To one and only.

COLOPHON

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Preface

ABSTRACT

This report presents the proposal for a new theatre for Aalborg, Denmark. The project is a new approach to the theatre building and performance itself. It combines tradition with new ideas.

The considered site lies by the Limfjord, north-west from the city centre, and it is area of approximately 10 000 m^2. Surrounding area consists mainly of the old industrial buildings, but Aalborg's waterfront is quickly developing, and new buildings are being erected, changing the character and expression of the space. The project fuses the new architecture of fast growing promenade, while trying to capture the feeling of the post-industrial atmosphere of the space.

Concept aims to extend the walk-able boulevard and invite people to visit the site. The project of the theatre building includes also the design for the surrounding area, creating the park at the end of the pier. The intent is to create place where people can rest for a while after the walk, or after the performance.

On the other side, building relates to the Musikkens Hus and Nordkraft, two big cultural hubs, starting the dialogue and giving the possibility for development of the cultural district. The project develops the new landmark, extending the waterfront, inviting people in. It creates cultural niche, while capturing the industrial feeling of the space.

PROLOGUE

This project was developed by Bartlomiej Rusiecki, Msc03/04 Arc 2014/2015 Architecture and Design at Aalborg University.
Project was developed using holistic approach to the design and taking into account various factors and parameters. The primary focus was creating high quality architecture, however project also includes, among other things, structural design, lighting design and meeting the requirements of the regulations of 2020 standards.

Designing process was supervised by Mads Dines Petersen, assistant professor at department of architecture, design & media technology at AAU, and technical supervisor Lars Anderson, associate professor at department of civil engineering at AAU.

GUIDE TO READING

This report presents proposal, of the new theatre for the city of Aalborg. The project was developed with the Integrated Design Process, synthesising the architectural vision and technical knowledge.

The report is divided into two parts, first being the theoretical study, focusing on artificial lighting, and the second one, showing the design of the theatre. The second part starts with the analysis, followed by the design proposal, briefly presenting the design process summed up with the conclusion and reflection. The end features annexes and list of references.

References are denoted with the Harvard method.

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Introduction

The main focus of this thesis is to investigate how light influences our perception of the surroundings. How the atmosphere of the place is created and what makes us feel in the specific way? What is the atmosphere of the architectural space? In the second part the acquired knowledge will be applied in the design process of the new theatre building for the Aalborg.

Light accompanies us from the very first day we are born. Life, as we know it, would not be possible without it. Throughout the history, light enabled us to, first, discover and explore the caves, thus providing us with shelter. Our ancestors discovered fire and were able to habitat dark, inaccessible before spaces. Later, the first primitive stone lamps, and after that, candles were created. Later light was used to improve the functionality of the buildings, and secondly create effects in the buildings and to add significance to the sacred places and gathering areas.

With the further development of architecture, people started to use light to mark important places or to create certain mood and to influence the visitors. This is most visible in the temples and other places of worship. The spectator was supposed to feel the presence of grater force. The cathedrals from middle ages filter the light through the stained glass-work, later during the Baroque: flickering light reviled the complicated architectural forms and details creating fantastic play of shadows.

Light is also inspiration and tool for other artists like painters and sculptors. It is light that reveals the shape and form. In the paintings of baroque masters, such a Caravaggio, it builds the atmosphere, and the mood (see Figure A.1 on the next page). The points of focus are very bright and exposed to direct light, while the rest is hidden in the shadows.

In the words of Walter Gropius - "This is the task of education: to teach what influences the psyche of man in terms of light, scale, space, form and colour. Vague phrases like "the atmosphere of a building" or "the cosiness of a room" should be defined precisely in specific terms. The designer must learn to see; he must know the effect of optical illusions, the psychological influence of shapes, colours and textures, the effects of contrast, direction, tension and repose; and he must learn to grasp the significance of the human scale." [Michel 1995]

To better understand how the light influences our perception it is also crucial to understand how our sight works. Everything we see is created by reflecting light - the colours, shadows shapes. Vision enables us to understand basic properties of objects without involving other senses. When presented with the image of fresh, juicy fruit we are able to imagine its taste, just by looking at it. The same thing applies to the touch. We are able to determine whether something is the rough or soft. Light and the way it reflects on differently finished surface makes it possible for us. But it also gives opportunity to create the illusion and deceive us.

As mentioned before, this report is divided in to two main parts. Despite that division it is meant to be treated as one. The design part was created using the theoretical studies from the first part. I have been divided into VIII chapters. It was written during two semesters at the Aalborg University in Aalborg, Denmark.

All the images, sketches, diagrams, etc. were created by the author, unless stated otherwise.

Figure I.0 - "*The Taking of Christ" by Michelangelo Merisi da Caravaggio.*

PART I

Chapter I

What is light? How does the human vision work? Types of light.

WHAT IS LIGHT?

According to the CIE (International Commission on Illumination), light can be defined as: “Any radiation capable of causing a visual sensation directly.” [CIE 1987] though in physics term ‘light’ may refer to any radiation, also non visible for human eye. [Narinder Kumar 2008]

There is certain spectrum of this electromagnetic radiation that is visible for average human (see Figure I.1 on the page 22). The wavelengths of visible light for average person are between 400nm up to 700nm. This range differs for everyone and some people are able to see wider spectrum of light. This applies especially to younger people, as with the age it gets narrower.

Modern light theory was based on the findings of physicist Max Planck, and later Albert Einstein. Light as we know it today, is a phenomenon which can be described in sometimes as particles, and sometimes as waves, depending on quantum state. In 1926, Gilbert N. Lewis used the term “photon” to describe the smallest unit of radiant energy. [Lewis 1926]

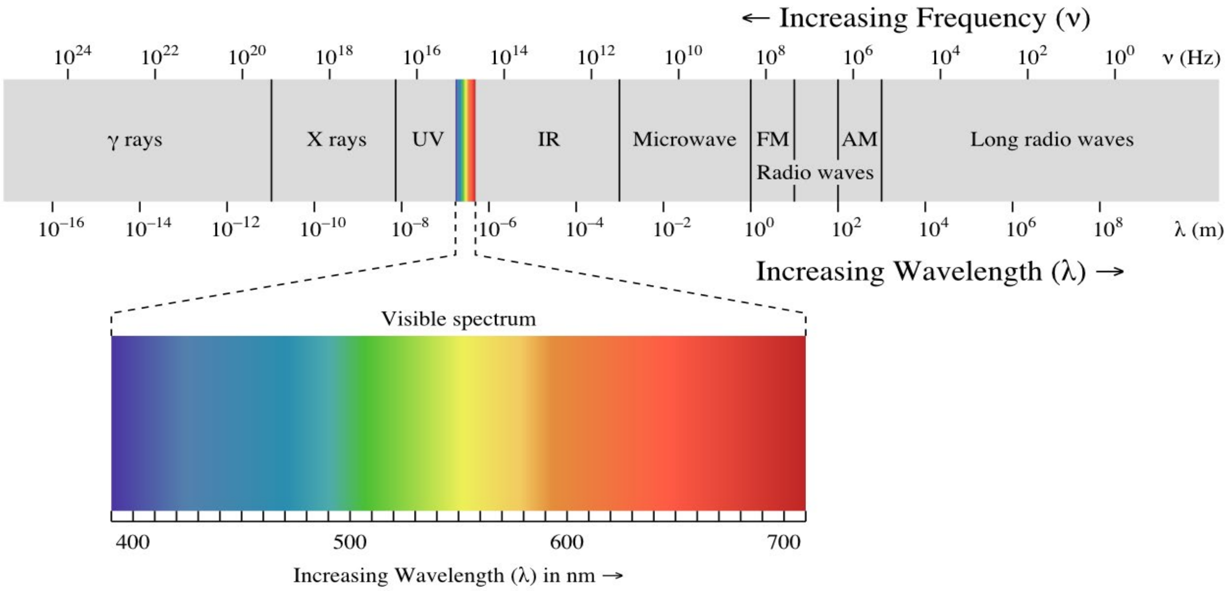

Figure I.1 - *Electromagnetic spectrum with visible light highlighted.*

HOW DOES THE HUMAN VISION WORK?

It is important for any designer working with visual environment to understand how the visual perception works. Basic knowledge can be useful in process of designing of the environments and can help to predict how it will influence people. Better understanding of those principles will allow designers to influence the visitors and make stronger impression.

Vision is an important part of our sensory system. Through the sight we distinguish the shapes of surroundings, also other properties such as texture and colour of object. Vision is connected to two other senses: hearing and touch. Every day we learn and memorize new things, and those information's are recorded in our brain. That is why we are able to see the difference in rough and smooth surface just by looking at the reflection.

PHYSIOLOGY OF THE EYE

In the book *Physiology of Behaviour* by Neil R. Carlson, we can read that the white outer layer of most of the eye called the sclera is opaque and does not permit entry of light and the cornea, the outer layer at the front of the eye, is transparent. The pupil, which is an opening in the iris (the pigmented ring of muscles situated behind the cornea), regulates the amount of light that enters the eye. The lens, situated immediately behind the iris, consists of a series of transparent, onion-like layers (see Figure I.2 on the page 23).

After passing through the lens, light traverses the main part of the eye and it falls on the retina, the interior lining of the back of the eye. In the retina are located the receptor cells, the rods and cones (named for their shapes), collectively known as photoreceptors. Those photoreceptors in the retina the rods and the cones

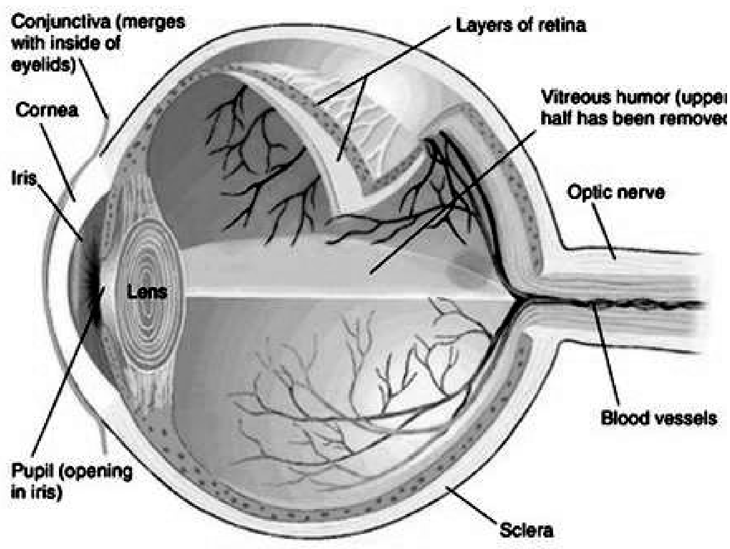

Figure I.2 - *The construction of the human eye.*

detect light. Muscles move the eyes so that images of particular parts of the environment fall on the retina. [Carlson 2012] Then, information is transformed into electrical impulses and travels through the optic nerve to the brain.

CONTOURS

Every time we look at some object, the first thing we register its outlines. Because of the way our eyes are build, we perceive surfaces as a gradients. The distinction between different textures is the difference of the smoothness of those gradients. When the difference in two gradients occurs, we see edges. For architects it means that the more is 'happening' on the surface (windows, doors, etc.), the less we focus on the edges.

CONTRAST

Being able to see the difference in the brightness of two objects or surfaces is the crucial part of visual perception. Comparing brightness is important for designers, as it shows the relations between texture, colour and the position of objects and surfaces in the space. This is connected to so called 'gamma movement', which is crucial for humans in spatial depth perception. We determine the distance of objects in the space by their shadow, colour, texture and size. It will be also factor in determining the position and quality of the light. Lou Michel writes: "Studies in visual perception performed outside the laboratory verify this fascinating relationship between spatial depth and brightness. After illumination on an object is increased, subject participating in these real-life studies evaluates its appearance as being closer and larger." [Michel 1995] Next he mentions that most of the time people are not aware of this effect, but the designer should always keep it in mind.

PATTERNS

Patterns are the part of our everyday life. The rhythmical pattern of windows on the buildings façades, the brickwork of the walls. Also inside buildings we can observe those repetitions - tiles in bathrooms/kitchens, blinds. If we see the collection of smaller units our brain interprets it as a pattern. If just one of those elements is different it changes viewer perception, and in some cases the mood of the whole

Figure I.3 - *Linear perspective.*

environment. But physical objects are not only things that can create patterns. They also can be result of lights and shadows.

LIGHT AND DARK ADAPTATION

The very important aspect of human visual perception is the ability of the eye to adapt to dark. It is crucial, when designing the lighting systems, to remember about it. People move through the buildings and spaces and through different light pre-sets. Eyes respond to changing levels of brightness and adapt. This can effect in temporary blindness, when we come across the environment with high contrasts. The good example is stepping outside from the theatre or cinema: "When the eye leaves the dark and enters bright surroundings, the iris contracts, letting much less light into the retina. If the viewer had been in total darkness for some time, a few minutes are required for adaptation to light." [Michel 1995] This should be considered while designing buildings with very darks spaces. The progression through light should be gradual. As we read later: "The order of theatre's spaces is noted here only to point out that the lighting values are to be sequenced from dark, to middle brightness, to bright daylight, each turn conforming to the natural process of the human vision". [Michel 1995] Spaces with high brightness contrasts should also have some sort of 'buffer zone' if possible. Great examples of simple solution are the luminaires or lamps situated next to the building entrance. They indicate where to approach the building and in addition to that prepare eyes for the brighter inside.

SPATIAL DEPTH PERCEPTION

The visual depth perception is the ability to see the surrounding word in three dimensions and to estimate the distance to the object. There are few so called 'depth cues', allowing us to perceive spatial depth. Depending on the source the number of cues varies but there some that are more interesting from the designers point of view.

Linear perspective - the most dynamic, and very visible in buildings and architecture in general. With increasing distance from the observing subject, the objects image on the retina is transformed in the way that they appear to reduce the size and the distance between each other, until they meet in 'vanishing point'. This can be easily observed on the railway tracks and in some architectural interior spaces (see

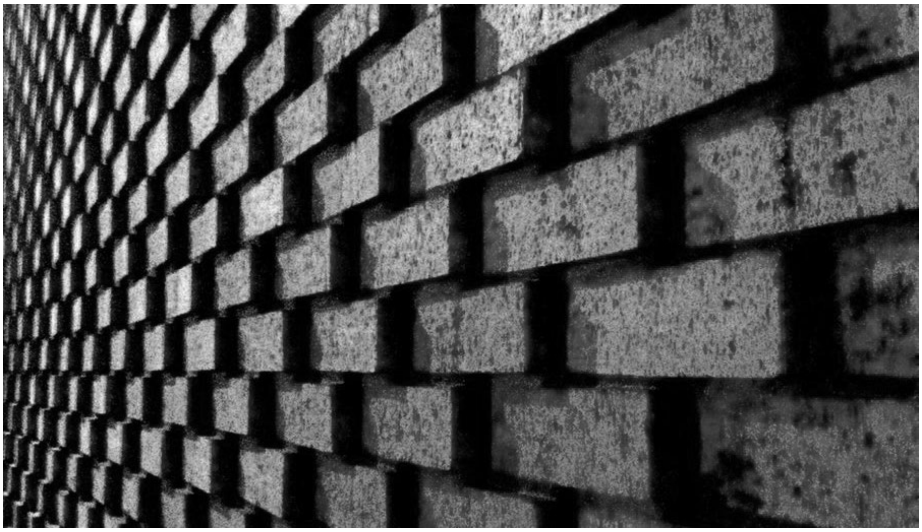

Figure I.4 - *Texture gradient.*

Figure I.3 on the page 24).

Relative size - People are able to determine the distance of the object by its apparent size, if they know its general physical size from the experience. Objects that are further in reality appear smaller, because their image on the retina is reduced in size.

Texture gradient - The surface with visible texture, seen from an angle, appear as a gradient. The further from the observer, the smoother surface will seem. This is particularly visible on the stepped brick or stone walls.

Superposition - known sometimes also as Interposition. In case when two objects overlap, the one with visible contour seem to be closer and in front of overlapped object. Depending on the case, objects may appear to be equally distant.

Motion parallax - When the body moves in relation to its surroundings, objects at different distances move at different relative rate. When we are in the moving vehicle, objects outside window seem to move much faster than the more distant ones.

Relative brightness - another very important cue. As discussed earlier, it can completely change the perception of one's spatial depth.

Shadow - it is also one of the things that help us perceive three dimensional spaces. It appears as changes of brightness or gradients in the space. This cue is widely used by artists in the paintings and drawings. The shadows also appear much sharper near the observer and they become the play of highlights, mid-tones and shadows in the distance. This is closely connected to the next spatial cue.

Aerial perspective - this cue is referring to how our vision changes in the air. When we look at the distant objects, they appear blurred. It happens due to the loss of detail and colour. Depending on the location objects in the distance appear lightly blue.

In his book, *Light: The Shape of Space*, Lou Michel [Michel 1995] describes also other cues, but those above were chosen as most important for the designers.

TYPES OF LIGHT.

The light sources were categorised into two main groups - natural light and artificial light. The first one cannot be controlled by humans, or it can be controlled only at some degree. On the other hand artificial light can be fully customized to our needs. The same applies to the effects, the light has on objects. We cannot predict how the all the possible scenarios involving the natural light. On the other hand it is possible to change and control appearance of space with the careful use of artificial light.

NATURAL LIGHT SOURCES	FIRE SUNLIGHT STARLIGHT METEORS AURORAS INCANDESCENCE BIOLUMINESCENCE FLUORESCENCE
ARTIFICIAL LIGHT SOURCES	ELECTRIC ARC INCANDESCENCE CATHODOLUMINESCENCE FLUORESCENCE ELECTROLUMINESCENCE LASERS

Figure I.5 - *Division of light sources.*

NATURAL LIGHT SOURCES

Sun - it is the first thing that comes to mind. Even though the Sun is one of many stars, it has a direct influence on Earth, unlike all the others. Apart from creating spectacular sight at night and giving us inspiration (to discover, to examine, to understand the universe), those other stars do not change our everyday life. Sun provides us with light and warmth. We learned to harvest the energy from its radiation. It made the life on earth possible. The quality of light is unlike anything else. With all the changes and effects, it is nearly impossible to replicate. At the same time sun makes the distinction between night and day, creating the natural cycle of life. Sun is widely recognised, as the most important source of light for designers. Many great architects work with sunlight, carefully crafting the spaces and their atmospheres. As Louis Kahn said: “No space, architecturally, is a space unless it has natural light. A room in architecture, space in architecture, needs that life-giving light - light from which nature is made” [Tyng 1984]

Starlight - mentioned above, starlight refers to the visible radiation of other stars. It is mainly observed during the night. Sometimes it is strong enough to create effects on object and surfaces.

There are also other types of natural light like:
Incandescence - the light emitted by the heated body (heated up metals, lava).
Bioluminescence - which is visible radiation produced by the living organisms.
Also Lightnings and Auroras. Though they can change the appearance of the building dramatically (especially lightning), they influence the surroundings for very short time and it is hard to consider them during the design process. Those types of light can be very beautiful, and produce magnificent effects, but they are insignificant for the building design.

ARTIFICIAL LIGHT SOURCES

Fire - the first ‘artificial’ source of light. The first invention of the human kind, allowed us to explore places, which were unreachable before. The fire allowed us to find shelter in caves. Humans were no longer limited by the darkness. Though with the invention of modern light it was less and less used, it was the main source of light, until the XVIII century. Even today, at some places candles are used as a prime source of light. Flickering light addresses our primal instincts, and we still like to look at it. It creates very cosy, intimate atmosphere. It was also used on the streets of the cities in form of gas lamps, making them much safer.

Incandescent light bulbs - the discovery of electricity and experiments in XIX century, brought a new era for human kind. The incandescent lamp was invented and provided people with new, safer than open flame, source of light. In 1881, the Savoy Theatre was lit by Swan incandescent light bulbs, was the first public building in the world, to be lit entirely by electricity. [Burgess 1975] Those lamps use the effect of incandescent incandescence occurring also in nature. Object heated up, in this case by electric current, starts to emit visual light. Incandescence lights are still used today, but due to low efficiency (around 95% of energy used is the heat loss [Steffy 2008]) it is being replaced with the new, more efficient light sources.

Halogen lamps - this is another type of incandescence light source. Those lamps are produced with the addition of a small amount of one of the halogen gases (such as bromine or iodine). Halogen light bulbs create so called ‘halogen cycle’ in which, tungsten that was deposited on the glass envelope is evaporated from the surface. It guarantees the constant light output through the entire lifetime of the light bulb. Halogen lamps are used mostly as headlamps of vehicles and also in stage lighting.
Fluorescent lamps - the next type of light fixture.

Called also fluorescent tubes, emit light trough the substance that absorbed electromagnetic radiation. The emitted light has the wavelength within the spectrum of visible light. In order to produce the light, mercury vapour reacts to the electric current (cathodes) creating ultraviolet radiation, which makes the coating layer of phosphor to glow. Fluorescent tubes are much more efficient than traditional tungsten light bulbs. They also have the longer lifespan, which, despite the higher initial cost, makes them more economical.

Compact fluorescent lamps - also referred to, simply, as CFLs are the smaller versions of fluorescent tubes. They are produced in the same sizes as traditional incandescent light bulbs, to be uses at households.

Light emitting diodes - popularly known as LEDs or also SSL (solid state lighting) were in use from early XX century, though were not commercialized. [Zheludev 2007] They don't have a filaments or cathodes and operate on very low voltages. That and the fact they don't produce a lot of heat, makes them very efficient and extends their life. Because of their efficiency and long lifetime, they are developed to be applied in many different ways also in the houses.
There are also many different types of artificial light sources, but they are usually used for very specific tasks and are not in the commercial use. All mentioned above are the conventional light fixtures, which can be found in almost every building.

Figure I.6 - *Traditional incandescent light bulb.*

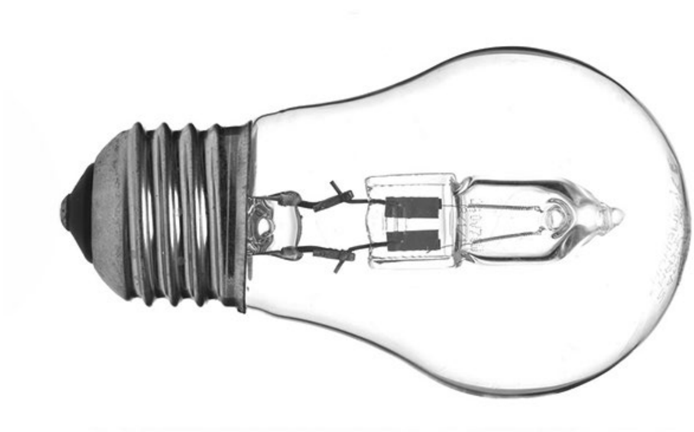

Figure I.7 - *Incandescent halogen light bulb.*

Figure I.8 - *Compact fluorescent lamp.*

Figure I.9 - *LED light bulb.*

APPLICATIONS

As mentioned above all described here types of light sources can be found in almost every building. Their main purpose is lighting up space. But light in buildings have also many other purposes. For one it can be used to inform and direct us inside the buildings. It can also be used in less obvious way, to create architectural quality. It can be arranged in a manner that will make one curious. It is possible to change the spaces mood with the light.

The technology is changing all the time, and therefore it is harder and harder to see the traditional incandescent lights in buildings. As we can read in "Architectural Lighting Design": "Given the state of energy codes and sustainability initiatives, filament lamps are already relegated to an extremely minor role in commercial construction." [Steffy 2008] As mentioned above the halogen lamps are also used in stage lighting (as the second part is focusing on the design of a theatre building they were included).

Traditional incandescent lamps are being replaced by the modern cathode lamps. They are very versatile and are produced in wide variety of shapes, sizes and colours. They are excellent for general purposes and for creating detail lighting or wall washing. They also have long lifetime and are more efficient. Today those lamps are most popular lighting fixtures. Most of the commercial buildings are equipped with fluorescent lamps, and they can also be found in households.

Rapid development of LEDs and optimization of production, introduced light emitting diodes into everyday light. Though they are not as popular as fluorescent lamps yet, it may soon change. LED light bulbs are commercially available and can be used with standard sockets. LEDs have very long lifetime and require minimum energy for work. They are very good for external use, as low temperatures extend the life of diodes. Even though the LEDs are very efficient, they are not very popular yet, as the initial cost of installation is very high. Also the palette of colours is still limited [Steffy 2008].

INCANDESCENT LIGHT	HISTORIC BUILDINGS RESIDENTIAL
HALOGEN LAMPS	AUTOMOTIVE INDUSTRY RETAIL STAGE LIGHTING
FLUORESCENT LAMPS	RESIDENTIAL RETAIL HOSPITALITY COMMERCIAL DECORATIVE HEALTH CARE INDUSTRY
LIGHT EMITTING DIODES	RESIDENTIAL RETAIL HOSPITALITY COMMERCIAL DECORATIVE HEALTH CARE INDUSTRY

Figure I.10 - *Applications of different light types..*

Chapter II

Brief history of artificial light. Artificial light in culture.

LIGHT IN CULTURE

Light is life giving force. It makes possible for us to see our surroundings. It enables vision to work and helps us to perceive spaces. But it is also regulates the natural cycles of life.

Around sun cycles, and changing of the seasons, first rituals were based and first cults created. In almost every believe system created throughout the ages, there was a cult of the sun and light, where the darkness and shadows, usually, represented the forces of evil. Today we still can find representation of those beliefs in the historic buildings and objects.

Later with development of fine arts, light shaped and created, first ancient sculptures, through the interiors of the cathedral, and later the paintings of baroque. To this day most of art addresses our vision.

People were always fascinated by light and effects it creates, therefore, since the dawn of mankind humans tried to control it. Today with the artificial lighting we discover new ways of utilizing it.

This applies also to the architecture. During the process of evolution sight became our prime tool of cognition. The conscious use of the light in buildings, natural but also artificial, allowed the designers to change the perception of the space and change the way it is perceived by the observers.

- 30,000	**TORCH** - discovered in Chauvet Cave, France, burned logs dipped in animal fat, are believed to be the first source of 'artificial light'.
- 15,000	**STONE LAMP** - discovered in Lascaux Cave, France, lamp from hollowed stone, with traces of fat fuel.
- 3,000	**CANDLE** - the invention of first candle made from tallow, later beeswax.
- 2,000	**GLASS** - the invention of glass in ancient Mesopotamia.
	RUSHLIGHT - The Romans used the stem of a rush dipped in the fat and held it in the special iron holders.
- 1,500	**OIL LAMPS** - invention of oil lamps, further developed in ancient Greece and Rome.
900	**GUNPOWDER** - Chinese invent the black powder. It was used mainly in entertainment.
	STAINED GLASS - the chronicle from Reims, mentions the stained glass.
1400	**MODULATED CANDLES** - modules for candles are created in France.
	FIREWORKS - beginning of the development.
1414	**OIL STREET LIGHT** - introduction of burning oil in open containers, first in London (Paris- 1524, Berlin- 1679).
1669	**OIL STREET LAMP** - development of oil lanterns for street lighting.
1792	**GAS LIGHTING** - William Murdoch invents gas lighting.
1807	**GAS STREET LIGHT** - first street in London is lit up with gas lamps, connected to centralised gas works (Paris- 1819, Berlin- 1826).

1811	GAS HOUSE LIGHTING - the first private house with gas lighting for individual use.
1815	GAS STAGE LIGHTING - The Olympic Theatre is the first theatre building using gaslight, also inside and as a stage lighting.
1820	INCANDESCENT LAMP - Auguste de La Rive passes electric current through the platinum wire, creating incandescent electric light.
	MUNICIPAL GAS - municipal gas plants and piping create central supply and introduce gaslight into dwellings.
1854	INCANDESCENT ELECTRIC LIGHT BULB - Heinrich Goebel develops first incandescent lamp using carbonised bamboo as filament and bottle as an envelope.
1881	SAVOY THEATRE - in London, is the first public building designed with incandescent lighting.
1887	INCANDESCENT STREET LIGHTING - first street in London is lit with incandescent lamps.
1895	CINEMATOGRAPH - Lumière brothers present their invention in public for the first time.
1905	TUNGSTEN FILAMENT - the first tungsten filament is made by Hans Kuzel. This extends the life of light bulbs to 1000 hours.
1907	NEON LAMP - the first neon tubes are introduced. Initially they produce only red glow, later blue and green. In 1933, the fluorescent powder coating allows the new range of colours.
	ELECTOROLUMINESCENCE - the discovery of phenomenon by Henry Joseph Round.
1926	FLUORESCENT LAMP - in Germany the tubular fluorescent lamp is introduced. Use of fluorescent powder coating, results in higher output and lowers the voltage.

1954	FIBRE OPTICS - fibre optics being developed by Narinder Kapany.
1959	TUNGSTEN HALOGEN LAMP - halogen is introduced to the tungsten lamp. It results in the eight times higher brightness and longer lifetime of light bulb.
1960	LASER - invention of the laser beam.
1962	LIGHT EMITTING DIODE - the development of the first practical LEDs within the visible spectrum.
1980	COMPACT FLUORESCENT LAMPS - development of CFL using the fifth of energy and lasting up to thirteen limes longer than incandescent lamps.
1985	DIMMING - development of system allowing to dim the lights through the control panel.
1999	DIGITAL CONTROL - development of The Digital Addressable Lighting Interface (DALI) allows dynamic and flexible control of lights.
2005	LED - further development of LEDs provides bigger variety of colours, better efficiency and lowers the cost of systems.

TIME LINE OF LIGHT SOURCES DEVELOPMENT

The time line presents selected, important inventions and discoveries concerning the development of artificial lighting. The more detailed time line can be found in the book "Made of light: The Art of Light and Architecture". [Major Speirs Tischhauser 2005] It was used as a departure point to create the time line in this report.

As we can see the light as we know it is not a new invention. It's almost 200 years old, and was developed through the years. Even the light emitting diode was developed in early 1960s.

Even though those inventions were around for a long time now, there is constant progress, regarding the efficiency, durability and lowering the cost of the systems. One of the main reasons behind that is the development of sustainable initiatives and thinking. The new technologies allow us to manage the light in more efficient way.

Figure II.1 - *Stained glass windows of Chartres Cathedral*

ARTIFICIAL LIGHT IN CULTURE

Through the history light had many purposes. Apart from extending our vision in dark spaces, it also became a tool for expression, entertainment, information and creation of moods.

The first source of 'artificial' lighting was fire. It provided us with light and warmth. Fire also allowed to habitat the inaccessible earlier caves, giving us the shelter. But there is something else. As Gottfried Semper wrote: "Around the hearth the first groups assembled; around it first alliances formed; around it the first rude concepts were put into the customs of a cult". [Semper 1851] The fire became the gathering place for people, the focal point for them. It helped with the forming of communities. Most of the people still enjoy sitting by fire, talking, feeling its warmth and looking at interplay of light and shadows.

People started to use light to emphasize the importance of the place, especially in temples and other sacred objects. At the beginning it was mostly natural light, but it was filtered and changed using different techniques. In early churches, particularly in Byzantine style, the interiors were finished with mosaics. Light reflected from their surface create spectacular sight: "A building singularly full of light and sunshine; you would declare that the place is not lighted by the sun from without, but the rays are produced within". [Procopius 560]

The Gothic cathedrals of Europe also provide excellent example of how people altered the light to create sublime spaces. The soften light filtered through the stained glass give the feeling of divinity. Those tall windows still make strong impression on us even today. Light was symbolising God, marked his presence in the space. At the same time it was decorating the

Figure II.2 - *"An Experiment on a Bird in an Air Pump" by Joseph Wright of Derby.*

interior with various colours and by emphasizing the structure.

After middle ages, light became also entertainment. The development of fireworks in Italy gave the new use to light. The 'rebirth' of the theatre also created new way of thinking. In early fifteenth century introduced new ideas, the first being the use of the artificial light and scenography for creating different characters. To this day the spectacles use dramatic lighting for creating dynamic illusions.

The light is also focus for artists. A lot of paintings, using very dramatic light, are created by masters such as Caravaggio, Rembrandt or later Van Gogh. Light gives a focal point and reveals things hidden in the darkness. It allows artists to create incredible tension, like in "An Experiment on a Bird in an Air Pump" painted by Joseph Wright of Derby (see Figure II.2 above).

The invention and popularization of an electrical light gave the new possibilities and created the new ways of using it. The light became the tool for advertising and providing information. The neon signs started to appear in the cities. Electrical light could also be applied on the elevations, which was impossible before. Shops and department stores would light up their façades and displays in order to lure clients inside. New lights were also means to show the power and strong brand. With passing time more companies started to do so, and the cities became brighter. Lights became the part of modern towns' landscape.

Light was used in the Lumière brothers invention, the Cinematograph. Development of motion pictures had large impact on the culture and everyday life of people. The rapid growth of film making industry gave people the entertainment and created many new work places. The

Figure II.3 - *Dramatic lighting in film noir.*

light was also used to create illusions and, like in the mentioned before theatre, atmosphere. It is visible especially in early horror movies and also in the film noir. The high contrasts create very dramatic environment and specific mood (see Figure II.3 above). Today, because of this invention, we can also better understand life in previous decades. There are many documentary movies recorded throughout the years, providing us with great source of knowledge about the generations before us.

Nowadays artists use light in for creating art. Probably best known are James Turrell, Olafur Eliasson and Dan Flavin. They created installations with light and space. Flavin was using the standard commercially available fluorescent tubes in his works. Olafur Eliasson is best known for his creation on the roof of ARoS Aarhus Kunstmuseum in Aarhus, Denmark. Opened in 2011 it already became one of the city's most recognisable attractions (see Figure II.4 on page 41). As we read in the description: "At any moment, the panorama will appear almost monochromatic through the glass panes, but the appearance of the surroundings changes according to the movement of the visitors. Thus, movement becomes the vehicle of the visitors' colour perception. Your rainbow panorama functions as an orientation tool. Dividing Aarhus into colour zones, it has the qualities of a lighthouse." [Eliassons 2011]

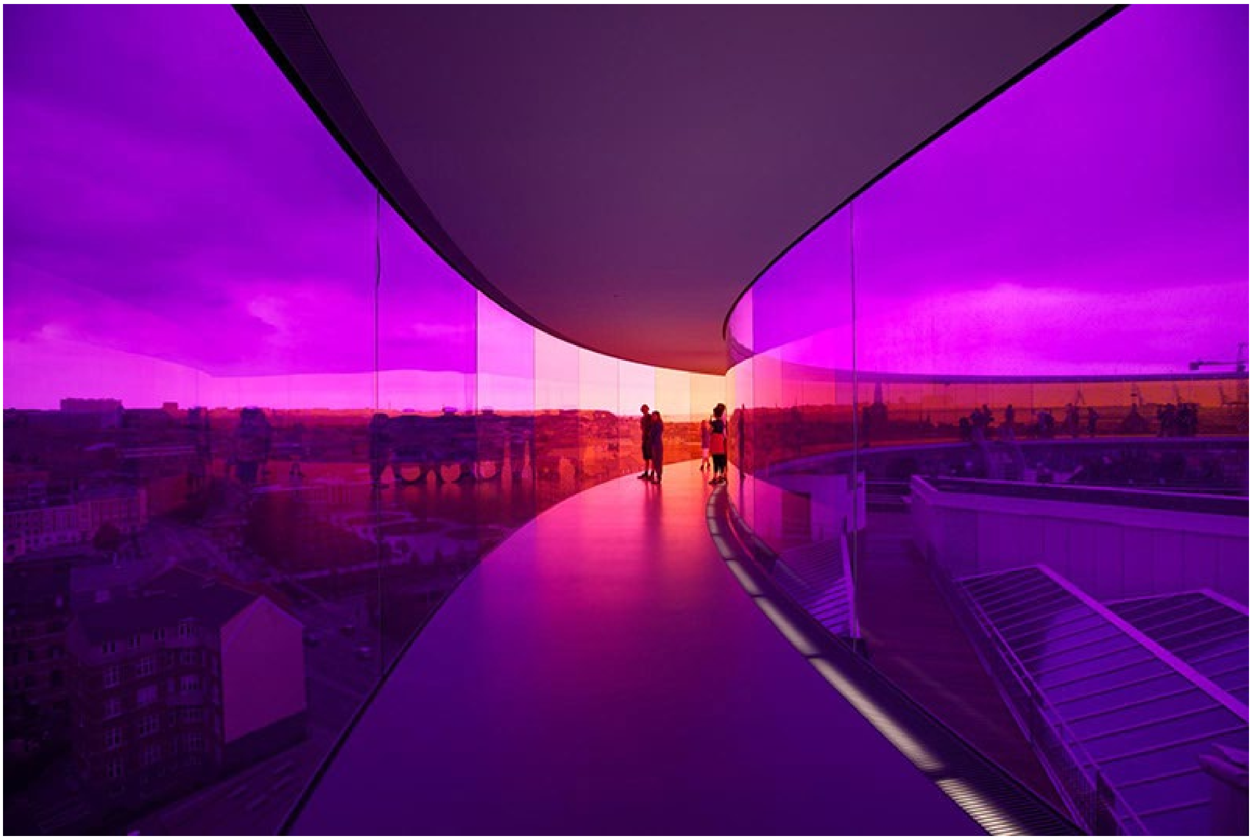

Figure II.4 - *View from the inside of "Your rainbow panorama", by Olafur Eliasson, Aarhus, Denmark.*

Chapter III

Functions of artificial light in architecture.

