezefendi Municipality in Denizli was selected as a sample building to examine the effect of cantilever masses on the natural light levels in the interior. The reason for choosing this building is the presence of cantilever masses in different directions and lengths, and the realization of the act of reading, where the level of illumination directly affects the performance due to its function. A detailed description of the building is given below.

4.1. Location and History of the Building

Merkezefendi Library is located in Denizli province, Merkezefendi district, Adalet neighborhood, 10127 street. The building designed as a library building was built between 2016-2019 and is actively used today. The location of the library building and its relationship with its surroundings are given in Figure 4a, and the general view of the building is given in Figure 4b.

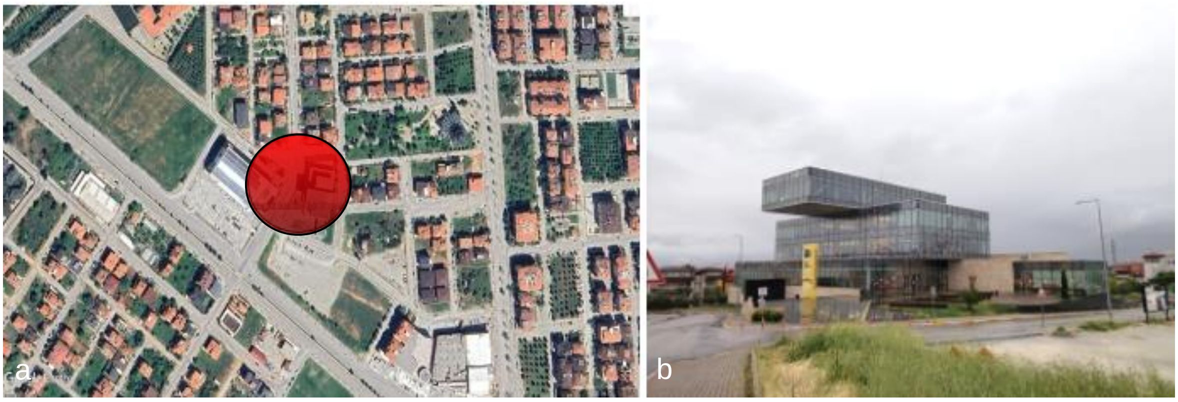

Figure 4. a. Location of the library (Google Earth, 2024); b. General view of the library (Çetin, 2024).

Accordingly, it can be said that the building is spread over a large area, is not in close proximity to the surrounding buildings, and is not close to a building at a height that would prevent it from receiving daylight. This situation is important in the evaluation of the criteria in the analysis.

4.2. Architectural Features of the Building

Located on an area of 4880 m², Merkezefendi Public Library includes spaces for different age groups. In addition to the preschool section, individual and group study rooms, classrooms and reading rooms, the library has special areas for the disabled (Figure 5), (Morf, 2024).

