Passive Design Strategies

For a public building in the dune landscape of Texel, The Netherlands

Thematic Research Paper

Architectural Engineering Graduation Studio
Delft University of Technology
Faculty of Architecture

Max van den Berg
4020332

Mentors
Carolin Bellstedt
Roel van de Pas
Mauro Parravicini

7 August 2017

"the shelter a house should offer, its essential function, means no more than that it should shut out the undesirable influences of nature while at the same time being as open as possible to those influences that are desirable."

- Gerrit Rietveld

Abstract

This paper researches passive design strategies that are applicable within the design of a public building for formal and informal events in the dunes of Texel, the Netherlands.
Through research of local climatic conditions and the natural dune habitat, an understanding of the site and context was acquired. The natural context presents a temperate climate, which is relatively sunny for the region. It has abundant natural surroundings which are very suitable for both leisure and more formal events.
Furthermore, the concept and program of the building were researched to provide a basis for assessment of suitable design strategies. The building comprises three main parts, which are a restaurant, a conference area and a museum. An extensive list of passive design strategies is composed to fit the project. Three of these strategies were studied in more depth to receive some feedback on how they would perform in the chosen building and its context. These three strategies were applicable in the project, and eventually used in the design.

Contents page

1 Introduction

1.1 Problem statement

On the Dutch island of Texel a progressive spirit has landed. Texel has the objective to become self-sufficient regarding electricity in the year 2020 TexelGeeftEnergie, 2015). Various projects at different scales have been set up on the island to work towards this objective. Amongst others there was the foundation of a cooperative for generating renewable energy in 2007 (*TexelEnergie*), the conversion of all public space lighting to LED's completed in 2016, and the online platform to showcase sustainable projects on the island (TexelGeeftEnergie, 2015). Since Texel is a popular holiday destination, combined with its modest scale and the fact that it is an island, gives this particular movement the potential to become a strong symbolic guide in the global field of sustainable transitions. However, this idea can only thrive with a meaningful vision about sustainability that would go beyond the acquisition of high-tech equipment. To be able to share, discuss and develop this vision a public debate centre would be the ideal stage for locals and visitors to come together. A powerful natural context is given by the dune landscape on the west coast of Texel. Its sense of remoteness combined with a fragile eco system create suitable yet challenging conditions.

1.2 Passive design strategies

Most *buildings* are designed for *people*. What these people *do* largely determines the organization, scale and aesthetics of a building. In other words, the nature of the task that a building facilitates defines its qualities. This could be: raising a family, attending university classes, assembling a car, or simply sleeping. Whatever the tasks are, a building should help its occupants to carry them out efficiently, by providing a comfortable, healthy and safe environment.

A building that offers a comfortable and healthy environment, successfully cultivates *human comfort.* The range and extent of human comfort that a building can fulfill can be divided into four categories: thermal comfort, visual comfort, acoustic comfort and air quality (Autocad, 2016A). Whether these aspects are experienced as *comfortable* depends on the kind of activity that takes place, the physical intensity of this activity and the type of clothing that is worn. A sense of comfort may also differ slightly between people of different age, region and/or culture and of course as influenced by personal preference.

This paper focusses on passive design strategies. The use of these strategies generates considerable advantages within the domain of sustainable building. Creating comfortable climates in buildings costs energy. Passive design strategies harvest this energy from ambient natural resources. Working with their natural surrounding, these sytems are often low-tech, as many of them were invented in times when passive climatization was the only way to change climatic conditions. These simple and logical systems do not need specialized maintenance, nor periodical updates. Passive systems are either regulated 'automatically' by climatic cycles, or by uncomplicated manual controls. When a passive system breaks, its simplicity often allows for unskilled people to repair it. Passive design strategies offer an appropriate and modest direction for ambitious sustainable building projects.

In order to select the right strategies for the graduation project, an understanding of the desired human comfort levels within the building is required. *Who* will use the buliding, and for *what* will they use it?

1.3 Reading guide

To identify useful passive strategies for the project, in other words, to answer the research question, information about the context and the program needs to be gathered. Therefore the first results chapter (Chapter 3) will be about analysis of local climatic conditions. Subsequently, in Chapter 4, the natural context of coastal dunes is examined. Thereafter, in Chapter 5, the basic characteristics of the project will be discussed and defined. Finally, an array of passive design strategies that are relevant for the project and its context will be collected. From this list three strategies will be selected and studied in depth to identify the pro's and con's of using them in the project (Chapter 6).

1.4 Context - Planet Texel

This research paper is part of the graduation project for the MSc title in Architecture at the Department of Architectural Engineering & Technology at the Faculty of Architecture and the Built Environment at Delft University of Technology in The Netherlands. The graduation project is comprised of two parts, the thematic research paper and a design proposal. The latter builds on the research by implementing its useful outcomes and conclusions.

Within the graduation studio of Architectural Engineering & Technology students choose from a list of around six locations, where they want to design their project. The chosen location for this design proposal and research paper is the dunelandscape of the Dutch island of Texel.

Situated in a unique natural context, the building designed for this graduation project welcomes islanders, local entrepreneurs, tourists and other visitors to get acquainted with the many projects that make the island more sustainable, as well as the long-term vision that guides these projects. Through the architecture, the public program, its spaces for presentations, discussion and education, an opportunity is created for the islanders and visitors to discuss and develop the long-term vision for a sustainable island. These facilities form a *campfire*-like atmosphere to discuss ideas in small and large groups and to make new connections. Moreover the physical building that houses the program is a statement in itself. By making use of passive design strategies, combined with locally sourced natural building materials and modest yet appropriate aesthetics, the building advocates a low-tech mindset with a collaborative relation to the natural context. This building goes by the name *Planet Texel*. This name originates from a platform for research and experiment that was set up in 2014 by two universities, to help Texel reach its sustainable goals (Planettexelacademy.nl, 2014). The name of this initiative is *Planet Texel Academy*. Its vision aligns well with the vision of the graduation project: to help Texel develop and meet their sustainable goals. From now on, the term *Planet Texel* will be used in this paper to address the design proposal part of the graduation project.

To be able to implement a number of passive design strategies in the design for Planet Texel, the thematic research focuses on finding useful strategies for the project. This paper describes the research and presents its findings.

1.5 Research question & goal

The goal of this research is to find, describe and study a list or 'menu' of applicable passive design strategies for the design of Planet Texel. To be able to reach this goal, the main research question needs to be answered:
Which passive design strategies are suitable for a public building in the dunes of Texel?

To be able to arrive at an answer of this question, it is needed to address the four sub questions:

1. What are the climatic characteristics of the location in the dunes of Texel?
2. What are the important characteristics of coastal dune landscapes for building sustainably?
3. What is the spatial program for Planet Texel, and what are its climatic needs?
4. Which passive design strategies can be employed to match the program?

1.6 Methods

As presented in Chapter 1.3, the main research question will be answered by splitting it up into four more specific sub questions, for which an answer is provided in four subsequent chapters, respectively. For each sub question an adequate research method was chosen to determine results.

Research methods for corresponding sub questions:

1. Literature review with keywords: climatic classification, local climate, climate and architecture. Search for a useful framework to determine local climatic conditions.
2. Literature review with keywords: dune formation, dune landscape, dune ecosystem.
3. Research by design, linking spatial climatic needs to local climatic conditions.
4. Literature review with keywords: passive design strategies, passive architecture. Filter useful strategies and list them, link to spatial program.

2 Texel climatic conditions

In this chapter climatic conditions of the location will be analyzed and presented.
To define the climatic characteristics of a location, a set of definitions and scales to place the specific context on is necessary. A framework for classification will be introduced, and then used to classify Texel's climate.

2.1 Climate classification

Helena Coch, Associate Professor of Environmental Control at Universitat Politecnica de Catalunya in Barcelona, introduces a clear model to classify different climates found on the planet in her paper on bio-climatism in vernacular architecture. A general classification for different climates is necessary to assess passive design strategies. To construct a simplified system for classification, Coch states that "temperature can be considered to be the most representative parameter, both in its average values and in annual and daily variations." (Coch, 1998, p. 68). Humidity is indirectly linked to temperature variation, because continental climates with lower humidity show greater variation in temperatures (Coch, 1998).

Coch identifies two primary factors that are critical for affecting local climates. *Latitude* and *continentality* (Fig. 3.1). Locations with a greater latitude will have lower average temperatures. Locations with greater continentality will have a dryer climate, with larger diurnal and seasonal temperature variations.