FUNCTIONAL LIGHT

Artificial light is used in many different ways. The most obvious and popular function is enabling users to see in enclosed spaces and after dusk. But modern architecture found many new and interesting applications for light.

Light in many cases gives unique character to buildings and make them easily recognizable. Especially in the big cities, after dark where the façades are bathed in light trying to charm the observer. Light on the façades is still considered as something building the prestige. But in everyday life light has many different applications.

This chapter will show, using study cases, different ways of using light in architecture, as it became not only means of expression, but also very universal tool for a designer.

Figure III.1 - *Allianz Arena is the building recognizable from the distance through its light.*

ICONIC LIGHT - ALLIANZ ARENA, 2005

In the book “Made of light: The Art of Light and Architecture”, we can read “We live in a visual age in which the image of architecture is a part of its function. Light plays a key role in creating image.” [Major Speirs Tischhauser 2005] Today light can be used to create the landmark. Light can become iconic, like in this case.

Allianz Arena, the football stadium build in Munich, Germany is widely recognised structure. Designed by the Swiss architect firm Herzog & de Meuron, has a facade composed from 2,760 inflated ETFE panels. The panels can be lit up, creating spectacular sight visible from long distance.

The stadium became the recognised landmark and part of the landscape due to its characteristic lighting. The designers state on in the description, on their website: “As a huge luminous body, the stadium marks a new location in the open landscape to the north between the airport and downtown Munich. The skin of the luminous body consists of large, shimmering white, diamond-shaped ETFE cushions, each of which can be illuminated separately in white, red or light blue” and later: “The changing appearance of the stadium will enhance its attraction as an urban monument even for people who are not interested in football.” [Herzog De Meuron 2005]

The light has capacity to create the icons and to create the landmarks. It can also change the character or transform the well-known structures, giving us the new way to look at the things we are used to (Eiffel Tower in Paris, France or Sydney Opera House).

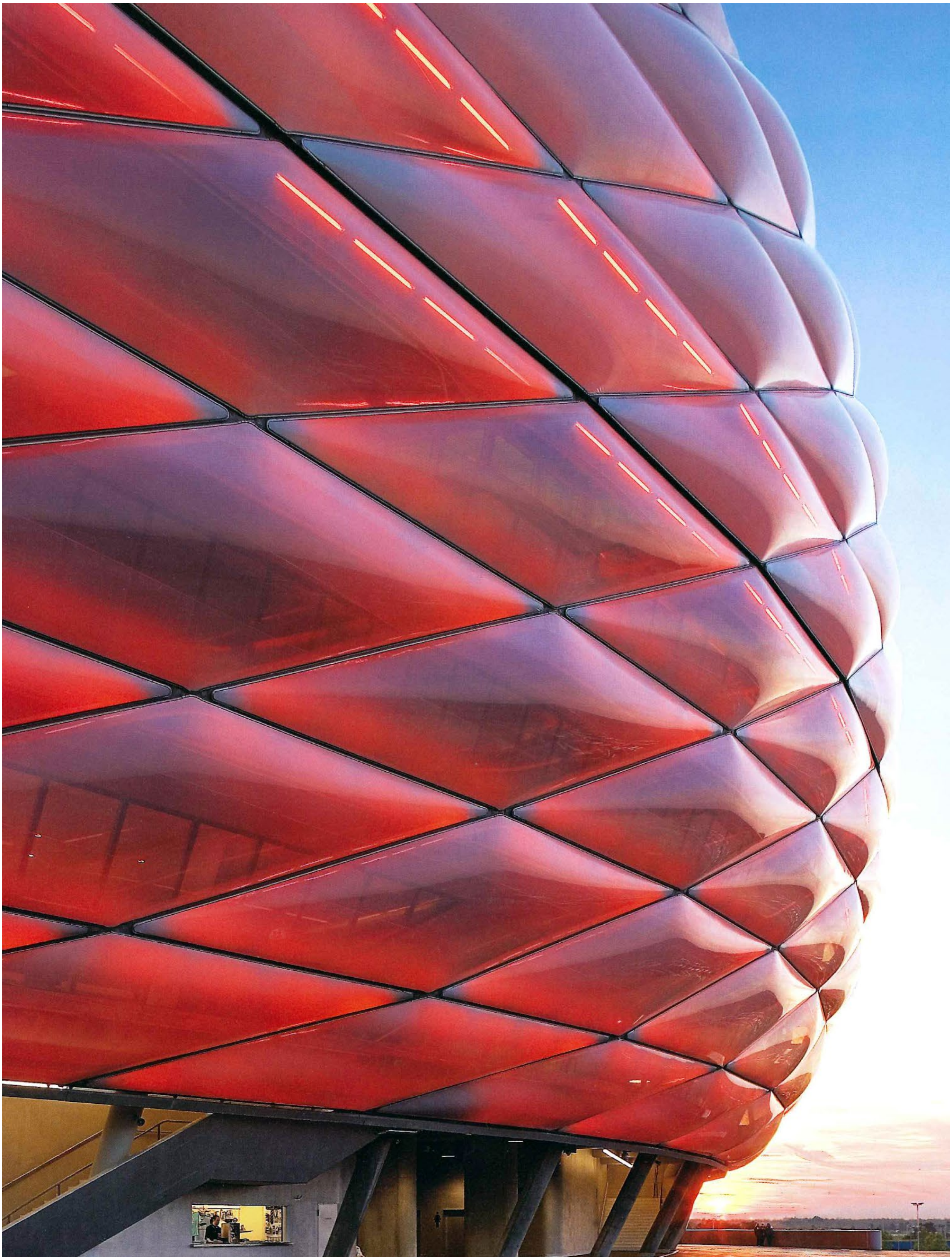

Figure III.2 - *ETFE cushions creating the facade of the stadium, lit up with the tubes.*

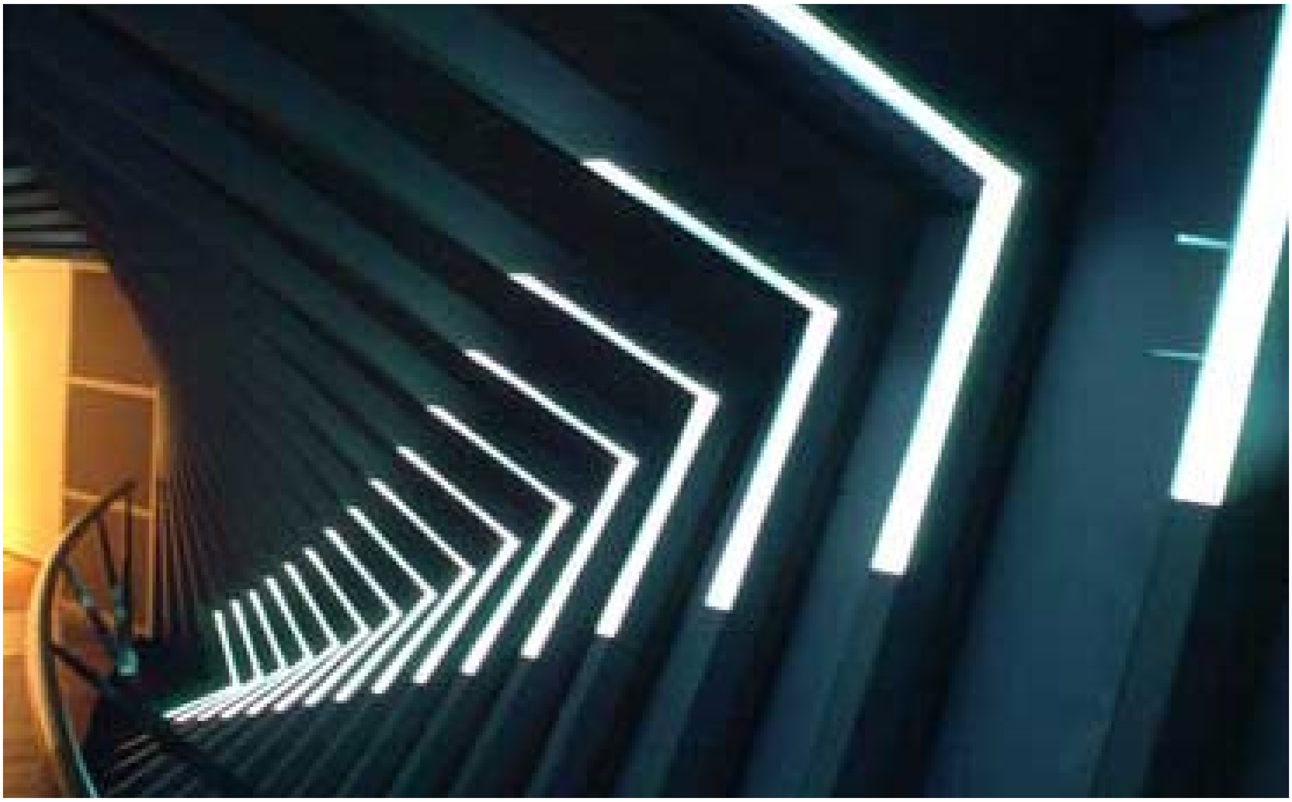

Figure III.3 - *L-shaped light fixtures installed in the corners.*

LIGHT TRANSITION - BRIDGE OF ASPIRATION, 2003

Light is used today in many different ways in architecture. Designers experiment with placement, light types and colours. Those ideas became new means of expression and enable architects to create new way of experiencing the space.

Bridge of aspiration is a structure connecting the Royal Ballet School with the Royal Opera House. It is constructed from the series of twisting aluminium frames, creating the dynamic form. Structure is highlighted by the custom L-shaped light fixtures installed in the corners of the frames (see Figure III.3 above). At the same time, light produced by those elements calms the dynamic of the form.

Two separate spaces at both ends of the bridge are illuminated with the low wattage down lights. Those luminaries bathe opposite walls in amber light providing the focus for people crossing the bridge (see Figure III.4 on page 47).

The bridge is the transition space between two buildings. Its lighting amplifies the feeling of progression, highlighting the dynamic spiral form, and providing the focus for the person crossing the bridge. It brilliantly connects two spaces, while keeping them separated at the same time.

Figure III.4 - *Amber light providing the focus for people crossing the bridge.*

Figure III.5 - *Tunnel passage with blue lights, along the movement direction.*

DIRECTING LIGHT - HIGH LINE, 2009

Lighting design is dynamically growing branch of design. It has been already long time since the light was used only for practical purposes. The possibilities of utilizing the light are being developed all the time.

The ability of light to guide people in desired direction is well known to the designers working with it. The long linear beams of light strongly suggest where to go inside the buildings or in the outdoor areas. It is connected with our spatial depth perception and linear perspective described in chapter I.

The High Line or High Line Park in New York, created on the old railway recycled into the modern urban space, uses the principle of guiding light in a bit more settle way. Direction is emphasized especially with the “soft perimeter lighting, installed on the underside of the guardrail structure and by low-rail walkway lights situated along the periphery of the pedestrian path.” [Descottes Ramos 2011] The used light sources have relatively low power, not to take focus from the lights of the surrounding buildings which create spectacular view. The lights are non-uniform, but at the same time amplify the direction of the path.

This is most visible in the tunnel passages with the blue coloured fluorescent lamps, fixed in the lines along the longitudinal direction (see Figure III.5 above). The tunnels are created where the High Lane passes through the building. The fluorescent tubes reminiscent of the interior spaces of the building.

Figure III.6 - *Light on the High Line Park, guide people in desired direction.*

Chapter IV

How does artificial light change the perception of the space?

CREATING ILLUSION

Artificial light, as mentioned in previous chapter, in present today in many aspects of our lives. We could not imagine life without it, as most of our work and entertainment uses the light in some way. All of our modern day electronic devices use the artificial light.

In the new buildings lighting design became a very important part of the whole design process. It is directly connected to the building energy consumption, limiting the costs and the impact the building has on environment. Required levels of light are necessary for the comfort of users, but artificial light can also provide possibility for architects to create certain moods and expressions.

There are buildings (performance venues, galleries and museums, shopping malls), that need mainly artificial light, as the environment in those buildings must be strictly controlled. Places such as galleries and museums need very specific light and it is much easier to achieve desired effect in enclosed, controlled environment.

Theatres and cinemas also need lighting that can be easily altered for creation of specific atmosphere, crafting of an illusion.

Figure IV.1 - *Face of the model is lit with the purple light from the top.*

Figure IV.2 - *Face of the model is lit with the purple light from the bottom.*

APPEARANCE DIFFERENT IN LIGHT

It is no secret that different light can change the appearance of the object. Lighting of the sculptures is perfect example. The most dramatic and exquisite sculpture will appear flat and not very interesting, when lit badly. This principle can also be observed, while interacting with people. The direction and the colour of light can change the way we perceive others: "Shadow also helps alter and modify our perception. As children, we would sometimes hold a torch under our chins to create a scary face, but in doing so we discovered the ability of light and

Figure IV.3 - *Face of the model is lit with the green light from the bottom.*

Figure IV.4 - *Face of the model is lit with the green light from the top.*

shade to change the character and meaning of objects and people." [Major Speirs Tischhauser 2005]

This was explored in short video clip directed by Nacho Guzman, who used lighting mounted on a ring and rotated around the model's face [Figures III.1- III.4 on pages 52 and 52]. The same principle applies to the spaces. Various lighting pre-set can change our psychological response to the space. It is subjective and every person reacts in other way, as everyone see things a bit differently, but general trends and patterns can be observed universally.

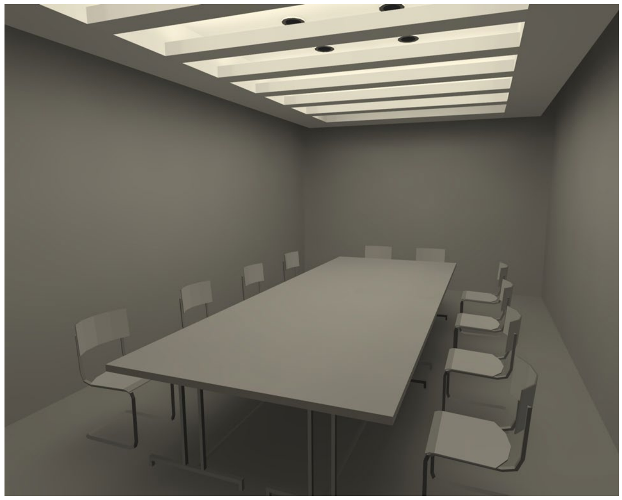

Figure IV.5 - *Indirect overhead light.*

Figure IV.6 - *Indirect overhead light with additional peripheral light.*

SUBJECTIVE IMPRESSIONS

Throughout years, the relations between luminance and human responses to the surroundings were investigated by many people. This resulted in basic understanding of this phenomenon and led to defining the five impressions influenced by different lighting settings.

These impressions can change the way occupants perceive given space even if they are ignored during the design process. It can result, for example, in smaller amount of the time spend in those spaces by the users.

VISUAL CLARITY

Visual clarity describes how well objects can be differentiating one from another. The space is referred to as clear or hazy. The easier objects are recognized, the higher the clarity of the room is. This is important factor for the design of the workspaces. High illuminance of the work surface (table, desk etc.) will result in impression of clarity. Wall lighting might also raise the perceived clarity of the space.

Figure IV.7 - *Direct overhead light.*

Figure IV.8 - *Peripheral lighting.*

SPACIOUSNESS

Spaciousness describes how people perceive volume of the space. Research suggests that lower levels of luminance result in space appearing as cramped and confined. It is acceptable in the places where people expect lower levels of lighting (rooms with Audio-Video sets; auditoriums of theatres and cinemas). Sense of spaciousness can be enhanced by applying higher levels of luminance to the walls. The impression of bigger spatial volume is desired especially in the areas with high occupancy (circulation spaces; transition spaces; halls).

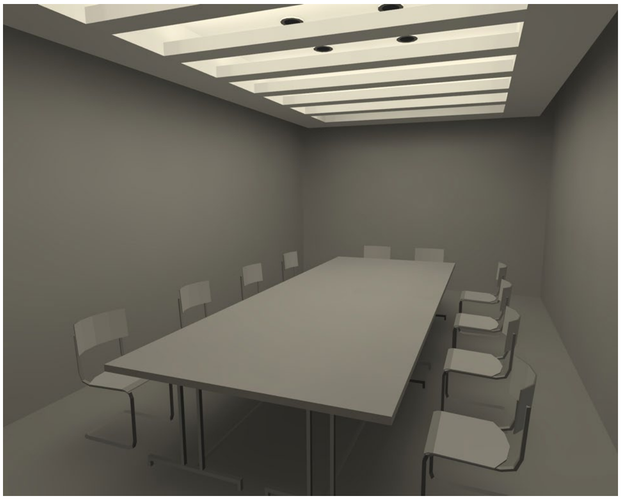

Figure IV.9 - *Indirect overhead light.*

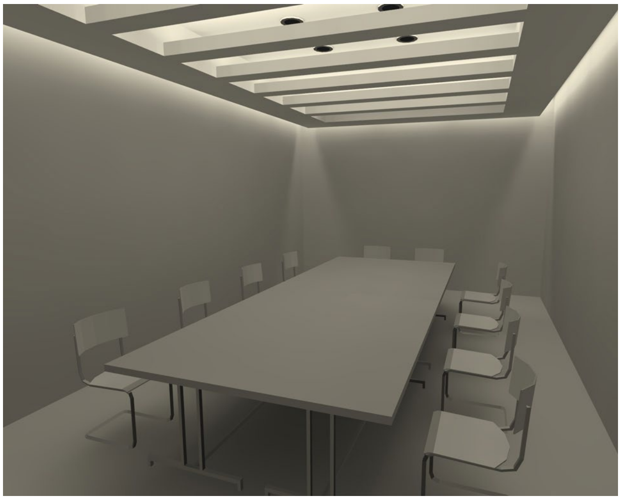

Figure IV.10 - *Indirect overhead light with additional peripheral light.*

<u>PREFERENCE</u>

This impression can be completely different for other people. Brighter spaces appear bigger to all the people, but the preference towards given space is purely dependant on the subject. However, there are some factors that can influence the way user's perception of the space. In general people tend to prefer areas that are lit non-uniformly, and in which there are different sources of light. This particular subjective impression is most important in the spaces that will be occupied for extended periods of time. To enhance the preference of the space the walls should be better lit.

Figure IV.11 - *Direct overhead light.*

Figure IV.12 - *Peripheral lighting.*

RELAXATION

The space can be perceived as tense or tranquil. Those areas are mostly lounges, waiting rooms, restaurants etc. It is also desirable in the hospitality buildings, to create the sense of tranquillity. To achieve that designer should avoid uniform direct lighting and provide more peripheral luminance, especially on the walls. However the research suggests that increasing the luminance intensity does not make a big difference. Accenting light also elicits the impression of relaxation.

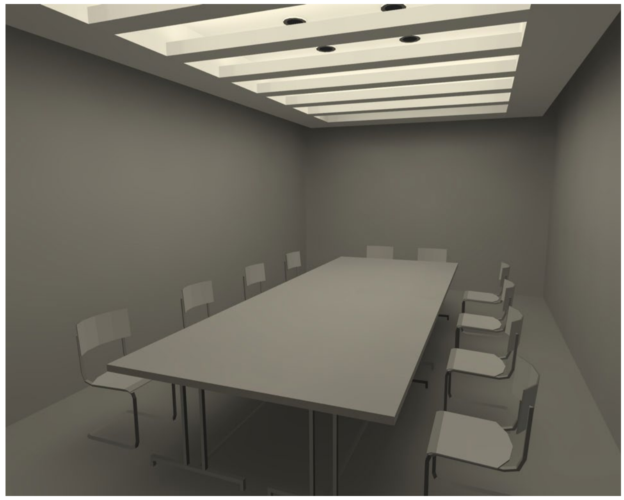

Figure IV.13 - *Indirect overhead light.*

Figure IV.14 - *Peripheral detail light.*

PRIVACY

Depending on the situation the space can be perceived as more private or more public. The higher levels of luminance and uniform placement of light sources indicate the public character of the area. To enhance the sense of privacy or intimacy the more non-uniform and peripheral lighting should be used. The impression of privacy is important in places such as lounges, restaurants, cafés and also residential spaces. In those areas lower luminance with the non-uniform lighting of the walls can greatly increase the sense of intimacy.

Many studies were done on subjective impressions and other topics connected with the perception of the space. This section focused on how the artificial light changes the perceived space. There are many other factors, which can be considered. It is clear that our perception can be changed by the careful design of the environment. Findings presented here were recreated, basing on the experiment described in book “Architectural lighting design” [Steffy 2008] and in the “Lighting in retail environments: Atmosphere perception in the real world” [Custers and team 2010].

In most cases, it is good idea to use as non-uniform light as possible. Of course it depends on the effect the designers want to achieve. For example in the office spaces it is better to have more uniform lighting, to increase focus. Non-uniform light in space provide many point of focus. Also peripheral lighting is a good idea as it increases the perceived spaciousness and creates more relaxed atmosphere.

Humans favour the natural light; therefore, we prefer the lighting settings resembling it. More diverse light reminds us of the sunlight which changes throughout the day, regulating our natural rhythm. Ideal would be the setting recreating the natural sunlight and the changes of the sky. Unfortunately systems like that are extremely expensive, if not impossible to install on most of the buildings.

Figure IV.15 - *The colour used for determining the CRI.*

COLOUR

COLOUR OF LIGHT

Colour of light also strongly influence the subjective impressions discussed earlier. For example red light (longer wavelengths), focuses behind the retina, causing the observed object or surface to appear closer. Blue light (shorter wavelengths), focus in front of retina. Blue surfaces and objects appear to be farther. This is effect called chromostereopsis, and can be used to change the perception of the space. [Steffy 2008] This means that even use of the cooler white light can alter the perceived spaciousness.

COLOUR RENDERING INDEX

According to the International Lighting Vocabulary colour rendering is the "effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with their colour appearance under a reference illuminant". [CIE 1987] CRI - colour rendering index is a scale with values up to 100 (100 being the highest). The bottom of the scale was not established, as the light source can have a negative CRI value. This means the colour under this light are rendered poorly and colour perception can be skewed. To assure correct appearance, and better, crisper contrast the lamps with high CRI (above 80) should be used. This is important in the spaces with low levels of lighting and also in applications such as photography and cinematography. The lamps with low CRI should be used only in the areas where the users spend short time or the colour appearance is not crucial.

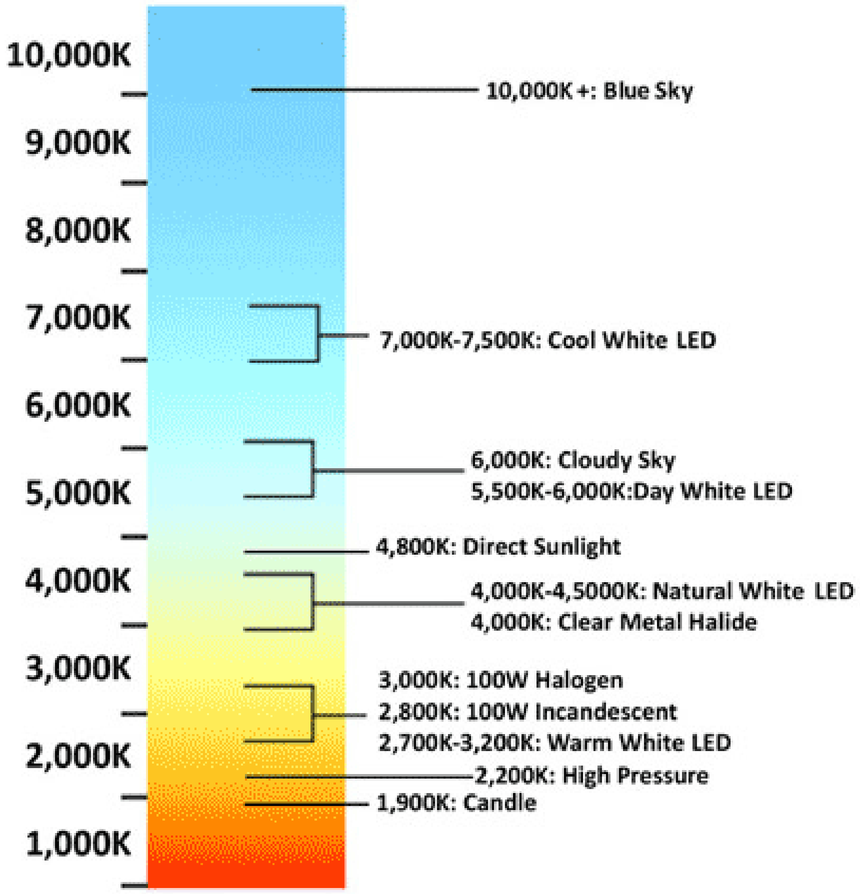

Figure IV.16 - *Diagram showing the colour temperatures for different light sources.*

COLOUR TEMPERATURE

Colour temperature describes the whiteness of the light and it uses the kelvin temperature scale for that. “The human visual system is incredibly adept at quickly correcting for changes in the colour temperature of light; many different kinds of light all seem “white” to us” [Sizes, Inc. 2013] In general the low colour temperature results in output of warmer tones. Under this type of light spaces appear dimmer and it enhances the impression of intimacy. Warmer-tone light is appealing to many users as it is considered more homelike and comfortable. The use of 3500K or cooler lamps in residential and hospitality buildings may cause some complaints, except for when it’s hidden. [Steffy 2008]

Figure IV.17 - *Luminous flux - 100lm; Colour temperature - 3000K.*

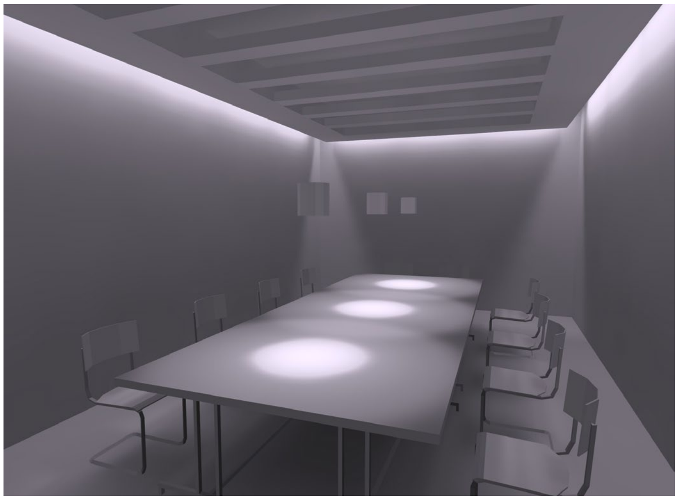

Figure IV.18 - *Luminous flux - 500lm; Colour temperature - 4000K.*

EXPERIMENT

To investigate subjective impressions an experiment was conducted. Group of people was asked to rate the privacy of the modelled room with different light settings. This is one of the discussed earlier subjective impressions and it was chosen as it is expected to be the easiest one to test. Other were declined, as visual clarity is hard to measure, especially on the picture, spaciousness is perceived more subconsciously in the real environment not observed, and the preference differs to much depending on person.

The focus group were students between 20 and 25 years old. They were given the set of 18 printed renderings of the mentioned room and asked to rate the appearing privacy from 1 being the most private to 10, having the most public-like appearance. Pictures were arranged all on the same surface and the order was changed multiple limes during the experiment. During the experiment the light conditions were changing (different times of day, different sources of light).

Figure IV.19 - *Luminous flux - 1200lm; Colour temperature - 3000K.*

Figure IV.20 - *Luminous flux - 300lm; Colour temperature - 5500K.*

The renderings show the same room with different luminance values and in three different colour temperature variants for every level. As the baseline white, temperature of 4000K was selected. The colour temperatures used were: 3000K for the warm white, 4000K for the neutral white and 5500K for the cool white.

The two light sources were used in the model: three suspended lamps over the table and wall-washers on the sides. The modelled room was covered in white paint to eliminate any other factors than luminance and colour temperature from the equation. Also no doors and windows were used and the furnishing was minimized, to avoid any possible skew in the output.

Findings were presented on the next pages in form of the diagrams and tables, along with the comments and thoughts on findings. Experiment provided a lot of different informations and results for interpretation.

EXPERIMENT RESULTS

Next pages show the findings of the experiment described earlier. Due to some technical difficulties with the printing (darker prints, skewed colours) the results may vary.

To randomize the results experiment was conducted in different environments and under various light settings, but it was not considered as a factor in the outcome of the tests. The total of the 24 subjects took part in the experiment (14 males and 10 females). Participants come from different countries, cultural backgrounds and various study programs, making them satisfactory group for this research. Obtained data shows that general trends support the theory and the tests conducted by others throughout the years.

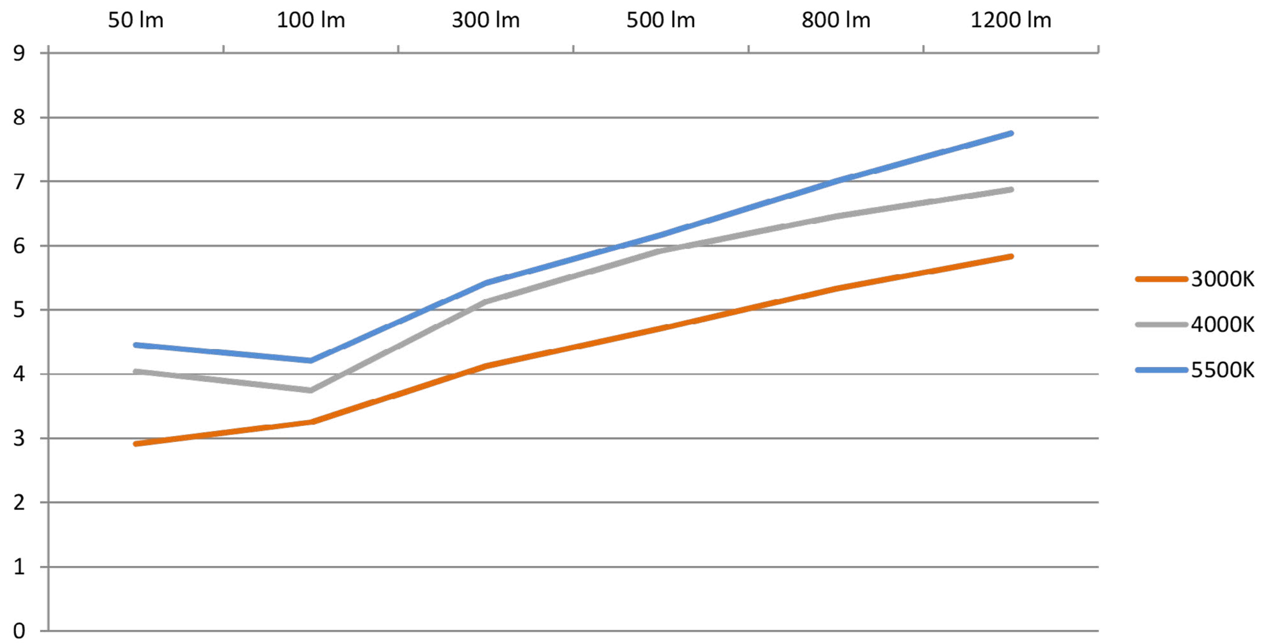

Figure IV.21 - *General results of the experiment.*

As expected, the results of the experiment were consistent with the assumptions of the theory, suggesting that the feeling of being exposed will rise with the higher levels of luminance. Diagram reflects this trend as with the higher luminous flux the level of perceived privacy of the space drops.

The same thing applies to the colour temperature used in the rooms. The warmer it is, the more private and enclosed the room appears. In this case the results of the results of the experiment also confirmed the predictions of the theories. The rooms with the light colour temperature of 3000K, were rated lower (higher level of intimacy), than rooms with the colour temperatures of 4000K and 5500K.

The results also show that so called warm lighting (lower colour temperature) is perceived as much more private. The difference between the neutral white light (4000K) and cool white light (5500K) is smaller than the difference between the neutral white light and warm white light. While somewhere the rating of the spaces with the 5500K and the 4000K lights differ only by around 2% to 3%, the rooms using the 3000K light are rated around 10% lower throughout almost the whole scale of light intensity.

The outcome of the experiment also shows that the level of luminance is the more important factor than the temperature of light, when it comes to room intimacy. As explained above the light colour temperature changed the perceived space privacy by 10% - 15%, where, in case of this experiment, light intensity changed the subjects' perception, making them rate rooms as 30% less private.