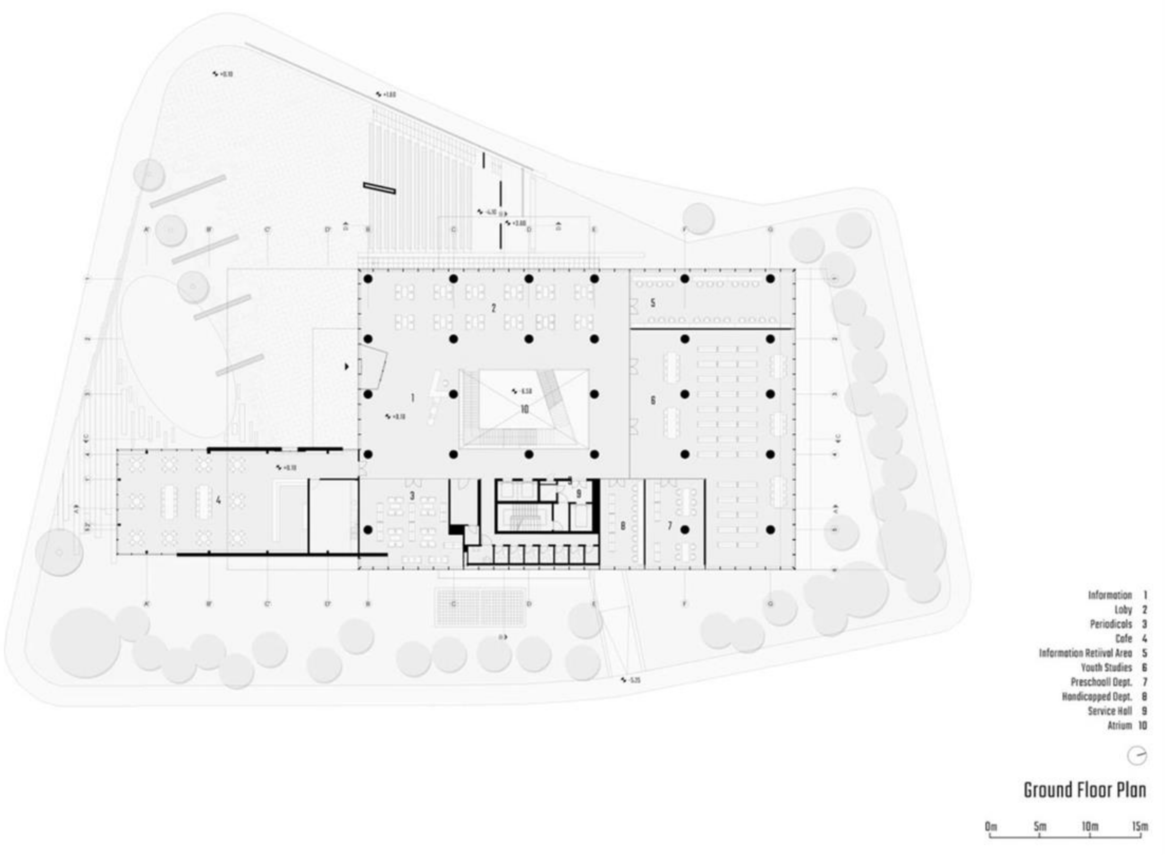

Figure 5. Merkezefendi Library Ground Floor Plan (Çetin, 2024).

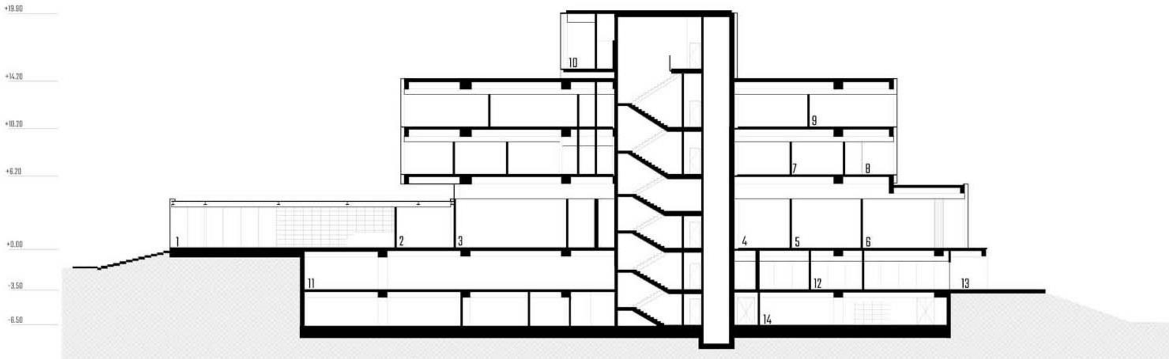

Figure 6. Merkezefendi Library Schematic Section (Arkiv, 2024).

In the design report of the building, it is stated that the design decisions taken were shaped in a hierarchical order, paying attention to the separation of sound and silent spaces. It can be said that the ground and lower level areas are reserved for more lively and intense activities, while the upper level areas are designed for quieter functions (Figure 6, 7).

Figure 7. Gallery Space in the mass (Çetin, 2024).

It is also stated in the design decisions that the concept of the library reflects the "Accumulation of Knowledge", that each floor in the mass represents new knowledge learned, and that this mass overlaps and the west-facing cantilever at the top level of the building is emphasized as the main design element and is intended to contribute to the building to be a city symbol. It is stated that the building was created using completely transparent facades in order to prevent shadow formation in the interior space and that the cantilever mass extending east of the entrance facade determines the lecture hall in the open space. In the design report, it is seen that the cantilever mass is preferred not only aesthetically but also functionally. In order to prevent this situation from turning into a disadvantage in terms of lighting, it is seen that a measure has been taken by using completely transparent facades.

However, it is necessary to investigate whether this measure is sufficient and whether it is not only in terms of illumination but also in terms of heating and shading in summer. In this study, simulations and analyzes were made only in terms of the effect of the cantilever mass on lighting.

4.3. Natural Lighting Simulation of the Building

The criteria that form the basis of the lighting criteria of the cantilever mass in the building and will be analyzed are determined as cantilever distance, cantilever direction and building (cladding) material. In addition, the simulations were run in both clear sky and cloudy sky conditions. After the modeling phase of the building was completed, in line with the data obtained through literature research and on-site observation, the peak usage hours and required illuminance values for the library reading area were entered into the Dialux program and natural lighting analysis was performed. The data entered into the program is given in Table 4.

