TALLINNA TEHNIKAÜLIKOOL

TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Academy of Architecture and Urban Studies

DAYLIGHT AS ARCHITECTURE. THE PERCEPTION OF SUNLIGHT THROUGH THE MUSEUM OF EMOTIONS

PÄEVAVALGUS KUI ARHITEKTUUR. PÄIKESEVALGUSE TAJUMINE LÄBI EMOTSIOONIDE MUUSEUMI

MASTER'S THESIS

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Tallinn 2022

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(eesti keeles) *Päevavalgus Kui Arhitektuur. Päikesevalguse Tajumine Läbi Emotsioonide Muuseumi.*

(inglise keeles) *Daylight As Architecture. The Perception Of Sunlight Through The Museum Of Emotions.*

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FOREWORD

This Master Thesis has been written as a culmination of my studies at the Academy of Architecture and Urban Studies in the Department of Civil Engineering and Architecture at Tallinn University of Technology in Estonia.

I would like to express gratitude to everyone, who contributed to writing this Master Thesis, especially my supervisor Kimmo Sakari Lylykangas. A great thanks to the professors of the Academy of Architecture and Urban Studies for giving me valuable advice.

I very appreciate my family and friends as well for eternal supporting and believing in me.

Keywords: architecture, daylight, Museum of Emotion, Master Thesis.

TERMS AND DEFFINITIONS

Aperture - a small and often narrow opening, especially one that allows light into a camera (Dictionary-Cambridge, 2022);

Chiaroscuro - the use of areas of light and darkness (Dictionary-Cambridge, 2022);

Circadian rhythms - the natural cycle of physical, mental, and behaviour changes that the body goes through in a 24-hour cycle (Dictionary-NCI, 2022);

Daylight – visible part of global solar radiation (EN17037:2018, 2018)

Diffuse – to (cause something to) spread in many directions (Dictionary-Cambridge, 2022);

EN – European;

Isl – Island or islands;

Illuminate - to light something and make it brighter (Dictionary-Cambridge, 2022);

Luminance - the intensity of light emitted from a surface per unit area in a given direction (Your-Dictionary, 2022);

Luxmeter – the device for measuring brightness (Dictionary-Cambridge, 2022);

Metaphysics - the part of philosophy that is about understanding existence and knowledge (Dictionary-Cambridge, 2022);

Pen – Peninsula;

Penumbra - the partially shaded outer region of the shadow cast by an opaque object (Dictionary-Cambridge, 2022);

SAD – Seasonal Affective Disorder

ABSTRACT

Since ancient times, light has been considered existential for the mankind. It provided warmth and protection, enabled a sense of confidence and inspired for a brighter future. Natural light breathes life into the surrounding space creating it like nothing else.

At one time - bright and scorching, at another - diffused and soothing - daylight has such diverse qualities that many architects around the world have already been accepted it as an independent material for creation. Architecture is dead without light, be it daylight or electric light, it revives the frozen melody of massive constructions filling them with the meaning and the special function.

It is no coincidence that in most architectural schools in the 18th - 19th centuries considerable attention was paid to the study of light and illumination. Contemporary masters of architecture, such as Santiago Calatrava, Louis Kahn, Jean Nouvel and Tadao Ando are known throughout the world for their masterpieces "playing with light and shadows".

The perception of architecture is influenced by such multi-purpose factors as space and form, mass and colour as well as lighting. If you do not perceive light only for its intended purpose, as an exclusively practical function, then the ways of its distribution, the contrasts of light and shadow, glare and reflections create not only a fascinating and salutary atmosphere, but also a bright, holistic artistic image.

This Master's Thesis is focused on the study of daylight affecting the perception of space and emotions stimulated by the quality of daylighting. These aspects cannot be measured, but they can be analysed in a typology characterizing the use of daylight in architectural space.

The architecture competition of the Museum of Emotions has provided the basis for the design project using light as the main material for articulating the spatial perception of architecture. Although the competition program requires only two halls - one inducing negative emotions and the other inducing positive emotions - this Thesis proposed a sequence of five interiors following the five-act structure of classical drama.

Since in the competition participants are free to choose any site for the implementation of the project, the small Estonian island named Prangli – sparsely populated and at the same time stunning in its pulchritude – has been selected as the site for the unusual museum concept.

For a general understanding of the inconstancy and the potential of light in architecture, ten simplified spatial models featured in the Matrix of Showing Spatial and Temporal Variability for Architectural Spaces (Rockcastle & Andersen, 2013) have been taken into closer scrutiny and have been reproduced as digital models for illustrative examples for the purpose of further elaboration. Moreover, the aim has also been to test typological models for their performance in Estonian latitudes at different times of the year. The main method for the study has been the examination of five scale models in the heliodon device, providing the recorded results that are presented in the subsequent parts of this Thesis.

The design part of the Master's Thesis applies the knowledge of the research obtained to identify the five most appropriate types of the daylighting models by Rockcastle and Andersen and develops them further as small pavilions celebrating the drama of light and shadow - the future Museum of Emotions.

The most simplified forms and materials are used in the design, where more attention is paid to the halls' meaningful interior. This has been done on purpose not to distract the viewer to extraneous factors, but to focus his attention exclusively on the "play of daylight and shadow".

ABSTRAKT

Alates iidsetest aegadest peeti valguse olemasolu elu üheks tähtsamaks komponendiks. See pakkus soojust, kaitset ja enesekindlust, inspireeris unistama helgemast tulevikust. Looduslik valgus hingab ümbritsevasse ruumi elu sisse, luues selle nagu ei miskit muud.

Kord on ta helge või pimestav, siis jälle - hajutatud ja rahustav. Päevavalgus on nii mitmekesiste omadustega, et paljud arhitektid üle maailma on seda juba aktsepteerinud iseseisva loomingulise materjalina. Arhitektuur ilma valguseta on surnud, olgu selleks siis päevavalgus või elektrivalgus – see taaselustab massiivsete konstruktsioonide tardunud meloodia, täites need tähenduse ja erilise funktsiooniga.

Pole juhus, et 18.-19. sajandil enamikes arhitektuurikoolides pöörati suur tähelepanu valguse ja valgustuse uurimisele. Mõned arhitektuurimeistrid nagu Santiago Calatrava, Louis Kahn, Jean Nouvel, Tadao Ando on tuntud kogu maailmas tänu oma meistriteostes esinevate "valguse ja varjudega mängudes".

Arhitektuuri tunnetust mõjutavad sellised mitmeotstarbelised tegurid nagu ruum ja vorm, mass ja värv ning ka valgus. Kui tajuda valgust mitte ainult selleks ettenähtud otstarbel, vaid eranditult praktilise funktsioonina, siis selle levitamise viisid, valguse ja varju kontrastid, sära ja peegeldused loovad mitte ainult lummava ja tervendava atmosfääri, vaid ka ereda, tervikliku kunstilise pildi.

Käesolev magistritöö keskendub päevavalguse uurimisele, mis mõjutab ruumi tajumist ja päevavalguse kvaliteedist stimuleeritud emotsioone. Neid aspekte ei saa mõõta, kuid neid võib analüüsida tänu tüpoloogiliste omadustele, mis iseloomustavad päevavalguse kasutamist arhitektuurses ruumis.

Emotsioonide Muuseumi arhitektuurikonkurss on andnud aluse ideekavandile, mis kasutab põhimaterjalina valgust arhitektuuri ruumilise taju artikuleerimiseks. Kuigi võistlusprogrammi jaoks on vaja esitada ainult kaks saali – üks negatiivseid ja teine positiivseid emotsioone tekitav – suurendatakse antud lõputöös klassikalise draama viievaatuselise struktuuri (ingl: five-act structure drama) järgi projekteeritavate ruumide arvu viieni.

Kuna konkursil on osalejatel vabadus valida projekti elluviimiseks ükskõik milline koht, siis valiti väike hõredalt asustatud ja samas oma kirkuses vapustav Prangli nimeline Eesti saar.

Valguse muutlikkuse üldiseks mõistmiseks on arvesse võetud kümme lihtsustatud ruumimudelit (Rockcastle & Andersen, 2013), mida analüüsiti, et reprodutseerida neid illustreerivate näidetena edasiseks töötamiseks. Lisaks on eesmärgiks ka tüpoloogiliste mudelite testimine Eesti laiuskraadidel erinevatel aastaaegadel. Töö põhiinstrumendiks on Tallinna Tehnikaülikooli otsese päikesekiirguse testimise laboris asuv heliodonseade, mille salvestatud tulemused on toodud käesoleva lõputöö järgmistes osades.

Magistritöö disainiosas on uurimistööst saadud teadmiste rakendamine viie sobivaima mudelitüübi väljaselgitamiseks kasutades Rockcastle'i ja Anderseni päevavalgustusmudeleid ja nende edasiarendamine tulevase Emotsioonide Muuseumi väikeste ruumidena.

Kuna rohkem keskendatakse saalide interjöörile, on kujunduses kasutatud lihtsamaid vorme ja materjale. See on tehtud meelega, et mitte juhtida vaataja tähelepanu kõrvalistele teguritele, vaid suunata tema huvi eranditult "päevavalguse ja varju mängule".

1. INTRODUCTION

1.1 RELEVANCY OF THE TOPIC

Light along with other physical indicators (for instance, fresh air) is an integral part of architecture. Be it electric or natural, without it the perception of colour, space and environment is impossible.

However, no matter how fast technology develops, man has always been dependent on the sun. The desire to reach for natural daylight is embedded in our subconscious. Generally, people when asked, always prefer to work in a daylight environment (Phillips, 2004, p. 40).

Human activity is higher in natural light than in artificial light. On a sunny day, people report higher productivity than on an overcast day. In winter, when daylight hours are shorter, we are less productive than in summer. Poor-quality light negatively affects the visual apparatus, causing fatigue, discomfort, migraines and insomnia (Boyce, Hunter, & Howlett, 2003).

This proves that daylight affects people both physiologically and psychologically. However, the feelings and emotions that we experience due to specific type of lighting are given negligible attention.

1.2 PROBLEM STATEMENT

The primary function of light sources has always been to illuminate, not to decorate. However, the most intelligent solution is when the light is both effective and spectacular. It is possible to evaluate the effectiveness of lighting by referring to the indicators of standards or making mathematical calculations, then about the spectacularity there are few scientific studies.

To establish the importance of luminous composition within interior architecture Rockcastle and Andersen presented a wide range of design strategies used in contemporary architecture and developed a matrix of contrast typologies against which each space could be compared on a relative scale from high to low (Rockcastle & Andersen, 2013). In their research the results are presented only for two top-lit spaces in Boston. However, for this Thesis all ten of them were analysed.

Thus, the purpose of the research is to review and reproduce Rockcastle & Andersen's typological models as scale models using a heliodon device for the purpose of further application of knowledge in the practical part.

The questions that the theory and the investigation part discussed are:

1. Are all the simplified models representing the matrix of spatial and temporal variability for architectural spaces applicable in the Estonian context?
2. What kind of emotions does a particular type of daylight distribution evoke?
3. How and why the daylight effects our state of mind?

1.3 OBJECTIVE

The main objectives of the Master's Thesis are:

1. To analyse and compare Rockcastle & Andersen's typological models and their applicability in the Northern climate;
2. Applying the appropriate and working methods to design a Museum of Emotions where the emotions are evoked by no other media than daylight and architecture. Five different interiors are designed to demonstrate human emotions following the five-act structure of classical drama.

1.4 BRIEF OVERVIEW

First of all, a research based on the typology created by Rockcastle and Andersen has been carried out. The aim is to explore the variations of sunlight distribution in a room.

For the research the program from Autodesk Revit have been used, where ten typological models for the Estonian latitude have been reproduced. Having received the required number of renders, matrices are compiled for a good example and assessment of the situation. The results made it possible to determine what kind of emotions - positive or negative - cause certain types of lighting.

Having identified the most enthralling options, five types of spaces have been selected for further work as separate halls for the Museum of Emotions.

Having decided on the configuration of the premises and their site location - Prangli Island has been chosen for the implementation of the project - the museum is designed, a description of which can be found in the following parts of the dissertation.

1.5 CONNECTION TO SIMILAR PROJECTS

In her Master's Thesis two years ago (Sepp, 2020), Liis Sepp was writing about instruments of light and daylighting in spaces for meditation.

Sepp's Thesis applies another theoretical framework and is focused on the differences between quantitative and qualitative evaluation methods supporting the design of meditation cabins in the Vale de Moses architectural competition.

This thesis focuses on testing the daylighting typology created by Rockcastle and Andersen in the Northern climate, in the framework of the museum of emotions, utilizing daylighting of space to stimulate both positive and negative emotions.

2. HISTORY

The history of architecture is closely connected to the history of the window itself, but its purpose has always been to provide people with light, air and information - to report on weather or the time of day. But as dwellings became more sophisticated buildings and individual rooms had been changed to be better lit by the rays of the sun.

In northern regions with predominantly overcast skies buildings had large, tall windows to let in as much daylight as possible, while in southern regions the opposite was true. However, due to the changes in the external climate, window openings began to require a suitable infill. At first various materials were used, such as thin slabs of marble, sheets of mica or oiled paper, but only with the advent of glass for windows the substantial progress was really made (Phillips, 2004, p. 3).

2.1 ANCIENT EGYPT

In the 3rd century BC daylight was presented to the interior of Egyptian temples with openings in the roof, which were established by different roof heights, creating shafts of light onto statues. The apertures were incised what provided diffused light in the temple. The appearance of buildings was derived from the interaction between mass, sun and sky (Ramzy, 2013, p. 220).

Since there was never a shortage of sunlight in Egypt, windows played quite minor role in architecture. This was the case until the era of the New Kingdom, when walls with an upper row of windows and partition walls became popular. Doors were used to let light into the room.

The primitive form of the window that was used throughout the history of Egyptian temple architecture is a narrow gap located at the junction of the roof and wall (Figure 1). These cracks were so high that nothing could be seen through them, and besides, they were too restricted to allow one to look inside from the roof (Clarke & Engelbach, 2009).

In some ancient Egyptian temples - in the temple of the sun of Amun in Karnak or in Abu Simbel - there is no uniform diffused illumination. The interior of the temples is architecturally "arranged" by a sunbeam that on the appointed day and hour penetrates the temple and snatches the sacred statues located there from the darkness of the cave.

The most remarkable lighting scheme is the solar phenomenon in the Great Temple of Abu Simbel, where the axis of the temple is in such a way that the first rays of the rising sun illuminate in turn the statues of two gods (Amon and Ra) and the deified Ramses in the centre between them.

On the days of the spring and autumn equinoxes on March 21 and September 21, the rays of the sun penetrate the sanctuary and illuminate the sculptures on the back wall. According to the layout, the fourth statue of the god of the Underworld - Ptah - always remains in darkness (Соловьев, Майстровская, Турчин, & Дажина, 2022, p. 12).

2.2 ANCIENT GREECE

Ancient Greek temples – similar to each other both in style and in general geometric – skillfully present the play of light-shadow relations. And although architects used natural light only to reveal the structure and shape of objects without putting an ideological and symbolic component into it (Шестаков & Насыбуллина, 2015, p. 75), the illusion of movement and penetration in space had been created by ancient Greek architects in each colonnade.

The feeling of an obstacle in the form of an outer wall was lost in the minds of viewers looking at the Parthenon, for instance, where the successive arrangement of columns and sunlight created the effect of a "transparent", permeable barrier. This illusion of permeability, knowledge of the hidden world personified the "house of the deity" (Figure 2).

The interiors of the sanctuaries were illuminated through doorways. It was sufficient especially in the petite temples. The sanctuaries dedicated to the sun gods were occasionally "hypaethral" or partially open to the sky forming a courtyard.

However, this system appears to have been reserved only for larger temples such as the Olympieion in Athens (Ramzy, 2013, p. 220).

2.3 ANCIENT ROME

Throughout its history Roman architecture borrowed many features from the cultures of countries and peoples conquered by Rome. For instance, the technique of vaulting has been adopted from the Etruscans, the design of which made it possible to obtain the integrity of the interior space and achieve its enjoyable natural light.

Also, one of the most important types of buildings in ancient Rome was the basilica. Roman basilicas until the 4th century AD were represented as civil buildings and were intended to accommodate large numbers of visitors in their interiors. The elongation of their plan and the division of the interior space into three or five naves was the common feature of all basilicas. The elevation of the central nave above the side ones served to receive the daylight (Соловьев, Майстровская, Турчин, & Дажина, 2022, p. 48).

In addition, the Roman Pantheon that was built in 120 AD, was a pioneering example of providing overhead sunlight. The opening, or oculus, with a diameter of almost 9 meters in the centre of the dome was the only source of light, as if hinting at the perfection of the sky (Figure 3). And thanks to the "divine" ray the emperor-God was often credited in direct relation with the heavens (Ramzy, 2013, p. 221).

2.4 BYZANTINE

In the Byzantine Empire, under the influence of the east from the 5th century, churches were built in the form of domed basilicas as well as the centric temples with a plan of a round, polygonal shape or in the form of a Greek (equal-ended) cross. An effective way was found to support the dome on a square base (using sail vaults). A complex system of combining a huge dome, half-dome and buttresses was implemented in the Church of Hagia Sophia in Constantinople (Заварихин, 2017, p. 16).

In the cathedral the dome, raised to a height of 40 meters (for comparison, this is twice as high as in the Pantheon), seems to barely touch the arches (Figure 4). At its base the dome is cut along the perimeter by 40 large windows (1.5 x 4.6 m), narrow gaps between which seem to dissolve in the air. Daylight streams from numerous windows grow in the interior from the periphery to the centre reach their culmination in the space under the dome (Соловьев, Майстровская, Турчин, & Дажина, 2022, pp. 60-61).

2.5 GOTHIC

Of all the arts forms Gothic architecture most powerfully expresses the spirit of medieval Christianity in Western Europe. The dialogue between massive stone and daylight in a Gothic cathedral as if sacred raises the observer elevating him from the human to the divine (Насыбуллина Р. А., 2020).

Shining with coloured reflections of stained-glass windows in a deep and gloomy space, the interior of Gothic cathedrals refers to the indicated unity of light and darkness. The replacement of a blank wall with a glazed arcade became possible due to the abolition of the high attic space above the side naves and the replacement of a shed roof over them with a hip roof.

In the interiors of Gothic temples, the idea of gravity, mass and supports, that carry it, seems to disappear, and stone lace seems to be a floating, weightless shell. Only narrow piers remain from the walls filled with the coloured glow of stained-glass windows, and all the elements of this airy structure seem

to rise up. The entire design of a Gothic cathedral maintains to reveal the idea of light (Figure 5). If the ancient world created classical examples of the facades of its sanctuaries, then the Christians created unprecedented interiors of churches and cathedrals, bringing the interior art to perfection, both in Byzantine and in Western Europe (Вороновский, 2019).

2.6 RENAISSANCE

With the Renaissance coming the spiritual component of light recedes slightly. The matter took a centre stage: compositional aspects, purity and conciseness of form, its completeness and accuracy of proportions. Even on heavily lit objects the game of shadows was barely perceptible. The shape and location of windows became more formalized, often less connected to the interior spaces they served. The appearance of the building, its height began to be a paramount importance (Phillips, 2004, p. 4).

2.7 BAROQUE

The Baroque era, on the other hand, demanded the return of the mystical component of the phenomenon of light: through strong light contrasts and hidden sources of illumination, it was possible to achieve the feeling of “theatrical production” (Kokorina, Bagramian, & Adonieva, 2018). The magnificent decoration of temples, the endless space of painting on the arches, the many glares and reflections on the gilding were the main features of Baroque architecture (Figure 6). While creating buildings in this style the architects paid close attention to daylight using and chose finishes depending on how it would be reflected. Via such techniques the masters emphasized contrast and drama, created a play of chiaroscuro in the room (Фастовская, 2021).

2.8 INDUSTRIALIZATION

Until the 17th century, room lighting was possible thanks to the windows and the sunlight passing through them. In case natural daylight was not sufficient, candles or oil lamps were used.

A significant turnaround in light provision occurred when daylight was supplemented with artificial sources of light. In architecture, both industrial and civil, steel mesh, membrane ceilings-shells, hyperboloid-paraboloid structures have been actively utilized (Formsma, 2021).

At the beginning of the Industrial Age engineers and designers worked on the problem of the essence of increasing the spans of steel structures, that in turn was supposed to provide the so-called "planning flexibility" of factory floors. Constructivists based the foundations for understanding figurative design and the image of light (Shabalina & Glavinskaya, 2019).

The introduction of sheet glass, steel, iron and new technologies opened new possibilities in the design and layout of buildings. The best example is the Crystal Palace in London.

2.9 EARLY 20TH CENTURY

In Europe the majority of 20th century architecture was the embodiment of rationalism (functionalism), the emergence of which was facilitated by a great need for dwelling. The main principles of architecture: rationality and functionality of forms, minimal construction costs, the use of ready-made parts to increase speed and economy. The modernist architecture was characterized by functional, simple and industrially produced type of architecture with a clean aesthetic applying simple shapes and lines. The primary task of the architect was to design using modern technologies. The result was a showcase of pure form, colour and new building materials, while maintaining historical principles of natural ventilation and orientation. The concept of symmetry has been replaced by asymmetry (Kuznetsova, Zhdanova, & Voronina, 2020).

The greater part of the architecture built since the 30s of the previous century was aimed at globalization and unification, and

later at post-war reconstruction. All over the world, communal houses and social cities with public functions were erected. The loss of load-bearing walls due to pillars and slabs made it possible to open large horizontal spaces in the walls, through which light evenly entered the rooms.

With new advances in technology – elevators, electronic devices – the function had become a key part of building design. Open floor plans, garden-like rooftops, continuous horizontal glass panels along the facades – that is what the new style began to include, while finding alternatives to natural light (Formsma, 2021).

2.10 LATE 20TH CENTURY

By the 1960s, it began to seem that artificial lighting would soon completely supplant natural light and become the primary source of light. Many factories and schools of that time were built completely without windows. It even got to the point that the rooms were heated by lighting, regardless of the time of day. The onset of the crisis in 1973 took people thought about the energy efficiency of the use of resources in everyday life. The conclusion was obvious: daylight has enormous positive effects on human health and habits as well as reduce energy consumption. Thus, many buildings were eventually reconstructed (Phillips, 2004, p. 5) (Formsma, 2021).

It should also be noted that in the late 20th century postmodern architects called for the disclosure of the semantic aspects of architecture. The concept of "metaphysics" appears as a science of super sensible principles and a set of subtle internal meanings of an architectural work that lead to a different use of light. And the architectural space becomes a field for revealing new, metaphorical meanings of form, space, and light (Насыбуллина Р. А., 2018).

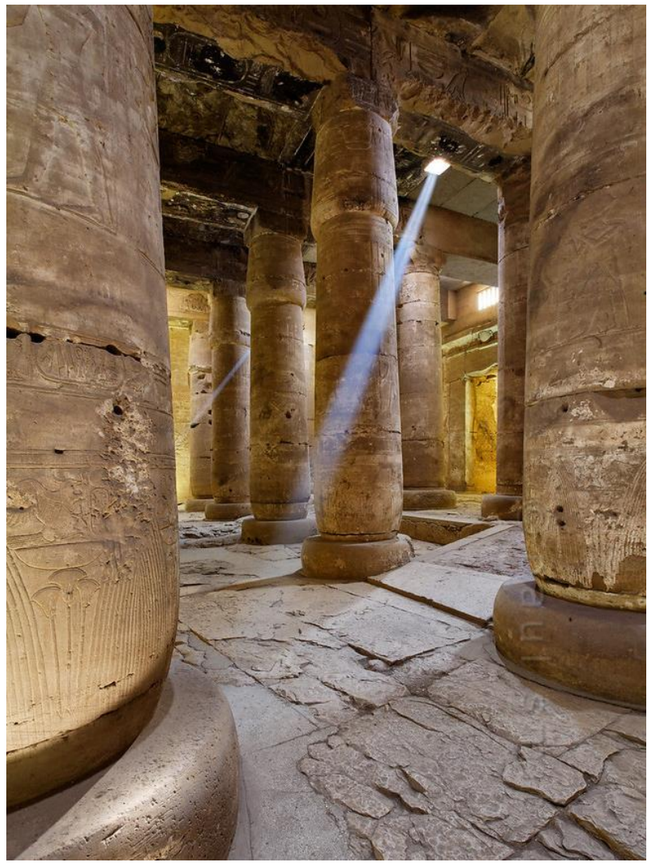


Figure 1. Second Hypostyle Hall of Seti I Temple at Abydos.
Photo: Paul Smit.

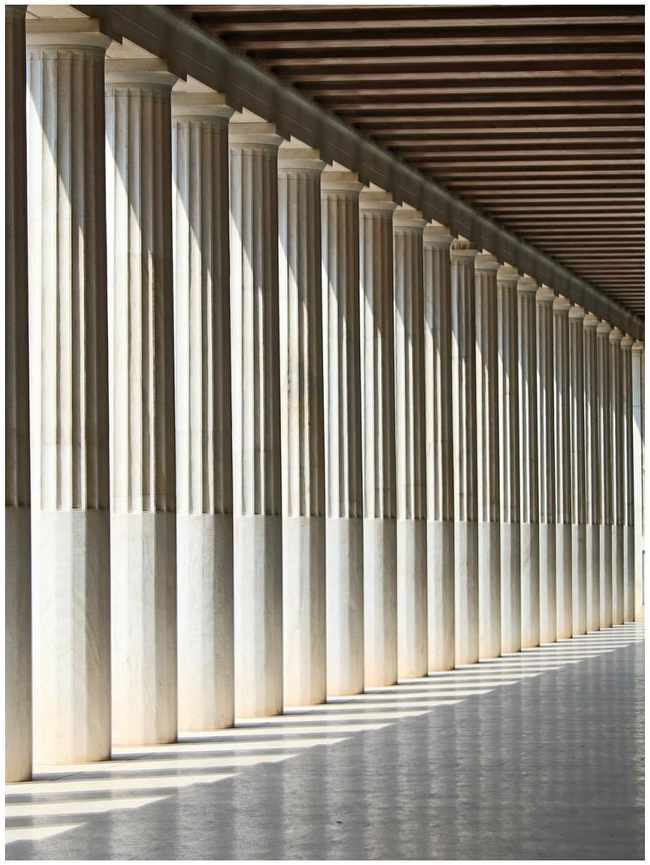


Figure 2. Museum gallery in Athens.
Photo: Hans Reniers, 2018.

Figure 3. Oculus of the Pantheon in Rome.
Arch: Apollodorus of Damascus, 126 AD.
Photo: Roma, 2014.

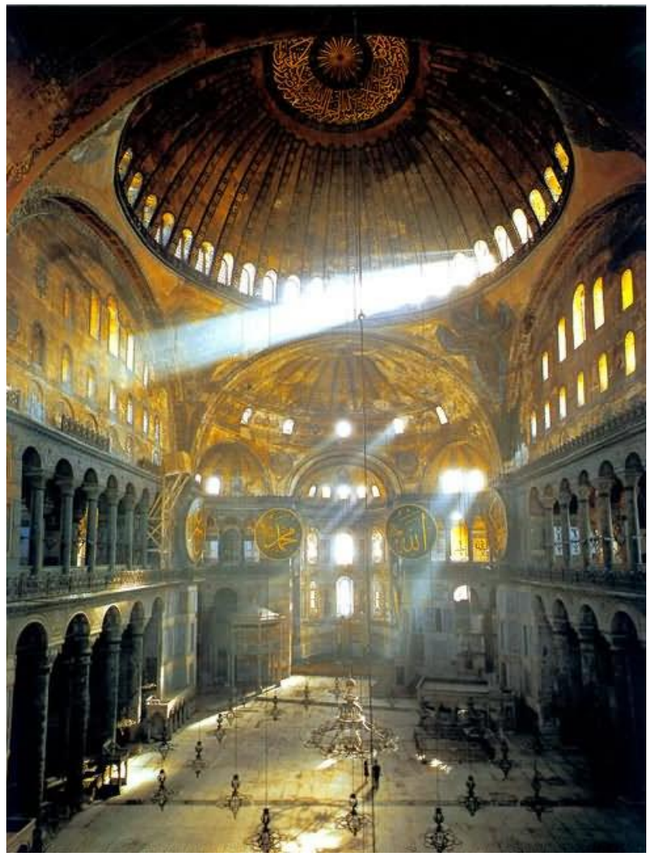


Figure 4. The dome inside The Hagia Sophia in Istanbul, Turkey.
Arch: Anthemius of Tralles & Isidore of Miletus, 537 AD.

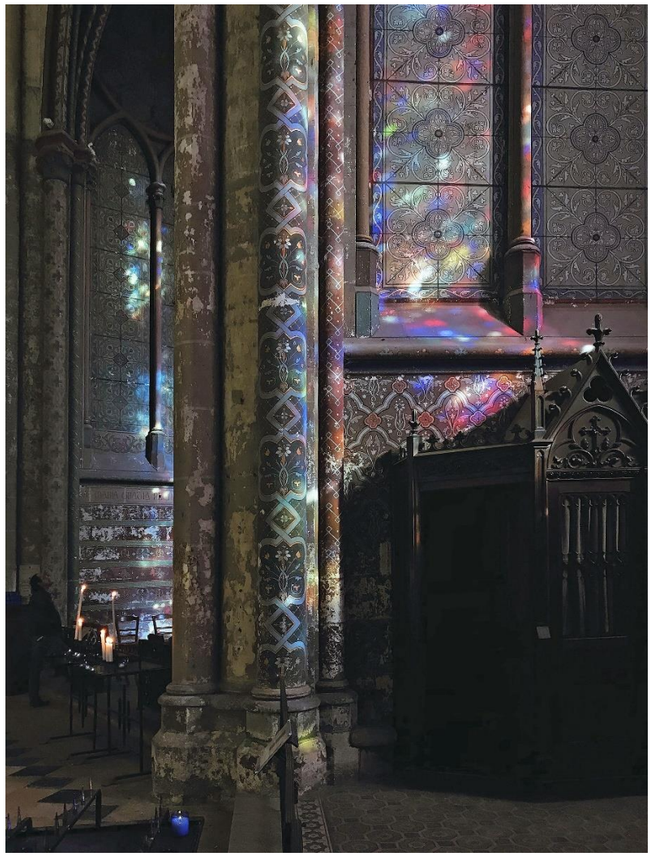


Figure 5. The interior of the Cathedral of St. Peter of Beauvais.
Arch: Enguerrand Le Riche & Chambiges, M., 1578.

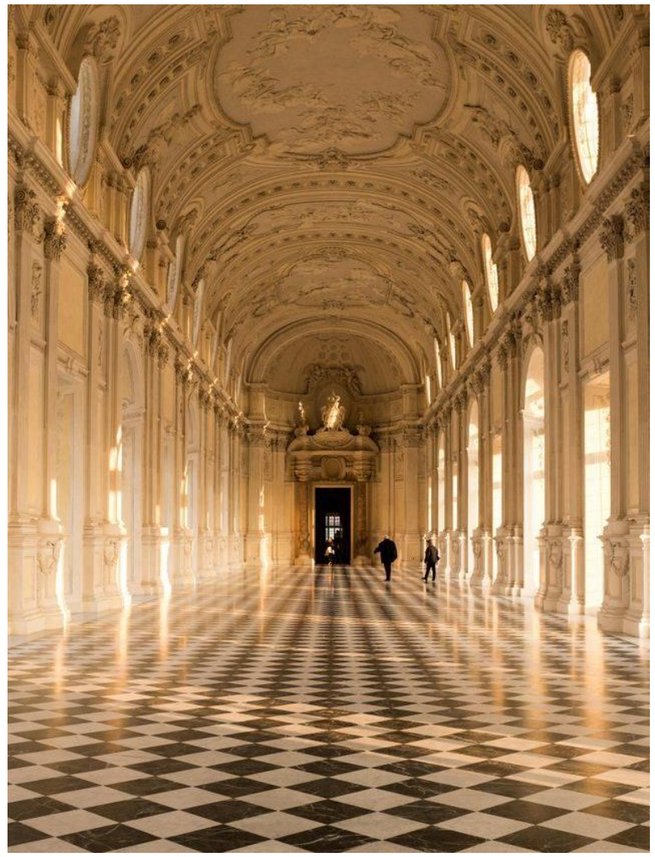


Figure 6. The Palace of Venaria.
Arch: Amedeo di Castellamonte, 1675.