However if we take closer look we can see that the change in the level of lighting is quite dramatic - from 50 lumen to 1200 lumen in the brightest space. And the rating stays more or less linear. This means that if the levels of luminance cannot be changed, or can be altered only marginally, it is much better to select the light source with the lower colour temperature. This

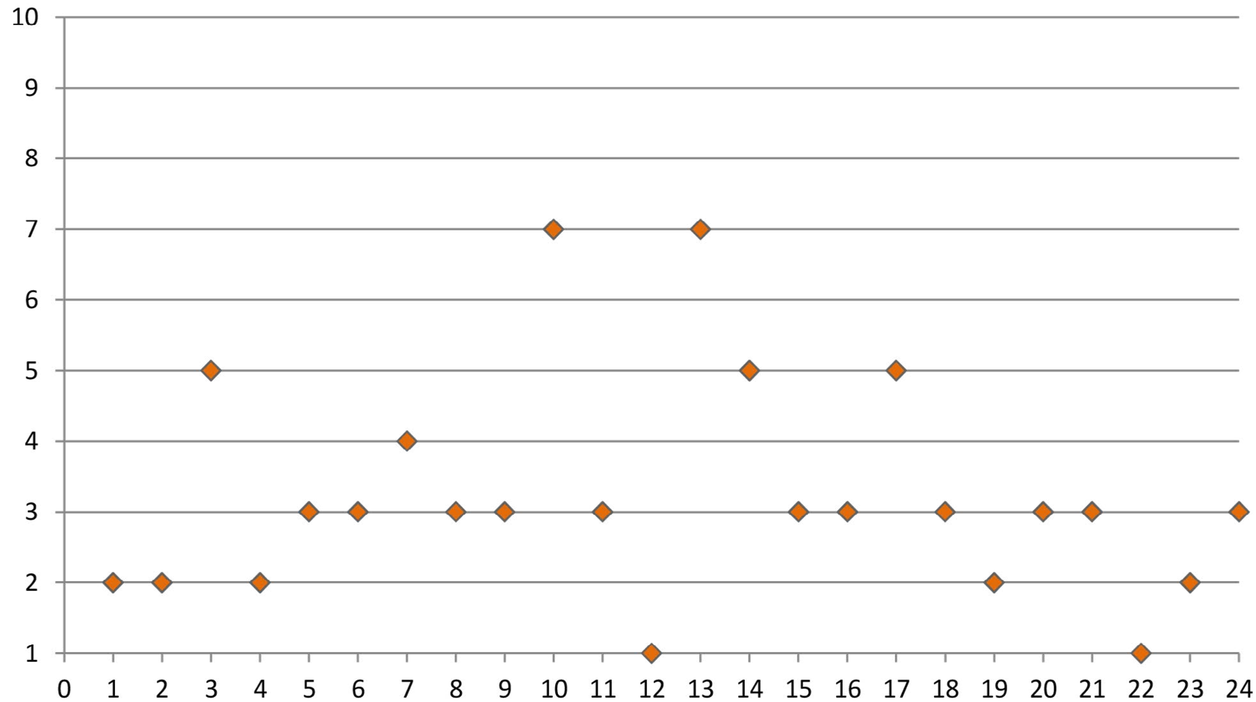

Figure IV.22 - *Rating of one of the room E, showing the variation of the results.*

way we can get instant results without adjusting the lighting. This knowledge might help architects to achieve desired moods, while designing spaces, which require certain levels of illumination (for example in the hospitals). The results show that with change of lighting settings the occupants' perception can be shifted.

Experiment tested the subjective impression of room privacy. There was however few minor distortions. First of all, mentioned before quality of print- the prints came out darker than expected; therefore the results might have been skewed. Secondly, human eye is an amazing instrument and it reacts differently, depending on various circumstances. Every person sees surroundings in other way, making the outcome of the experiments like the one described hard to evaluate. Also human eye have amazing capability to adapt to changing light conditions and varying environments. One's sight can adjust to different shades of white as a reference to other colours, causing the change in received images.

Another factor influencing the results is the personal preference of the observer. Some of the rooms were rated using the full scale from 1 to 10 (see Figure IV.22 above). As there is no write answer, all the results are valid, even those extreme ones. The subject group was top small to be able to determine the general trend; however most of the results oscillate around the average. The prediction is that with the growing number of the tested subjects, rating would become more consistent with the average value for the given room.

The discussed effect becomes obvious, while comparing ratings of the two rooms, side by side. First is the room with the warm white light (colour temperature of 3000K), with the luminance level set to 100 lumen. In this case the room rating was 3, 3 on average and it is clear that most of the marks were around this value. However on the next side (Figure IV.23 on page 67), we can observe much bigger variations of the room ratings. The diagram presents the val-

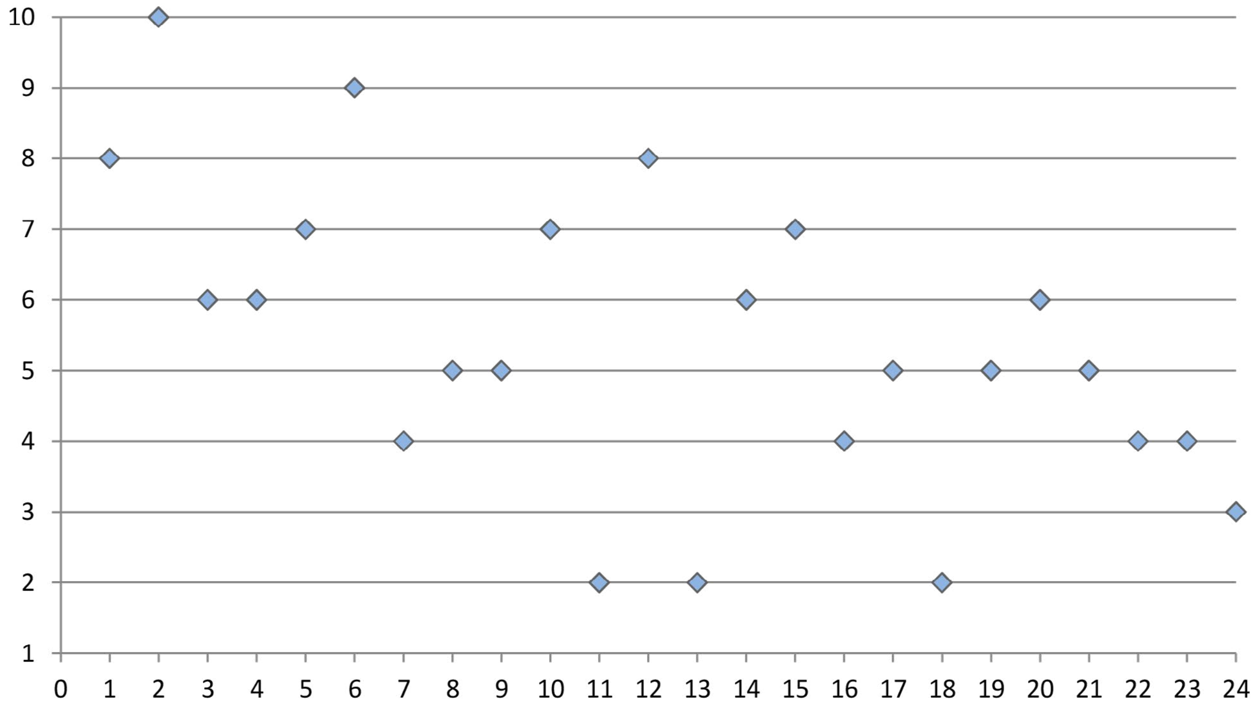

Figure IV.23 - *Rating of one of the room P, showing the variation of the results.*

ues given by the test subjects to the room with cool lighting (colour temperature of 5500K) and the luminous flux of the lamps set to 300 lumen. Here the differences are much bigger, and the average rating of 5, 4 do not reflect how much values change. Most of the results remain in the close proximity of the average; however the bias appears to be much bigger.

This data show that measuring the subjective opinion is hard and can give inconclusive results, but as mentioned earlier there is no wrong answer in this case. Outcome of the experiment may be interpreted differently by different people. Some of the elements influencing the outcome of the experiment can be hard to control, and may change the results quite dramatic.

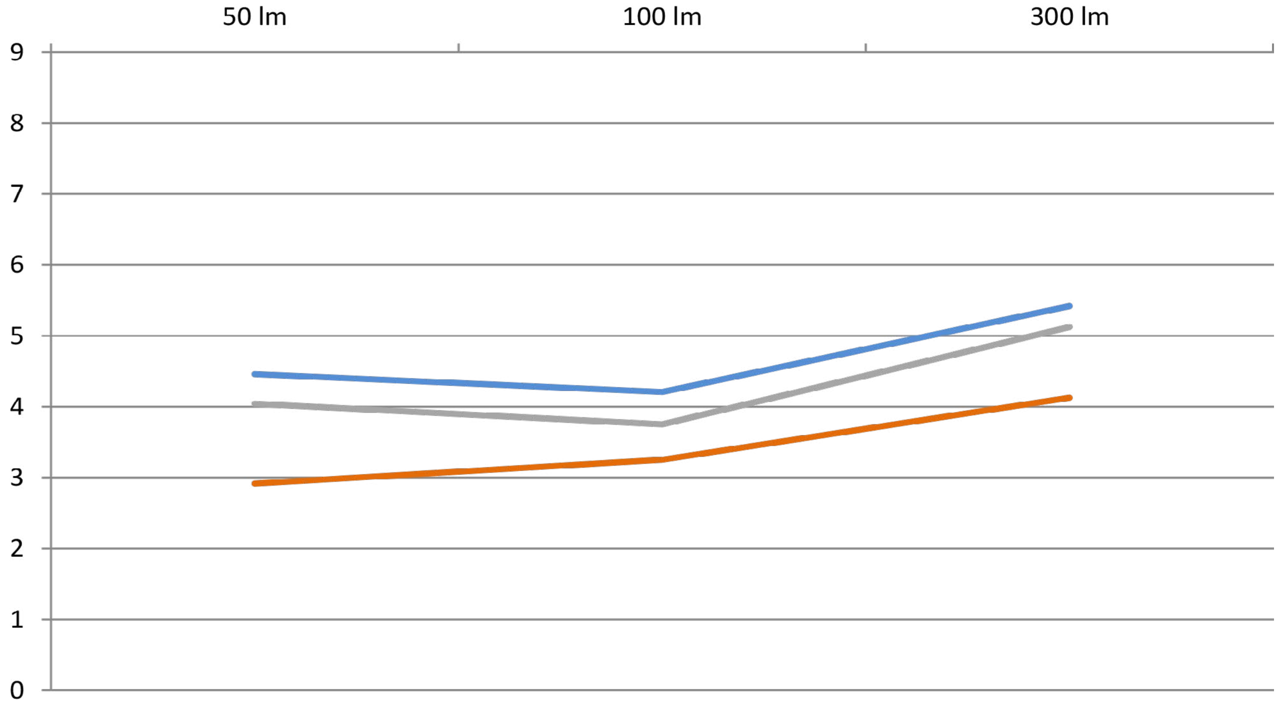

Figure IV.24 - *Close-up showing unexpected results for the rooms K and L.*

The data obtained from the experiment shows many interesting things. One of the surprising results was the ratings for the rooms with the light colour temperatures of 4000K and 5500K with the low levels of luminance (in both cases 50 lumen and 100 lumen). According to the theory, those spaces with less light should be perceived as more private, but as we can see on the diagram (see Figure IV.24 above), clearly the rooms with lights set to 100 lumen were rated better.

The further investigation of the ratings of both rooms (see Figures IV.25 and IV.26 on page 69) reveal, that many test subjects rated both rooms with high marks (lower privacy). The outcome for both rooms covered big part of the scale, and the notes are scattered. People taking the test, asked for the comment about the high ratings said that rooms were: “creepy”, “unpleasant”.

This shows how personal the preferences are, and what for some appears as too dark, by others is still perceived as very private. There appears the thin boarder between the room with colour temperature of 4000K and 5500K. In general people who gave the low marks to one room also gave the responding note to the second. However some people rated space with the warmer light as more private.

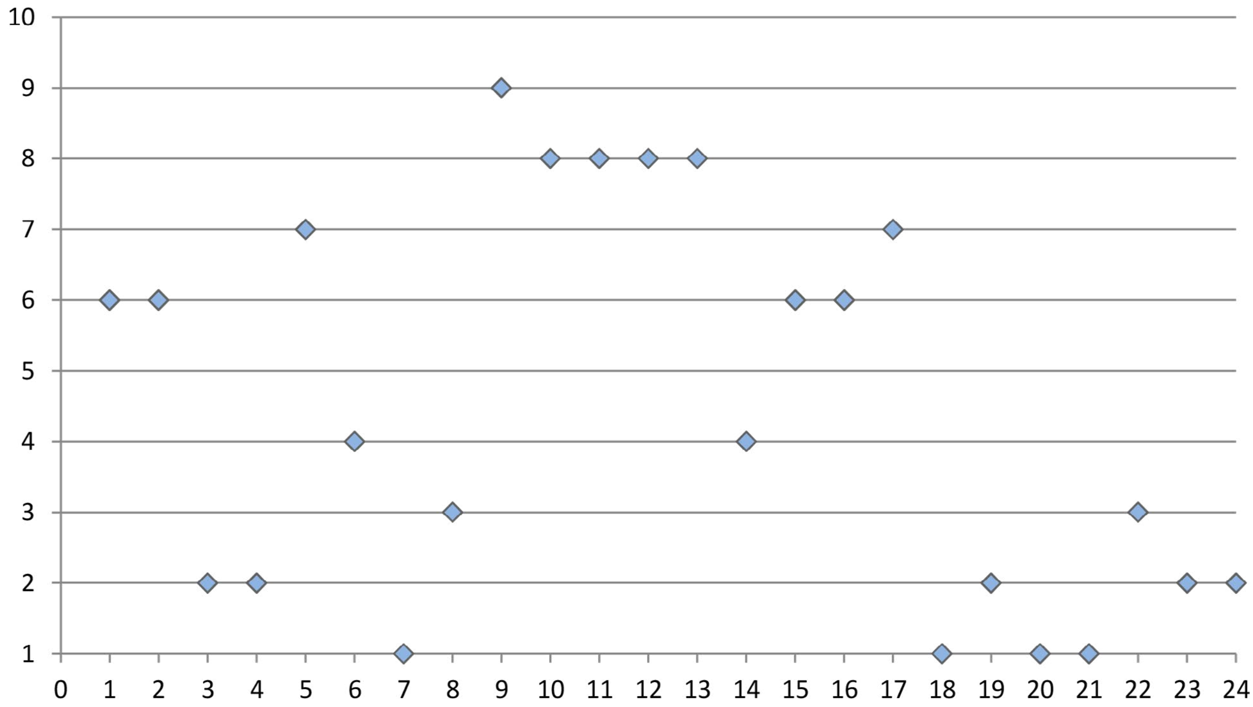

Figure IV.25 - *Rating of one of the room K, showing the variation of the results.*

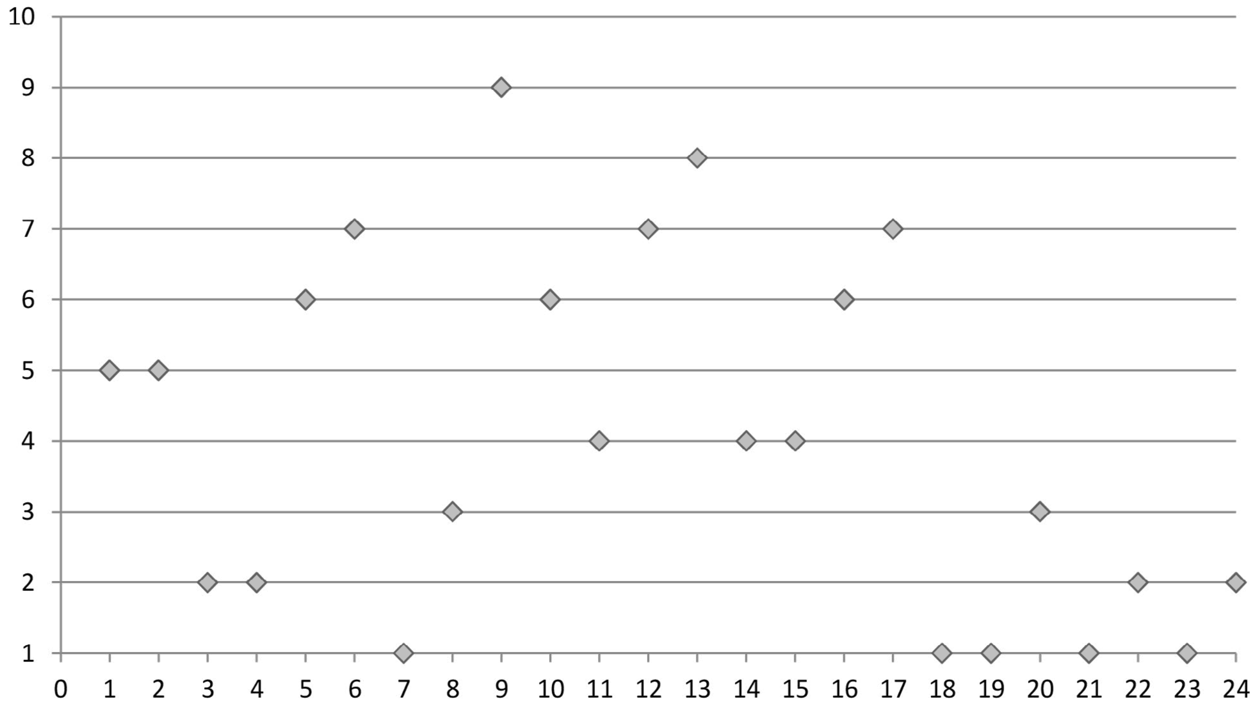

Figure IV.26 - *Rating of one of the room L, showing the variation of the results.*

Chapter V

The applications of the artificial lighting in case studies.

ADJUSTING THE SPACE

Artificial light have been used by humans from prehistoric times. First it was the fire in the caves, later- the filtered daylight creating required mood and atmosphere and finally the discovery of the electrical lighting.

Besides the obvious application which is enabling us to see through the dark, light also have other applications. Now more than ever. It is used, as mentioned before, in almost every electronic device we have today. Is help artists to create performances and art connected with the light. Also the photography and cinematography would not exist without development of the artificial lighting.

Light finds use in many aspects of our life. However this chapter will focus on the applications of artificial light in architecture. In can direct, inform, indicate or be used for warnings. Light can connect spaces or as showed in the previous chapter alter our perception and create certain feeling- mood. Light might be applied to create the landmark or quite simply as decoration.

“AMRTA”, 2011

The space presented on the next page is one of the James Turrell’s creations. Turrell is an American artist, primarily concerned with light and space. In artists words: “I make spaces that apprehend light for our perception, and in some ways gather it, or seem to hold it…my work is more about your seeing than it is about my seeing, although it is a product of my seeing.” [Turrell] He produces the spaces skewing the perception of the observer.

Presented here installation is a part of the “Ganzfeld” series. It referrers to ganzfeld effect (German for “complete field”) and is the perceptual deprivation, the phenomenon of perception caused by exposure to an unstructured, uniform stimulation field. [Metzger 1930]

Turrell works are the extreme examples of how light can transform the space and alter ones perception of it. They are not conventional architecture, but illustrate excellent how the normal, environment could change with the use of light alone.

Figure V.1 - *James Turrell's "Amrta" from 2011, part of the Ganzfeld installation series.*

Figure V.2 - *Light fixtures hidden in the ceiling openings.*

CHAPEL OF REST, 1967

Crematorium chapel in Aarhus, designed by Henning Larsen Architects in 1967 is the great example of how well designed lighting can transform the cold, concrete space into something completely different. With the employment of light, chapel bring to mind some greater power watching over visitor and creates mood of peace and silent focus.

The effect is achieved with the light, entering the space trough the openings in the ceiling. During the daytime sunlight gets down into the chapel with the dramatic, ever-changing light, reminding visitors about passing time. The down lighting amplifies the atmosphere of holiness and at the same time creates a focal point on the altar in the middle.

At the same time the effect is enhanced through the use of artificial lighting. The light fixtures hidden in the ceiling openings bath the space in soft, warm light creating the sublime atmosphere. Through the colour of light and down lighting on the walls on both sides of the wall chapel appear more spacious and inviting.

The architects created amazing space and with the use of light, achieved the right mood for the sacred place. At the same time the chapel is very universal and could be used by almost any religion as a place of rituals.

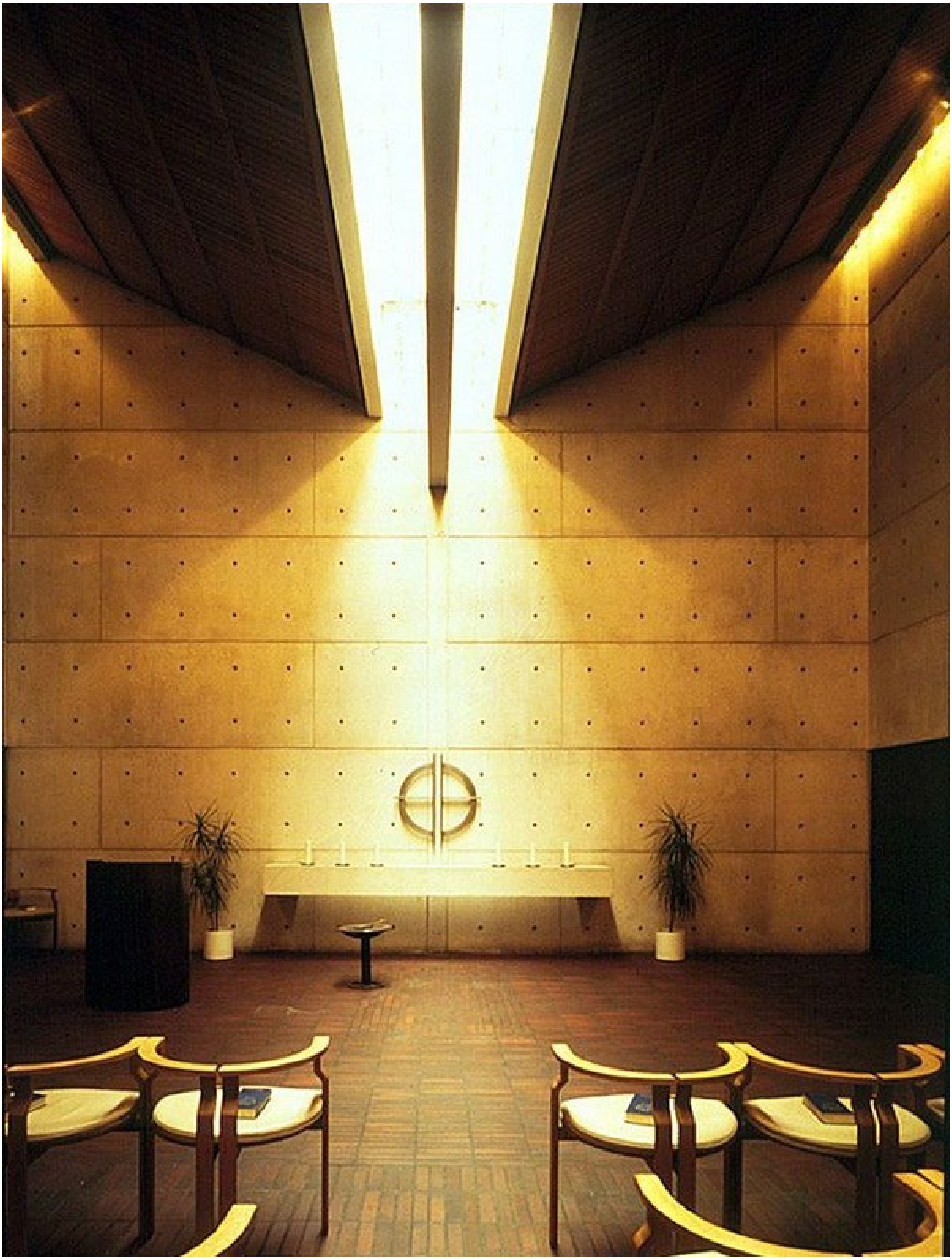

Figure V.3 - *Warm light creates sublime atmosphere.*

Figure V.4 - *Coolly-lit wave formed from steel enclosing The Water Pavilion.*

MAGNA SCIENCE ADVENTURE CENTRE, 2001

The "Magna" centre was created in the old, abandoned steel mill in Rotherham, England. Building consists of four pavilions, representing Aristotelian elements - earth, air, fire and water, all of which are used in the steelworks. The main goal was to create educational space, designed primarily for children.

Building employs only artificial light in order to create specific atmosphere of the steel mill. "By sealing the space from daylight, the new museum is revealed within the remnants of the industrial past. To achieve the right effect the lighting was kept to a very low level, so that it approached the threshold of perceived safety." [Major Speirs Tischhauser 2005]

The spaces in the centre are designed with light to create dramatic and dynamic effect. In the main space of the Fire Pavilion, the installation with the real flame tornado is used. "The Water Pavilion is enclosed by a coolly-lit wave formed from steel." [Wilkinson Eyre Architects 2001]

Entrance to every of the pavilions creates different mood and uses different effects. Arriving in the Fire Pavilion we enter through the mist produced by the machines, lit with the red light from the high and narrow shaft. It creates high humidity environment and gives the impression of high heat, whereas the path to the Water Pavilion leads between two big bodies of water. The light is projected on the walls and combined with the water sprinklers generates the illusion of constant rain.

Figure V.5 - "*The Big Melt". Use of red light indicates danger and raises perceived temperature of the room.*

Figure V.6 - *Tunnel lit up with low levels of light.*

THE BLUE PLANET, 2013

Aquarium build in Denmark in Kastrup near Copenhagen is one of the biggest in Europe. It was designed by 3NX architectural firm, and opened in 2013. "Den Blå Planet" accommodates more than 450 different species and 20,000 fish and aquatic creatures from various environments and different places.

Architects aimed to build the space giving visitors the unique feeling of being under the see. Upon arrival, visitors proceed to the round foyer - the centre of the whirl. "There, one is literally under the sea, because the ceiling is made of glass and you look up through the bottom of a basin. Daylight is refracted by the water in the basin and creates a flickering of dots of light in the room, as if you were really under the sea." [Danish Architecture Centre 2014]

In the creation of the building's atmosphere artificial light was also used in a careful manner. Light is set to low levels, building the sensation of an adventure and mystery. Most of the light radiates form the tanks with water, changing the hue towards the cool blue. At the same time it creates brilliant effect by refracting light, making the impression of the whole space being underwater (see Figure V.7 on page 79).

The light in water tanks has also high colour temperature to help keeping the tanks clean and killing the bacteria. The additional lights help to direct people and mark the point of interest. They also amplify the desire to further explore the building.

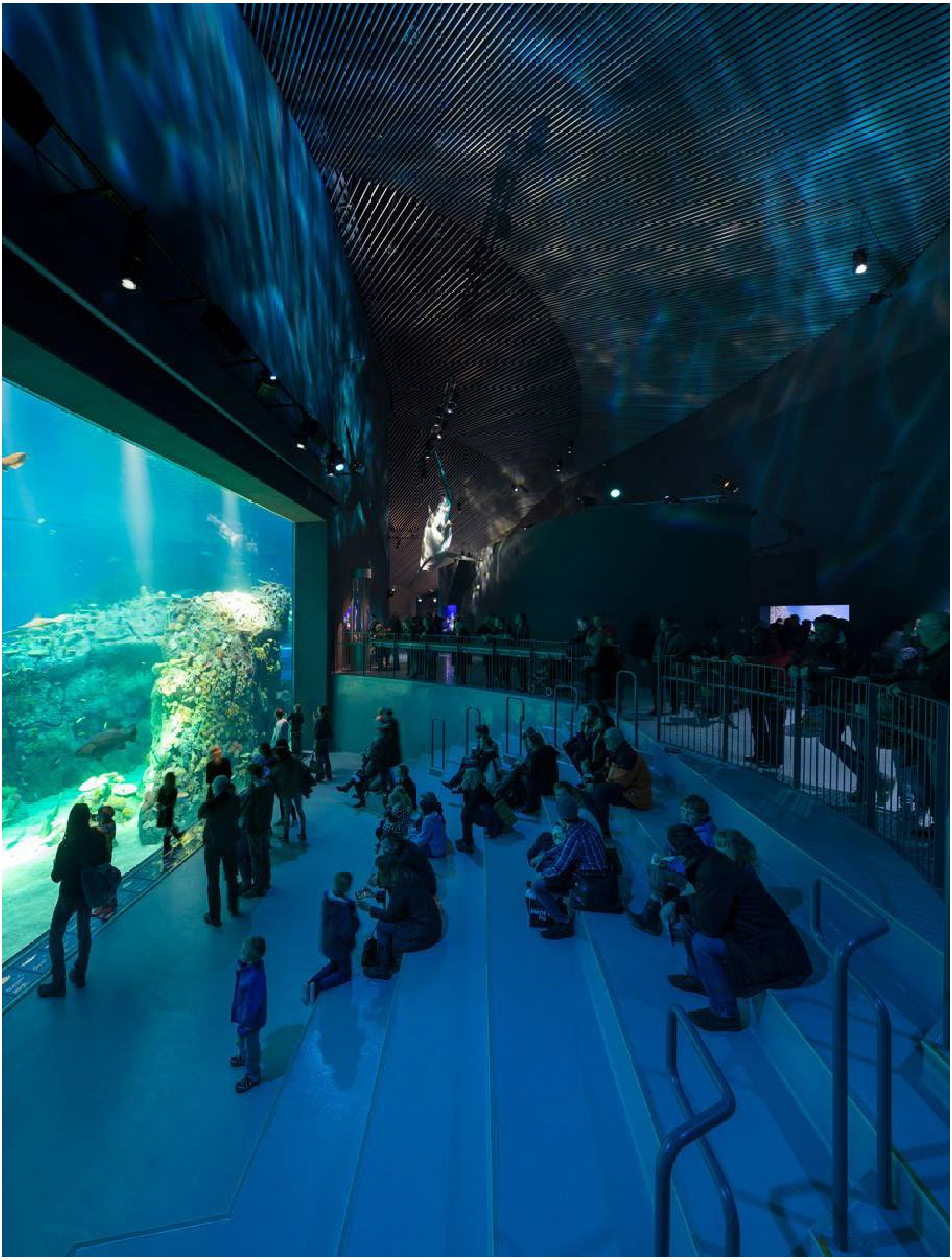

Figure V.7 - *The effect of being underwater achieved through the employment of artificial light.*

PART II

Chapter VI

Subject analysis. Site analysis. Theme analysis.

INTRODUCTION

Theatre is important part of human history. It helped us develop culture. We have need for telling stories and projecting them onto our lives. As Debra Bruch, Associate Professor of Theatre at the Michigan Technological University writes: “Unlike any other art, the total, intense focus of theatre is on the human being, his or her existence, and his or her relationship with life. It is a part of human nature to need to examine who we are in relationship with where we are.” [Bruch 1990]

Theatre has also an educational purpose. It helps people understand each other, teaches about the surrounding world and helps to find the connection with a God or Gods. If we take a closer look it also informs us about our motivation and psychology.

Almost every culture developed some sort of theatrical performances. First it was ritual dancing, bringing people together. It was their need to gather and contemplate the performance or event with others. From this need the theatre was born.

BRIEF HISTORY OF THEATRE

Like many other things in culture, theatre has roots deep in very old rituals connected to the ancient beliefs. First performances were probably the ritual dances. The first recorded quasi-theatrical events were so called “passion plays” performed in ancient Egypt around 2000 BCE. [theatrehistory.com 2015]

The next big step to the theatre as we know it was the development of the Greek theatre ca. 600 BCE. Shortly the improvements and inventions followed, when around the 460 BCE the first dressing rooms for performers appeared, along with the stage machinery and painted scenery. [glencoe.com 2015]

Around 430 BCE, Theatre of Dionysus is built in Athens. Over next hundred years, many theatres were built across the Mediterranean area. Also the first Roman theatrical performances are recorded. Constant development of drama, results in first wooden theatre building being erected in Rome 180 BCE. Hundred years after the first amphitheatre is built in Pompeii.

Around 300 CE first religious plays were performed. Nearly 300 years later Roman spectacles seize to exist. This starts a long period of regression in theatre history, as most of plays were performed by traveling circuses.

Finally around 1100 CE the first recorded miracle plays are performed. 150 years later the German drama is born. After next 125 first English plays appear. The professional actors reappear from 1430 CE. Ca. 1500 CE Spanish dramas are developing and 50 years later renaissance artists and engineers reintroduce scenography in theatres. At the same time classical drama becomes subject in English schools and the universities. Soon the first permanent theatre opens in London.

Golden age of theatre begins and brings many new ideas and improvements into plays. In year 1660 female roles are played by actresses In English theatre. Around 1715 first theatre appears in America, and not long after, in 1750, first playhouse opens in New York. By the 1800 costumes and sets become more realistic.

Development of light bulb introduces the electrical lighting in the first playhouse in 1881, starting new era in the history of the theatre. The new century brings the further development of the theatre, along with the new wave in art. Later the invention of the television results in decreasing popularity of the theatre. In the 80’s modern technology is introduced to the performances, giving the possibilities like never before. [Brockett Hildy 2010]

CULTURAL PURPOSE

The first performances resembling theatre were rituals and dances connected to cult. The main purpose of them was to honour the memory of ancestors, or to please deities. There were sacred ceremonies for people taking part in them. The ancient theatre had a bit different purpose. It still remained ritual, often connected with important events, with the sense of holiness, but the main aim was to become purified. Reaching the catharsis - purgation of emotions through art [Merriam-Webster 1995]

After that theatre performances lost the initial meaning and became rather source of entertainment, than sacred rituals. It started to change again in later middle-ages, when plays were reintroduced as passion or miracle performances in the churches. They were supposed to help people visualize things thought by priests and enhance the experience of holiness. After that, theatrical performances once more became mainly source of entertainment, first for privileged and aristocracy, later for the masses.

For approximately last 200 years theatre once more started to become the means to better oneself. Today it is considered form of high art and it resembles a bit the ritual like ones in ancient Greece.

ATMOSPHERE OF THE THEATRE

Theatre has very hard to grasp atmosphere, something very unique. It resembles a bit of a church, but at the same time it is not, as serious as sacred space. It is welcoming and inviting and then along the path to auditorium prepares one for the spiritual experience. It is the building that keeps the balance between everyday life, and something with deeper meaning. It is the place of learning and the place of pleasure. In words of Sir Anthony Quayle, famous British actor, successful theatre is “half a church, half a brothel”. [Mackintosh 2003]

Designing buildings like that is always a challenge, the buildings creating certain moods, fulfilling expectations people have. Today, architects, have more tools to stage building in any way they desire. The theatre buildings need very careful design to create proper mood, to lure the visitor in with promise of spectacular experience, prepare him for that, and then through the staging and performance – deliver.

FUTURE DEVELOPMENT OF THEATRE

Theatre transformed and evolved through the years, to become what we know it to be today. But this is constant process, and just like every other thing, it will continue to change and adjust to new circumstances. Probably the biggest factor behind the changes in theatre in XX century was discovery of television.

Since the 60s and 70s the amount of people going to the theatres was constantly decreasing, forcing the inevitable change. The theatres started to use the modern technology to enhance the illusion. The stage lighting was upgraded, allowing creating of spectacular effects during the performances.

Today theatres continue on this path, using the modern equipment and technologies during the performances. To keep up with the expectations of people used to the many visual incentives, more and more often theatres use projected images and change the ways in which the sound and light is used.

There also a lot of unconventional performances, ranging from very purist and intimate performances in rooms for around twenty persons, to large scale light & sound shows in biggest venues. The general trend is to build small dramatic theatres with wider range of possible applications. Due to decreasing popularity, theatres had to become more flexible and smaller. As we can read in Judith Strong's book *Theatre Buildings: a design guide* "Typical seating capacities will be in the range of 250-350 seats. The temptation to build over-large auditorium for big occasions such as speech days and concerts should be resisted, as the space will work less well for theatre." [Strong 2010]

Depending on the character of the theatre it can be designed in many different ways, depending on the type of performances. The shapes can shift from traditional to very unique. The In-the-round setting puts the stage in the middle of the auditorium, designed for performances with minimal use of props. The traverse format auditorium also allows wide range applications. The corner auditorium is more traditional and keeps design close to the most popular form, but at the same time it allows to develop more three dimensional space for performances (see Figures VI.1-3 on page 87).