Table 4. Planning Data Entered into Dialux Program (Çetin, 2024).

Planning Data	
Usage	Library
Measurement Time	16:00-17:00
Measurement Season	Summer (in July)

According to the on-site observations made in the library; Merkezefendi Library is intensively used from 10:00 in the morning until 22:00 in the evening. Although it changes periodically, ambient lighting supported by electric lighting is used at 20:00 in summer and 16:00 in winter.

But all the natural lighting measurements have been done in July at summer season, between 16:00-17:00 hours, which is the rush hour of the library. All the calculations that was done in the case is gotten from this simple simulation. Although the cloudy 17037 standard suggests that the most accurate data can be obtained by measurements to be made throughout the year, the data obtained in this study were obtained at a certain time and hour of the year. Since the aim of this study is to measure the effect of the cantilever on the level of illumination it creates on the mass it is on, it has been assumed that the rate of the cantilever effect affecting the level of illumination will be similar in the data to be obtained throughout the year. However, studies can be conducted to observe the changes that may occur in different months.

The meteorological data of Denizli for cloudy and clear sky conditions are given below (Table 5).

Table 5. Monthly Average Cloudy and Clear days at Denizli (General Directorate of Meteorology).

Months	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Annual Average**
Average Cloudy Days	20	19	20,2	20,4	18,2	11	5,5	5	7,3	13,9	17,2	20,4	178,1
Average Clear Days	8,3	7	8,2	8,3	12,1	18,9	25,8	26,2	22,7	16,3	11,6	8	173,4

As seen in Table 5, the annual average number of clear days and cloudy days in the region is approximately equal to each other. For this reason, the data on the level of illuminance in the study are considered within the scope of clear and cloudy sky conditions. The sun is included in the calculations under clear and cloudy sky conditions.

4.3.1. Current Situation

In the study, firstly, the current illuminance level of the building was analyzed. The solid model of the building was created with the Dialux program and lighting simulation was performed. The general view of the library is given in Figure 8.

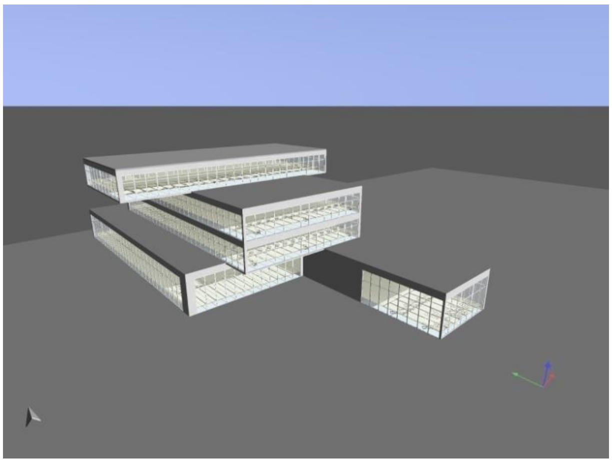

Figure 8. General View of the Library Building (Çetin, 2024).

The existing façade system and glazing design, cantilever spacing, building material and cantilever orientation of the library were modeled with the Dialux program after on-site inspections. The data used in the model is given in Table 6.

Table 6. Existing Building Information Entered into Dialux Program (Çetin, 2024).

Current Building Data	
Cantilever Direction	East
Cantilever Material	Wood
Cantilever Length	10 meters

After the modeling phase of the building was completed, the hours of use and the required lux values for the library reading area were entered into the Dialux program in line with the data obtained from the literature review and natural lighting analysis was performed. The data entered into the program are given in Table 6. However, among the criteria determined to analyze the effect of the cantilever mass on the level of illumination in the interior space;

Direction variable; to measure the effect of which facade the cantilever mass is located on the level of illumination in the interior space,

Distance variable; to measure the effect of the cantilever length of the cantilever mass on the illumination in the interior space,

The building cladding material variable was determined to measure the effect of the reflectivity level of the material covering the base of the cantilever mass on the illumination in the interior space.

