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INTRODUCTION

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Toronto Metropolitan University, 350 Victoria St, M5B 2K3, Toronto, Ontario, Canada

Ibrahim Agah Tastemir
Istanbul Sabahattin Zaim University
Architecture
Halkalı st. No:281 Kucukcekmece
34303 Istanbul
Turkiye

Dr. Umberto Berardi (IBPC 2024 conference chair)
Canada Research Chair in Building Science
Toronto Metropolitan University
350 Victoria St.
M5B 2K3, Toronto, Ontario
Canada
+1-416-979-5000 (553263)

20/Aug/2024

To Whom It May Concern

Dear Sir or Madam,

We confirm that **Ibrahim Agah Tastemir** participated at IBPC 2024.

Ibrahim Agah Tastemir is author/co-author of the following accepted contribution(s):

A decomposition method for energy prediction metamodels and surrogate models in early design stage of buildings
Author(s): Tastemir, Ibrahim Agah; Koymen, Erdem; Yasa, Enes
Presenting Author: Tastemir, Ibrahim Agah
Submission Type / Conference Track: Building Physics for Energy saving and ZEBs

Daylight and energy performance relationship of classroom and office spaces : Comparative Study of Istanbul Commerce University Küçükyalı Campus Building.
Author(s): Yalçın Koçak, Nur Sümeyye; Taştemir, İbrahim Agah; Köymen, Erdem; Yaşa, Enes
Presenting Author: Yalçın Koçak, Nur Sümeyye
Submission Type / Conference Track: Ligthing in Building Physics

With best regards,

Organizing Committee of the conference
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A Decomposition Method for Energy Prediction Metamodels and Surrogate Models in Early Design Stage of Buildings

| Conference paper | First Online: 19 December 2024

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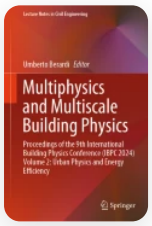

Multiphysics and Multiscale Building Physics

(IABP 2024)

İbrahim Agah Taştemir, Erdem Köymen & Enes Yaşa

Part of the book series: Lecture Notes in Civil Engineering ((LNCE,volume 553))

Included in the following conference series:
International Association of Building Physics

Abstract

Early design is an important design phase for energy efficient design, as decisions about buildings have the highest impact on final performance at the lowest cost. A judicious selection of building form and variables in the early stages of design, especially in the conceptual design phase, can help to improve design performance early in the design

Daylight and Energy Performance Relationship of Classrooms and Office Spaces: Comparative Study of Istanbul Ticaret University Kucukyali Campus Building

| Conference paper | First Online: 23 December 2024

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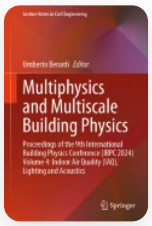

Multiphysics and Multiscale Building Physics

(IABP 2024)

Nur Sumeyye Yalçin Koçak, Ibrahim Agah Tastemir, Erdem Koymen & Enes Yasa

Part of the book series: Lecture Notes in Civil Engineering ((LNCE,volume 555))

Included in the following conference series: International Association of Building Physics

Abstract

Natural lighting is important for human comfort and should not be ignored in architectural design. Natural light allows students and instructors to establish healthy visual communication with each other and their surroundings and is known to affect physiological and psychological health. In this study, the architectural design workshops of the Istanbul Ticaret University Kucukyali Campus Building, which was transformed from a leather factory into an educational building, and the office spaces used by the lecturers of the architecture department are examined in the context of natural lighting. In the fall and spring semesters of the 2023–2024 academic year, measurements were made with a lux meter on December 21 and March 27, when suitable sky conditions were provided, and the radiation-based Designbuilder program was used for daylight simulation analysis. In four different interior spaces, illuminance level measurements were made. The illuminance measurements of the volumes were calculated at 12:00, 14:00, and 16:00 for December 21, 2023, and at 10:00, 12:00, 14:00, and 16:00 for March 27, 2024. By evaluating the data obtained, the general lighting conditions of the space and the access status of the users to these conditions were revealed. It was determined that the presence of fixed horizontal shading devices placed in the building without paying attention to orientation significantly affects the amount of illumination in the volumes and increases energy consumption. It is recommended to increase the level of illumination by making the shading devices movable with an automation system according to the effect of sunlight on the facade and painting the volumes with materials with high reflection multipliers.