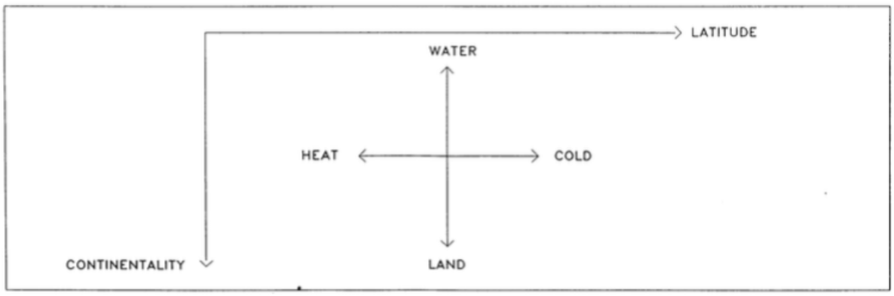


Figure 2.1: General climate classification

Coch also introduces four secondary factors, which modify the impact of the primary factors, which are described above. The first secondary factor is *absolute height* above sea level. Locations with higher altitudes show a fall in average temperatures, an increase in temperature variation and a fall in humidity. The second factor is *topographic relief.* The morphology of the landscape can produce microclimatic variations in relation to the sun and dominating winds. The third factor is *vegetation.* More vegetation will induce greater thermal stability and higher humidity. The last secondary factor is *human action.* Human settlements have the opposite impact on the local climate compared to vegetation, hence greater temperature variation and less humidity.

2.2 Texel climatic conditions

Regarding the primary factors introduced by Coch, the project location's *latitude* is approximately 53ºN (Fig. 2.2), which is in the upper zone of the temperate climate zone of our planet (Fig. 2.3). Average temperatures on Texel are shown in Fig. 2.4. *Continentality* of the location is zero, as it is located directly at the North Sea. This means the location has a humid sea climate with modest diurnal and seasonal temperature variations.

Regarding Coch's secondary factors, the *absolute height* above sealevel is negligible, as the dunes only protrude a few meters above the nearby sea. Therefore effects of height are absent. Topographic relief is clearly present in the surrounding dune landscape, recognizable with its small peaks and valleys that create local microclimates that attract specific species of flora and fauna. The valleys receive more shadow, and are protected from wind by the peaks, whereas the peaks are exposed and receive high winds and solar radiation.
The site is surrounded by dune *vegetation* for hunderds of meters on three sides, consisting of grasses and low bushes behind the first row of young and high dunes (Fig. 2.5 & 2.6). An exception is the car park to the East, that measures roughly 100x100m, visible as "P" in the far right image (Fig. 2.2). To the West there is the beach and the North Sea. Like Coch mentions, this vegetation will slightly temper heat and cold. The large car park and the road towards it as well as the concrete path from the car park to the beach, that passes by the project site, are the local signs of human settlement. The car park may heat up faster than the surrounding dune meadows, creating a spot of warmer air to the East of the project site. Although this will only be noticeable in windless conditions.

Compared to the Dutch mainland, Texel's climate is less cloudy and therefore relatively sunny. According to measurements it is even considered the sunniest region of The Netherlands (Waddenweer, 2016). Due to the proximity of the sea however, maximum summer temperatures are slightly lower, and winters are slightly milder compared to the mainland average (Waddenweer, 2016).

On Texel, wind is often present. Especially at the coast, where nothing is physically blocking incoming Western winds, it is often windy. Dominant wind direction is Southwest, see Texel Windrose (Fig. 2.7).

Figure 2.2: Planet Texel location & site

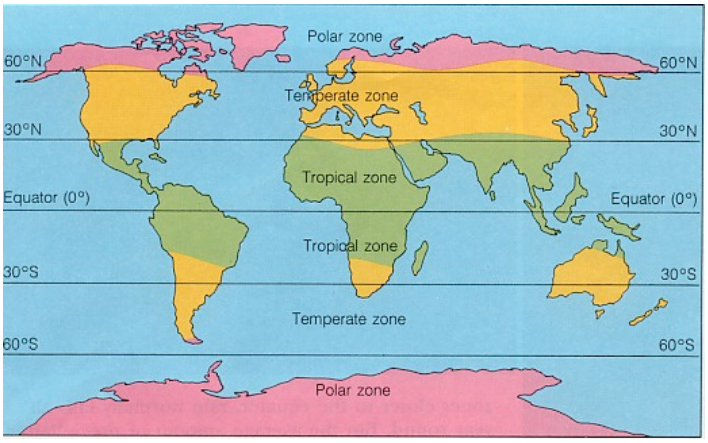


Figure 2.3: Earth's climatic zones

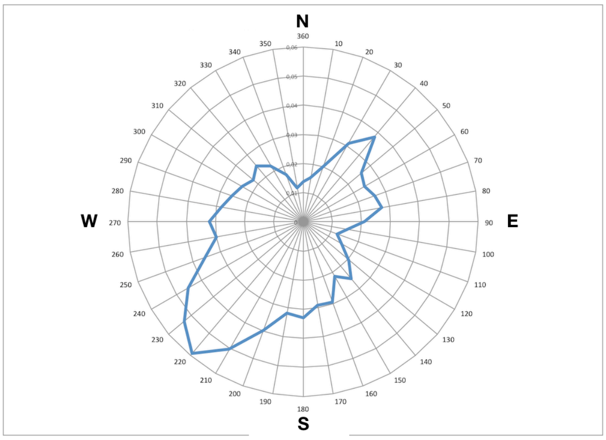


Figure 2.7: Texel Windrose

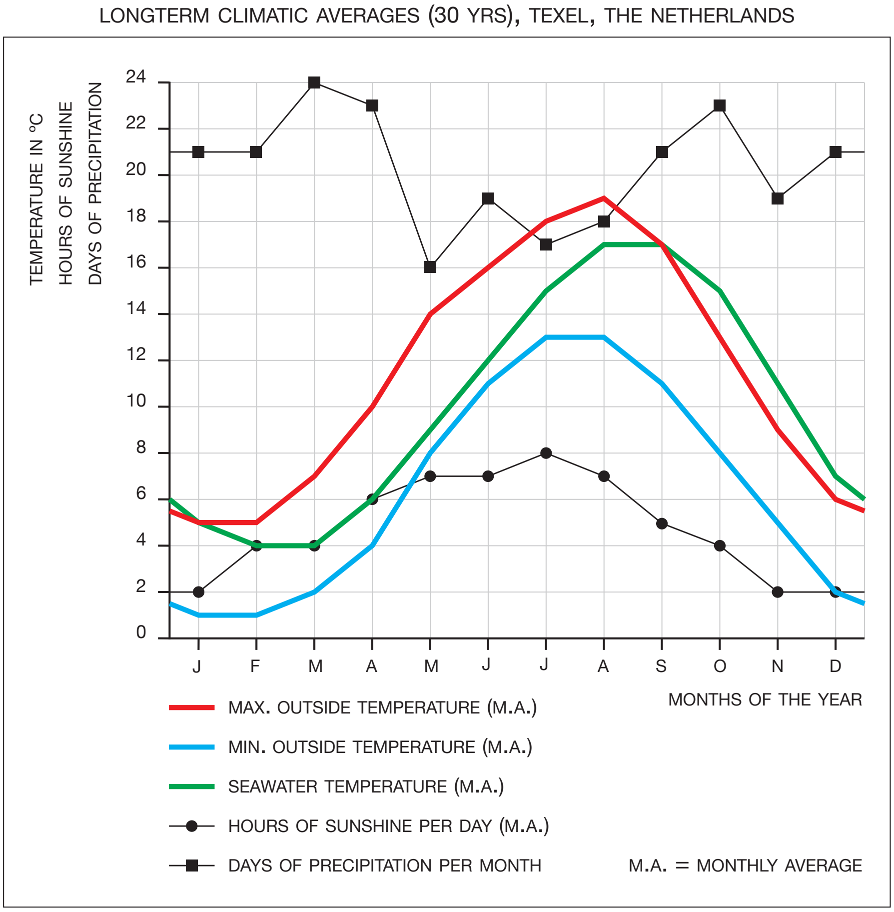


Figure 2.4: Longterm climatic averages for Texel

Figure 2.5: A view on the dunescape

Figure 2.6: A view on the young & high dunes

3 Coastal dunes

In the previous chapters the local climatic conditions were mapped. In this chapter, the most important characteristics of the natural surroundings of the project, coastal dunes, will be explained. Coastal dunes are a very specific natural surroundings, with its own flora and fauna, qualities and threats. These need to be understood in order to formulate a meaningful proposal for a building.