All these variables were considered under both clear sky and cloudy sky conditions. When the data are analyzed in Dialux program with these variables in the current situation; the numerical results regarding the daylight usage in the reading area in the false colors representation of the reading room located on the lower floor of the cantilever mass given in Figure 12 are expected to be 500 lx on average and above, which is the reference value determined in the working plane in the reading area, while the data obtained as a result of the simulation show that this value is 444 lx on average in the current situation in the cloudy sky. However, as seen in the false color representation, it can be said that the overly bright areas at the window edges increase this average value, while the middle areas, where most of the use takes place, are around 200 lux on average. In this case, it is seen that daylight is insufficient in the reading area. In particular, it can be clearly seen that the illuminance levels at the location of the cantilever mass (at the center top point of the plan) are very low (130-230 lx) unlike the other facades (Figure 9).

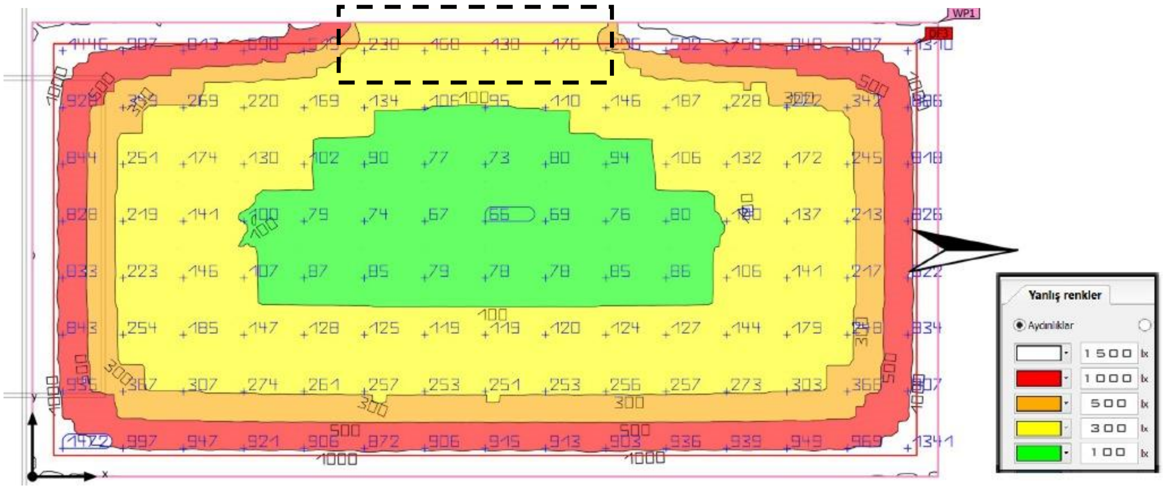

Figure 9. False Colors Representation of the Reading Room on the Lower Floor of the Cantilever Mass in the Existing Condition (Çetin, 2024).

In the scenarios to be analyzed in the study, each criterion to be measured is considered as a variable and calculations are made by keeping the other criteria constant. In the first case, the cantilever distance and cladding material were kept constant and the direction variable was analyzed. When the existing cantilever distance (10 m) and cantilever material (wood material) are kept constant and the cantilever direction variable is analyzed, the illumination level in the interior space with the cantilever mass in the east direction (the current direction) is 444 lx on average, 488 lx on average if it is designed in the west direction, 458 lx on average if it is designed in the north direction and 503 lx on average if it is designed in the south direction, and the target illumination level can be met only when it is designed in the south direction.

In case 2, the cantilever distance and cantilever direction were kept constant and the cantilever material variable was analyzed. When the existing cantilever distance (10 m) and cantilever direction (east) were kept constant and the material variable was analyzed, while the illuminance value was 444 lx on average with the existing building cladding material (wood), the illuminance level increased to 488 lx on average when it was proposed to be covered with aluminum, a material with a high reflectivity value, but did not meet the target lighting level.

In case 3, in order to analyze the effect of the distance variable, analyses were carried out with no cantilever overhang (0 m) and with the cantilever overhang half of the existing condition (5 m). Since these analyzes are analyzed in detail, they are discussed under 2 separate headings below.

4.3.2. Proposal Case Without Cantilever

In the current situation, when the cantilever mass distance is 10 m, the illuminance level in the interior is 444 lx on average. The data used in the natural lighting analysis of the building without cantilever mass is given in Table 7.

Table 7. Building Information Entered into the Dialux Program in the Absence of Cantilever Projection (Çetin, 2024).

Absence of Cantilever	
Cantilever Direction	East
Cantilever Material	Wood
Cantilever Length	None

Accordingly, other variables were kept constant and only the cantilever mass was removed. In this case, an illumination of 512 lx on average was obtained in the interior (Figure 10). Again, in the absence of the cantilever mass, the illumination levels from the other facades were 556 lx on average in the west direction, 526 lx on average in the north direction, and 571 lx on average in the south direction, and it was seen that the target illumination level was met in all directions. However, when the situation without the cantilever mass and the direction of the cantilever (east) is kept constant and the material variable is analyzed, replacing the building cladding material with aluminum, a material with a high reflectivity value, increased the illumination level to 562 lx on average and met the target illumination level.