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Author information

Authors and Affiliations

İstanbul Ticaret University, Istanbul, Turkey
Nur Sumeyye Yalçin Koçak

Istanbul Sabahattin Zaim University, Istanbul, Turkey
Ibrahim Agah Tastemir & Erdem Koymen

Istanbul Technical University, Istanbul, Turkey
Enes Yasa

Corresponding author

Correspondence to Nur Sumeyye Yalçin Koçak .

Editor information

Editors and Affiliations

The International Association of Building Physics, Toronto, ON, Canada
Umberto Berardi

Ethics declarations

The authors have no competing interests to declare that are relevant to the content of this article.

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Daylight and Energy Performance Relationship of Classrooms and Office Spaces: Comparative Study of Istanbul Ticaret University Kucukyali Campus Building

Nur Sumeyye Yalcin Kocak[1](✉), Ibrahim Agah Tastemir[2], Erdem Koymen[2], and Enes Yasa[3]

[1] İstanbul Ticaret University, Istanbul, Turkey
nsykocak@ticaret.edu.tr
[2] Istanbul Sabahattin Zaim University, Istanbul, Turkey
[3] Istanbul Technical University, Istanbul, Turkey

Abstract. Natural lighting is important for human comfort and should not be ignored in architectural design. Natural light allows students and instructors to establish healthy visual communication with each other and their surroundings and is known to affect physiological and psychological health. In this study, the architectural design workshops of the Istanbul Ticaret University Kucukyali Campus Building, which was transformed from a leather factory into an educational building, and the office spaces used by the lecturers of the architecture department are examined in the context of natural lighting. In the fall and spring semesters of the 2023–2024 academic year, measurements were made with a lux meter on December 21 and March 27, when suitable sky conditions were provided, and the radiation-based Designbuilder program was used for daylight simulation analysis. In four different interior spaces, illuminance level measurements were made. The illuminance measurements of the volumes were calculated at 12:00, 14:00, and 16:00 for December 21, 2023, and at 10:00, 12:00, 14:00, and 16:00 for March 27, 2024. By evaluating the data obtained, the general lighting conditions of the space and the access status of the users to these conditions were revealed. It was determined that the presence of fixed horizontal shading devices placed in the building without paying attention to orientation significantly affects the amount of illumination in the volumes and increases energy consumption. It is recommended to increase the level of illumination by making the shading devices movable with an automation system according to the effect of sunlight on the facade and painting the volumes with materials with high reflection multipliers.

Keywords: Visual Comfort · Shading Device · Daylight · Illuminance

1 Introduction

Daylight is an important factor that has a positive physical and mental impact on human health. [1–3]. Research shows that natural light reduces people′s stress levels, alleviates symptoms of depression and anxiety, regulates sleep, and helps increase serotonin levels

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and decrease melatonin levels in the body [2, 4]. Natural lighting, when used in the interior of a building, provides many visual and psychological benefits. For example, natural light enhances the impact of architectural devices by making colors appear realistic. In addition, natural lighting helps to identify spaces that need to be emphasized and affects the atmosphere, feel, and aesthetics of the space [5]. Providing appropriate lighting conditions depends on many design parameters, such as space shape and size, ceiling height, internal reflection, and the and the shape and size of the glazed area [6]. Philips states that factors such as ceiling height, room depths, sunlight intake, and indoor temperature should be taken into account in building design, considering its current and future function, and window size and placement are the most complex aspects of this process. These factors are of great importance in terms of user comfort and energy efficiency while affecting building costs [7]. Arranging the location and dimensions of the opening to make the best use of daylight, choosing the color and texture of the interior and exterior surfaces to achieve a good reflection without dazzling the eyes, and using shading devices to prevent direct sunlight from entering the room are some important points to be considered in natural lighting [8]. While fixed shading devices are used to reduce solar radiation entering the space and reduce cooling loads, movable shading devices are used to provide useful gains in winter and save energy spent on heating while blocking the summer sun that increases cooling loads [9].