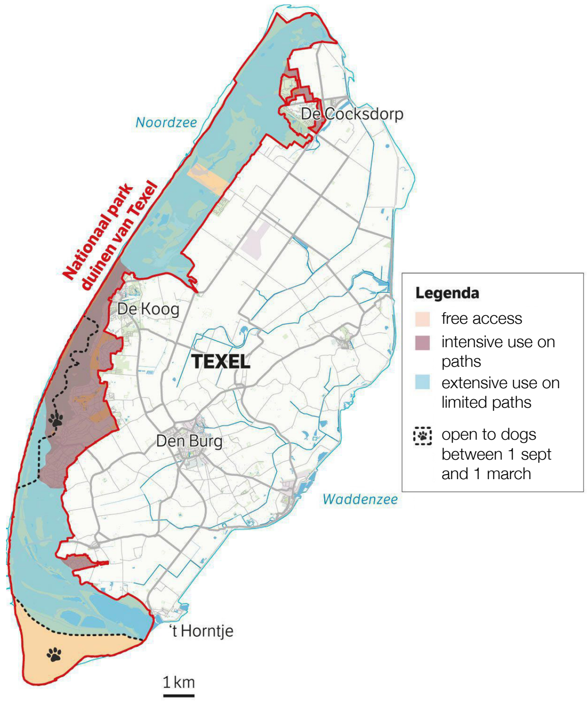


Figure 3.1: National park *Dunes of Texel*

Coastal dunes form the barrier between continental and marine habitats, between dynamic sandy beaches and more stable dune fields. Coastal dunes are found on many of the world's shorelines, at sea and around lakes. They are broadly distributed over nearly all latitudes, from polar to tropical (Fig. 3.2), which makes their eco systems very diverse (Martínez et al., 2008). In the middle of one of the largest coastal dune ecosystems in the world - which stretches from France to Denmark - an elongated strip of 254 km of dunes covers almost the entire North Sea coast of The Netherlands (Ecomare, 2016). These dunes range in width from 200m until 4km (Verstrael, 1996).
On the island of Texel, coastal dunes cover the west coast, stretching for 20 km, with a width varying from 1 up to 5 km (Fig. 3.1). In 2002 the Texel dunes received the official status of a National Park, protecting its flora and fauna (NRC, 2016).

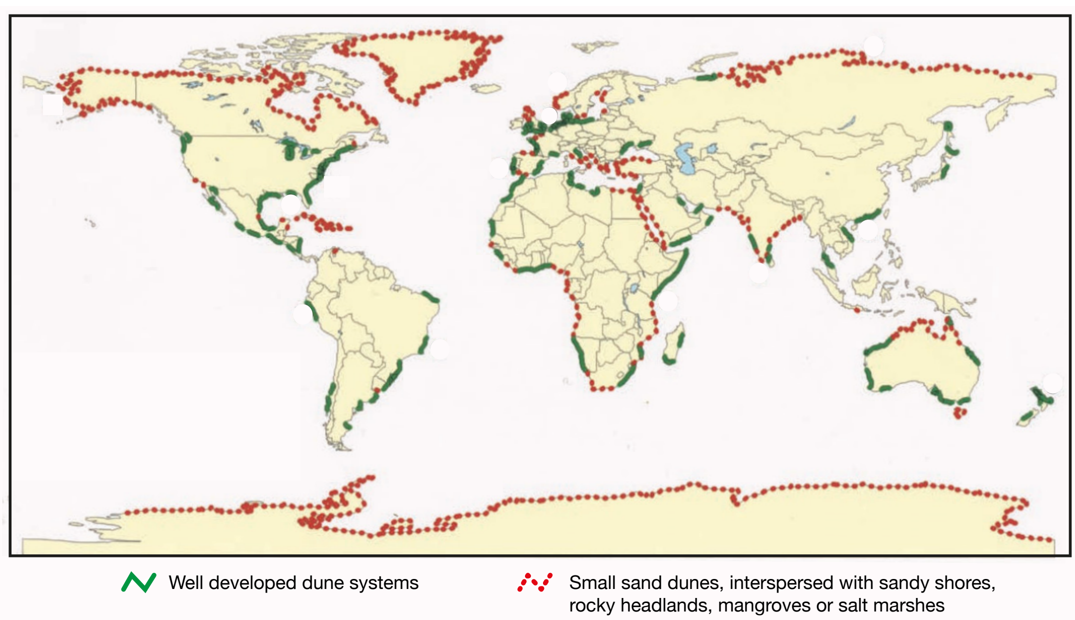


Figure 3.2: Coastal dune systems on planet Earth

3.1 Flora & Fauna

The coastal dunes in The Netherlands cover only 1% of the total land area. This relatively small area is a highly valuable habitat for plants and birds. Of 180 migratory and wintering bird species that breed in the country, 80% breed in the dunes (Verstrael, 1996). Furthermore, of all plant species found in The Netherlands, between 65 and 75% grow in the dunes, with 10% growing exclusively in the dune habitat (Ecomare, 2016).

3.2 Formation

Coastal dunes mainly emerge along sandy and shallow coastlines, with dominant onshore winds that transport sand inland to build broad dune areas (Martínez et al., 2008). A small bump of sand on the beach creates a leeward area behind it where sand collects. As the wind blows in more sand, the bump will grow. Small salt-water grasses can settle on the bump, reinforcing it with their roots. When the bump reaches a critical height, it will be able to hold a bubble of fresh water after a rain shower, making it fertile for marram grasses, which grow rapidly, further reinforcing the young dune. Eventually a numer of young dunes grow together to become one strip of coastal dunes. This creates a dune valley on the landside, where more plants can thrive, keeping a definitive hold of the loose sand (Ecomare, 2016). See Figure 3.3 and 3.4.

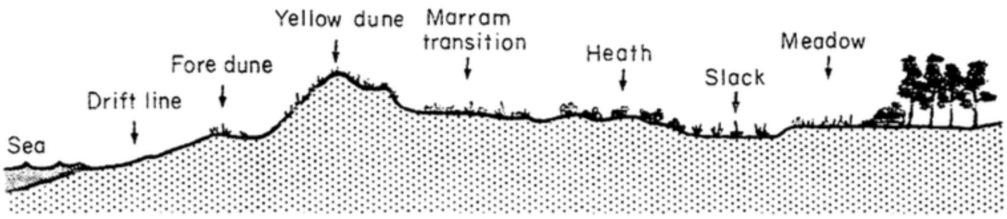


Figure 3.3: Coastal dune section

3.3 Relevance

Coastal dunes work like natural dikes during storm surges, protecting many of the world's shorelines from high water levels (Carter, 1991). Apart from coastal defense, dunes have been used by humans through history for many economic purposes such as extraction of drinking water, agriculture, sand mining, housing and tourism. For example, in The Netherlands, large areas of old inland dunes were excavated to use the sand for city expansions in lower inland areas (Martínez et al., 2008).

3.4 Threats

As a result of drastic increases in coastal recreation in the last century, combined with a majority of the world population settling in coastal areas, pressure is increasing on these habitats. Often native species are wiped out by newly introduced exotic species. This growing intensive use has already eliminated or irreversibly damaged many dune systems of the world, with damage from storm surges becoming more frequent. Adequate management and conservation policies are indispensable to preserve still existing coastal dune systems for future generations of animals, plants and humans (Martínez et al., 2008).

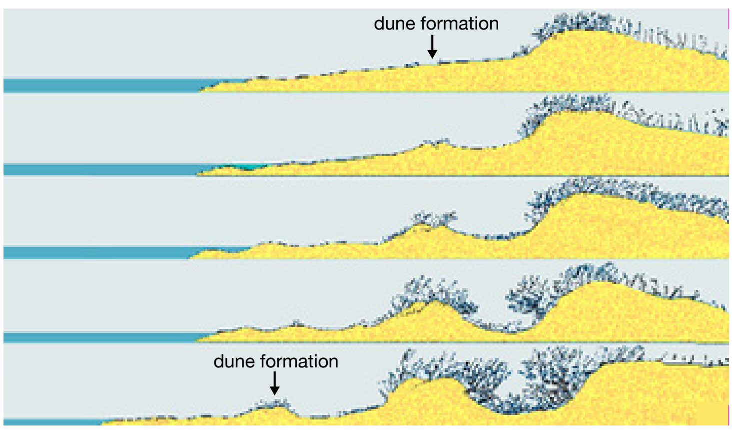


Figure 3.4: Coastal dune formation

4 Planet Texel

In the previous chapters the local climatic conditions were mapped and the characteristics of coastal dunes were explained. In this chapter, the most important characteristics of the Planet Texel building will be defined. These characteristics will be explained through the building's concept, users, site, program and desired indoor climate.

4.1 Concept

The project's main goal is to enhance Texel's sustainability vision. To achieve this goal, two strategies are used. Strategy one is to *Improve Texel's vision* in two ways. The first is *enhancing & accelerating Texel's vision* through a place that is suited to discuss and develop the broader vision as well as smaller projects; create a campfire setting. This improvement also entails uniting and connecting sustainable projects on the island, creating an opportunity for cross fertilization. The second is to *Passify Texel's vision* by designing a building that aims at providing wellbeing and comfort through relations to the natural context with materials and passive design strategies. Strategy two is to *Increase impact*, again in two ways. The first is to *generate public awareness* by creating a physical place for people to visit and learn about Texel's vision, which is also a place to eat, enjoy the sun and go to a conference or celebration. The second is to *Broaden the user scope* by making use of conference, culinary and site facilities as well as the natural context to be used by external groups for formal and informal events.