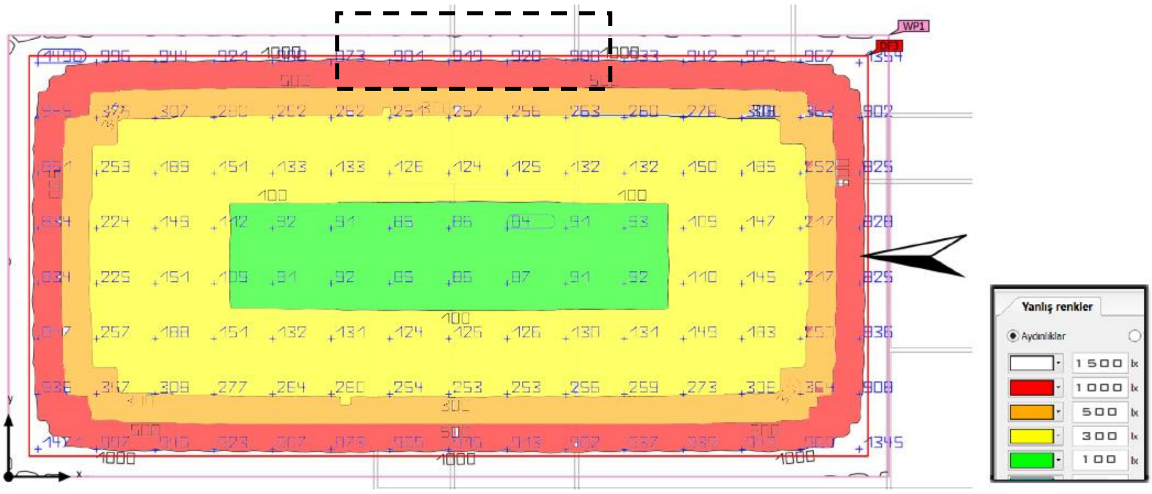

Figure 10. False Colors Representation of the Current Situation (Çetin, 2024).

As seen in Figure 10, in the section where the cantilever mass is located, the illuminance levels in the absence of the cantilever have reached approximately 1000 lx levels as in the other facades. This has led to an increase in the average illuminance level. However, it is seen that natural light shows a homogeneous and regular distribution in the interior areas.

4.3.3. Proposal Case with 5 Meters of Cantilever

The cantilever mass distance of the building was re-modeled as 5 meters and natural lighting analysis was performed. The data entered into the program are given in Table 8.

Table 8. 5 Meters Cantilever Building Information Entered into Dialux Program (Çetin, 2024).

Absence of Cantilever	
Cantilever Direction	East
Cantilever Material	Wood
Cantilever Length	5 meters

The results of the analysis (Table 8) when the cloudy sky is evaluated; Accordingly, when the cantilever distance is 5 m and all other criteria are the same as the existing situation (cantilever in the east direction and covered with wooden material), the illuminance level in the interior space is obtained as 458 lx on average (Figure 11). In this case, it cannot be said that there is a significant increase in the illuminance level compared to the case where the cantilever is 10 m. However, when the cantilever distance was kept constant at 5 m and the direction variable was analyzed, the illuminance values of 502 lx on average were obtained when the cantilever was in the west direction, 472 lx on average in the north direction and 517 lx on average in the south direction, and in this case, the west and south directions met the target illuminance level. When the console distance of 5 meters and the console direction (east) were kept constant and the material variable was analyzed, replacing the building cladding material with aluminum, which has a high reflectivity value, increased the illuminance level from 458 lx to 503 lx and meets the target illumination level.