Today there are no limits to what theatre can be, and design of the auditorium can shift significantly, depending on the need.

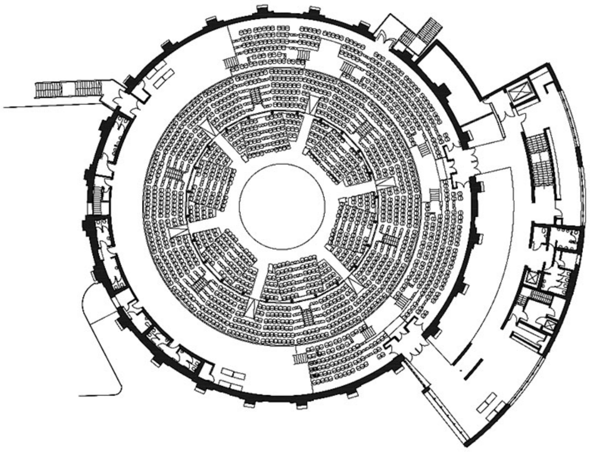

Figure VI.1 - *The Roundhouse; London, UK.*

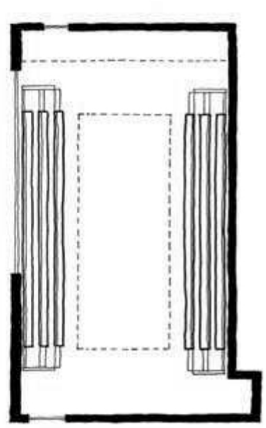

Figure VI.2 - Traverse format.

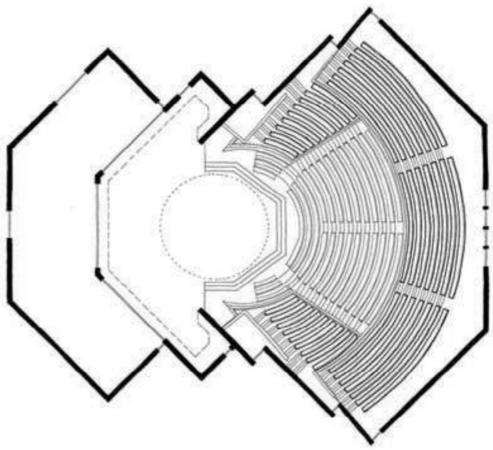

Figure VI.3 - Corner stage format; The Olivier auditorium at the National Theatre, London.

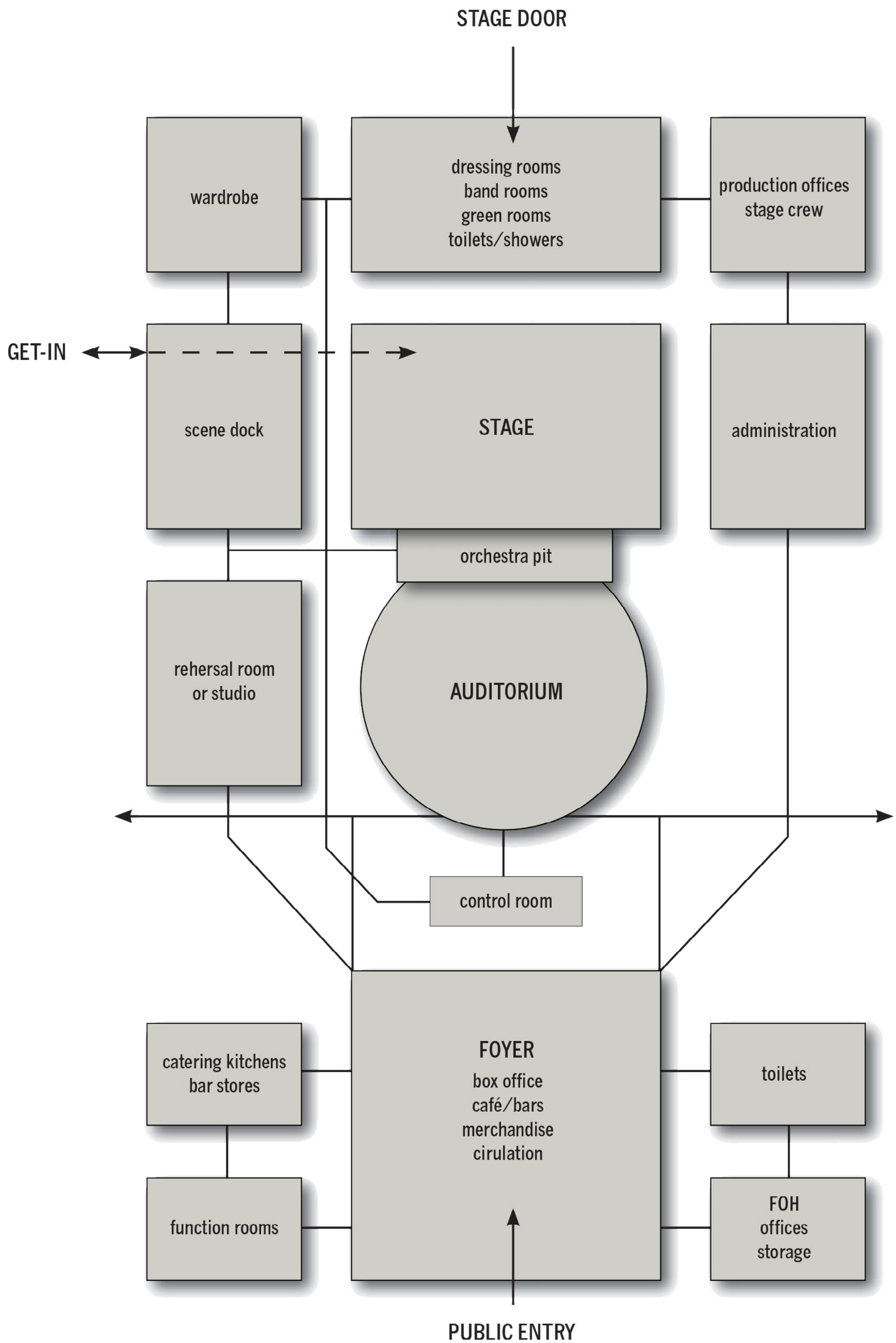

Figure VI.4 - Theatre functional diagram.

Zone	Room
Front Of House	Foyer
	Toilets
	Cloakroom
	Cafe
	Offices
	Meeting rooms
	Exhibition areas
Auditorium	Control room
	Auditorium
	Stage
	Rehearsal rooms
	Toilets
Backstage	Storage
	Workshop
	Wardrobe
	Dressing rooms
	Technical room
	Toilet/Shower
	Green room
	Offices
	Administration

Figure VI.5 - Room program.

<u>ROOM PROGRAM</u>

Theatres are very complex buildings, requiring a careful design and function placement. Functions scheme should be developed as soon as possible in the design process.

Theatre building can be divided into three main zones, which are: front of house, auditorium and stage and backstage. The size of the building and those components may vary significantly, but functional relations keep the same basic character [Strong 2010]. In addition to those three core areas there are supporting and additional functions, which can change depending on the clients demand.

Front Of House - Term front of the house refers to the foyer and all the facilities connected. It should be able to accommodate a large number of people for the time before the performance, intervals, and after the show. „This phenomenon requires the building to be planned to accommodate large numbers of people moving through a sequence of activities as they progress to and from the auditorium." [Strong 2010] The foyer should also be designed in such manner, that the path towards the auditorium is clear and easy to find.

Auditorium And Stage - Auditorium is the main and most important part of the theatre. Its design and relation to the stage is the main factor making the theatre good or bad. It is crucial to design this space in the way enabling visitors to see and hear performance. It should also consider the unique relationship, the bond, created between audience and the performer.

Design of an auditorium also has to include all the supporting equipment, such as: sound system, lighting and scenery handling equipment.
Backstage - Backstage includes all the spaces required by both, artists and staff of the theatre. These areas should be well connected, allowing at the same time, to maintain the illusion and mystique of the performance.

Backstage area includes dressing rooms, with toilets and showers. They have to be connected with the wardrobe, containing costumes, room for relaxation and waiting. Dressing rooms should be in close proximity to stage.

Backstage should also be connected with the delivery dock and/or workshop to make handling of scenery property easier. Ideally it should be on the same level as the stage.

Next space included is the technical area connected directly to the stage for the props, musical instruments, lights, drapes and pieces of scenography used on regular bases.

Administration - Theatre building needs also space for administration workers. The offices should be placed in such manner, which allows staff easy access to both: front of house and backstage if needed.

Other functions - Modern theatres building may also facilitate other functions such as: educational space, café or restaurant, meeting rooms, studios and rehearsal rooms.

Figure VI.6 - View from the site to the north.

Figure VI.7 - View of the industrial bildings to the east.

Figure VI.8 - View towards the end of the pier.

Figure VI.9 - Apartment buildings south of the site.

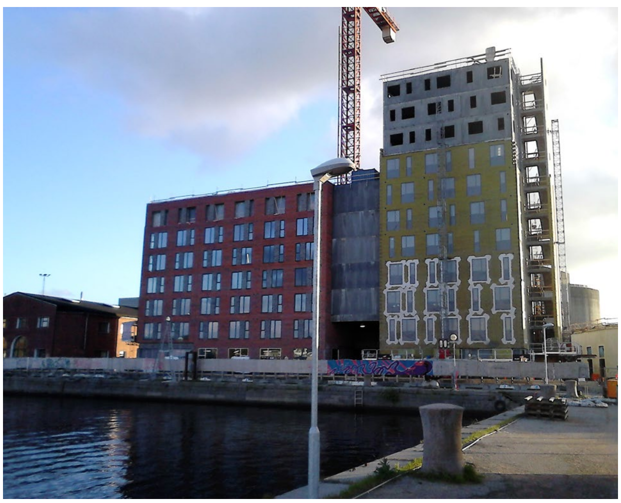

Figure VI.10 - Dinamicly developed new buildings in the west of site.

Figure VI.11 - Selected site marked with colour.

SITE ANALYSIS

The considered site lays by the Limfjord to the north-west from the city centre, and it is area of approximately 10 000 m2. Surrounding area consists mainly of the old industrial buildings, but Aalborg's waterfront is quickly developing, and new buildings are being erected, changing the character and expression of the space.

The site is the end of the walkway, along the shore, and is a perfect place for creating a recreational area to gather people, and offer a place to rest, while admiring the beautiful surroundings, in the close proximity of the city centre.

There are numerous green spots along the waterfront and creating a park at the end of the pier, would allow continuity and extension for city green system.

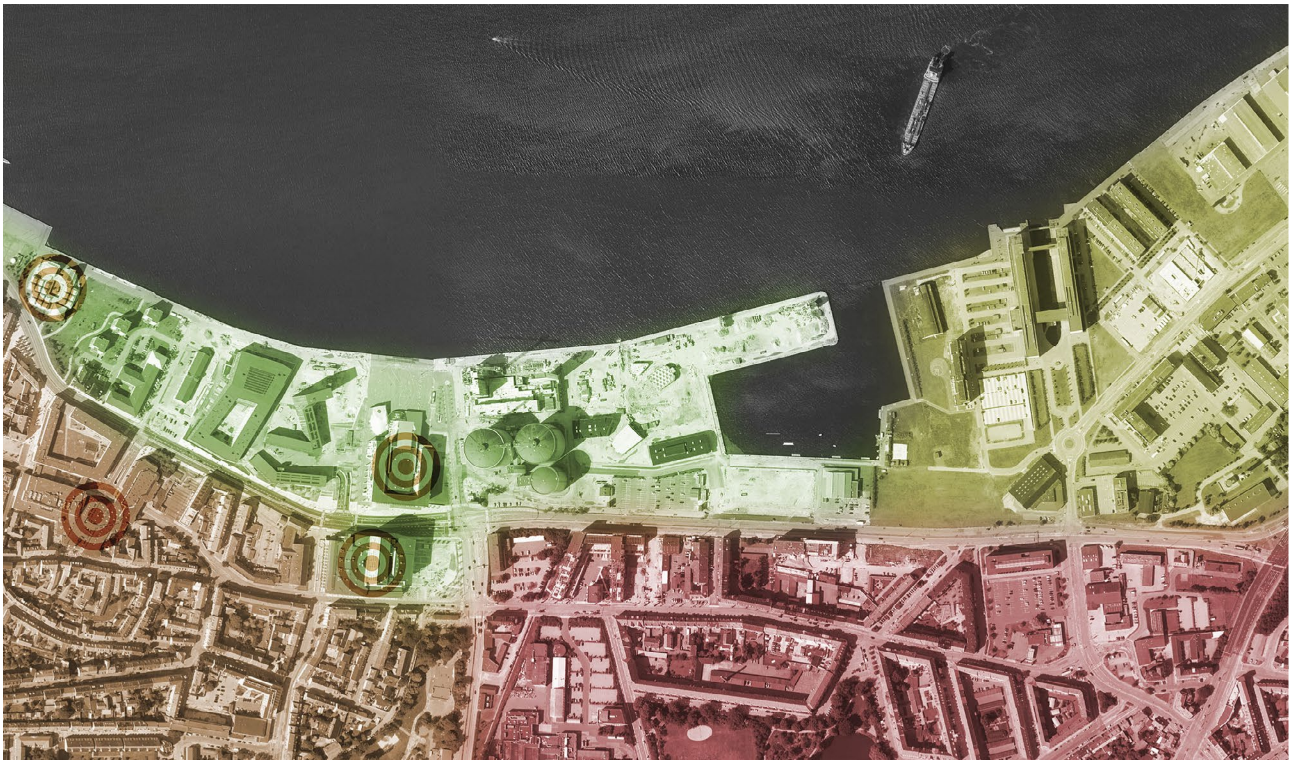

Figure VI.12 - Neighbourhood and surroundings.

NEIGHBOURHOOD

Neighbouring areas can be divided into four typologies. To the west, dense city centre with narrow streets (orange). In the north, north east of the site more green areas can be found with mostly residential buildings (a bit taller, but much less dense – red colour). To the east there is more industrial area with some office buildings (yellow).

The site is also located in close proximity to few points of interest for potential visitors: Utzon Centre, Musikkens Hus, Nordkraft and Hovedbiblioteket (main city library) all marked with the circles on the map. All of those buildings are the cultural institutions and the planned theatre could gain from their close position.

Marked with green colour is the waterfront of Aalborg with the buildings placed on the shore of the Limfjord. Buildings mentioned before are all close to that area, giving the possibility to develop cultural hub for the city. In this area the new landmarks of the city are developed. Two very unique buildings (Utzon Centre and Musikkens Hus) and also new building of Aalborg University create character the new Aalborg waterfront. That could be connected with development of a pedestrian zone, starting at the Østre Havn, continuing along the shore, passing first Musikkens Hus, next the Utzon Centre, and going further to the west.

Figure VI.13 - Infrastructure.

INFRASTRUCTURE

Site is well communicated with the city, as shown on the next diagram. It is around 160 meters from one of the main arteries connecting the city (Nyhavnsgade) and is connected with small local street (Havnemøllegade), part of which was transformed into temporary car park. It can be also accessed from the road on the shore of the fjord (Østre Havnepromenade). Some of the bigger components or prefabricated elements for the building can be also delivered on the ships, by the water, directly to the construction site.

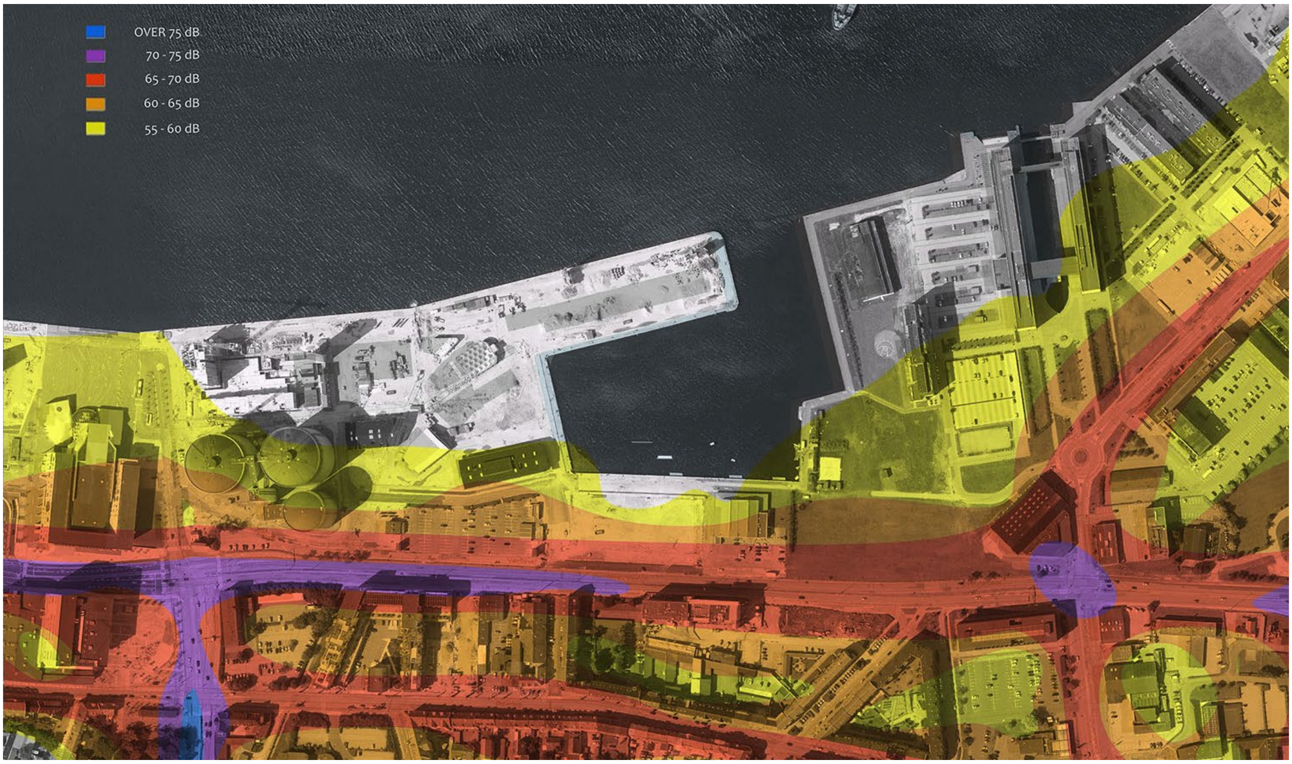

Figure VI.14- Noise pollution.

NOISE

Next diagram presents the noise pollution in the area. As many other venues, theatres require good sound insulation from the external noise. The selected site, despite the close proximity of the streets with heavy traffic, is secluded from almost all noise pollution. Most of the noise coming from the Nyhavnsgade is blocked and reflected by the existing buildings surrounding the area. The map below clearly shows that noise is not a problem at the location, however the levels of noise should be considered during the design process, in case of transformation of the neighbourhood in the future.

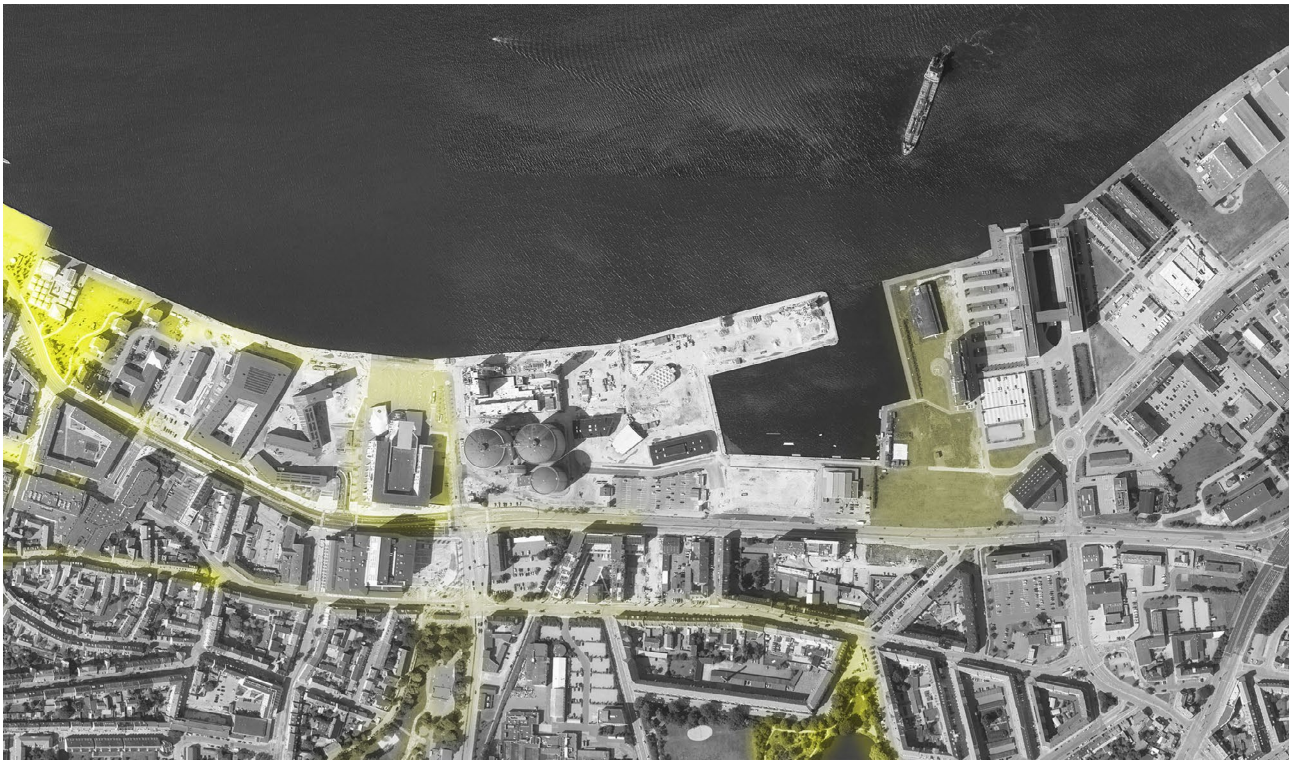

Figure VI.15 - People flow.

FLOW

Close to the site there are few big areas attracting people. Some of the streets, which are occupied mostly by pedestrians, were marked on the map below. The selection includes also some spaces like parks and plazas, favouring walking people. The biggest one is probably small park next to the Utzon Centre, continuing to the west in form of a boulevard. Also newly developed Musikkens Hus with the surrounding area crates inviting space. A bit less popular, visited mostly by the residents of the neighbouring buildings, is the large, undeveloped area to the east of the Østre Havn. In future the promenade can be extended to the end of concrete pier, including the designed theatre with surroundings, enabling people to walk along the fjord further to the east.

For the pedestrians site is now accessible through the boulevard on the shore (Østre Havnepromenade) and through the smaller local streets. The area is now subject to changes in the traffic organization, due to nearby construction of the apartment buildings.

Figure VI.16 - Vegetation.

VEGETATION

In the neighbourhood of the selected site, there are also some green areas. This includes mentioned earlier undeveloped area, east of the harbour. To the north, two big parks, invite flora deep into the centre of the Aalborg. Finally the small park next to the Utzon Centre, also mentioned before. All this creates areas for relax in close proximity to the considered space. Diagram below shows also the vegetation of the courtyards and city squares. Comparing surroundings, the city block where the site is placed, looks grey and unattractive. The area misses the plants and trees and seems to be completely covered with concrete. This needs consideration, as green areas, usually attract people.

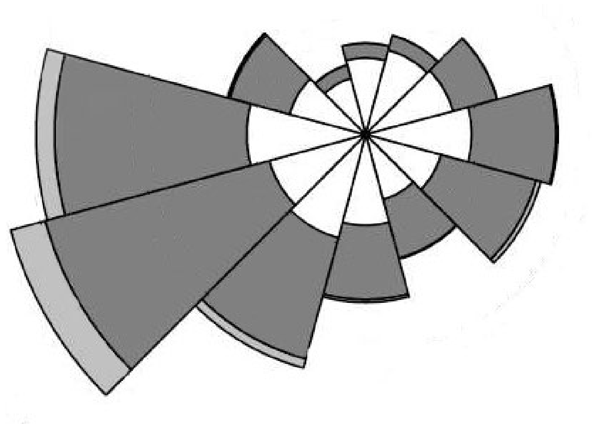

Figure VI.17 - Wind diagram.

CLIMAT

Denmark is the country with quite stable throughout the year. It is influenced by Atlantic Ocean on the west and the Baltic Sea in the east. [weatheronline.co.uk]

Aalborg has average temperature of around 7.5 degrees C during the year, with mean temperature of 16.5 degrees C during the warmest month and around-1 degrees C during the coldest. Yearly average precipitation is around 603 mm. [mitrejsevejr.dk 2015]

Wind is pretty strong, due to close proximity of the fjord, and the seas on the bigger scale. Most common is the wind from the west and south-west. The average wind speed is around 7 meters per second. The stronger winds come during the storms from east (Baltic Sea) and from north-west (Atlantic Ocean). Site is located on the edge of the fjord, which may cause the strong wind, going directly from over the water, to cause some discomfort.

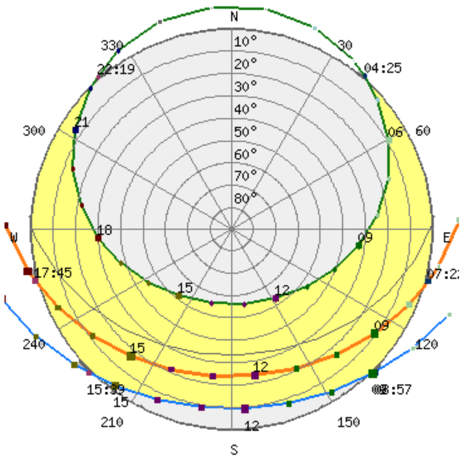

Figure VI.18 - Sunpath diagram.

SUNLIGHT

Sunlight, due to the northern location, varies dramatically throughout the whole year. In summer sun shines for around 18 hours during the day, whereas during the winter there is only 6 hours of sunlight.

Theatre building, like other venues of this sort, functions mainly in the evenings. The long hours of the sunlight, have therefore to be taken into account, during the design process. At the same time it creates possibility for implementing some solutions limiting the use of power in the buildings.

Sun, especially during the summer, can be also used to generate some energy through implementation of PV's. The nearest tall buildings are around 150 meters away to the west, meaning there are no problems with overshadowing. South side of the site, which is most desirable for placement of the PV panels, is (and will be) completely free of buildings, because of the harbour.

Figure VI.19 - *Naust paa Aure* (2010) by TYIN tegnestue Architects - great example of Nordic approach to architecture.

NORDIC ARCHITECTURE

The design traditions differ depending, among other things, on context, culture and history. Scandinavian, Nordic countries are no exception. They seem to have deep respect for the surroundings and work better with the context, in which the buildings are erected. In words of Christian Norberg Schulz, Norwegian architect: “Every place, every region, is significant, and it is our task to understand and respect this”. [Norberg Schulz 1997] This shows that, Nordic approach to the design comes from the culture, and does not necessarily refer to geographical location.

Nordic architecture takes a space, and works not to exploit it, but works within the context, amplifying natural beauty of the place. Designers with the Nordic background approach the site with humbleness and try to develop project in harmony with the surrounding area.

Nordic architecture, as mentioned before, is humble and simple. The structuring is usually clear and much care is put into detailing, as it becomes the decoration of the building. High level of quality and careful craftsmanship creates sublime architecture, without unnecessary, vulgar ornamentation.

All of those qualities are revealed in light, which is something cherished in the north. During summer, the long days, almost completely without nights, light renders the surroundings very sharply and during the winter it creates brilliant play of shadows, showing everything differently. Nordic architects take this into account and skilfully use it to their advantage.

Figure VII.20 - Fine detailing and high level of craftsmanship - classic traits of Nordic architecture.

'*Naust paa Aure*', project of the boathouse from 2010, by Norwegian studio TYIN tegnestue Architects, is a great example of Nordic architecture. Its simple form, use of the traditional material, along with modern technologies and humble placement in the surrounding, are the characteristic elements of the Nordic design. Architects themselves say: "The simplicity of the old building, its good placement and honest use of materials would become key sources of inspiration for the design of the new building." [TYIN tegnestue Architects 2015]

Nordic design takes environment into account and uses local materials from sustainable production. 'Naust paa Aure' is no different: "The cladding is made from Norwegian pine, pressure treated using a product based on environmentally friendly biological waste from the production of sugar (Kebony).", and later: "150 year old materials from the old boathouse is used to clad some of the indoor surfaces, and behind this cladding one can find most of the constructions bracing." [TYIN tegnestue Architects 2015] Finally the level of detail and craftsmanship, show the great care about the smallest elements of the project.

Figure VI.21 - *St. Henry's Ecumenical Art Chapel* (2005) in Turku, Finland.

TECTONIC ARCHITECTURE

Tectonic approach in the design has a lot in common with the Nordic design tradition. It praises the simplicity and honesty of the structure and puts a lot of focus on the quality of the relationships between the elements. The joints become the focal point and the decoration. In his "The Tell-The-Tale Detail", Frascari writes: "Details are much more than subordinate elements; they can be regarded as the minimal units of signification in the architectural production of meanings." [Frascari 1981]

Tectonic theory says that structural unit, becomes the very essence of the architectural design. The detail creates the ornamentation for the structure. The simplest way, to describe the tectonic approach in the design, could be referring to it as a poetics of structure.

St. Henry's Ecumenical Art Chapel in Turku from 2005 shows many qualities of tectonic architecture. Its form brings to mind fish, symbol of Christianity. The exterior is covered in plates of metal resemblance the scales of the fish, while the inside structure brings to mind the skeleton. The construction is very simple and skilfully crafted, creating the ornamentation for the building. The regular placement of elements creates rhythm, and carefully designed lighting articulates it with the game of light and shadow.

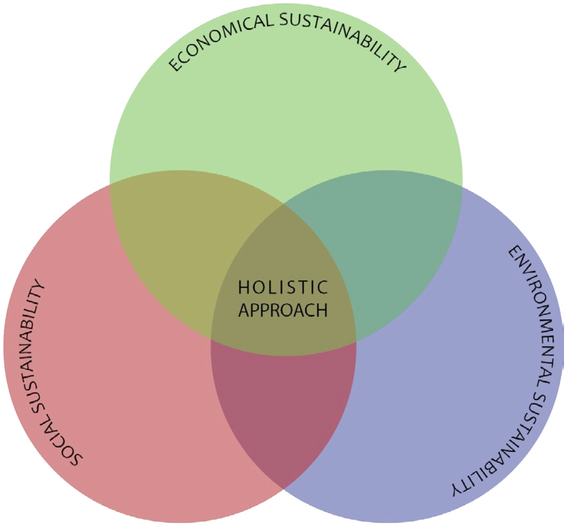

Figure VI.22 - Diagram showing holistic approach to sustainable design.

SUSTAINABILITY

Word sustainability is relatively new term, although the ideas behind it were present for some time in collective consciousness. It derives from verb to sustain, which, according to Oxford Dictionary means: “Bear (the weight of an object) without breaking or falling” [Oxford Dictionary 2015]

The World Commission on Environment and Development in 1987 introduced and defined Sustainable development in words: “Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. “ [World Commission on Environment and Development 1987]

Since the report there was a lot of changes and development in the field of sustainability. It became main goal of high developed countries, like Denmark, to better the situation, especially in energy connected fields and in industries. All the newly developed buildings have to fulfil the requirements of EU 2020 regulations. In this project, to achieve that BSim will be used.

Theatre buildings use enormous amounts of energy, but efforts are made to achieve economic, social and environmental sustainability, the requirements of a holistic approach to sustainable architectural development.

There are six main objectives, described in the book “Theatre Buildings: a design guide” by Judith Strong [Strong 2010], that should be considered in the designing process:

- Operational carbon neutrality
- Self-sufficiency in water use
- Use of sustainable materials
- Ability to cope with future climate change
- Make a positive contribution to the community and built environment
- Sustainability in operation

The same book also enlists few key points to be considered during the design process, as they may influence financial savings in the theatre life cycle. The few of the issues can include:

- High levels of thermal insulation
- Materials which provide thermal storage
- Low-energy lighting
- Control systems which reduce energy use
- Good orientation and avoidance of solar gain

Chapter VII

Methodology. Vision. Concept presentation. Case studies.

INTRODUCTION

The Clockwork Theatre, is my proposal for the new Aalborg's theatre, and new landmark for the city waterfront. The idea is to create unique experience for the visitors, while taking context and surroundings into account.

On the next pages I will present the methodology and try to capture the essence of the idea, and present it with use of plans, sections, elevation drawings, visualisations and diagrams.

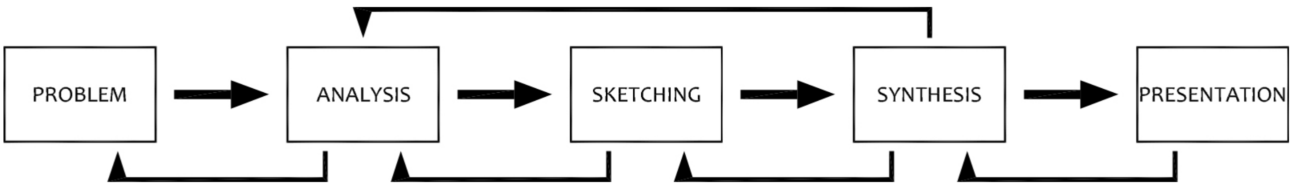

Figure VII.1 - Diagram showing the steps in the Integrated Design Process.

METHODOLOGY

Architectural design is a complex process combining both, engineering and art. Today it is even more so, due to new systems and solutions used in modern buildings. Technologies connected to the sustainability, user comfort, energy preservation, etc. require from architects broad knowledge and ever closer cooperation with specialist and system designers.

The Integrated design process was developed by Mary-Ann Knudstrup [Knudstrup 2005] to bring together all the aspects of building design, and include the engineering knowledge in very early stages of project development. This enables designer to have belter control over many parameters, detect possible issues during the design process, and solve them when it is much easier and cheaper.

Taking all the parameters into account, results in more holistic approach to the design of the building. It makes electrical systems, construction and other engineering disciplines part of the design, not a "necessary evil", allowing architects to focus more on the aesthetics, without worrying about need of compromise in later stages of the design.

The design will also include the PBL – Problem based learning. This method is promoted at the Aalborg University, as the name suggests, it is the method based on answering to the main design question, formulated at the beginning of the design process. In this case the problem is: How to design a modern, functional theatre, as the new landmark on Aalborg's Waterfront?

Figure VII.2 - Silo the inspiration for the form and the materiality.

VISION

The idea was to crate theatre building, with unique qualities, which could become Aalborg's new landmark, while embracing the quality of the surroundings.

Close proximity of the fjord, and harbour, create spectacular sight, and connecting the building to this view maintained one of the main goals during the design process. Other important factor was to invite people into the everyday life of the theatre - to keep it alive, and to prevent it from becoming just a monumental building.
At the same time I wanted to preserve the industrial feel of the site. The form of the building, and used materials, were used to relate to the huge concrete silos standing nearby. Those tall grey forms are a very recognizable structure.