4.2 User groups

Three user groups are involved in Planet Texel. The first group are the islanders. These are interested citizens, local entrepreneurs, school children, elderly, everyone who is interested in learning about Texel's future or helping to shape it. Texel has 13,582 inhabitants (Texel.net, 2016). The second user group are the spontanious visitors, which are the tourists. On average Texel welcomes around 800,000 tourists each year (Ecomare, 2016). This relatively large group (58 tourists per inhabitant) is Texel's economic backbone that is responsible for 70% of the island's economy (Ecomare, 2016). Therefore many sustainable initiatives on Texel will involve or serve tourism. At Planet Texel these spontanious visitors can learn about sustainability on the island, and get involved through events or activities like collecting plastic on the beach. The influx of tourists fluctuates over the year. Although precise numbers of tourists per month are not recorded, the amount of persons carried by the Texel ferry gives a fair estimate of proportions (Fig. 4.1). The third user group are planned visitors. This group rents facilities of the building for congresses, celebrations, dinners, festivals or other events.

4.3 Site

Planet Texel is located at the *Paal 28* pedestrian pathway to the beach (Fig. 2.2), which goes through the dunes. It will either replace a bungalow style restaurant that is currently occupying the site on top of the dune (Fig. 4.2), or be placed on the car park. In front of the site there is currently a large car park for around 450 cars and bicycle parking spots as well (Fig. 3.3).

4.4 Program

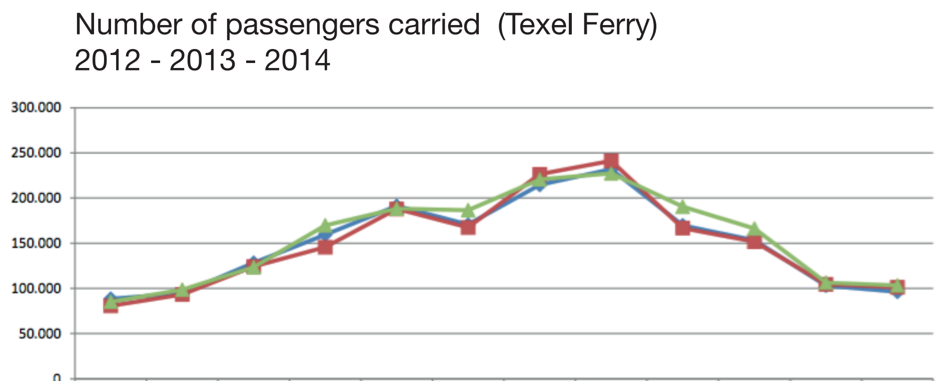
A carefully considered program is necessary to house the four user groups mentioned above in a building that successfully enacts the concept of improving Texel's vision and increasing impact. The program comprises three main elements, a restaurant with a sunny terrace, a conference area with a large foyer and a room for discussion and a museum-like space where the story of Texel's sustainable vision along with its projects can be told. Figure 4.3 and 4.4 are schematic representations of the building's spatial program, and do not represent floorplans.

4.5 Desired indoor climate

Figure 4.4 shows the schematic program, with four parameters of human comfort for each individual space, expressed in colored dots. More dots of one color correspond with more importance for *that* aspect of comfort for a particular space. Generally speaking, spaces that are occupied by users for longer periods of time demand high comfort, and spaces for temporary human occupancy demand less comfort. These program schemes serve as a tool to assess passive design strategies for their suitability to create the demanded climatic conditions. Note that the dots system is a subjective qualification by the author.

4.6 Building lifetime

The building is intended to generate awareness and increase impact of the sustainable solutions implemented in important areas on Texel, such as tourism, building, transport, nature conservation etc. As long as these important economic areas on the island can improve on a sustainable level, the project and building can be relevant. The coastal borders of the *Wadden* are always moving, this might pose a hazard for the project, because it's situated so close to the sea. However in 1990, the shoreline of Texel was consolidated. Since that year a number of sand-suppletions were carried out to keep the island's shoreline in place (Cleveringa, 2001).



	Januari	Februari	Maart	April	Mei	Juni	Juli	Augustus	September	Oktober	November	December
2012	88.498	94.391	128.381	159.482	191.291	170.684	214.602	231.810	169.831	153.221	103.072	96.257
2013	80.748	93.289	124.206	145.604	187.925	167.410	226.288	241.152	166.805	151.650	104.514	101.252
2014	85.292	98.597	123.475	169.779	188.306	186.565	220.714	227.287	190.453	166.221	106.369	103.339