3. ENVIRONMENT

The environment with its various aspects, has a significant impact on the design of buildings, their functioning and appearance. This primarily includes illumination, where the sun, as the main source of natural light, plays a significant role. Its factors such as variability, direction, colour, and intensity should never be ignored even in the early stages of design.

3.1 CHANGE/VARIETY

Constant change is one of the most important and obvious qualities of daylight, which gives endless variety to interior appearances.

The states of light change continuously throughout the day from morning to evening, from the first rays of the rising sun to twilight, thus increasing the need for artificial illumination. Visual sensations have a powerful effect on a person since the perception of the surrounding world occurs mainly due to light.

However, the time of day is not the only factor influencing the variability of natural light. The intensity of solar radiation also varies due to different weather conditions. The days can be sunny and clear, overcast and rainy. Small clouds running across the sky tend to cast shadows. And with a clear sky, depending on the position of the sun, the direction of radiation could be converted.

The shift of weather, in turn, is caused by changes in the seasons, where each month has its own character. For example, during a heavy snowfall the amount of light penetrating into the premises will be significantly less than on a clear summer day.

Certainly not all nuances in correlated colour temperature are visible to the human eye, so the best way to measure illumination is using a luxmeter (Phillips, 2004, p. 9).

The examples of daylight situations and correlated colour temperatures (DIAL, 2016) are presented on Figure 7-9.

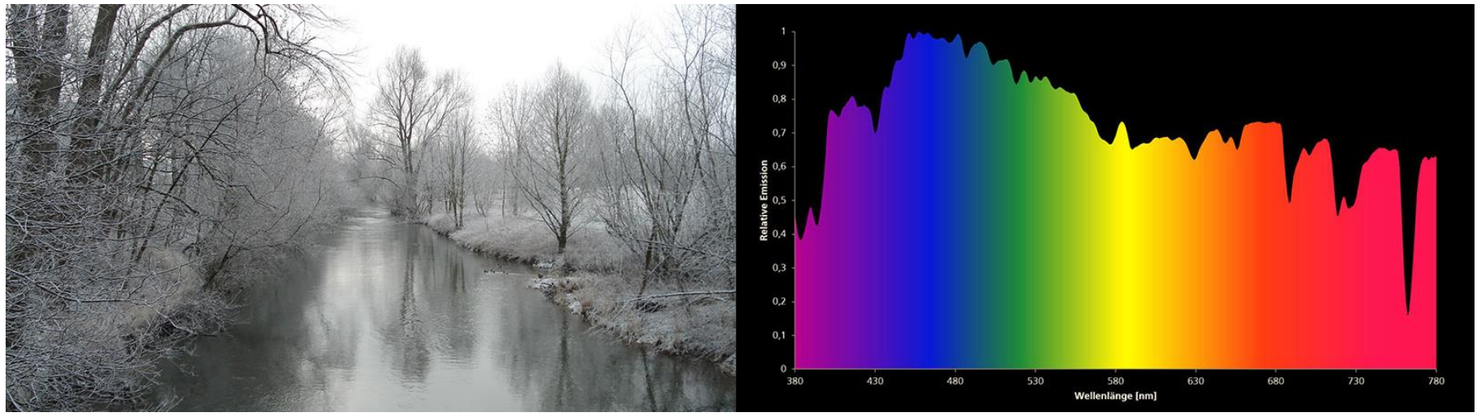


Figure 7. Daylight situation. Overcast sky (approx. 7 000 K).

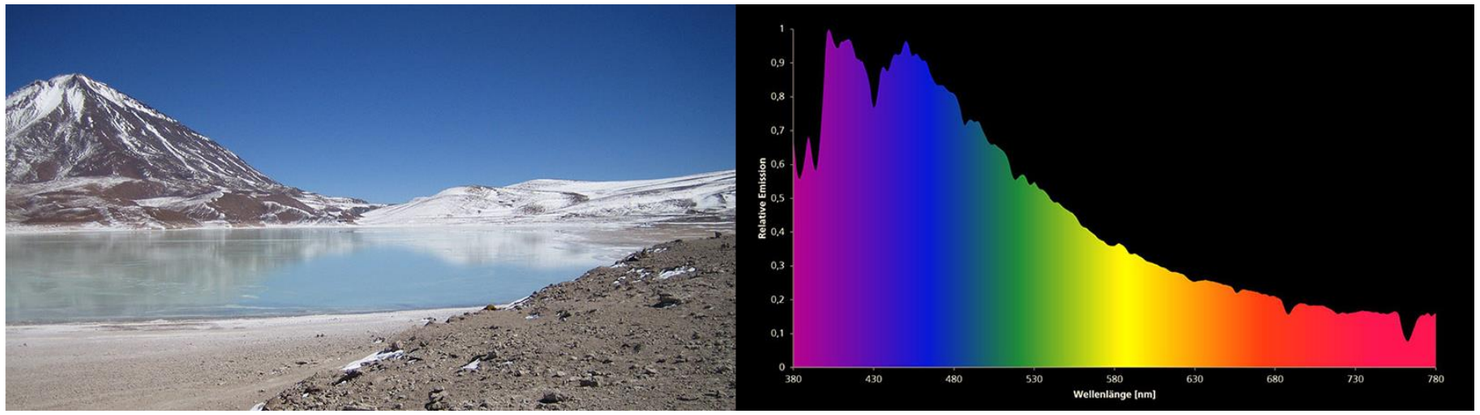


Figure 8. Daylight situation. Blue sky (approx. 25 000 K).

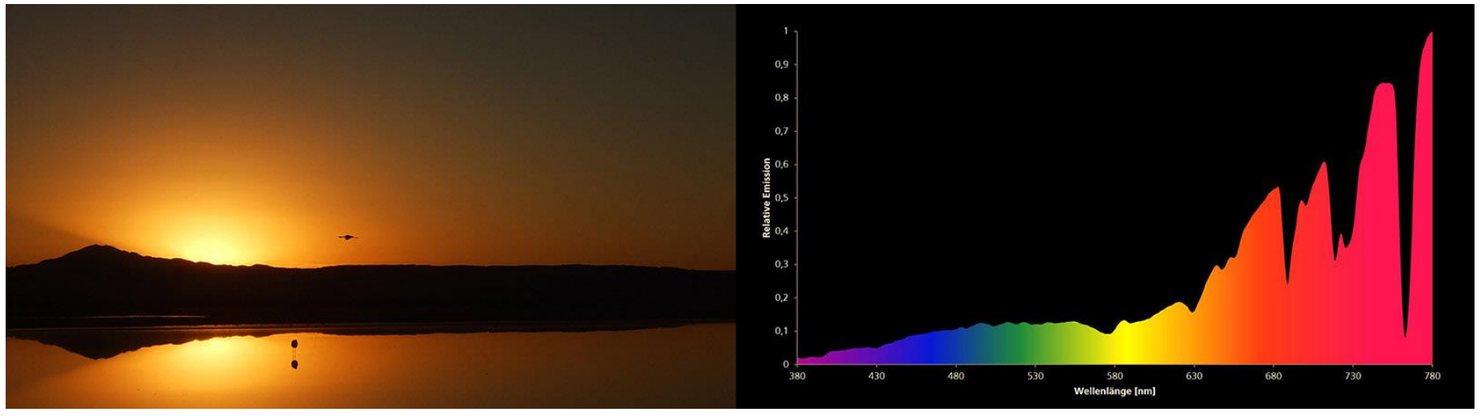


Figure 9. Daylight situation. Sunset (approx. 3 300 K).

3.2 ORIENTATION

One of the important architectural and compositional solution of buildings is its orientation. The rational orientation of the building relative to the cardinal points is the simplest solution that can ensure favourable and reduce the adverse effects of natural and climatic factors on a person inside the space (Скороходова & Семенова, 2020). The buildings can be placed in three different ways: W-E direction, N-S direction and NE-SW or NW-SE direction (diagonal position) (Figure 10).

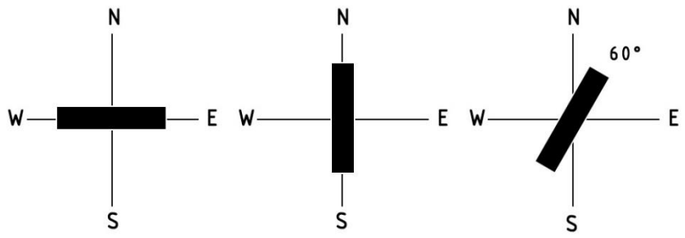


Figure 10. The orientation of buildings based on the Sun Exposure.

The optimal orientation of buildings is regulated by special requirements for various natural and climatic conditions and considers the normative and permissible sanitary and hygienic conditions of human life. This classification is quite applicable to individual construction, but it works more with small private houses. Instead, the more attention should be paid to the orientation of the premises inside and to the site location relative to neighbouring buildings and trees (Kolosvetova, 2019).

The most common practice in low-rise construction is the location of non-residential premises on the north side of the building, and the bedroom and guest rooms - on the south (W-E orientation). In this case, the largest number of rooms will be illuminated throughout the daylight hours, and in summer, the rooms located on one side of the facade will not overheat.

In multi-apartment buildings, a staircase is located on the north side, while one-room apartments are more likely to be located on the south side of the house to ensure the insolation of the living room (Подкопаева & Шехватова, 2021).

With the W-E orientation of the building the largest area of facade glazing should be on the south side (a deviation of up to 30 ° from the azimuth almost does not reduce the use of solar energy). In this case the windows will serve as solar collectors that accumulate thermal energy inside the building. This effect is achieved due to the properties of glass: the short-wave spectrum of thermal rays passes through it faster than the long-wave radiation coming from heated objects. To avoid heat loss through windows, when designing large openings, it is important to use double-glazed windows with low thermal conductivity or specialized ones with energy-saving spraying (oxides of tin alloyed with fluorine (FTO), indium-titanium (ITO), indium (InO), silicon nitride (SiN) etc.) (Kolosvetova, 2019).

When designing multi-storey public or residential buildings, the use of an L-shaped or U-shaped building in plan should be avoided. With these layouts the building can be shaded that negatively affects the insolation of the premises. Also, the wind rose should not be forgotten. The least favourable are the northwest winds, characterized by increased gusts, coldness and strength. In this case, in the area where the wind data is the most severe, the N-S orientation of the building is unfriendly. However, if such an arrangement of the building is necessary, the facade exposed to gusts of wind can be protected by a closed gallery or solid loggias. Prevailing winds can also have a positive effect on buildings, as they help to create natural ventilation of the premises that makes them more comfortable in high humidity or temperature (Подкопаева & Шехватова, 2021).

Another aspect of orientation that is soothed by the presence of daylight is the subliminal desire of people inside the building to keep in touch with outside world just to better perceive information about the weather or the time of day. For instance, in shopping centres with no daylight people often feel themselves disoriented. Also, many of them have trouble to find exits (Phillips, 2004, p. 11).

3.3 LOCATION

A comfortable environment for a person is determined by two parameters: physical and psychological. Access to solar radiation, its thermal and visual effects are usually vital for the inhabitants of the interiors.

During the day, sunlight can provide a higher level of illumination and safety, but too much of it can have the opposite, detrimental effect.

Consider the effect of sunlight on several examples from different climatic zones.

NORTHERN CLIMATE

A temperate and cold climate prevails in most European countries. There are pronounced four seasons - not hot enough summer, cool spring, cold autumn and very cold winter.

Here the amount of sun received in the sky fluctuates greatly throughout the year. The sun either constantly shines overhead or does not appear at all due to the horizon.

For instance, in some northern Scandinavian cities, such as the tiny Norwegian town Rjukan, the sun does not often pamper residents with its visit.

The city is in a deep valley among high mountains. Therefore, a cold winter lasts from September to March, and at this time of season there is practically no sun. Without sunlight some people became depressed, because it seemed that the gloomy grey of winter penetrates right under the skin.

Local artist Martin Andersen (Geddes, 2017) said: “More than other places I’ve lived, they like to talk about the Sun: when it’s coming back, if it’s a long time since they’ve seen the Sun. They're a little obsessed with it!"

People quit their jobs and left because they could not stand life in the dark. However, in 2013 the problem was solved. On the top of the mountain, at a height of about 450 meters, three huge mirrors were installed, each with an area of 28 m². The reflective surfaces are controlled by a computer system and rotate to

follow the sun every 10 seconds, providing constant illumination of the central square of Rjukan in 600 m².

Thus, the Mirror project is now bringing the long-awaited light to the Norwegian city, which used to be in darkness for up to eight months (Кирик, 2020).

SOUTHERN CLIMATE

In southern countries, there are no problems with the amount of light received. On the contrary, it is so abundant here that people either do not go outside at all during the day or hide in the shade of balconies or trees.

The Mediterranean climate is characterized by long and dry summers, short winters and warm autumns and springs.

One of the main aesthetic advantages of Mediterranean architecture is the variety of balconies, terraces and patios, because it is just impossible to live in this climate without them. In the summer, the premises are equipped with workplaces controlled by special sun protection devices. This provides shelter from excessive sunlight causing overheating and blinding (Darulaa, Christoffersen, & Malikova, 2015).

Low-rise buildings, as well as relief became one of the main assets of the Mediterranean region in architecture. This factor is also facilitated by the desire to make houses earthquake resistant.

There are many tiny houses with varied exteriors. For the locals, the conditions dictated by nature are not at all considered as advantage, but rather a given that they have to live with.

One of the general requirements for the design of houses in areas with a tropic climate is their protection from natural light that depends on the conditions of external lighting. Its intensity comparing to a temperate climate increases the level of insolation of the premises by about 4.5 times and amounts to about 280 lux (Соловьев А. К., 2018).

3.4 COLOUR

The whole multifaceted play of colouring of nature can be observed mainly in the morning or afternoon, at the time of day when nature is illuminated by the sun. On a dark night, it is almost impossible to distinguish neither coloured nor objects at all. Therefore, light is necessary for colour recognition. Despite the wide range of different light sources, the sun is the strongest and most significant one, giving the most opulent and spectacular colouring of objects (Лепикаш, 2020).

Sunlight at noon in a clear sky may appear white or yellow-white. Firstly, because yellow is the brightest part of sunlight. And secondly, gases in the atmosphere diffuse some of the blue light passing it to the sky tone.

Objectively, there is no such thing as "white light". This is a phenomenon created by our brain. In other words, "white light" is a mixture of light frequencies (Figure 11).

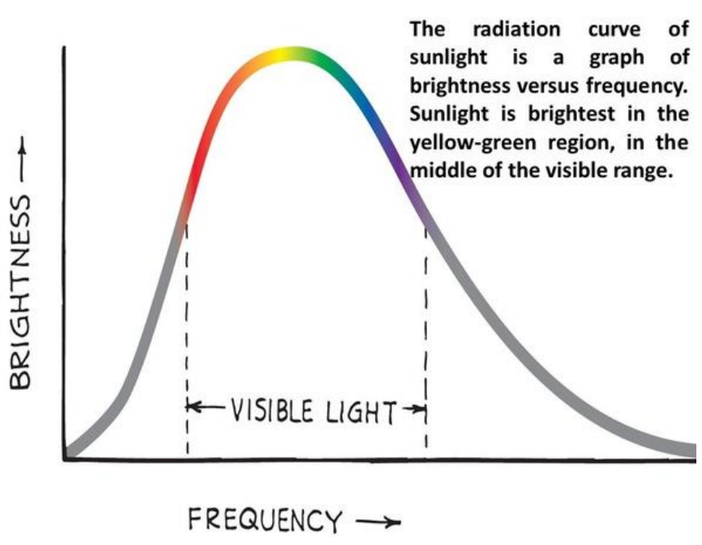


Figure 11. Sunlight emission curve (Adams, 2020).

Thus, sunlight above the Earth's atmosphere is a mixture of all the colours of the rainbow, as well as X-rays, radio waves, gamma rays, and everything else in the electromagnetic spectrum. Without any gases to diffuse the blue colour, it appears white to the eyes.

However, the number of different frequencies of light coming from the sun varies. Yellow is the brightest one from them.

If the sun is at the horizon its light passes through the gases and it is also absorbed by dust in the atmosphere. When all the blues, greens, and some yellows are dispersed the sun appears dimmer with shades of orange and red (Adams, 2020).

In architecture an interior colour-light environment is formed inside the objects interacting with the surrounding context. Colour is a method of shaping here that is able to highlight both the size of an object and draw the attention of its individual elements and details. With its help, it is possible to visually transform items, to enhance certain qualities of a configuration.

Due to the light, objects are perceived as three-dimensional, and it becomes realizable to make colours visible. In most cases, in open space, the tone of objects directly is contingent on natural light, its direction and intensity. The shade of the surface of an architectural form depends on how much of the rays will be absorbed and how much will be reflected. If sunlight hits the surface directly, it creates a deep shadow, thereby highlighting the structure and shape of the object. With diffused light, the shadow falls more thinly that creates the appearance of the plane of the object merging against the general background. The brightness or, contrariwise, the dimness of the light in the room allows people to distort the perception of the tone of the object. So, in bright light the human eye begins to go blind and the ability to distinguish colours sharply decreases, because they are perceived more faded, yellowed, and when there is an insufficient lighting, the shades of items become barely distinguishable (Nikitina & Shiryaeva, 2021).

3.5 IMPORTANCE OF VIEW

Recently, an increase in the built environment, as well as a growth in population density has led to dense cities, where there is a decrease in natural, landscape areas and, as a result, buildings are forced to put up with more restricted daylight and views. Nowadays, an actual problem is people's concerns about

the energy and carbon footprint of buildings. Many entrepreneurs strive to design zero-energy buildings that leads to tightening of energy efficiency norms and standards.

Real estate development mainly due to financial pressure brings about deeper and taller buildings, reducing the amount of sunlight and views received per square meter. Therefore, many standards impose prescriptive limits on window area to reduce energy consumption that also restricts design options for views and daylight.

Windows and the views from them have a profound effect on many aspects of physiology as well as human health and well-being. This includes sleep patterns, blood pressure, memory formation, hormone release, immune response, and even body temperature (Lee, Matusiak, Geisler-Moroder, Selkowitz, & Heschongd, 2022).

At the end of the 20th century Professor Roger Ulrich (Ulrich, 1984) in a study of 46 patients recovering from surgery, found that the view from the window of the ward to the forest had a much more positive effect on the recovery process than the view of a brick building. Patients not only recovered faster, but the convalescence process itself was less painful. Studies have shown that intensive care units are often without windows, which provokes depression, hallucinations, disorientation and partial memory loss. Moreover, this significantly delays the recovery process (Plaksina, 2021).

However, the boundary between the home and the outside world affects emotions, so "letting the outside world into the house" should be limited. Full-wall windows cause a sense of danger and anxiety, while too small ones provoke stress due to insufficient visibility. The need for shelter to survive is balanced by the desire to have a spectacular view. The requirement for an exciting view is due to several reasons that are a consequence of the lifestyle of our ancestors. One of the reasons is the instinctive desire to see any threat in advance to prevent the invasion of enemies and predators. Another reason is that the panoramic view allows you to explore the area in search of food and water and assess weather conditions.

So, in living quarters it is important to strive for harmony between a panoramic view and a sense of security (Shamaeva, 2020).

4. MENTAL HEALTH AND EMOTIONAL MOOD

4.1 MENTAL HEALTH

Despite the constant improvement of light sources up to modern LED - daylight, as before, is the main component in human life. In the morning and at sunset, the light is subdued and warm, with a yellow tint. During the day it is white and much brighter. The blue spectral component suppresses melatonin and activates cortisol.

Such a spectrum of radiation due to the correct use in a certain amount and depending on the time of day has a positive effect on a person's performance, his vigilance, reaction time, mental and physical activity. In turn, radiation in the yellow spectrum is also necessary for the body, since under its influence the body relaxes and replenishes vitality. Thus, by changing the colour temperature and light level humanity has the opportunity to influence their well-being and mood during the day (Shamaeva, 2020).

Life on earth is possible only thanks to the sun. Daylight is necessary for the normal functioning of human biorhythms, and it is substantial for metabolism as well. It has been established that under the action of sunlight, vitamin D is produced, which promotes the processing of calcium. There is no sun - the bones become brittle, the teeth crumble, the hair falls out, the nails exfoliate, the skin peels off. It is believed that 15 minutes spent in the sun per day is sufficient to benefit the human body (Залетов, 2012).

There is a pineal gland in the human brain - an endocrine gland. It is responsible for the production of the hormone melatonin, which regulates the body's internal clock. If the content of melatonin in the organism decreases, or on the contrary, is produced too much, then biorhythms can fail that leads to rapid aging of the body (Stulikova & Terentyev, 2018). Due to the hormone melatonin human circadian rhythm system regulates periods of activity and sleep. Without exposure to the normal 24-hour day/night cycle, a person's sleep/wake cycle can be disrupted. An unbalanced set can lead to progressive or delayed sleep phase disorders, as well as chronic sleep deprivation.

The lack of daylight inside a building does not necessarily mean the end of the world for its occupants. Exposure to bright light at the appropriate time of day and for the appropriate duration can alleviate these disorders. But only daylight can provide such an impact at the optimal time for a person and with an optimal duration.

Light can have a positive impact on a person's condition, invigorate him, create a comfortable environment and thereby increase labour productivity, but it can also suppress. The darkness of the night is critical to a healthy sleep-wake cycle. To keep melatonin suppression to a minimum one should be exposed to light at night as little as possible, and that light ought to be dim, warm or red (LightContract, 2014).

4.2 EMOTIONS

Natural light in the context of architecture affects, first of all, the emotions of a person, a viewer. Throughout history, in one form or another, light has been used to enhance the emotional perception of a building and strengthen the connection of a person with the internal space of an architectural structure, emphasizing architectural techniques, volumes, shapes and silhouette of a building. Concepts such as plasticity, rhythm, volume, materiality in architecture are directly interconnected with light and depend on the physical nature of natural light.

Daylight also affects our mood. There is a concept as "winter blues" that occurs during the dark season. "Winter depression" or "light deficiency depression". In particular, residents of the northern Scandinavian countries suffer from this.

There is even a Light Café in Stockholm and bus stop in the Umeå, Sweden, with illumination of real "shower of light" that is supposed to protect citizens waiting from winter depression (Figure 12).

Figure 12. The bus stop in the Umeå, Sweden.
Photo: Ola Bergengren.

These measures are quite questionable since neither the spectral composition of daylight nor illuminance can be simulated. Nevertheless, these experiment shows how significant daylight is for people.

After all, in the light, the body produces the hormone serotonin, which is responsible for the emotion of "happiness". Thus, to maintain a good psycho-physiological state of the body, it is necessary to receive a sufficient dose of solar radiation and healthy sleep (Stulikova & Terentyev, 2018).

The sun stimulates the production of "pleasure hormones", that is why sunlight is considered to be the best natural antidepressant. Its positive influence also extends to the sphere of interpersonal relationships: if the cold encourages us to "close", then the sun, on the contrary, "opens" us in relation to the outside world and others. That is why in the summer it is more effortless for us to make new friends.

The energy of happiness comes from the sun (Залетов, 2012).

5. DAYLIGHT IN THE WORKS OF ARCHITECTS

Throughout the history of architecture, the principles and techniques of chiaroscuro modelling of the artistic image of the interior space of buildings have been studied in architectural theory from a utilitarian standpoint of comfort. However, the main attention was paid to the material and functional aspects of light zoning, while the conceptual and moral components remained of little demand and were insufficiently explored.

Over time, sunlight in architecture began to be used to express the semantic and emotional-spiritual state of a person and the environment. A significant role in the emergence of feelings or perception of the architectural environment is played by lighting solutions formed by means of natural light. Its rational use helps to create the necessary mood and meaningful emotionally filled image.

5.1 TADAO ANDO

The most striking examples of using variability of lighting are works of the Japanese master Tadao Ando. In general, modern Japanese architecture is characterized by the flexibility of space, which the master uses gracefully. Without departing from cultural traditions there is an access to natural light and open landscape in almost all of his facilities. At the same time, the facades of the buildings are minimalistic, and the spacious interiors are always filled with sunlight. Lighting of the architectural space is built on the principle of using halftones: light penetrating into the room is reflected from the surface of the earth losing brightness and goes in an upward flow.

The master's creations fully reflect the philosophy of the Japanese, suggesting that the space between man and the universe is filled with a special substance that rises above forms and time. Konovalova N. A. (Коновалова, 2009) – the researcher at the Department of the History of Architecture and Urban Planning – wrote that the use of bright light in Japanese architecture is not common, and the function of darkness is used as an additional barrier to the most important architectural details. The use of direct sunlight is not accepted either in the architecture of residential buildings, or in sacred constructions, since the Japanese prefer indirect lighting from diffused light.

In Japan, penumbras are instrument for creating a certain mental state of a person. The functions of diffused light are laid down when forming the concept of a future project to create the right mood. Traditionally, the ideology of Japanese architecture is that nothing should prevent immersion in the atmosphere of the formed architectural and artistic image. It is presented as a source of emotions, helping to achieve a certain state of mind.

In the exterior and interior of the most famous creations of Tadao Ando is the Church of Light and the Chichu Art Museum that also traces the influence on the formation of the spiritual world of man and the impact on human feelings, psyche and physiology.

The concept of the project of the Church of Light is spirituality, religious fusion, commonality of religions, cultures, nature and people with its unique location with maximum use of sunlight in the morning hours. At the same time, the church has an elementary architectural form - a concrete rectangle with a slot made in the shape of a cross. This combination brings natural peace and tranquillity, the task is to shield parishioners from the unrest of external worldly life and direct them to search for inner spirituality and loveliness (Bazhenova & Suvorova, 2019).

The interior is practically absent: bare concrete walls, rough dark wood floors and benches, an organ. The only compositional accent in the interior is the light aperture that embodies the main symbol of Christianity. The rays of the sun passing through it forms a burning cross (Figure 13-14), symbolizing the sacred path or the desire of the soul for the Divine light from the limited dark space of the physical body.

The main component of the interior of the temple is its emptiness, due to which attention is not concentrated on the environment, but moves on to the thoughts and feelings of the parishioners.

Through the combination of natural light with dark tones of concrete and wood a philosophical, emotional and intellectual dialogue between architecture and man is formed. Everything is focused on contrasts here. As in traditional Japanese architecture, light is opposed to darkness, solid concrete walls to the asceticism of the interior, and the strength of concrete to the fragility of glass. Therefore, as a feature of the architectural solution of the church, the raw surface of the walls and the lack of decorations can be highlighted (Erzen, 2003).

The Chichu Art Museum (Chichū Bijutsukan) is the clearest example of modern architecture that includes various art objects. Each site is unique in its own way. The literal translation of " Chichū Bijutsukan" is "Museum of Art in the Earth".

This is a place where you can feel the special relationship between nature and man. The name of the museum is based on its location inside the hill. The concept of the author's project was aimed at preserving the historical landscapes of The Seto Inland Sea.

Despite the unusual location of this architectural object, the primary thing in the underground space of the museum is natural light. The exterior of the museum is ideally combined with the external environment, maintaining a balance between the building materials used and light. The central artistic element of the museum complex is an open-air oval hall located on a hilltop.

In addition, the master placed a completely open part of the roof in the form of an ellipse over the pool, which was called the "Pond of Reflections". This technique made it possible to cover this space exclusively with daylight. At the same time, direct sunlight enters the building that through natural interference is reflected from the surface of the water. The basic focus is on sunlight and shadows in the glare of the water.

Figure 13. The Church of Light, 1989. Arch: Tadao Ando. Photo: Ahmed Serbest.

Figure 14. The burning cross in the Church of Light, 1989. Arch: Tadao Ando.
Photo: Mith Huang/flickr

Figure 15. The Chichu Art Museum, 2004. Arch: Tadao Ando.
Photo: Jonas Bentzen.

5.2 LOUIS KAHN

Louis Isidore Kahn is one of the outstanding and significant American architects of the second half of the 20th century. Exploring the nature of architecture, he comes to the logical conclusion that light is one of its most important components.

Kahn avoided using direct sunlight. In his works windows or doorways are almost always hidden behind shutters or a secondary wall. In this way, indirect penetration of natural light is ensured, which is scattered and reflected. Due to this the viewer's attention is not focused on the light source, but on the effect it produces.

Each specific form of the opening introduces certain light and shade modelling features into the composition: windows of the correct shape, clarity of shadows that changes only their length and angle of incidence (Tomova & Kropacheva, 2019, p. 31).

In the **National Assembly Building** (Bangladesh, 1962-1983), the architect creates the space filling it with light, shadow and air. Following the key design principles developed over the years of practice allow Louis Kahn to optimize the structure of the space and at the same time convey the spirit of the ancient culture of Bangladesh. The monumentality of the ensemble is in some extent concealed by the surrounding space. Also, the nearby lake reflects the building, adding completeness to the composition and transforming it into an elusive unsteady image that tells about the transience and variability of life (Быстрова, 2012). Each window in the National Assembly has an individual configuration, including a window opening and strengthening of window fittings, which serves to accumulate shadow and light in the interior (Figure 16-17).

Window openings are taken by mullions pressed into the depth of the walls and have various shapes: rectangle, triangle and circle.

Louis Kahn not only loved the ordinary shapes like circles and squares, but they were also the central figures in his architectural geometry. He transferred them from the horizontal of the plan to the vertical of the facades and internal walls. The gigantic scale of vertical motifs in his compositions immediately made Kahn's handwriting unique and inimitable.

An example of masterly use of sunlight is the **library of the Phillips Academy** in Exeter (USA 1973) (Wiggins, 1997, p. 58) Kan leads the visitors from shadow to light, thereby making the process of obtaining books more dynamic. Here the window openings are turned into internal partitions. There is an empty space in the centre of the building - a large hall that is illuminated by natural light from above (Figure 18).

All four facades of the library in New Hampshire are structured in the same way, with the entrance located on the north side. The space has the shape of a cube formed on the basis of elementary geometric shapes (square, circle, diagonal) and their ratios. The magnificent brick and concrete building has a basement and a central part, as well as an attic. The supports expressively narrow as they move upward, depriving the archetypal-simple forms of the construction of monotony. Between them are two-tiered windows, the lower part of which is made of wood. Next to it are niches for reading and large glass surfaces allow full use of sunlight during the day (Быстрова, 2012).

Moreover, one of the fascinating works in terms of protection from direct sunlight is the **American Consulate** in Luanda (Angola 1959 - 1962). In order to achieve ideal lighting, the architect uses additional wall-screens that have been stand at some distance from the main openings. Shutters or sunscreens - devices for protecting window openings from excess light are presented in the form of frame structures of various configurations. Depending on weather conditions, the shutters can be open (creating dropped shadows of a rectangular nature) or closed (creating light planes, without obvious shadow accents). „…And I thought how wonderful it would be if one could separate the sun problems from the rain problems…" – said Louis Kahn (Kahn, 2003, p. 99) on the discussion in 1961. Therefore, the architect fabricates a second roof, independent of the main one to protect from the sun. The material for it is light-refracting tiles that forms a kind of lattice that lets in the rain, but not the sun.

The **Kimbell Art Museum** in Fort Worth (USA, 1972) is also an example of masterful handling of natural light. Art objects require special, unique lighting, which is provided by a competent choice of constructive structure and method of light supply.

The volume of the building is formed with six cylindrical vaults, one of which faces the street, while the others form galleries and storage rooms. In the museum Louis Kahn created diffused lighting. According to ancient Greece design, Kahn made sure that the sunlight penetrated through the narrow lanterns at the junction of the halves of the vaults, and was reflected from the metal reflectors. They distribute it further up the barrel vaults and down onto the walls. The vault does not perform a constructive function, but becomes a way of transmitting light. The light seems to envelop the concrete surface, softly blending with the warm reflections of the white oak floor. There is no reflective glare in the paintings that improves the perception effect (Tomova & Kropacheva, 2019).