The other parameters taken into account were sustainability, tectonics and structural design, and lighting, both, artificial and natural. All of those had influence on final proposal.

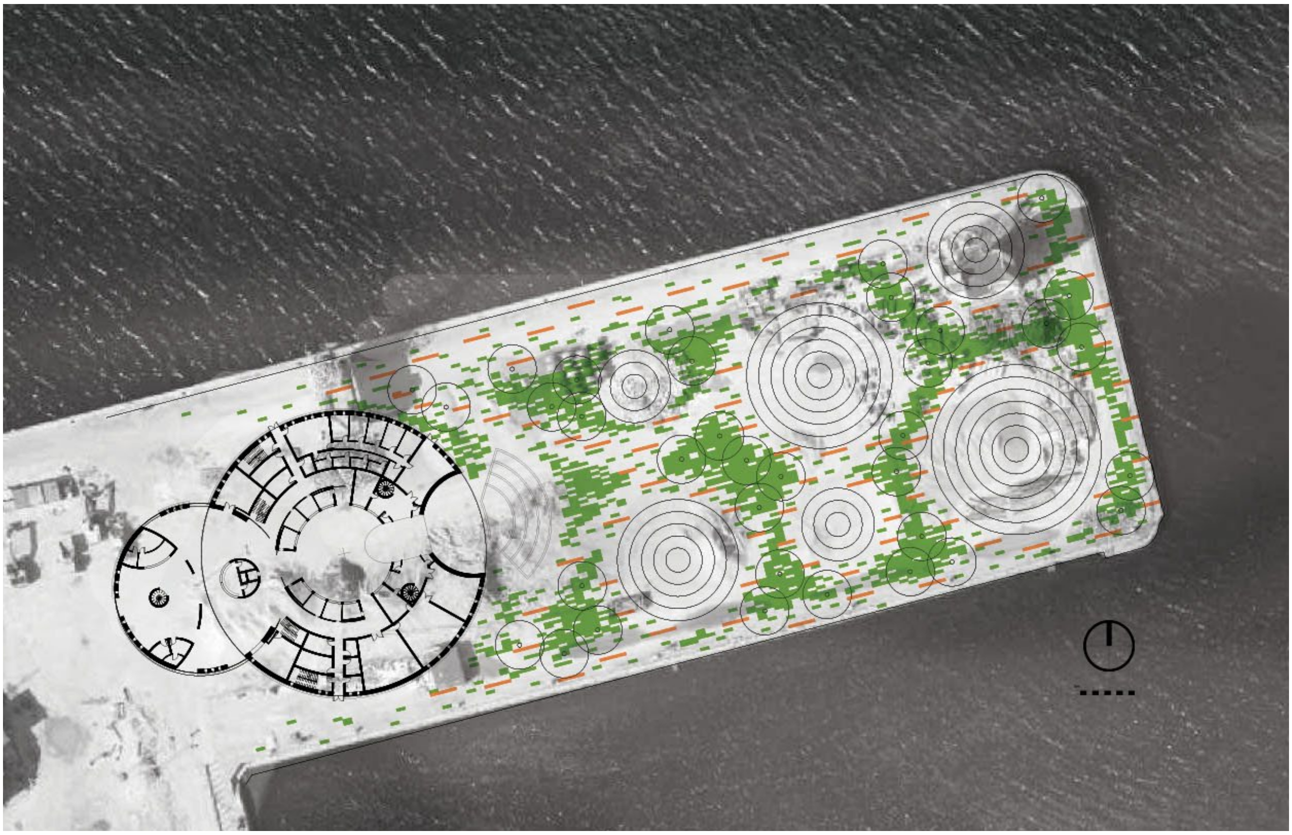

Figure VII.3 - Masterplan

MASTERPLAN

Master plan presented above, gives the general idea about the building placement on the site. It is placed on the edge of the pier, creating two niches on both sides, directing visitors towards the entrances, but leaving enough space to walk around the building. The form of the theatre suggests the movement around, and as we proceed alongside, it uncovers the park behind.

The park is designed to invite people in, and offer them a place to stay and relax after a walk along the waterfront. Theatre auditorium has an opening and uses the surroundings as the natural scenography. The step structures in the park invite to sit down, and stay for a while. At night led light panels lit up the whole area, creating very distinctive expression.

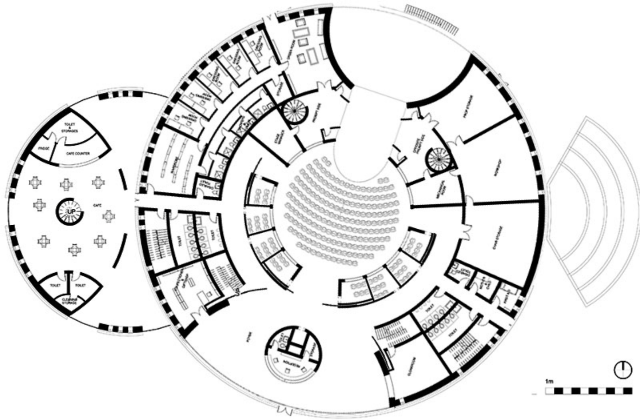

Figure VII.4 - Building rotation 75^{o}.

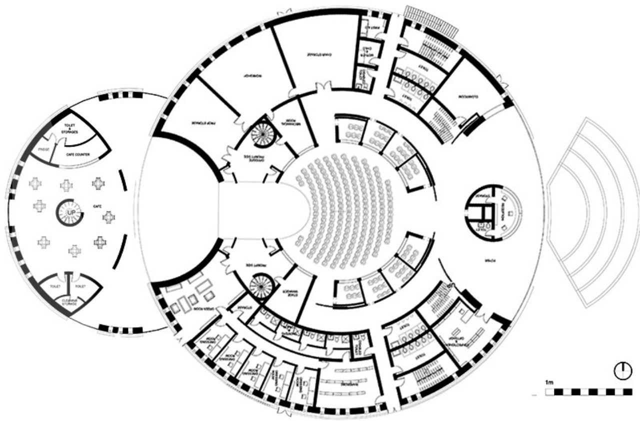

Figure VII.5 - Building rotation 180^{o}.

ROTATION

The building is placed on the rotating slab. This allows employing the surroundings of the building to become a natural background for the performances. With rotation, play can be set on the shore of the fjord, overlooking the passing ships. The building can be turned to point toward the city, placing the performance in the urban environment.

Building becomes the camera, rotating an observing ever-changing life around, making it part of the performance.

This also allows complete transformation of the venue - theatre can be rotated 180o, and foyer becomes scene for the amphitheatre placed behind the building, or making the cafe scenography for the performance.

With rotation building literally opens to the public and connects the outside space with the insides. Foyer becomes part of the public area, and the outside becomes part of the foyer.

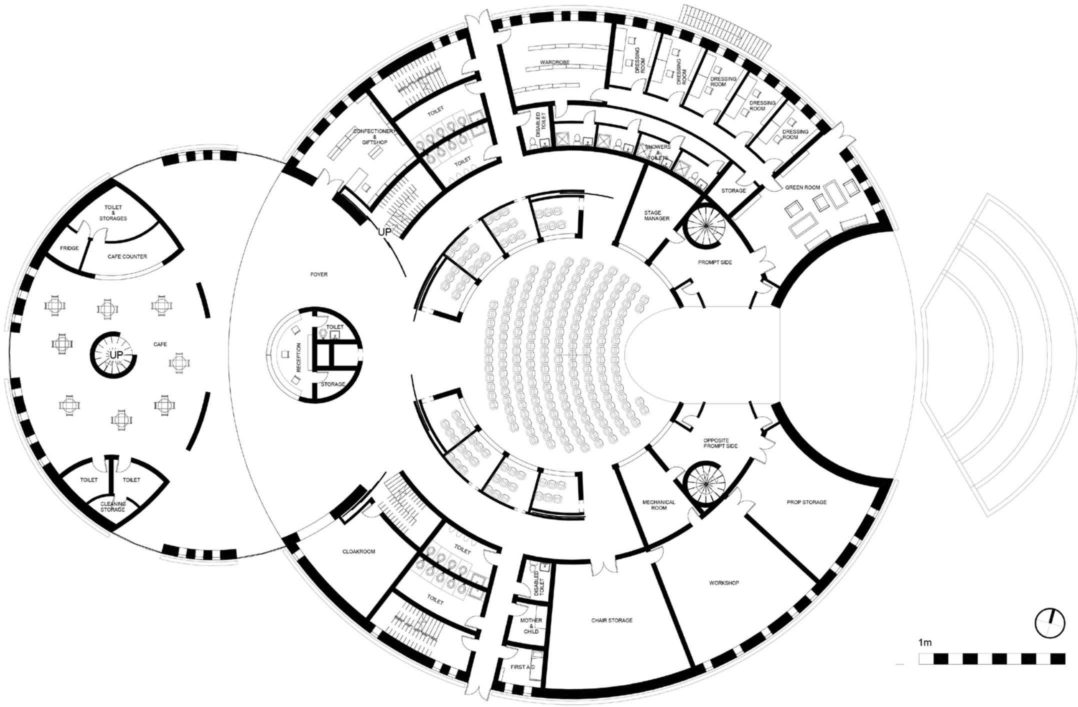

Figure VII.6 - Plan- ground floor level.

PLANS

<u>GROUND FLOOR</u>

In front of the theatre part of building there is cafe, which is connected with the rest, creating big, open space, which becomes a foyer.

The division of the functions of the theatre is quite traditional. First there is a big, light foyer inviting visitors, with the reception with box office and ticket sale in the middle. On one side of the foyer there is cloakroom, on the other shop with programmes, gifts and confectionery. Next there is circular corridor distributing people, toilets and behind that, there is the backstage with the wardrobe and the dressing rooms on one side and the workshop and prop storage on the other.

Auditorium itself is very traditional in its shape, with the seats pointing towards the scene, behind which, there is a big opening, showing the outside world. This creates the unique quality in theatre, as the surroundings become the scenography for the performances. Circular form and balconies create very intimate atmosphere with the focus on window, capturing life, like the lens of the camera. With the movement, theatre shows different situations, different events, which become the expression of life.

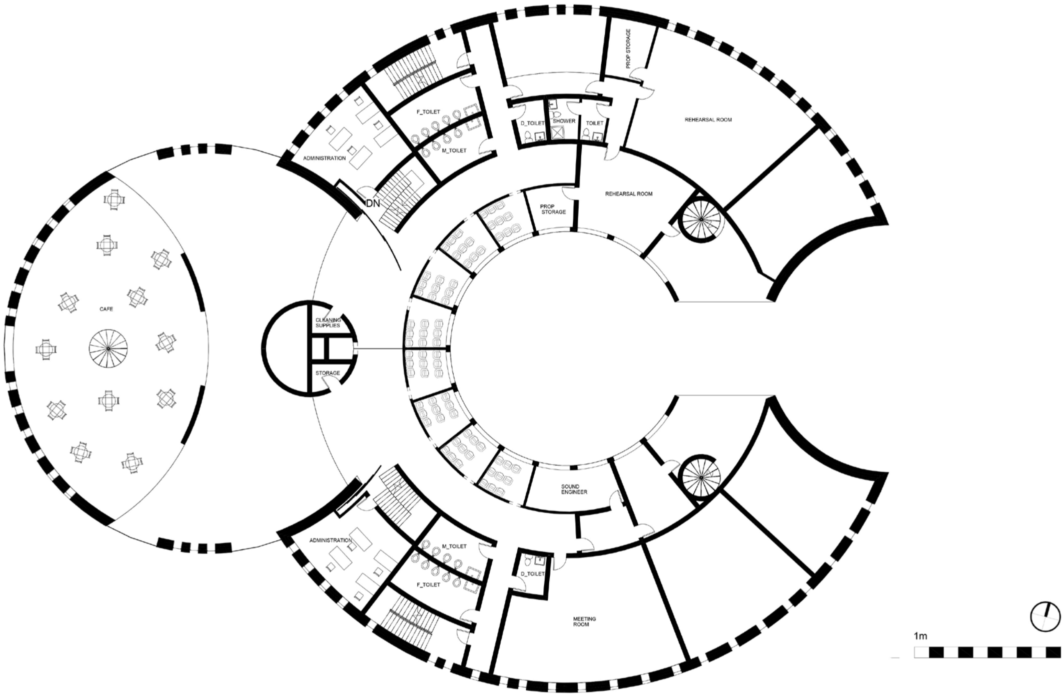

Figure VII.7 - Plan- second floor.

SECOND FLOOR

Second floor repeats the functional program of the ground floor. Instead of dressing rooms there are two rehearsal spaces for the actors. On the opposite side, one big conference room was placed.

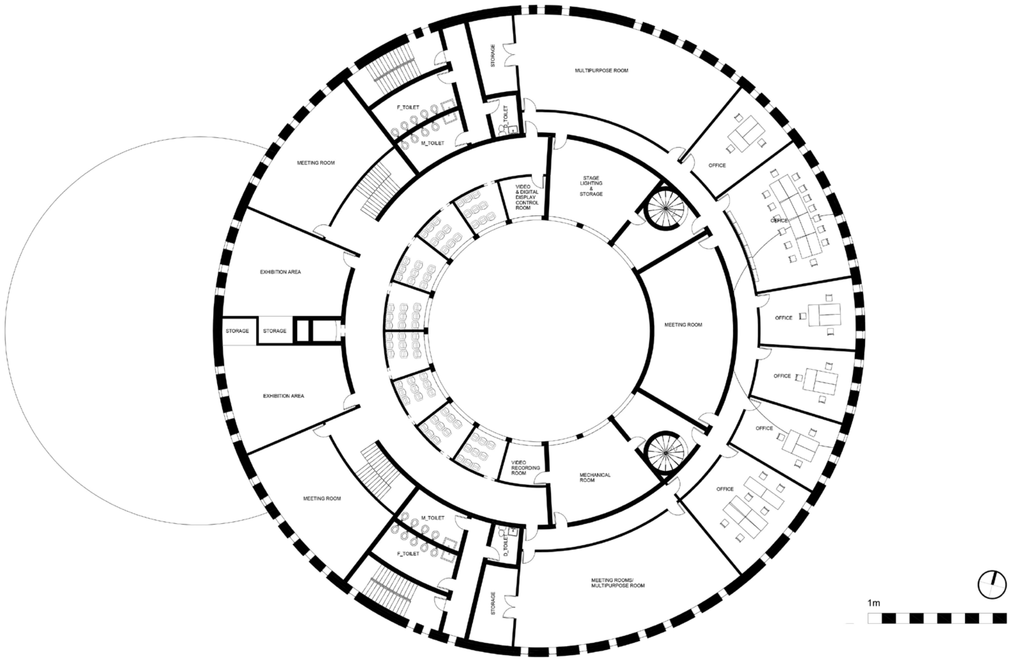

Figure VII.8 - Plan- third floor level.

<u>THIRD FLOOR</u>

Third floor facilitates offices for the permanent staff of the theatre. There are also conference and meeting rooms. At the west side of the building there is exhibition space.

The administration area is secludes from the rest of the floor with implementation of separate corridor, connecting offices with technical rooms and supporting functions.

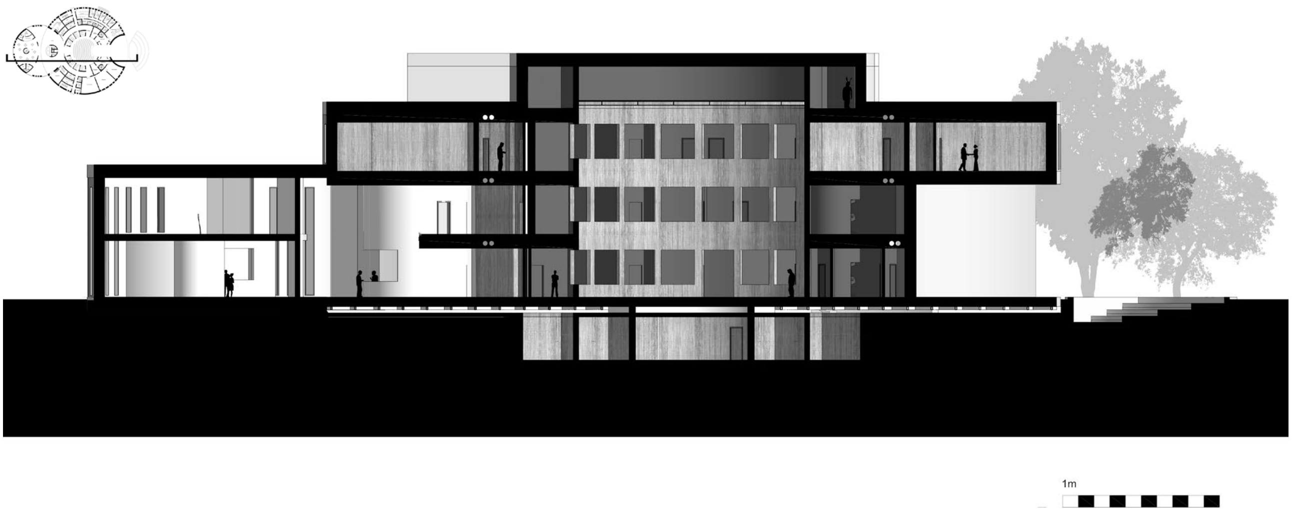

Figure VII.9 - Section of the building.

Figure VII.10 - Cross section of the building.

SECTIONS

Section of the building, showing the height of the spaces. Clearly visible auditorium in form of well, creates very enclosed space with intimate atmosphere.

Suspended ceiling covers the ventilation ducts, pipes and cable trays.

ELEVATIONS

Rough material on the exterior, relates to the nearby industrial buildings. The tall windows cut through the whole elevation, making the structure lighter in perception.

In the night, building illumination, relate to the nautical lights, as the building is placed near the fjord and sailing rout.

Figure VII.11 - West elevation

Figure VII.12 - East elevation

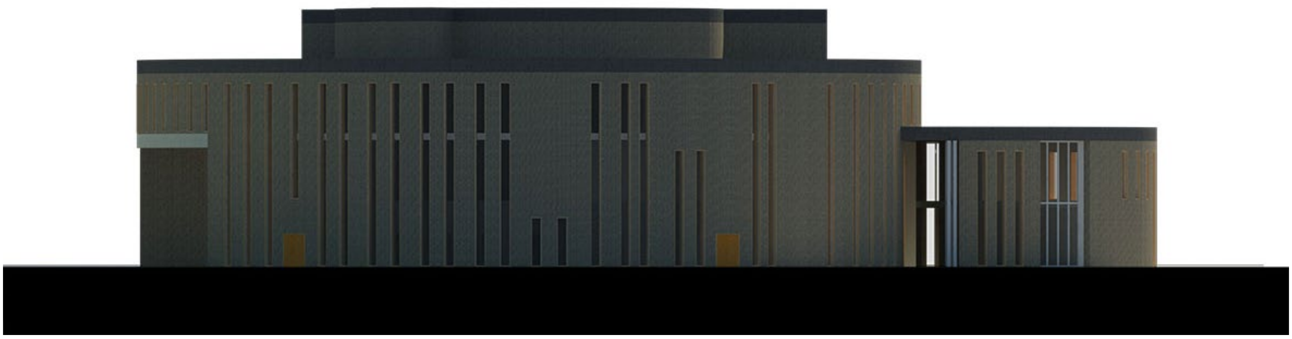

Figure VII.13 - North elevation

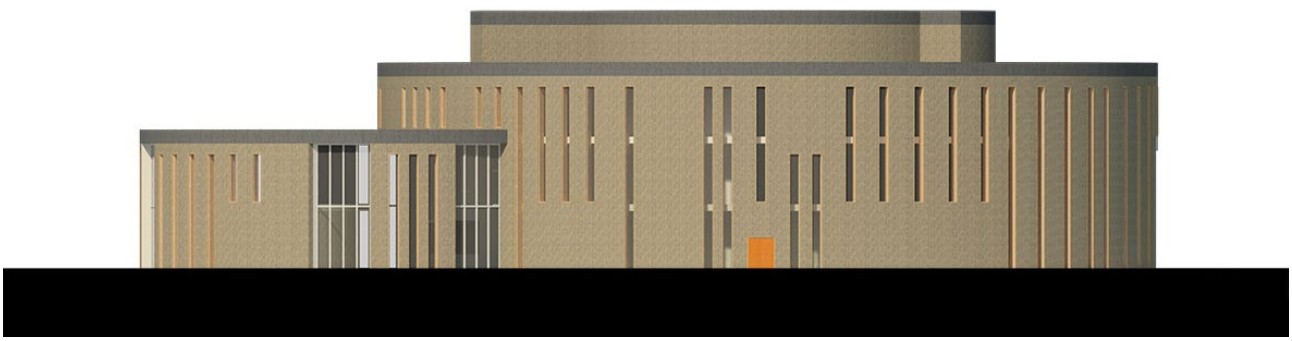

Figure VII.14 - South elevation.

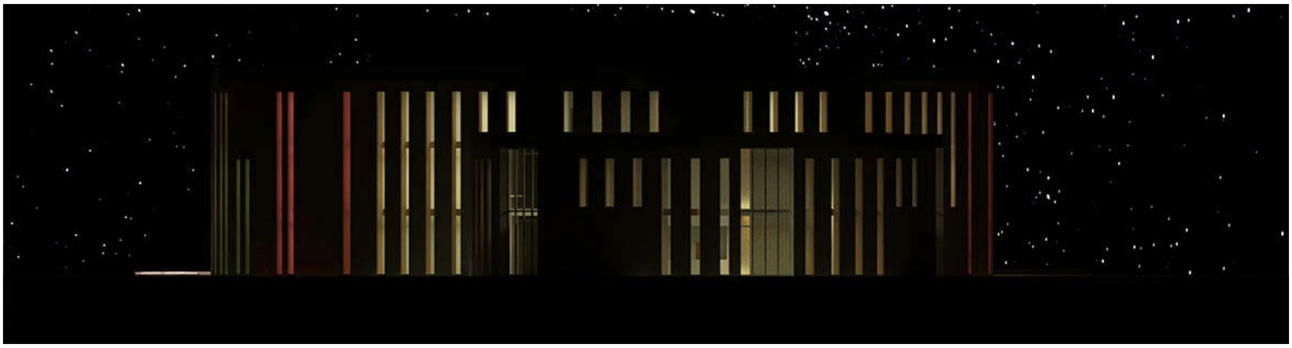

Figure VII.15 - West elevation at night.

Figure VII.16 - East elevation at night.

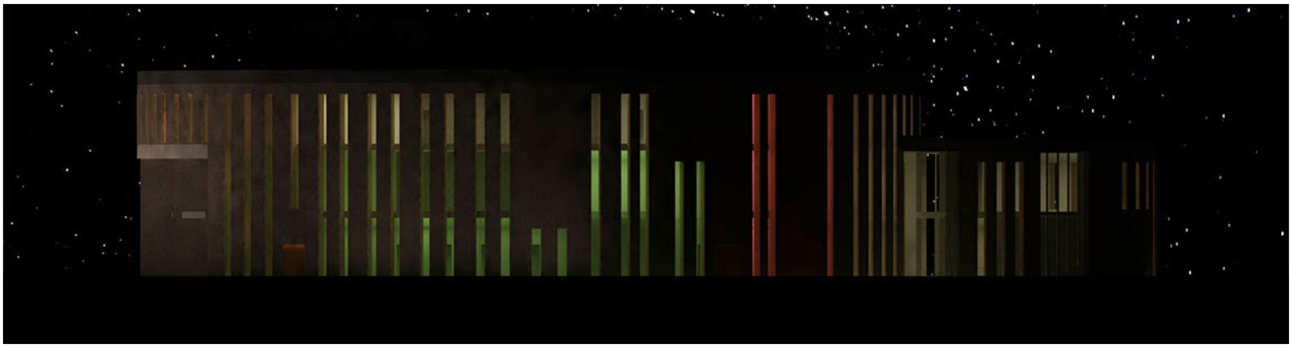

Figure VII.17 - North elevation at night.

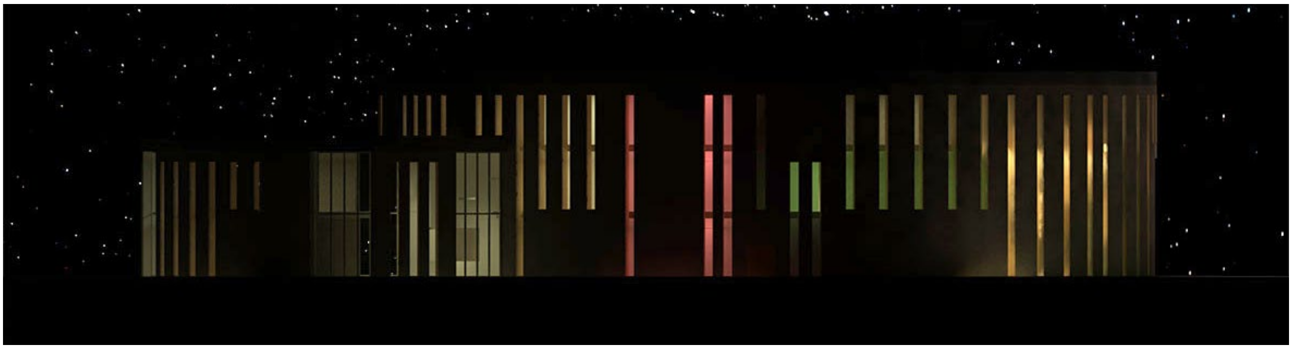

Figure VII.18 - South elevation at night.

Figure VII.19 - View of the building with park.

Figure VII.20 - View of the building (rotated) with park.

OUTDOOR AREA

The visualisations show the placement of the building on the pier. The concept for the park is also presented. As visible above, building opens to public after rotation becomes more inviting. The border between the inside and outside disappears making the spaces intertwine.

The round shape of the building creates the gesture directing the flow along the curve, toward the green area in the back. In the park, the shape of the building is repeated by urban furniture allowing stopping and resting in the nature. At night all area lit up, creating spectacular view. The night lighting of the building refers to the spectrum of nautical lights.

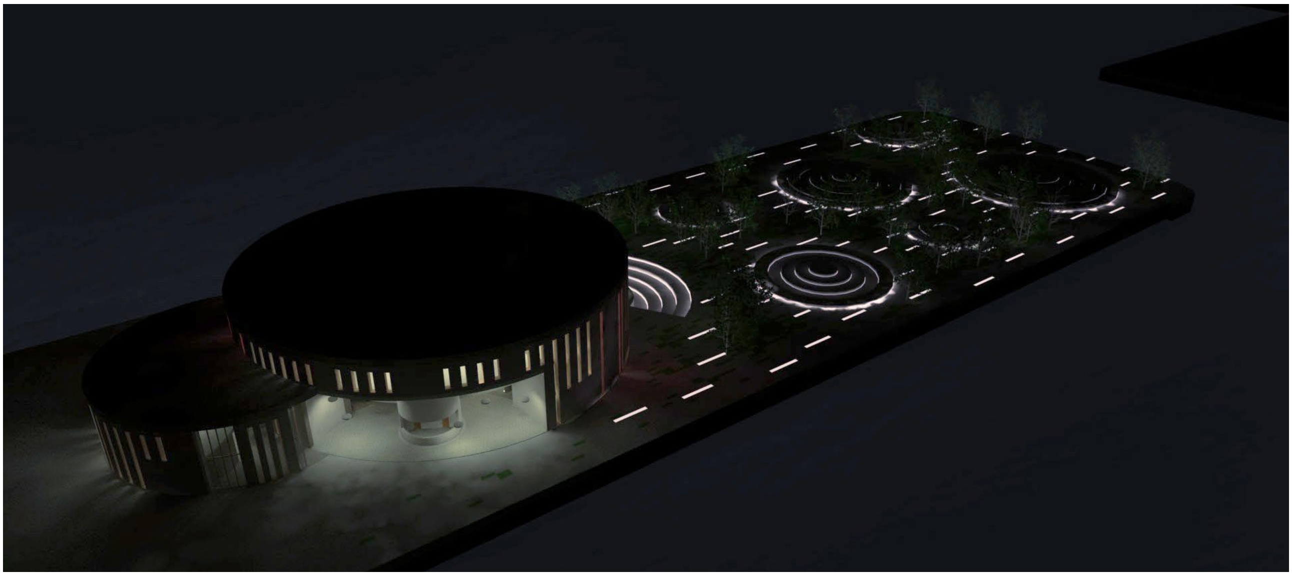

Figure VII.21 - View of the building (rotated) with park, at night.

Figure VII.22 - View of the urban furniture in park, at night.

Figure VII.23 - View of the foyer at night.

FOYER

Visitors entering the foyer can see big circular structure in the middle. At the moment they enter the building, even if it's their first time, they know instantly where to go. The structure in the middle facilitates reception desk with box office and ticket sales.

At night the wall washing light, lit up the reception, informing people, where they should direct first.

Round form, suggest movement along the curve, directing and distributing visitors to the corridors going to the main auditorium.


Figure VII.24 - View of the foyer at night.

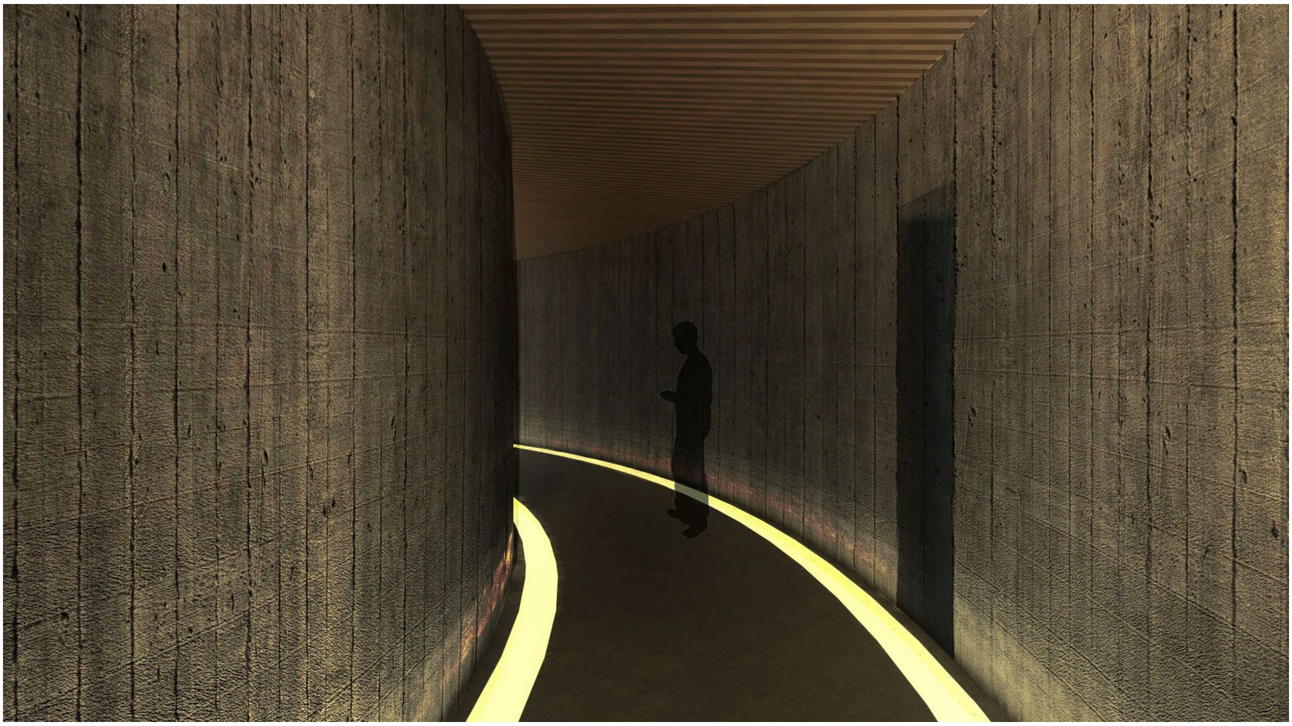

Figure VII.25 - Corridor.

FOYER

As mentioned before foyer form direct visitors to the corridors, which take them into the auditorium.

The journey through the corridors prepares people for what to expect inside the auditorium. Walls are cast in concrete, with a texture of boarding left unrefined. This creates very rough surfaces. In contrast with lighter and polished floors, walls remind of a rock.

Used wall washers create very dramatic effect with the texture of the wall. At the same time they form to stripes of the warm light, along the curved surface of the wall.

Levels of light decrease with the progression of the tunnel to enhance the mystique, but light source at the end of the corridor, makes promise of safety, relating to our primal instincts.

Figure VII.26 - Auditorium with view to the outside world, in the background.

AUDITORIUM

Auditorium is the central space of the building, and all the functions are placed around it.

Auditorium itself is very traditional in its shape, forming a very enclosed well. This gives the feeling of the confinement and draw viewer deeper into the illusion of being in different space, from which, he studies the live revolting around.

The seats are pointing towards the scene, behind which, there is a big opening, showing the outside world. This creates the unique quality in theatre, as the surroundings become the scenography for the performances. Circular form and balconies create very intimate atmosphere with the focus on window, capturing life, like the lens of the camera.

Like walls in corridor, walls are cast in concrete, with a texture of boarding left unrefined. Again wall washers are employed, to create dramatic effect end embrace the structural finishing of the wall.

Lights are important part of the expression of the space. They show the texture of the walls, mark exits (slightly green hue), and also light up the frames of the balconies, around the auditorium, putting everything happening in those spaces on display, and also including it into the performance.

Figure VII.27 - Office during the day.

WORK SPACES

For some people, theatre is not only a place visited once in a while, but a place of work. Therefore it is crucial not only to design spectacular building for the visitors, but for all its users.

Offices, workshops, meeting rooms, and other utility spaces have to fulfil the number of requirements. In presented proposal, those rooms continue the expression of the rest of the building, using the same materials. Lighter ceiling makes the room seem taller, while the darker and heavy walls give the impression of safety and closure. The colour of used structural concrete adds warmth to the space, and so do wooden elements.

Dramatic lighting from the public spaces was changed to more calm down lighting, hidden in recessed ceiling. Tone and position of light also warm up the space and peripheral luminance make space seem less tense.

Figure VII.28 - Office at night, with high levels of illuminance for work.

Figure VII.29 - Office at night, with low levels of illuminance after work.

Figure VII.30 - Rough concrete texture on the wall.

MATERIALITY

The materiality, according to the Collins English Dictionary is "the state or quality of being physical or material" or simply "substance; matter". [Collins English Dictionary 2003] Everything that surrounds us is composed from mater. And architecture is no different. It is the art of composing from shapes and materials. Different substances have different appearances and change the way we perceive the buildings. The structure made out of wood makes impression other than the same constructed out of stone.

Our perception of environment and surrounding is closely connected to our vision. What we see, or don't see, usually determines how we feel about certain surroundings. The material is revealed by light and creates the space, defines the boundaries. It can be discovered sometimes with the use of other sense, but in most cases first we see something, and then we proceed with the further investigation using smell, touch.

VISUAL PROPERTIES OF MATERIAL

Every material can be defined by its physical properties. In the book "Materials for Interior Environments", we find the description:

Colour - Depends on quality and quantity of light; materials have one or more innate colours; other integral colours if processed.