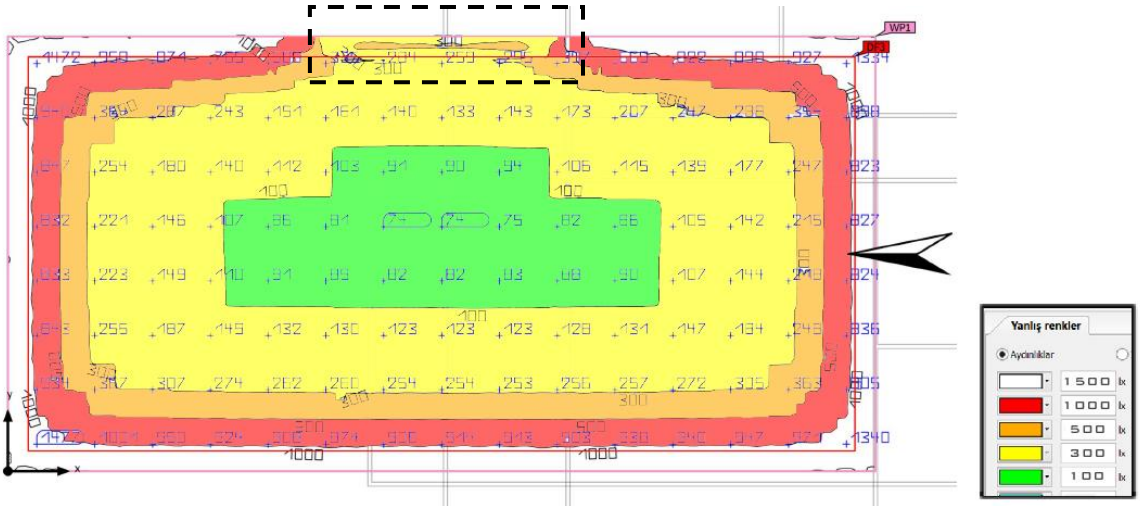

Figure 11. False Colors Representation of the Current Situation (Çetin, 2024).

As seen in Figure 12, it is seen that the illuminance level decreases again when the cantilever mass is proposed as 5 m, but the values obtained are approximately 100-120 lux more than the situation where the cantilever is 10 m. This shows that the cantilever length is inversely proportional to the illuminance value and that the length of the cantilever is an important factor in indoor illumination.

5. Findings and Evaluation

The results of the analyzes performed in the study are given in a single table in Table 9. In the current situation, it was observed that the cantilever mass does not meet the lighting level at the targeted level. However, when the cantilever distance is reduced to 5 meters or when there is no cantilever mass, it is observed that the lighting level meets the target level. This shows that the effect of the cantilever mass on natural lighting may vary depending on factors such as cantilever distance and building material.

Table 9. Reading area daylight utilization analysis results (Çetin, 2023).

CANTILEVER		CLOUDY SKY			CLEAR SKY		
		LENGTH			LENGHT		
DIRECTION	MATERIAL	0 m	5 m	10 m	0 m	5 m	10 m
EAST	Wood	512 lx on average	458 lx on average	444 lx on average	2582 lx on average	2524 lx on average	2506 lx on average
	Alunımıum	562 lx on average	503 lx on average	488 lx on average	2810 lx on average	2745 lx on average	2726 lx on average
WEST	Wood	556 lx on average	502 lx on average	488 lx on average	2806 lx on average	2744 lx on average	2726 lx on average
	Alunımıum	606 lx on average	547 lx on average	532 lx on average	2988 lx on average	2937 lx on average	2906 lx on average
NORTH	Wood	526 lx on average	472 lx on average	458 lx on average	2604 lx on average	2552 lx on average	2524 lx on average
	Alunımıum	576 lx on average	517 lx on average	502 lx on average	2790 lx on average	2758 lx on average	2728 lx on average
SOUTH	Wood	571 lx on average	517 lx on average	503 lx on average	2810 lx on average	2775 lx on average	2745 lx on average
	Alunımıum	616 lx on average	562 lx on average	547 lx on average	2980 lx on average	2945 lx on average	2916 lx on average

The results of all cases and scenarios given in Table 9 are given considering both cloudy and open skies. According to Figure 12 and Figure 13, it is seen that the best illumination level in the interior space is obtained when the cantilever mass is on the south facade and the cantilever mass is covered with aluminum material. On the other hand, the lowest level of illumination is obtained when the cantilever mass is on the east façade, 10 meters long and covered with wood. In other words, an increase of approximately 100 lx in the level of indoor natural illumination is observed when only the direction of the cantilever mass and the material it is covered with are changed without changing the length distance of the cantilever mass. Contrary to popular belief, the length of the cantilever mass does not cause a significant change in the natural illumination of the interior space, while the direction and cladding material can significantly affect the illuminance level.