L. Kahn proclaims two interrelated concepts in his architectural program. It is silence and light (Desvaux & Tordesillas, 2017). It is light that allows silence to express its voice, to show its architectural and aesthetic dimension. After all, silence can be creative, thanks to the light.

Thus, the space in modern architecture is experienced more sensually, physically, through the impressions that arise in a person. Light, along with facture, texture and form, becomes one of the tools of emotional impact. Louis Kahn was constantly looking for a harmonious fusion of space and light. He refused the artificial climate, always strove not for the maximum, but for the necessary lighting. It can be said that in modern architecture and in the architecture of Louis Kahn, light does not touch the body, but the soul.

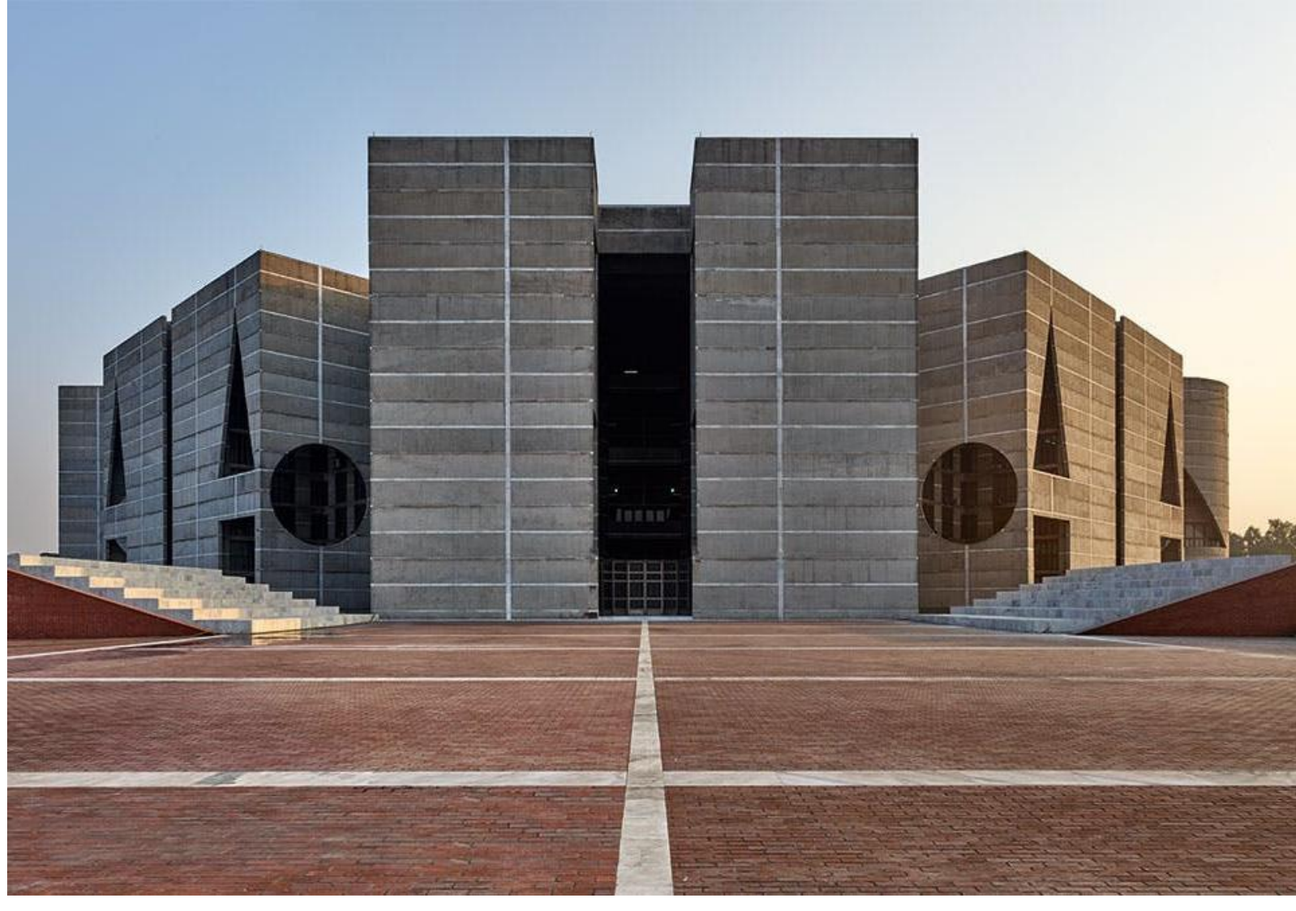


Figure 16. The National Assembly Building of Bangladesh. Dhaka, 1983. Arch: Louis Kahn. Photo: Cemal Emden.

Figure 17. The interior of National Assembly Building of Bangladesh, 1983. Arch: Louis Kahn. Photo: AKTC.

Figure 18. The atrium of Phillips Exeter Academy Library. New Hampshire, 1972. Arch: Louis Kahn. Photo: Carol M. Highsmith.

5.3 DANIEL LIBESKIND

The passionate desire to rethink the architectural activity has made Daniel Libeskind one of the brightest figures in world architecture. The depth of his personality, the philosophy of the creator are reflected in each creation. His unconventional take on contemporary architecture breathes new life into an unshakable world of frozen stone, glass and concrete. For Libeskind, there are no static, motionless forms; the flight of his imagination embodied in any structure can only be compared with music.

A powerful emotional response comes from the museums of a famous architect who publicly deconstructs the concept of a plane and a wall. Libeskind is known as the architect of three Jewish museums. The most striking of them – the Jewish Museum in Berlin is a zigzag, space-slicing, very aggressive building with frighteningly narrow rooms and slit windows (Figure 19).

In the architecture of Libeskind, the building adapts the objects inside; the primary thing for an architect is not to show a specific object or historical document, but to make the visitor feel it (Dedovec, 2016, p. 11).

Daniel Libeskind considers light as an element capable of linking the past and future with the present. Revealing the concept of the "Jewish Museum", the architect says: "The light is something that penetrates through, a sharp point where you come to realise something about the past, which is also about the future. Suddenly, you see light in a different way, and yourself too." (Libeskind, 2015).

In such a building, the outer shell predetermines the interior, and the way information is presented, while in the global museum tradition, architecture should provide the creators of exhibitions with maximum freedom.

The view of the museum from above resembles the split Star of David, that shines for him in the process of work and became not only a sign of the museum's Jewish theme, but also a symbol of the tragic fate of the German Jews.

From the outside, the Jewish Museum is built in a trendy avant-garde style. The building, covered with galvanized iron, resembles a huge abstract sculpture and makes visitors feel as if they are facing an indescribable horror that loomed over the Jewish people during the era of German Nazism. Extensive surfaces of acute-angled facades on zigzag sections, lined with sheets of metal, are dissected by narrow rectangular window slits that look like scar cuts made with a knife. The appearance of the building creates the effect of having just survived a natural disaster and preserved its traces in the form of deep cracks and chips.

Any museum building must have volume, useful exhibition space and proper lighting. Therefore, Libeskind used enormous sections of the building's zigzags for expositions, each of which led to a certain stage in the history of the Jewish people. The architect revealed it in the complex geometry of the interior space, enhancing the emotional impact of the organization of light.

The construction is dominated by "spear-shaped volumes", narrow windows and random "holes-signs" punched in the walls do not illuminate, but only let sharp, thin rays through, evoking associations of Jewish existence "in the shadows".

The museum was originally planned and implemented in such a way that visitors would not only suppose, but feel all the hardships of the fate of the Jews in Germany. Once inside, visitors lose their sense of balance, as the floor of the museum is tilted, and efforts must be made in order to move forward to get acquainted with the centuries-old history. The building is organized in such a way that when viewing its architectural models, visitors soon begin to feel that the gloomy and oppressive spaces have "retraction properties", generating feelings of anxiety and disorientation, reproducing the vague feelings of those who were exiled (Супрыгина, 2008).

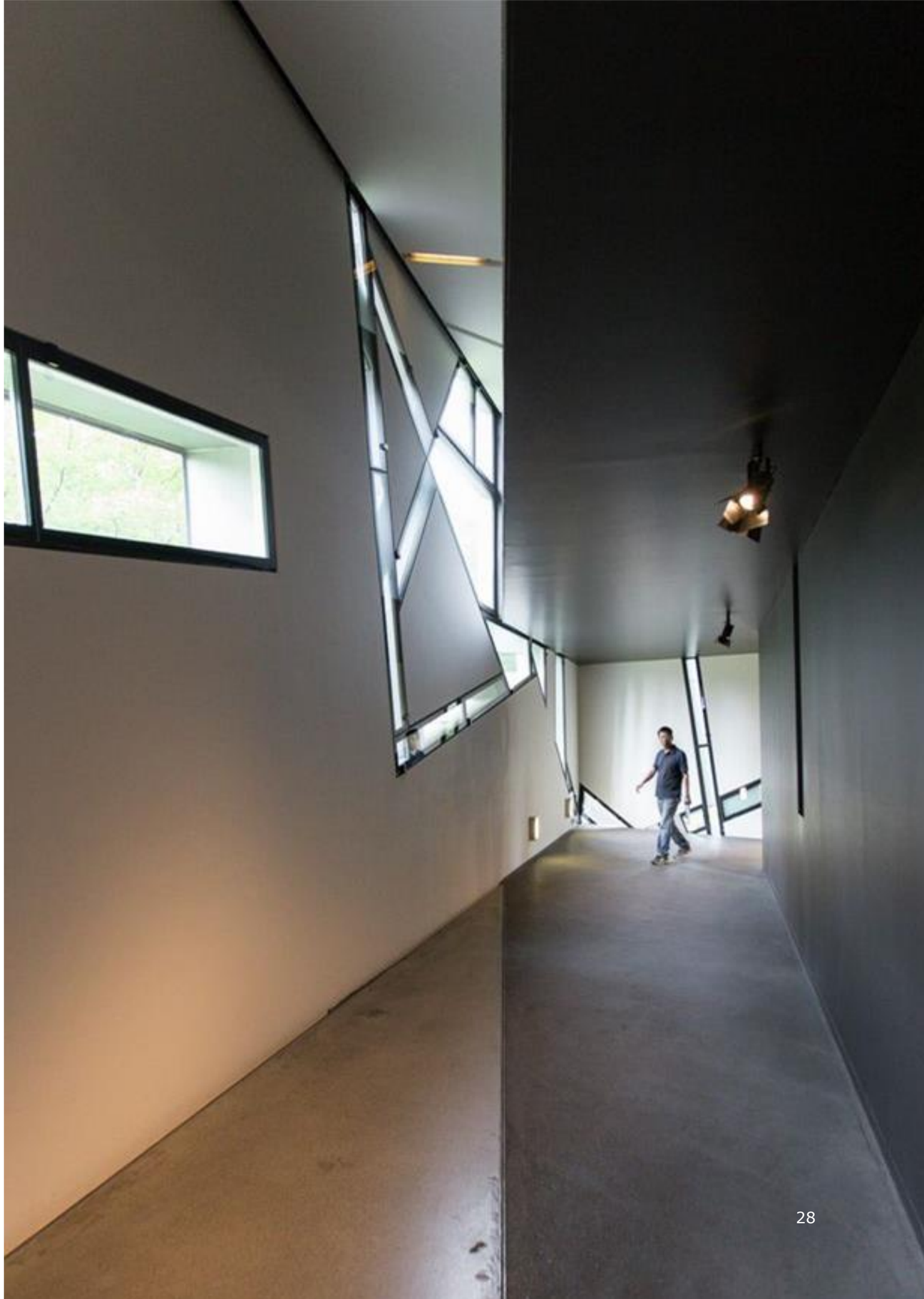


Figure 19. The Jewish Museum. Berlin, 2001. Arch: Daniel Libeskind. Photo: Laurian Ghinitoiu.

6. DAYLIGHT RESEARCH

6.1 THE ARCHITECTURAL AND THE TYPOLOGICAL MATRIX

To show and establish the importance of light composition in the interior Rockcastle, S. and Andersen, M. in their article (Rockcastle & Andersen, 2013) presented a survey to develop a better vocabulary about temporal and contrast variability in daylight conditions.

Rockcastle and Andersen created a matrix capable of covering a broad range of design typologies. It can easily compare any space on a relative scale from high to low, contextualize the perceptual impacts of daylight, and report on the composition of perceived luminosity in a space.

The main tool for developing this matrix was the trained authors' intuition. Each architectural example was positioned within a linear gradient to visualize the degree of spatial and temporal variability of daylight. The photographs were studied and evaluated against the indications of spatial contrast, after which its relative position within the gradient was discussed.

If individual images had similar contrast characteristics, they were added to the existing category; but when the images demonstrated their uniqueness, they formed a new category.

Thus, the final matrix consists of ten categories, each of which contains 5 exemplary spaces (Figure 20).

The matrix horizontal axis shows the linear value of the gradient from high to low spatial and temporal variability in the distribution from left to right.

50 examples from all over the world were taken for the research, where each of them combines different ideas (a diverse mix) of architectural designers. All photographs have been chosen for their valuable representational perspective of the interior space, and not by the way of a graceful, non-descriptive picture, which could be often found in architects' publications.

Using the matrix as a reference, 10 simplified spatial models were created, one for each category. These simplified spatial models make it possible to generate annual visualizations and compare the results obtained throughout the year (Rockcastle & Andersen, 2013).

Figure 20. Matrix of Spatial and Temporal Variability for Architectural Spaces (Rockcastle & Andersen, 2013).

6.2 PROBLEM STATEMENT

The Rockcastle and Andersen's research described only two top-lit space results. However, the full picture should be seen for the total understanding of the combination of light and shadows in the interiors, as well as their impact on human perception. And to achieve this, it is necessary to consider the results of all ten models.

Secondly, the Rockcastle and Andersen's models refer to a more southerly climate because their sun studies are from Boston, USA (42.4° N, 71.1° W). However, for this Master Thesis the indicators of Tallinn (59.4° N, 24.8° E) as the largest nearest city to Prangli Island is used as a site (Figure 21).

So the questions that the research part discussed are:

1. Are all the simplified models representing the matrix of spatial and temporal variability for architectural spaces applicable in the Estonian context?
2. What kind of emotions does a particular type of daylight distribution evoke?

6.3 OBJECTIVES

The main objectives considered in the Master's Thesis:

1. Reproduce all ten simplified typological models related to the matrix of spatial and temporal variability for architectural spaces;
2. Test the models for Tallinn latitude;
3. Create matrices from sunrise to sunset according to results.

6.4 TECHNICAL DATA

For the research each of ten typological models were digitally modelled in Revit (https://www.autodesk.com/products/revit, 2021) with consistent parameters for the floor area (5 x 7 m), ceiling height (3,3 m), and camera location that was positioned to face Sought and centred in East-West direction.

The room inside is painted with light grey colour. The walls and roofs thickness are 200 mm.

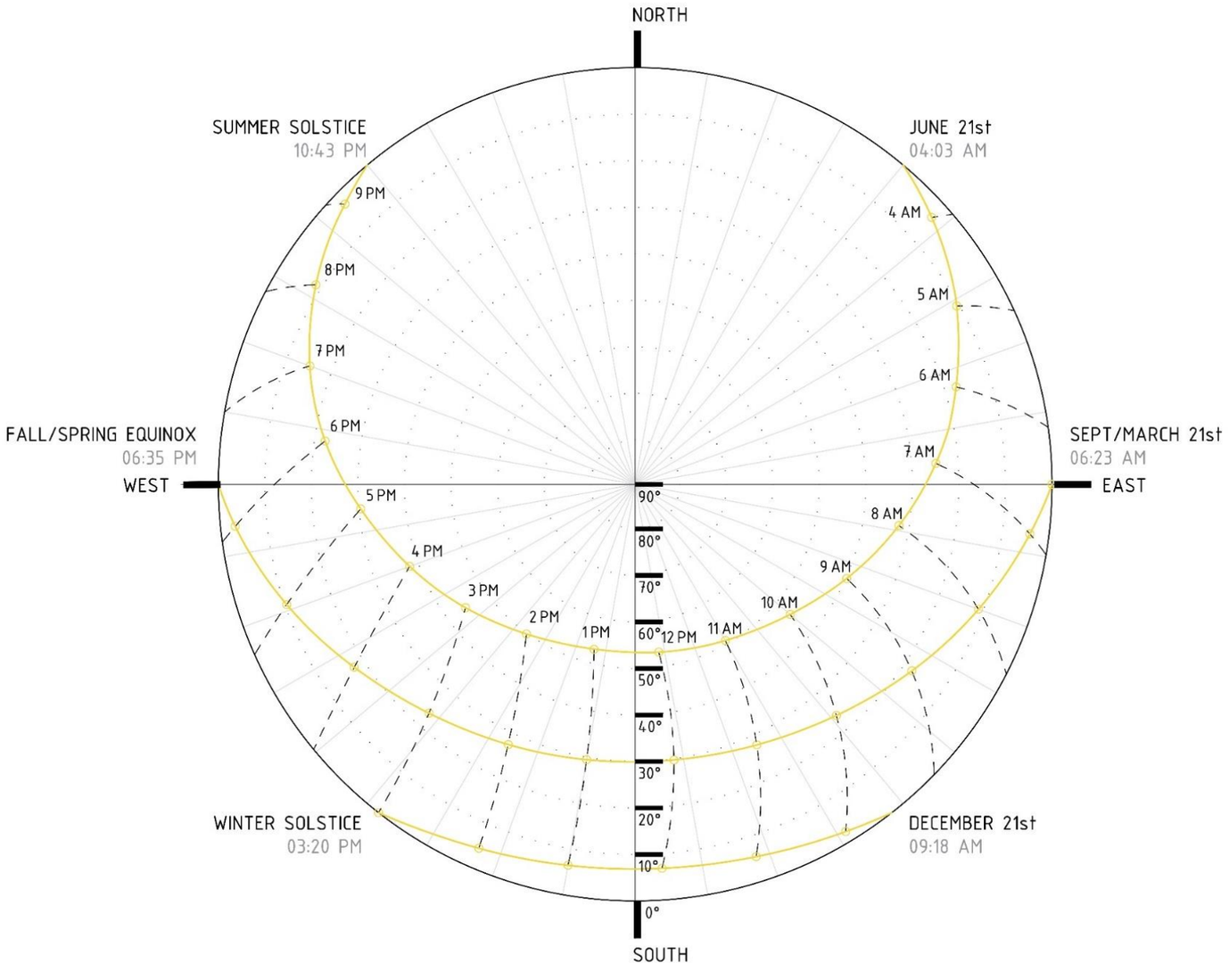


Figure 21. Sun Path, Tallinn (Thesis author).

6.5 TYPOLOGICAL MODELS

6.5.1 MODEL 1. DIRECT & EXAGGERATED SUNLIGHT

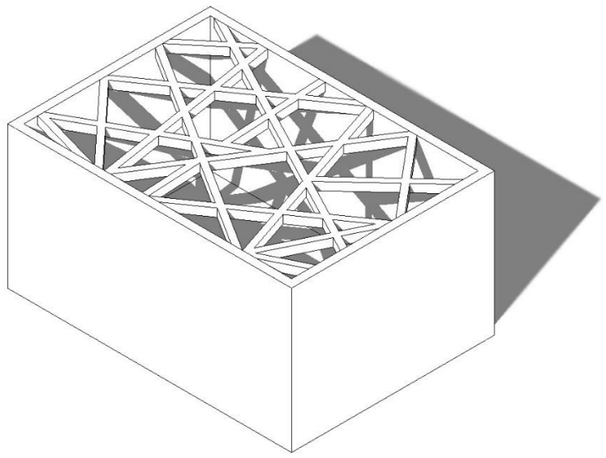


Figure 22. 3D model. Direct & Exaggerated sunlight.

The Direct and Exaggerated sunlight category includes a wide variety of top-lit spaces such as the Milwaukee Art Museum by Santiago Calatrava, OMA's Seattle Central Library, Kogod Courtyard by Norman Foster and Cite du Design by Finn Geipel and Giulia Andi.

The aim of Model One is to show a highly contrasted interior with variable composition and strength due to the inconstancy of dynamics of sunlight that enter the box leaving sharp corners from the silhouettes on the floor and walls.

The sun rays can penetrate the room without a hindrance mainly through the roof with thick beams (Figure 22). The windows are necessarily covered with a kind of large-gap grid, the shadow of which gives a spectacular and energetic space.

This type is not only well illuminated, but also causes a wide variety of diversified emotions. For someone intensive change of shadow on light and the game with contrasts awakes amazement, and for the others, constantly changing contrast can cause irritation.

It is important to note that even with the absence of clear sunny weather, this type of windows and the construction design will provide constant lighting of the room, although the emotional spectrum will be significantly lesser.

The sun study results (Figure 23) indicates that the model does not work to the full extent evenly throughout the year. The top-hours generally occur in the summer months, as well as a few hours before and after midday the chiaroscuro looks especially fascinating.

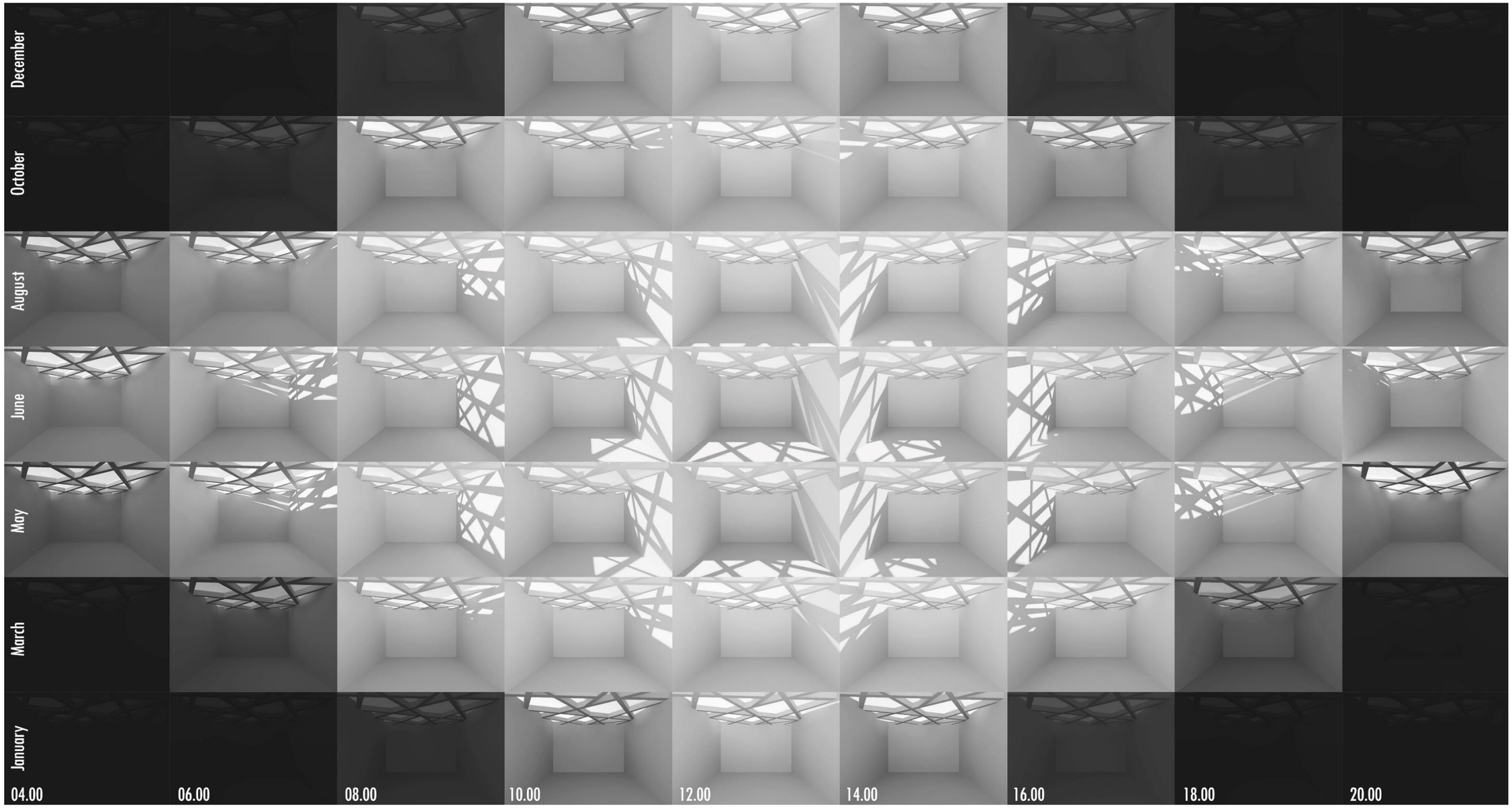


Figure 23. Model 1. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.2 MODEL 2. DIRECT & DRAMATIC

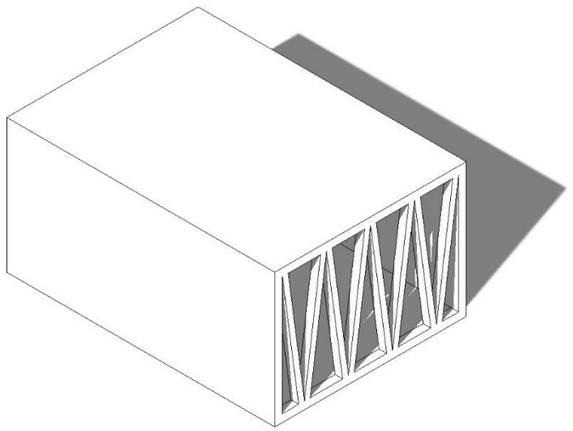


Figure 24. 3D model. Direct & Dramatic sunlight.

The Direct and Dramatic sunlight category includes side-lit spaces with large light patches emitted. For instance, the Zollverein School by SANAA, Jean Nouvel's The Gherkin, Prada Store by Herzog & de Meuron and Mikimoto Store by Toyo Ito.

The Model Two is quite similar to the previous specimen. It presents a highly contrasted interior with irregular composition of sunlight. However, the purpose of this model is to reduce the ingress of sunlight over the viewer's head, limit and narrow the picture perceived by space due to an overhanging low ceiling.

The sun rays can penetrate the accommodation through certain openings of various shapes to give it more drama (Figure 24).

The windows are large enough to light the room, but they have more solid wall area than The Direct & Exaggerated sunlight model. It is also important to note that the ceiling/roof is not used for illuminating in this model.

The level of received sunlight is great that penetrates through the windows immediately and in a straight line, creating spectacular shadow patterns and silhouettes on the floor and neighbouring walls.

The digital 3D model developed by Rockcastle and Andersen does not convey an accurate information about this type of sunlight.

The examples used in the Matrix of Spatial and Temporal Variability for Architectural Spaces (on the right of this page) involve at least two walls with uneven windows. Nevertheless, the typological designed model of the original version was used in compiling the light matrix (Figure 25).

The sun study results describes that the second model has the most engaging lighting solutions in autumn and winter seasons from sunrise to sunset.

From the top: 1. SANAA. Zollverein School, 2006. 2. J. Nouvel. The Gherkin, 2003. 3. Herzog & de Meuron. Prada Store, 2003. 4. Toyo Ito. Mikimoto Store, 2005.

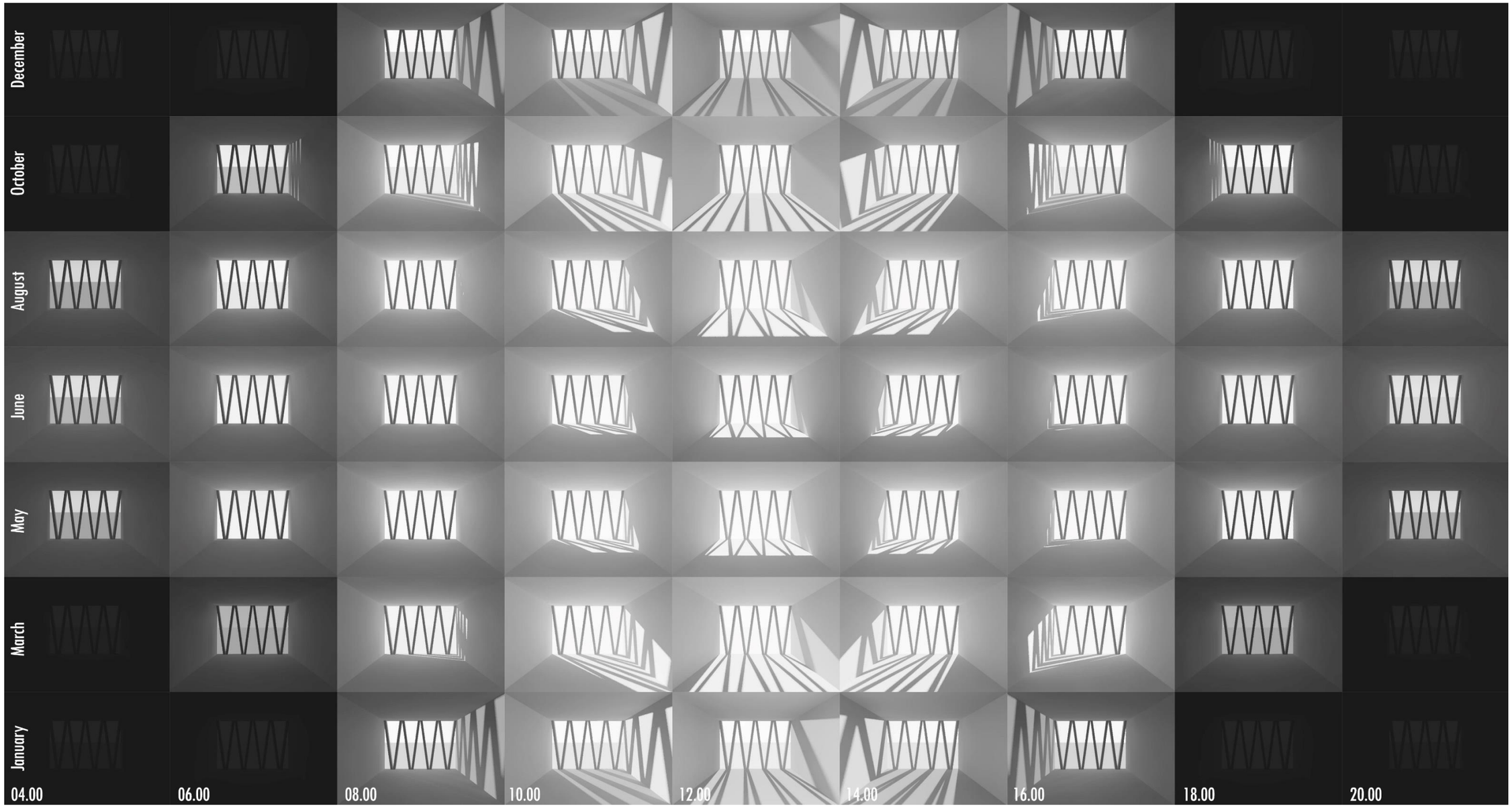


Figure 25. Model 2. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.3 MODEL 3. DIRECT & SCREENED

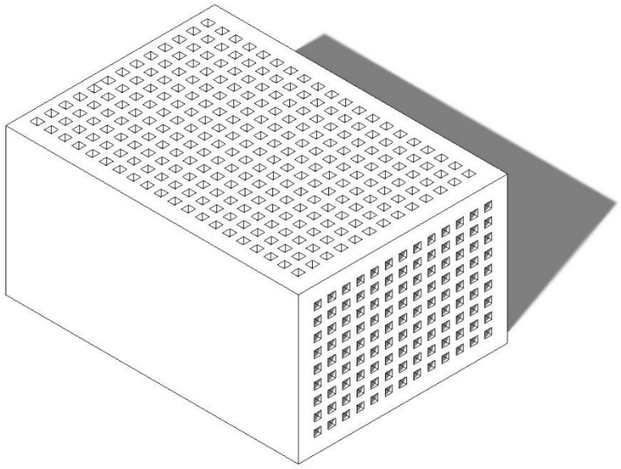


Figure 26. 3D model. Direct & Screened sunlight.