In cases where the correct lighting conditions are not provided, energy consumption increases with the use of artificial lighting. In addition, improper placement of artificial light sources impairs people′s eye health. According to a study conducted by the Ministry of Education in China, the rate of myopia in students has increased significantly. While the incidence of myopia in university students was 84.72% according to 2010 data, it was determined that this number affected more than 90% of students according to 2020 data. This suggests that the daylight quality of classroom environments is critical for students' comfort and long-term visual health [10]. In another study, the relationship between students' performance and daylighting was examined over 8000 children in 450 different classrooms and it was concluded that there was a 20% improvement in the grades of students in classrooms with sufficient daylight [11–13]. In the field of architectural education, workshops are more important than other classrooms due to their duration of use. Particular attention needs to be paid to the quality of daylight in workshops to improve students' performance, visual comfort and overall mood [13]. It is known that well-designed, safe, clean, clean, bright and comfortable educational buildings and classrooms have a direct impact on the quality of education [14], while in office buildings, natural lighting has many positive effects, including increasing the productivity of employees [4, 15]. Making efficient use of daylight in buildings reduces the dependence on artificial lighting, which accounts for 40% of the total energy consumption of the building, and has a positive impact on the carbon footprint and energy economy [16, 17]. Natural lighting is of great importance in terms of protecting human health and improving architectural aesthetics. Therefore, it is necessary to conduct studies on natural lighting design.

In this study, both the illuminance levels and illuminance distributions of 2 atelier and 2 office units in Istanbul Ticaret University Faculty of Architecture and Design, which was converted from a leather factory into an educational building, are evaluated.

In-situ measurements were made on December 21 and March 27 using a luxmeter, and simulation measurements were made using Design Builder software. In order to reveal the effect of a horizontal fixed shading device on the volumes, simulation measurements were also made according to the scenario without a shading device, and results were obtained regarding energy consumption. Geographical and climatic data for Istanbul province were used. Potential improvements are proposed to provide better visual conditions.

1.1 Daylight in Education Buildings

In educational buildings, lighting is very important in terms of visual comfort and energy consumption due to the education and training process that continues throughout the day. It is known that the right lighting design not only improves the quality of the learning environment but also increases energy efficiency.

Table 1. Summary of relevant research of daylighting in Education Buildings

Ref	Location	Space type	Factors examined	Methodology	Simulation Engine
[18]	Izmir Institute of Technology Turkiye	Classroom, Office, Laboratory	Window size, Transmittance of the glass, glare, Illuminance	On-site measurement	Luxmeter
[4]	IUST School of Architecture Iran	Classroom and atelier	DF, Illuminance	Simulations, on-site measurement, survey	Luxmeter, DIALux
[19]	Izmir Institute of Technology Turkiye	Classroom, Office, Laboratory	Illuminance, Uniformity, Energy consumption	Simulations	DIALux
[20]	Incehon South Korea	Classroom	Facade shading types, Daylight Autonomy (DA) and Useful Daylight Illuminance (UDI)	Parametric design and indoor lighting analysis	Grasshopper DIVA

(*continued*)

Table 1. (*continued*)

Ref	Location	Space type	Factors examined	Methodology	Simulation Engine
[21]	Adana Turkiye	Classroom, office and other spaces	Illuminance, Uniformity, Glare, Energy consumption	Analytic Hierarchy Process; AHP, simulations, on-site measurement, survey	Luxmeter, DIALux
[22]	Ege University Turkiye	Classroom and other spaces	Illuminance levels provided by natural and artificial lighting	On-site measurement	Luxmeter
[23]	Kocaeli University-Faculty of Architecture Building Turkiye	Atelier	Illuminance, Uniformity	Simulations, on-site measurement	Luxmeter, DIALux Evo
[24]	The German University in Cairo Egypt	Atelier	Daylighting availability, Daylight Glare Probability (DGP)	Parametric simulation, sensitivity analysis	Radiance, Genetic Algorithms (GA), SPSS
[25]	The National University of Villa María(UNVM)/ Argentina	Classroom	Illuminance, Daylight Glare Probability (DGP)	Simulations, on-site measurement	Velux, Climate Studio, Rhinoceros 3D,Solemma