Figure 4.1: Texel ferry passenger numbers

Figure 4.2: Current building on building site

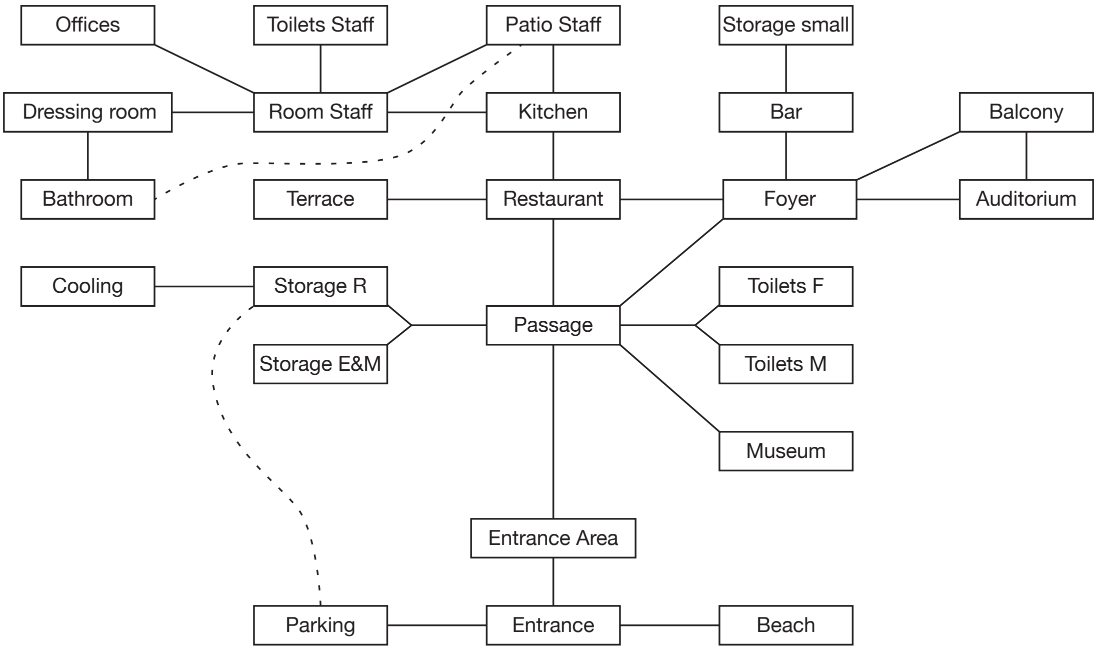


Figure 4.3: Planet Texel spatial program

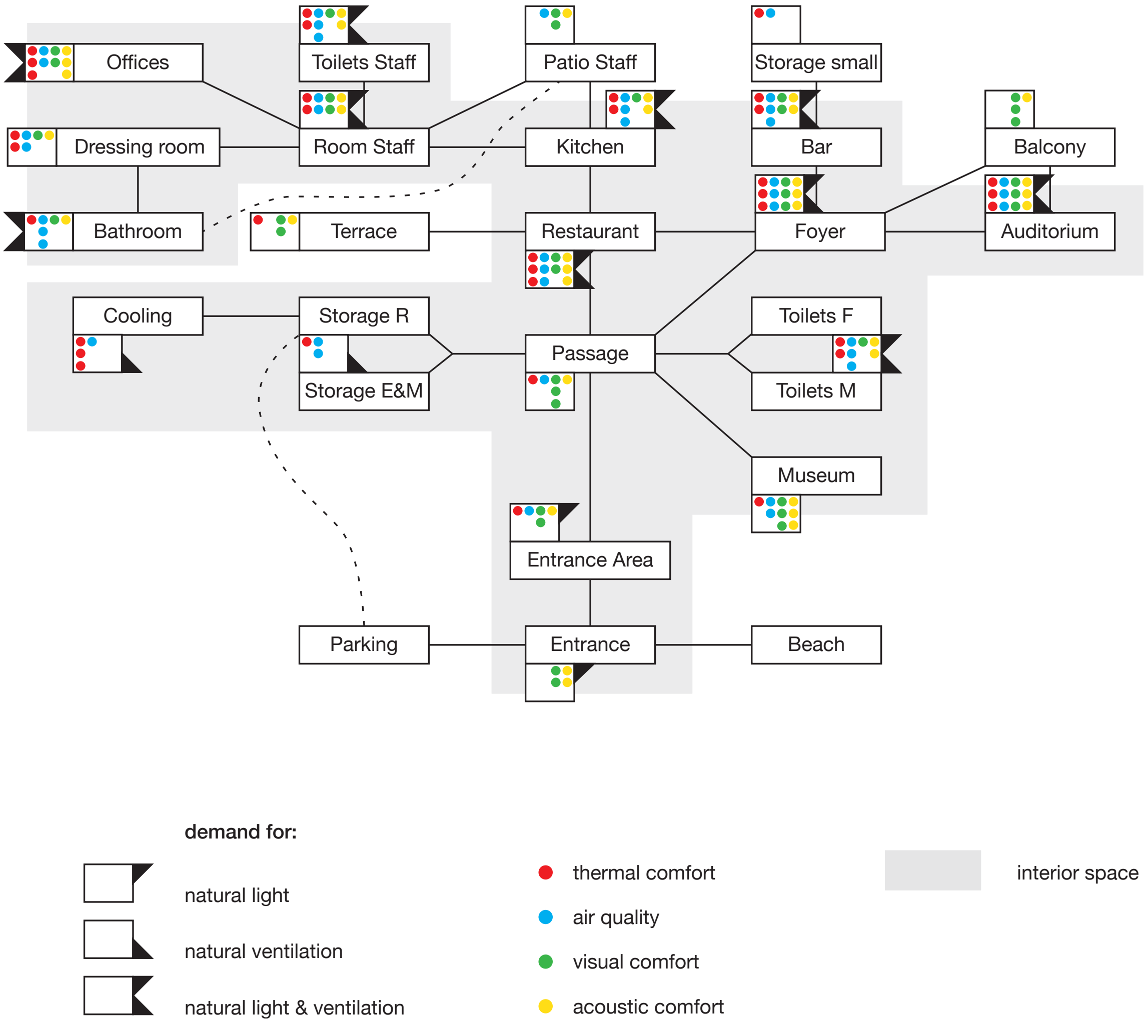


Figure 4.4: Planet Texel spatial program + comfort

5 Passive design strategies

Now that the local climate and the main characteristics of the project are defined, the collection of useful and relevant passive design strategies will be presented in this chapter.

Passive design strategies can perform four different actions; heating, cooling, daylighting and ventilation (Autocad, 2016A). Through these actions, the elements of *human comfort* are created, respectively: thermal comfort, visual comfort and air quality (Autocad, 2016). Acoustic comfort is also created through passive design strategies, however not through the actions described above, but mainly by secluding certain spaces for certain tasks combined with adequate sound insulation.

To create human comfort in these four categories, buildings use a set of *design strategies.* Design strategies for human comfort are systems that generate thermal, visual, acoustic or air quality comfort or a combination of these, often by tapping from an energy source (Autocad, 2016B). Looking at the type of energy source they depend on, design strategies can be divided up into three categories:
- *Active design strategies* use externally generated energy like electricity and natural gas to create comfort, e.g. central heating, air conditioning and mechanical ventilation. Locally generated renewable energy to power climate systems are included in this category, e.g. PV cells on the roof that power a ceiling ventilator.
- *Passive design strategies* use natural ambient energy from the sun, wind and earth, which is present at the buildings location to create comfort, e.g. natural ventilation, passive cooling or daylighting.
- *Hybrid design strategies* use externally generated energy to enhance the use of natural ambient energy sources, e.g. solar thermal systems and heat pumps.

To compose a coherent and readable list, it is helpful to categorize the strategies. Each strategy triggers an action on a certain scale within the design; the *urban* or landscape scale, the *building* scale and the building *component* scale. These scales are used to structure the list.

The final elaborate list of strategies with relevance for the project and its context is included with this paper as Annex 1.

To obtain a better understanding of what specific passive design strategies can do for the Planet Texel project, three strategies were selected from this list for further analysis. One strategy from each scale category (urban, building, component). Chosen strategies for further analysis are: Topographic microclimates, Periodic transformations and Earth edges. Each of these strategies address a few characteristic aspects of the building and its natural surroundings. Below, the three selected strategies will be elaborated and analyzed, and put into relation to the Planet Texel building.

A general note on passive design strategies.

Note I: Design strategies that work for extreme climates with little temperature variation, e.g. polar or tropical, are often singular, showing one clear solution. This is comparable to human clothing, which can be of one sort in extreme climates, like a thick furry suit with gloves and a hood that can be worn whole year round in polar regions. For temperate climates with more thermal variation, strategies are generally less obvious and often less impressive, comparable to layered clothing, that can adapt to changing circumstances.

Note II: Larger buildings with larger user groups are less receptive of comfort fluctuations than small buildings with few users. Therefore, the indoor climate in larger buildings is seldom controlled by one person, but rather by a system with a common comfort norm (Fig. 5.1).

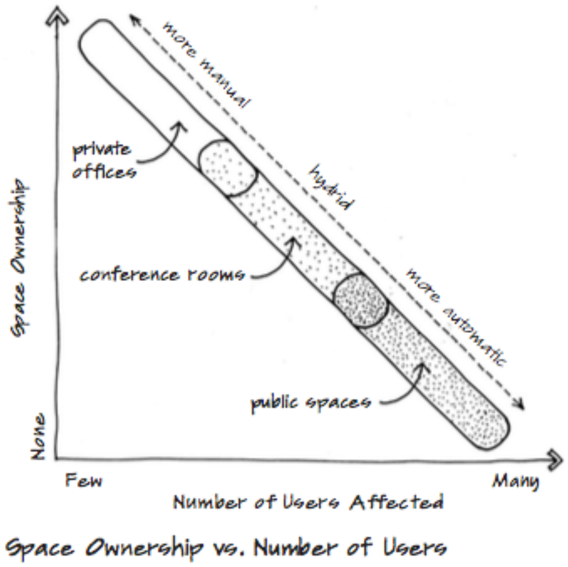


Figure 5.1: Space ownership vs. number of users

5.1 Topographic microclimates

This is a strategy for heating, cooling and daylighting, hence thermal comfort and visual comfort a landscape scale.

Description

Locations with mountains or hills, combined with wind or proximity to large bodies of water will present microclimatic differences (DeKay&Brown, 2013).
The usefulness of micro-climatic differences is higher in temperate climates, where the outside climate matches the desired indoor climate for at least a period of the year. In extremely hot or cold climates, buildings need constant cooling or heating, making them more inward oriented (DeKay&Brown, 2013).

Hills & Mountains

Mountaintops and hilltops are exposed to high winds and maximum solar radiation.
Valleys receive more shade and are sheltered from the wind by surrounding hills.
At night, a layer of cool air settles in the lowest part of the valey, because cool air is more dense, and flows downhill (DeKay&Brown, 2013).
Hillsides have specific characteristics depending on their orientation. On the Northern Hemisphere, South facing slopes receive much more sun than North facing slopes. East facing slopes receive morning sun, and West facing slopes receive afternoon sun.

Proximity to Water

Locations that are near large bodies of water like oceans or big lakes, experience a lower temperature variation between night and day and between winter and summer compared to continental locations. Generally speaking, at these locations high summer temperatures are lower and low winter temperatures are higher (DeKay&Brown, 2013).

Project relevance

By making use of microclimatic differences at the Planet Texel site, more desirable parts of the site may be chosen for certain uses. Building parts can be located to increase thermal comfort, natural light, and decrease energy use by influencing the length of their heating and cooling season.

The Planet Texel site is located in the sloping coastal dune landscape (Fig. 2.5), next to the North Sea. The microclimatic effects of (small) hills and valeys, and of large bodies of water will be present (Chapter 3). Especially late spring, summer and early fall climate on Texel matches with the desired indoor climate, with comfortable outside temperatures around 22ºC (Fig. 2.4). Microclimatic advantages, like cool winds from the sea or hot windless dune valleys can be taken into consideration in the orientation of specific spaces of the building.

Another interesting of the dune and valley microclimates of the site's natural context is its experience. Standing on the dune tops, a dramatic scene unfolds, with a blowing wind, wide views on vast landscapes and a large horizon (Fig. 5.2). Standing in the dune valleys, the experience is opposite. Sheltered from the wind, with no horizon in sight, a more intimate *microclimate* unfolds (Fig. 5.3). The attention is drawn by smaller details such as the grass, or small insects walking through it. These aspects of experience, linked to topographic microclimates, can be used within the building to enhance the function of spaces. For example, the conference room for discussion benefits from an atmosphere of concentration. Large views on the horizon or the setting sun over the sea will likely distract the visitors of a discussion or presentation. Lower windows with views on a dune valley with grasses moving in the wind, with a bird occasionally passing by, can enhance concentration combined with the realization of being in the coastal dunes. The foyer however, a place for celebrations and performances, can be strongly connected to the dramatic dune landscape and the sea with large windows.