The Direct and Screened sunlight category contains examples of roofs and facades that emit small frequent patches from direct sunlight, like the Farmacias Benavides by Guillermo Hevia, Hiroshi Nakamura's Lanvin Boutique, Dominus Winery by Herzog & de Meuron and Jean Nouvel's Arab World Institute.

The orderly or chaotic, specific or abstract forms in massive quantities of tiny holes on walls and ceilings (Figure 26) cause frisky rhythm and create the effect of an increased accumulation of units per one sq. meter.

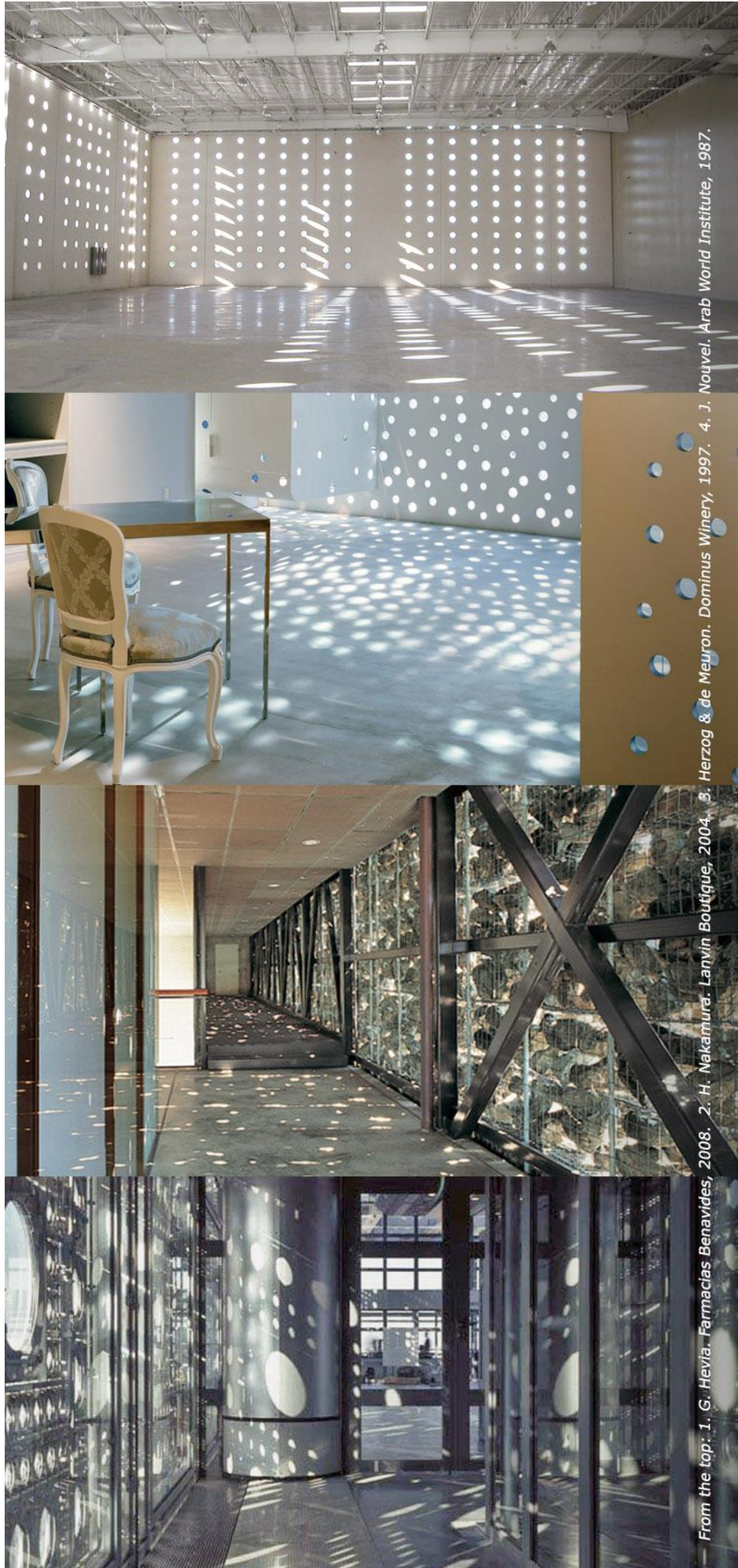
This type of sun lighting resembles a swarm of bees or a school of fish that moves smoothly around the room as the sun changes its position. And it is really amazing and delightful to observe the miniature silhouettes "running" around the room in the arms of shadows.

Windows as such are not used here. The small-scale openings, in average size of about 7 cm, are not glazed and are not meant to be looked through. This type of construction is more likely to be used for loveliness and articulating a particular mood, because the daylight factor in Model Three seems to be low.

The sun study results indicate quite dark interior views with an unremarkable summer season.

The most attention should be paid to the months from January to March and from October to December, where the shadows are stretched and take shapes that are no longer similar to primordial holes (Figure 27).

Very mysterious is the phenomenon at noon in May, where the solar angle is so high that no shadows are cast at all. The same can be seen in the month of August, where during the day the wall with its mini windows does not cast any shadow. Perhaps the reason is the rather thick walls.



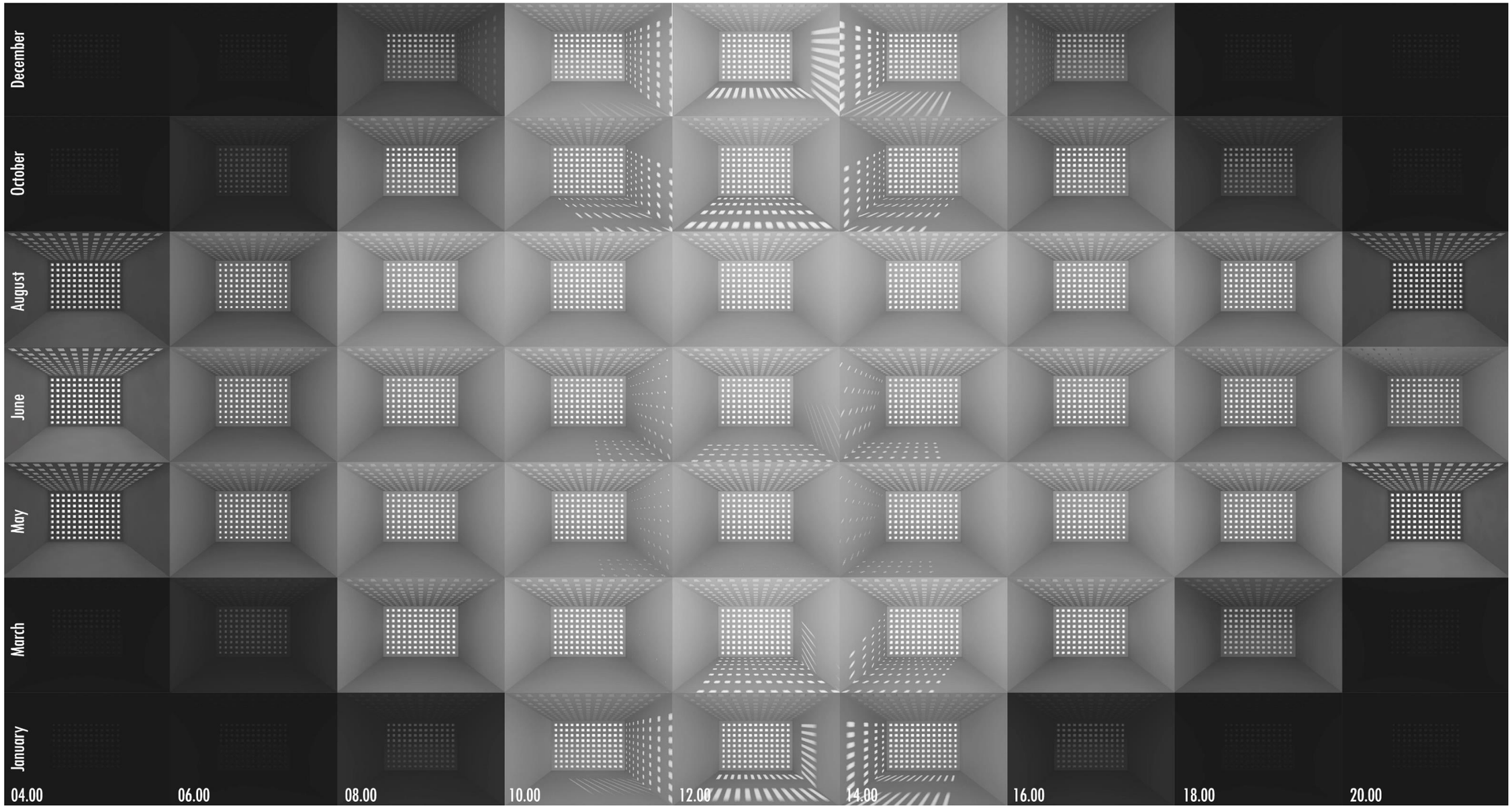


Figure 27. Model 3. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.4 MODEL 4. PARTIALLY DIRECT

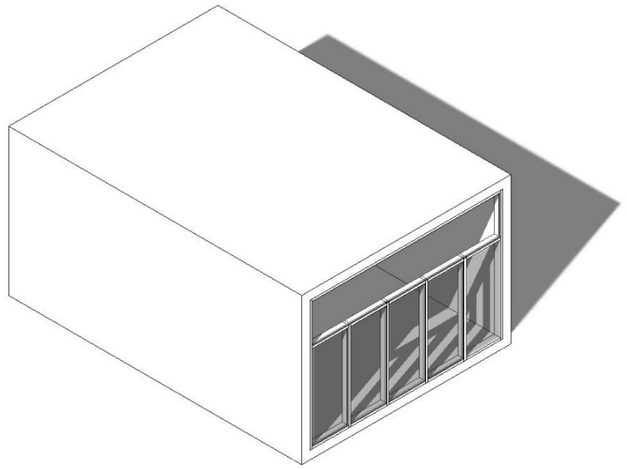


Figure 28. 3D model. Partially Direct sunlight.

The Partially Direct sunlight category contains side-lit spaces that allow sunlight through louvers, tinted glass or repetitive facade elements. The famous spaces from this category are Cambridge Library by William Rawn, Rose House by Engelen Moore, Glenn Murcutt's Magney and Fletcher Houses.

The purpose of Model Four is to simultaneously transmit both direct sunlight, that has no obstacles to enter the room, and sun rays, that are forced to seep through the curtain of blinds.

Thus, the Partially Direct model represents the shape of a parallelepiped, where one of the short sides is entirely designed for windows (Figure 28). The upper part, that makes up about a third of the entire wall area, has the typical glazed strip of windows, while the lower part is used to reduce the amount of direct sunlight penetrating inside.

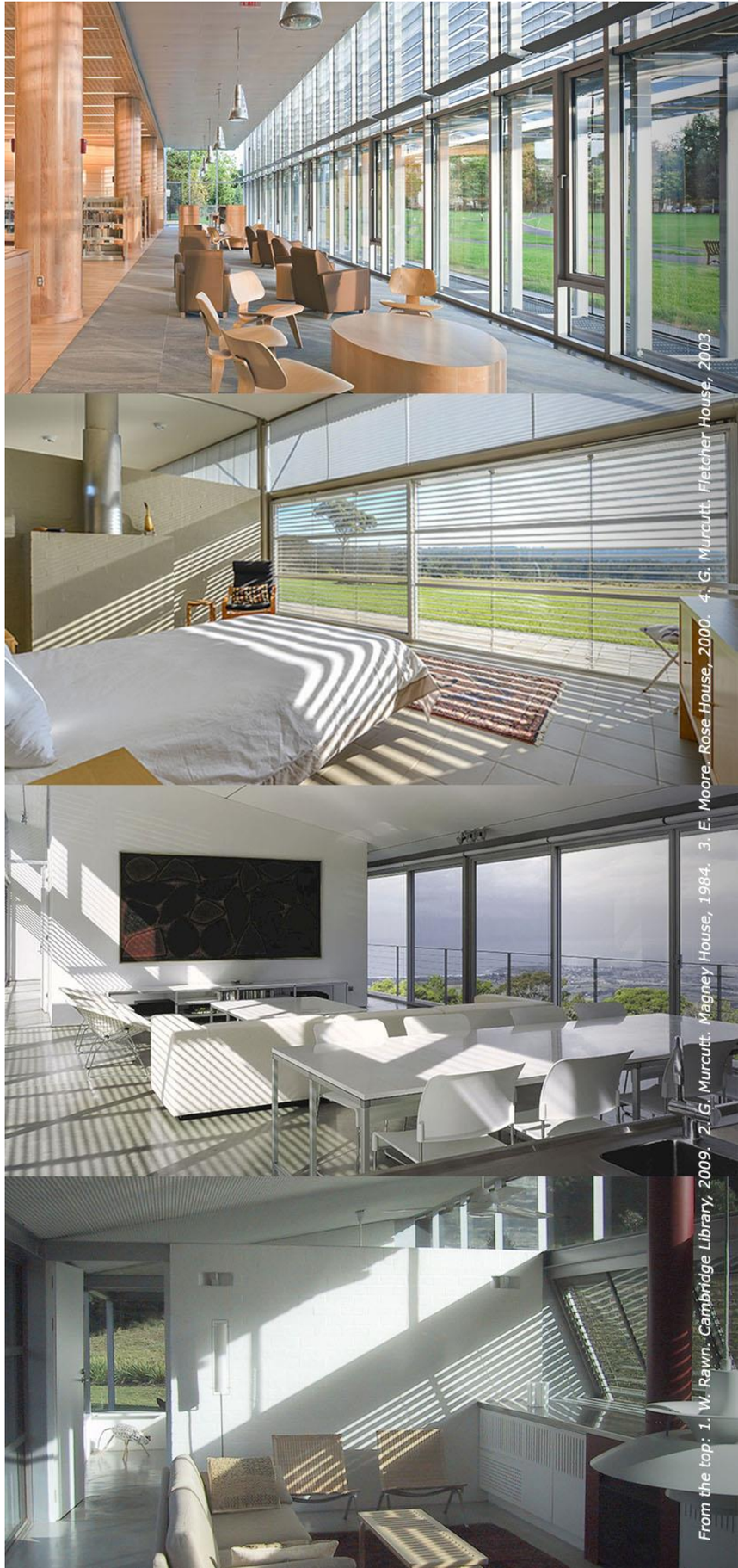
There are no sharp contrast transitions from light to shadow in this sunlight category. The light here lies on the floor and walls uniformly and smoothly moves around the room, leaving only alternating black and white stripes all around. The daylight factor is undoubtedly high and can even become a problem in the summertime, because due to the abundance of windows in the room air conditioning may be needed.

For the sun study in this Thesis tinted glass was used as a filter to drain out completely direct rays from partial ones.

The results of the study showed that the shadow is most playful between 10 AM and 2 PM throughout the year (Figure 29).

With such an arrangement of space, when the windows face exactly to South and the room has a standard shape, the sun does not penetrate inside either at dawn or at sunset. The only exceptions are the winter months when the solar angle is the smallest.

The longest shadows are also detected from December to February.



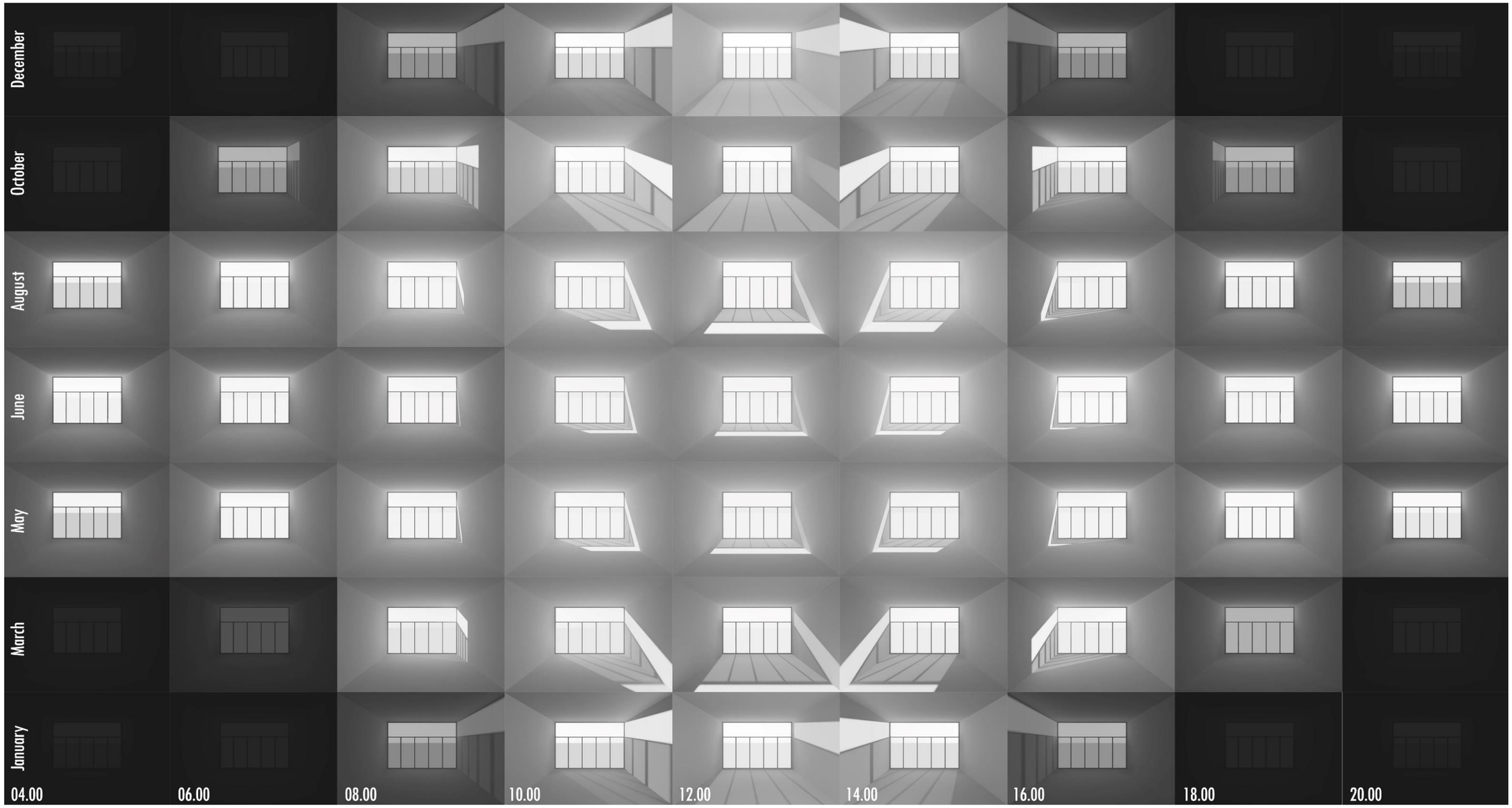


Figure 29. Model 4. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.5 MODEL 5. DIRECT

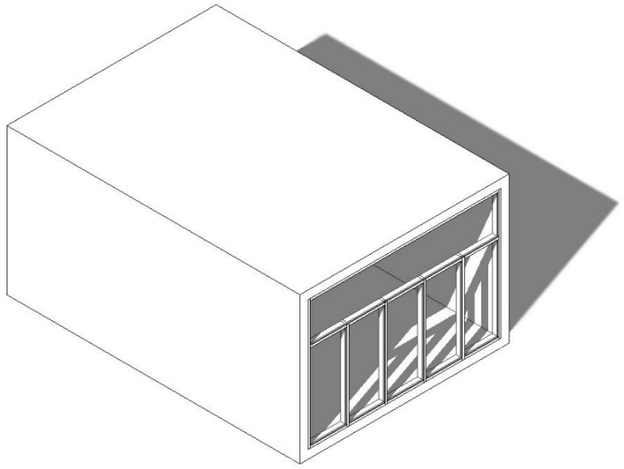


Figure 30. 3D model. Direct sunlight.

The Direct sunlight category is on its structure resembles the previous model – the space is side-litted, but with minimal obstructions (no louvers). For instance, Bombala Farmhouse by Collins and Turner, SANAA's Glass Pavilion, The Farnsworth House by Mies van der Rohe and Michael Bell's Prismatic House.

The Model Five is quite similar to the Model Four and has a prevalent use in contemporary design. And the reason for this is obvious - the purpose of the Direct sunlight model is to transmit the maximum amount of daylight through wide panoramic windows (Figure 30).

These, in turn, are located, as in the previous version, over the entire area of the wall of a rectangular box from floor to ceiling. However, in this version, the glass has a clean transparent surface and offers excellent views of the surrounding nature, creating a kind of spectacle.

This design is often referred to as an aquarium, since the vast open transparent windows seem to expose your essence, making it impossible to hide and feel safe. Although this is a purely subjective opinion, because how many people - so many opinions.

The sun study results indicate consimilar indexes with Model Four except for the use of tinted glass (Figure 31).

If the windows face exactly to South and the space has a simplified shape, the sun cannot penetrate inside either at dawn or at sunset. The exceptions are detected only from winter season.

Between 10 AM and 2 PM the games of light and shadows are more engaging, as well. However, the ability to see the full picture from the window without any obstacles is probably a much more significant factor for the perception of the atmosphere prevailing in the room.

From the top: 1. Collins & Turner. Bombala Farmhouse, 1997. 2. SANAA. Glass Pavilion, 2006. 3. Mies van der Rohe. The Farnsworth House, 1951. 4. M. Bell. Prismatic House, 2007.

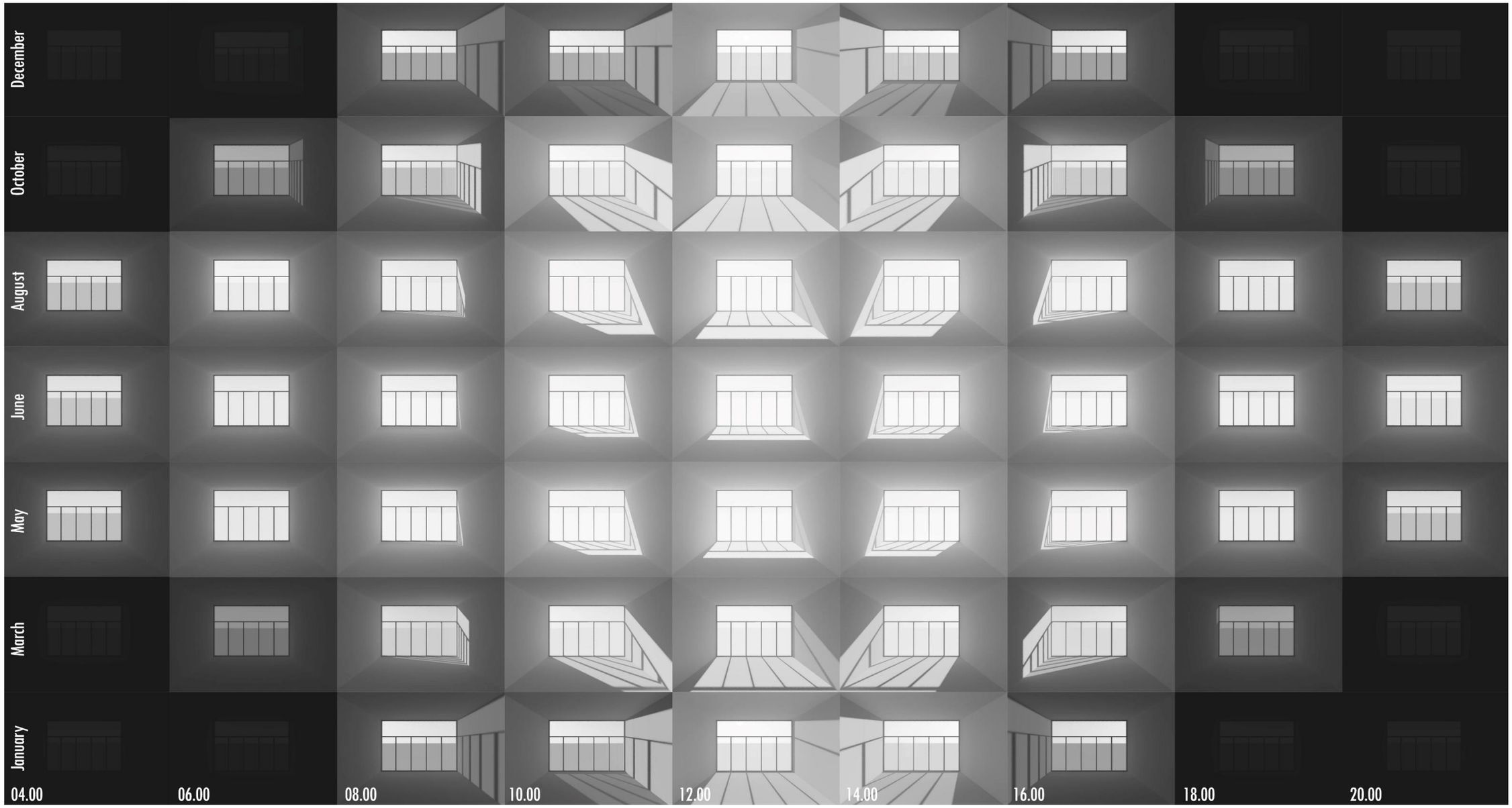


Figure 31. Model 5. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.6 MODEL 6. SELECTIVELY DIRECT

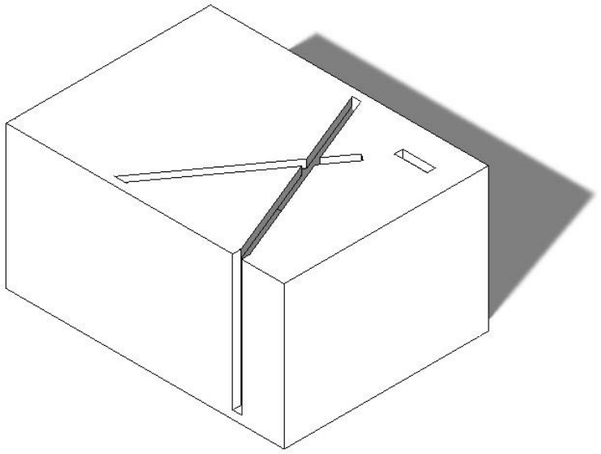


Figure 32. 3D model. Selectively Direct sunlight.

The Selectively Direct sunlight category contains the spaces that emit sunlight in restrain instances, such as The Royal Ontario Museum by Daniel Libeskind, Tadao Ando's Church of Light, Tulach a' tSolais monument by Scott Tallon Walker or Peter Zumthor's Thermal Baths in Switzerland.

The aim of Model Six is to show a high contrast between light and darkness in the interior with using insignificant number of narrow strips of light aggressively space related to each other (Figure 32).

The Selectively Direct sunlight model is probably the most exciting in the entire research. There are no standard windows for perception, and those gaps that are used to let light into the room are more like LED strips to decorate it.

Generally, the main task of this type is not illuminating, but the transmission of a certain mood and emotion to the viewer. The darker the interior with the narrow openings is, the greater imprint on a person such space leaves. It's like a long-awaited light at the end of the tunnel that will lead you out of the darkness. Or vice versa - it brings fear and helplessness to you, looking into the most hidden corners of the soul, so as not to leave you indifferent.

The sun study results for Model Six shows absolutely unique indicators since they differ significantly from each other at every angle (Figure 33). Silhouettes cast by the shadow have completely different forms, regardless of the month or time of day.

For example, huge crosses on the western wall after dawn in May or June cause horror, prohibition. While closer to sunset, the shadows become calmer and take on the appearance of closed figures.

The model itself is rather dark on the inside, since there is so little daylight coming through that it is unable to illuminate the room as much as it should be.

But nevertheless, this model has a very strong ground for reflection.

From the top: 1. Libeskind. Royal Ontario Museum, 2007. 2. T. Ando. Church of Light, 1989. 3. S. Tallon Walker. Tulach a' tSolais, 1998. 4. P. Zumthor. The Thermal Baths, 1996.

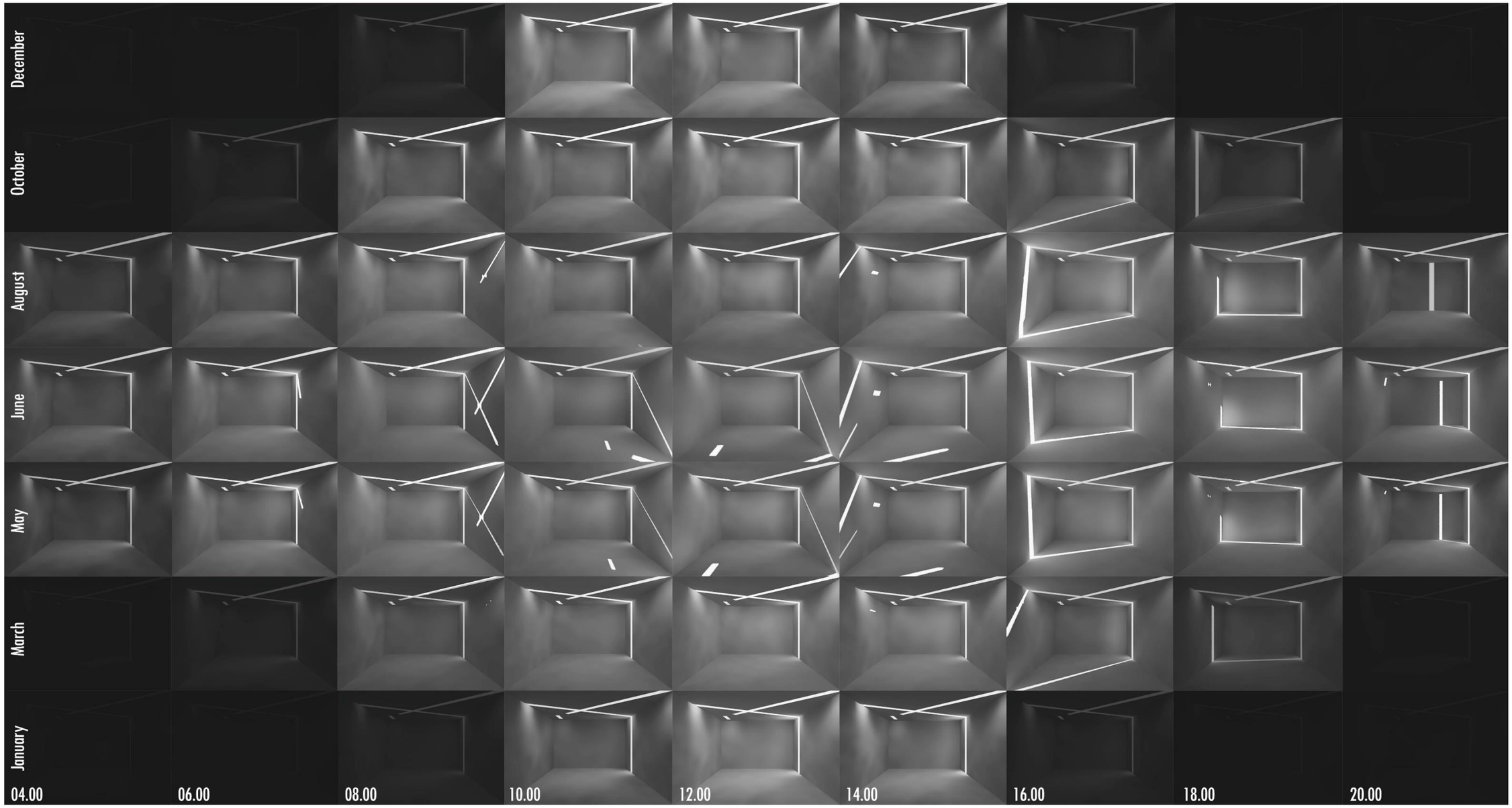


Figure 33. Model 6. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.7 MODEL 7. DIRECT & INDIRECT

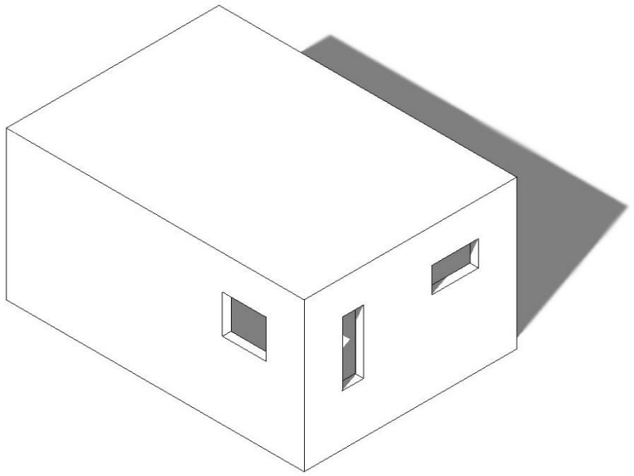


Figure 34. 3D model. Direct & Indirect sunlight.