Visual comfort is a multifaceted research area and there are many national and international studies in the literature; [1, 4, 13, 14, 18, 22, 26, 27]. However, when the existing literature is examined, studies in which office and educational units are evaluated together are limited; [18, 19, 21]. Studies in the field of hospitals, shops, schools, offices and rarely educational facilities show that there is a connection between daylight and the physiology and psychology of building occupants in different building typologies [13]. Studies on the relationship between the importance of daylight in educational environments and building energy consumption have been addressed with various methodologies under different geographical and climatic conditions (Table 1). While emphasizing the positive effects of daylight on student performance and health in educational environments, the importance of optimal lighting solutions in terms of energy efficiency and visual comfort is also revealed [4, 18–25].

2 Methodology of the Study

During the fall and spring semesters of the 2023–2024 academic year, illuminance level measurements were made in a total of 4 different interior spaces, including classrooms and lecturers' offices. The daylighting performances of these volumes were evaluated on December 21, 2023, and March 27, 2024, in order to make accurate measurements under the appropriate sky conditions, measurements with a luxmeter, and simulation environments with the Design Builder program.

2.1 Case Study

Istanbul Ticaret University Kucukyali Campus Building consists of 3 blocks. In this study, 2 offices and 2 classrooms in the A block of the building are examined. Block A has 3 floors and Fig. 1 shows the offices 208 (1 person study room) and 217 (4 person study room) on the 2nd floor of the building. Figure 2 shows the classrooms numbered 308 and 310 on the 3rd floor of Block A.

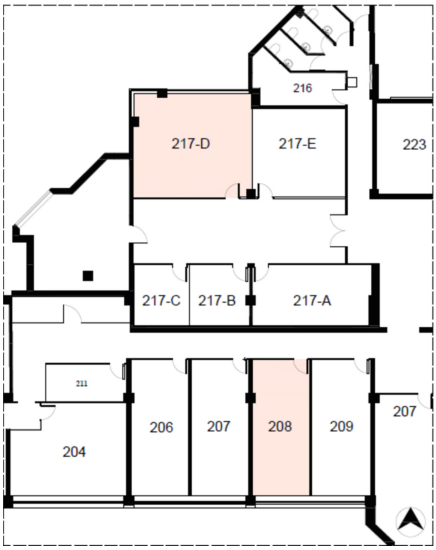


Fig. 1. Second floor office plan

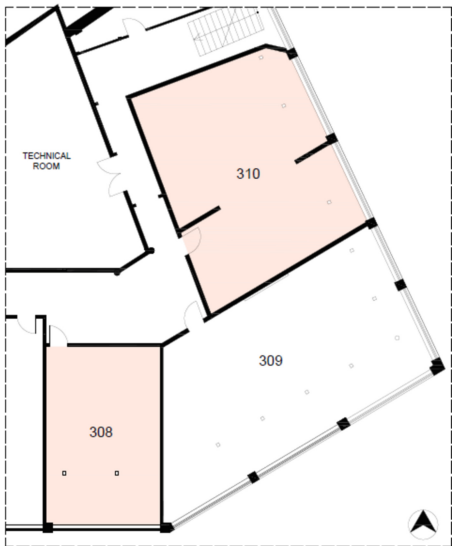
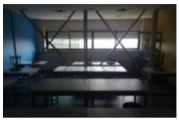
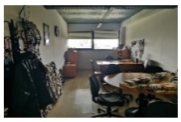


Fig. 2. Third floor class plan

Classrooms have furniture such as whiteboards, tables and chairs. There are horizontal fixed shading devices throughout the building without considering the orientation. The units were examined in detail and their plans were drawn by taking surveys.

Table 2 shows the interior images, area size, façade direction, parapet height, parapet height and number of openings of the volumes studied.