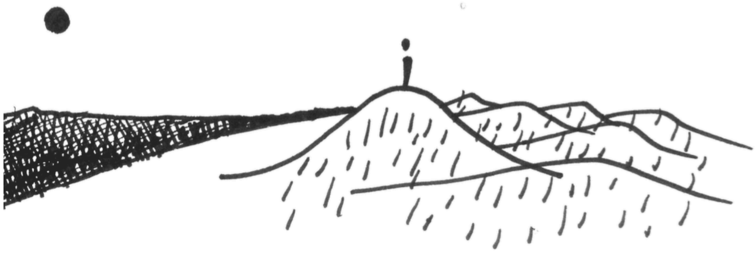


Figure 5.2: 'Sublime' experience on dune top

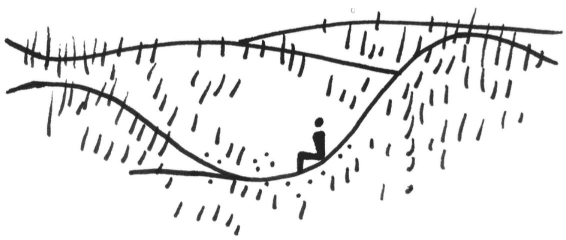


Figure 5.3: 'Intimate' experience in dune valley

5.2. Periodic transformations

This is a strategy for heating, cooling and daylighting, hence thermal comfort and visual comfort on a buliding scale.

Description

Local climatic conditions vary over the day and over the seasons. These variations occur in cyclical patterns with relatively predictable conditions (night, day, winter, summer, spring, fall). There are several strategies to respond to these patterns to maintain comfort. One is to *transform* the building in its spatial layout. Expanding or opening up with pleasant outdoor conditions and closing to create a protected shell with inhospitable outdoor conditions. So, the building expands and shrinks periodically.

Another strategy is *migration*, in which occupants move from one space to another, following pleasant conditions and orientation to the sun and wind. Migration can be a daily or seasonal routine. The last strategy are *controls*, which can be ajusted by the occupant or automatically to manipulate the climate with fans, windows, shades, etc. (DeKay&Brown, 2013).

Transformation can also be combined with the strategy of *buffer zones*. These are spaces with low temperature requirements that can form a thermal buffer zone between living areas that need accurate temperature control and the outside environment (DeKay&Brown, 2013).

Project relevance

Tourist visits to the island have a stable curve, with peaks in the warmer months and also in the weekends (Fig. 4.2).

As the event facilities are only necessary during scheduled events, their appearance may change during times of no use. This also counts for the restaurant part, that will experience high demand in summer months, but considerably lower demands during winter time. A layer of buffer zones could work for the restaurant (Fig. 5.4). With a central core that is heated in winter, providing sufficient space for low visitor numbers, a buffering U-shaped space around it for spring and fall temperatures and more visitors, and a large summer terrace with a surrounding windprotection, possibly made of natural dune shapes. This approach of periodic transformation gives the used space a sense of intimacy during each season, because it is never too large. It also helps to safe resources for heating during winter time.

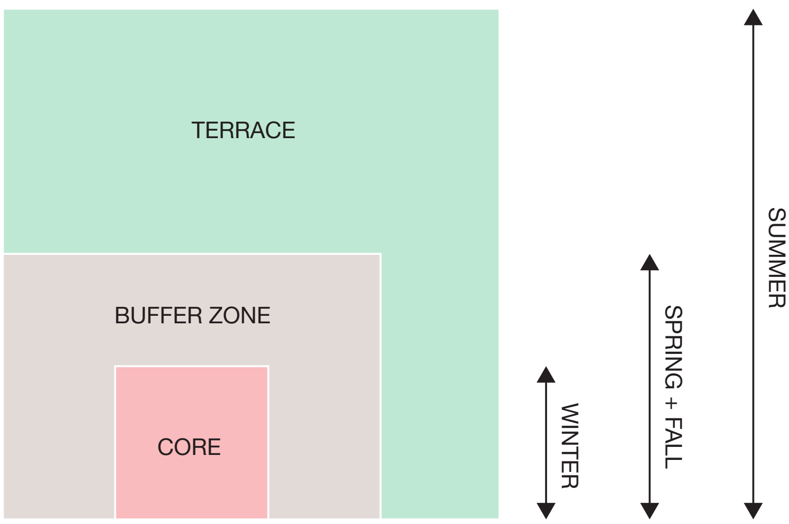


Figure 5.4: Restaurant buffer zones

5.3 Earth edges

This is a strategy for heating, cooling and daylighting, hence thermal comfort and visual comfort on a building component scale.

Description

When a building is dug in, partially or completely, its earthen surrounding provides shelter for extreme temperatures and wind, and it can provide passive cooling (DeKay&Brown, 2013). To create earth edges a building can be either sunken into the ground, earth can be piled or bermed up against its walls, or it can be built into a hillside (Fig. 5.5).
Earth sheltered buildings often need heavy structural elements to carry the earths weight. Extra attention is also needed to ensure adequate daylighting and ventilation (DeKay&Brown, 2013).

Project relevance

Benefits of earth sheltering for buildings include (1) energy conservation; (2) efficient use of scarce land; (3) conservation of aesthetic, cultural, natural and/or historical values; (4) noise protection; (5) lower facade maintenance cost; and (6) protection against natural or human hazards (Barker, 1986).

Energy conservation

Contrary to what is generally assumed, earth is not a good insulator, especially when compared to standard building insulating materials (Barker, 1986). However, with a massive earth envelope like in earth sheltered buildings, heat loss has to leak over such a large distance that a poor insulating material becomes an effective *thermal mass* blanket for the building (Barker, 1986). This massive earth blanket thus lowers a building's energy consumption for heating and cooling the interior. When outside temperatures are low and heating is needed for thermal comfort, the earth acts as a heatsource. When outside temperatures are high and cooling is needed, the earth acts as a cooling source. The lower temperature difference between the earth temperature and the comfort temperature demands lower energy use, resulting in more modest systems for thermal comfort, hence lower construction and maintenance costs (Barker, 1986).

Thermal mass versus thermal insulation

Thermal insulation are materials that highly decrease heat flow through minimal radiation, convection and conduction. The result is that heat or cold is captured efficiently within a building envelope. Thermal mass are large volumes of conductive material, that store heat for a period of time, releasing it in cooler periods of the day (Al-Homoud, 2005). It is important to acknowledge this difference when using these terms.

Thermal mass is most effective in dry climates with high summer temperatures and large day to night temperature variations. For humid climates with high summer humidity and temperatures and small day to night temperature swings, insulation is more effective (Al-Homoud, 2005).

Conservation of aesthetic, cultural, natural and/or historical values

The Dutch dune landscape is an important natural and cultural asset. This became clear in 2015, when the liberal government party (VVD) decided to lift the long-term ban on real estate development in the dune landscape (Trouw, 2015). As a reaction, six nature

conservation organizations joined forces to start a large protest campaign. With more than 100.000 Dutch citizens, and the second government coalition party (PvdA) backing their campaign, the decision was successfully reversed, forcing the responsible minister to keep the ban on building in the dunes in place (Natuurmonumenten, 2016).
The opposition against building in the natural dune landscape clashes with the intentions of the project. Although a public building with clear societal and educational value like Planet Texel will probably not encounter the same resistance as a commercial real estate like a hotel or private houses. Nevertheless, opposition from breeding bird protectors, critisizing increases in visitor numbers can be expected (Verstrael, 1996).

The aim of the building should be to improve the current situation. Electrical busses to reach the location can eliminate the need for car parking space. The visual and physical impact of the building on the landscape can be reduced by (partially) building it into or under the dunes. This strategy also ensures a *efficient use of scarce land*, because the building program can be larger than what its appearance or visual impact suggests.

With the two projected large event spaces, the auditorium and the foyer, *noise protection* is an important aspect. On the one hand to create quiet spaces for the visitors to concentrate on a speaker or act, on the other hand to ensure that noise from occasional loud events does not disturb local fauna. Earth edges are a feasible strategy to achieve good acoustic insulation for the event spaces (DeKay&Brown, 2013).

The building needs to be able to handle *natural hazards* like high winds during stormy weather, and high water levels in a storm surge. Its placement on top of the coastal dune ensures relative safety for high water levels. A large drain on the lowest floor leading to the lower car park or beach may be installed to drain the building after a possible flooding. Protection against heavy winds can be arranged by digging the building into the dunes, or by building aerodynamic dune like (roof) shapes above groundlevel that experience less pressure from high winds.

To summarize, earth edges are relevant to the project because they provide thermal mass with the local building material of sand. Also by banking (parts of) the building in earth edges, the aesthetic and acoustic impact of the building will be smaller, which is benefitial for local fauna and the experience of natural surroundings. Lastly, the dune like earth edges for Planet Texel create a more aerodynamic form for the building, decreasing its impact on wind patterns. The blue rectangle in Figure 5.5 shows the most feasible solutions for Planet Texel. The sunken variant is ruled out, because the groundwater levels are very high near the sea, and the project will focus on using natural building materials like sand, with which building a water-tight basement is not a very logical choice.