The Direct and Indirect sunlight category consists of spaces that emit light through thickened openings in building envelope resulting in both direct sunspots and indirect wall washing. Spaces in this category are the House Bierings by Rocha Tombal, Steven Holl's Sarphatistraat Offices, Ronchamp Chapel by Le Corbusier and Pezo von Ellrichshausen's Poli House.

The aim of Model Seven is a skilful combination of both direct and indirect solar illumination of the space. The 3D projection (Figure 34) has a rather simple solution - two windows of various sizes and at different heights are located on the South wall and one window is on the west wall.

In this Direct & Indirect sunlight model, the thickness of the outer walls plays a particularly important role, since the thicker they are, the less possible it is for direct sunlight to enter the room.

On the examples indicated on this page on the right, can be seen that openings that are completely different from each other are suitable for describing the same type. There are both narrow small strips and windows with the size of a person. Depending on the orientation, the space may receive more or less daylight.

However, its distribution is always smooth without unnecessary aggressive transitions.

The sun study results for Model Seven shows quite typical results from simple apartment.

Around noon the sun's rays penetrate the room and draw specific shadows from the surrounding factors (Figure 35).

If there are no windows on the eastern wall, then at sunrise the sunlight does not penetrate into the room, that is quite logical. The presence of openings on the western wall guarantees the illumination of the space until sunset, regardless of the month of the year.

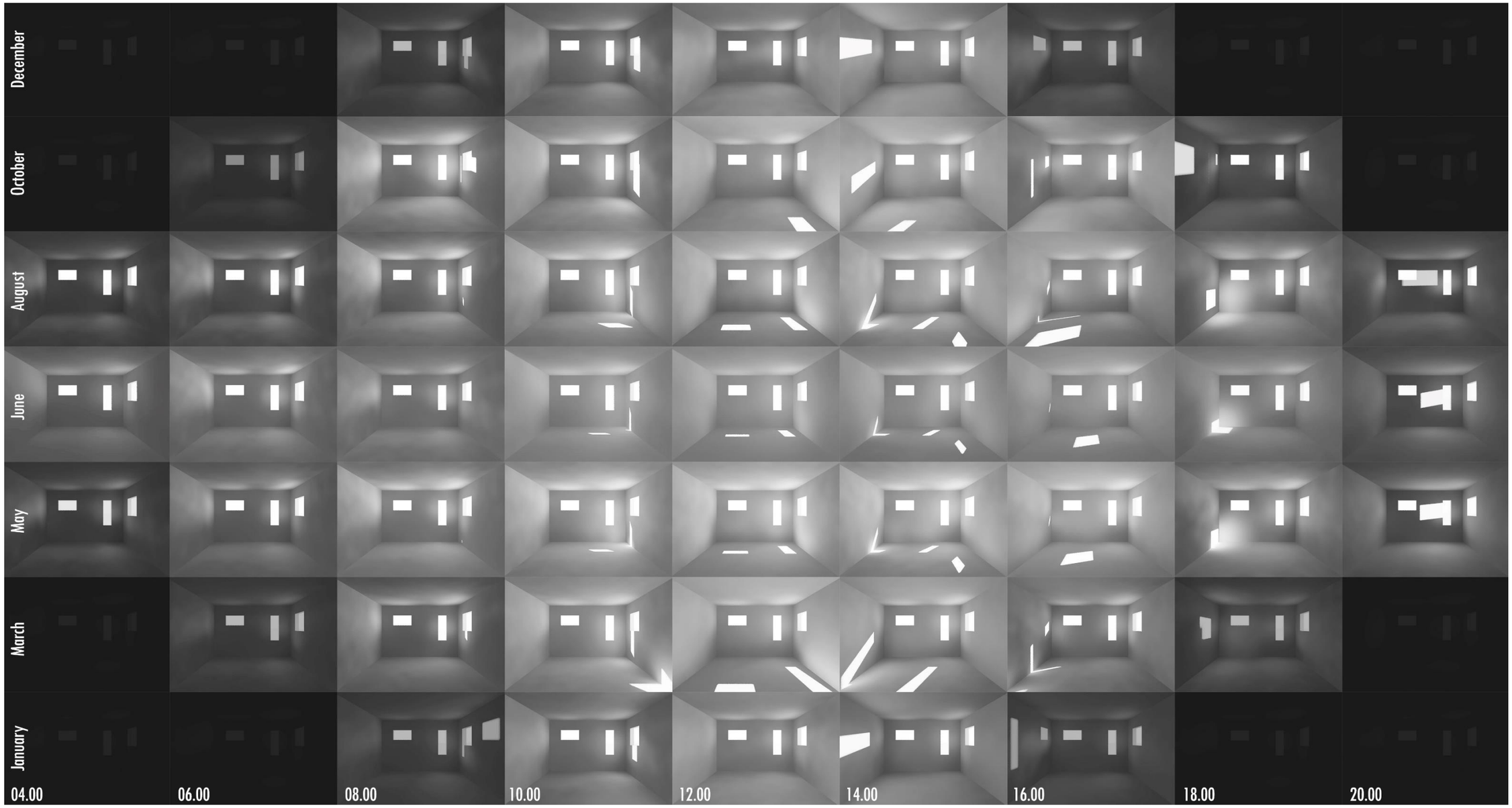


Figure 35. Model 7. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.8 MODEL 8. SPATIAL INDIRECT

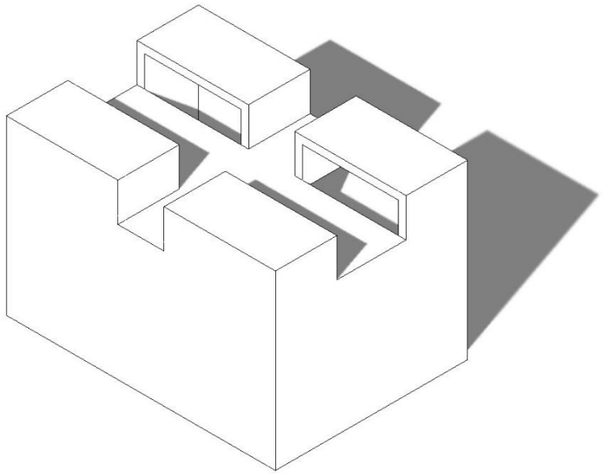


Figure 36. 3D model. Spatial Indirect sunlight.

The Spatial Indirect sunlight category is defined by different spaces that cast indirect sunlight across interior surfaces. It includes, for instance, the HEART Museum and St. Ignatius Chapel by Steven Holl, Louis Kahn's First Unitarian Church, as well as the Tanatorio Municipal de Leon by BAAS.

The aim of Model Eight is to show how indirect light affects the perception of the surrounding world, while not being able to look out the window and admire the views.

As can be noticed on the 3D model (Figure 36), the windows of rather large sizes are located under the ceiling, since their direct purpose is to illuminate the room and give the viewer a special mood. For example, in the St. Ignatius Chapel the sunlight from behind the altar evokes a sense of divine presence, although only well-placed openings are used for such a strong effect.

Indirect light does not cause strong contrasts, but only forms smooth transitions from light to shadow. For some people it may be complicated to be in a room without standard windows, since not everyone can be in the ignorance about events outside (weather, time of day, etc.) for a long time.

The sun study results for Model Eight are quite gloomy as the only rays that penetrate the room can be seen in the morning between 8 AM and 10 AM and in the late afternoon between 2 PM and 4 PM during the period from March to October (Figure 37).

An interesting feature of the model is that at noon, when the sun is at its zenith, the amount of light penetrating inside is significantly less than an hour earlier or later. This must be caused by the fact that at 12 PM the solar angle is so great that the shadows fall on the model's roof from the outside.

From the top: 1. S. Holl. HEART Museum, 2009. 2. L. Kahn. First Unitarian Church, 1962. 3. BAAS. Tanatorio Municipal de Leon, 2000. 4. S. Holl. St. Ignatius Chapel, 1997.

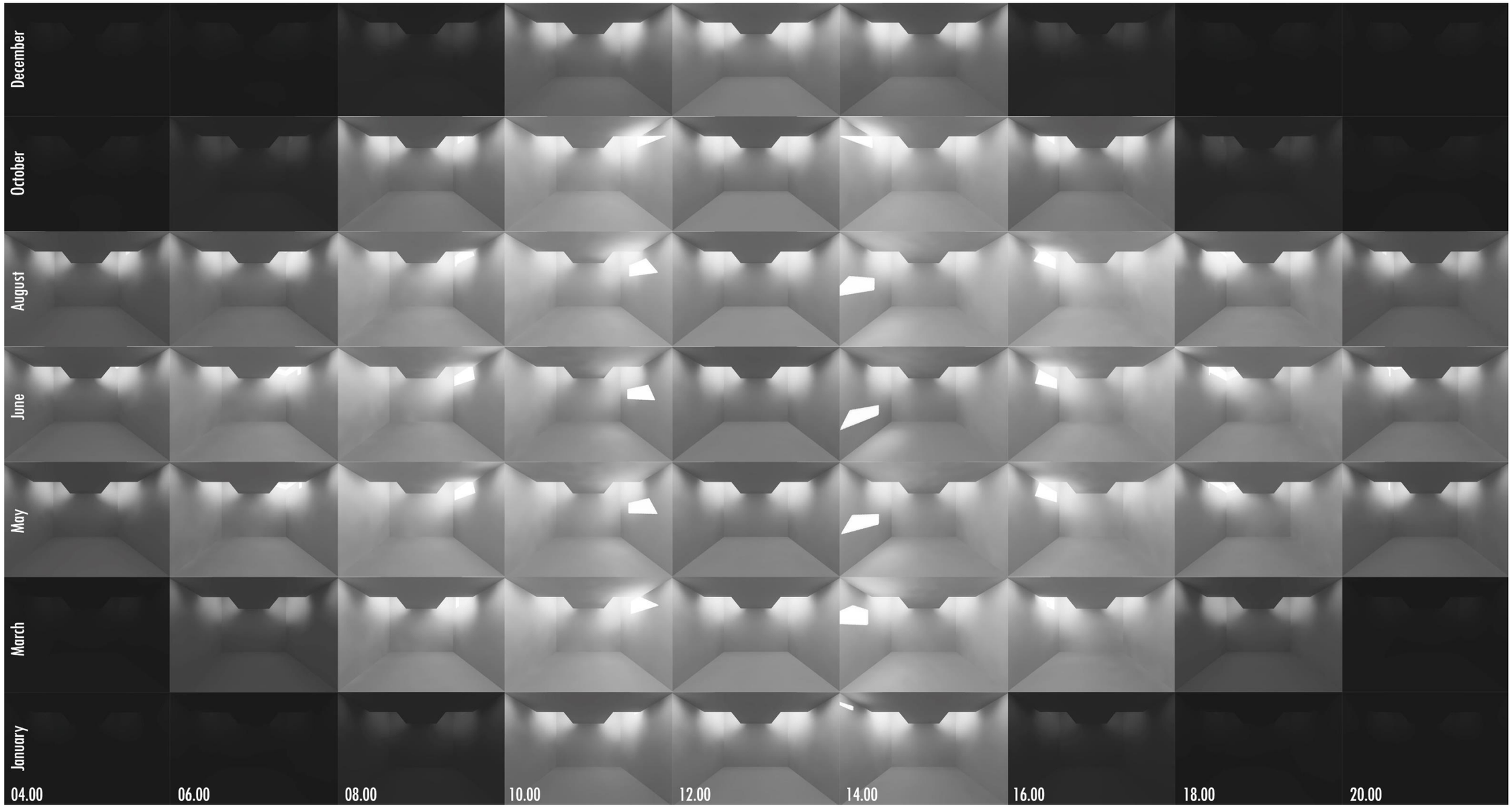


Figure 37. Model 8. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.9 MODEL 9. INDIRECT

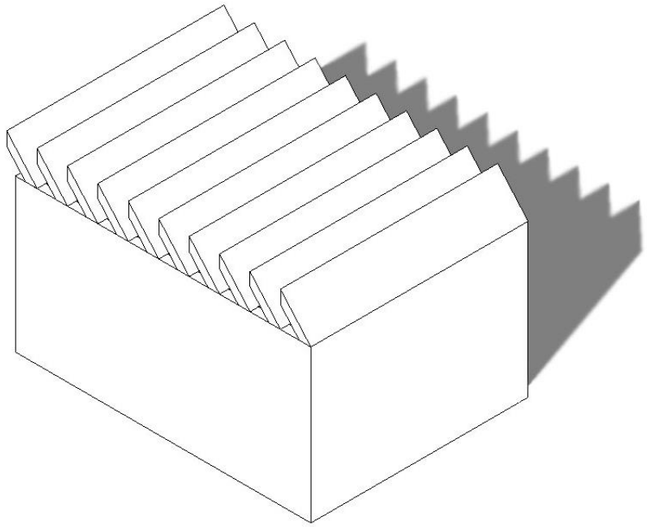


Figure 38. 3D model. Indirect sunlight.

The Indirect sunlight category contains spaces with indirect emission of light through openings in the roof or North-facing monitors. It includes, for instance, DIA: BEACON by Open Office Architecture, Renzo Piano's High Museum and the Resnick Pavilion, as well as Hong Kong International Airport by Norman Foster.

The goal of Model Nine is to show a static interior with relatively low contrast. There are no sharp transitions from light to shadow, in the Indirect model the sunlight is scattered evenly throughout the room.

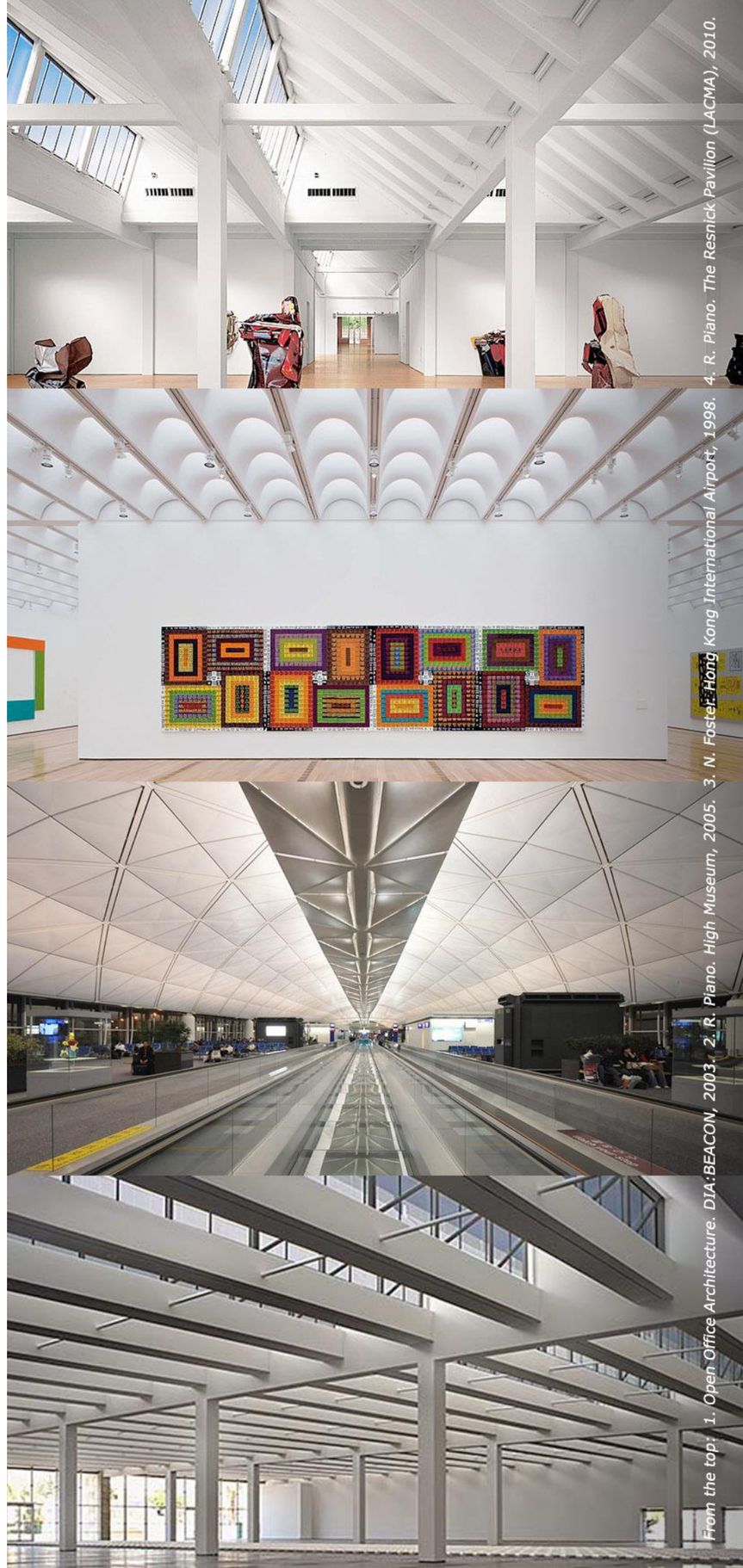
As in the previous Spatial Indirect version, the windows are located under the ceiling and serve exclusively to illuminate the space (Figure 38). Through them it is complicated to determine the weather outside, because the use of this type of lighting can be difficult for other operations.

However, the more essential is the fact that such lighting works great even in cloudy weather since there is no need for constant direct sunlight for this model.

The sun study results of Model Nine show a rather uniform picture throughout the year. The only exception is the play of light and shadows after dawn and a few hours before sunset in the summer season (Figure 39).

The rest of the year direct sunlight practically does not get inside, leaving a stable, measured luminance that does not particularly cause any emotions.

One gets the impression that the sunlight just comes to "visit" the room for summer period, after which it goes into hibernation and becomes inaccessible to the viewer throughout the autumn, winter and spring.



From the top: 1. Open Office Architecture. DIA:BEACON, 2003. 2. R. Piano. High Museum, 2005. 3. N. Foster. Hong Kong International Airport, 1998. 4. R. Piano. The Resnick Pavilion (LACMA), 2010.

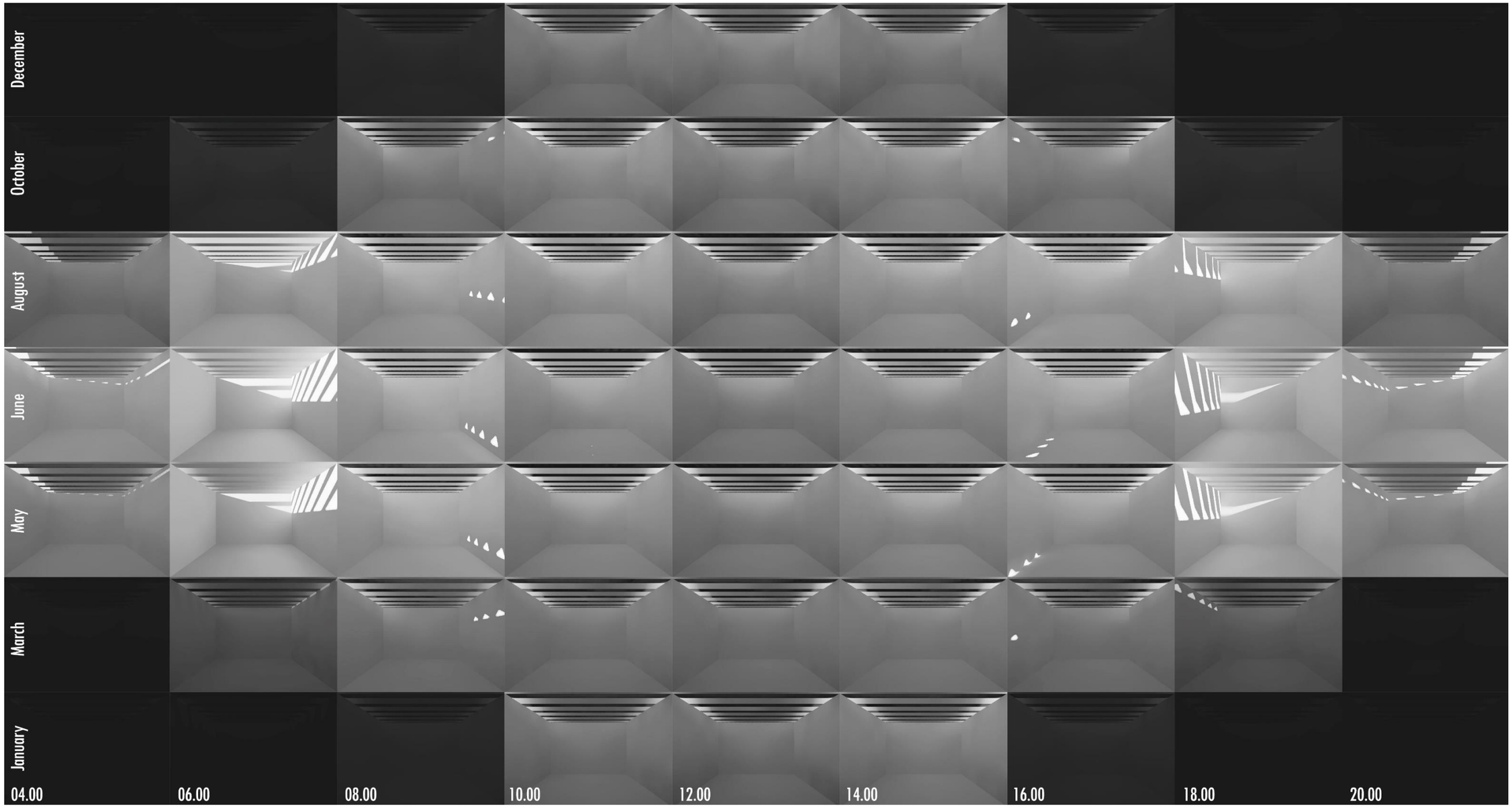


Figure 39. Model 9. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.5.10 MODEL 10. INDIRECT & DIFFUSE

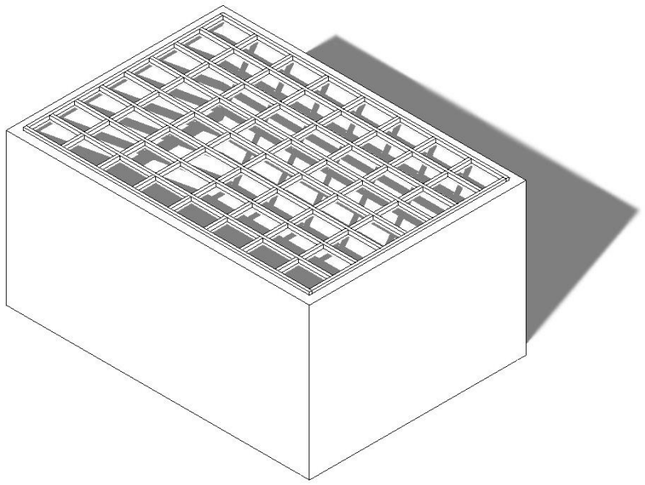


Figure 40. 3D model. Indirect & Diffuse sunlight.

The Indirect and Diffuse sunlight category is the last one in this research that illustrates separate and wide range of daylight strategies in different variations of contemporary architecture. The Chicago Art Institute by Renzo Piano, Olson Kundig's House of Light, Jun Aoki's Louis Vuitton and Naked House by Shigeru Ban are the best examples for describing this category.

The main task of the windows of Model Ten is the complete isolation of direct sunlight through their dispersion in space. To achieve this, mat glasses of predominantly light shades are used, or an opaque tarpaulin is pulled over the windows, etc. And although, these openings are located on the ceiling or roof to gain maximum effect (Figure 40), Jun Aoki makes extensive use of side-litted diffuse lighting in his Louis Vuitton projects.

There are no sharp transitions here, the lighting is stable and easily fills the entire space, regardless of weather conditions.

There is one significant minus in the design of this model - the windows exist, but they do not carry any additional information besides letting in daylight. They are not suitable for ventilation, too.

The sun study results of Model Ten demonstrates the most stable result and a highly predictable trend. At dawn at any time of the year in the room the daylight factor rises, reaches its peak by noon, and begins to decline closer to sunset (Figure 41).

This type of model allows to effectively illuminate the room without any distraction of viewer from his task. Diffusion windows are ideal for use in showrooms and galleries, where in most cases the visitor is unlikely to even guess the nature and essence of the light inside.

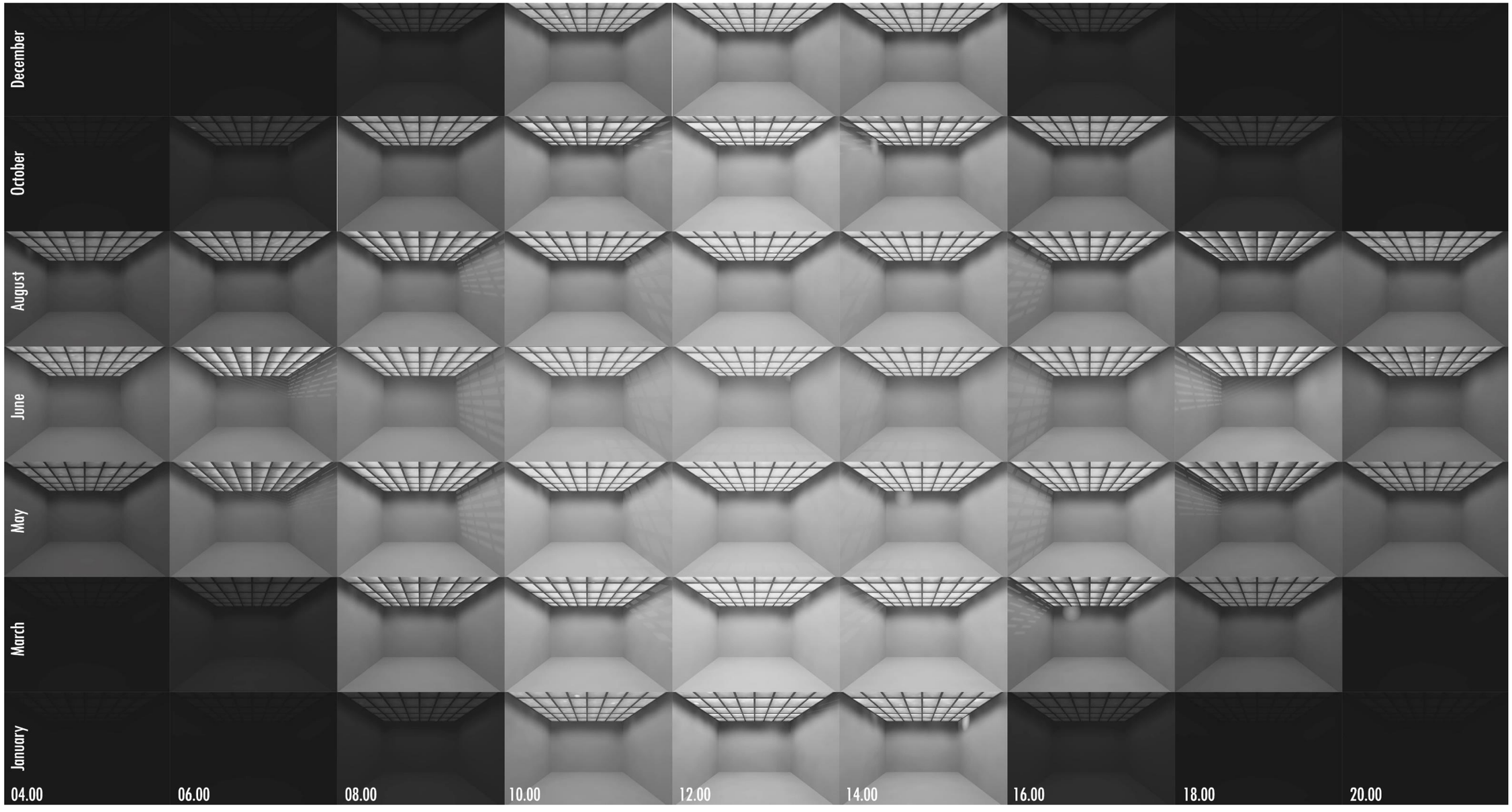


Figure 41. Model 10. Daylight Matrix for Tallinn throughout a year. The study presents data from the 21st day of each month.

6.6. FIVE-ACT STRUCTURE

In architecture, all objects must be interconnected by a special idea, be part of a unified composition. Like the words of a song that flow from one to another. In poetry there is such a concept as five-act structure.

The five-act structure (drama) is a framework of story's structure that divides a story into five specific parts, called acts. This usually includes exposition or introduction, conflict or rising action/movement, climax, falling action and resolution (Figure 42).

The origins of the five-act structure go back to ancient Greece, when the first plays were originated. Aristotle was one of the first who distinguish three main segments in drama: beginning, middle and end (Ray, 2019).

Some argue that Shakespeare was the inventor of five-act dramatic structure. The best example is his famous creation "Romeo and Juliet".

Over time, the Roman playwright Horace advocated five-act plays. And many centuries later, the German poet of the mid-1800s, Gustav Freytag, created the famous Freytag's pyramid, that is currently the most widely taught frameworks of story structure in the world, where each of acts has its own purpose (Bunting, 2019).

Act 1: Introduction

The introduction consists of the beginning of the story, including the exposition.

The purpose is to introduce the audience/visitors to the world of storytelling and its characters to set up the elements of the plot so that the viewer, as the protagonist of the story, wants to move on.

The first act usually contains about 10 % percent of the whole story.

Act 2: Rising Movement

The second act consists of two parts: an "exiting force", that provokes an incident or causes a conflict situation, and a rising movement, which smoothly leads to the climax of the story, heating up the situation.

Thus, the purpose of the act two is to continue the movement of the story to its climax.

The scenes here should be breath-taking, both deepening the complexity of the story and expanding the plot.

The second act is usually the longest, containing about 35 % to 45 % of the content of the entire story.

Act 3: Climax

The climax occurs exactly in the middle of the story and is considered not so much the moment of the greatest drama as the point of reflection. For example, if the protagonist's things have been going poorly step by step, then after the peak, they start improving.

The middle or climax of the drama is the most important place in this structure. First, the viewer is brought to the point of the most acute emotions, after which they are slowly released.

The duration of act three is the shortest in the framework, since its task is to instantly evoke a certain mood, to stun the audience. Therefore, it especially consists of one scene or about 5 %.

Act 4: Falling Action

The falling action contains scenes between the climax and the finale act.

In this action, in case of a tragedy, everything that has been going nicely for the protagonist starts to go terribly. Or on the contrary everything that has been going awfully starts to go excellently, in the case of comedy.

One aspect of falling action is the power of the final suspense. The audience is given the final moment of doubt before the outcome. In the case of comedy, the viewer is unhurriedly moved away from sharp emotions, while maintaining suspicions about the final scene, where it hints at a slight possibility of a reversal.

The fourth act, like the second act, contains the majority of story, around 25 to 30%. However, it is necessarily shorter than the action two, that's why Freytag's pyramid is slightly tilted to the right.

Act 5: Resolution

In the last fifth act, all things that have been built before finally occur all at once. For instance, in the tragedy, it is a scene where everyone dies. Or it is a big wedding in a comedy.

Action five is also quite succinct act that is usually less than 10 % of a story (Bunting, 2019).