Table 2. Description of classrooms and offices

Type	308 (Classroom)	310 (Classroom)	217D (Office)	208 (Office)
Visual				
Direction	Southwest	East	Northeast	Southwest
Area(m2)	54 m^2	94,2 m^2	38 m^2	19,3 m^2
Parapet heights	110	117	82-90	110
Number of window	1	2	3	1

Illuminance Field Measurement

In Istanbul Ticaret University Kucukyali Campus Building, illuminance measurements were made on December 21 and March 27 in volumes 217D, 208, 308 and 310. The determination of the measurement points in the volumes was calculated using the room index formula according to CIBSE requirements [18].

$$Roomindex(K) = \frac{-LxW}{H(L+W)} \tag{1}$$

L: internal volume depth, W: internal volume width, H: internal volume height
K < 1 = > 4 points,
1 ≤ K < 2 = > 9 points,
2 ≤ K < 3 = > 16 points,
3 ≤ K < … = > 25 points

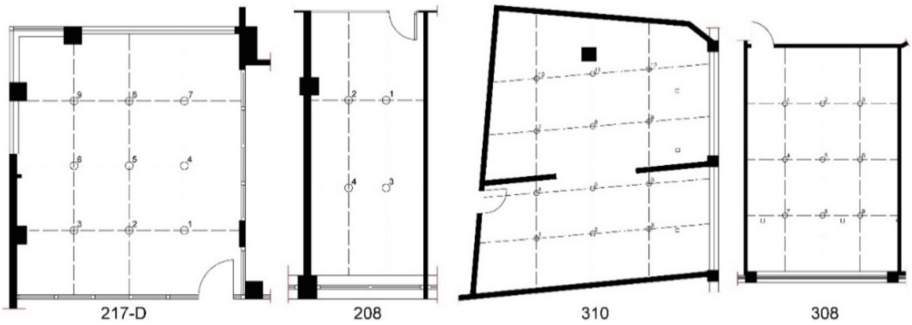


Fig. 3. Determination of measurement points of volumes

In the volumes shown in Fig. 3; 9 measurement points were determined in office 217D and classroom 308, 4 in office 208 and 12 in classroom 310. While determining the location of the measurement points, the depth and width of the volumes were divided into

equal parts. The horizontal working plane was assumed to be 0.80m above the ground. While measuring the illuminance level, artificial lighting devices were turned off and shading devices were left on. 308, 310 and 208 have horizontal fixed shading devices. In volume 217D, the ventilation duct affects the daylight entering through the window. The measurements were performed with a pre-calibrated Lutron LX-1108 digital light meter. The device was always kept in a horizontal position and motionless. When taking measurements, care was taken to ensure that the light did not shine directly on the device, that the person taking the measurements wore black clothes to prevent light reflection, and that he/she stood in a way that did not prevent the light from reaching the device. The data were collected during the academic year when the classrooms were available. Field measurements aimed to determine the actual daylight performance and homogeneity.

Description of the Simulation Model

Radiance-based DesignBuilder program was used for daylight simulation analysis. Climate data for Istanbul was obtained from EnergyPlus and measurements were taken on December 21 and March 27 under clear skies. On December 21 at 12:00, 14:00 and 16:00 and on March 27 at 10:00, 12:00, 14:00 and 16:00.

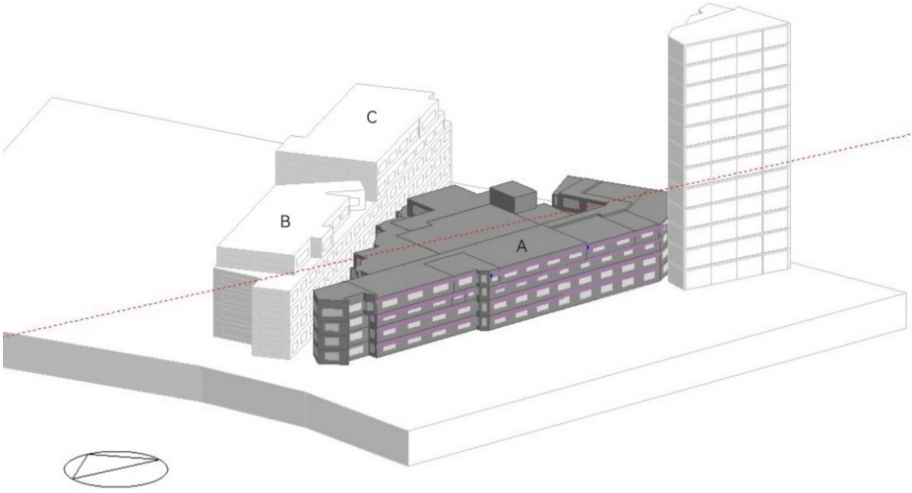


Fig. 4. The geometry of the case study building derived from DesignBuilder.