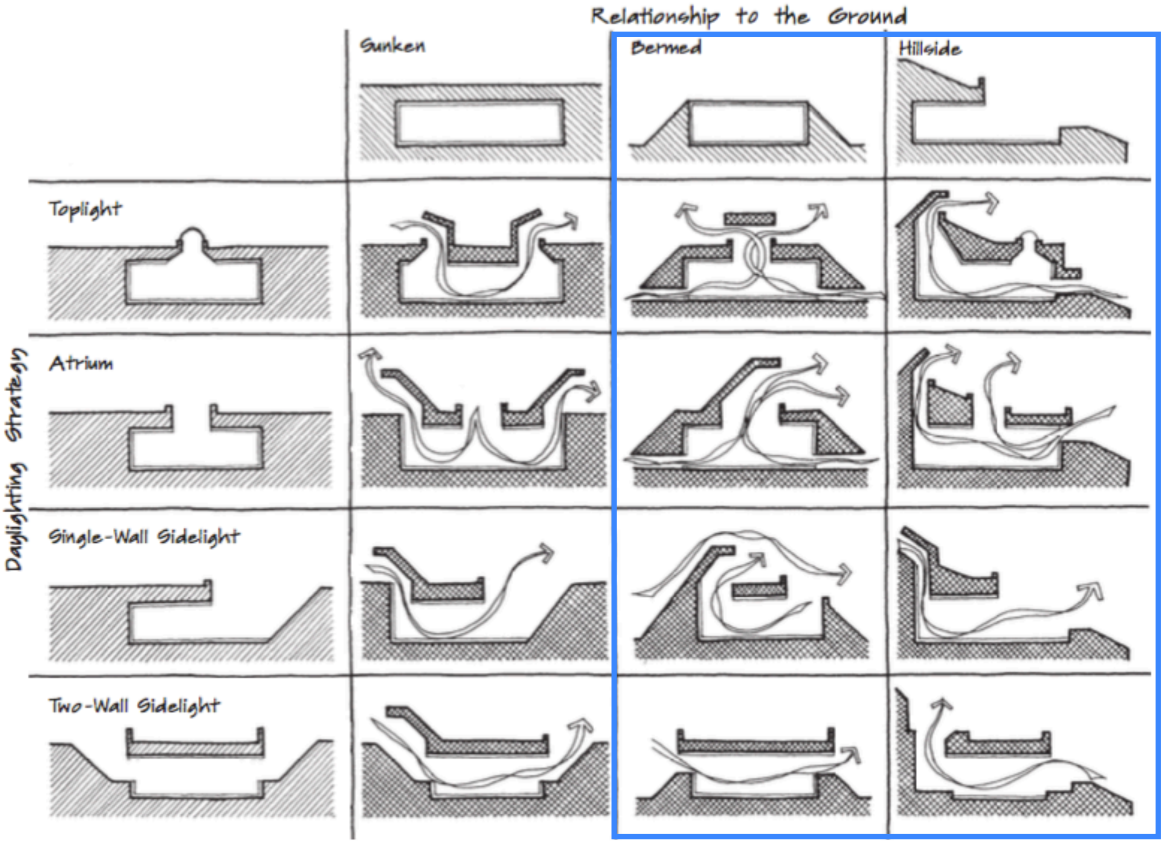


Figure 5.5: Earth edges configurations

6 Discussion

The nature of the main research question, with its focus on finding *specific* passive climate strategies, directs the conclusion towards a plain list of strategies, as can be seen in Chapter 5. This answer, in the form of a list, is legitimate regarding the question it answers. However, the depth of the research in this paper does not rely very much on the answer of the main research question. Most of the valuable results are presented in the chapters that focus on the aspects of the sub quesions (Chapter 2, 3 and 4).

This research paper serves as a basis for the design part of the graduation project. In that sense it presents valuable results about local climate, natural habitat and building concept and program, which are all necessary for the succesful implementation of passive design strategies within the design.

If the research could be expanded, it would be interesting to seek extra sources for passive design strategies, and to thoroughly assess more strategies within the project and context. Analysis of existing buildings that make use of specific passive design strategies can also add to the overall understanding of strategies and their potential for implementation.

7 Conclusion

The main research question of this paper is *Which passive design strategies are suitable for a public building in the dunes of Texel?* To answer that question, four sub question were introduced (Chapter 1.3). Each sub question was researched and results were presented in four respective chapters (Chapter 2, 3, 4 and 5).
In Chapter 2, Texel's climatic conditions were clarified. The climate was classified as a temperate sea climate with modest diurnal and seasonal temperature variations. Furthermore results show that Texel has a relatively sunny climate with strong winds, predominantly from a Southwestern direction.
In Chapter 3 the coastal dune habitat was researched. Its economic relevance as well as its importance for the Dutch flora and fauna became clear. The status as a National Park protects the dunes on Texel from degradation, which is common for other coastal dune areas around the globe due to human activity.
In Chapter 4 the spatial program of Planet Texel was elaborated. With three main elements, e.g. A restaurant, conference space and a museum, the building houses the user groups and implements the concept.
In Chapter 5 a list of passive design strategies was put together (Annex 1). Furthermore three strategies were studied more extensively and put into the project's context to assess their usefulness.

The main research question is eventually answered in Chapter 5, after researching vital aspects in Chapter 2, 3 and 4. The answer is twofold, with one part being a list of passive design strategies, found in Annex 1. The second part is the selection of three design strategies, in which more information about these specific strategies is presented. These three cases show their applicability within the Planet Texel building design and context. All three are effective within the projects natural context, and will be used within the eventual design of Planet Texel.

Bibliography

Al-Homoud, M. S. (2005). Performance characteristics and practical applications of common building thermal insulation materials. Building and environment, 40(3), 353-366.
Carter, R. (1991). Near-future sea level impacts on coastal dune landscapes. Landscape Ecology, 6(1-2), 29-39.

Autocad (2016) A. (Last update 2016, September 3). *Sustainability Workshop - Occupant comfort.* [online:web] Retrieved December 20, 2016, from https://sustainabilityworkshop.autodesk.com/buildings/occupant-comfort

Autocad (2016) B. (Last update 2016, September 3). *Sustainability Workshop - Passive design strategies.* [online:web] Retrieved December 20, 2016, from https://sustainabilityworkshop.autodesk.com/buildings/passive-design-strategies

Barker, M. B. (1986). Using the earth to save energy: four underground buildings. Tunnelling and Underground Space Technology, 1(1), 59-65.

Cleveringa, J. (2001). Zand voor zuidwest Texel: Technisch advies RIKZ over vier mogelijke ingrepen in het Zeegat van Texel. Rapportnr.: OS/2001.031.

Coch, H. (1998). —Bioclimatism in vernacular architecture. Renewable and Sustainable Energy Reviews, 2(1), 67-87.

DeKay, M., & Brown, G. Z. (2013). Sun, wind, and light: Architectural design strategies. John Wiley & Sons.

Ecomare (2016). (Last update 2016, November 11). *Recreatie op Texel.* [online:web] Retrieved December 17, 2016, from http://www.ecomare.nl/ecomare-encyclopedie/gebieden/waddengebied/nederlands-waddengebied/texel/recreatie-op-texel/

Martínez, M. L., Psuty, N. P., & Lubke, R. A. (2008). A perspective on coastal dunes. In Coastal Dunes (pp. 3-10). Springer Berlin Heidelberg.

McLachlan, A. (1991). Ecology of coastal dune fauna. Journal of Arid Environments, 21, 229-243.

Natuurmonumenten (2016). (Last update 2016, December 23). *Terugblik campagne bescherm de kust.* [online:web] Retrieved January 15, 2017, from https://www.natuurmonumenten.nl/over-natuurmonumenten/standpunten-en-beleid/bescherm-de-kust/terugblik-campagne-bescherm-de-kust

Texel Geeft Energie (2015). (Last update 2015, December 26). *Wat is Texel Geeft Energie.* [online:web] Retrieved December 26, 2016, from http://www.texelgeeftenergie.nl/home/wat-is-texel-geeft-energie

Texel.net (2016). (Last update 2016, December 4). *Cijfers over Texel.* [online:web] Retrieved December 27, 2016, from https://www.texel.net/nl/over-ons/vvv-texel/wist-u-dat-van-texel

Trouw (2015). (Last update 2015, December 19). *Bouwen in de duinen, Het mag.* [online:web] Retrieved January 15, 2017, from http://www.trouw.nl/tr/nl/4492/Nederland/article/detail/4211062/2015/12/19/Bouwen-in-de-duinen-Het-mag.dhtml
Waddenweer.net (2016). (Last update 2016, October 12). *Klimaat op Texel.* [online:web] Retrieved December 15, 2016, from http://www.waddenweer.net/klimaatinfo/klimaat-op-texel.html

Verstrael, T. J. (1996). Research on breeding birds in Dutch dune areas. Landscape and Urban Planning, 34(3), 301-313.

