Amager Beach Park and the Dark Silver Lining

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Abstract:
This project is about making lighting adapt to the darkness rather than conquer it.
During walks to the beach it came to my attention that the lighting in certain zones of Amager Beach Park (ABP) were lacking any form of immediate lighting. From a survey by the Amager East Local Committee it was possible to see that I was far from the only one that had thoughts on that matter. Yet those whom were concerned about darkness were also concerned about the amount of light they would be exposed to.
Through gathering theory about lighting design and how we perceive light, the project continued into the analysis phase. An analysis of ABP was done according to the historical and architectural aspects, while a categorisation of the current users was taken in order to define a user group to design towards.
Using qualitative analysis of similar projects, observations, and analysis of the current light conditions, a research Question arose:

"To what extent can a lighting design preserve the night views, while enhancing the level of orientation for slow movers throughout Amager Strandstien?"

To do this some design experiments were completed on the different aspects of the lighting e.g. angle of the light source, intensity. These were done according to the design criteria.
The final design was a composition of the results from the different design experiments and the design concept. A line of light that guides through darkness in a way that enables the visitor to view its surroundings, while at the same time perceiving other visitors as they traverse through the darkness momentarily exposing themselves in narrow beams of light. The same light would enable the visitor a sense of scale to the path in the darkness.

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1 Introduction

1.1 Foreword

To inspire the creation of light that emboldens the dark environment. This project is done as a master thesis within the M.Sc. of Lighting Design at Aalborg University in Copenhagen. As part of this lighting design project I intend on synthesizing the knowledge gained throughout the education into a light design scheme. This synthesis of knowledge is drawn from within three different categories of studies: Architecture, Media Technology, and of Lighting Technology.

The project intends to describe the design process in which a lighting design of a path called Amager Strandstien (AS) is the site of focus. The path runs through Amager Beach Park (ABP), a urban beach park.

Illustration 1: The northern area of Amager Beach Park with a vantage point towards the airport. (Photo by: Jonathan Jones)

1.2 Report Structure

To start off, an introduction to the project, in general, and its goals. This is followed by a collection of theory. This information will help analyse the information in the analysis chapter and also help define a problem statement. Once the research question is defined, a description of the different methods will be used in an array of tests and observations that will be described in the Method chapter where the project will accumulate with a design proposal based upon the results followed by a discussion about the results and a conclusion.

1.3 Motivation

"As far as possible, a good city for walking must function all year round, day and night."

– Jan Gehl [Gehl, 2010]

When walking through the park at night I admire its views of dark waters and a lit city skyline, yet see few that share this with me. It sparks a surge of motivation to find a way to encourage more of those that know of ABP or for new comers to discover its simplistic near meditative environment. Due to a boom in development, an opportunity to voice the already burning concerns about the lighting has risen, and this report will hopefully add to the flame.

The project will let future visitors experience a lighting design that blends into the existing environment, one that plays along with the existing landscaping. The light should guide throughout the path yet not overpower its surroundings. It is to enrich the landscape, yet not steal from the experience that the dark hours bring so rarely with in urban zones.

"I suggest, that there is just enough light to see the path. There should not be too much light, since it will destroy the experience of being in the nature."

– Anonymous survey respondent [AELC, 2017]

This is just one of the many requests for an enhancement of the lighting at ABP. This quote engulfs a lot of what this project is attempting to achieve.

1.3.1 Project Goals

This project strives to achieve the following goals:

- Retain the visitors' view of the darkness of the sea.
- Allow the visitors to see the lights of the city.
- Mark the path in low lighting and dark conditions.
- Encourage people to use the park during the dark hours.

1.3.2 Research Area

From this initial analysis of the location and its users it is possible to assess the public request for an adequate level of lighting along the pathways of ABP. Also, via an analysis of the current users and a qualitative observation of the lighting conditions a more focused research question is presented in section 3.5. The area of work will be on creating a design proposal for enhancing how the light can help create an environment where both AS is illuminated and avoiding glare so the views remain visible.

Which brings to the Theory chapter, where there will be delved into some light design theory regarding visual perception. Followed by some design theory concerning light design and urban design This will help give some background knowledge to help understand the design process.

2 Theory

2.1 Introduction

In order to address the goal established in the previous chapter this chapter will hold a collection of theories that will be used to help define a lighting design further on in the project. The theories will vary between light theory and urban design theory, starting with a better understanding of conditions that need to taken into consideration when lighting for a dark environment.

2.2 Visual Perception

To get a better understanding of how the light of the space can be designed it is worthy to understand how the light affects our ability to perceive the world around us. Perception is a term that describes how we interpret the sensations that we experience. Since this project aims towards the visual perceptual sense, a presentation of some basic theory about the visual perception will be essential for a further development of a lighting design that relys on them. We see the world through our eyes which in turn send the information to our brain where we interpret the images. But considering lighting what types of vision are there?

2.2.1 Types of Vision

The visual perception changes drastically according to the amount of light that the eye is exposed to and how the eye receives the light. It is possible to divide our vision into photopic vision, Scotopic Vision and Mesopic vision. These types of vision are relevant to the project due to how are perception works under the different light environments and how a future design can be implemented with these types of vision in consideration.

2.2.1.1 Photopic Vision

During exposure to well-lit environments (daylight, artificial light) the cone photoreceptors on our retina are stimulated. There are three types of cones:

- S-cone – Sensitive to short wavelengths of light.
- M-cone – Sensitive to medium wavelengths of light.
- L-cone – Sensitive to long wavelengths of light.

With these cones we are able to perceive colour and also higher level of acuity.[Wolfe et al., 2012]

This the optimal type of vision for visual orientation in a space due to the higher level of acuity that can warn us against obstacles in our environment. In most lighting designs the ambition is to create a space where this type of visual perception is enabled. Though in the case of this project the lighting levels should be low due to the risk of glare (see section 2.2.3.2).

2.2.1.2 Scotopic Vision

Under low light conditions the cone photoreceptors fail to get stimulated, in this case the rod photoreceptors on our retina are stimulated. Different than the photopic vision, the scotopic vision gives a low level of acuity.[Wolfe et al., 2012]

In regards to designing light for the visibility of darkness it is important to understand

2.2.1.3 Mesopic Vision

Mesopic vision is a state in between the photopic and the scotopic. In this state both the rod photoreceptors and the cone photoreceptors are activated. This state is usually activated during the shift between the photopic and scotopic states e.g. dusk light.[Boyce, 2014]

This knowledge is relevant to deciding the lighting at night. There is a tendency in urban lighting to aim at creating environments that enhance photopic vision, yet naturally during the dark hours our vision is attuned to the scotopic vision. This means that the design of the lighting should take the levels of lighting that fall into the visual field of the pedestrians.

2.2.2 Visual Field

When setting our gaze in a certain direction, our vision is limited to the ”window” of our visual perception. The window is a metaphorical mean to explain the angles of light that enter our eyes and how well we perceive them.(illustration 2) Our gaze is shaped like a cone. Our visual field allows us to see the majority of the things in front of us, in the direction of our gaze. It is also noticeable in the image that our optimum visual field is angled downwards to the floor. This is due to our natural development to seek obstacles on the ground. Outside of the visual field we have our peripheral vision. In this region of our vision the level of acuity is very low, and functions mostly as a way to direct our gaze to things that are happening in our periphery.[Lam, 1992][Ganslandt, 1992][Gehl, 2010]

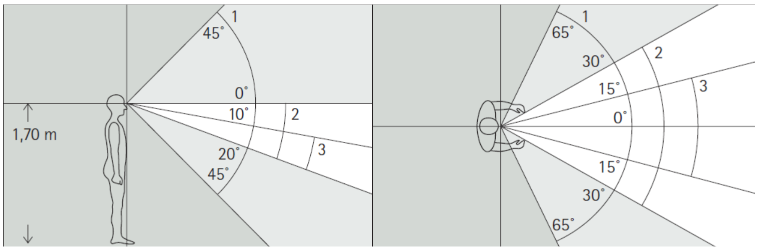


Illustration 2: The angles of vision where the zones marked with (1) are within the visual field, (2) the preferred visual field, and (3) within the optimum visual field.[Ganslandt, 1992]

2.2.3 Contrast and Its Affect on Visual Discomfort

Through our vision we can detect a lot of information due to a certain contrast in visual input, e.g. a difference in motion, colour or size. For example, we are able to identify a red apple on a table more easily if the background contrasts enough from it (Illustration 3). While talking about contrast it is mostly common to be referred to by a ratio between two variables. When dealing with contrast in lighting it can be regarded to multiple variables; e.g. illuminance, colour etc. But most commonly Contrast will refer to a ratio of luminance.[Livingston, 2014][Lam, 1992]

It possible for us to see in different levels of lighting. Whether in a well lit room or under a moon-lit sky. Our vision however is obscured whenever we either make sudden changes to the light environment.[Major, 2005] These transitions will be thought into the design, and what this confirms is that the wrong amount of contrast in the wrong context can aggregate visual discomfort. In specific, the report will delve into definitions of uniformity and Glare.

Illustration 3: The left apple has a higher contrast from its background than the right one. this can help in perceiving it more easily

2.2.3.1 Uniformity

The ratio between the lowest measured illuminance and the average illuminance of a space at the height of a specified task. Regarding contrast, or non-uniformity, the conclusion was that without visual contrast our perception of things would become more difficult. The play between light and dark would disappear and object would lose their contours. This understanding of uniformity will help in the lighting of the path. But also extreme non-uniformity, otherwise known as glare, should be mentioned.

“How much more mysterious and inviting is the street of an old town with its alternating realms of darkness and light than are the brightly and evenly lit streets of today!”

– Juhani Pallasmaa[Pallasmaa, 2005]

2.2.3.2 Glare

When exposed to extreme non-uniform light, it can handicap the visual input and cause discomfort. This handicap is called glare. There has been a suggestion that glare can be divided into eight different forms, where the majority are not relevant for the scope of this project. Disability Glare and Discomfort Glare are two types of glare that are more common under the circumstances of the projects design.[Boyce, 2014]

2.2.3.2.1 Disability Glare

This type of glare occurs when luminance of an object, in the visual field (see section 2.2.2), has a high contrast of luminance to its background. This will affect the perception of the adjacent background via a luminous veil. The luminous veil is caused by light from a source in the visual field that scatters within the eye.[Boyce, 2014] As an example of disability glare, in illustration 4, if you are trying to look just past the lamp. The light would scatter in the eye and cause a luminous veil as can be seen in the image.

Illustration 4: Example of a source of disability glare or discomfort glare in a park scenario.(Photo by: Carole A. Lindstrom)

2.2.3.2.2 Discomfort Glare

When a luminance source in the visual field (see section 2.2.2) involuntarily distracts the attention of the observer from the intentioned focus and by so causing discomfort. However, discomfort glare is not only due to contrast of luminance, but can also be caused by luminance flicker.[Ganslandt, 1992][Boyce, 2014] Again using illustration 4 as an example, though this time if the intention was to look at something that positioned the lamp in your peripheral vision may cause discomfort glare. This can be related to the visitors on the path looking out towards the scenery. If a fixture was to be visible in the peripheral vision it would cause glare for the visitor.

2.3 Lighting Design Theory

When describing and analysing potential or existing lighting designs its is beneficial to use a base of theory that can be referred to. This project is no different. It will take inspiration from Richard Kelly, and William Lam.

2.3.1 Richard Kelly

A pioneer of qualitative lighting design, defines three layers of lighting that can be used to determine a general lighting design. The light effects can be divided into: Focal glow, Ambience luminescence, and play of brilliants. A light designer must take into account all three of these layers when planning a light design. The different layers should not be planned to exist apart from each other but as an interplay of light that fulfils a complete lighting design.[Kelly, 1952]

“Visual beauty is perceived by an interplay of all three kinds of light ...”

– Richard Kelly[Kelly, 1952]

2.3.1.1 Focal Glow

When describing the different layers, focal glow can be defined as a tool of highlighting a certain object or space. Light that brings ones attention to a detail or a collection of details in a desired composition of light. This could be shown as a reading light above a chair.[Kelly, 1952]

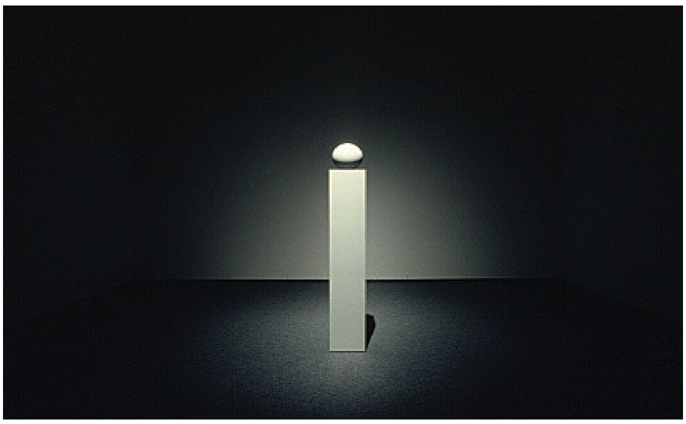


Illustration 5: An example of focal glow lighting.[ERCO]

2.3.1.2 Ambience Luminescence

This would be considered the light that uniformly lights a space. Where focal glow refers to light that directs attention, Ambience Luminescence is a bland layer, that hints no attention towards any item or area. It is the light on a bright overcast day, or a diffused light bulb hanging from the ceiling. This type of lighting is also referred to as indirect lighting or general lighting.[Kelly, 1952]

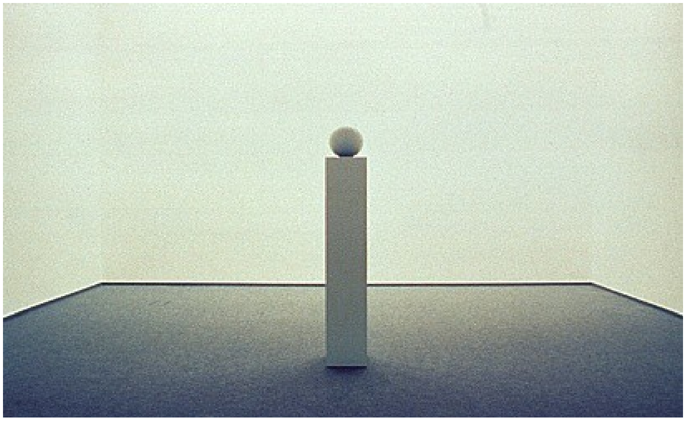


Illustration 6: An example of ambience luminescence lighting. [ERCO]

2.3.1.3 Play of Brilliants

This layer of light can be referred to as a layer of perceptual excitement. It is the sparkle of a full moon on a rippled water surface, or the twinkle, of what might seem, an infinitive amount of stars. It is the creative layer that intends on stimulating the observer, or as Richard Kelly sums it as a way to “stimulate the spirit.”[Kelly, 1952]

William M.C. Lam refers to this layer as sparkle “An attractive brilliance”, and the term brilliance as an uncomfortably extreme element of brightness.[Lam, 1992]

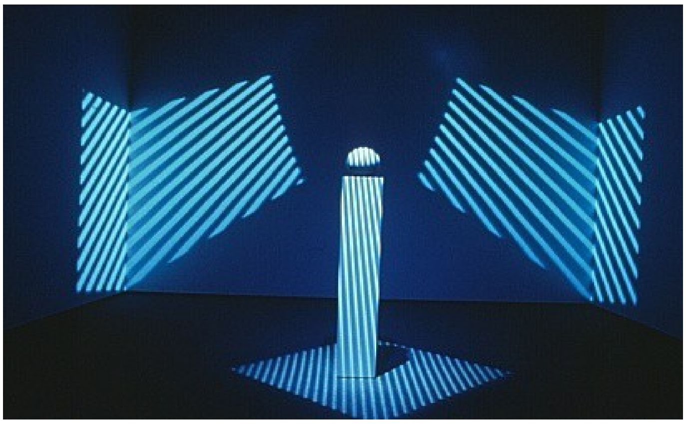


Illustration 7: An example of play of brilliance lighting.[ERCO]

2.3.1.4 Layer of Interaction

Richard Kelly mentions these previous directions of thought to take before creating a design. This project would like to extend on this framework another layer: the layer of interaction. Is the light inviting interaction with the space or with the light itself? This is a a thought that needs to be done when creating the lighting design for the users. An example of a light that invites a certain level of social interaction and interaction directly with the light is a project by Studio Roosegaarde that involves the use of light to create a space for people to stop on a path and interact with the light and with each other.[Roosegaarde, 2010]

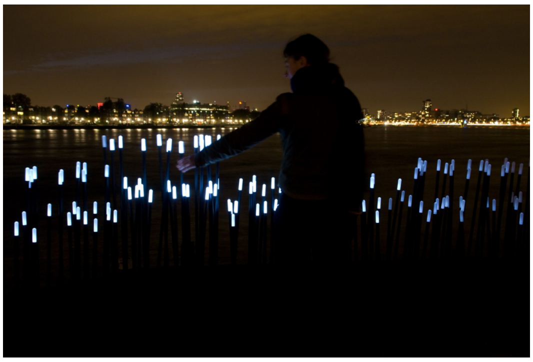


Illustration 8: A permanent lighting installation that interacts with those that walk on the path adjacent to it.[Roosegaarde, 2010]

2.3.2 William Lam

A renowned architect that pushed towards a more qualitative orientated lighting Design. Unlike Richard Kelly, Lam designed lighting via the needs of its users. These needs were split into two groups, the Activity needs and the Biological needs.