Form - three-dimensional quality, defined by length, width and depth.

Texture - Relative smoothness or roughness of surface; has scale. Tactile texture can be felt. Visual texture is seen; depends on the patterns of light and shadow, suggesting tactile texture. [Binggeli 2013]

Book mentions a lot more properties, but those are the ones concerning the perception of the material in light.

Light interacts with materials in many different ways. First of all it's reviling to us how does it look like and what are its properties. The lights and shadow render the texture of the material revealing if it is smooth or rough. It also creates what we recognize the colour of the material. But there are other interactions depending on the properties of given substance. Light can be reflected of the surface it hits, it can be absorbed or it can be diffused. The appearance of the material change, depending on how much of the radiation is absorbed or reflected.

For this proposal concrete and wood were selected as main constructional materials. The interiors are formed in concrete. It generates a sense of longevity and strength of the building and refers to the industrial buildings nearby, especially to big concrete silos, shape of which was direct inspiration for the final form of theatre.

Concrete used for the walls is darker than the one used for floors and ceilings. It is left with a texture of boarding, which is revealed by the light from the wall washers. It contrast with lighter and polished floors, walls remind of a rock. On the other hand glossy horizontal planes reflect light and brighten up spaces inside the building.

This connection of materials creates a flow through the building. This flow is complimented by wooden frames in the doorways and other openings. Their look is closer to the floors than the walls so they extend floors vertically. But frames not only help to divide spaces but also make the project warmer and more like a house.

On the outside there are prefabricated concrete panels. They are thin and light, as there are hung from the structural wall. Nevertheless despite being thinner the panels bring the character of internal walls outside and make the building communicate with wider audience.

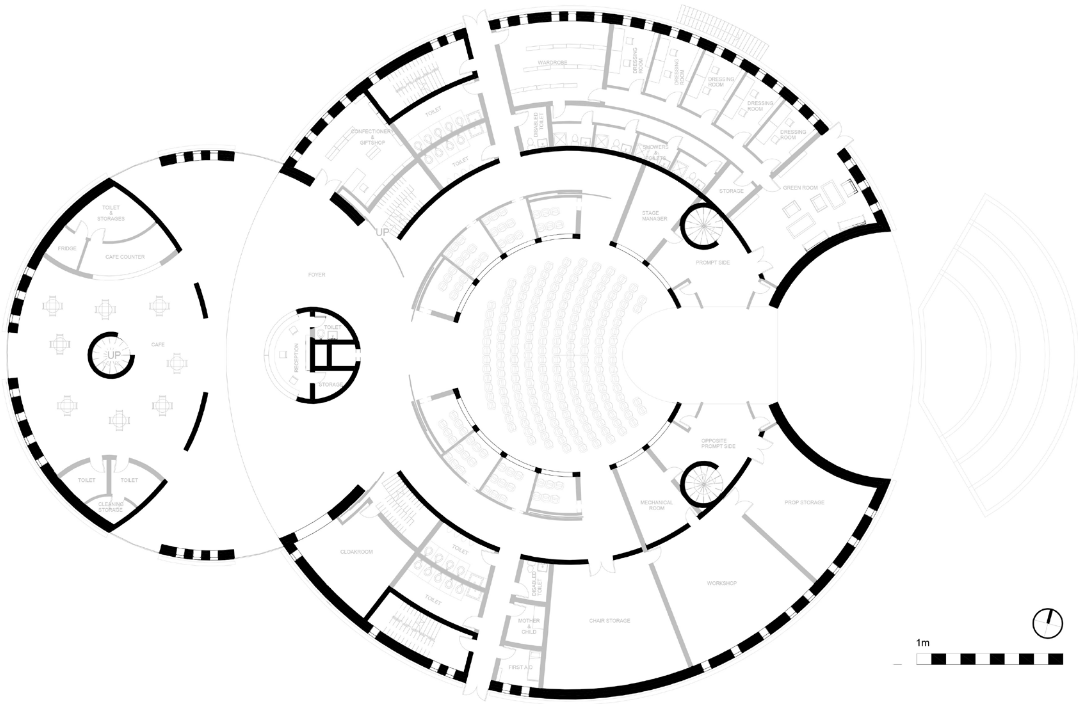

Figure VII.31 - Load bearing system.

STRUCTURAL SYSTEM

Structure of the building is simple. It is concrete construction, with load bearing walls (see diagram above) and concrete slabs. The span of elements does not exceed 8 meters. Because of the buildings form construction is also very rigid and stable. Due to fire safety staircases on both sides are designed as separate structure.

For the structural analysis Grasshopper plug-in was used for the initial design. The construction had to be simplified, before modelling, and was recreated as simple beam and column system. Since the radiuses of the walls were fixed values, spacing between columns was changed. Also the beams and columns cross-sections were changed to investigate, how the structure could be utilized further.

After the initial analysis with the Grasshopper, structure was exported to Autodesk Robot, where further analysis was done. As the Grasshopper was not developed for the concrete structure analysis, results might be inconclusive.

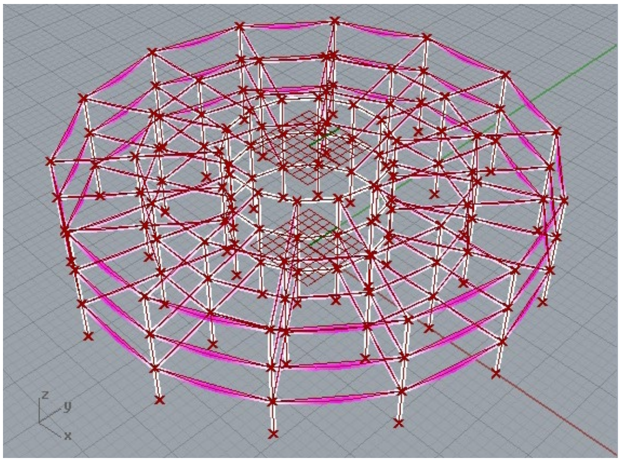

Figure VII.32 - 14 columns with 10,2 m interspace; beams cross-sections 300 x 300- displacement ~ 0.1m

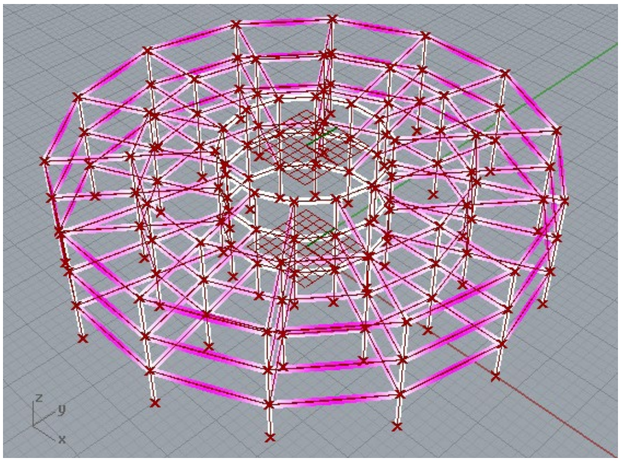

Figure VII.33 - 14 columns with 10,2 m interspace; beams cross-sections 600 x 300- displacement ~ 0.02m

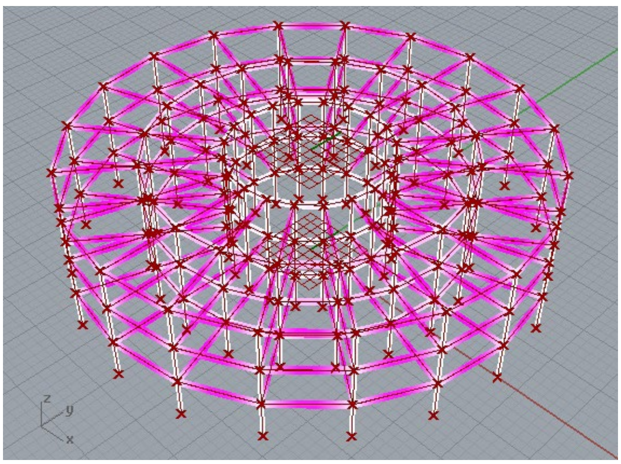

Figure VII.34 - 20 columns with 7,2 m interspace; beams cross-sections 600 x 300- displacement ~ 0.007m

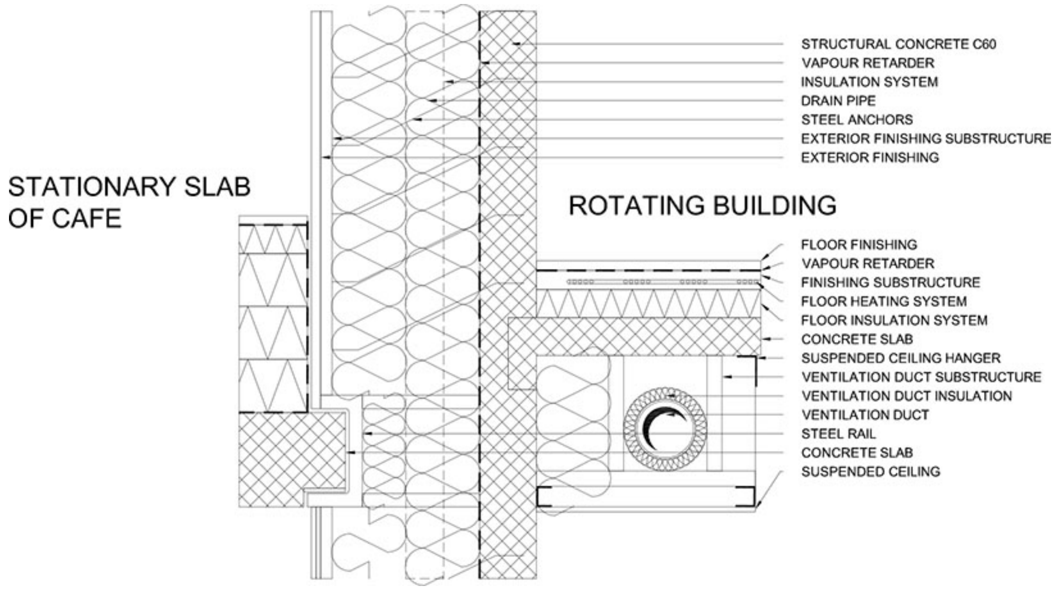

Figure VII.35 - Constructional detail of rotating buiding connection.

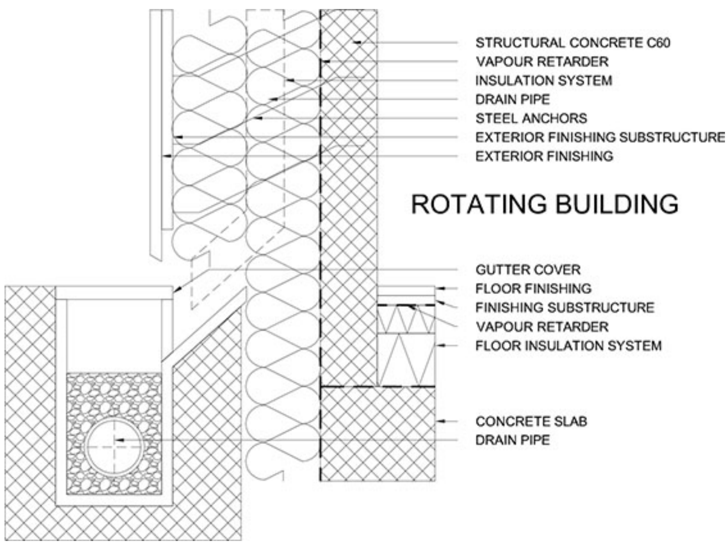

Figure VII.36 - Constructional detail of rotating building water drain system.

CONSTRUCTION DETAILS

Presented here details show possible solutions for the connections, between the rotating and stationary elements of the building. Decision, to make building movable, demanded individual approach to the detailing of structure.

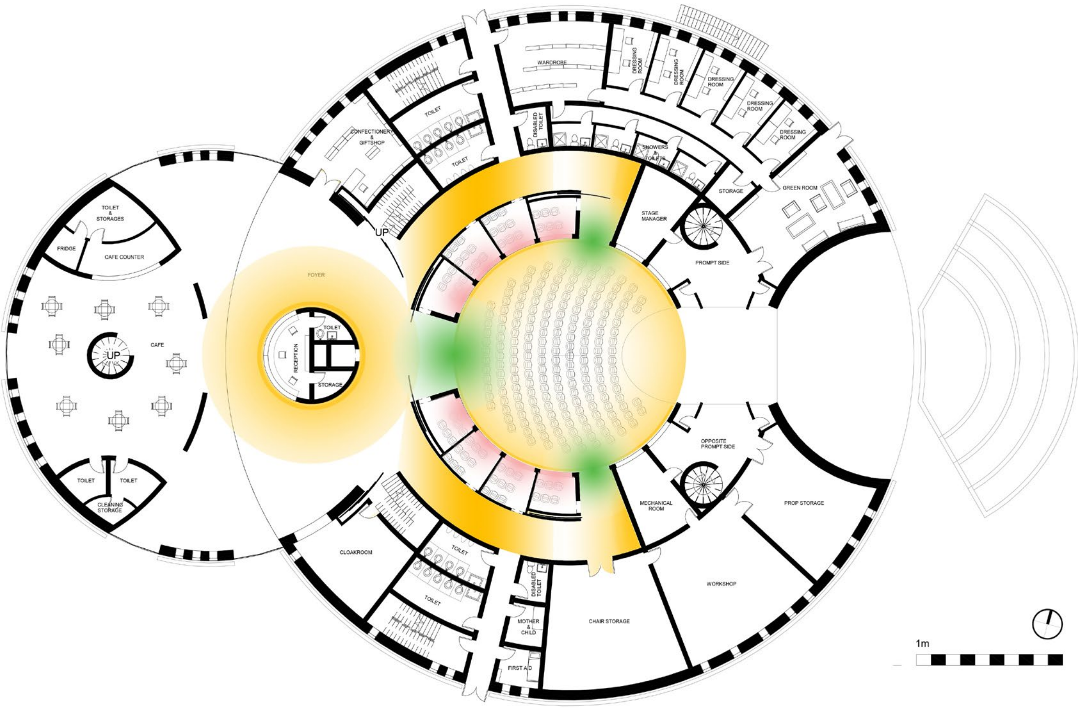

Figure VII.36 - Diagram showing the placement of the mood lighting.

MOOD LIGHTING

In the first part of this thesis, artificial lighting and change of space perception was the main area of focus. The knowledge gained was applied also in this project. Combined with right materials, creates specific atmosphere.

The first point of interest is the reception desk. Lit up circular structure draws the eye and evokes curiosity (see Figure VII.23 on page 118). This encourages people to come in and see what is inside. The reception desk becomes a beacon for visitors arriving in the building for the first time.

After approaching the reception desk, visitor is able to see into the corridors, directing to the auditorium. The circular shape of the building, suggests movement along the curved wall, deeper into the mystery waiting at the end. The light invites to continue along the path, to unravel whatever is at the end.

Light becomes dimmer and darker, enhancing the mystique, but at the same time additional light placed at the end of the tunnel, gives the feeling of security.

Linear wall washing luminaires guarantee enough light, create significant contrast between the floor and the walls, and accentuates the tactility of the rough finish of the concrete walls.

To design lighting in corridors Dialux was used. Due to imperfection of the modelling tools in the program, the corridor representation was simplified. Also the material quality is poor and should not be taken into consideration, as final design. Next pages present the results of the investigation. The rendering show desired effect (see Figure VII.37 & VII.38 on page 130).

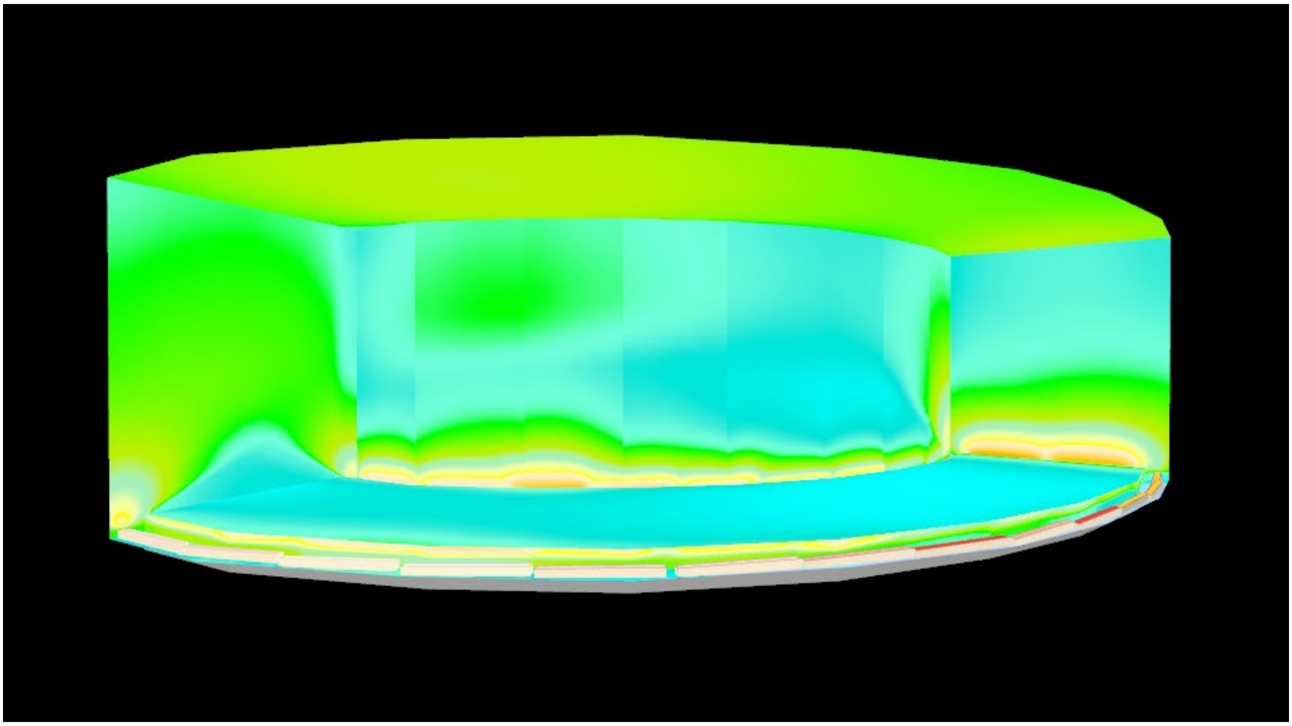

Figure VII.37 - Levels of perpendicular illuminance on the walls.

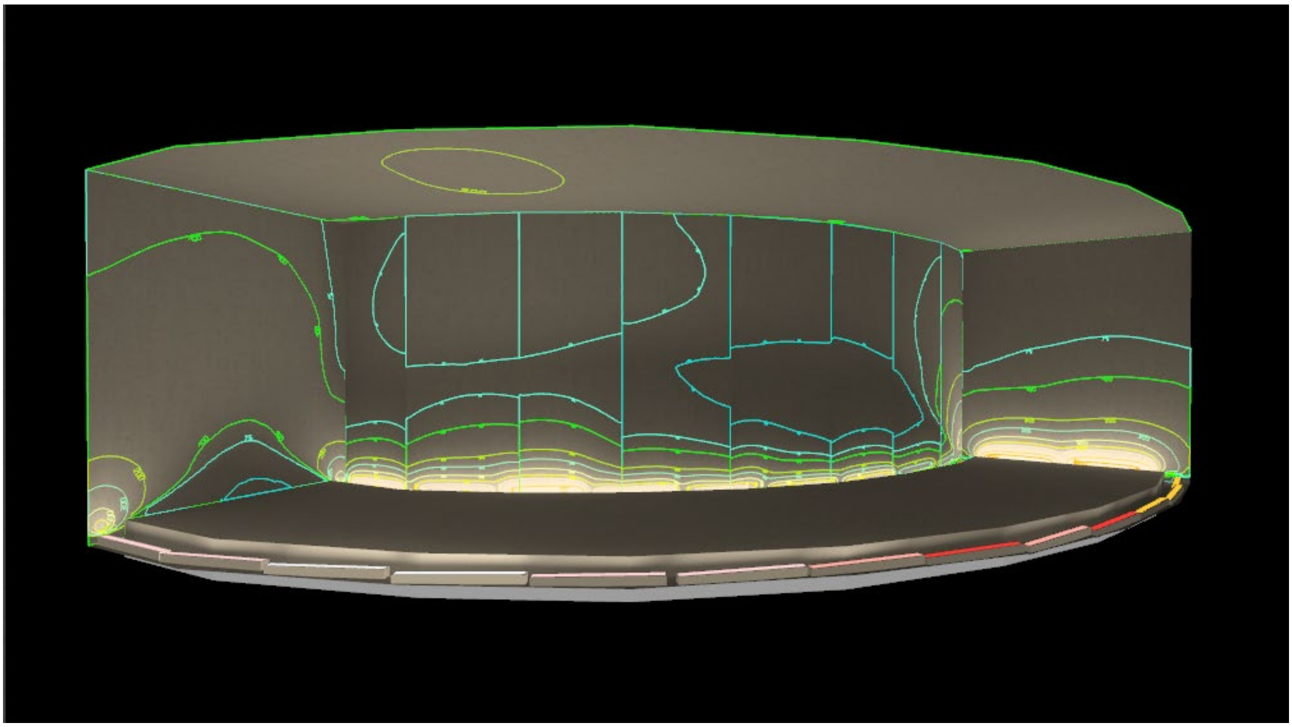

Figure VII.38 - Levels of perpendicular illuminance on the walls.

Figure VII.39 - The big wall with openings to the street.

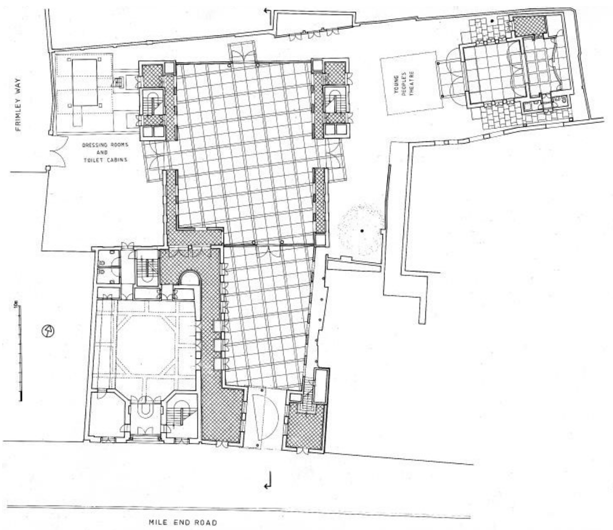

Figure VII.40 - Plan of the Half Moon Theatre.

CASE STUDIES

<u>HALF MOON THEATRE, 1985</u>

Located in London and designed by Florian Beigel was a very interesting concept. As we can read: "The architectural concept for the design of the theatre is an archetypal scenic street. The design is based on the most direct forms of theatre of the past, such as the Italian Commedia del Arte, and the Elizabethan theatres with galleried courtyards, such as Shakespeare's Globe Theatre. It gives rise to theatrical activity by encouraging both actors and audience to see and be seen." [ARU 2015] The space of the theatre invites unconventional thinking. Due to its flexibility it can facilitate many different types of performance. The big wall with openings to the street, reminds us about the world outside, and makes it part of the performance. This inspired the connection between the inside of the theatre, and the surroundings.

CHAPEL OF REST

One of the building selected as a case study is the crematorium chapel in Aarhus, designed by Henning Larsen Architects in 1967 (see Figure V3 on page 75). The combination of heavy material and warm light was the inspiration for the interiors of proposed design. It shows that concrete doesn't have to be cold and uninviting, but can be successfully used to create atmosphere of safety and confinement.

THE HIGH LANE

The High Lane park in New York (see Figure III.6 on page 49), was an inspiration, while designing the park at the end of the pier. In the parks project long linear beams of light suggest where to go. The lights are non-uniform, but at the same time amplify the direction of the path. This inspired the lighting of the outside areas in the proposal for the surrounding areas of the designed theatre. Light strips on the ground suggest the direction but the uneven distribution of fixtures doesn't force visitors to stay on the predefined path, allowing them to drift and discover areas beyond.

Chapter VII

Design process.

INTRODUCTION

Designing a building is a complex process and everyone, calling themselves designer, knows that it can be very chaotic. Ideas appear, are processed, changed, discussed, analysed, synthesised and so on. But every design process starts somewhere, and there are certain steps that can be put in chronological order. This chapter shows the steps, which led to final proposal for this project.

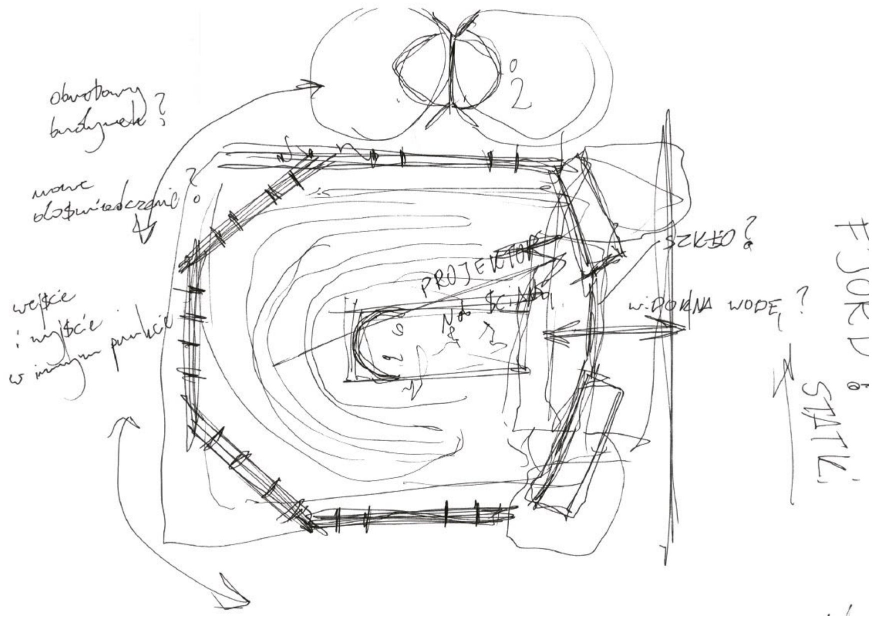

Figure VIII.1 - One of the first sketches showing the idea for rotation, along with scene in form of an isle.

As I mentioned before, the final form and used materials derive from the surrounding buildings, especially from the two big silos standing nearby. The initial sketches were loosely connected with the context, but then the new idea emerged.

The first sketch presented here, shows the first thought to connect the building with context, by showing the surrounding world in as brought spectrum, as possible. The idea to show different perspective, while in the building, led to allowing theatre to rotate.

Other ideas also contributed to the final proposal. Crating unique quality for the building, a unique experience for the users and visitors are the important parts of conceptual design. The rotation opened the possibility to give people new sensations, as they would enter the building on one side, enjoy the performance, just to discover, they travelled in space, and now they exit building at different point.

Finally the big, rotating structure refers to shipyard cranes, and marine context of the building placement on the pier, enclosing the harbour.

At the same time the surroundings were considered and planed. Initial idea to place building at the end of the pier was discarded. The new plan positioned building at the beginning of the pier, leaving the place for designing some space that everyone could enjoy, even if they didn't plan the visit in the theatre. This is how the concept for park was developed.

Site analysis made before the designing part, shown that neighbourhood lacks green spaces, where people can come to rest and relax. There is a grass area on the opposite side of the harbour, but it lacks the infrastructure and people have to go all the way around the harbour to get there, which very often means, they end their walk prematurely and turn back. Giving to public a place to sit after walking along the waterfront, would invite more visitors to the

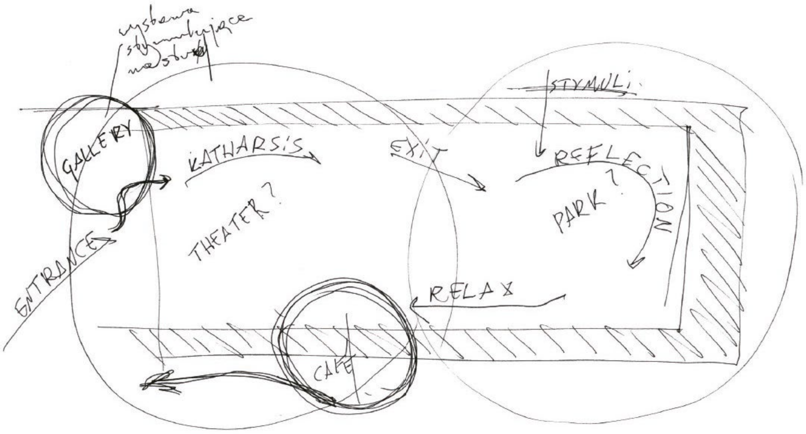

Figure VIII.2 - Initial sketche of master plan design.

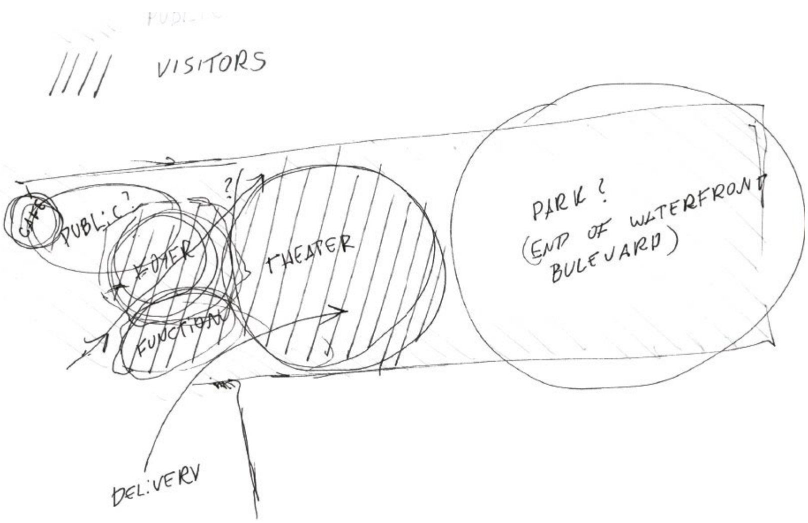

Figure VIII.3 - Initial sketche of master plan design.

Figure VIII.4 - Sketch showing the placement of the lighting underneath the bench.

site, and keep space alive. This would also give an opportunity to people arriving at the theatre early, to spend some time in pleasant surrounding, while waiting for the performance. The park could also provide a place to reflect, after the performance. Finally it would correspond with the other green areas along the waterfront, creating the continuity.

From the very early stage the idea of employing light somehow was present. The sketch above presents one of the possible uses- the soft light from underneath the bench informing people, were they can sit, and making the heavy form nimble and seemingly floating in the air. Finally light was used to mark the pathway, and to up light the concrete steps to sit on (see Figures VII.21 and VII.22 on page 117). The idea was inspired by The High Line Park in New York City, used as a case study in the first part of this thesis (see pages 48-49).

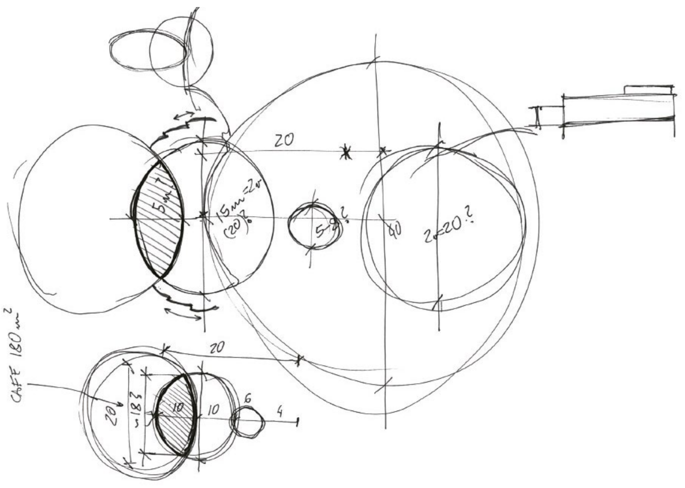

Figure VIII.5 - Initial sketch of building plan.

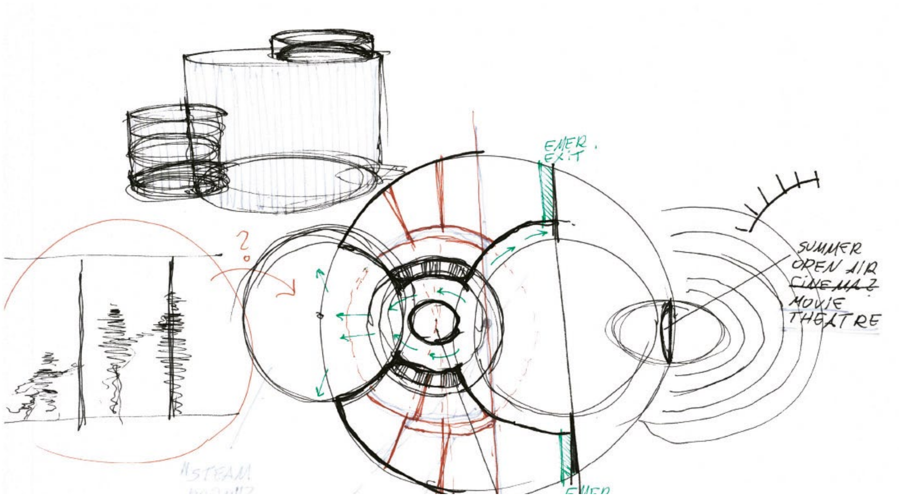

Figure VIII.6 - Initial sketch of building plan with fire safety conssiderations.

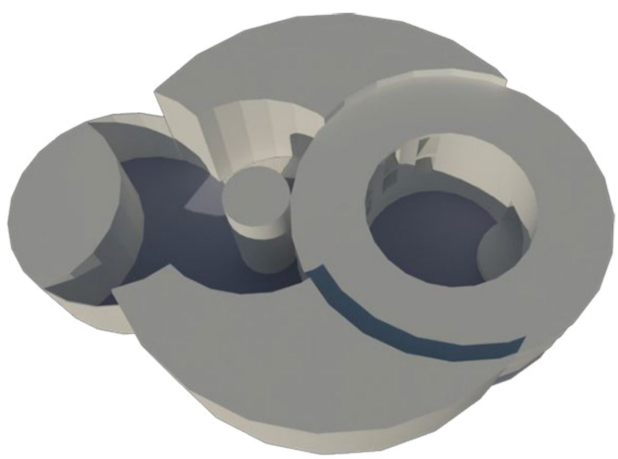

Figure VIII.7 - Initial render of building's first form.

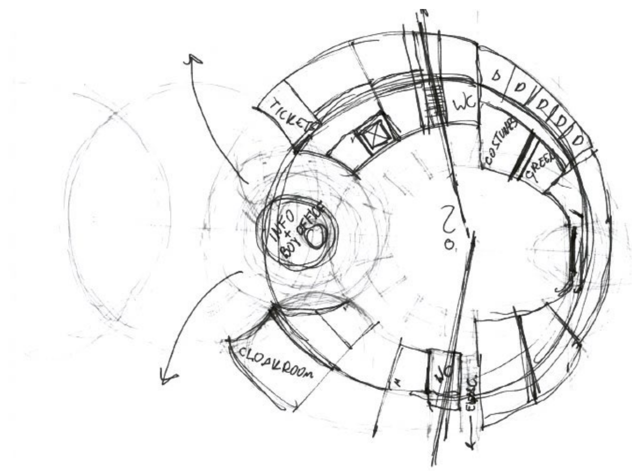

Figure VIII.8 - Initial sketch of building plan with function placement.