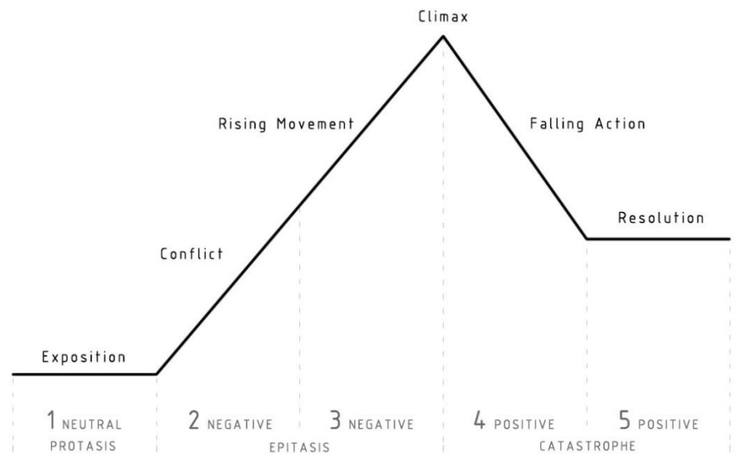


Figure 42. Freytag's pyramid of five-act structure.

7. CONCLUSION OF THE ANALYSES

The importance and necessity of light, not only as a source of illumination, but also for the pacification of the soul, was understood even in the era of ancient civilizations. Then sunlight was perceived as something divine, bestowed by heaven.

However, now we clearly understand that there is no mysticism in this. Light is electromagnetic radiation perceived by the human eye (Dictionary-Cambridge, 2022). It warms, gives energy and improves mood, but at the same time, its improper use can have the opposite effect.

Natural light is changeable, it is always in motion. Therefore, this aspect must be taken into account when designing in order to make the most advantageous use of the orientation of the object. In northern latitudes, where the length of a sunny day depends on the season, it is significant to consider all possible variations. After all, the shadows falling from objects in winter are significantly different from summer ones.

Wintertime is generally given to many people stressfully. Lack of sunlight worsens the condition of the body, causes headaches, depression, apathy. On a bright sunny morning, it is much easier to wake up and go to work than if it is cloudy or raining outside. From this can be concluded that our physiological and psychological health directly depends on the correct use of sunlight in everyday life. One type of lighting is pleasing to the eye, while the other can cause aggression and hostility.

In order to find out and understand the varieties of light penetrating into the room, Rockcastle and Andersen's research (Rockcastle & Andersen, 2013) was used as a basis. They identified similar features of the distribution of light in the works of famous architects, systematized them according to similar indicators, distributed results into a matrix and created simplified typological models.

However, in the course of writing this Thesis, have been revealed that not all typical models convey this type of lighting to the full. For example, I disagree with the minimization of model two "Direct & Dramatic". According to the given references for that type, the windows should not be located along the entire length of the wall, they should be more presented as a random dotty variation. I suppose, if more chaotic drama or asymmetry was added to the typological model, the more correct result would be.

Due to the fact that only two top-lit spaces are described in the study of Rockcastle and Andersen, it is not possible to compare all of ten models produced in this Thesis. However, those that were presented in the study have similar indicators to those obtained in the suburbs of Tallinn.

As for the use of Andersen's work in the Estonian context, 10/10 models (if the parameters of the rooms remain unchanged) are acceptable for use near Tallinn. Whether such coverage will be effective and justified in the end is a moot point. The research have shown that the shape of the parallelepiped is not the most advantageous, since an abundant amount of rays, for instantce, in the winter season, when the altitude is smaller, are passed in vain. Direct sunlight does not enter the room during the periods from November to January if there is only a window on the roof. But in the case of a slight deformation of space changing the degree of roof's slope and making a more abstract work out of a simple "box", the amount of direct sunlight coming in could be increased.

The next step was to determine which type of lighting in typological models evokes what kind of emotions. One lighting calms, the other inspires fear, and with the third you can generally get lost in space. But emotions are in most cases an individual vision of each person, based on personal preferences. So, if the ten simplified models should be divided into black and white (positive and negative) for me the division looks like:

- Positive emotions: 1) Direct & Exaggerated, 3) Direct & Screened, 5) Direct, 7) Direct & Indirect, 9) Indirect;
- Negative emotions: 2) Direct & Dramatic, 4) Partially Direct, 6) Selectively Direct, 8) Spatial Indirect, 10) Indirect & Diffuse.

For a Museum of Emotions each room should convey a special mood, and in order not to lose the integrity of the composition, a five-act structure will be used in the design. According to this, three types of lighting for positive – Direct & Exaggerated, Direct & Screened, Direct & Indirect – and two for negative emotions – Selectively Direct and Spatial Indirect – are selected. Since their originality aroused the greatest interest in the study, this was the reason for their choice for further work.

8. ANALÜÜSI KOKKUVÕTE

Isegi iidsete tsivilisatsioonide ajastul mõisteti valguse tähtsust ja vajalikkust mitte ainult valgusallika, vaid ka hinge rahustajana. Tollal arvati, et päikesevalgusel on jumalik olemus, mis avaldab mõju inimhingele.

Nüüd mõistame aga selgelt, et valguses pole müstikat. Valgus on elektromagnetkiirgus, mida inimsilm tajub. See soojendab, annab energiat ja parandab tuju, kuid samas võib selle ebaõigel kasutamisel olla vastupidine mõju.

Loomulik valgus on muutlik, see on alati liikumises. Seetõttu tuleb seda aspekti projekteerimisel arvestada, et objekti orientatsiooni võimalikult soodsalt ära kasutada. Põhjapoolsetel laiuskraadidel, kus päikesepaistelise päeva pikkus sõltub aastaajast, on oluline arvestada kõigi võimalike variatsioonidega. Talvel objektidelt langevad varjud erinevad ju oluliselt suvistest.

Talveaeg on paljudele inimestele üldiselt stressirohke. Päikesevalguse puudumine halvendab keha seisundit, põhjustab peavalu, depressiooni, apaatsust. Palju lihtsam on ärgata ja tööle minna selgel päikesepaistelisel hommikul, kui siis, kui taevas on pilves või sajab vihma. Sellest võib järeldada, et meie füsioloogiline ja psühholoogiline tervis sõltub otseselt päikesevalguse õigest kasutamisest. Üks valgustusviis on silmale meeldiv, teine aga võib põhjustada agressiivsust ja vaenulikkust.

Tuppa tungiva valguse variatsioonide väljaselgitamiseks ja mõistmiseks võeti aluseks Rockcastle'i ja Anderseni uurimused (Rockcastle & Andersen, 2013). Nad tuvastasid kuulsate arhitektide töödes sarnased valgusjaotuse tunnused, süstematiseerisid need sarnaste näitajate järgi, jagasid tulemused maatriksiks ja püüdsid luua lihtsustatud tüpoloogilised mudelid.

Selle lõputöö kirjutamise käigus aga selgus, et mitte kõik tüpoloogilised mudelid ei anna etteantud tüübi valgustust täielikult edasi. Näiteks ma ei nõustu teise mudeli „Direct & Dramatic" minimeerimisega. Vastavalt antud näidistele ei tohiks aknad asetseda kogu seina pikkuses, need tuleks pigem esitada suvalise „täpilise" variatsioonina. Minu meelest, et kui tüpoloogilisele mudelile lisada kaootilisust, draamat või asümmeetriat, oleks tulemus korrektsem.

Kuna Rockcastle'i ja Anderseni uurimuses on kirjeldatud vaid kaht kõige kriitilisemalt valgustatud ruumi, ei ole võimalik võrrelda kõiki kümmet käesolevas töös esitatud mudelit. Uuringust välja toodud tulemused on aga sarnased Tallinna äärelinnas saadud näitajatega.

Mis puudutab Anderseni teoste kasutamist Eesti kontekstis, siis Tallinna läheduses on 10/10 mudelid (kui ruumide parameetrid jäävad muutumatuks) kasutamiseks vastuvõetavad. Kas selline valgus on lõpuks tõhus ja õigustatud - on vaieldav küsimus. Uuringud on näidanud, et rööptahuka kuju ei ole just kõige soodsam, kuna talvisel ajal, kui päikese kõrgusnurk on väiksem, läheb ohtralt kiiri asjata mööda. Otsene päikesevalgus ei pääse tuppa perioodil novembrist jaanuarini, kui aknad on vaid katusel. Kuid ruumi kerge deformatsiooni korral, muutes näiteks katuse kallet ja tehes tavalisest "kastist" abstraktsema teose, saab sissetuleva otsese päikesevalguse hulka suurendada.

Järgmise sammuna tehti tüpoloogilistes mudelites kindlaks millist tüüpi valgustus milliseid emotsioone esile kutsub. Üks valgustus rahustab, teine tekitab hirmu ja kolmandas võib segadusse ajada. Kuid emotsioonid on enamasti iga inimese individuaalne nägemus, mis põhineb isiklikel eelistustel. Seega, kui kümme lihtsustatud mudelit tuleks jagada must-valgeks (positiivseks ja negatiivseks), siis minu jaoks, näeks see jaotus välja järgmiselt:

- Positiivsed emotsioonid: 1) Direct & Exaggerated, 3) Direct & Screened, 5) Direct, 7) Direct & Indirect, 9) Indirect;
- Negatiivsed emotsioonid: 2) Direct & Dramatic, 4) Partially Direct, 6) Selectively Direct, 8) Spatial Indirect, 10) Indirect & Diffuse.

Emotsioonide muuseumi jaoks peaks iga ruum edasi andma erilist meeleolu ja et kompositsiooni terviklikkust mitte kaotada kasutatakse kujunduses viievaatuselist struktuuri (ingl: five-act drama). Selle kohaselt valitakse positiivsete emotsioonide jaoks kolm valgustustüüpi - Direct & Exaggerated, Direct & Screened, Direct & Indirect - ning kaks negatiivsete emotsioonide valgustust - Selectively Direct ja Spatial Indirect. Kuna nende originaalsus äratas uurimuse vastu suurimat huvi, siis see oligi põhjuseks, miks just need mudelid on valitud edasiseks tööks.

9. ARCHITECTURAL PROJECT – MUSEUM OF EMOTIONS

9.1 THE COMPETITION

For the Museum of Emotions competition, participants are asked to design a museum that consists of two separate spaces that bring out contrasting emotions – one positive emotion, and the other one inductive negative emotion.

The main purpose of the museum is to design an architectural composition using lighting, scales of spaces, colour and various finishing materials for creating different emotional states.

For the competition the project concept must be transmitted only through the use of visual materials, without any description text. Moreover, participants have complete freedom of choice for site location. Even an imaginary world can be used.

Figure 43. The cover photo of competition.

9.2 ARCHITECTURAL CONCEPT

Rockcastle and Andersen's research, where the distribution of sunlight in various spaces had been explored (Rockcastle & Andersen, 2013), was originally intended to be used as the basis for the design of the architectural project for this Master Thesis.

However, having accidentally stumbled upon a competition task on the Internet so remarkably complementing the project, it was decided to combine the two ideas to create an enthralling Museum of Emotions.

Despite the fact that in the competition only two halls might be presented, in this Thesis the number of designed premises is increased to five. There are three spaces for positive emotions and two for negative characterized only by daylight and architecture.

The room's main purpose is to provide guests with the opportunity to immerse themselves in their own mental world and listen to their feelings.

Each room is designed to be visited by one person at time, because the emotions of all are individual and for a complete feeling they require maximum concentration.

The Museum of Emotions is not a standard usual museum that are used to be seen before. It is more like landscape art or installation. There are several separate pavilions that are connected to each other by a common path to enable the visitor's free pass from one room to another.

The museum is not intended for permanent residence and are not equipped with either electricity or water inside. It is also intended to be used during the lighter season of the year - from April to August.

Most simplified forms and materials are used to pay more attention to the halls' meaningful interior. The extraneous factors should not distract the viewer from contemplating the "play of daylight and shadow." Besides, the museum should harmoniously fit into the forest environment and be a part of the world around.

The main material for the construction of pavilions is timber, as it is an environmentally friendly and naturally occurring material widely used in the construction of houses on Prangli Island.

Dark timber is utilized on the outside of each pavilion, while white plaster is used on the inside for a stronger light perception effect.

Also, three different types of sunlight are used in the project:

- Direct sunlight
- Indirect sunlight
- Sunlight reflected from water

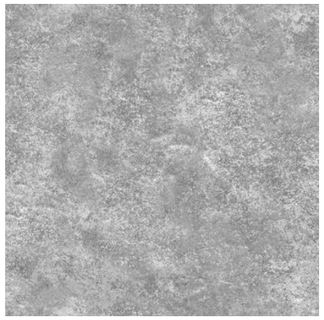
For the construction, wood is used, covered with hydro isolation and a double layer of timber from the outside.

Facade is ventilated from all sides, and rainwater is drained thanks to the structure and flows down the wall behind the finishing material.

DARK TIMBER

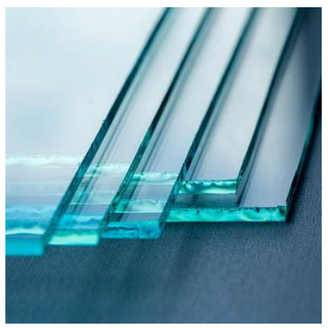
PLASTER

LOCAL TIMBER



CONCRETE

GRAVEL/STONES



GLASS

9.3 PROJECT LOCATION

For the site location it was necessary to find a quiet secluded place away from noisy cities where people could come to relax. So, the small Estonian island on the North named Prangli – sparsely populated and at the same time stunning in its pulchritude – has been selected as the site for the unusual museum concept.

Prangli Island is located in Estonia in the Gulf of Finland, less than 10 km from the Viimsi Peninsula. However, the length of the waterway between the most used ports (Leppneeme on the mainland and Kelnase on the island) is 18 km, as Kelnase is located on the opposite side of the island. Prangli has an area of 6,4 km² and a coastline of 26,4 km.

DESCRIPTION OF THE AREA

The Prangli nature area consists of the Prangli Landscape reserve (139 ha of land). The Conservation area covers the northern, western and south-western coastal areas of Prangli Island together with small islands, lagoons, reefs and shallow waters in the sea. The nature area is located in the territory of Viimsi municipality (Keskkonnaamet, 2014).

There are three villages on the island - Lääneotsa, Idaotsa and Kelnase. The settlement is concentrated in the centre of the island, where the shop, school and community centre are located. The outskirts of the island are very sparsely populated. The average population density is 29 people / km². In the Prangli Conservation area and the Prangli Landscape reserve construction and development activities are limited (Viimsi Vallavalitsus, 2020).

WEATHER

The island's climate is affected by its location in the Gulf of Finland. Spring is late and summer is short, autumn is warm and long, but full of storms.

Prangli is foggy. It has an average of 30 fog days due to island's position and temperature changes. The prevailing winds are South-West winds.

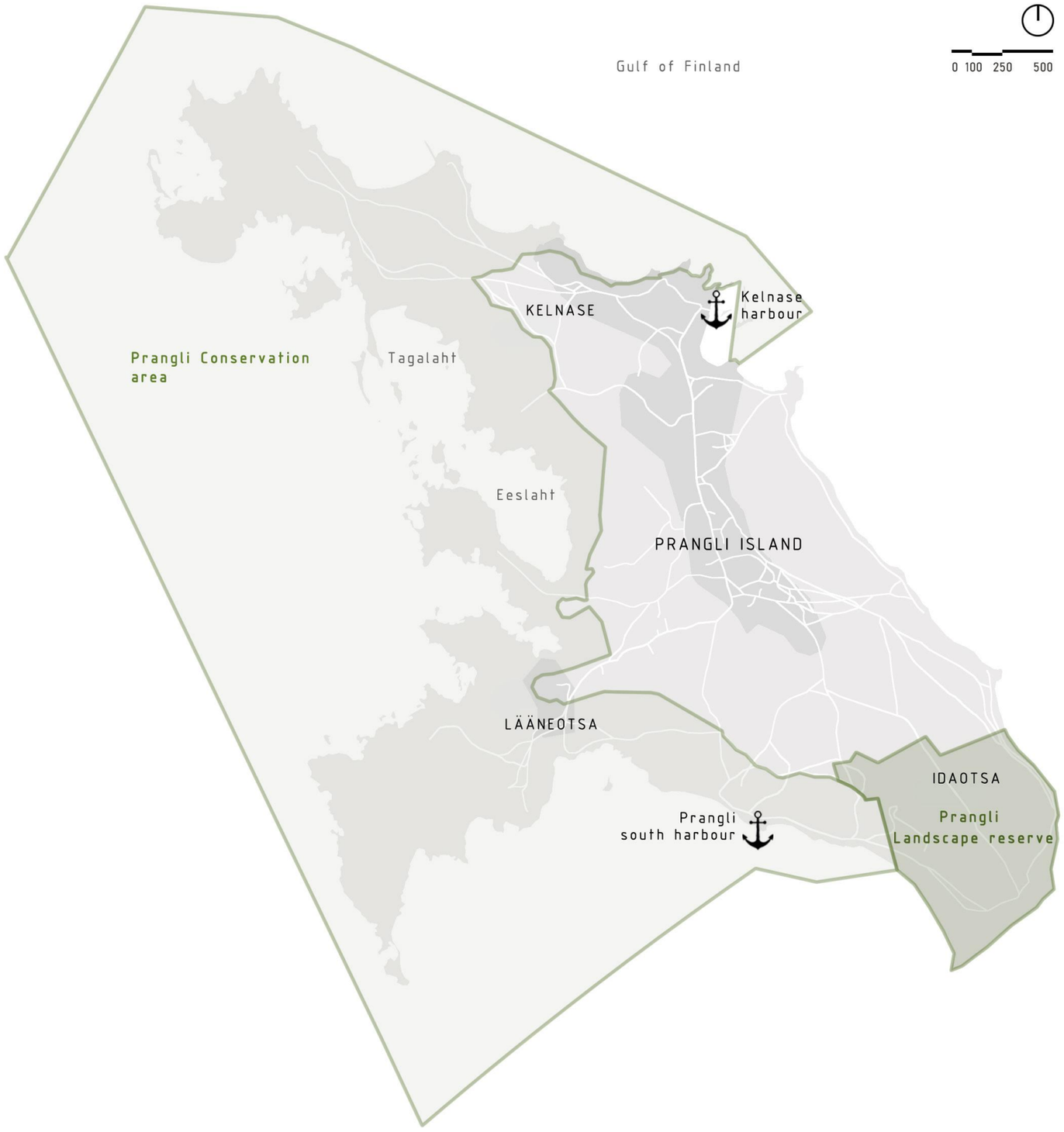


Figure 44. Prangli Island (Thesis author).

RELIEF

The island is flat in relief, rising barely to the East and South-East. A large part of the island does not reach more than 2-3 meters in height. The highest place is Kullamägi in the south-eastern part of the island (10 m above sea level).

The western part is low and rocky, the eastern part alternates with pebbles, embankments and sand dunes. In the west and northwest there is an egg-shaped moraine, in the northeast above Liimeneeme there is a large blizzard. Boulders are everywhere in every size, colour and shape. In particular, there are plenty of boulders on the west coast of the island.

On the land the largest of the boulders are the Red Stone (est: Punane kivi 31,1 per 2,8 m) at the south-eastern end of the island in the Korve Forest and the Kotkakivi (19,7 m per 3,6 m) in Kelnase Village.

VEGETATION

The vegetation of the island is diverse. The northern and north-eastern part of the island is dominated by uncovered open sand dunes, in the eastern and south-eastern part there are pine and heath pine forests, in the central and western part there are wooded meadows with black alders, birches and rowans.

In the south-western part of the island juniper is widespread, and pine is also found on the southern and south-eastern shores.

Pines dominate in the forest (Korve forest, Vanakabel forest, etc.). The forest cover of the island is about 40 %.

Historically, only the bark is harvested from the island's forest, withered trees and windbreaks, firewood and construction timber are brought from the mainland.

Also, blueberries and lingonberries can be found here.

FAUNA

Due to the isolation and small area, there are no large mammals on the island. Some rabbits, squirrels and foxes live here instead. There are a lot of hedgehogs and lizards. In addition, the birdlife of Prangli is abounding and various (about 40 species).

Herring, sprat, flounder and turbot are present in coastal waters. Eels and salmon are scarce, pike and other freshwater fish are mainly sourced from the west coast (Pakosta, 2010).

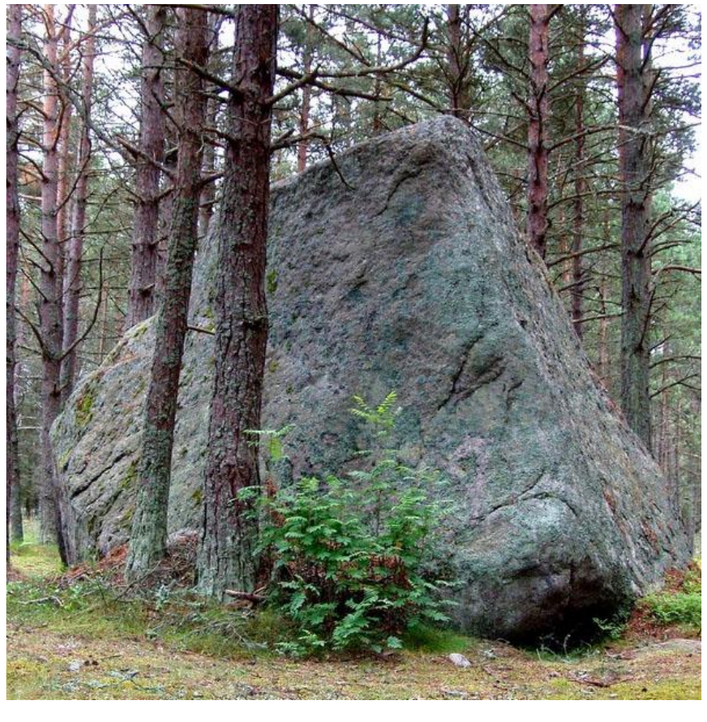


Figure 45. Kotkakivi in Kelnase Village. Photo: Ivo Kruusamägi.

Figure 46. Pine branch.

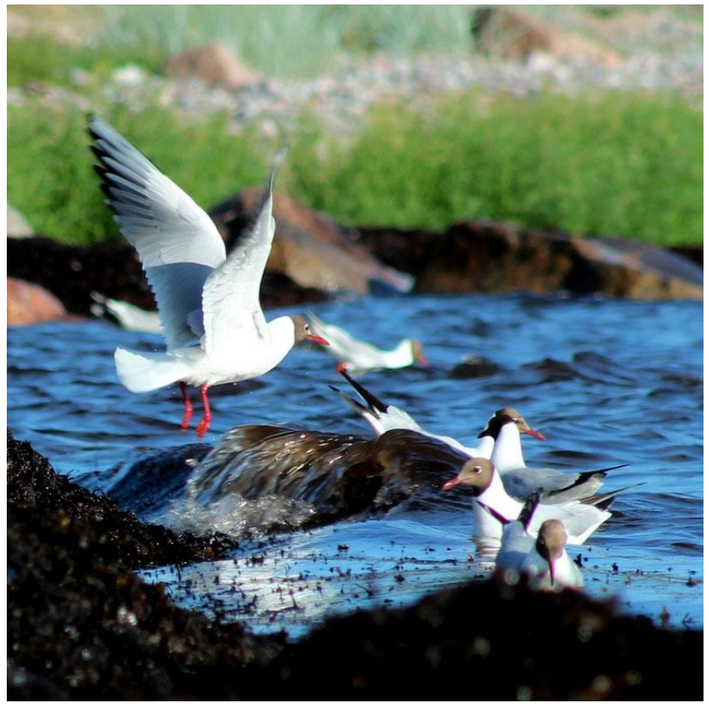


Figure 47. Seagulls. Photo: Eesti FotokunstiÜhing.

9.4 RESTRICTIONS

Prangli has been a home to many species of creatures for centuries, some of which are now endangered. This is the reason why there are so many restrictions for building on the tiny island northeast of Tallinn.

First of all, there is the Conservation area and Prangli Landscape reserve that covers the northern, western and south-western coastal areas of island (Figure 48). The decent amount of protected single objects or points of interest can also be found inside and outside of the preserved territory.

The next restrictions belong to the Estonian prohibition on building on an area closer than 50 meters near the coastline (Figure 49).

And although the coastal part of the island would be a perfect place for site location in its general idea - a large secluded open space for sunlight, excellent calming views of the sea, and the ability to use reflection from the water to transmit light - but in this case the project would not meet the requirements. So, the museum should be located further from the sea to the inland.

The most appropriate site for the museum is a quiet, non-crowded place near the harbour, which is constantly used by tourists.

In addition, it should be as open as possible to sunlight, since in the middle of the forest the Museum of Emotions simply lose its effectiveness. About forty percent of the whole Prangli is covered with forests (Figure 50), and there is a minority of free fields near the city that have a more private area on island at the same time.

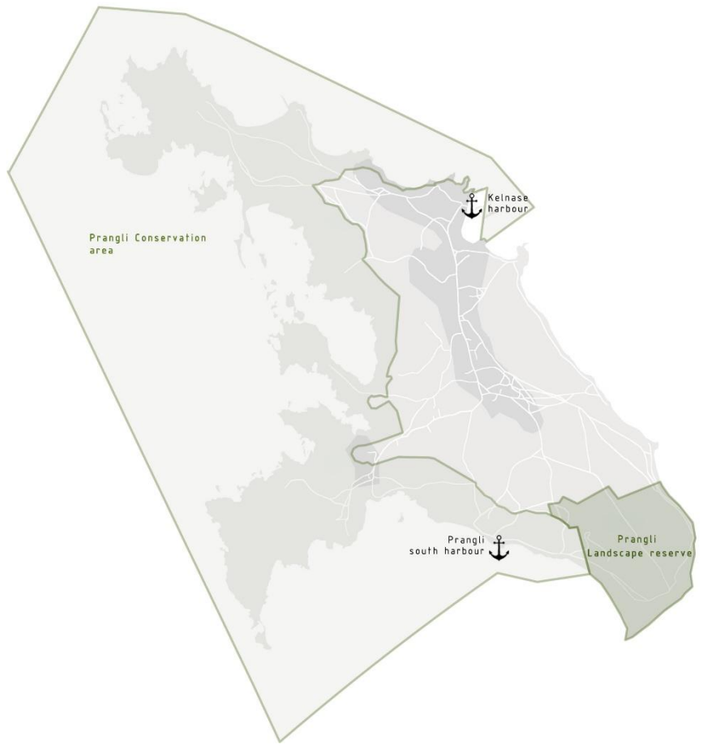


Figure 48. Prangli restrictions by Natura 2000 (Thesis author).

Figure 49. The construction exclusion zone (50 m from coast) (Thesis author).

Figure 50. Prangli forests (Thesis author).

9.5 FORM CREATION

STEP 1

A research of Rockcastle and Andersen's typological models indicated that the usual rectangular shape of the room largely limits the amount of sunlight coming inside.

Of course, the usual layout of a room in the shape of a rectangle has many advantages. For example, the corners in a room have a positive effect on vision and perception of the world, as they help to better orient themselves in space.

Rectangular rooms are economically and technically more uncomplicated to build, they are comfortable, stable and have a maximum of usable space.

STEP 2

However, to increase the amount of daylight penetrating into space, it makes sense to slightly modify the parallelepiped, turning it more into a trapezoidal structure.

With the addition of sharp corners, sunlight can be used more efficiently. And since this configuration will be used to create a Museum of Emotions, and not standard residential complexes, then the use of such an angular form is beneficial.

Thanks to it, more opportunities can be opened up for obtaining the necessary sunlight. Moreover, it is more effortless to orientate in such a space than in a spherical one.

STEP 3

In order to give the room even more dynamism and mystery, some corners were cut in the second step.

The creation of such a multifunctional form made it possible to use it in different positions at different angles without changing the original idea. Thus, all five museum pavilions turned out to be different, but united by a common idea, reproduced from a unified form.

In the course of further testing, some options were slightly transformed to get a better sunlight results. However, the basic concept has remained unchanged.

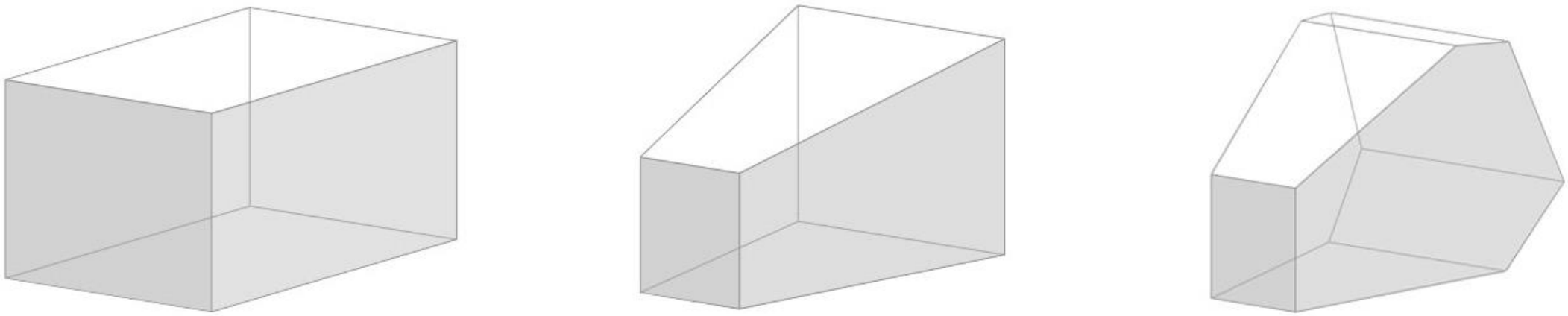


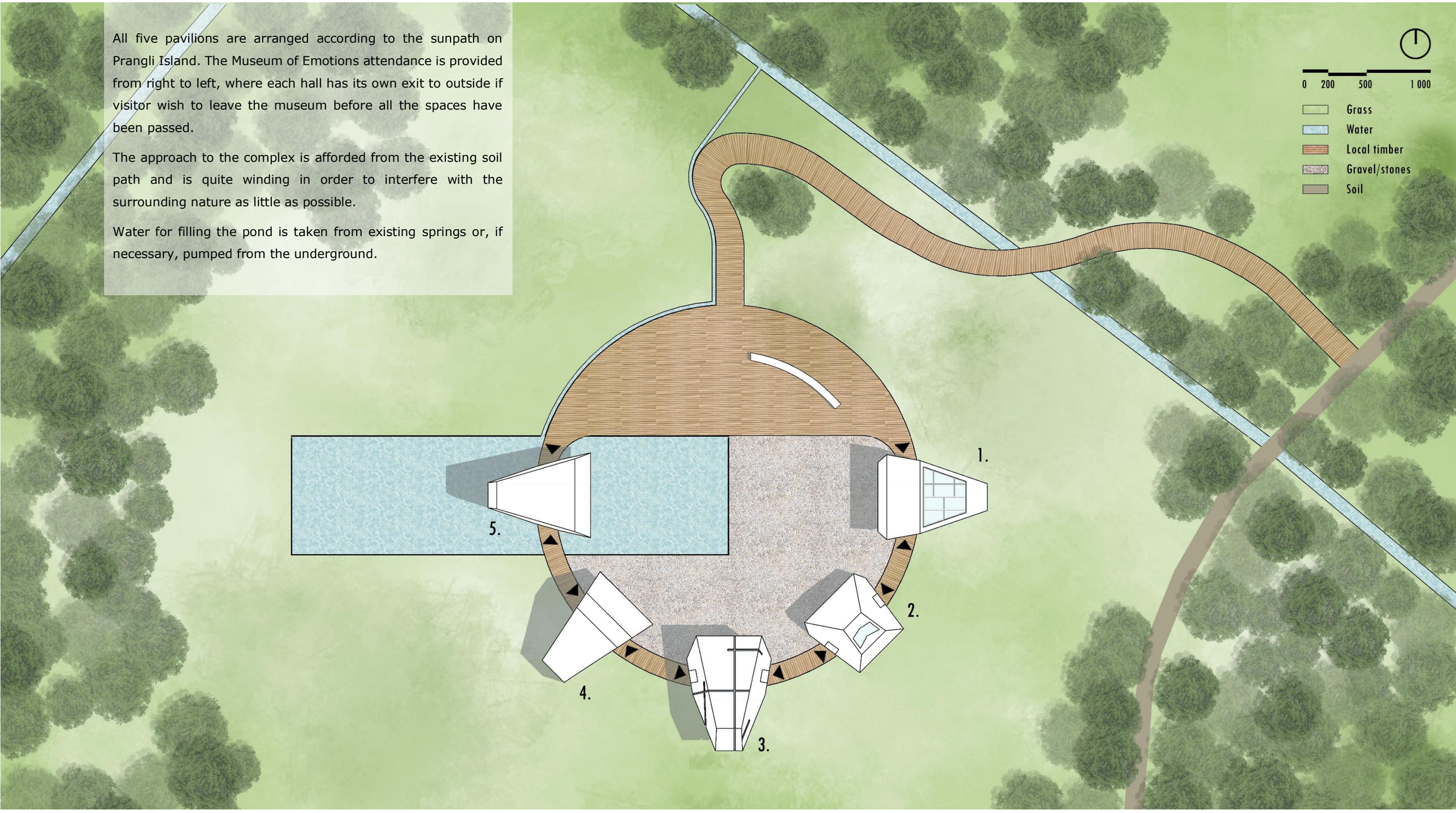
Figure 51. Search for the optimal form in three steps (Thesis author).