As seen in Figs. 4, 3 blocks of the university and the nearby high-rise building were modeled and horizontal fixed shading devices were added.

Light reflection multipliers of surfaces; The range specified for the wall is 0,5–0,8, the floor is 0,3–0,6 and the ceiling is 0,7–0,9 [21]. The reflectivity multipliers of interior surfaces are as indicated in Table 3: ceiling: 0.70, walls: 0.50, floor: 0.30. The simulation measurements were configured using the same grid and point height to compare with the in-situ measured data.

Table 3. Daylight simulation conditions

Parameter Name	Description	Value
Working plane height (m)	Working plane height of classrooms and offices of model	0.80
Sky Model	Daylight simulation sky model type	Clear Sky
Visible Absorptance Wall (Emmisivity)	Visible absorptance value of simulated model walls	0,50
Glazing light transmission	Construction glazing light transmission value	0,744
Target illumanance	Target illuminance of spaces for artificial lighting	Office:500 lx Classroom:300 lx
Working Schedule	Working Schedule for artificial lighting	Weekday 09:00–18.00

3 Results and Discussion

In Istanbul Ticaret University Kucukyali Campus Building, measurements were taken with luxmeter on December 21 and March 27 in 4 places and the volumes were simulated in Designbuilder.

Table 4. Measurement illuminance and uniformity results

	Time	ILLUMINANCE (Lux)				UNIFORMITY(U)			
		308	310	217D	208	308	310	217D	208
21.12.2023	Hour	Eavg	Eavg	Eavg	Eavg	Emin/Eavg	Emin/E avg	Emin/Eavg	Emin/Eavg
	12.00	36	38	48	21	0,16	0,44	0,43	1,85
	14.00	43	24	52	16	0,27	0,41	1,22	1,25
	16.00	31	12	13	4	0,25	0,41	0,6	1,5
27.03.2024	10.0 0	14	40	70	8	0,57	0,27	0,31	0,75
	12.00	50	175	252	49	0,72	0,2	0,36	1,22
	14.00	108	98	170	37	0,29	0,34	0,26	1,02
	16.00	103	88	225	56	0,57	0,4	0,3	0,42

Table 4 shows average illuminance level values obtained from the December 21 and March 27 on-site measurements and the uniformity values of the volumes. In the TS EN-12464–1:2021[28] standard, the target illuminance level for working space in classrooms is specified as 300 lx for classrooms and practice rooms, 500 lx for working units, and uniformity 0.6. According to DIN5034, it is recommended that the evenness

should be above 0.67 [19, 29]. It was observed that the units examined were much lower than the minimum target illuminance level, and there was no homogeneous daylight distribution. To evaluate the measurements made in general terms, it was determined that natural lighting is sufficient at the window edges, but as it moves away from the window edges, it reaches an insufficient level as it approaches the front parts of the classrooms.

The locations of the measurement points given in Fig. 3 in the on-site calculations were determined in the results obtained from the simulation and the average amount of illuminance (lux) was calculated.