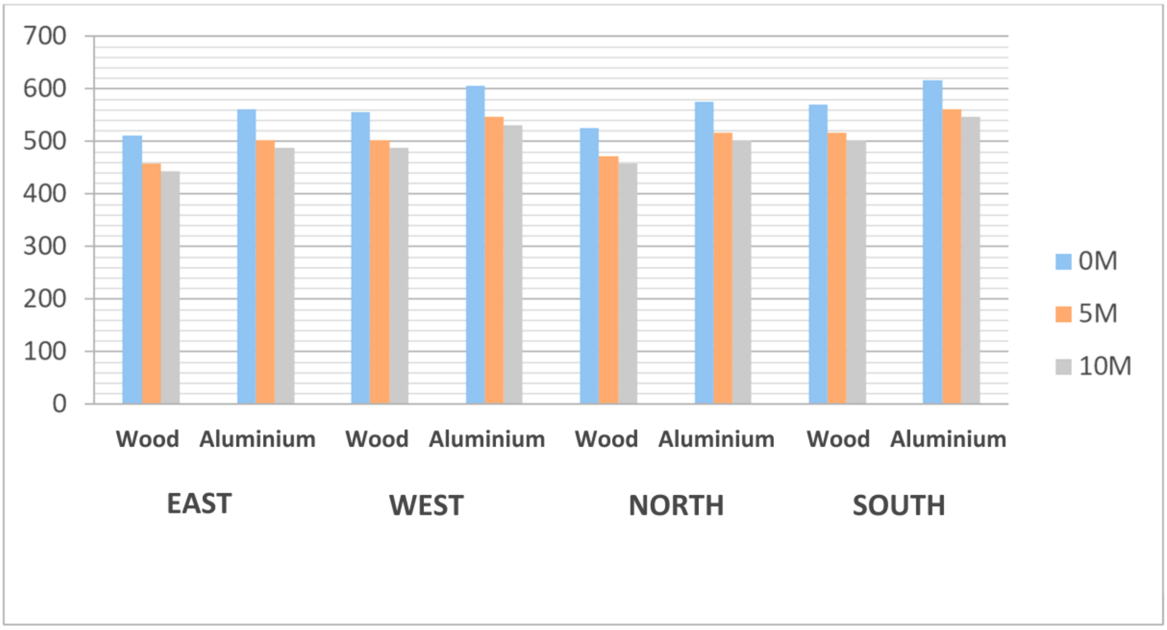

Figure 12. Cloudy Sky reading area daylight utilization analysis results (Çetin, 2024).

However, as can be seen in the false colors representation, it can be said that the over-illuminated regions at the edges of the windows increase this average value, the middle regions, where most of the use takes place, are currently around 200 lux on average, and this value can go up to around 250 lux at most in recommended cases. Therefore, it can be interpreted that the majority of the area that is actually in use is not actually illuminated as much as these average values given in the program under cloudy sky conditions.

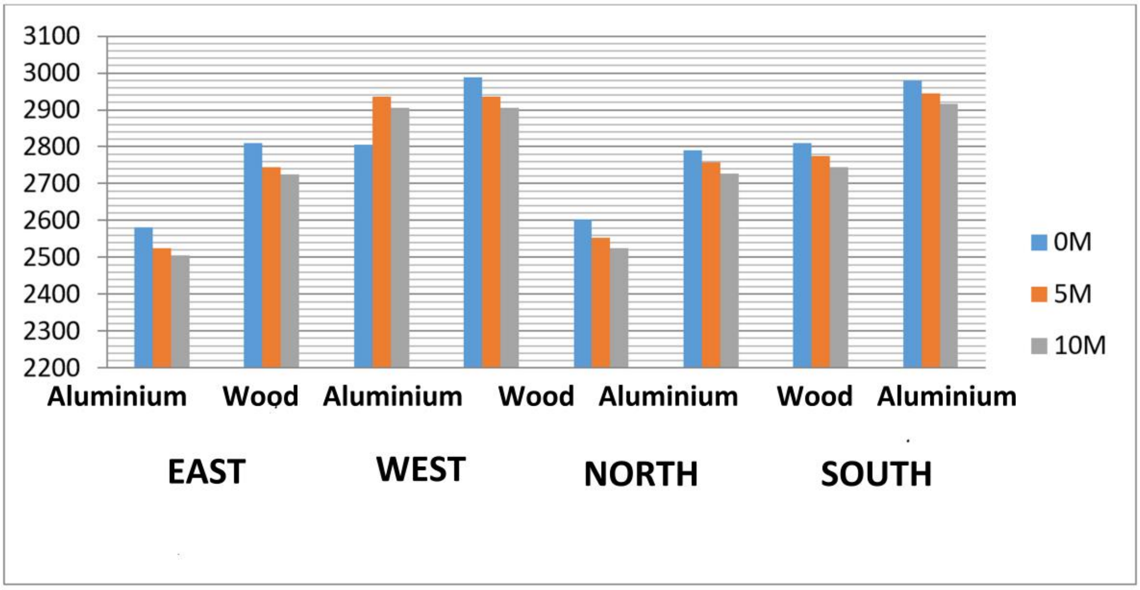

Figure 13. Clear sky reading area daylight utilization analysis results (Çetin, 2024).