10. SITE PLAN

All five pavilions are arranged according to the sunpath on Prangli Island. The Museum of Emotions attendance is provided from right to left, where each hall has its own exit to outside if visitor wish to leave the museum before all the spaces have been passed.

The approach to the complex is afforded from the existing soil path and is quite winding in order to interfere with the surrounding nature as little as possible.

Water for filling the pond is taken from existing springs or, if necessary, pumped from the underground.



11. MUSEUM DESIGN

11.1 EXPOSITION – DIRECT & EXAGGERATED LIGHT

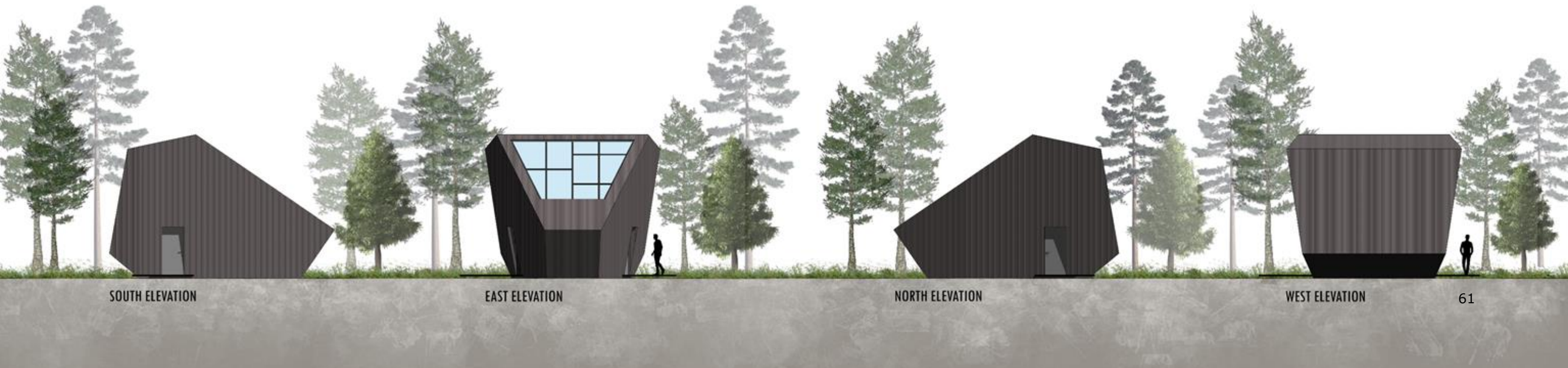
DESIGN IDEA

According to five-act classical drama, that idea is used as a logical connection between pavilions in the Master Thesis, the first space is like introduction or the main entrance that calls its guests inside. It should not frighten or immediately evoke sharp emotions, because in this case the viewer will either refuse to go in at all, or subsequent halls will already seem too insipid after a racy start (Figure 52).

So, aim of the first hall is to show a contrasted interior with variable composition and strength due to the inconstancy of dynamics of direct sunlight that enter the room with clear corners from the silhouettes on the floor and walls.

And at the same time, the pavilion, despite its external appearance, should be as familiar and comfortable as possible for the viewer inside.

Figure 52. The first pavilion elevations (Thesis author).



FLOOR PLAN AND SECTION

The room, a little over 5,5 meters long, is quite spacious and tapers towards the eastern facade (the narrowest place is 1,75 m).

Floor area is 16,9 m² and the highest point ~ 5,5 m.

Two of four walls are perpendicular to the floor and a large window on rooftop makes this pavilion to look like quite standard usual apartment (Figure 53).

Between the inner and outer walls from the east and west there are some spaces serving construction purposes not possible for visiting. Their purpose is to make the interior more familiar to the visitor for straight walls.

EMOTIONS

Being inside a person will not experience feelings of discomfort. Even in the case of a cloudy day, it will still be light in such hall, since the sky is visible through a large window so skilfully articulating the play of light and shadow.

Thus, due to straight walls and a large window, being on a rooftop with a calm and familiar window design, it can be predicted that emotions caused by this space could be positive and even optimistic.

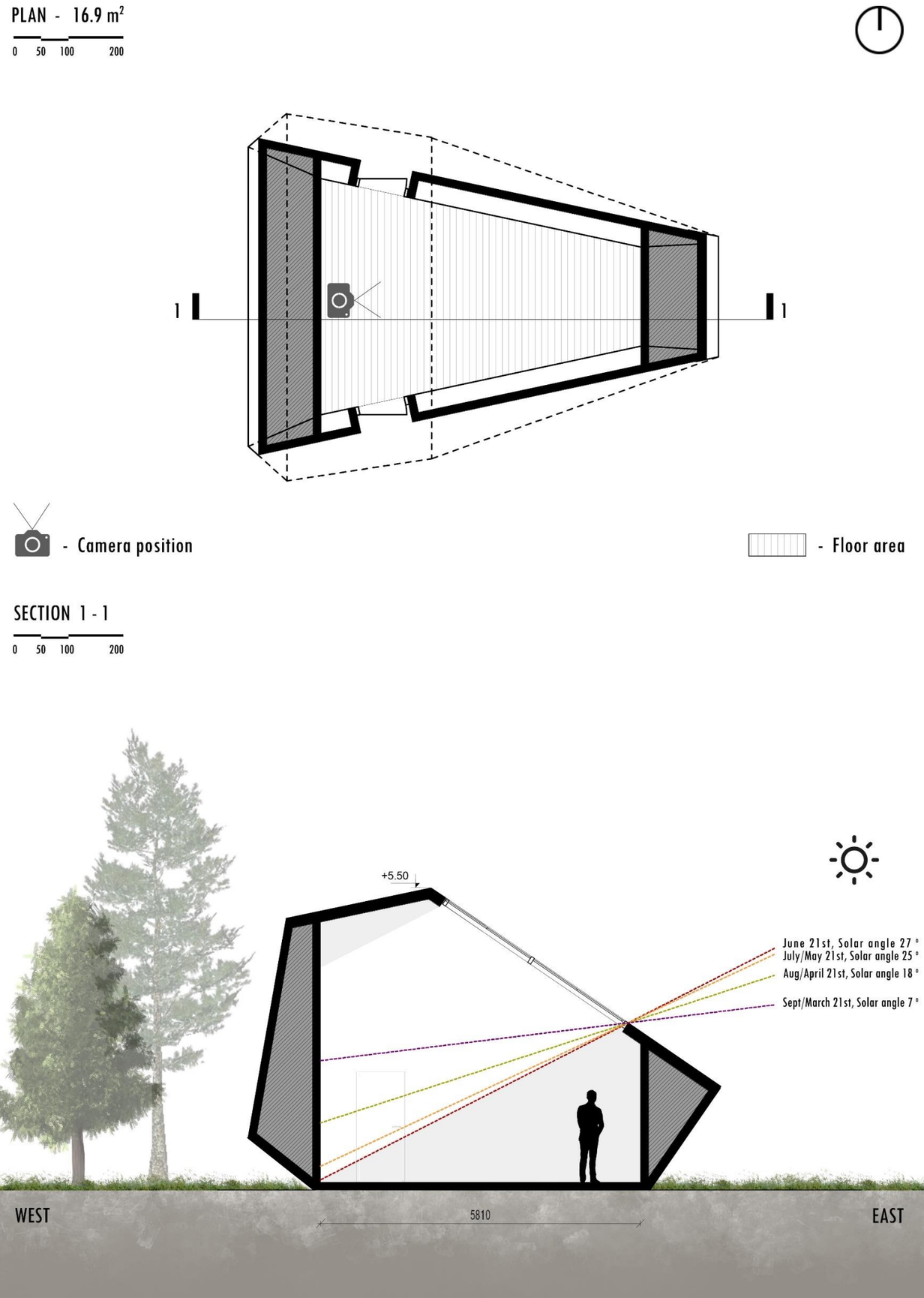


Figure 53. The first pavilion plan and section (Thesis author).

DAYLIGHTING

For the daylight analyses the cardboard scale models (M 1:32) have been created (Figure 54). The model's window on the rooftop is simplified for tests since it does not significantly affect the perception of the pavilion and the final results. The primary idea was to demonstrate direct and exaggerated sunlight type working (Figure 55).

Tests have been carried out using a heliodon device in the solar labour in TalTech main Campus.

The orientation of the first model is from West to East. The study involved the months from April to August, when the sun is most active and pleases tourists with its presence.

Since the study was carried out in a dark room, where the "sun" from the heliodon served as the only source of light, it was not possible to obtain scattered light from the sky.

Therefore, the interior of the model has been either nicely lit by direct "sunlight", or has been completely dark since indirect lighting could not be achieved. In the results presented on the next page, it is indicated "from sunrise to sunset", however, it does not mean sunset or sunrise in general, but this is a period of getting direct sunlight for the model itself.

Thus, direct sunlight in pavilion one is observed in:

- June from 4:00 to 17:00
- May-July from 4:00 to 16:00
- April-August from 5:00 to 16:00

These time interval results are presented in Figure 55. The rest of the time, the lighting will be just indirect from sky.

Figure 54. The cardboard first scale model's 3D section.

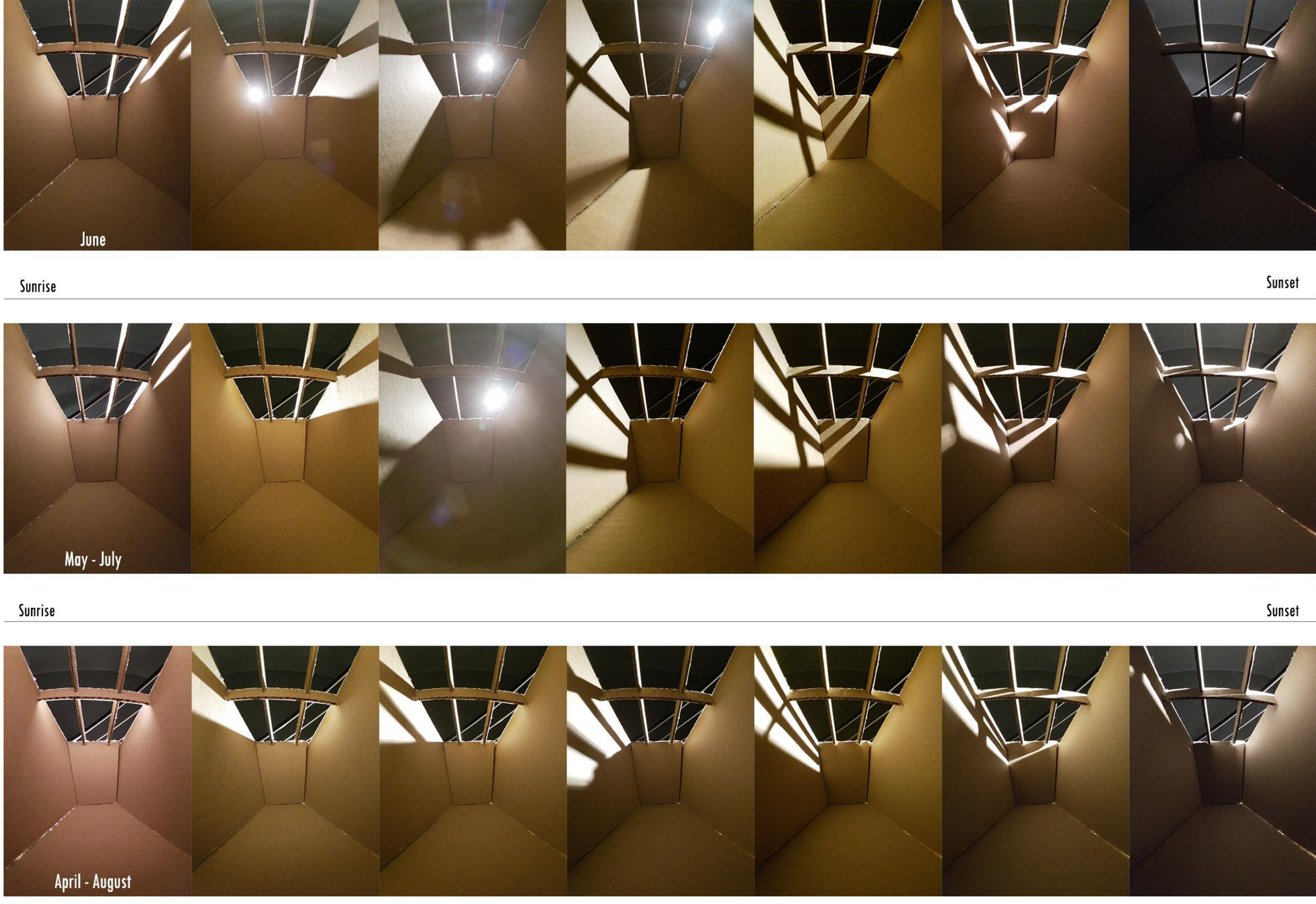


Figure 55. The direct and exaggerated sunlight type demonstration for the first pavilion called "Exposition".

11.2 CONFLICT – SPATIAL INDIRECT LIGHT

DESIGN IDEA

The second step in classical drama provokes an incident or causes a conflict situation, and smoothly leads to the climax of the story, heating up the situation.

The inspiration for the second design was given from caves and cracks in the gorges. Once in a place with limited space and the amount of light received, person lose touch with the world around, some may even begin to feel claustrophobia (Figure 56).

The aim of "Conflict" model to show how indirect light affects the perception of the surrounding world in restricted conditions, while not being able to look out the window and admire the views. Especially if daylight also enters a little inside.

Figure 56. The second pavilion elevations (Thesis author).

FLOOR PLAN AND SECTION

This type of space is a rather narrow corridor, entering which you do not immediately see the next exit. Here the walls hang over the viewer, demonstrating their mass and grandeur (Figure 57).

Under the ceiling at a height of more than 6 meters there is a small window through what light enters. Direct rays never reach the floor, but hover somewhere in the middle.

Floor area is 10,3 m² and the highest point ~ 8,2 m.

As in the first model there are some spaces between the inner and outer walls for construction that are closed for visiting.

EMOTIONS

This model is designed to evoke negative emotions in the viewer, to experience fear, doubt or uncertainty. Of course, each of us perceives situations differently and may experience completely different emotions when visiting this museum. However, when creating the second model, it was precisely the concept of fear that could be caused by a peculiar interior and an insufficient amount of light that was taken as the basis.

Light coming in from a small window somewhere near the ceiling creates a sense of mystery and uncertainty. And the high massive walls create a narrow corridor, as if leading us along the path of the dark paths of the soul.

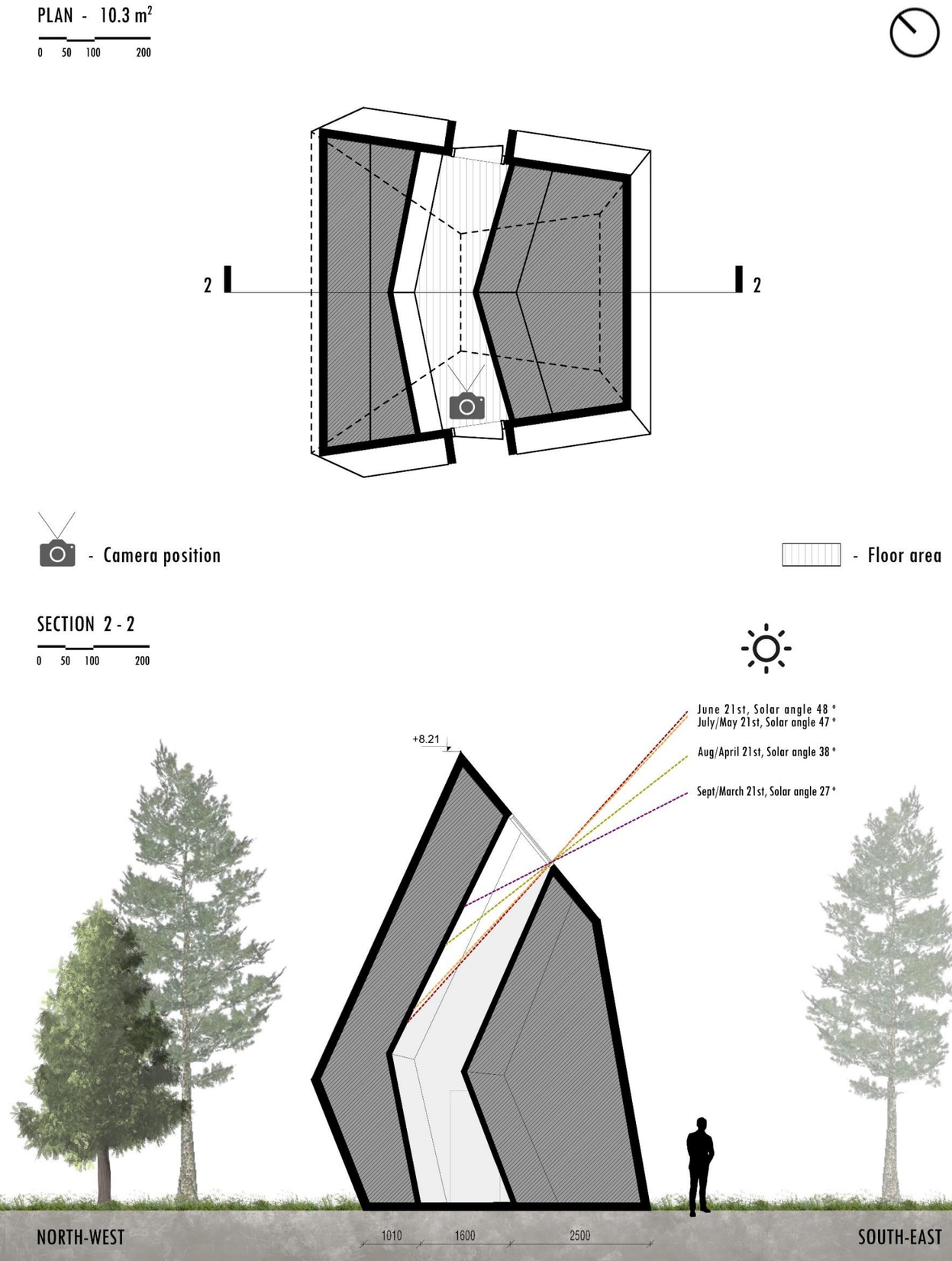


Figure 57. The second pavilion plan and section (Thesis author).

DAYLIGHTING

The prototype of model two was also created from the cardboard in quite unusual scale 1:32 (Figure 58). This is at least fifth variation, because the previous models have not worked properly.

The most essential task was to find the right angle at which sunlight could enter the room without reaching its floor. It was also important to determine the distance between the inner walls, since if the corridor was too narrow, it would be difficult to install a door.

To test the model, a heliodon device was used in the solar laboratory in TalTech, and attempts were made to study the distribution of light simply using a flashlight and a table lamp.

The orientation of the second model is from North-west to South-east. The study involved the months from April to August, when the sun is most active in Estonia.

As in the first pavilion, due to the lack of extraneous light in the room, it was not possible to get diffused light from the sky.

The results shown on the next page indicate " from sunrise to sunset", but this does not mean sunset or sunrise at all, but the period of direct sunlight on the model itself. Since its illumination was carried out due to the "sun" of the heliodon.

The direct sunlight in pavilion two is observed in:

- June from 7:00 to 15:00
- May-July from 8:00 to 14:00
- April-August from 9:00 to 14:00

These time interval results are presented in Figure 59. The rest of the time, the lighting will be just indirect from sky.

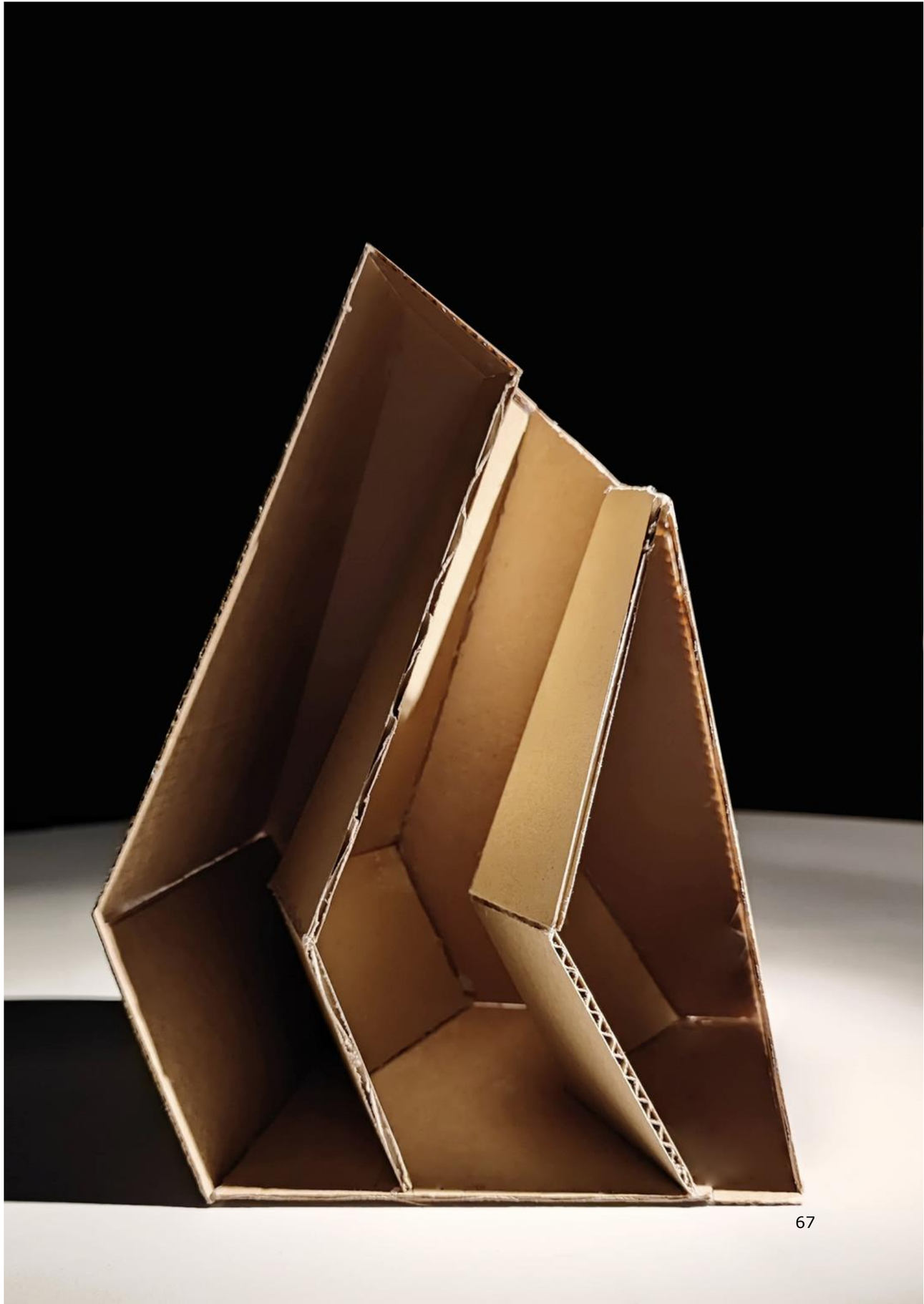


Figure 58. The cardboard second scale model’s 3D section.

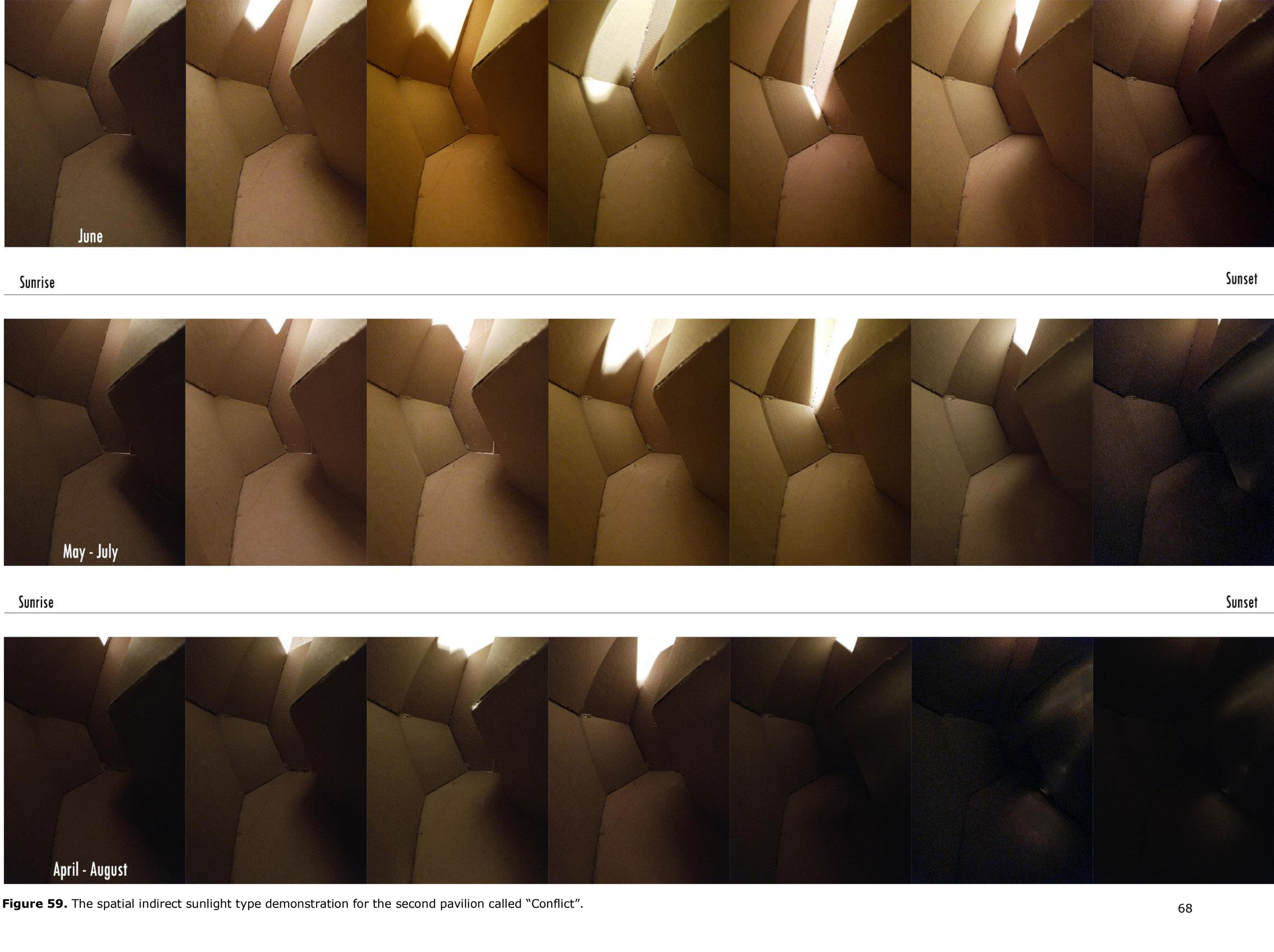


Figure 59. The spatial indirect sunlight type demonstration for the second pavilion called “Conflict”.

11.3 CLIMAX – SELECTIVELY DIRECT LIGHT

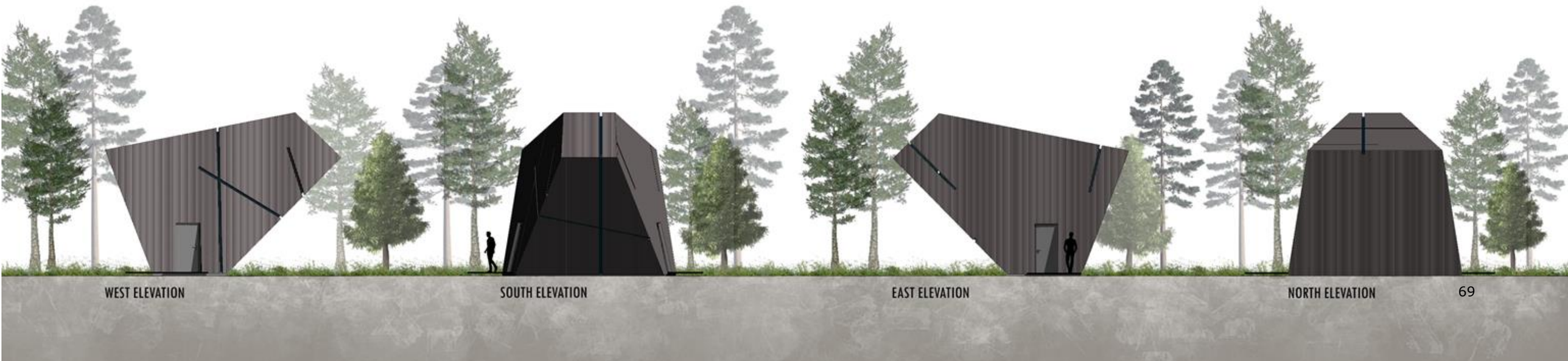
DESIGN IDEA

The third model as a climax in classical drama occurs exactly in the middle of story and is considered not so much the moment of the greatest drama as the point of reflection.

If the task of the previous pavilion was to frighten the viewer or sow panic in him, then the third hall of the Museum of Emotions should inflame the viewer's feelings even more (Figure 60).

The aim is to show a high contrast between light and darkness in the interior with using insignificant number of narrow strips of light aggressively space related to each other. Generally, the main task of this type is not illuminating, but the transmission of a certain mood and emotion to the viewer presenting how aggressive sunlight rays can be.

Figure 60. The third pavilion elevations (Thesis author).



FLOOR PLAN AND SECTION

This room tapers upward, the western facade of which is incised with criss-crossing lines of openings in the structure. The eastern facade is calmer, as it is a kind of screen for the projection of aggressive rays from the opposite side.

During the planning process, as many sharp corners as possible were used to better articulate the atmosphere (Figure 61).

Despite a fairly large airspace there are no standard windows, just glazed strips 10 cm wide for getting sun inside.

Floor area is 14,5 m² and the highest point ~ 6,2 m.

EMOTIONS

If the previous space was intended to create a frightening effect of uncertainty by not enough visual amount of light, then the third hall or "climax" plays more aggressively, directing the stripes of light in different directions.

Strong contrast causes negative emotions, and constant slanted lines and crosses can contribute to an invasive state and a hostile mood. The pavilion refers to the idea of the Libeskind Jewish Museum, where sharp contrasts make a person think and look deeper into himself.