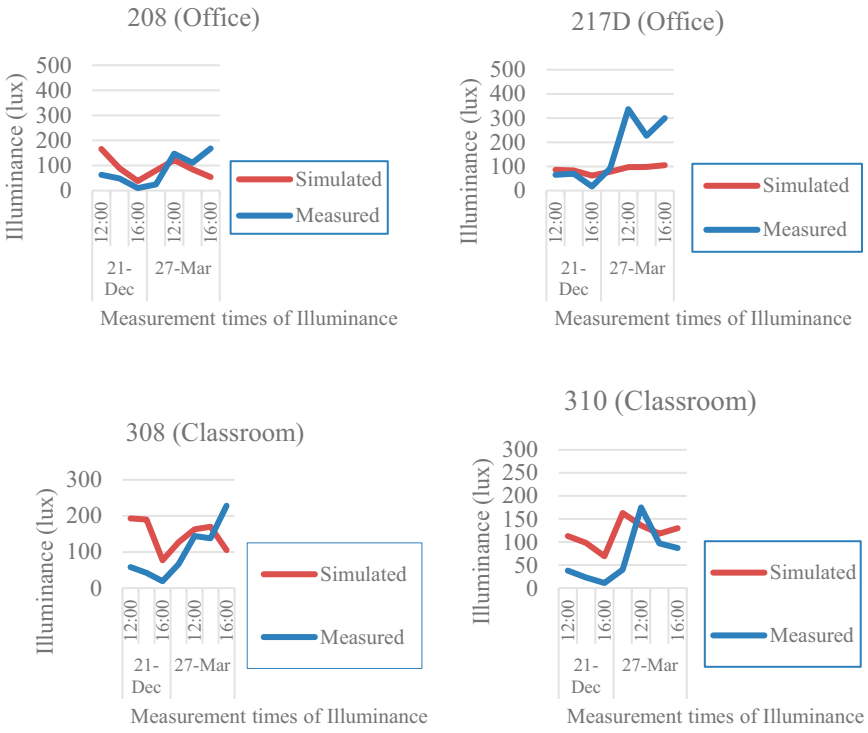


Fig. 5. Comparison between measured and simulated illuminance values

In order to make a comparison between the simulation results and the measured data, the graphs shown in Fig. 5 were created. It is concluded that there is consistency between the two datasets in volumes 208 and 310, while there is no correlation in volumes 217D and 308.

In Fig. 6, the annual illuminance level situation is evaluated with the scenario where there are no horizontal fixed shading devices in volumes 208, 308, and 310 and the ceiling is not lowered in 217D. It has been observed that classroom 308 and office 208 do not receive sufficient daylight throughout the year and require artificial lighting. Office 217D receives sufficient daylight at certain times of the year, but may require artificial lighting

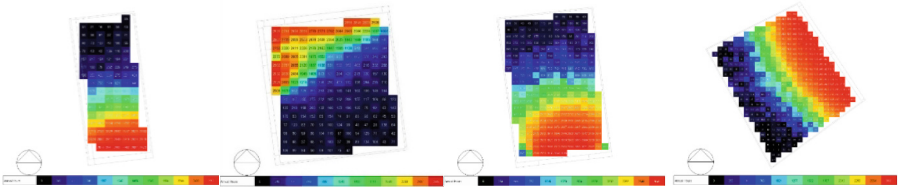


Fig. 6. sDA distribution in annual hours without shading device

at other times. Classroom 310, on the other hand, receives sufficient daylight throughout the year.

Table 5. Energy consumption with and without shading device

Space	308	310	208	217D
Energy consumption with shading device [kWh]	763.12	851.39	844.99	1834.65
Energy consumption without shading device [kWh]	555.40	844.73	488.17	1780.88

In terms of energy loads, the fixed position of the shading devices increases the monthly artificial lighting energy expenditure. When the scenario without shading devices is evaluated, it is seen in Table 5 that there will be a decrease in energy consumption assuming that the volumes are used between 9 and 18 h.

4 Conclusion

An adequate amount of illumination has a positive effect on learning and working performance. In this study, the office and classroom units of Istanbul Ticaret University were analyzed. The measurements showed that the classrooms and office units do not meet the minimum illuminance level. It is seen that the average illuminance level in the office numbered 217D is below 300 lx. The probable reason for this is that the volume faces the north-east direction, the ceiling is lowered for the ventilation duct, although there are no fixed shading devices, and the B block prevents daylight from entering the interior. In volumes 208, 308, and 310, it was determined that the fixed shading devices in the building envelope prevented daylight from entering the building sufficiently.

It is seen that dark colors with low reflection factors are used in classrooms, and it is recommended to increase the light reflection factor values by painting the interior surfaces. In addition, it is recommended to demolish the walls made of plasterboard in the middle of the non-load-bearing volume, which obstructs the students' view in classroom 308.

When the position of the shading devices is connected to the automation system according to the effect of sunlight on the facade, more positive results will be obtained

both in terms of visual and climatic comfort and in terms of lighting and heating-cooling loads. In the future, the current study can be expanded by creating different design scenarios to determine the optimum slat angles and shading device type by considering the building orientation to improve the lighting of the building. By looking for a way to get daylight into the depths of the volume all year round, a façade suggestion can be made with a light shelf.

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