However, when the clear sky conditions are analyzed, although the difference between the illuminance levels of the scenarios considered is at a similar level, values well above the target illuminance level are obtained in terms of quantity. Considering the climatic conditions of the region, especially in the summer months, it is thought that the sun's rays come more steeply and excessive glare and glare may be in question, especially in locations close to the facade.

6. Conclusion

As a result of the analyses carried out in the study, the effect of the cantilever mass on natural lighting in the building was examined and different scenarios were modeled and comparative analysis method was used. As discussed in the findings section; when the cantilever mass is designed in the west and south directions in the best case, regardless of the length and material of the cantilever, it does not significantly affect the level of natural light in the space underneath, while when it is designed in the north and east directions, the opposite is true. However, regardless of the direction and length in which the console is designed, the level of natural light in the interior increases when the material of the console is aluminum. According to the results of the analysis, the effect of the cantilever mass, which also has various design-related functions in the building, on natural lighting is variable according to different conditions, but different situations and scenarios were analyzed in order to reveal its concrete effects as much as possible. The correct positioning and sizing of the cantilever mass is very important in terms of providing homogeneous lighting in interior spaces and maintaining a continuous light distribution throughout the day. However, none of these criteria alone produces extraordinary effects.

Before the study, it was thought that the effect of the building, which appears as a very solid and full mass at first glance, and the cantilever mass designed at the upper level on the level of illumination would be of primary importance, but with the scenarios created in the study, it was seen that the fact that the cantilever mass has different lengths, materials and is designed in different directions with the current situation has improving effects on the level of illumination, but it is not a factor that will affect it primarily. In addition, studies in which the length and width of the cantilever mass can be evaluated and the optimal option can be found will be included in future studies.

All of the analyses were performed considering both cloudy and clear skies, showing that daily weather conditions significantly affect the illumination of the interior space, independent of the cantilever mass. Basically, the analyses performed by taking into account the results of cloudy skies try to achieve the minimum limits of the target illuminance level specified for the reading function in library buildings, while the analysis performed in the case of clear skies shows that the illuminance level in the interior is almost at the level of excessive glare. Just as insufficient natural lighting has a negative impact on the efficiency of the function envisaged in the space, uncontrolled excessive daylight illumination similarly reduces the efficiency of the function. In addition, the design of facades that are completely transparent in all directions leads to overheating of the interior, especially in summer, and the need for significant energy consumption for cooling the space. In this case, the areas close to transparent windows, where natural lighting can be utilized to the maximum extent, are not preferred due to both the glare effect and the excessive temperature effect.

The values obtained in the study were made by taking the minimum illumination level values specified in the TS-EN 17037 standard as reference, and the inferences were taken into consideration accordingly. However, considering the external view information recommended in terms of natural lighting specified in the standard, the sky, landscape and other layers can be seen from 75% of the interior volume, considering the completely transparent external structure of the building. However, due to the physical location of the building, it is far from external obstacles at the average measurement distance specified in the standard. When viewed from this perspective, it can be said that other physical factors that will prevent the natural lighting of the building and the external view from inside the building are at a minimum level.

Therefore, it is known that the transparent facades, which are stated in the design report of the building to be completely transparent in order to reduce the effect of the cantilever mass on the level of illumination in the interior, on the other hand, have negative effects on the interior space in terms of uncontrolled daylight intake and thermal performances. In this case, it is one of the important results obtained from this study to find solutions for these concerns only on the facades where the cantilever mass is located and to find balancing solutions by taking into account the visual and thermal comfort issues on the other facades.

The effect of the cantilever mass on natural lighting is an important issue to be considered in building design. In this study, the negative effect of the cantilever mass on the lighting performance can be reduced and a homogeneous lighting can be provided in the interior spaces with the right directional planning and material use. This study emphasizes the importance of visual comfort and lighting in architectural design and draws attention to the importance of lighting design of library buildings.

Declaration of Ethical Standards

The article complies with national and international research and publication ethics.

Ethics Committee Approval was not required for the study.

Conflict of Interest

There was no conflict of interest between the authors during the research process.

Authors’ Contributions

All authors contributed equally to the article.

Declarations

The authors take full responsibility for the content and any modifications made during this process.

Originality Report

According to the originality report obtained from the iThenticate software, this article's similarity rate is 7%.

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