2.3.2.1 Activity Needs

The lighting design of a space should address the needs of the activities in that space, e.g. a drawing table should have lighting that supports visual perception of detail. This category of needs can be also referred to as the quantitative factor, as it is mostly the certain numeric factors (uniformity, illuminance etc.). Lam's theory includes, that light is not to be limited to targeting a dominant activity in the space, but to create a synthesis of lighting that addresses all of the activities in the space. The other group of needs is the Biological needs.[Lam, 1992]

2.3.2.2 Biological Needs

The activity needs handle upon how light should help user interact in the immediate space. On the other hand, the biological needs are more focused on the psychological needs of the user to the environment. It is about how we perceive the space to be in regards to the feeling of our wellbeing. When filling out a certain visual task our attention is targeted consciously at that specific task. But at the same time the visual system will take in the surrounding environment (see 2.2.2) to analyse for any change. When a change occurs the visual environment alerts the conciousness. How this environment is perceived will affect the emotional evaluation of the observer.

2.3.2.2.1 Orientation

When walking It is important for are biological needs that there exist cues to our orientation in the space and how the space lies out according to our stance. Visual cues help us orientate how a space is laid out. Our need to see a horizon in situations where it is usually available is something that gives reassurance to the natural thought that "the world acts the way we expect it". It is our use of cues to create a sense of orientation in the space and of the space itself. Lam goes further to also describe how orientate ourselves in regarding to the spatial location of possible destinations and transition zones, e.g. entrances/exits, reception desk. [Lam, 1992]

In the case of the Amager Strandstien the orientation of the user at night would be towards the horizon and the skyline of the city, while also on the possible directions to walk on the path. This would mean that in the design an emphasis on creating cues for the visitor should be made.

2.3.2.2.2 Directional cues

When creating directional cues it is important to reflect on the extreme complexity of the environments that we traverse in. The environments include more "...visual information than we can comprehend or use". in order to orientate through these environments we use previous experiences of patterns and visual information. These experiences are then used to decode the environment for orientational and directional cues. The problem is, due to the complexity of environments, there should be set familiar patterns to direct us through the environment. These patterns do not necessarily have to invoke us on a concious scale of awareness. When traversing an environment that is unfamiliar, patterns that are perceivable and persistent will be a positive influence on guiding through the environment. Specifically in this thesis in regards to an exterior environment.[Lam, 1992]

2.3.2.2.3 External lighting

Common outdoor activities lighting needs are mostly of the biological group and because of that the lighting of a space must address the specific needs that can rise in a the environment; safe movement orientation etc. The needs of the lighting however can be solved via low level lighting if a clear level of orientational cues are given to the user.

Another note from Lam regarding external lighting is the thought of layering. Creating a "background" layer and a "foreground" one. The background is to be illuminated with the intention of not being obtrusive to those traversing the space or to widows of nearby buildings. While the foreground layer is to have a much more orientation based lighting to help with circulation.

2.4 Design Principles of Gestalt

When looking at the broken white lines on a road our minds seem to connect between invisible dots and create a connection between the broken lines. We perceive a whole line with spaces rather than individual lines. This is not the only occasion. Our minds are set to interpret scenarios in order to create a bigger picture that make sense to us. This is a very thin summary of Gestalt. This project will focus on the writings of Rudolf Arnheim where he defines Gestalt as:

"The word gestalt, the common German noun for shape or form, has been applied since the beginning of our century to a body of scientific principles that were derived mainly from experiments in sensory perception."

– *Rudolf Arnheim[Arnheim, 1974]*

This regards not only creating a single collectively perceived form out of a group of sensual stimuli but also a collective of sub groups that then form a collective form.

Arnheim further goes on to mention an experiment where twelve observers were each given a different single tone of the same complete melody. Each observer described how they experienced and perceived the tone. Yet when the tones were assembled to a complete melody their experience of the tones could not correspond to what they had experienced while listening to them individually.[Arnheim, 1974]

The same would apply to light on a path. We can experience the light that one light source brings. Each light source adds to the sum of experiences that strengthen a united purpose. Only when we connect the multiple light sources into a larger form, can we really experience the lighting of the path as a whole.

2.5 Feeling of Safety

When talking about safety it is best to divide between feeling safe of physical accidents and the psychological feeling of insecurity of other people. In daylight it is possible to see our surroundings and people within them, but when entering a low lit, or dark space our visual perception lowers. In a familiar space this may not affect us much, but in a new place we are forced to act more carefully in order to avoid obstacles.[Lam, 1992]

2.5.1 Feeling of Insecurity

The level of insecurity, one has, in a dark space is also related to the expectations one has with it. When darkness appears without it being expected, it can increase the level of unease and insecurity, yet if the darkness is expected then it is more comfortable.[Major, 2005]

Using light to lighten up a space can help relieve some of the fear that some have of being present in dark spaces. The larger the distance of illumination, the more that can be perceived, which leads to feeling more secure. But regarding to the contrast (Section 2.2.3) at some situations lighting can create luminous veils that can hide details in the dark background and intensify the feeling of insecurity.[Arup, 2015]

"The potential for a safe city is strengthened generally when more people move about and stay in city space. A city that invites people to walk must by definition have a reasonably cohesive structure that offers short walking distances, attractive public spaces and a variation of urban functions. These elements increase activity and the feeling of security in and around city spaces."

– Jan Gehl[Gehl, 2010]

Jan Gehl also mentions that a safe city space has people using it frequently. The point of having more eyes throughout the space increases the feeling of security. This effect also encourages more people to visit and utilise the space, and thus encourages the feeling of security.[Gehl, 2010]

In other words. Picture yourself sitting by a campfire. The light of the flames flickers and illuminates your immediate surrounding and you are safe. But facing the fire and looking beyond the illuminance enclosure that it creates, there is darkness. Detail is very hard to comprehend, and your ability to see if anything approaches is reduced to the use of the other 4 senses. Facing away from the fire, the border of the illuminance enclosure seems to stretch and blend more smoothly with the dark surroundings. Unfortunately when considering urban areas another factor has to be taken into account

2.6 Urban Sky

"For myself, I declare I don't know anything about it. But the sight of the stars always makes me dream..."

– Vincent Van Gogh (extract from letters to Theo)[Gogh, 1888]

The night sky is a marvel of the infinite darkness of space contrasting with the luminance sparkle of stars that has travelled thousands of light years to arrive at earth years after its origins decease. We have always admired the night sky, and its way to make us feel small. But through out the world there are skies where the stars are not as visible. The skies above urban zones around the world are suffering from a phenomenon that is stealing the view of the stars. Boyce refers to this phenomenon as light pollution (see illustration 9 for example). This has an uncontrollable effect on how the lighting at night is perceived, and will continue doing so even after. Therefore the project must rather than work around this, but work with it due to the mass scale of this feature. However the project can make sure that the lighting it adds to ABP does not contribute directly to the sky glow.[Boyce, 2014] [Arup, 2015]

Illustration 9: The images before (right) and after (left) a power shortage that show the affect of light on the visibility of stars.

2.7 Conclusion

From the theory it is possible do withdraw that the design of Amager Strandstien should address the limitations of the visual perception regarding the level of acuity that we want the pedestrians to experience. This being done by taking the light levels, distribution, and uniformity into consideration.

This project will try and combine the thoughts and theory of Richard Kelly and William M.C. Lam into a synthesis that is used in the Design chapter (see chapter 5) to argue for solutions to design criteria. Kelly has inspired with the way he categorises a lighting design into three layers. Although useful knowledge when planning a design, his theory is aimed mostly towards indoor urban environments where layers of light are more applicable. Kelly's theory will be used in the describing of certain inspirational lighting designs (see section 4.3).

The psychological aspects of how a pedestrian will experience the design should be dwelt upon in the process of deciding a design. Also, a look into the paradox of lighting in the dark to improve the visibility of other path visitors and the path itself, yet preserve the visibility of the night scenery and the prevention of glare towards the visitors.

3 Analysis

3.1 Historical Background

Amager Beach Park (ABP) is a man made recreational park for large varieties of land and water activities. It is in proximity to a flourishing new urban neighbourhood, which observation throughout time this area of light in nature is most often associated with sunlight. To first understand the problem that faces this project it is essential to get a contextual comprehension of the locations history. This will be separated into: ABP before and after the reconstruction on 2005.

3.1.1 ABP Before 2005

The first official construction of a beach park in the proximity of ABP was completed in 1933. During the period 1943-1947, south from the park was a landfill of household and industrial waste. Due to a popularity increase of the beach, the municipality of Copenhagen had already decided in 1944 to halt the activity of the landfill during the summer months between may and august With the interest of protecting the beach goers well being.

While the beach was equipped with a Samaritan guard, toilets and changing facilities, it had no lifeguards or kiosks. For the duration of app. a decade in 50's, there was a popular outdoor dance-hall, named “The Beach Pavilion”, that had burned down in 1961. In the 70's, a movement to create a new ABP was initiated, and due to bureaucratic procedures the work on site only began in 2004.

Illustration 10: An early photo of Amager Beach Park. At this point the artificial island was not even conceptualised.

3.1.2 ABP Post 2005

The most recent development was planned by Hasløv & Kjærsgaard Arkitektfirma I/S(H&K) and was completed in 2005. The plan introduced the addition of an artificial island to the ABP, and a lagoon that separates it from the shore. The artificial island shores to the east with the Øresund is divided into two zones: a north zone and a south zone.

On the island is a network of promenades. These promenades connect five beach stations and small squares. They are numbered chronologically from one in the north to five in the south. The beach stations are inspired of small artificial cliffs and act as vantage points and within house facilities e.g. changing rooms, kiosks. The artificial island is accessible via four bridges, and two of them can only be accessed by pedestrians and cyclists. The north zone of the island was given a natural character while the south zone was given an urban character. This is noticeable in the landscape planning in general, yet also in the lighting plan in specific. In a phone interview with Charlotte Buhl director at H&K the following concerns regarding the current lighting:

- The light plan was designed to be basic and simple.
- Due to the park being public and scarcely visited during certain hours, the design had to take into account of the vulnerability of the fixtures due to vandalism.
- Also due to the nature of the elements of the park environment, and the weather the design needs to be robust.
- The amount of light pollution that is currently illuminating the park from the city and the airport.
- Surrounded by many different visible light sources. Sea windmills, apartment buildings, road.
- The design took into account the residents that have a view of the beach as to not overpower the view or act as a disturbing distraction.

- Small squares along the path are given an identity with sunken fixtures in the pavement that illuminate in a different colour for each square.
- The safety of the ships sailing through the Øresund are taken into account.

This report focuses on the lighting of Amager Strandstien (AS), a cement path that winds through sand dunes. AS crosses the north part of the island dividing it lengthwise, from Beach station number one to number three. The sand dunes are characteristic by the beach grass that covers them and in the way they act as vantage points over both beaches. According to the Lighting masterplan by consultancy Citelum for the municipality of Copenhagen, there can be established low, non glaring light fixtures alongside the path. The next section will focus on the topographic, demographic and geographical characteristics of ABP and of the area it is located in.[Citelum, 2014]

3.2 Topographic, Demographic and Geographical Description

ABP is located in Amager east, a neighbourhood on the east side of the island, Amager. The island is part of the greater region of Copenhagen, The capital of Denmark. Amager is connected both to the Island of Zealand, and to the Swedish city of Malmö, by means of bridges. This helps us understand the sheer amount of potential visitors to Amager have immediate access to ABP via public transport.

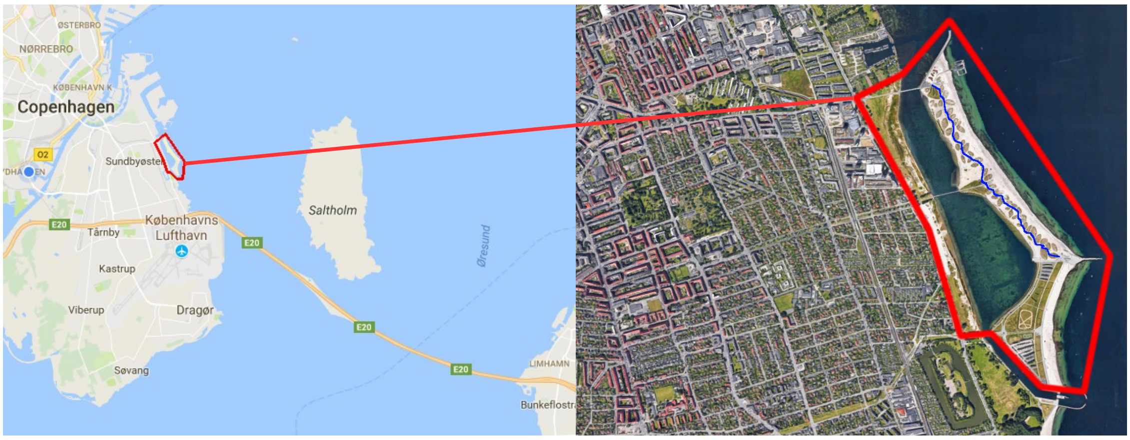


Illustration 11: Map of the greater region with a zoom in to the closer area of focus. The red marks Amager Beach Park area while the blue line marks the Amager Strandstien (Photo by: Google maps)

Amager (and Copenhagen in general) is under a building boom.[Burhøi, 2017] In the neighborhood of Amager East most of the new development involves tall apartment complexes, restaurants and cafes. Throughout the northern area of East Amager are the main development points. These buildings dominate the landscape at day competed only by the windmills in the north east for horizontal dominance. At night however these buildings turn into a decorative play of brilliance in the horizon. The man made sparkle (this will be described in further detail in section 4.2.1.2).

The length of Amager Strandstien is approx. 1.3 km long and is on average 3.5m wide. It winds between the sand dunes of the northern part of the island of Amager Beach Park between beach station 1 and 3.

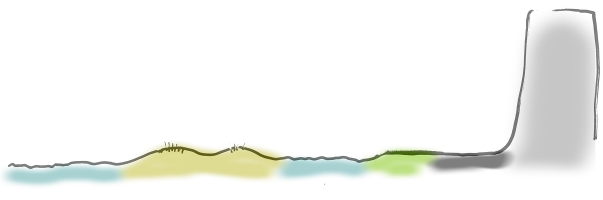


Illustration 12: A slice of the urban topography looking from North to South. Left to right: The waters of the Øresund, the island of ABP, the lagoon, ABP, busy road, urban area (to the north tall apartment complexes, to the south villa neighbourhoods)

3.3 Online Survey

In order to get an idea of what were peoples thoughts about the current lighting conditions an online questionnaire was made. The hypothesis was that a majority of the respondents would feel that the lighting of Amager Beach park was inadequate. The online questionnaire was created on the online platform google drive, and was distributed via Social media websites e.g. Facebook in relevant groups to Amager Beach Park (ABP). The full questionnaire can be found in the appendix (see section 9.1) After the questionnaire was released to be answered it received 47 responses. The average age of the respondents was ~43[1] and the sex of the users was not asked for.
It is worthy to note that, the respondents of the survey are probably restricted to those that feel strongly about the subject enough to answer a questionnaire in their free time.