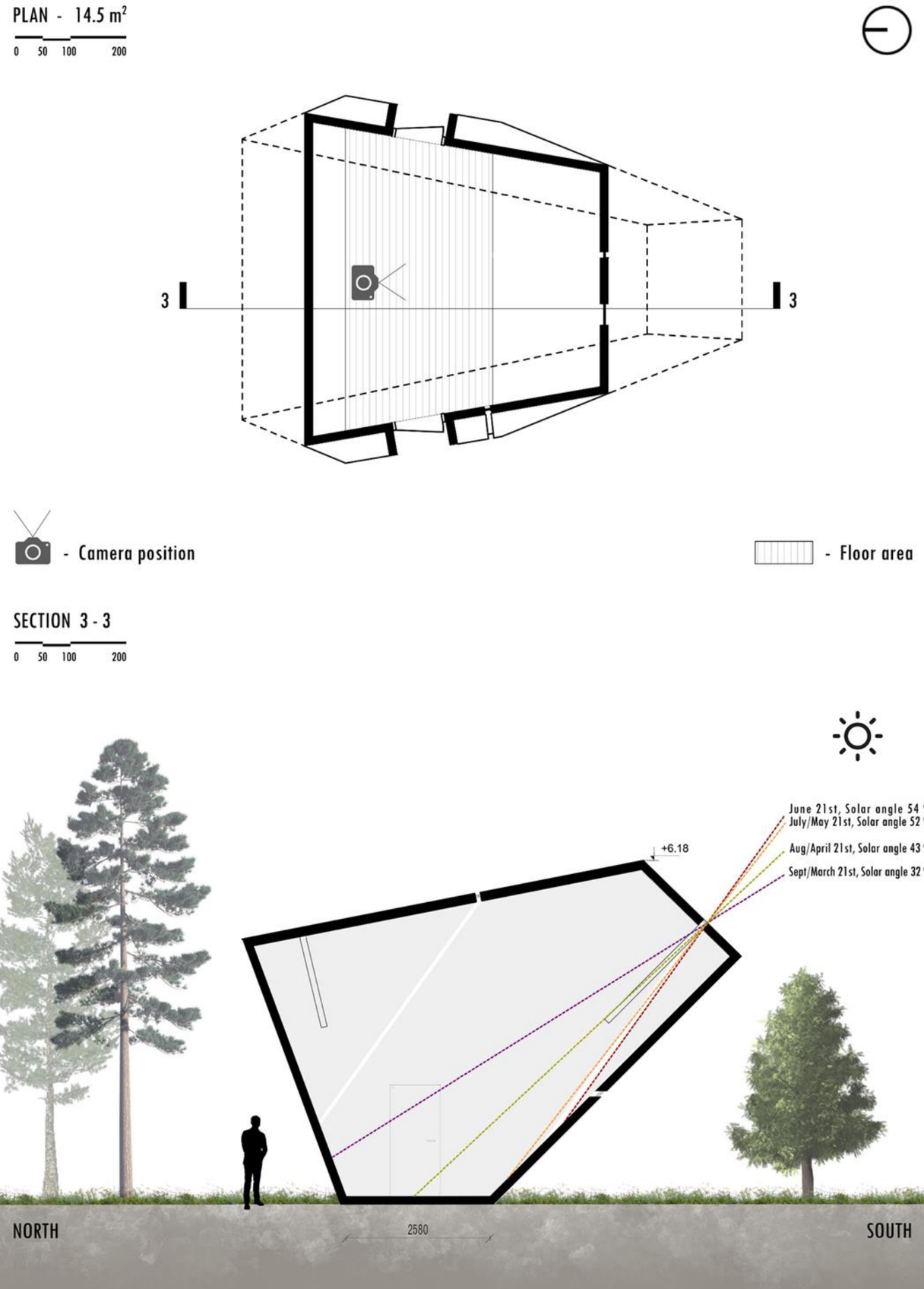


Figure 61. The third pavilion plan and section (Thesis author).

DAYLIGHTING

The creation of the third hall of the Museum of Emotions took more time and resources than all the others. All walls of the scale model have a three-layer structure: cardboard, as the structural material of the model, transparent thin double plastic layer in place of the windows and to connect the parts of the composition to each other, and tinted paper to match the colour of the cardboard to eliminate glare from plastic (Figure 62).

The scale is also 1:32.

With the number of crossovers, the main thing was not to overdo it, since the shadows look more spectacular on a completely solid surface.

Testing was carried out using a heliodon in the solar laboratory of the university.

For orientation, the direction from North to South was immediately chosen, since according to the idea, the southern part of the facade at noon exactly should illuminate the room in such a way that the strip of light divides the space exactly into two parts.

The study involved the months from April to August, when the sun is most active in Estonia. However, due to hall advantageous location, this pavilion also works well during the winter months.

The uniqueness of the model allows you to catch direct sunlight at any time of the day, regardless of the season.

Only the "sun" of the heliodon was used as a light source.

The direct sunlight in pavilion three is observed in:

- June from 4:00 to 21:00
- May-July from 4:00 to 20:00
- April-August from 5:00 to 19:00

These time interval results are presented in Figure 63.

Figure 62. The cardboard third scale model's 3D section.

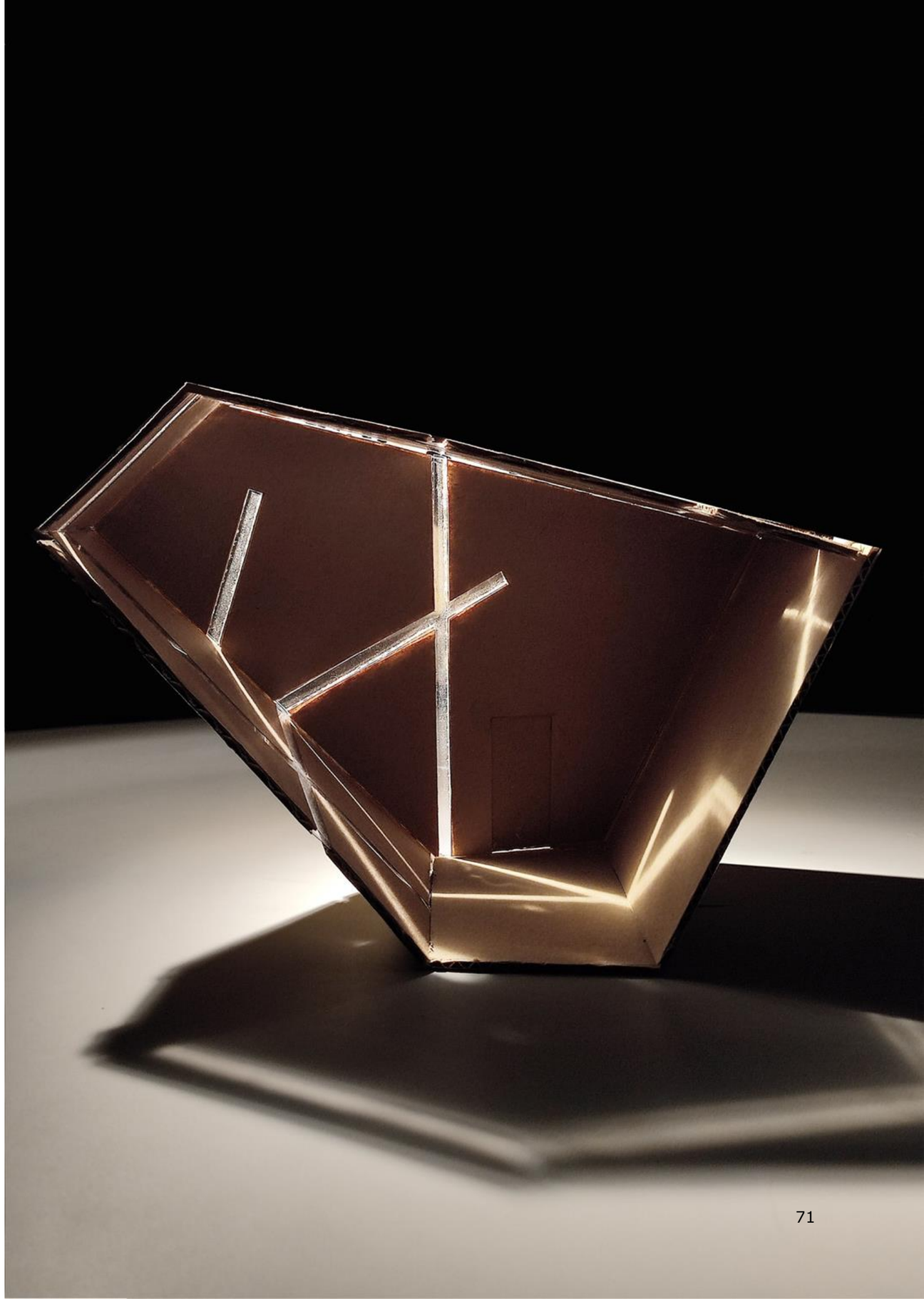


Figure 63. The selectively direct sunlight type demonstration for the third pavilion called "Climax".

11.4 FALLING ACTION – DIRECT & SCREENED LIGHT

DESIGN IDEA

According to five-act classical drama, everything that has been going awfully before starts to go excellently.

One aspect of falling action is the power of the final suspense. The viewer is unhurriedly moved away from sharp emotions, while maintaining suspicions about the final scene, where it hints at a slight possibility of a reversal.

The idea of forth model is to lift the mood and give it a cheerful touch of playfulness, to evoke a frisky rhythm and create the effect of an increased accumulation of units on one square meter using a huge number of tiny openings on the walls (Figure 64).

Figure 64. The fourth pavilion elevations (Thesis author).

FLOOR PLAN AND SECTION

This model differs from the others in that all the walls of the facade, with the exception of the northeast one, are located perpendicular to the floor. The room also has a large amount of air space and the largest area among other pavilions – 21,5 m² where the highest point is ~ 5,5 m (Figure 65).

The elements of the north-western and south-eastern facades are installed so that they form narrow openings 7 cm wide at a distance of 15 cm from each other. These "windows" are not glazed and are open on all sides.

The south-western wall, like the roof, is solid.

EMOTIONS

Abundant lighting is perceived positively by alternating play of light and shadow since the shadow areas differ little in width from the light strips and have a clear ordered structure.

Being in such a room one involuntarily recalls Greek and Roman temples, where architects used natural light only to reveal the structure and shape of objects without putting an ideological and symbolic component into it.

Thus, this space creates a playful and cheerful atmosphere, gives stability and confidence, which was so lacking in the previous pavilion.

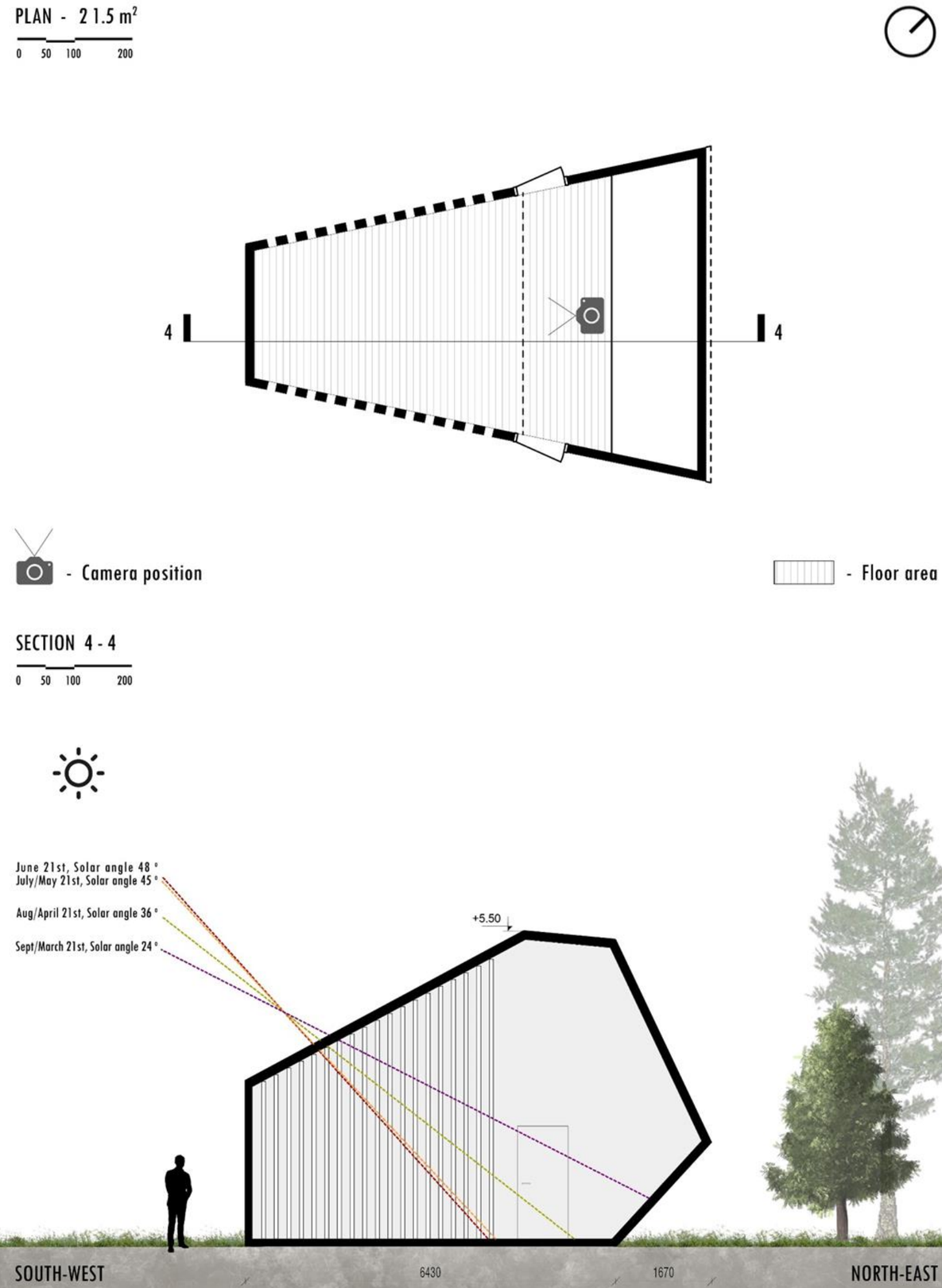


Figure 65. The forth pavilion plan and section (Thesis author).

DAYLIGHTING

The implementation of the fourth model have been changed drastically several times during the design of the project. Initially, it was conceived as an indirect sunlight model whereby installing walls with vertical slots from the floor to the ceiling on different layers, a three-dimensional effect would be achieved. However, numerous researches had been not successful and it was decided to simplify the model to one layer of the wall.

The model is made of thin cardboard in 1:32 scale (Figure 66).

The orientation of the hall from Northeast to Southwest provides an excellent opportunity to catch both morning and evening sun rays. An interesting moment is two o'clock in the afternoon, when the sun shines exactly on top of the pavilion and there is no shadow is cast inside during this period.

To test the model, a heliodon device was used in the solar laboratory in TalTech.

The study involved the months from April to August, when the sun is most active in Estonia. However, due to hall advantageous design the direct sunlight penetrates inside at any time of the day, regardless of the season.

Only the "sun" of the heliodon was used as a light source.

The direct sunlight in pavilion four is observed in:

- June from 5:00 to 21:00
- May-July from 5:00 to 20:00
- April-August from 5:00 to 19:00

These time interval results are presented in Figure 67.

Figure 66. The cardboard forth scale model’s 3D section.

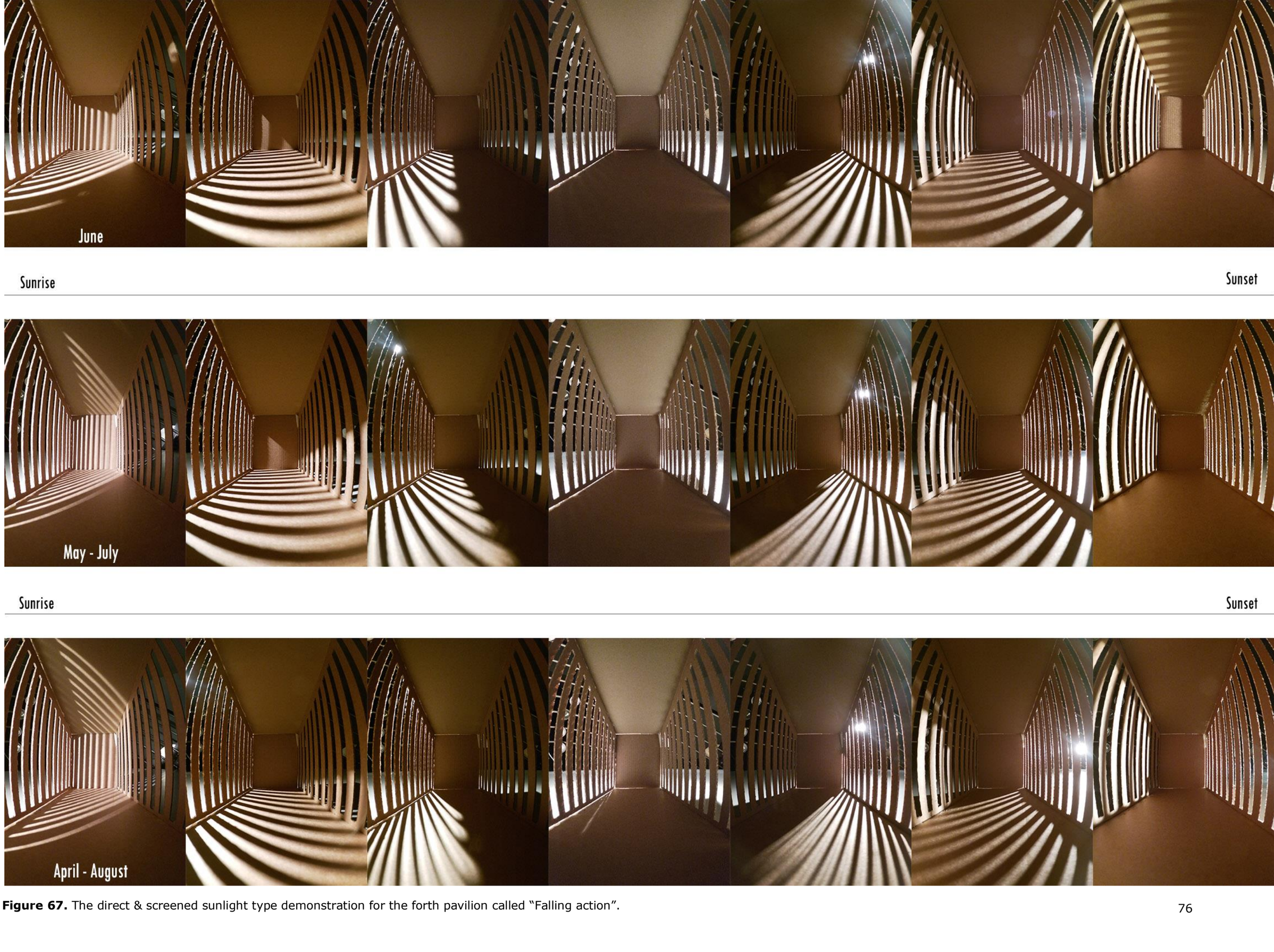


Figure 67. The direct & screened sunlight type demonstration for the forth pavilion called "Falling action".

11.5 RESOLUTION – DIRECT & INDIRECT LIGHT

DESIGN IDEA

The last model sums up and logically completes the tour of the museum. In the ideal, as for example in the structure of the classical drama, everything that has been built before it finally happens at the same time.

Thus, the pavilion should include both direct and indirect sunlight. However, in order to further diversify the emotions of the viewer and put an end to the excursion with this space, it was decided to use the reflection of water as a light transmitter. Thanks to this, the visitor can both admire the water surface and the play of light on the ceiling and walls of the hall (Figure 68).

The purpose of the latest model was to create a special soothing space that brings peace and tranquillity.

Figure 68. The last one pavilion elevations (Thesis author).

FLOOR PLAN AND SECTION

This type of space also consists of a rather narrow floor strip – 1,9 m. When entering the room, the first thing that catches your eye is the walls expanding towards the ceiling, one of which has a huge window overlooking the water surface (Figure 69).

Initially, it was planned to place the second window opposite the first one, but this idea had to be abandoned, because otherwise it would not be possible to see the glare running along the wall from the reflection of the water.

Floor area is 8,4 m² and the highest point ~ 6,8 m.

Compared to the previous pavilions, the hall has the insufficient floor area, but there is a lot of airspace.

EMOTIONS

This model is designed to soothe and soften the agitated feelings of the viewer. Here you can be enchanted by the calm surface of the water, enjoy the breath-taking nature outside the window or watch the play of light and shadow on the ceiling.

The last hall of the Museum of Emotions should leave an exceptionally positive mood, so that people willingly want to come back here again and again.

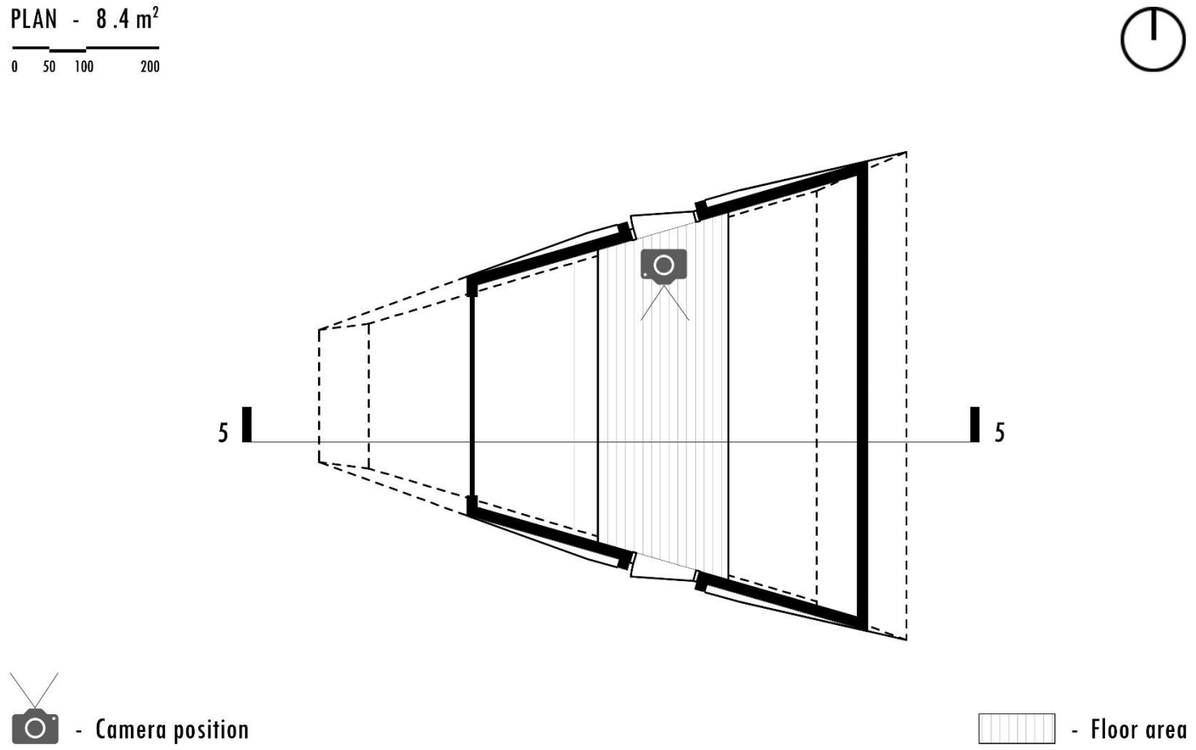


Figure 69. The last one pavilion plan and section (Thesis author).

DAYLIGHTING

The cardboard scale model (M 1:32) was also used for the last one space design. The model's window on is simplified for tests since it does not significantly affect the perception of the pavilion and the final results. The primary idea was to demonstrate direct and indirect sunlight reflected from water (Figure 70).

The original model had two large windows on opposite sides, but since the second window played a rather passive role, it was removed. Also, the angle of inclination of the western facade was raised in order to better illuminate the interior.

Tests have been carried out using a heliodon device in the solar labour in TalTech main Campus.

The orientation of the model is from West to East, as well as for the first pavilion. The study involved the months from April to August, when the sun is most active and pleases tourists with its presence.

Since the study was carried out in a dark room, where the "sun" from the heliodon served as the only source of light, it was not possible to obtain scattered light from the sky (Figure 71).

In the results presented on the next page, it is indicated "from sunrise to sunset", however, it does not mean sunset or sunrise in general, but this is a period of getting direct sunlight for the model itself.

The direct sunlight in the last pavilion is observed in:

- June from 9:00 to 21:00
- May-July from 10:00 to 20:00
- April-August from 11:00 to 19:00

These time interval results are presented in Figure 71.

Figure 70. The fifth cardboard scale model's 3D section.

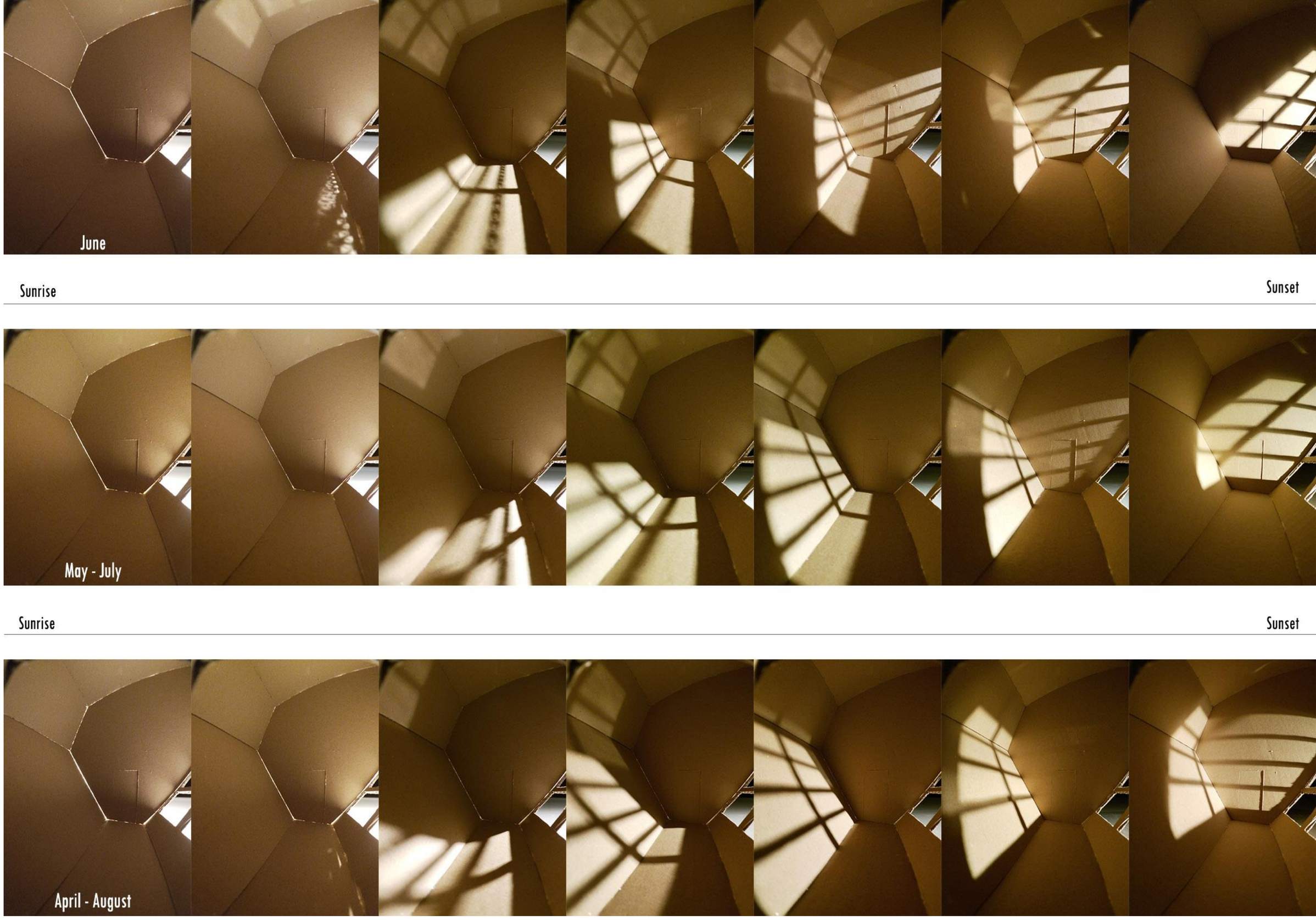


Figure 71. The direct & indirect sunlight type demonstration for the fifth pavilion called "Resolution"

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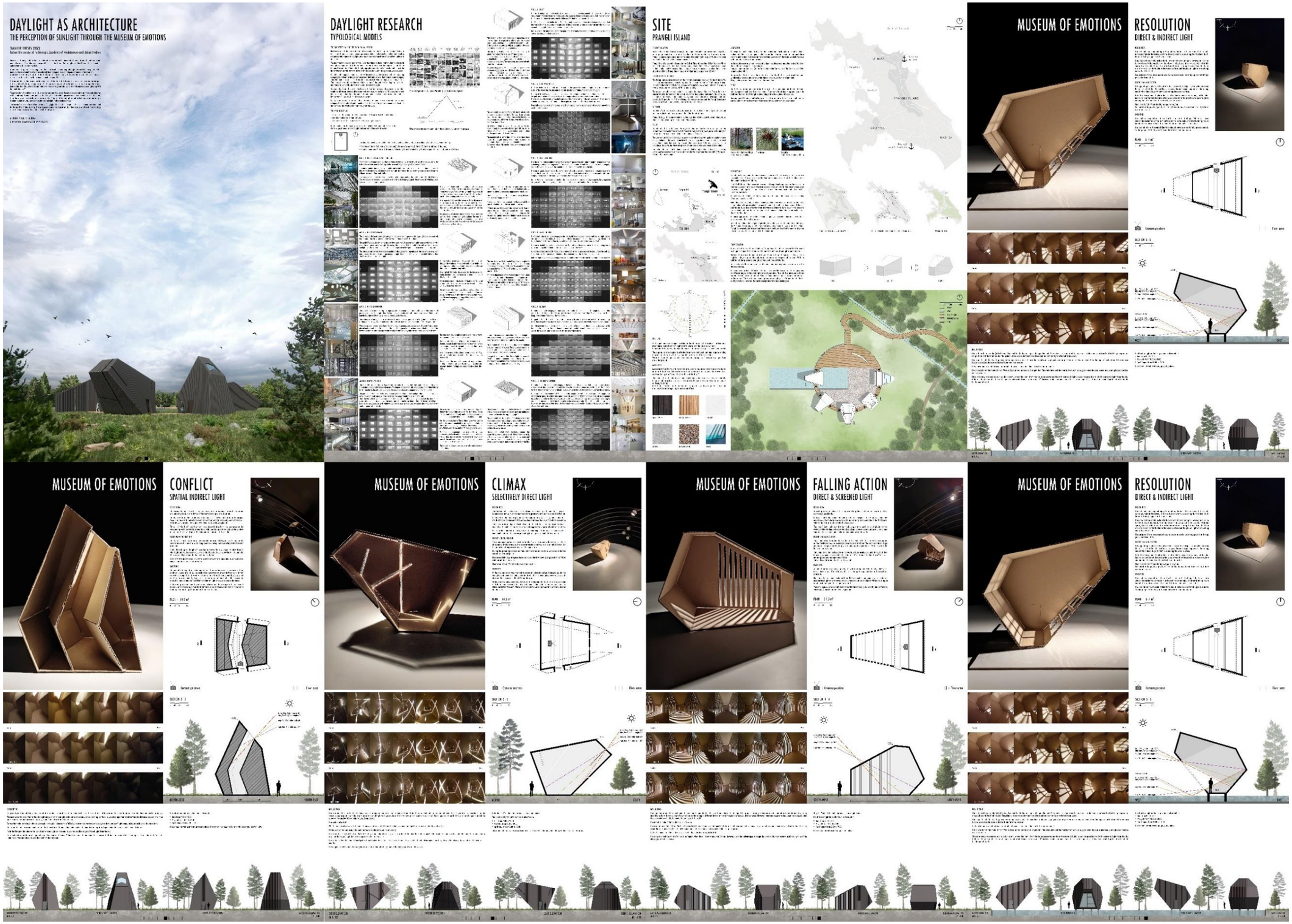
PANELS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