Building circular shape was inspired by the form of the silos, but also by its function. Auditorium was designed in very traditional form of a well, with three levels of balconies. It combines the classical design of seat arrangement with the more modern ideas. The created form is very private and gives a sense of mystique and privacy. The people, in balconies, become part of the scenography. The scene background - window to the world, becomes very strong expression, making the visitors the witnesses of the life around. It makes them more aware of the surroundings.

Due the very awkward spaces created in initial design, the concept was altered, and the auditorium was moved, to become the centre of the whole building, giving it even stronger expression. The idea of rotating auditorium was born, but it had many flaws, so it was changed back. The auditorium had to be raised above the building, to see surroundings past the building walls. This created many functional and technical problems, and the idea of placing the performance in the real world beyond didn't work above the ground. The auditorium became detached from the context, therefore the concept of rotating the whole building was chosen, creating more elegant gesture and simpler form.

Rotation of the whole building creates also opportunity to transform the whole venue. After rotating the building 180O, cafe at the front, becomes a background for the performance. This gives the new possibilities to directors to employ the real life as a scenography, or to create plays with incredible depth. The same principle can be used with floating scenography in the harbour or, on the opposite side, fjord with passing ships.

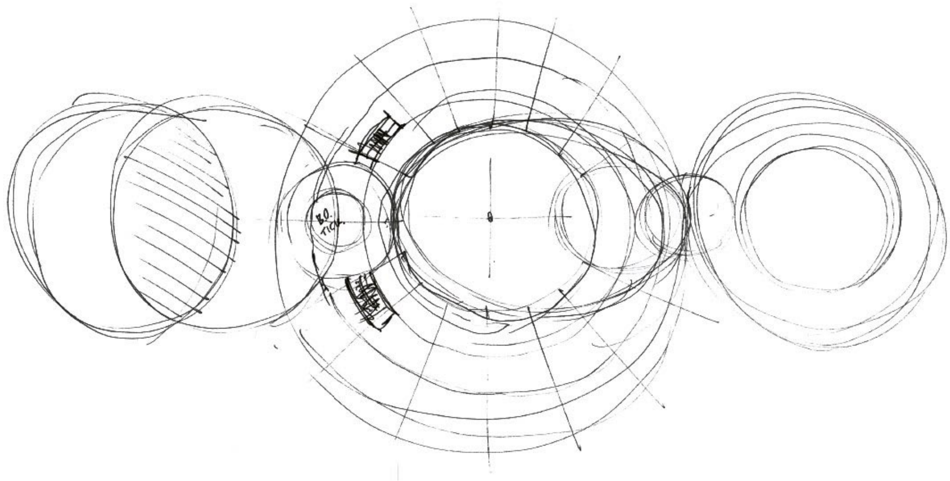

Figure VIII.9 - Initial sketch of the final underlay of the building.

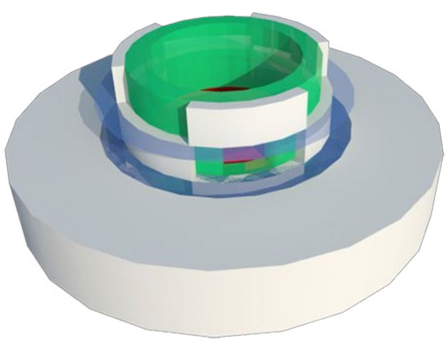

Figure VIII.10 - Render of solution for rotating auditorium.

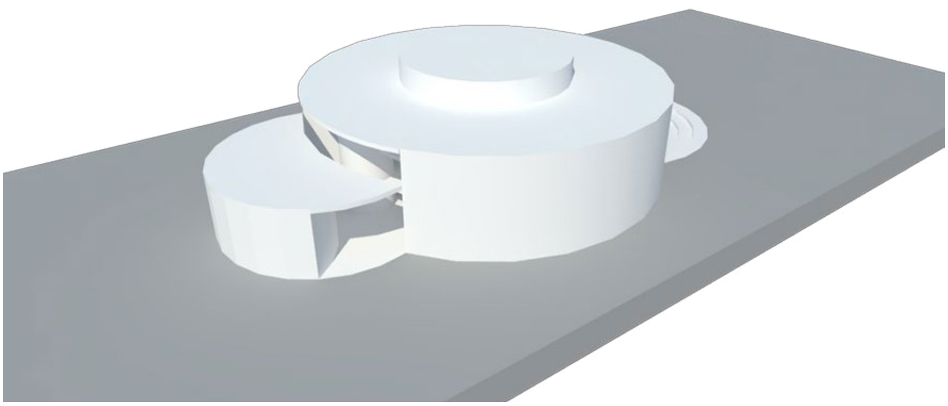

Figure VIII.11 - One of the first renders of the final form of the building.

From very early stages of design, there were some ideas that were implemented in the final proposal for the building. After selecting concrete as main construction material, the idea about wall washing the rough structure with light appeared. This inspired the vision of corridor with dark, heavy walls with visible texture rendered in light.

Also the central form of the reception desk in foyer derives from one of the early sketches. Presented here form ended up in project almost without any alterations. In addition the light, illuminating the structure, makes it stand out and creates the beacon and informs the newcomers, where to go first.

The windows and their expression on the facade were also one of the elements designed quite early. Their tall narrow shape, accentuates the vertical direction, makes the building seem lighter and taller. Some early stage light studies were done to determine the final size.

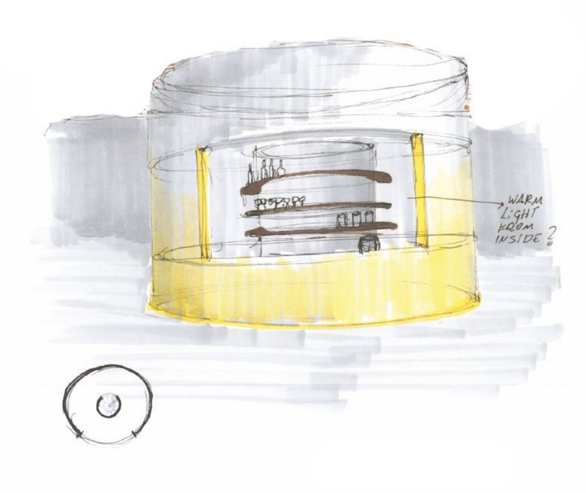

Figure VIII.12 - Initial sketch of the reception desk in foyer.

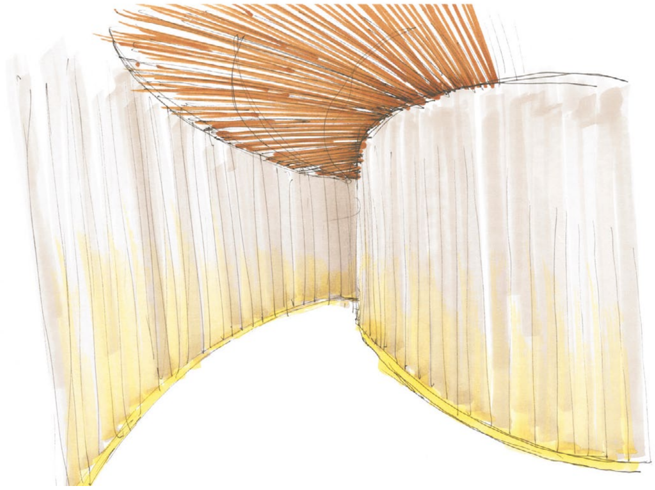

Figure VIII.13 - Initial sketch of the corridor.

Figure VIII.14 - Initial sketch showing the high narrow windows.

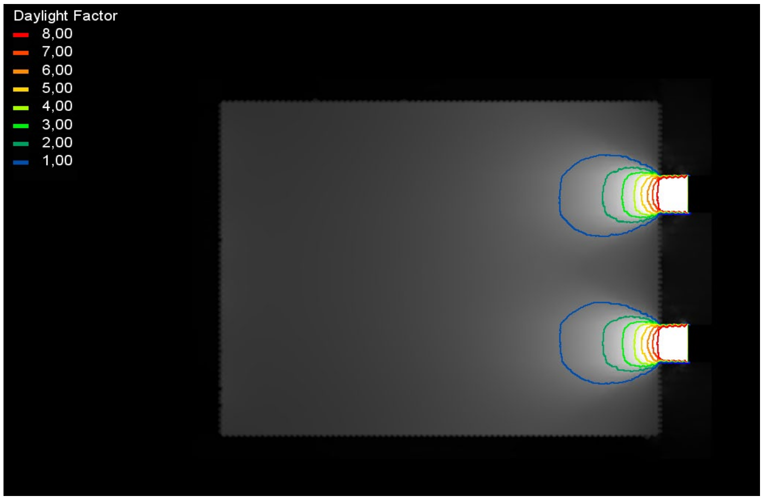

Figure VIII.15 - Two windows 2000mm x 500mm at 500mm height- average daylight factor of 1,1.

Presented here daylight studies helped determine the final design of window placement and dimensioning. They show daylight factor investigations done on one of darker spaces, with the need for high levels of light (one of the offices). Few solutions were tested with different window placement height, width of window, distances between windows and the height of the window itself. In addition scenarios with two and three windows were tried out.

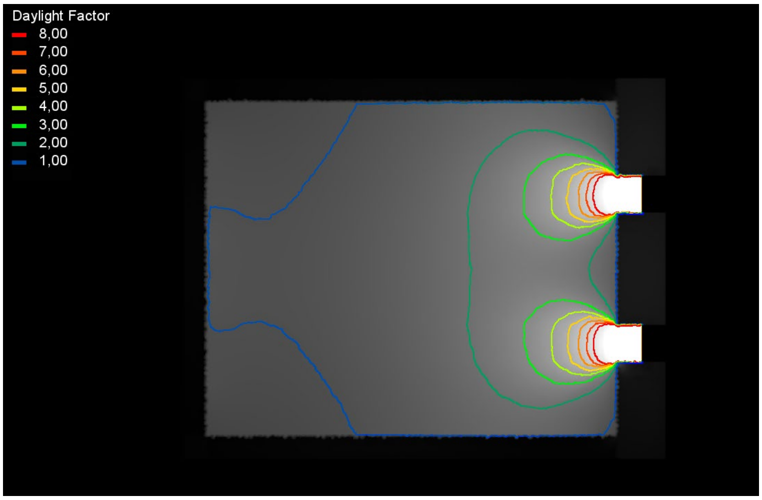

Figure VIII.16 - Two windows 2500mm x 500mm at 200mm height- average daylight factor of 1,6.

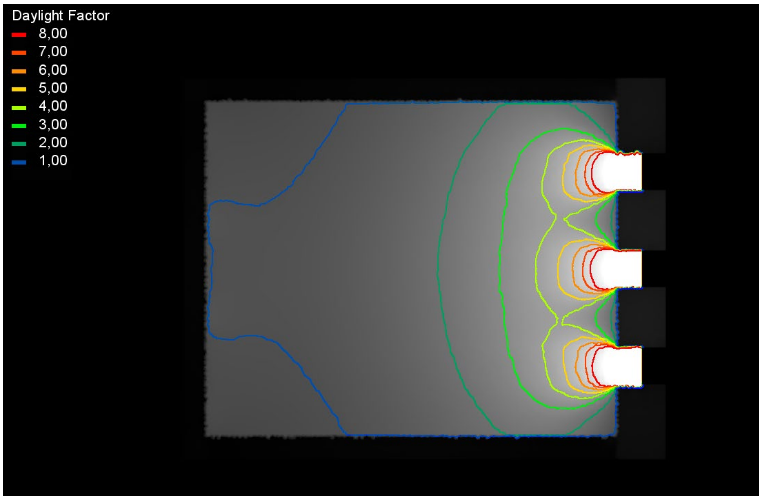

Figure VIII.17 - Three windows 2000mm x 500mm at 500mm height- average daylight factor of 1,9.

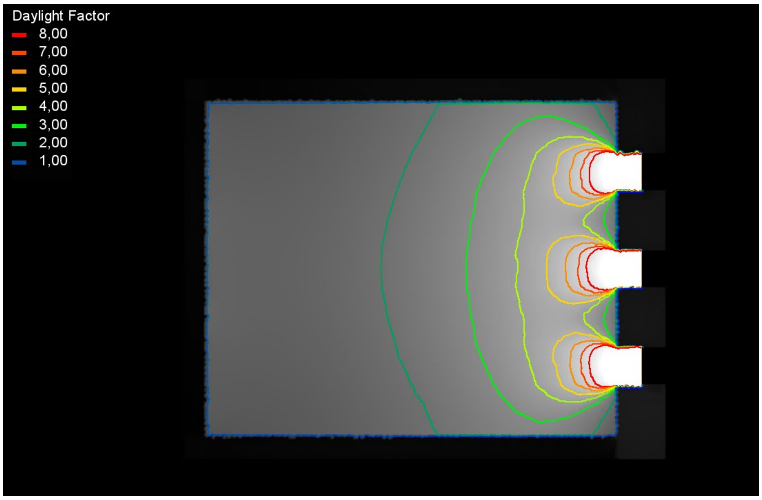

Figure VIII.18 - Three windows 2500mm x 500mm at 200mm height- average daylight factor of 2,4.

Epilogue

CONCLUSION

Designing a theatre building or any type of performance venue is very complex and hard work. There are many things to be considered, and on many levels too.

The complexity of the designing process today is even bigger due to the development of new systems and need for implementing the new solutions. The amount of knowledge required to be able to successfully execute building design is constantly growing and changing. The buildings get old much faster than they used to and it is crucial to maintain the high quality of the design. It is important to try to create something universal and long-lasting, not only walls and slabs, replaceable with another structure, but unique quality.

The form of the designed building derives from the context in which the building is placed. The nearby silos shape directly inspired the circular plan, which also reflects the classic auditorium shape inside of the building. The building rotates on the slab, opening to the public, inviting visitors to interact, to become part of the spectacle. The motion also creates unique quality, which allows change of the background for the performances. The opening in the back wall of the theatre provides view to the surroundings, connecting the buildings inside to the life by which it is surrounded.

The big, light, open space of foyer is very monumental, but as one proceed deeper and deeper into the building, it becomes private and enclosed. Dark corridor directs visitors towards mystery in the middle, with illumination decreasing along the way, just to open up to the space of auditorium. Here the circular form and levels of balconies create the atmosphere of confinement, but at the same time, window behind scene links one to the life outside, giving the opportunity to look from different perspective at the same things. Visitor becomes the witness of life, becomes connected with whatever is happening, beyond that opening.

Performance venues are built to last decades and they should be designed in the manner allowing them to change or transform, depending on the time and need. The invention of television forced theatre to transform and adapt to the new reality. We cannot predict what the future will bring; therefore it is important to crate architectural quality, which can withstand the passage of time.

REFLECTION

Doing project of this scale alone was a great challenge. I gained a lot of knowledge, learned a great deal about theatres. I wish I had more time, to polish this project, and I wish I made some decisions earlier. Some say, that architects work is never done, and there is always something that can be done better. But everything comes to an end and the designing has to stop at some point.

During writing this project I learned, that good time management and work planning is crucial, for the building designing process. I cannot emphasize enough, how important it is to stay motivated and continue working, no matter what happens. It is crucial to be critical towards the work done, but also to stay focused on the idea.

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ILLUSTRATION LIST

Figure V.2	Available at: http://kobenhavenkronicles.files.wordpress.com/2012/02/img_1374.jpg (ACCESSED: 07-12-2014)
Figure V.3	Available at: http://www.dac.dk/Images/img/1920x1200M/(31273)/31273/056-Aarhus-Kapel-Inter-02.jpg (ACCESSED: 07-12-2014)
Figure V.4	Available at: http://farm4.static.flickr.com/3564/3473698716_336fa5005c.jpg (ACCESSED: 08-12-2014)
Figure V.5	Available at: http://news.bbcimg.co.uk/media/images/52123000/jpg/_52123483_bigmelt.jpg (ACCESSED: 08-12-2014)
Figure V.6	Available at: http://www.dac.dk/Images/img/1920x1200M/(47756)/47756/den-blaaplanet-adam-03.jpg (ACCESSED: 13-12-2014)
Figure V.7	Available at: http://www.3xn.com/img/4707/1920/1920/Fit/ID_4707 (ACCESSED: 13-12-2014)
Figure VI.1- VI.4	Technicians, A. B. T. (2010) Theatre buildings: a design guide. Edited by Judith Strong. 1st edn. New York, NY: Routledge; p: 258
Figure VI.5- VI.13	own illustrations
Figure VI.14	Trafikstøj (2014) Available at: http://miljoegis.mim.dk/spatialmap?&profile=noise (ACCESSED: 20-02-2015)
Figure VI.15- VI.16	own illustrations
Figure VI.17	Wind diagram Available at: http://www.2012.denbedstevej.dk/ (ACCESSED: 22-02-2015)
Figure VI.18	Sunpath diagram Available at: http://www.gaisma.com/en/info/help.html (ACCESSED: 22-02-2015)
Figure VI.19- VI.20	Naust paa Aure (2010) Available at: http://www.tyinarchitects.com/downloads/ (ACCESSED: 25-02-2015)
Figure VI.21	St. Henry’s Ecumenical Art Chapel (2005) Available at: http://www.daniellaondesign.com/uploads/7/3/9/7/7397659/4425721_orig.jpg (ACCESSED: 25-02-2015)
Figure VI.22	own illustrations
Figure VII.2- VII.39	own illustrations
Figure VII.39- VII.40	Half Moon Theatre Available at: http://aru.londonmet.ac.uk/works/halfmoon (ACCESSED: 20-05-2015)
Figure VIII.1- VIII.18	own illustrations
Figure A.1- A.27	own illustrations

Appendix

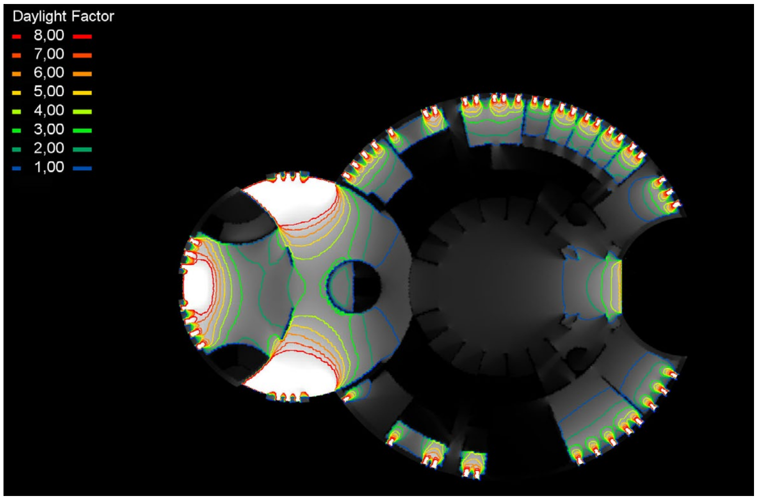


Figure A.1 - Daylight factor for the groun floor.

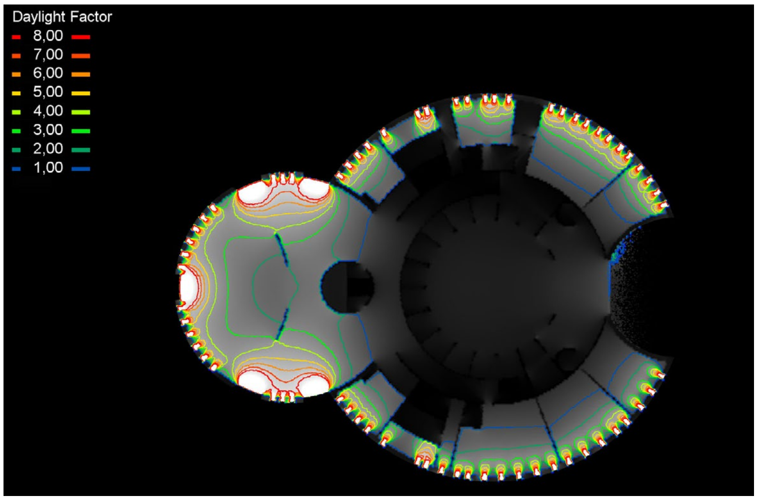


Figure A.2 - Daylight factor for the second floor.

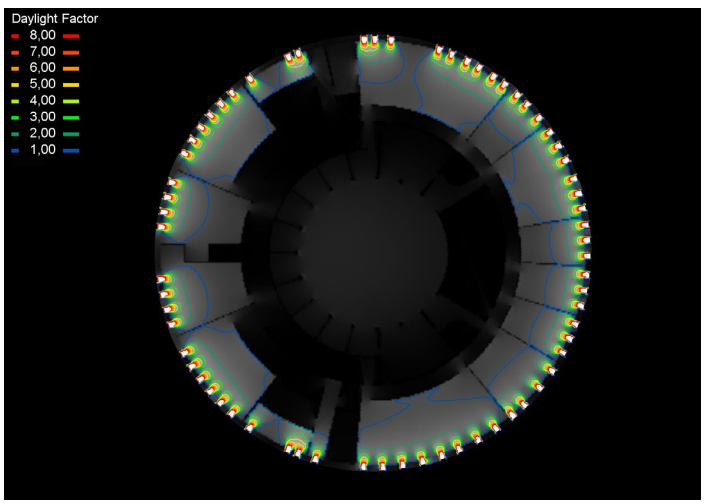


Figure A.3 - Daylight factor for the third floor.

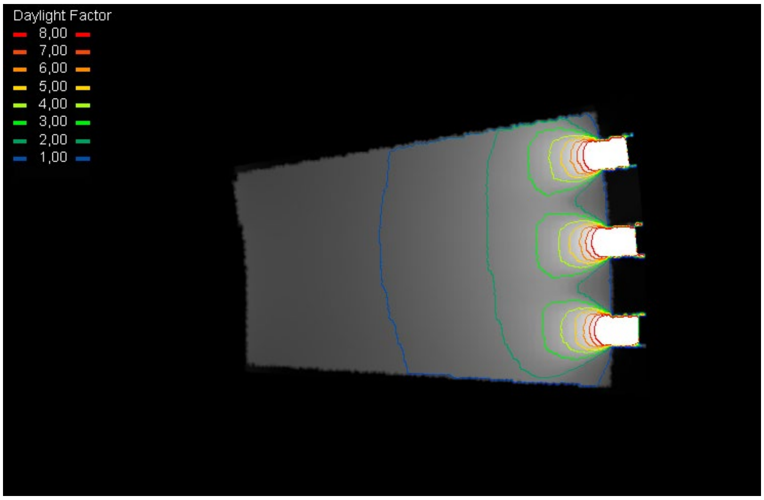


Figure A.4 - Daylight factor for the office (average over 2%).

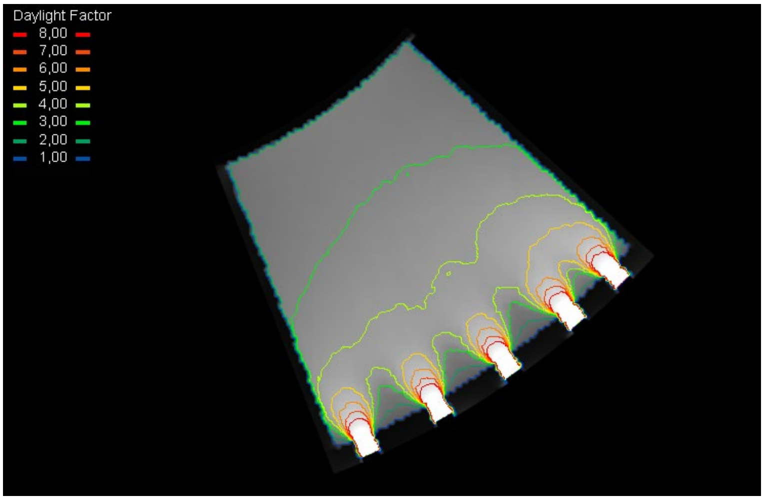


Figure A.5 - Daylight factor for the workshop (average of 4%).

DAYLIGHT

During the design, daylight factor was taken into account. The office space should reach the factor of 2% to be considered well lit. The offices and meeting spaces fulfilled this requirement, with average above 2%.

In addition some spaces provide much higher levels of daylight. The presented here workshop space reached well above 4%.

The highest factors are observed in the foyer. Its big windows and door openings guarantee long hours of direct daylight.

Daylight factor was also influenced by the materials used. Polished wooden frames in windows reflect the rays of the sun into the spaces. The light polished concrete floors and light ceilings also influence the way sun penetrates the rooms, helping reaching the desired levels of daylight.

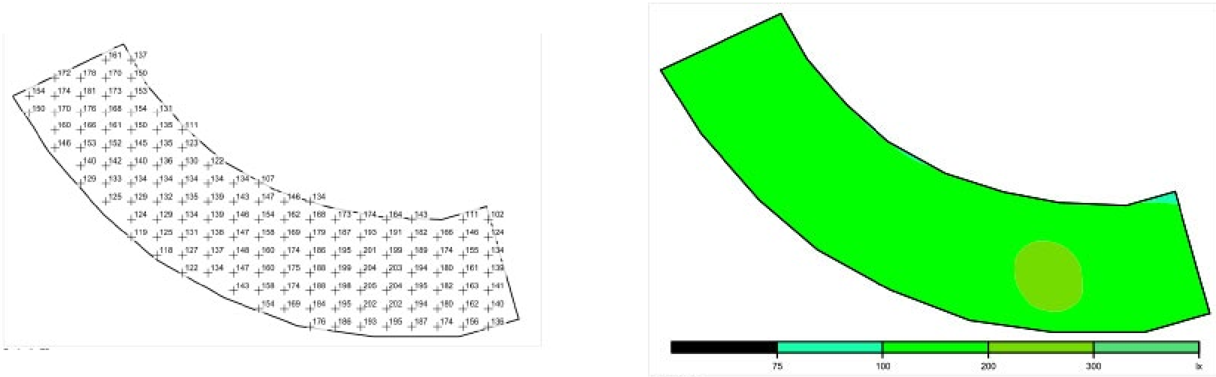


Figure A.6 - Levels of perpendicular illuminance (in lux) on corridor ceiling.

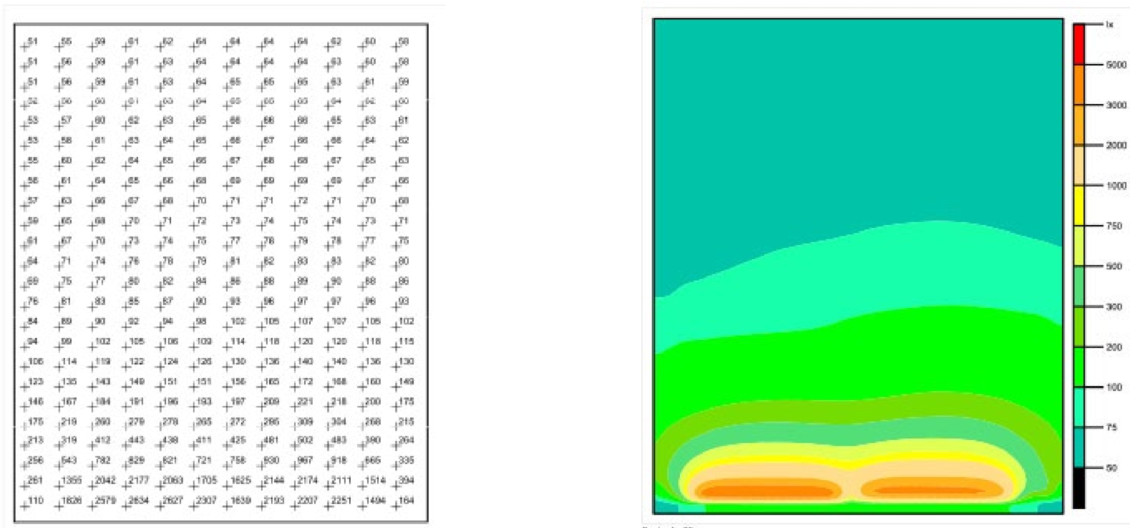


Figure A.7 - Levels of perpendicular illuminance (in lux) on end wall of the corridor.

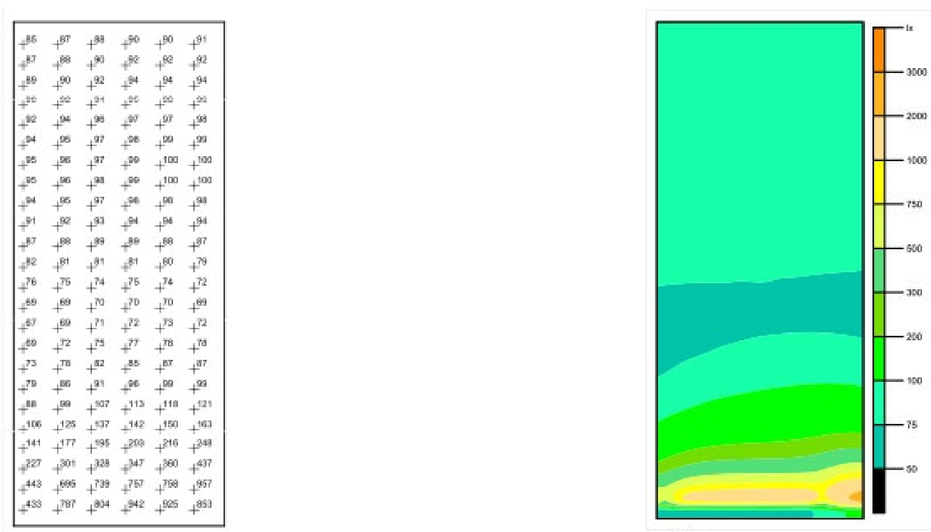


Figure A.8 - Levels of perpendicular illuminance (in lux) part of the corridor wall.

LIGHTING DESIGN

Diagrams show the more detailed results of light design calculations for corridor. To design lighting in corridors Dialux was used. Due to imperfection of the modelling tools in the program, the corridor representation was simplified.

Diagrams present levels of perpendicular illuminance (in lux) for ceiling, end wall of the corridor, and for part of the corridor wall.

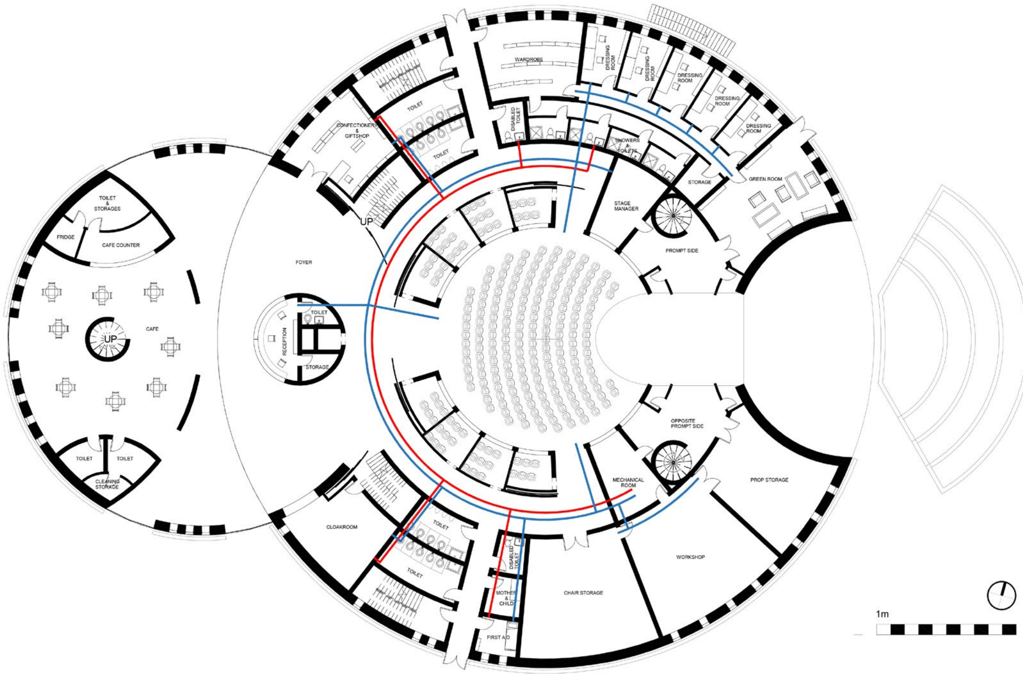


Figure A.9 - Mechanical ventilation system for the groun floor.

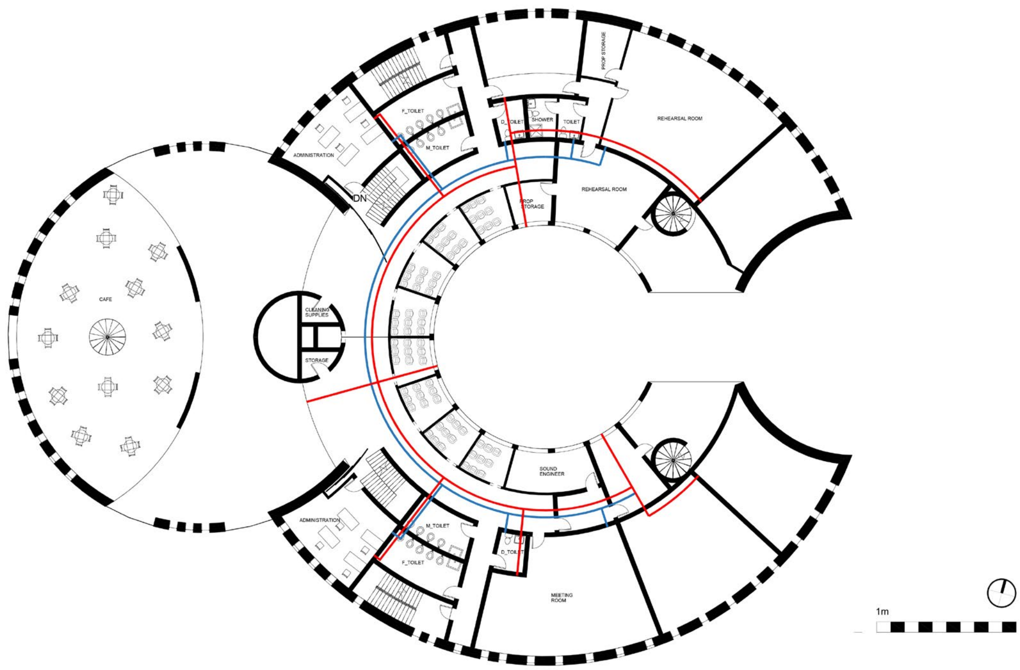


Figure A.10 - Mechanical ventilation system for the second floor.