To the question: Do you find the lighting at ABP to be adequate? 61.7% answered that they do not feel that the lighting is adequate. The same question, targeted at a more specific area of the park (Amager Strandstien), gave a similar result with 57.4% answering that they feel that the lighting is inadequate.
This is a large sign that the hypothesis is correct in its belief that the lighting is inadequate for the needs of the users.

1 The respondents age was not a required question to answer, yet 40 out of 47 answered.

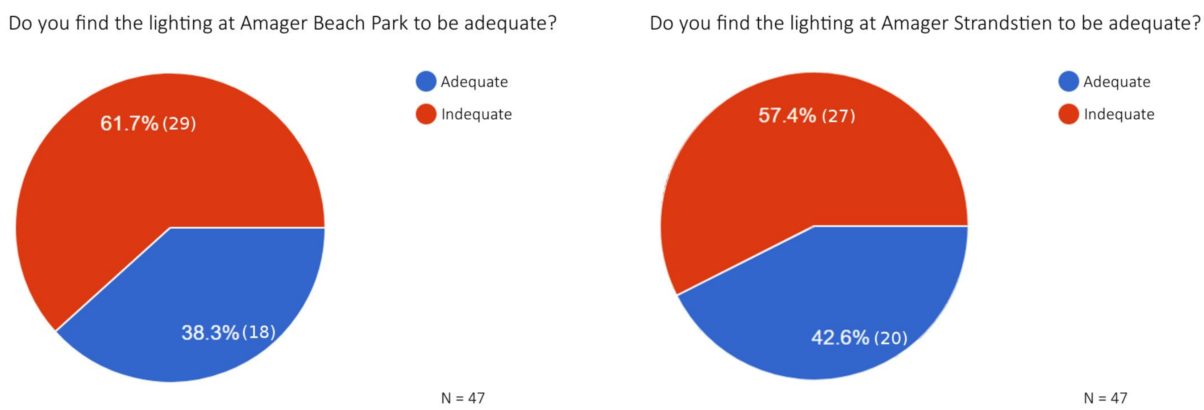


Illustration 13: Answers to whether the respondents felt that the lighting was adequate

These answers seem to correspond with the answers given regarding a comparison between the annual amount of visit to ABP and specifically Amager Strandstien (AS). But also the difference in how many times they visited each corresponding area during the dark hours of the day.

It is possible to conclude that the respondents are visiting ABP, and AS in specific, more during the day hours than during the dark hours. This can be associated to the lack of lighting at AS.
From the responses it can be hinted to an issue that although a majority of the respondents reply that the lighting is inadequate, there is also a large group that feel that the lighting is adequate. These groups are so contrasting that it would be very difficult to find a design that satisfies both sides.

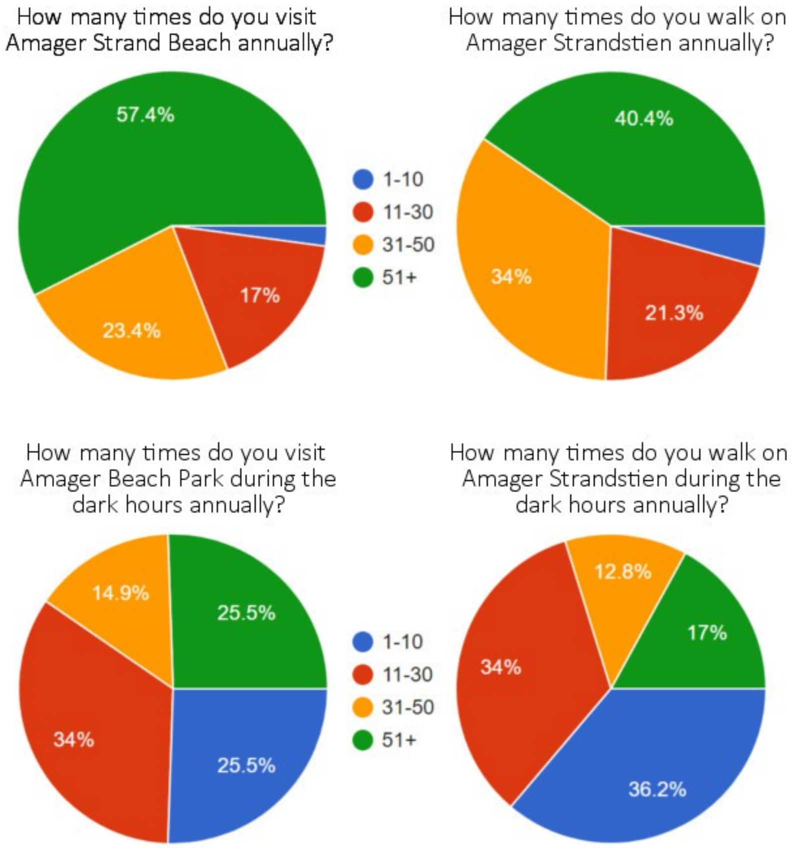


Illustration 14: (top left and right) A comparison between how many times each respondent visits the Amager Beach Park in general and Amager Strandstien in specific.
(bottom left and right) a look into how many of the respondents visit Amager Beach Park in general and Amager Strandstien in specific during the dark hours.

While receiving results for the questionnaire a respondent made it noticed to me that the local committee had made a relevant questionnaire themselves.

3.4 Current Users

Amager East Local Committee (AELC) has committed a survey with 2331 participants. This survey reveals first the request of the users for more lighting along the paths in general, but also in many cases the specific path of AS. According to the survey many of the users would like to have more light (see illustration 15) yet there are also those that are satisfied with the light situation. Those that are satisfied may though be doing so due narrow sight into the options of lighting nowadays.

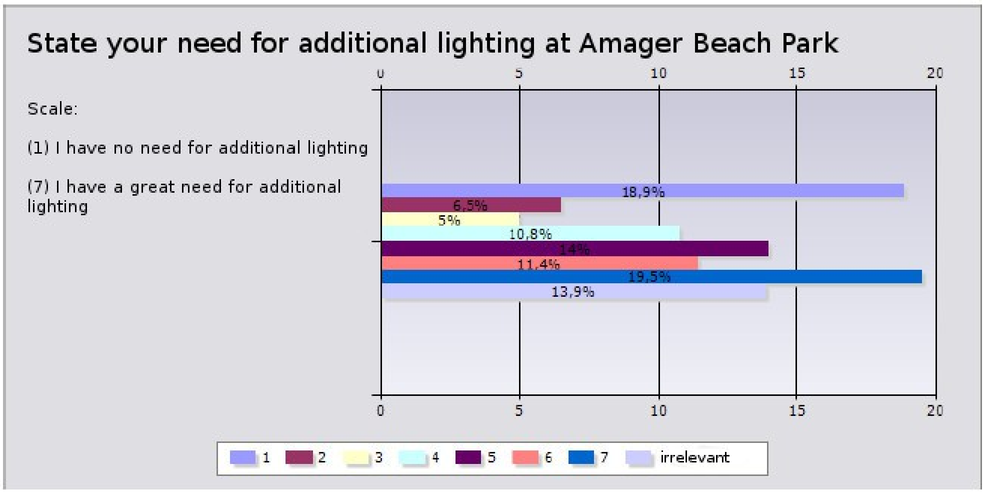


Illustration 15: A graph taken from the survey of AELC that shows the majority of respondents having a need, to some extent, for additional lighting. Translated from [AELC, 2017]

Through qualitative observations of the users, conducted during both the light and dark hours of ABP, and the survey conducted by AELC, this project has defined three user groups depending on the speed of motion and vantage point of the users. The three groups are divided into: slow movers, fast movers and observers.[AELC, 2017]

Illustration 16: Fast movers and slow movers at ABP. (Photo by: Jonathan Jones)

3.4.1 Slow Movers

This group includes those that have the time to observe their surroundings and take in the view. This could include pedestrians that are Jogging/strolling/walking/sitting along the path. AELC found

in their public survey that about 55% of the visitors[2] arrive by foot to ABP. This added with the percentage of those that arrive by car is approximately 60% of the visitors.[AELC, 2017]
Moving slowly means that one has less need to focus on the path they are walking and more time to observe the scenery. Joggers were included due to a previous experience that most jogging is slower than cycling and less sensory demanding.

3.4.2 Fast Movers

Moving fast makes spotting subtle detail difficult, and the lighting should show the borders for safe movement. Cyclists are the main group of visitors that land into the description of fast movers. At night time they are moving fast and their ability to see the edges of the path and pedestrians is at a disadvantage in correlation to the speed of movement. 33% of the AELC survey responds answered that their preferred method of travel to ABP is by bicycle.[AELC, 2017]

3.4.3 Observers

Those that are at a vantage point toward the path can see the path at a different scale. This will be taken into consideration when planning the lighting. The participants of this group could either be placed in an apartment complex with a view of the park or at the park on one of the many vantage points. For this group adding lighting would be a highlight to a landmark. An extra layer that makes the landmark more visible.

In order to to narrow the scope of the project to a more defined target group it is important to return to the motivation behind the project (see section 1.3). it is about being able to perceive the darkness yet also experience the sensation of moving, comfortably through it. The fast movers tend to be focused on the task of controlling their means of transport and navigating through the space. This subtracts from the amount of time they have to experience the dark views. The observers on the other hand can take their time in taking in the darkness, yet they are not the target for this project. They lack the ability to experience the darkness and the path. During the daytime they can see the path and the views beyond. During the darkness, however, they are surrounded by light sources that are potentially creating a luminance contrast (see section 2.2.3) that disables their ability to perceive the views. The Slow Movers are those that fulfil all the motivational parameters to why this project was initiated.

2 Note that these numbers are the percentages from the survey of visitors who visit in general and not a daily diagnosis of visitor travel means.

3.5 Research Question

As to get a better comprehension of the knowledge gained in the analysis, the next compiled points will act as a summary.

- Being able to experience nature that is easily accessible for the residents of a city is something that has pushed the importance of Amager Beach Park as a part of urban landscape.
- The building boom of housing in the neighbouring areas close to ABP will create a need for more recreational spaces even during the dark hours.
- The landscape of the city creates a “wall” that rises up from the park creating a defining line.
- According to an online questionnaire, the majority of respondents find the current lighting inadequate. This works as a motivational point for the project to create a lighting that will enhance the experience of visiting ABP.
- The user groups were defined using observations and the data received by AELC. This was used to narrow the scope of the project to a single group out of the three defined, based upon the motivational aspects of the projects.

From this summary, and the conclusion of the Theory chapter, a focus for the project was gathered. It was decided that this project will focus on trying to answer this research question:

To what extent can a lighting design ***preserve the night views****, while* ***enhancing the level of orientation*** *for* ***slow movers*** *throughout Amager Strandstien?*

To break the question into different points:

Preserve the night views – Due to input from the users it is important that the view will not be obstructed either by physical objects or by luminous veils created by glare.

Enhancing the level of orientation – To ensure that those that use the path can see the way of the path and navigate it in a secure manner (both physically and psychologically).

Slow movers – This will narrow down the scope of the project to those that will stay the longest each visit (due to speed of motion).

4 Methods

4.1 Introduction

This chapter will describe the different methods used in order to find the information on which a design will be based. The methods take into account the theory and analysis that have been established. A survey of the site was done in order to gain a better understanding of the qualitative lighting conditions, an interview with visitors on site, and a list of the prominent materials that affect the path. This is followed by an inspirational analysis of existing light designs. In the conclusion of the chapter a list of design criteria will be presented.

4.2 Site Survey

In order to understand the aspects that influence the design based upon the location a needs it is important to understand the current lighting conditions and materiel properties of the surfaces at the location of interest.


Illustration 17: Birds-eye view of the section of Amager Strandstien of interest for design experiments

4.2.1 Current Lighting

The current lighting of the Amager Beach Park can be separated into three parts:

1) The cycle of the sun in the sky
2) The surrounding electrical lighting's influence.
3) The existing electrical lighting conditions at the location.

From the analysis of the existing lighting condition it is possible to receive a better picture of how to solve the lighting needs in a way that works with the surroundings and also what changes to the lighting at the immediate location

4.2.1.1 Sun Cycle

The sun cycle is an approximation to the placement of the sun in the sky throughout the year. This approximation take into account the rotation of the earth around the sun and earth's spin on its own axis. Most importantly the calculation takes into account for what position on earth the sun cycle is calculated. From this information it is able to get an understanding how the sunlight can affect the electrical light.

Due to ABP being located in Scandinavia, the natural cycle of the sun changes drastically throughout the seasons of the year. Whether it be the arc of the suns position in the sky throughout a cycle, or the times of day that the daylight is visible.

In the summer time the amount of daylight each day reaches its maximum at the summer solstice (see illustration 18). The sun will rise early in the morning and set late in the evening. Its journey through the sky will start in the north-east and reach around midday the middle of the sky with a slight offset to the south. The sun then arcs back to the northern side of the sky in the north-west. What is special about the summer sun cycle though is that during the dark hours of the day, the sky never gets completely dark. It holds a level of twilight, due to light from the sun being visible from the northern hemisphere. Due to the length of the daylight, visitors to ABP tend to visit throughout more of the day. This is due to extended hours where visibility is adequate.

On the other hand, during the winter solstice the days get shorter. The sun rises in the south-east and cruises through the sky at a low angle with the southern horizon This means that the light environment for AS is dark during a majority of the day. The design of the lighting will, most probably, benefit the visitors of ABP during the winter months.

Aside from that conclusion, the design of AS should address the transition between the day and night, light and dark. Whether it be by addressing the shift in the correlated colour temperature (CCT) of the light, or by utilising the transition between the daylight and the existing electrical lighting in the area.

00:00—06:17	— night
06:17—07:02	— astronomical twilight
07:02—07:51	— nautical twilight
07:51—08:38	— civil twilight
08:38—08:43	— sunrise
08:43—15:34	— daylight
15:34—15:39	— sunset
15:39—16:26	— civil twilight
16:26—17:15	— nautical twilight
17:15—18:00	— astronomical twilight
18:00—00:00	— night

00:00— n/a	— night
n/a — n/a	— astronomical twilight
n/a —03:25	— nautical twilight
03:25—04:26	— civil twilight
04:26—04:31	— sunrise
04:31—21:53	— daylight
21:53—21:58	— sunset
21:58—22:59	— civil twilight
22:59— n/a	— nautical twilight
n/a — n/a	— astronomical twilight
n/a —00:00	— night

Illustration 18: The sun cycles of the winter solstice (left) and the summer solstice (right). (Data from SunCalc.net)

4.2.1.2 Surrounding Electrical Lighting

The lighting of the surroundings create a glow that depending on the cloud density can affect the levels of light at the location of interest. Firstly the Amager Beach Park (ABP) is based, as noted in section 3.2, in an urban area. The light from the city that is adjacent to the park sheds an aura of light throughout the park on days with overcast skies, as one can see in illustration 19. This illumination however is not reliable due to its reliance on the the cloud density to reflect the light. The lights from the buildings give the surrounding views a layer of sparkle. This unintended play of brilliance is one of the reason some of the existing visitors walk in the darkness. The contrast. The sparkle. When present at the path either looking North or South it is as if being positioned on the border between the light of the city and the dark of the sea. Again, the contrast. As if the light of the city is bleeding over the border into the darkness.

Illustration 19: The view from the location of interest towards the city. (Photo by: Jonathan Jones)

4.2.1.3 Location Electrical lighting

Currently at the location there is no electrical lighting. Which is a large reason for the need of a lighting design project. The area can get quite dark on a cloudless day with no moon in the sky. The only lighting that is close is the lighting that can shine from the beach stations, yet these are not always on either.