List of figures

Figure 5.1
DeKay, M., & Brown, G. Z. (2013). Sun, wind, and light: Architectural design strategies. John Wiley & Sons, p. E.264, (E-book section).

Figure 5.2
Max van den Berg

Figure 5.3
Max van den Berg

Figure 5.4
Max van den Berg

Figure 5.5
DeKay, M., & Brown, G. Z. (2013). Sun, wind, and light: Architectural design strategies. John Wiley & Sons, p. E.208, (E-book section).

Annex 1 *Selected passive design strategies*

H=heating, C=cooling, L=daylighting, V=ventilation

URBAN SCALE

Urban fabric

- **Topographic Microclimates** wind, shelter and solar radiation produce different microclimates in sloping areas. Use can be matched with characteristics of certain areas. This can reduce energy for heating or cooling, change length of outside comfort etc. In extreme climates less important, since cooling or heating is generated inside. H+C
- **Shared Shade** buildings arranged to shade each other. C
- **Daylight Density** configuring building masses and streets to support natural light into each building. L
- **Loose Urban Grid** for allowing cool breezes in hot and wet climates. C
- **Dense Urban Grid** for shade in hot arid climates, and for protection against winter winds. H+C
- **Plants & Water in built environment** reducing summer heat especially in arid areas. C+L
- **Winter Courts** by arrangement of buildings, to provide a sunny and wind protected area. H

Urban elements

- **Daylight+Solar Enveloppes** building volumes shaped to allow sufficient solar heat and light to enter surrounding spaces and buildings. H+L
- **Shadow Umbrella** buliding mass and elements providing shade for open sapces. C
- **Windbreaks** shelter buildings and open spaces and buildings from (cold) winds. H+C
- **Greed Edges** of vegetation cool imcoming breezes. C

BUILDING SCALE

Room compositions

- **Seasonal / Daily Migration** activities take place in warmer areas during cool periods and in cooler areas during warm periods of the season / of the day. H+C
- **Periodic transformation** make the building adapt to changing environmental conditions. H+C+L
- **Cooling zones** grouping rooms with similar cooling demand, sharing the same cooling strategy through time C+V
- **Heating zones** grouping rooms according to their need for heating, and their heat sources, passive or active H
- **Daylight zones** rooms with high light demand near windows/daylight sources, other rooms further away from them. L
- **Deep sun** in compact buildings, pathways in plan and section to allow natural light to penetrate into deep spaces. H+L
- **Buffer zones** rooms that can have temperature swings before living spaces to temper unwanted hot or cold fresh ventilation air. H+C
- **Permeable building** open plans and sections to enable cross and stack ventilation. Air flow is best with uninterrupted pathways, windward inlets and leeward outlets (-) Texel: SW. C+V

- **Outdoor rooms** extend outdoor comfort season by relating outdoor space to sun and wind. H+C
- **Stratification section** rooms vertically organized according to their heat demand, taking advantage of temperature stratification. H+C
- **East - West plan** long east west plan layouts to have large winter sun facing facade to collect solar radiation and light. H+C
- **Clustered/compact building** reduce skin surface, thus heat loss and gain. Keeping in heat in winter, keeping surface in summer small, so low heat gain. H+C
- **Mixed Mode building** combining passive, active and hybrid climate systems to create comfort in different building zones at different times of day and year. Different zones may have different cooling/heating/ventilation strategies, or in one season one aspect is done passively, and below a certain outside temperature switches to active or hybrid. H+C+V
- **Borrowed daylight** planning small rooms next to large or tall daylighted rooms (toilets) L

Individual rooms

- **Room orientation** increase solar heating and cross ventilation by facing the sun & wind. Inlets windward, outlets leeward. H+C+L+V
- **Wind catchers** catching the roof breeze for rooms with no acces to wind. C+V
- **Evaporative cooling towers** cooling rooms without fans or wind C+V
- **Toplit rooms** light rooms from above, avoiding glare and shade, while creating focus on matter/conversation. L
- **Daylight room geometry** designing the pattern of daylight distribution in a space throughout the day. L
- **Glare-free spaces** by making use of light reflection elements or louvres. L
- **Windowhight : Roomdepth** the depth of a space should not exceed 2.5 times the height of a window, when there is only side light, to keep an evenly lit room that is experienced as well lit. L
- **Breezy courtyards** wide, low and permeable, cool outdoor spaces C
- **Calm courtyards** closed and high enough to shelter from the wind, however enough width to welcome sun. H
- **Shady courtyards** narrow and tall, able to function as cool air columns during the day C
- **Convective loops**

COMPONENT SCALE

Building systems

- **Mass arrangement** thermal mass can be placed for solar heating and passive cooling. H+C
- **Water edges** cooling incoming breezes, to lower temperature of ventilation air. C
- **Outside insulation** allows heat to be stored in the constructive mass, thus stabilizing interior temperature. H+C
- **Shade layers** horizontally over the building can protect building or courtyard from high sun. Vertical shading protects for low sun. C
- **Reflected sunlight** for daylighting in climates with clear skies. L
- **Daylight roof** welcoming and distributing light with apt quantity and direction into room. L
- **Combined or Seperated Openings** for light, solar gainor ventilation, depending on building, context and aesthetics. H+C+V+L

- **Ventilation openings arrangement** increasing effectiveness of cross ventilation or stack ventilation. C+V
- **Supporting Active Systems** passive systems are often designed to create comfort in normal local conditions. In extreme conditions these passive systems are often not enough, then some active systems may help. H+C+V
- **Mechanical heat distribution** helping passive heat accumulation to spread through the building or rooms. H+C
- **Window placement** well placed windows can reduce heat loss in winter and heat gain in summer. Also responsible for distributionpattern of light in the room. H+C+L
- **Artificial lighting zones** in layers parallel to window facade, allowing for individual rows to be switched on. L

Building elements

- **Earth Edges** to protect a building for exteme heat and cold. Also to provide (a portion) of cooling needs. H+C
- **Radiant surfaces** delivering comfort, and changing perception of comfort, with passive + active heating and cooling of floors, walls and ceilings. H+C
- **Breathing walls** for preheating incoming ventilation air in winter, with south facing perforated dark metal wall as inlet. H+V
- **Solar reflectors** increase incoming solar radiation through windows. With reflecting outside surfaces or ponds. H+L
- **Low contrast windows** help to reduce glare and bad vision. With surrounding surfaces at an angle, and painted in a light color, the daylight comes in nicely without high contrast. L
- **Skylight wells** a deep sun strategy to bring daylight into rooms that have no facade nor roof. Daylight captured at roof level with skylights is distributed down through highly reflective shafts or tubes towards rooms.
- **Window Apertures** for solar gain; larger on sunny sides to increase passive heating supply. For daylight and view; the amount of light that reaches interior is a combination of apertures placement and size, room proportion and size. Wall reflectance and outside obstructions. H +L
- **Windfang / air flow windows** are buffer spaces for fresh ventilation air to warm up or cool down, and to let people enter a building without changing the interior climate too much.
- **Light shelves** deviding up a window in upper part for ambient lighting and lower part for views, while providing shading and reducing glare. Reflecting light off the top of the horizontal surface towards the ceiling, reflecting it deeper into space. C+L
- **External shading (+daylight enhancement)** placed horizontally above the window on the outside reduces solar heat gain. When shading is done with louvres in non reflective light colour, daylight entry and view can be preserved. C+L
- **Moveable insulation** to be put over windows to reduce heat loss at night. H project: stadhuis brabant?
- **Task lighting** with daylight as ambient lighting, and local high illumination lights as task lighting. L+P
- **Rock Beds + Mechanical mass ventilation** rock beds as thermal storage for heat or cold, with air movement past them to increase cooling and heating potential. H+C
- **Mechanical ventilation** at times of low natural ventilation forces (wind, stack effect). With space cooling (outside to inside) or people cooling (fans). C+V
- **Active Air Pipes** can transfer warm air in high spaces from top to bottom, or cool air from cold spaces to hot parts. H+C+V

- **Earth-Air Heat Exchangers** cooling in summer and tempering incoming ventilation air in all seasons. H+C+V
- **Air-Air Heat Exchangers** reclaiming heat and cold from ventilation air. H+C
- **Manual vs. Automated controls** for HVAC and lighting to increase satisfaction and comfort while at the same time raising the efficiency of passive strategies. H+C+V+L

Materials

- **Mass surfaces** rock beds as thermal storage for heat or cold, with air movement past them to increase cooling and heating potential. H+C
- **Daylight reflecting surfaces** to increase daylight penetration into space. With skylight for example light floor color, or light ceiling with light reflected from ground surface exterior. L
- **Exterior surface colour** dark in cold climates to increase surface temperature, so the heat loss through the envelope is reduced. Light in warm climates to reflect solar radiation. H+C
- **Double skin materials** Summen sun is partly reflected by a building, partly absorbed. Absorbed part will conduct inward, increasing heat gain in building. Double skin materials protect the inner climate. H+C