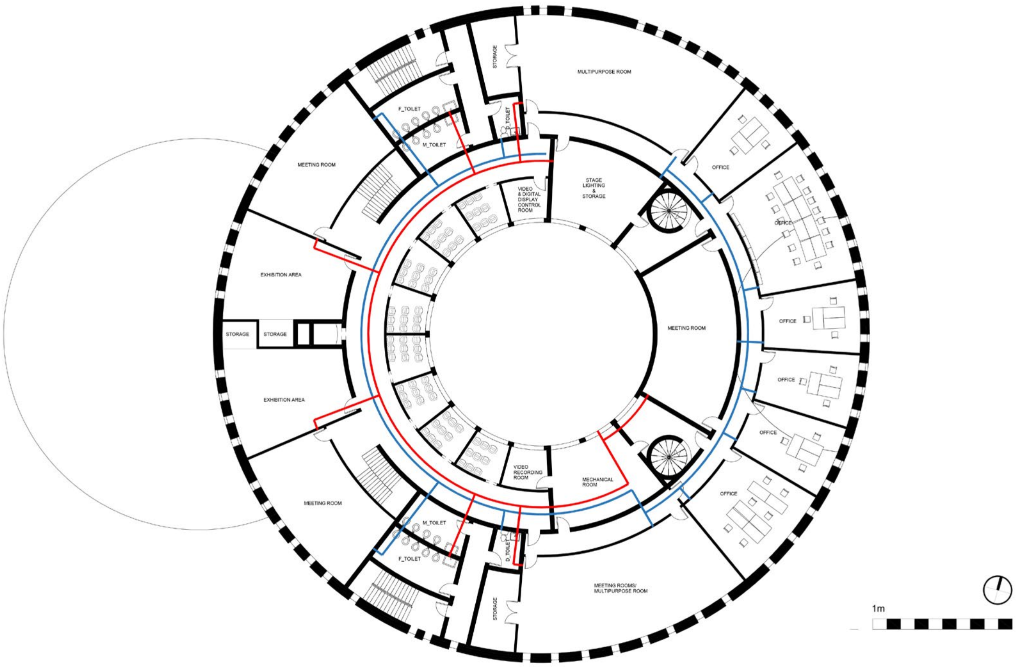


Figure A.11 - Mechanical ventilation system for the third floor.

MECHANICAL VENTILATION

Theatres are buildings with high occupancy, therefore mechanical ventilation system was considered. Presented here diagrams show the proposed solution for the mechanical air supply system.

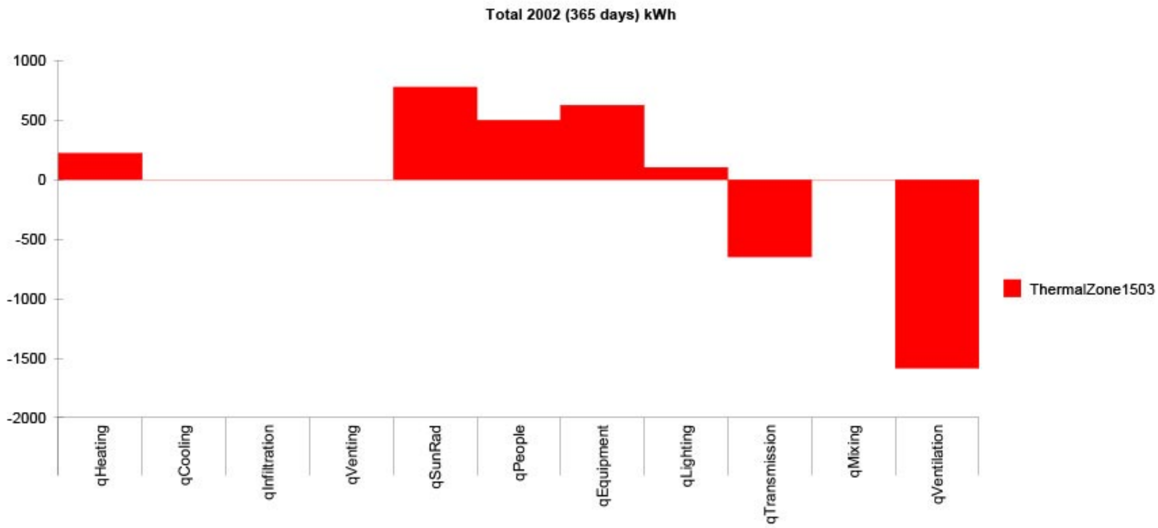


Figure A.12 - Energy balance.

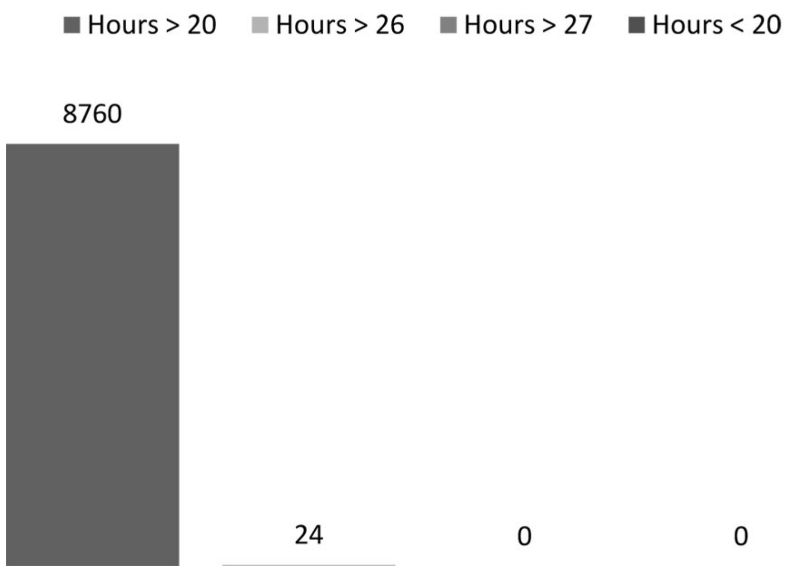


Figure A.13 - Hours overheating.

BSim

Sustainability and concern for limiting energy losses is present in architecture for some time now. Our knowledge on the topics concerning sustainable design and development is evolving constantly demanding designers to adjust.

There are numerous ways and strategies to limit the energy use. One of them is indoor climate analysis from the very beginning of the design process. The tools for that are becoming better and more users friendly. Presented here analysis was performed using BSim software, and the aim was to fulfil the requirements of EU 2020 regulations.

This mean the average maximum temperature in normal condition should be between 20°C and 24°C, and in summer between 23°C and

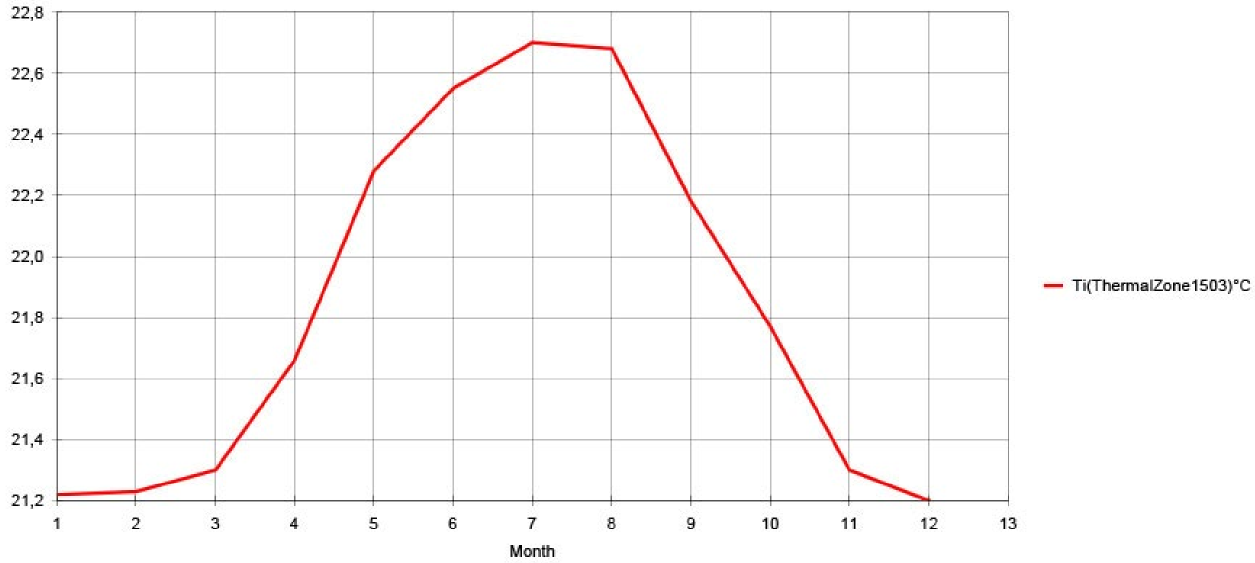


Figure A.14 - Diagram showing top average temperatures during the year.

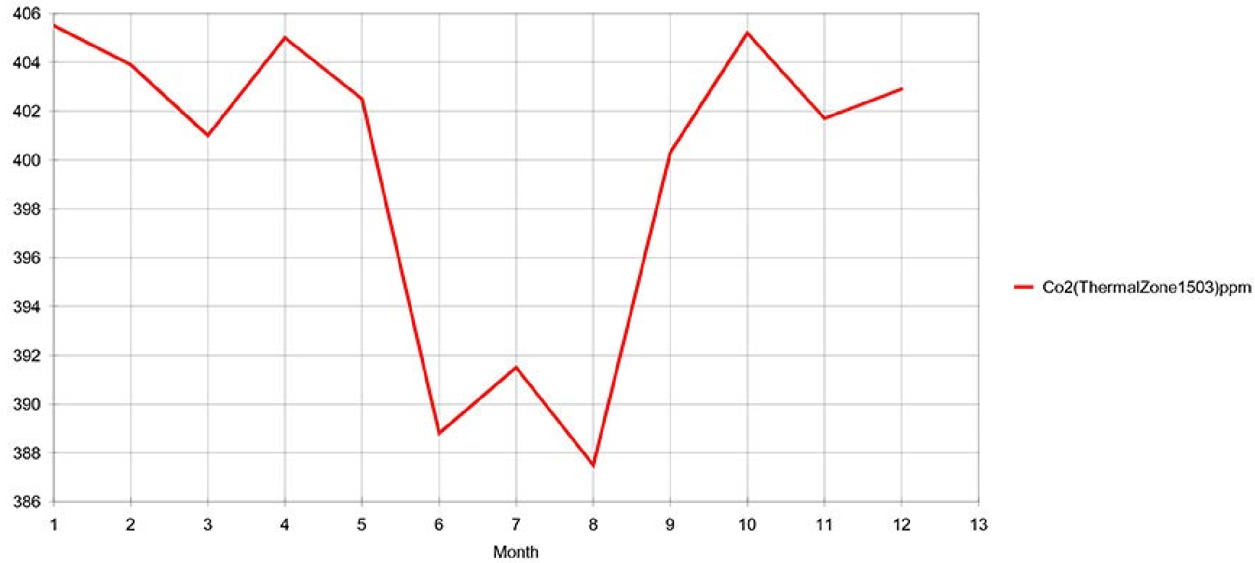


Figure A.15 - Diagram showing levels of CO_2.

26ºC. Additionally the number of hours with temperature above 26ºC should be lower than 25h/year.

For analysis, worst case scenario was selected. Considered space is an office occupied by 2 people, positioned towards south. This was the room with biggest overheating problems.

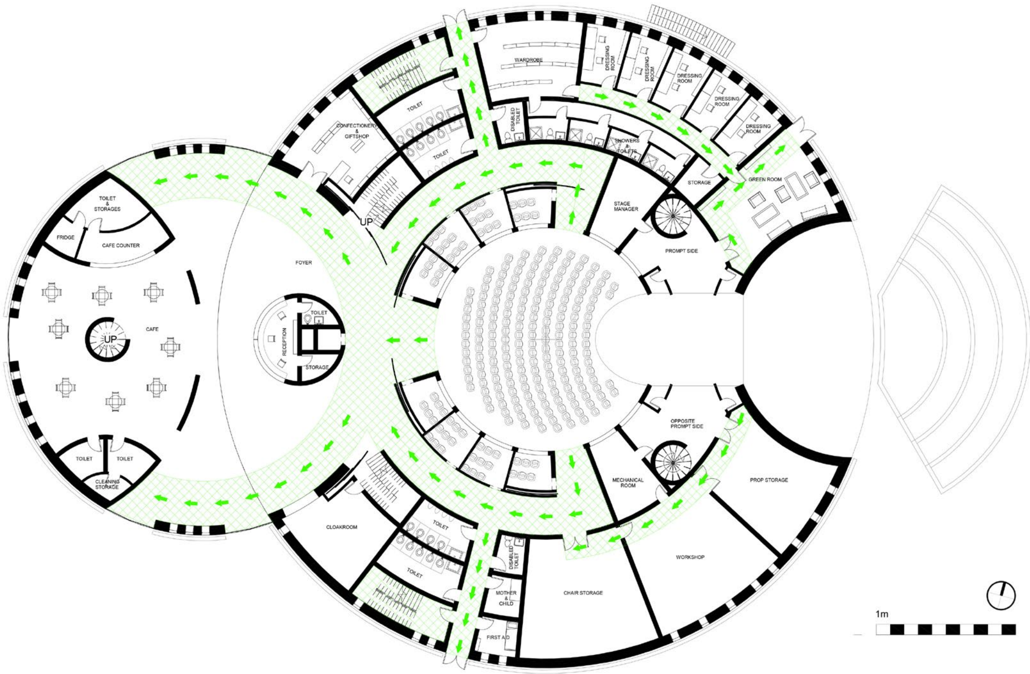


Figure A.16 - Fire safety and evacuation routs.

ESTIMATED REVERBERATION				
Number of Points: 5080 (6 Reflections)				
Mean Free Path Length: 9.063 m				
Effective Surface Area: 2041.922 m2				
Effective Volume: 4626.348 m3				
Most Suitable: Norris-Eyring (Highly absorbant)				
	TOTAL	**SABINE**	**NOR-ER**	**MIL-SE**
FREQ.	**ABSPT.**	**RT(60)**	**RT(60)**	**RT(60)**
63Hz:	4541.212	0.16	0.00	7.03
125Hz:	3521.753	0.21	0.00	6.65
250Hz:	2558.085	0.29	0.00	3.10
500Hz:	489.938	1.12	1.33	0.82
1kHz:	840.628	0.89	0.69	0.25
2kHz:	1669.168	0.45	0.21	0.20
4kHz:	2010.069	0.37	0.09	0.30
8kHz:	1640.357	0.45	0.22	0.32
16kHz:	1919.176	0.39	0.13	0.36

Figure A.17 - Diagram of estimated reverberation time RT_{60}.

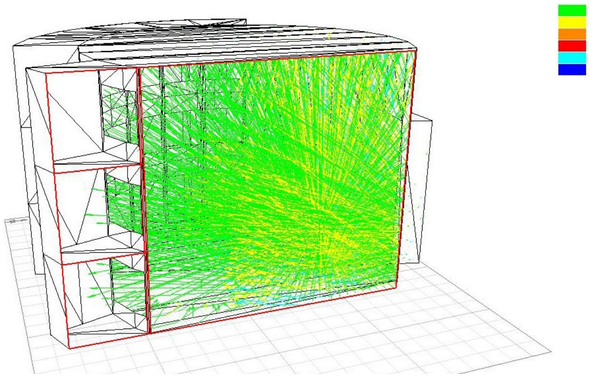


Figure A.18 - Diagram showing reach of direct sound after 40ms..

ACOUSTIC

Acoustic design is an important part of projects of venues such like theatres. Studies were conducted to determine the performance of designed building auditorium.

Design was based on the knowledge acquired during the studies, and based on the section "Acoustic considerations" in book *Theatre Buildings: a design guide* [Strong 2010].

The same book states also the distance from the furthest seat in auditorium, should not exceed distance of 20 meters. Auditorium in this project was designed following that principle.

Analysis performed with Ecotec shows that direct sound reaches the furthest seats in auditorium just under 40ms.

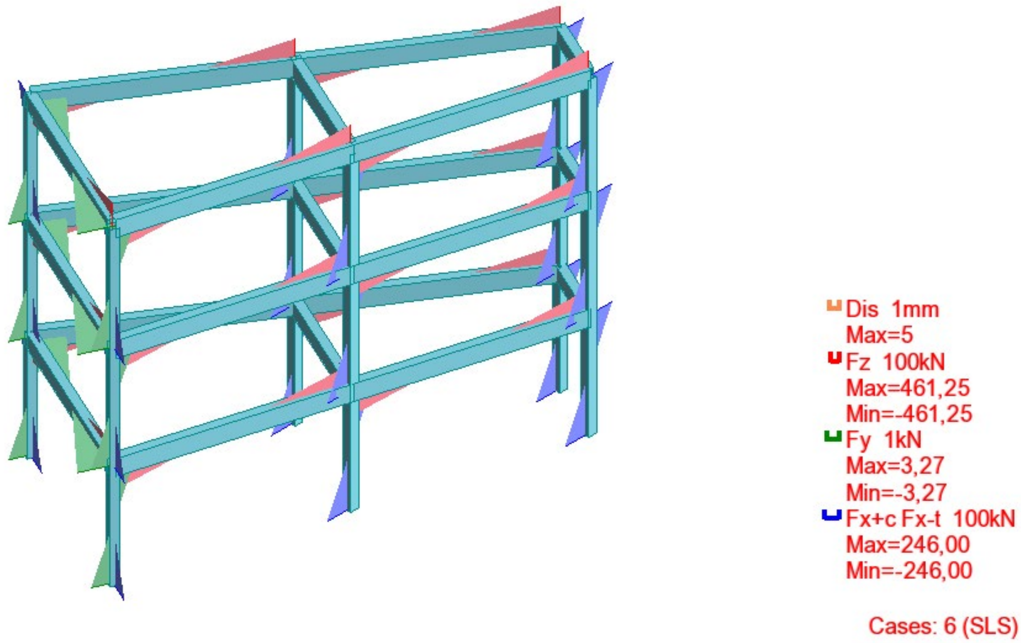


Figure A.19 - Diagram showing axial forces for SLS.

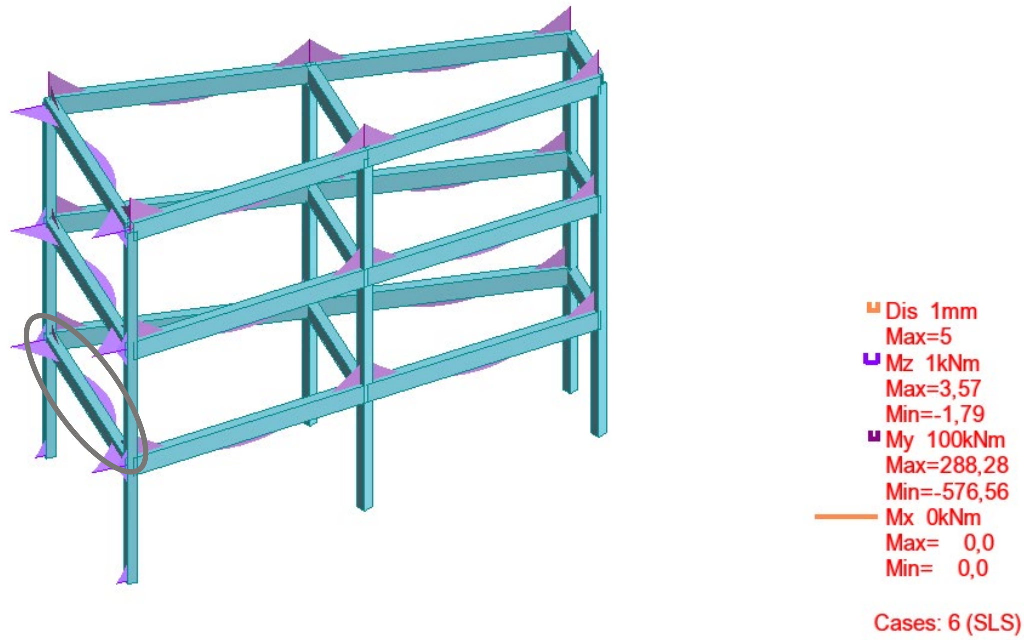


Figure A.20 - Diagram showing moments for SLS.

STRUCTURAL SYSTEM

Diagrams present proposed solution for the structural system. As mentioned before, structure was defined and modelled in Grasshopper first, and due to its limits, was simplified. Grasshopper model helped with determining the size of the concrete members, and count of columns in the system, which translates to the length of one of the beams (marked with grey circle above.

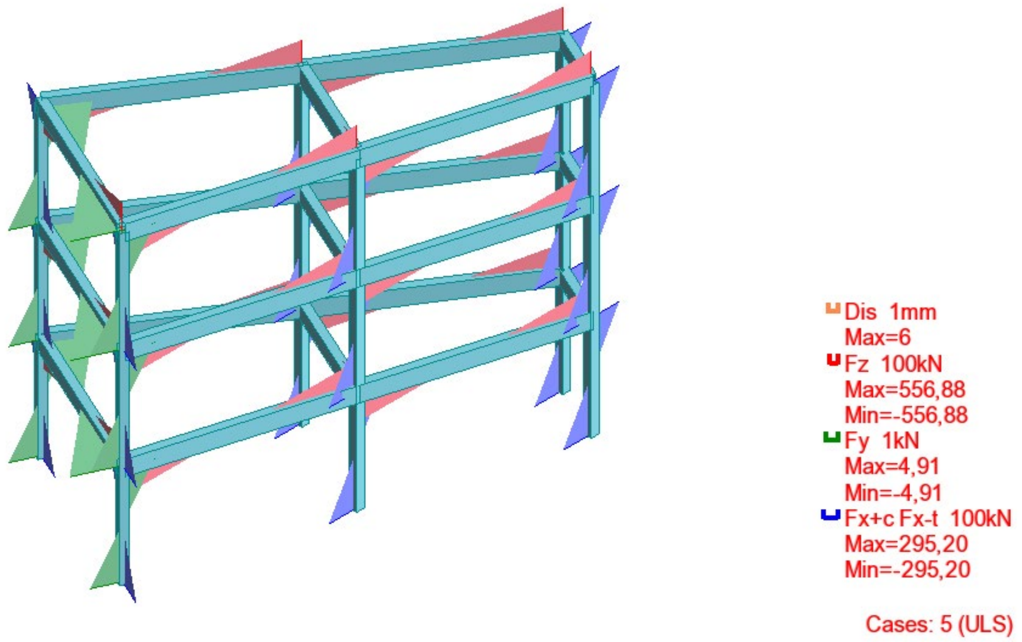


Figure A.21 - Diagram showing axial forces for ULS.

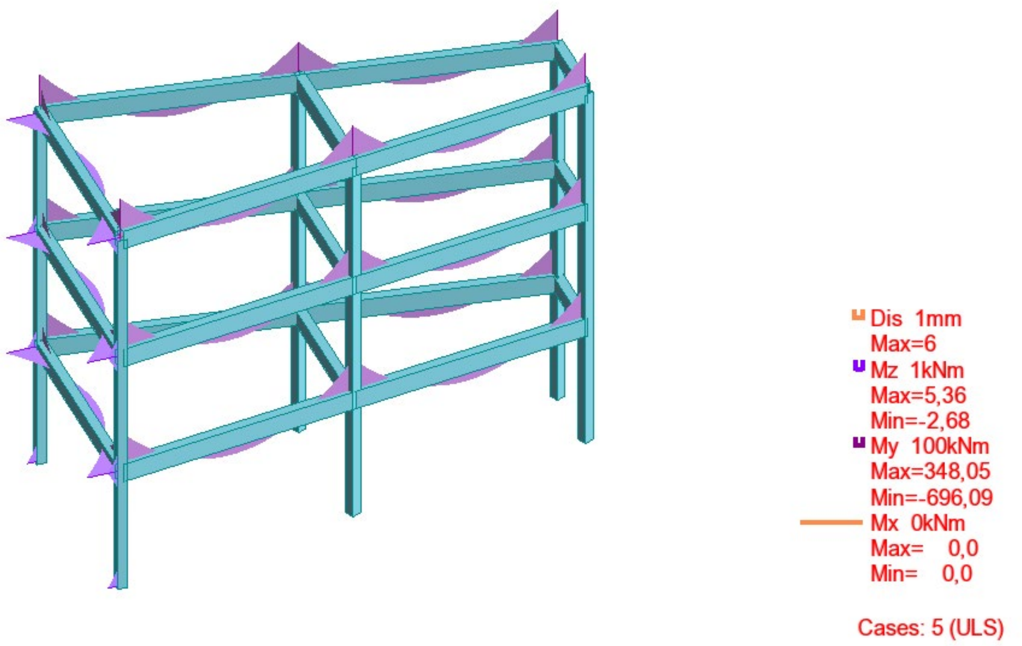


Figure A.22 - Diagram showing moments for ULS.

Due to the simplification of the construction, some alterations were needed. The presented solution consists of beams and columns, where in proposal for the building it is construction with slabs. Therefore additional dead load was added to the model in Robot, representing the self-load of the slabs. The force was calculated and rounded up to 120kN.

For further investigation, some elements of the structure were calculated for reinforcement.

Pos.	Reinforcement		Code	Shape	Steel
1	12Ø14	l=1237	00	1237	B500C
2	46Ø6	l=102	31	23 / 7 / 23	B500C
3	92Ø6	l=38	00	23	B500C

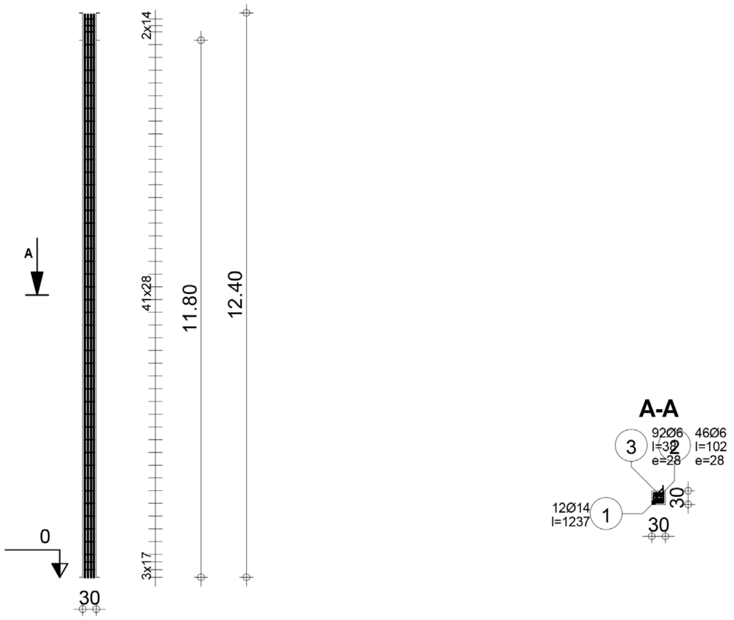


Figure A.23 - Reinforcement needed for the column.

Pos.	Reinforcement		Code	Shape	Steel
1	3Ø12	l=263	00	236	B500C
2	3Ø12	l=236	00	236	B500C
3	24Ø6	l=55	00	5 / 43	B500C
4	24Ø6	l=142	31	23 / 7 / 43	B500C

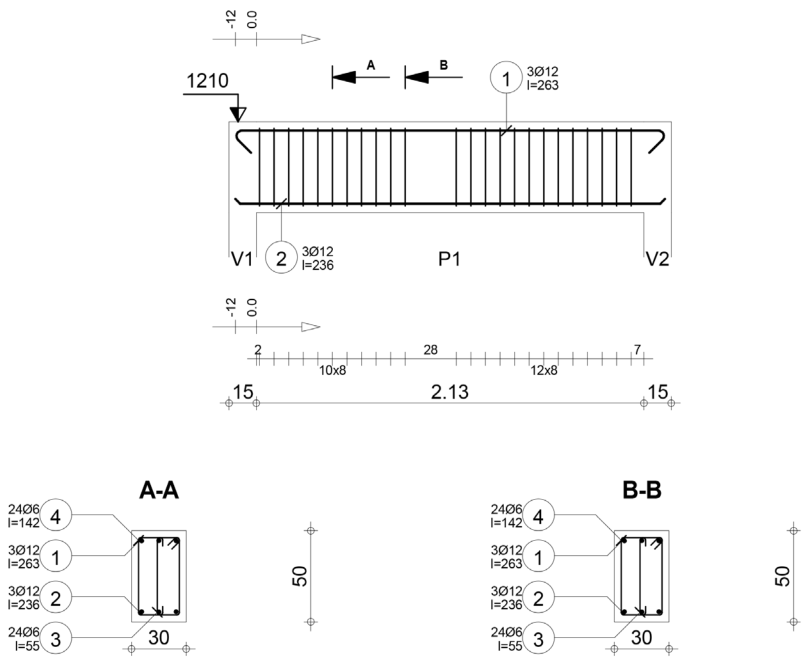
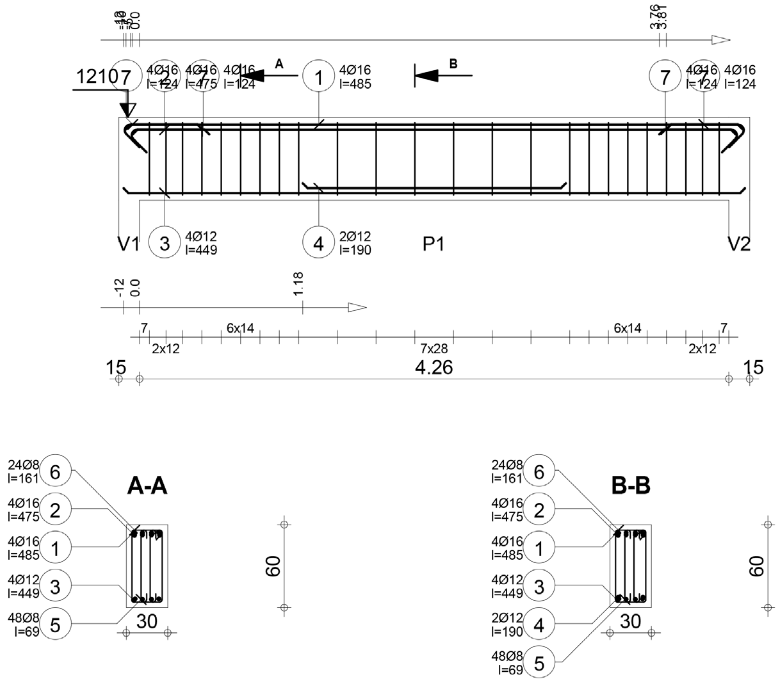
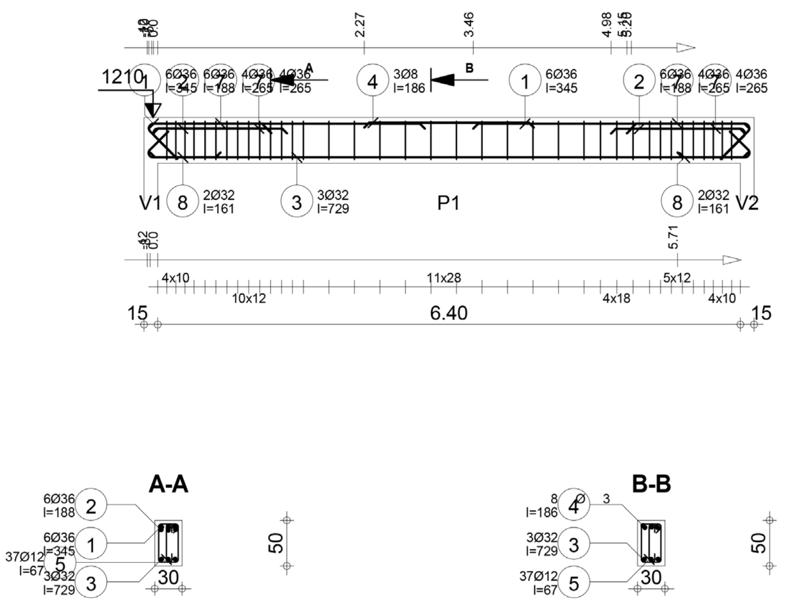


Figure A.24 - Reinforcement needed for the beam.



Pos.	Reinforcement		Code	Shape	Steel
1	4Ø16	l=485	00	18 449	B500C
2	4Ø16	l=475	00	18 439	B500C
3	4Ø12	l=449	00	449	B500C
4	2Ø12	l=190	00	190	B500C
5	48Ø8	l=69	00	6 53	B500C
6	24Ø8	l=161	31	23 53 7	B500C
7	4Ø16	l=124	21	18 56	B500C

Figure A.25 - Reinforcement needed for the beam.



Pos.	Reinforcement		Code	Shape	Steel
1	6Ø36	l=345	00	42 305	B500C
2	6Ø36	l=188	00	42 148	B500C
3	3Ø32	l=729	00	35 663	B500C
4	3Ø8	l=186	00	186	B500C
5	37Ø12	l=67	00	10 43	B500C
6	37Ø12	l=143	31	23 43 10	B500C
7	4Ø36	l=265		14 131	B500C
8	2Ø32	l=161	21	14 79	B500C

Figure A.26 - Reinforcement needed for the beam.

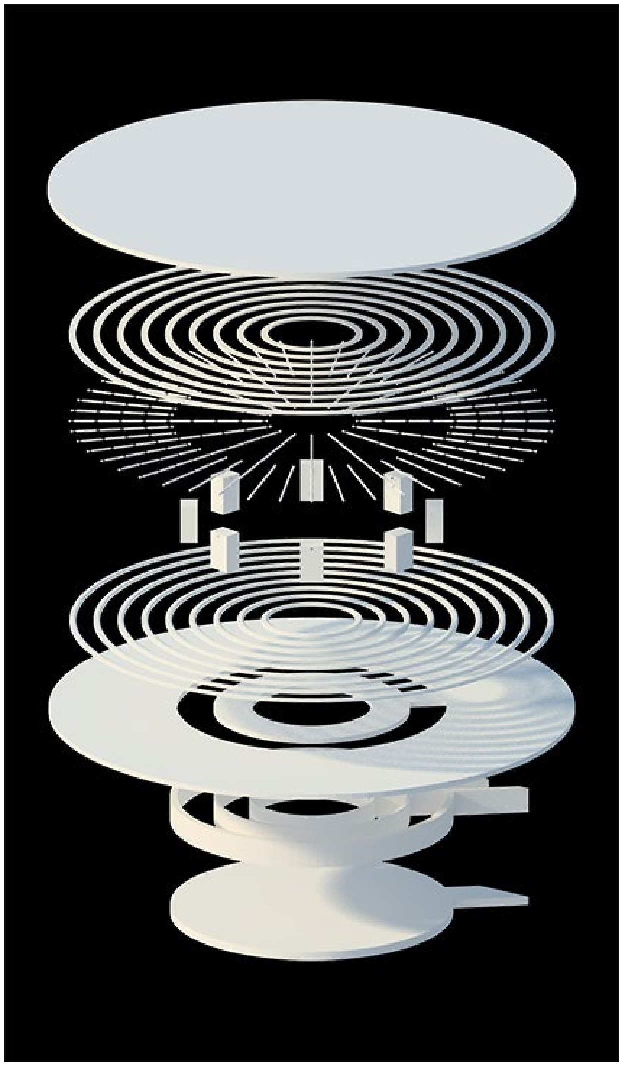


Figure A.27 - Schematic construction of the slab rotating system.

SLAB ROTATING SYSTEM

This rendered scheme, shows one of the possible solutions for rotating slab. Plate, on which building is erected, rests on concentric beams, creating tracks. Undernith, there are big rods on which the slab lays. The rods are placed on bearings, allowing rotation. Generators rotate rods, which work like train wheels, putting the slab above into motion.