The darkness of the path in contrast with the lights of the city give the background a more intriguing aspect. As if standing outside the city, looking in and seeing its facade.

4.2.2 Interviews

While visiting the site during dark hours some interviews were conducted so to get an idea of why those that visit the park during the dark hours do so. The interviews were semi-structured interviews and conducted on site. The questions were built around the reason they visited the site, their thoughts about the existing lighting conditions, and how they could be improved.

The interviews were performed during the month of April, at a time of day where not many were about. This was an attempt to get an answer from those that would use the path during the dark hours of the day. There were in total five participants that were questioned in two groups. One group persisted of an elderly couple going for a walk through the park, While the second group persisted of three young male adults that had walked to and from a session of skateboarding. Below are a list of remarks that the interviews managed to collect from these visitors.

“That it is so dark that you can see the city, Isn’t this a beautiful skyline you can see from here. If there was light all around you couldn’t see anything”

“I think that it is cosy that there isn’t too much light...and you can enjoy the light from the city...”

“There shouldn’t be added lighting. It would be a shame. So if the elderly ladies are afraid of being assaulted they can go to the lit areas”

From the remarks it can be understood that there is, for this limited amount of participants, an issue concerning the reservation of the view to the dark skies. This, backed by the notion of the importance of a view to our biological needs (see section 2.3.2.2) will demand the design take this into utmost consideration.

4.2.3 Materiel Analysis

An observation of the materials used at the site will help decide the light effect in the design. The path is made of a light grey cement that is lightly bumpy in texture. On each side of the path are sand dunes that have a wild sea grass growing on them. One of the issues with the materiel of the pavement is the reflective characteristic it receives when wet. This can via reflection, due to the field of view of an average pedestrian (see section 2.2.2), create situations of glare (see section 2.2.3.2).

Illustration 20: The main materials at the site are very organic in nature. From left to right: Cement, sea grass, and sand.

4.3 Inspiration

In order to gain a better comprehension of the qualitative aspects that the lighting design should contain, an analysis of similar cases was taken. This collection of lighting design cases are analysed so to use the conclusions towards the lighting design of Amager Strandstien (AS) path at Amager Beach Park (ABP).

4.3.1 Gray's Lake Park Bridge

To describe the lighting I will be using the theory in section 2.3. The lighting of the walk bridge is categorised by an array of light fixture hanging at land railing height. These lights illuminate the floor through colour filters that are embedded in the railing. Creating a combination of a focal glow on the bridge in contrast to it's dark surroundings yet also a play of brilliance due to the sparkle that the lights create and the colourful lighting. It also seems that the lights create a layer of ambience luminescence on the floor via reflections and the angle of distribution of the fixtures.
From the images it seems as if the light sources are not very well shielded. It could be discussed whether this can be described as Lam's version of sparkle or his version of brilliance.[Lam, 1992]

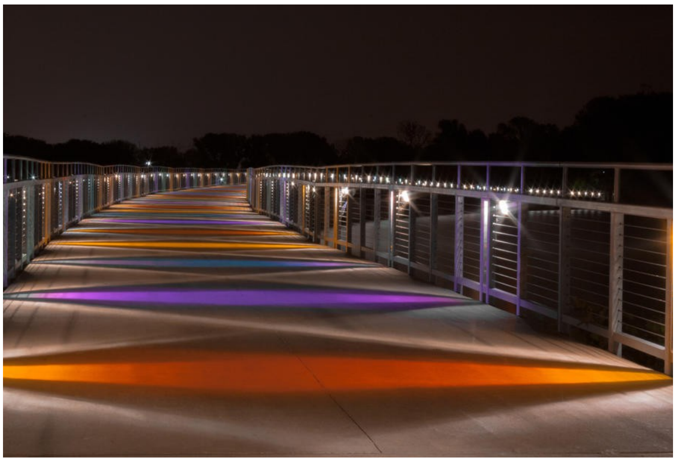


Illustration 21: The lighting of the bridge over Gray's Lake in Des Moines, Iowa. (Photo by: Jeremy J. Einsweiler)

4.3.2 The Mülimatt Footbridge

The lighting of the bridge is characterised by precise placement of LED narrow distribution spot lights. The effect similar to that of the previously named project yet with some interesting differences. Rather than shining the light through the railings, as done in the Gray's Lake project, the lights are embedded into the railings. This makes the fixtures lower in the visual field yet also the light source is hidden helping avoid glare issues.

To analyse the layers, the focal glow gives emphasis to the bridge as seen from a distance. The level of ambience luminescence is extremely low and only from reflected light bouncing from the floor. The play of brilliance that this lighting scheme brings is in the pattern that is created by the light.

The experience of the light of this bridge creates a high luminance contrast ratio between the bridge surface and its background. This can risk creating a luminous veil that hides the background. Something that the design for ABP is trying to avoid.

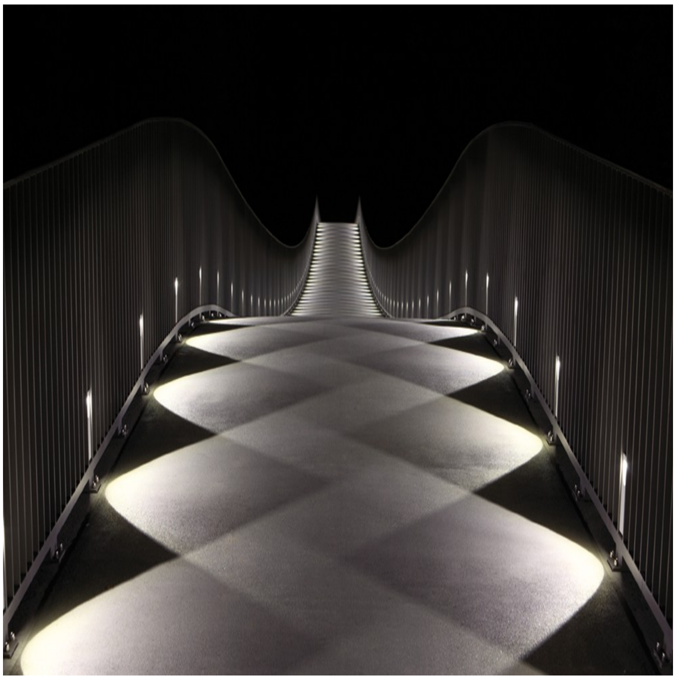


Illustration 22: Mülimatt footbridge oder the River Aare in Windisch/CH. (Photo by: Inventron AG und Rutronik Elektronische Bauelemente GmbH)

4.3.3 Helsingborg Harbour

The lighting of the pavement resembles stars scattered across the floor, although in this case very low intensity lit stars. This form of environment lighting is very focused on acting as a layer with a lot of play of brilliance. The sparkle from the fiber optic tips invites users to interact with the space. The low lighting levels lowers the risk of glare, and enables the views of the scenery.

Illustration 23: The stars on the ground. Fiber optic lighting by ÅF Hansen-Henneberg. (Photo by: Ulf Celandar)

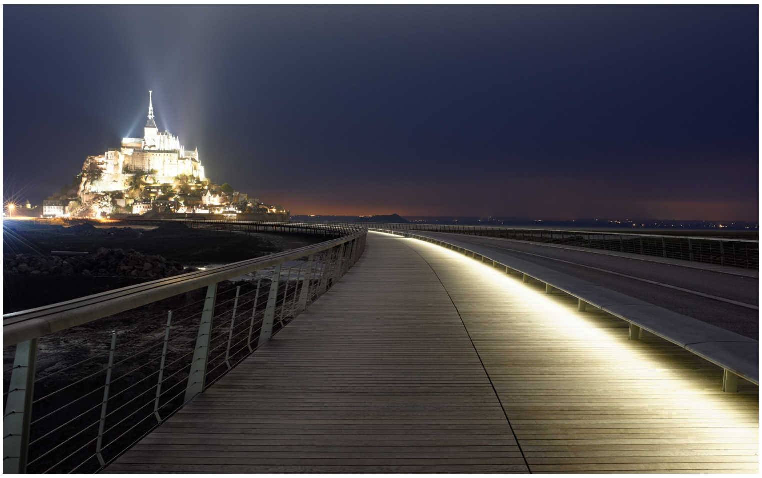


Illustration 24: The Jetty to Mont Saint-Michel. The lighting is embedded into the divider between the pedestrian area and the road. (Photo by: David Boureau)

4.3.4 Dune 4.2

An evolution of a project by Studio Roosegaarde. The installation is located by river bank in Rotterdam, Holland. It utilises small low light LEDs encapsulated in a diffusive materiel. These light sources are placed on flexible rods, and as a whole imitate marsh reeds. The light creates an effect of ambience luminescence on the surfaces, while in itself acting as a play of brilliance. The lights also invite the users to interact with them and the space they are located in. This type of installation is relevant due to the low level lighting element and the way it invites users to interact.

Illustration 25: Dune 4.2, a lighting installation by the river Maas in Rotterdam, Holland. (Photo by: Studio Roosegaarde)

4.3.5 The Jetty to Mont Saint-Michel

The jetty is illuminated along its divider between the shuttle-bus access road and the pedestrian path. The lighting is based upon discreet placement of the light fixtures underneath the divider (see illustration 24). The light given is indirect and diffused, and acts as a sort of guidance tool for pedestrians lighting the path to their destination while not overpowering the view of the medieval village.

4.4 Conclusions – Design Criteria

After looking at the current conditions at the design site it is possible to assess that the sites current condition is not sufficient for the users. This can act as a reinforcement to the existing comments by the visitors of the park in online surveys (see section 3.3 and 3.4) an analysis of some examples of lighting where inspiration can be drawn from it is possible to conclude the following criteria that are used to create the design. These criteria are divided into four groups: Orientation, Aesthetics, The View, and The User.

Orientation

This is due to the importance of human needs for orientation of a space,

- The users should be able to see the edges of the path.
- A sense of horizon should be prevailed as much as possible.
- The lighting should give the user a sense of scale of the path during the dark hours.

Aesthetics

- The lighting must make the path feel as a whole, rather than separate “islands” of light.
- The light should complement the landscaping of the path and not contrast it.
- The light sources would need to be better hidden from direct view. In contrast to what seems visible in the lighting of Gray's Lake Park Bridge.
- The lighting should transition between the day and the night

The View

- Current lighting is non-sufficient for orientation, but the scenery grants a view with a horizon that we find reassuring. The placement of lighting fixtures should not obstruct the view of the scenery, both the city and the sea.

- The light levels should be sufficient yet not create too much of a contrast with the background.

The Users

- The distribution of the light from the fixtures should not act as a discomfort to the users.
- The lighting should be placed so as to avoid being a source of glare towards the users.
- The movement of the users should not impact their ability to see the view, yet enable others to see them and themselves to see others

5 Design

5.1 Introduction

This chapter will run through the process of taking the concluded criteria, featured in the previous chapter, and establishing a lighting design upon them. This will be done first by establishing a concept, followed by some design experiments that will help fine-tune the concept to a final design

5.2 Design Concept

As stated in the introduction chapter (section 1.3), this project has a main focus on creating a lighting design that firstly enables the park to be visited by more people throughout all the seasons. Secondly, that the lighting would not compromise the experience of a walk in the darker environment than that of the city. A reconnection with nature only a few steps away.

The Concept of the lighting design can be divided into four categories:

The Line, The Scale, The Transition, The Movement in Space and The View

5.2.1 The line

The concept developed from the notion of a line (see illustration 27). From the gestalt principle of continuity, the line would be seen and disappear behind dunes and then reappear. The user perceives the connection even with obstacles (see illustration 26).

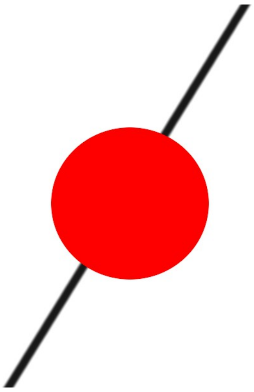


Illustration 26: An example of the perceived continuity of a line behind a circle. Even though the line could in fact be two separate parallel lines we perceive them as one creating a bigger meaning out of the the small pieces.

Illustration 27: An early sketch of the lighting showing a line of red light, and an array of floor grazing spots. (photo by: Jonathan Jones)

The light that marks the edge of the path is to be used as a way of orienting ones self with the paths passage through the darkness. Like looking at a line of dim firelight, resembling the light of embers keeping the night alive. This is also inspired by the effect that the city lights create when day turns to night. The sky is illuminated with a warm orange glow that verifies the existence of life in the dark.

This idea of the concept addresses the design criteria regarding the users perception of the path edges.

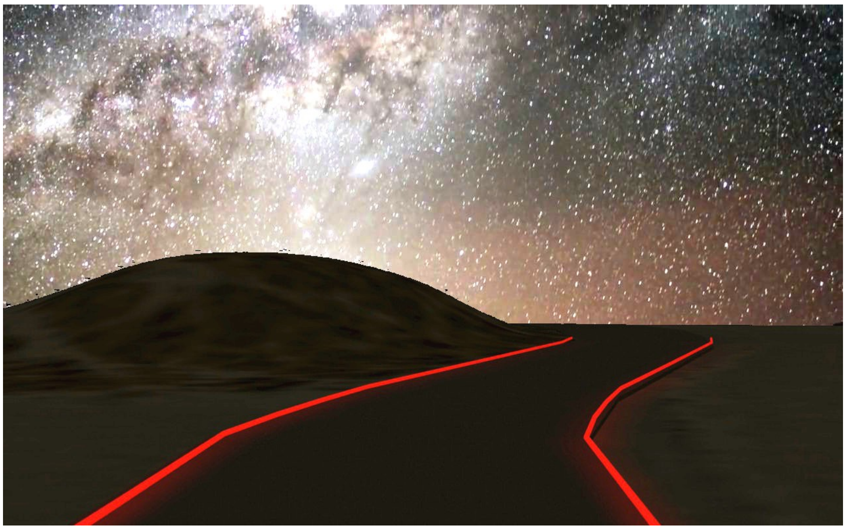


Illustration 28: Concept render. Two red light lines that run along the edges of the path AS.

In order to avoid glare the light fixtures will run close to the ground within a low cove. The luminance of the light source and the surfaces it hits should be low to avoid contrast that leads to glare. Also this feature would enable the lighting to complement the landscaping rather than work against it.

Illustration 29: A digital interpretation of how the line of cove lighting, on its own, would affect the current lighting.

5.2.2 The Scale

The light of the line is joined by a chain of lights that, at a normal angle to the paths edge, shed narrow light beams. The light creates slices of space where it hits matter Since we only perceive light when it reflects off of something. In the case of the path it will be the people passing by. The light is not to be constant, but fluctuating. The visitor will In the larger perspective the fluctuation will resemble the flicker of roadside lanterns fluttering ever so slowly in the wind. This will add a dynamic part to the experience of walking through the light.
The distance between each slice of light is constant, giving the visitor an indication of space and scale to the path. At the same time the distance between each slice of light should not be to small as to not take away from the main attraction: the view. This is inspired by linear perspective, lines that converge in the distance create the sense of depth.

Illustration 30: A sketch showing the principle of how the light will enhance the perception of scale.

5.2.3 The Transition

The transition of the day to the night, light to darkness, is to be accompanied by a transition of the light that illuminates the path. From the analysis of the existing light environment (see section 4.2.1.1) it is mentioned that when the sun sets in the east behind the city "wall" of buildings the sky light changes. On a cloudy day the colour of the sky can go from a white light of the diffused sunlight in the clouds to a warm orange colour of the lights of the city lighting up the sky. The line of light and the lines of scale will adapt to the light of the sky by adjusting the temperature (correlated colour temperature) of the light from a high kelvin to a low kelvin throughout the sunset and the opposite for the sunrise. This gradient will shift in a similar tempo to the shift of the sky light. Hence adapt to adapt to the surroundings in a camouflaging way.

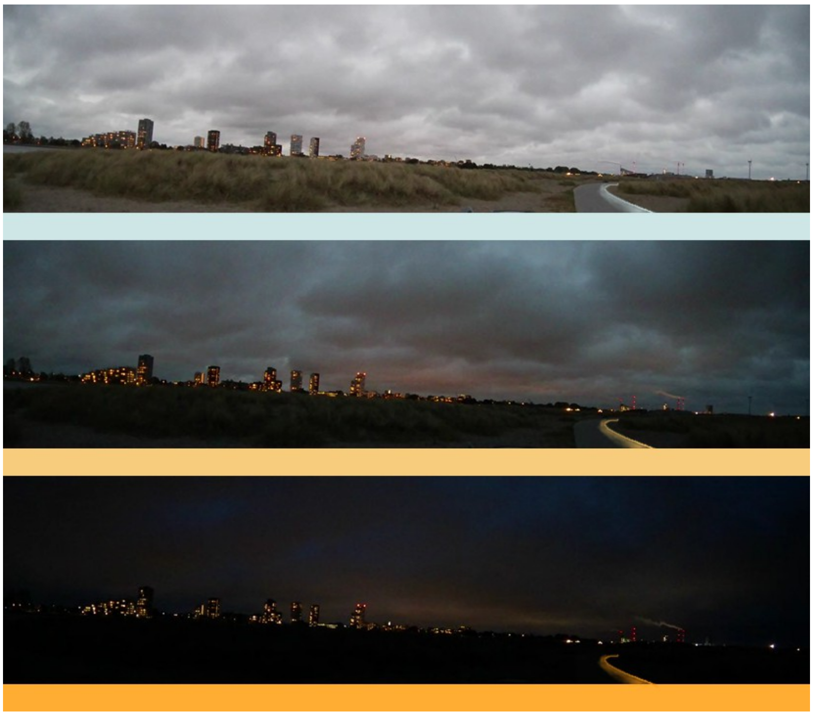


Illustration 31: Concept of the transition of the lighting in accordance to the affect of urban light spillage into the sky. Taken 23-10-2017.

5.2.4 The Movement in the Space

Walking down the path that separates between the light of the city and the dark of the sea. The perspective of the user can change drastically, and with it the experience of the visitor. Walking down the path is adding another dimension to the concept.

The narrative of someone walking down the pavement can be described using Gestalt theory as an experience of walking along the threshold between darkness and light. Light will guide and orientate the visitors in the physical space. At the same time, the same light will guide and orientate the user regarding the position of other visitors. The light that enhances the sense of scale will also visually reveal the visitors when they pass by them. Adding a layer of experience for the user. Not only experiencing the effect of the threshold but also experiencing others move through the space and become an active part of the experience themselves. This is according to the notion, by Jan Gehl, that the negative affect of insecurity related to darkness can be negated if enough people are present (see section 2.5.1).[Gehl, 2010]

But the meaning of movement through the space is also way of interacting with the space. The lights that help create the environment of the space also help in encouraging the visitors to interact with it. As stated in section 2.3.1.4, the light is inviting the visitor to interact with the space.

To conclude in one sentence; the interaction of the users with the light throughout the space drives the movement in the space.

Illustration 32: A sketch of the how the scale lights will illuminate those that move through them and by doing so illuminating their movement.

5.2.5 The View

When walking down the path the experience of the visitors should be of a line of light that orientates them through the path, yet mostly it is important that the light itself does not take centre stage over the night scenery from Amager Beach Park. It is the night scenery that is the “main event” for the those that visit the beach. Adding light should not detract from that experience, only enhance it.

The lighting does not serve as a distraction for the view of the night sky, light of the city, and darkness of the sea. It only acts as a form of guiding light along the path ensuring those that walk it that they are safely doing so.

To make the lighting connect more with its surroundings., an element of intensity fluctuation inspired by wind and the way it influences the beach-grass. The light would embrace an organic feature that would travel along the line of light and spots. This would add to the dynamics of the lighting design (see illustration 33).

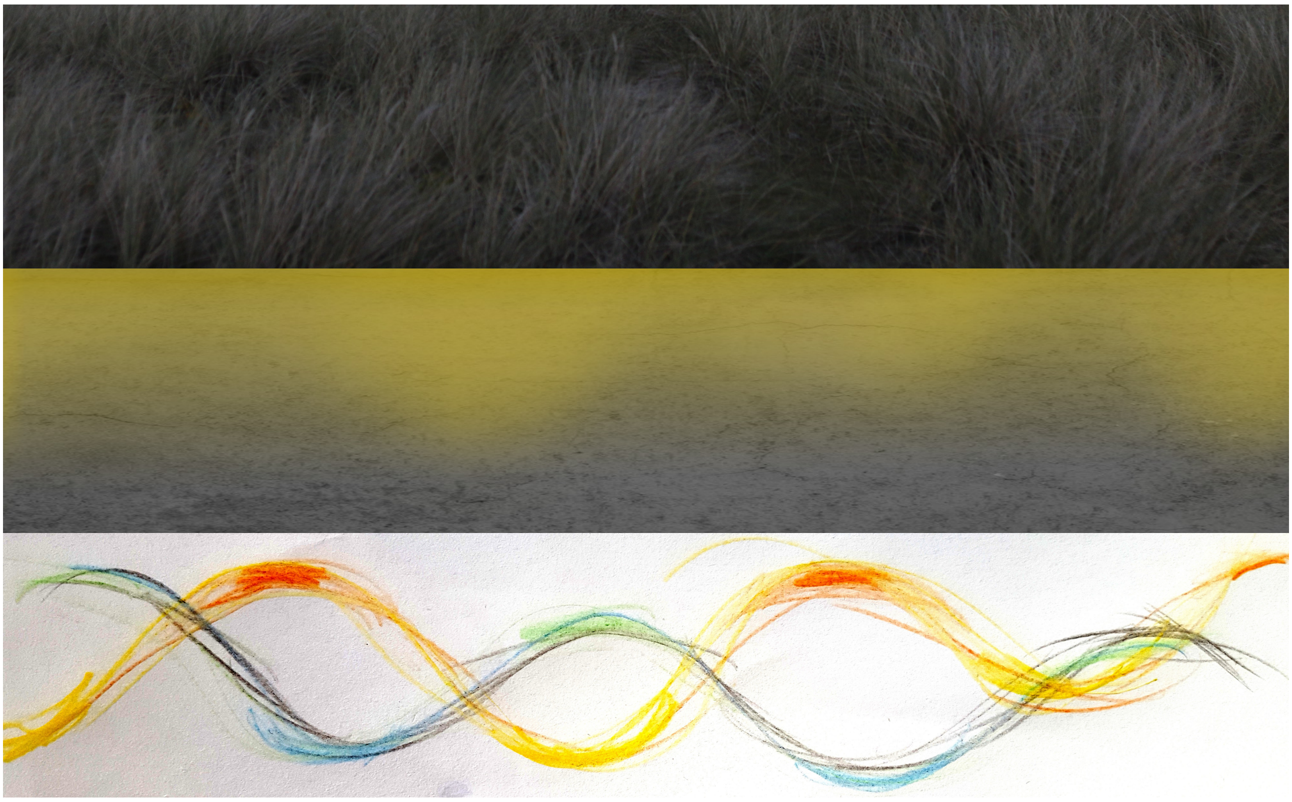


Illustration 33: The concept of waves of wind rushing through the beachgrass. the yellow/red line resembles the light colour, while the blue/green line resembles the amount of wind.

5.3 Design Challenges

To make sure that the design would comply with the criteria a number of experiments were carried out. A group of sketch renders of possible light placements and fixture on correlation to a layout of a section of AS. Each render will explore the different aspects of the light distribution.

Even so Juhani Pallasmaa refers to modern architecture too guided towards the visual render, therefore some experiments will be made on site so to provoke the senses with a closer experience to that which is planned.[Pallasmaa, 2005]

This experiments that were carried out were with the following goals in mind:

- Testing the Affect that Addition of Light Has

  Finding out how the addition of light will be perceived by visitors, and how light added interacts in a qualitative manner with the existing lighting conditions.

- Fixture Placements

  An experiment to see how the light fixtures should be distributed in the space in order to fulfil the design criteria and the concept.

- Angle of Light Distribution

  To find out what type of light distribution will direct the light in a way that meets the design criteria and also based with concept in mind.

- Finding the Appropriate Flux

  Finding the threshold between too little light and too much. In the case of darkness the latter is more of the case.

- Finding Adequate Fixtures

  An insight into the considerations of different lighting fixtures.

5.3.1 Testing the Affect that Addition of Light Has

When adding light fixtures to a space it is important how it affects the existing lighting and also the perception of the space in general. In the case of AS a test of adding light was conducted to find out whether the light could be perceived and in what way. As a side observation the test was looking at whether the addition of light attracts visitors to the location.

Illustration 34: The test was inducted on location at ABP. In the background is the light from an industrial area north from the site. The fixtures were placed with 4 meters spacing on the edge of the path facing perpendicularly towards the opposite edge.

The test was conducted using 6 battery driven LED tea lights that fluctuated in lumen to resemble a flame tea light. Due to weather conditions the tea lights were put in jars that were wrapped in aluminium foil except one the bottom. The tea lights were set along the edge of the path with the foil free end facing inwards to the path at a 90 degree angle to the path.

Illustration 35: An improvised tea light fixture minus the aluminium foil, used to test the addition of light and later on the fixture placement.

This test, based upon the knowledge gained in sections2.2.1 and 2.2.3, wanted to find out how the addition of low light sources would affect the current lighting that is primarily from the urban light spillage. It is basically an initial test to find whether the background lighting (The city) would drown the lighting of the tea lights or will the tea lights be perceived even though they are not very powerful.

The results were unanticipated. The tea lights, even though they are very low in intensity (app. 1 lumen) the light was extremely visible. Especially when entering the periphery vision. This means that the lights should be placed in a cove that will avoid direct vision of the light source.

In contrast to this the light was not as visible on the floor as when it hit passers by. This is probably due to the angle of incidence between the light and the floor.

5.3.2 Fixture placement

The fixture placement is connected to how the users perceive the space as a whole, so it is not only about where the fixture are present but also where they are not. As it was explained in section 2.4 the gestalt is the experience of the whole and not the sum of its parts.

When planning the placement of the light fixtures it is important to test whether the fixtures placement fulfil the design criteria. The placement of the fixtures needs to be seen in context with the use of the path. The fixtures should be placed low as to not obstruct the view. Yet also need to maintain a height as to be able to illuminate the path more equally.

This was decided by creating a mock up of the path at the studio at Aalborg University, and also with Dialux renders.

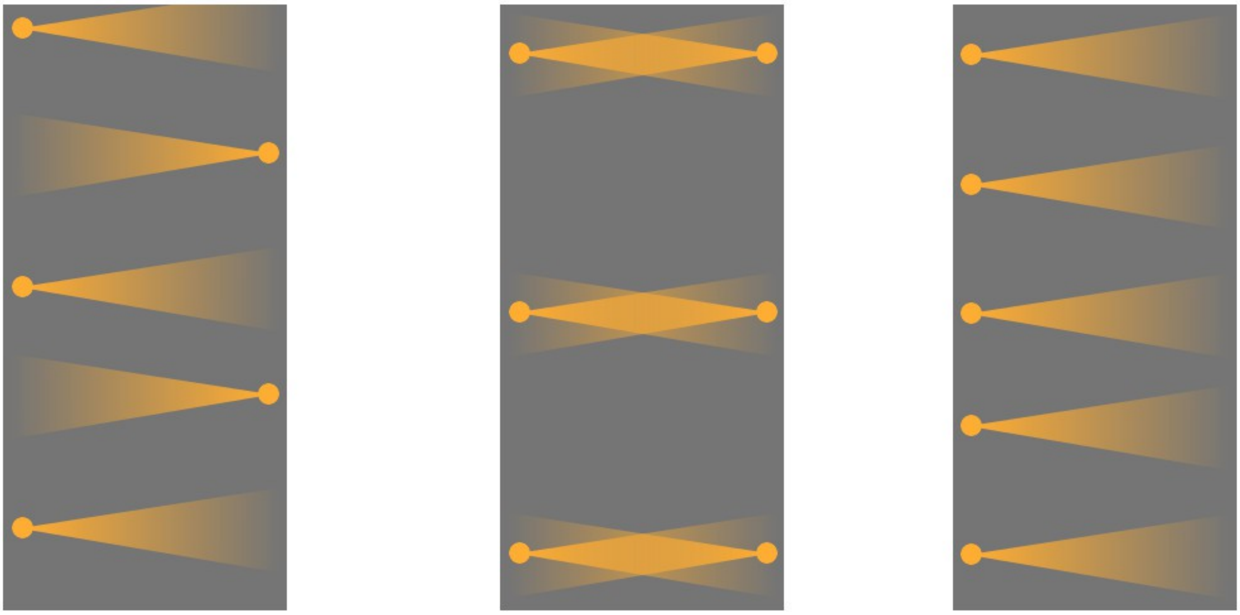


Illustration 36: Different methods of creating placing the narrow spotlights along the path edges.

The mock up of the of the path was created using a carpet with a pattern resembling the path and six LED tea lights. The tea lights were placed on the carpet in different compositions to assess the overall image that they will create. The test included multiple placements of the tea lights according to structures of fixture placement that can be seen in illustration 36.

Illustration 37: Test of spot placement between sawtooth placement (right) and linear placement (left)

The concept of the line brings the light to the edge of the path. This is also as part of the criteria to complement the current landscaping rather than create something new.
Therefore the test examined whether the light should be placed on both sides of the path, the edge of the path closer to the city or closer to the sea.

From qualitative observations it was decided that out of the different options, the line of light was most appropriate for the location. This decision is based upon light spillage. Although this project would like to minimise the light spillage to a fully it understands that it cannot avoid it, however it can control in which direction it is more concentrated. By placing the fixture on the edge of the path closer to the sea facing the city. The light spilt from the path will create less of a visual contrast between the park and the city. Maintaining the views to the city. If the light fixtures were to be placed towards the the sea it would create a higher contrast level between the background (the dark sea) and the mid-ground (the dunes) causing a veil on the details in the darkness. This can be better understood by looking back at section 2.2.3 about

Regarding practical matters of safety and maintenance, the fixtures are to be placed at a height that makes them easy to step over, and easy to maintain.

5.3.3 Angle of light Distribution

The angle of distribution of the features is important to test due to the risk of glare in dark conditions. This connects with the sections about visual field (section 2.2.2) and glare (section 2.2.3.2).

During a test of the affect of adding light it was noted that the shielding of the light sources was not sufficient. The light source within the fixture seemed to create a luminous veil (see section 2.2.3.2) that disrupted the view to the darker area. A way around this was to place the fixtures in a cove. The majority of the light that is distributed towards the path will be cut-off by a ledge.

This test in Dialux examines the aspects of shading the light fixtures. How tall can the shading be and how deep should the cove be.

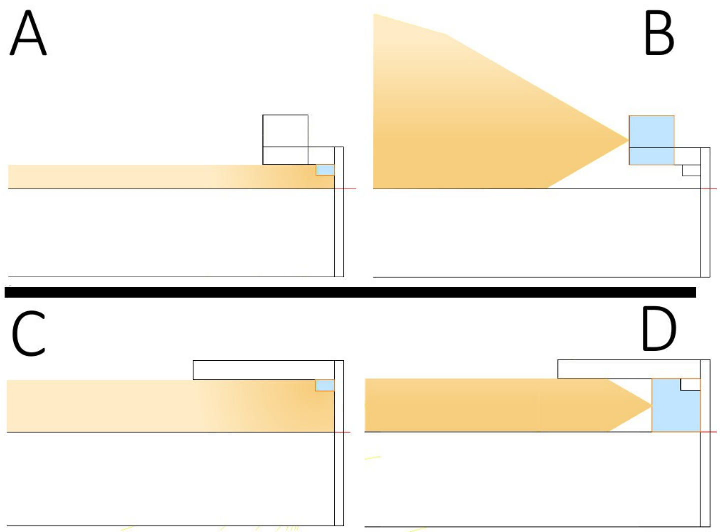


Illustration 38: Shading test. Two scenarios with each two types of fixtures.

The test paired many steps but for the sake of example the image above (see illustration 38) will show some of the process. When looking at whether the spots should be placed under the cove or on it a demonstration of possibilities is made and judged for pros and cons. Picture A and picture B are from the same plan and show each type of fixture and its distribution, where A is a light strip and B is a spot. In this example it can be seen that the light from the LED strip in image A is narrow in distribution once it leaves the cove and therefore is less efficient at lighting the opposite edge of the path. A pro point for the angle of distribution in image A, is the way that the fixture is not shining in an angle will cause glare thus fulfilling the design criteria. The narrow beam in image B, however, is not fulfilling the criteria for avoiding discomfort to the visitors via glare. It is placed above the cove and risks creating glare. In images C and D the narrow light beam is placed under the cove so as to block the beams distribution from reaching the head of an average sized adult. The cove is also wider and higher in order to enable the light from the LED strip to reach the other side of the path while remaining out of direct sight. The effects of the distributions can be seen in illustration 39.

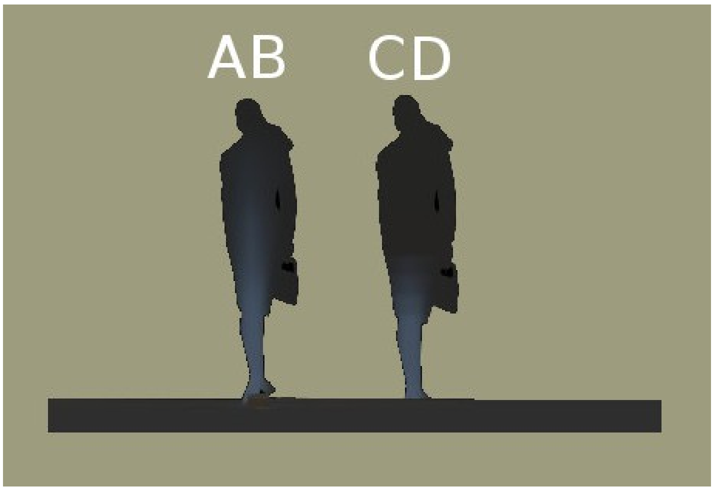


Illustration 39: The distribution cut off affect on a vertical surface (a person).

The results from this test is that the light should have a certain cut-off point that will make it extremely difficult to create a situation where the user is suffering from glare from direct sight of the fixtures. Also that the light distribution of the spots that illuminate the visitors briefly as they pass by are to have a narrow distribution. This is to avoid situations where the users will be vulnerable to disability glare (see section 2.2.3.2.1).

5.3.4 Finding the Appropriate Flux

Once the placement of the fixtures are tested, the adequate angle of light distribution per light fixture defined, it is important to find out how much light should the fixtures emit in order to achieve the desired affect in the concept.

To find the amount of lights that seem to be most sufficient a simulation that tested the difference between two setups of identical fixtures. The setups used are the same that are mentioned in the previous section (see illustration 38), the combination of A and B and the combination of C and D.

Once the the more adequate is declared a variation of the light intensity is used to find how much lumen each fixture should emit.

Since maintaining darkness is essential for the project, the light levels needed to be tested in order to get a level of light that was efficient. Because of this the light levels need to be very low. This can create some issues in testing via a simulation program instead of on site. The biggest issue being, not being able to see how the environmental lights (urban light spillage) affect the lighting levels. The doubt is tied to the way we see in the dark (see section 2.2.1.2).

Another problem with testing the quantitative levels on site is the that most instruments for testing light levels are not able to accurately represent very low light levels.

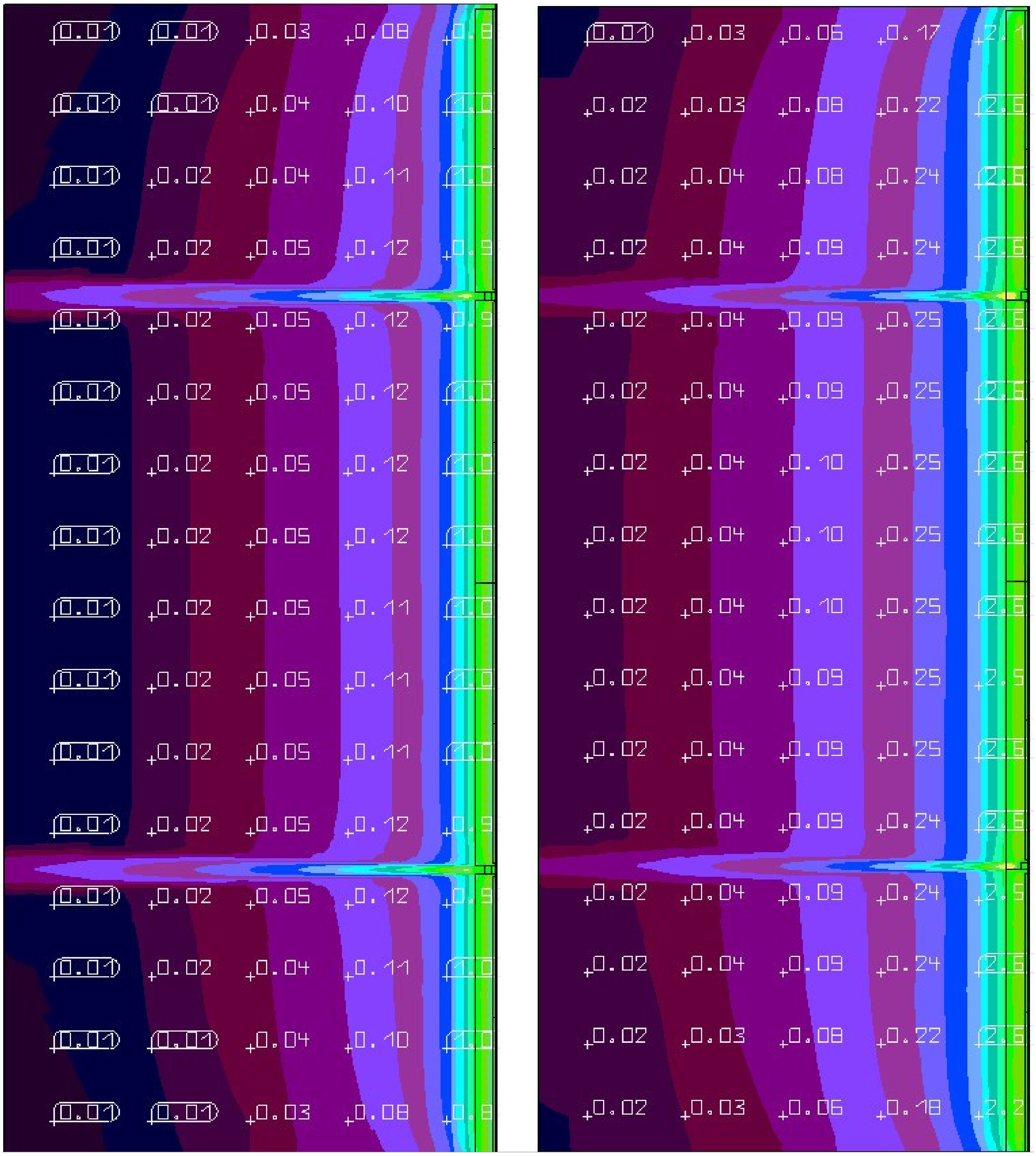
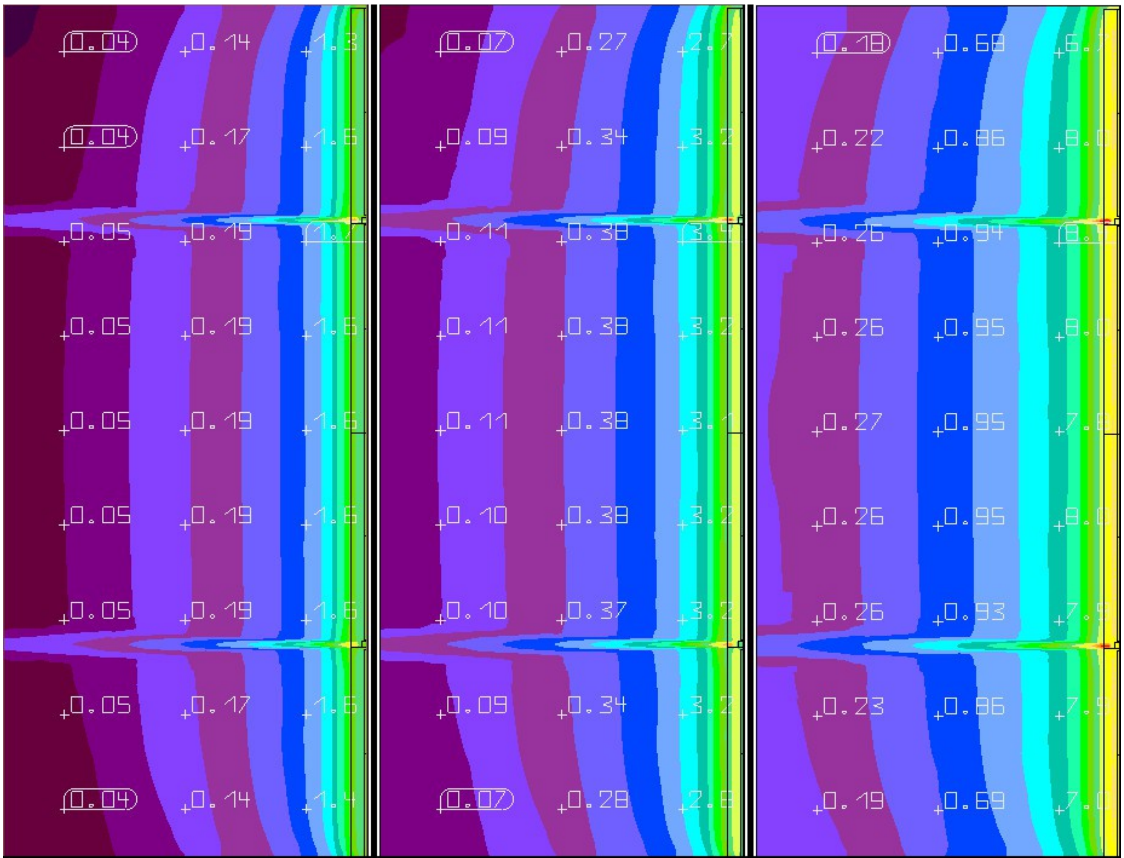


Illustration 40: A calculation of the lux distribution using the previous examples of lighting distribution (see illustration 38) from section 5.3.3. (left) Uses the fixture distribution of fixtures A and B, while (right) uses the fixture distribution of fixtures C and D. The fixtures are set at

When looking at the calculations (see illustration 40) it is apparent to see that the fixture placement of C and D is better at creating a more uniform wash of the pavement while maintaining the lighting that give the impression of scale.

The test was performed in the light Simulation program Dialux.



LED strip	42 lumen	84 lumen	210 lumen
Narrow spot	74 lumen	148 lumen	370 lumen

Illustration 41: A comparison of three different levels of lumen using the same setup on a section of the path.

5.3.5 Finding Adequate Fixtures

In the search for a solution to the different aspects of the design, diverse types of light sources were considered and chosen. Below are a few examples of light sources that were not added to the final design, and some that were.

Among the consideration were how the fixtures would complement the theme of the design concept, and which fixtures were suitable for the environment of the lighting. Due to the ABP being low and close to the sea line it is prone to being submerged or damaged by sand/dust. Because of this, any considered light fixture can be excluded if it did not have a reasonable IP rating[3].

Creating a Line:

When looking at how to implement the line different methods came to mind. The first type of fixture utilises the internal reflection of fiber optics to transfer light from a source through a cable to the other end where it escapes. This type of fixture is interesting since the main source of light for the fixture can be hidden. While researching this fixture it came apparent that this fixture could also be equipped with a fiber optics cable that is side emitting. Further more that in Skive, Jutland, the same type of product is used to light the edge of a roundabout.

The problem with this type of fixture is that it is not available to test in lighting simulation software. Other than that, it is not as dynamic and variant, as said LED strips which can be very versatile.

Another light fixture that came to my attention was the Electro Luminescent (EL) wire. The way the EL wire is constructed with a very thin copper wire coated in phosphor that gets excited when alternating current is run through it. The problem with this fixture is that it has a tendency to fade after time, and is relatively fragile.

The LED strips fulfilled all of the needs for the fixture to create an ambient line of light. It has flexibility that lets it be placed in small places, and it comes in a huge variety of IP ratings to suit the need of any project.

Also due to the way the line, with the design concept in mind, will fluctuate as an abstract representation of wind flowing through the beachgrass. The LED strips offer flexibility.

To create the line a led strip from ProLED was tested although there were alternatives that could be tested in future variations of the project that could also be compatible.

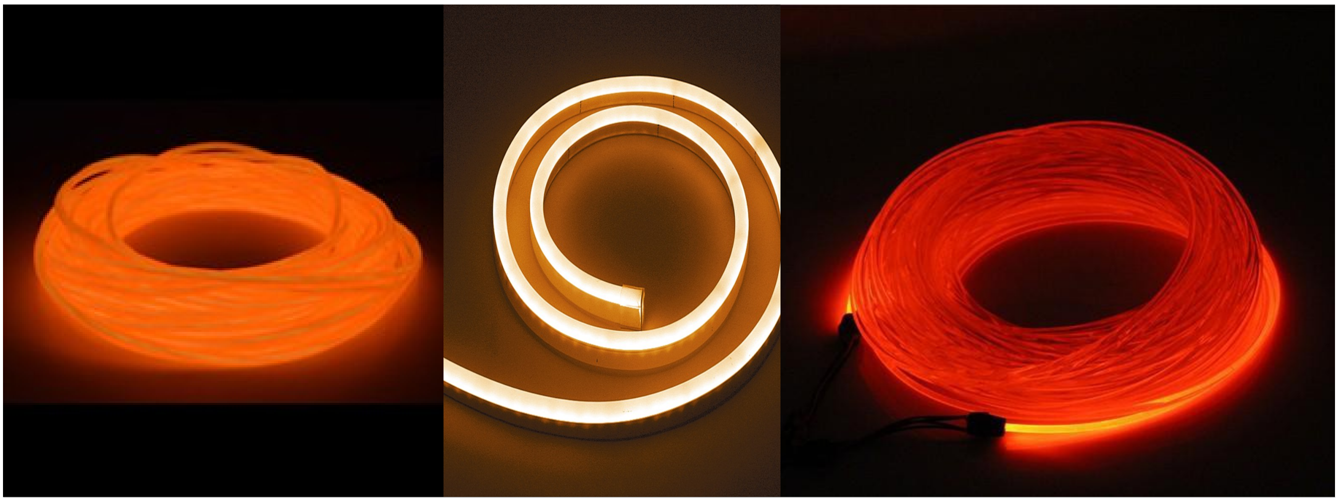


Illustration 42: From left to right: Fiber optics side emitting cable, LED flexible strip, Electroluminescent wire.

3 IP ratings help define how water proof a light fixture is and how prone it is to have dust/other foreign articles inserted into it.

Giving the Impression of Scale:

The fixtures that were taken into consideration were chosen for the way that they enable the visitor to get a grasp of the scale of the path during the dark hours. This is done by testing a few parameters.

- The distribution – That the fixture is coherent with the conclusions of the tests regarding light distribution
- Controllability – It is important that the light intensity of the light fixture are able to be scaled in and Colour Correction Temperature (CCT). In order to comply with the criteria regarding transition.

With these parameters in mind, one potential fixture was used. An effect light from iGuzzini.

This was the only fixture that was considered due to its unique asymetric distribution that can be seen in the Appendix (see section 9.2.2).

Illustration 43: An effect lighting fixture with a very narrow distribution of light.

It is important to note that any fixture that is chosen to be included in the final design is a matter of recommendation that is based upon the features it has. Any fixture that shares the same features can be used.

5.3.6 Results

The conclusions of each of the design challenges are summarised and reflected upon here.

A better understanding of the light conditions was gained when experimenting the addition of light to the current lighting environment. The light from the surrounding electrical lighting (see section4.2.1.2) was suspected to be too powerful an influence on the lighting of the beach for any subtle lighting effect to succeed. It was thought that there was too much light and that the addition of light would have to be done by adding a higher amount of light. This preconception of the situation was due to the theory regarding contrast and uniformity (see section 2.2.3) regarding contrast and perception of luminance. But during the test it was obvious that even though the difference of luminance was so different between the background (city) and the foreground (the path) the point of view of the user was more of a decisive matter. Even a little tea light, in the right context added a lot when it was isolated against a darker background. Therefore it is important to make sure to "hide" the light sources.

The next step was to create an understanding about how the fixtures should be placed in order to both coincide with the design concept and apply the knowledge from the previous test. A comparison between different layout of fixtures resulted in a layout of fixtures that support the concept of a line of light hugging the edge of the path. The different layouts that were compared were all planned with the design criteria in mind. This test initiated a decision to place the line only on the edge of the path closest to the sea. This was due to the matter of the light that would spill from the path onto the surroundings. It is better if the light spills towards the city than the sea because of the contrast between the foreground and the background.

This led to a need to understand which light distribution each of the light fixtures would have in order to fulfil the concept within the borders of the design criteria. This test is more about defining how the light will

To help conclude the results from the different tests into one summary the knowledge from the theory chapter regarding´lighting challenges and also lighting design theory will work as a tools

5.4 Final Design

Based upon the design experiments a final design is set together. A lighting design that utilises the gestalt theory of continuity and subtleness, and creates an environment that future visitors of Amager Beach Park will be able to experience. They will be able to walk through a space on the edge of urbanity and encounter nature and darkness. They will find orientation via a line of light.

This Line of light will enable them to see the path that they walk upon, but also others that are interacting with the line of light. The light though is a subtle part of the space as it is not there to be in the main focus. The view is. The view is what brings the visitors to the park. The light should be something that enables the visitors orientation and direction in a careful way. And although this experience is only whole when all the pawns are in place. The design itself can be broken down into four layers of focus:

- The Line – Lighting that acts as a guide for the slow movers that traverse Amager Strandstien.
- The Scale – Enabling the slow movers to perceive the scale of the path even in the darkness. By doing so help the slow movers perceive the path while they traverse it, but also help them perceive others that traverse the path.
- The Transition – Creating a transition that integrates the electrical light with the changes of the colour in the night sky. The transition is inspired by the light glow that is caused by the urban light spillage into the sky.
- The View – Enable the slow mover the view of the dark scenery that makes Amager Beach Park unique.

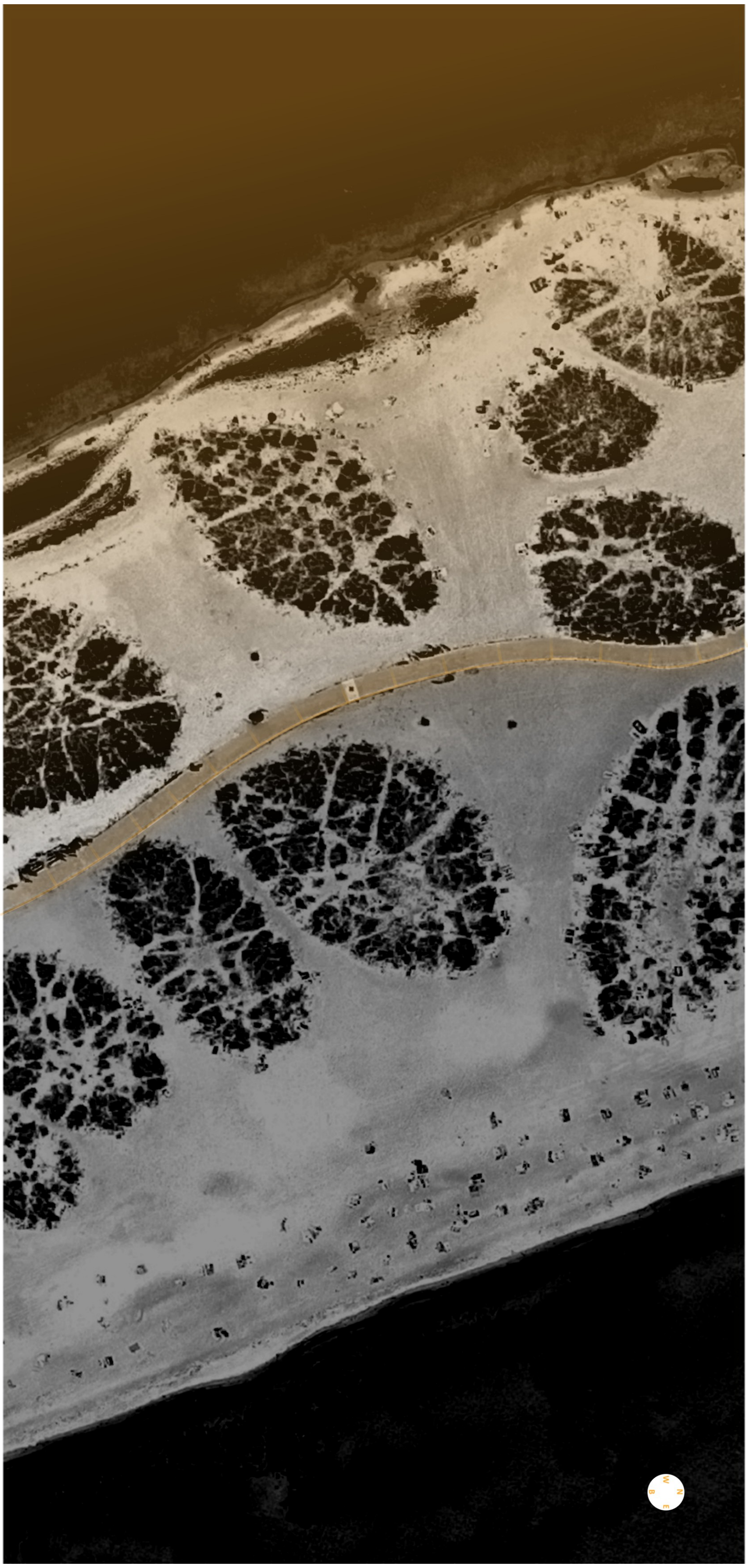


Illustration 44: A birds-eye view of a visualisation of the Final Design

5.4.1 The Line

Illustration 45: A visualisation of the line of light acting as a directional cue and an orientational device for visitors during the dark hours

Utilising the flexibility of the LED Strip, the light hugs the edge of the path and illuminates the surface of it. The fixtures are located in a cove that is 76mm tall from the surface of the path and 160mm wide. The LED strip is placed in the top corner of the cove facing away from the cove wall, and is set to 20% of its power (42 lumen). A more in-depth description of the fixture can be found in the appendix (see section 9.2.1) The strip is programmable and can therefore support the transition between the day and the dark. The line acts as an orientation device yet also a directional cue for the visitor.

This aspect of the design fulfils the following design criteria:

- As stated above, enhances the users orientation by making the edges of the path more visible. It is done using the gestalt theory of continuation of a line to guide the user through the park.
- The light is created to guide, yet as the design criteria state, the light should be a continuous connected flow of light to make the path feel as a whole and enhance the feeling of orientation.
- The line of light is set to be at the edge of the path not just for orientational reasons but also for aesthetical ones. The light complements the path and the landscaping in following the

curves that path creates.

- The light from the line should not be either a discomfort or a source of glare to those experiencing it.
- The light source are to be hidden in a cove that restricts the vision of the light sources, but also restricts the distribution of the light sources so that the previous point should not occur.

5.4.2 The Scale

The narrow beams of the effect light create layers in which the lower parts of those walking through the path are caught for brief moments (see illustration 46. For the purpose of visualising this part of the design, the effect is being created by the use of a light fixture by iGuzzini. With its narrow beam that creates a line of light it was ideal to create the effect of motion through space. Also the effect of the lines create a pattern that help the observer gain a better perception of the scale of the path during the darkness. The fixtures of the scale effect, like those of the line, are set to 20% intensity with an output of 74 lumen. This fixures specifications can also be found in the Appendix (see section 9.2.2)

The design criteria that the scale effect fulfils are as follows:

- To give those walking on the Amager Strandstien path a better perception of the scale of the path. The scale effect is inspired by the linear perspective often used by artists to create a notion of depth.
- The same lights that give the user the perception of depth give the user also the perception of other users move through the path.
- As the Line layer, this layer is also responsible to making sure that none of the the passer bys is either discomforted or suffers from glare due to the fixtures.

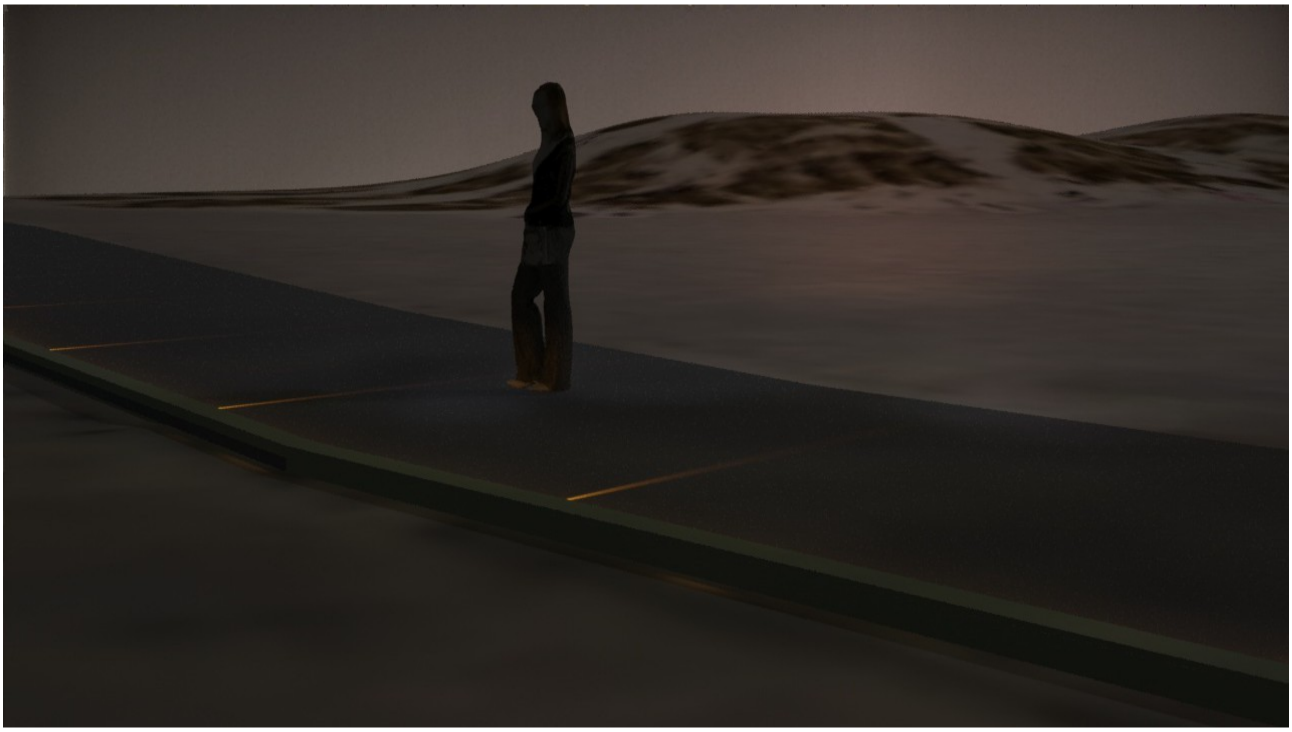


Illustration 46: A visualisation of the scale effect up close.

5.4.3 The transition

When the day ends and light turns to dark. A transition of light in the sky is created. This transition is what has influenced the effect of the transition layer. The sift of the correlated colour temperature (CCT) between 6000 Kelvin during early dusk to 4000 during twilight until it reaches 2000 Kelvin during the night. In the morning the transition occurs in reverse from 2000 Kelvin during the darkness, towards 4000 Kelvin during earl dawn, ending at 6000 Kelvin.

Illustration 47: A visualization of the transition effect in comparison to the night sky. (top to bottom) 2000 Kelvin, 4000 Kelvin, 6000 Kelvin.

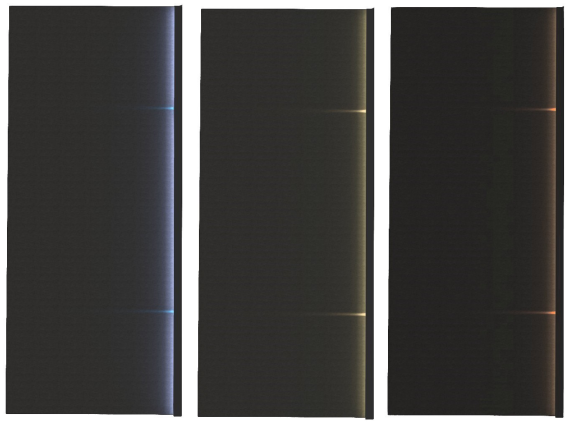


Illustration 48: Transition between the different states of white light, from 6000 K (left), 4000 K (middle), and 2000 K (right)

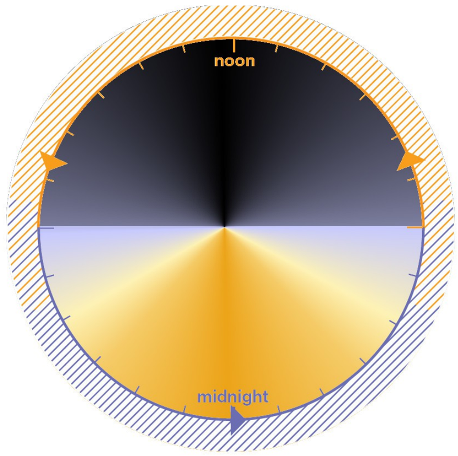


Illustration 49: outer ring shows the light hours of the day the inner fill shows the corresponding light Kelvin.

This layer fulfils the design criteria which notes that the lighting should transition between the day and the night.

5.4.4 The View

Due to the scope of the project that is trying to avoid addition of distractive elements that would take away from the experience of walking in darkness in an urban nature park. It is important to show that the lights do not detract from that experience. This design is maintaining the views that people are used to seeing.

These following points are considered in the final design in order to prevail the view yet enlighten the path:

- It is important that the sense of the horizon is not obscured. The preservation of the horizon is essential for orientating one self (see section 2.3.2.2.1)

- This is done by avoiding fixture placement in areas that can obstruct or impair the vision of the horizon or the view in general. This is avoided by placing the light fixtures low and within the physical restraints of a cove.
- The light should however not be too intense as to create a luminous veil due to discomfort glare. Therefore the lights are at low intensity in accordance to the luminous flux test described in section 5.3.4.

Illustration 50: The view should be enabled despite the addition of light.

6 Discussion

When writing a report it is important, and difficult, to create a broad understanding of what could have influenced the results. This is true for both the bad influences (bias) and the good ones (inspiration). Furthermore these influences can be discussed on two levels, the micro and the macro.

6.1 *Micro Influences*

The projects starting base is built upon the influence of one persons perspective and conception of an idea based upon an observation, that light was being used to enable the orientation of people through spaces. But at the same time the light was erasing the darkness. The idea that using less light, but do it in a way that respects the darkness is the drive behind the project.

But not everyone is under that impression as we as individuals have different perceptions of how things should be done. Fortunately, by gathering data from individuals it is possible to group them under mutual motives and navigate the project to apply to the motives that we agree with. In the case of this project at section 3.3 Online Survey, the majority of the respondents to the online survey had answered that they find the current lighting at Amager beach park (ABP), and also specifically Amager Strandstien, to be inadequate. But not with an outstanding margin. This could incline that nearly half of the respondents do not wish any additional lighting to be added to

Amager Strandstien. Yet this is also a hint a problematic question that has defined that there is an issue with the lighting beyond the individuals opinion. A more nuanced range of answers could have helped, yet the issue is not what people answered but what they pictured their answer resembled. Asking people in person, when they answer that they find the lighting adequate because they do not want the nature inspired part of the island into a lighted urbanised pavement.

Another aspect that needs to be taken into consideration regarding for whom is the lighting design intended. The research question is targeted at the slow movers of the beach, yet the discussion should be; How does the final design include the fast movers? The easy answer is that we do not know. But one can assume that the lighting should not have much of a difference in how it affects the fast movers more than the slow movers. The only part of the design that should be tested is; How does the scale lighting affect the perception of the fast movers (especially the cyclists)?

One of the biggest issues the project encountered is the paradox of lighting for darkness inherits another paradox regarding the feeling of insecurity. One of the ways of tackling the feeling of insecurity is to create a level of lighting and distribution that allows people, in the space, to be seen. Most importantly is the vertical illumination of the faces. This enables the perception of the emotional state that the person is in. The problem with this, in the case of the current project, is the glare potential that it brings with it. It is not possible to remain the natural vibe of the space and have it illuminated entirely. While at the same time light that is only aimed at the people will create either discomfort or in worse situations disability glare.

6.2 *Macro Influences*

In the broad scientific spectrum of how this project can influence future projects. The conclusion that it is possible to enhance orientation of the users while respecting the darkness. In future projects it is important that this matter is brought up. When we introduce light what are we taking away? If the answer is nothing then that is a safe call to make, but when answers like removal of an opportunity to experience darkness in a natural inspired environment, the designer must reconsider options that go beyond the standards that are handed down (if applicable).

Another thing that can be taken away is how easy lighting can create interactions without much effort. When consulting the theory from Richard Kelly it was possible to see that as a whole it did not fit to the project with mostly due to this project lack of any “play of brilliance”. In its core it is to be a minimal addition to the setting. As minimalism is applied it is usually the more powerful attributes that are left in a project. For instance the transition of the lights with the transition of the day.

7 Conclusion

This project has been an ongoing process of understanding how to create an experience that is both visible and hidden at the same time. Beginning from the theory that helped understand the perceptive nature of the eye in order to be able to design for the eye and also helped with the planning of the design experiments. With the use of light theory it was possible to create a better description of the lighting design.

An analysis of the site and the area it is located in helped understand what type of location it is and what stories it may have to inspire. The answers from the online survey being afraid of losing the view of the dark towards an industrial zone. Creating a definition of the different types of users and also a research question.

The research question was followed by the methods chapter. An analysis of the site was made. This gave a better understanding to the affects of current lighting conditions. This was followed by a small list of inspirational profiles of lighting near urban settings with the intention and thought behind the use of light on a site. With this completed the presentation of the Design criteria is presented as a conclusion for the methods chapter.

In the design chapter the concept is presented. It is based upon the design criteria. To find a lighting design solution on how it would be possible to create the narrative of the lighting design. One of appreciation for the darkness. But first to get to that point an accumulation of design experiments and previous information helped mature a design that looks to reserve the darkness so to humbly apply light. The transition between night and day is very poetic in itself, marking new beginnings and ends that are bound to return.

This project although is based around a motivation to create better lighting in general for all visitor of Amager Beach Park is mainly focused on one research question:

To what extent can a lighting design ***preserve the night views****, while*
enhancing the level of orientation *for* ***slow movers*** *throughout Amager Strandstien?*

Although the lighting was not tested on site, the multidisciplinary knowledge that was gathered through out the design process, from the research of theory to the design experiments, enabled a final design. This design will enable future slow moving visitors of Amager Beach Park to walk along Amager Strandstien and enjoy on one side the urban view of a skyline while on the other side a dark view of the sea between the sand dunes. When they move on the path they will be seen by other visitors that are traversing the path. All this happening in the moment while throughout the night the light transitions in regards to day cycle.

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9 Appendix

9.1 Online Survey

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QUESTIONS RESPONSES 47

Amager Strand Stien

Som en del af mit speciale om belysningen på Amager Strand Stien, har jeg brug for nogle svar med henblik på brug af Strandparken i de mørke timer. Herunder er præsenteret et kort af parkens placering og den specifikke sti, som jeg arbejder med.

Den rød streg på billedet markerer Amager Strandpark
Den blå streg markerer Amager Strand Stien.

Amager Strandpark ved Amager Øst

Hvad er din alder?

11-30

◯ 31-50

◯ 51+

Hvor mange gange om året besøger du Amager Strandpark i de mørke timer? *

◯ 1-10

◯ 11-30

◯ 31-50

◯ 51+

Hvor mange gange om året går du på Amager Strand stien i de mørke timer? *

◯ 1-10

◯ 11-30

◯ 31-50

◯ 51+

Beskriv venligst dit formål, når du besøger Amager Strandparken i de mørke timer? *

Long answer text

Beskriv venligst dit formål, når du går på Amager Strand Stien i de mørke timer? *

Long answer text

9.2 Light Fixture Data

9.2.1 LED tube light

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Site 1 / PROLED L372000 Flex Tube Flat RGB 1xLED Red, 1xGreen, 1xLED Blue / PROLED - Flex Tube Flat RGB (1xLED Red, 1xGreen, 1xLED Blue)

DIALux

PROLED L372000 Flex Tube Flat RGB 1xLED Red, 1xGreen, 1xLED Blue

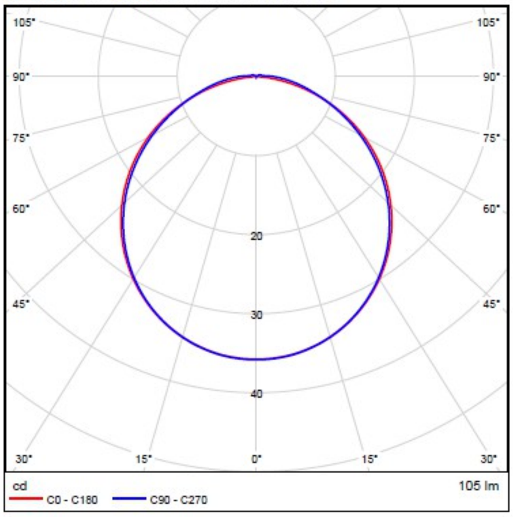
The PROLED FLEX TUBE FLAT RGB is an innovative LED product replacing the classic neon tubes. It can be used at every location including edges and corners. The FLEX TUBE has cutting signs printed on for an easy cutting to the required length. Installation is quite easy. Due to the high flexibility and pliability various shapes and designs are possible. With an operating voltage of 24 VDC and the protection rating IP67 FLEX TUBE is absolutely safe for indoor and outdoor use.

- dimmable, autom. color change, DMX 512, DALI, 1-10V, KNX controllable by MBNLED RGB MULTY power supplies/controller
- When used indoors (constant temperature), up to 10m with a single power supply line, up to 20m with power supply lines on both ends from same power supply.
- When used outdoors (because of temperature fluctuations and different thermal expansion coefficients of the materials), max. 7m.

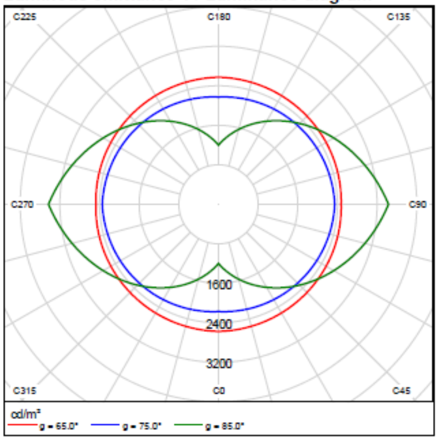
Absolute photometry
Luminaire luminous flux: 105 lm
Power: 11.0 W
Luminous efficacy: 9.6 lm/W

Colourimetric data
1xLED Red: CCT -, CRI -
1xGreen: CCT 7247 K, CRI -18
1xLED Blue: CCT -, CRI -

Luminous emittance 1 / Polar LDC



Luminous emittance 1 / Luminance diagram



Luminous emittance 1 / UGR diagram

Glare evaluation according to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	16.1	17.4	16.4	17.6	17.9	15.9	17.2	16.2	17.5	17.8
	3H	17.6	18.8	18.0	19.1	19.4	17.5	18.7	17.8	19.0	19.3
	4H	18.2	19.3	18.6	19.7	20.0	18.2	19.3	18.5	19.6	19.9
	6H	18.6	19.7	19.0	20.0	20.3	18.8	19.9	19.2	20.2	20.5
	8H	18.7	19.7	19.1	20.1	20.4	19.1	20.1	19.5	20.5	20.8
	12H	18.8	19.7	19.2	20.1	20.5	19.4	20.4	19.8	20.7	21.1
4H	2H	16.7	17.8	17.1	18.2	18.5	16.6	17.7	17.0	18.1	18.4
	3H	18.5	19.4	18.9	19.8	20.2	18.4	19.3	18.8	19.7	20.1
	4H	19.2	20.1	19.6	20.4	20.8	19.2	20.1	19.6	20.4	20.8
	6H	19.7	20.5	20.2	20.9	21.3	20.0	20.7	20.4	21.1	21.6
	8H	19.9	20.6	20.3	21.0	21.4	20.4	21.0	20.8	21.5	21.9
	12H	20.0	20.6	20.4	21.0	21.5	20.8	21.4	21.2	21.8	22.3
8H	4H	19.5	20.2	20.0	20.6	21.1	19.5	20.2	20.0	20.6	21.1
	6H	20.2	20.8	20.7	21.2	21.7	20.5	21.0	20.9	21.5	22.0
	8H	20.4	20.9	20.9	21.4	21.9	21.0	21.5	21.5	21.9	22.4
	12H	20.6	21.0	21.1	21.5	22.0	21.5	21.9	22.0	22.4	22.9
12H	4H	19.6	20.2	20.0	20.6	21.1	19.5	20.2	20.0	20.6	21.1
	6H	20.3	20.8	20.8	21.3	21.8	20.5	21.0	21.0	21.5	22.0
	8H	20.6	21.0	21.1	21.5	22.0	21.1	21.5	21.6	22.0	22.5

Variation of the observer position for the luminaire distances S

S = 1.0H	+0.1 / -0.1	+0.1 / -0.1
S = 1.5H	+0.2 / -0.3	+0.3 / -0.3
S = 2.0H	+0.4 / -0.6	+0.4 / -0.6
Standard table	BK06	BK07
Correction summand	3.3	4.1

Corrected glare indices referring to 105lm Total luminous flux

The UGR values are calculated in acc. with CIE Publ. 117. Spacing-to-Height-Ratio = 0.25

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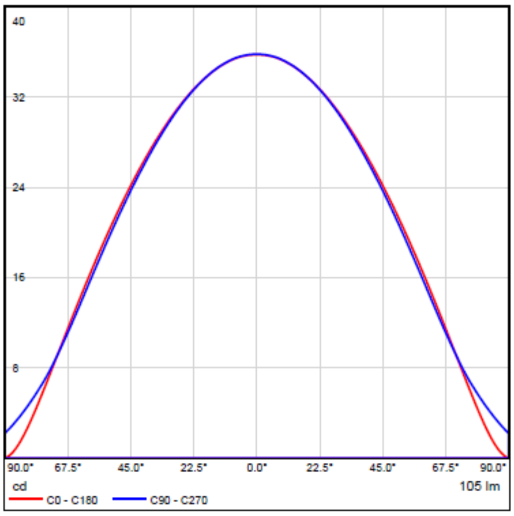
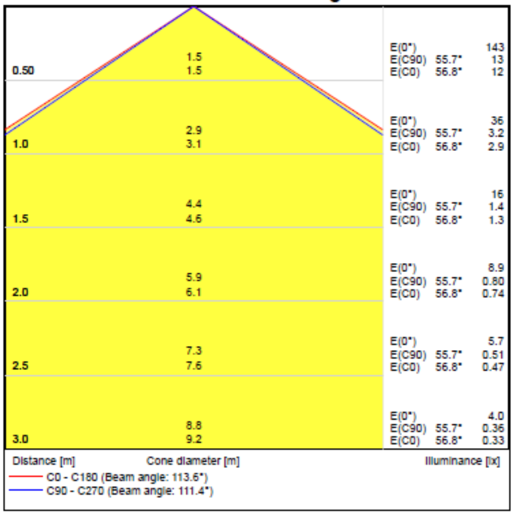
DIALux

Luminous emittance 1 / Linear LDC



Luminous emittance 1 / Cone diagram



9.2.2 The Scale Light

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Site 1 / iGuzzini illuminazione S.p.A BK03_LJ18 iPro: Outdoor wall-mounted luminaire - Warm White LED - max 500mA - Light Blade optic - 4.5W 370lm - 3100K 1xLED / 4.5W / iGuzzini illuminazione S.p.A - iPro: Outdoor wall-mounted luminaire - Warm White LED - max 500mA - Light Blade optic - 4.5W 370lm - 3100K (1xLED / 4.5W)

DIALux

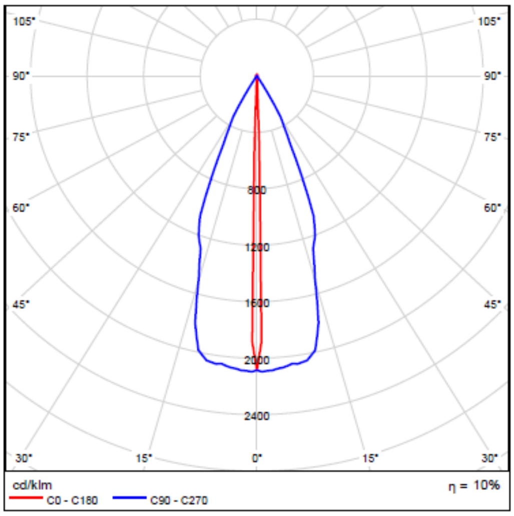
iGuzzini illuminazione S.p.A BK03_LJ18 iPro: Outdoor wall-mounted luminaire - Warm White LED - max 500mA - Light Blade optic - 4.5W 370lm - 3100K 1xLED / 4.5W

See our luminaire catalog for an image of the luminaire.

Light output ratio: 9.97%
Lamp luminous flux: 370 lm
Luminaire luminous flux: 37 lm
Power: 4.5 W
Luminous efficacy: 8.2 lm/W

Colourimetric data
1x: CCT 3100 K, CRI 80

Luminous emittance 1 / Polar LDC



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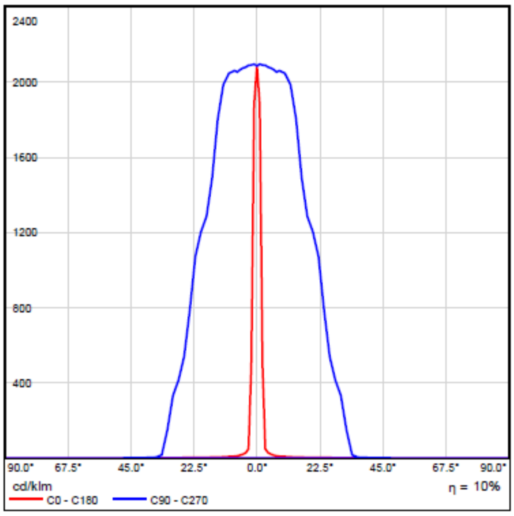
DIALux

Luminous emittance 1 / Linear LDC



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Site 1 / iGuzzini illuminazione S.p.A BK03_LJ18 iPro: Outdoor wall-mounted luminaire - Warm White LED - max 500mA - Light Blade optic - 4.5W 370lm - 3100K 1xLED / 4.5W / iGuzzini illuminazione S.p.A - iPro: Outdoor wall-mounted luminaire - Warm White LED - max 500mA - Light Blade optic - 4.5W 370lm - 3100K (1xLED / 4.5W)

DIALux

Luminous emittance 1 / Luminance diagram