[Wind]scapes : Engaging the shifting nature of the wind formed landscapes of Denmark

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A thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Architecture
University of Washington
2016

Committee:
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Program Authorized to Offer Degree:
Architecture

University of Washington

Abstract

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Unlike the other natural elements like water, wind has been little explored in architecture for its physical and sensory qualities. Design considerations have been limited to mitigating damage or harnessing an energy source, typically overlooking the experiential qualities of wind. This thesis proposes that architecture has the potential to reveal the complex nature of this natural force by tracing the evolution of wind through studying the built constructions and their corresponding material landscapes. What emerged was a methodology that uses architectures key components of structure, material and physical experience to reveal an invisible force.

The resulting design engages the shifting ground plane of an extreme [wind]scape, to heighten a visitor's understanding of the evolution of the landscape over time and enhance a personal experience with wind as a force. Through the eroding site of Rubjerg Knude, on the northwest coast of Denmark, architecture's stationary nature is used as a datum to measure and reveal the progression of the landscape both long term, on a geological level, as well as more immediately in its daily fluctuations.

This thesis attempts to establish a relationship between wind landscapes and the architecture placed within them. The introduction of an intervention does not aim to maintain the environment as is but acknowledges that by inserting this intervention into the landscape, it will inherently result in changes to the patterns of the site. However, the possibilities of how the environment will respond to human intervention is equally compelling and unforeseen.

Thank you to...

Brian and Nina	... for pushing me
Louisa Iarocci	... for the constant encouragement
My Family	... for a lifetime of support

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INTRODUCTION

An Understanding of the Wind

Wind, or moving air, is pervasive in our environment both as a natural force and mythological concept. As stated by A.K. Lobeck, "this force creates changes by virtue of its movement, becoming an agent of erosion… which changes the face of the earth in a large way."[1] Structures designed for wind have treated it as either a source of energy to be captured and tamed for human consumption, or as a destructive natural force to be blocked and resisted for survival. (Figure 1.0) However, unlike other natural elements like water, wind has been little explored in architecture for its physical and sensory qualities. Design considerations have been limited to mitigating damage or harnessing an energy source, typically overlooking the experiential qualities of wind. Alternately, aesthetic installations have neglected the scientific role moving air plays in shaping the environment. But it can be argued that architecture has the potential to bridge this gap and reveal the complex nature of this natural force.

[1] Lobeck, A K. Geomorphology: An Introduction to the Study of Landscapes. New York: McGraw-Hill Book Company, Inc, 1939. Print.

This thesis traces the evolution of wind through studying the built constructions and material landscapes by which it has been controlled and revealed as a moving and invisible force of nature. The investigation of the use of wind as a resource for consumption and as a source of artistic inspiration will demonstrate its utility as a scientific and artistic medium. The analysis of the historic role of wind reveals how this moving force of nature has been engaged through architecture to reveal its potential for a more powerful connection to the unique landscapes it creates. Examining the evolution of wind through the built constructions and material landscapes by which it has been controlled and revealed exposes the architectural potential of establishing a powerful connection to the landscapes wind creates.

To achieve this goal, this thesis engages the shifting ground plane of an extreme [wind]scape, to heighten a visitor's understanding of the evolution of the landscape over time and enhance a personal experience with wind

Figure 1.0 :

Existing variations of wind infrastructure.

as a force. Through an intervention in the eroding site of Rubjerg Knude on the northwest coast of Denmark, architecture's stationary nature is used to measure and reveal the progression of the landscape as visitors explore the larger site and its affected infrastructure. Here the wind has eroded the cliff side, creating a massive dune landscape that has encroached upon the historically significant architectural fabric of the area. Using the lighthouse as a reference point while allowing its natural decay, an inhabitable datum is extended across the landscape creating a tangible way to measure wind, both long term on a geological level and immediately in its daily fluctuations. Further, moments throughout the path heighten awareness to variations in wind and their corresponding landforms.

Science of Wind

As an invisible and even inexplicable force, wind has long been a subject of scientific investigation. Throughout history, the flow of air on the earth has been documented by written and mapped means. As far back as the 18th century, people began documenting daily patterns witnessed in nature.[2] The primary means for recording these observations was in logbooks or journals kept by mariners who relied upon wind for orientation.[3] Lacking the scientific vocabulary of later meteorologists, observations were written in lyrical, poetic narratives describing events through personal experience, while quantifying its characteristics. In 1703, an anonymous English writer chronicled the weather conditions in a diary entry:

…we had a constant thick & heavy Sea of clouds & close dark nebulous expanse, or Black sad Atmosphere baked in massy clouds, & I could compare ye huge rising body & vast aeriall Load or ye mundane smoak to nothing more than a Diffusion of ye Ocean or steam of some infinite Abyss…[4]

Through the steady documentation of wind in logs, directional patterns grew increasingly apparent. Mariners began to make the connection between wind patterns and the navigation of ships. This led to the development of the 'wind rose' as well as the first automated weather station.[5] (Figure 2.0) Originally this graphic device was used on charts and maps to visually note the direction of winds. Barbara Kenda observes that it quickly became a scientific tool that would inform regional conquest, city grid orientation and even building window placement.[6] The continued documentation of prevailing winds in maps informed an infrastructure of trade routes for navigating the globe. The knowledge gained through scientifically mapping the wind allowed people to physically move themselves and alter their environments by harnessing its power.[7]

[2] Hill, Jonathan. Weather Architecture. London: Routledge, 2012. Print.
[3] Hill, Weather Achitecture, 12.
[4] Golinski, Jan. 'Exquisite Atmography': Theories of the World and Experiences of the Weather in a Diary of 1703. The British Journal for the History of Science .Vol. 34, No. 2 (Jun., 2001), pp. 149-171 .Internet resource.
[5] Hill, Weather Architecture, 12.
[6] Kenda, Barbara. Aeolian Winds and the Spirit in Renaissance Architecture: Academia Eolia Revisited. London; New York: Routledge, 2006. Print.
[7] Kenda, Aeolian Winds and the Spirit in Renaissance Architecture, 06.

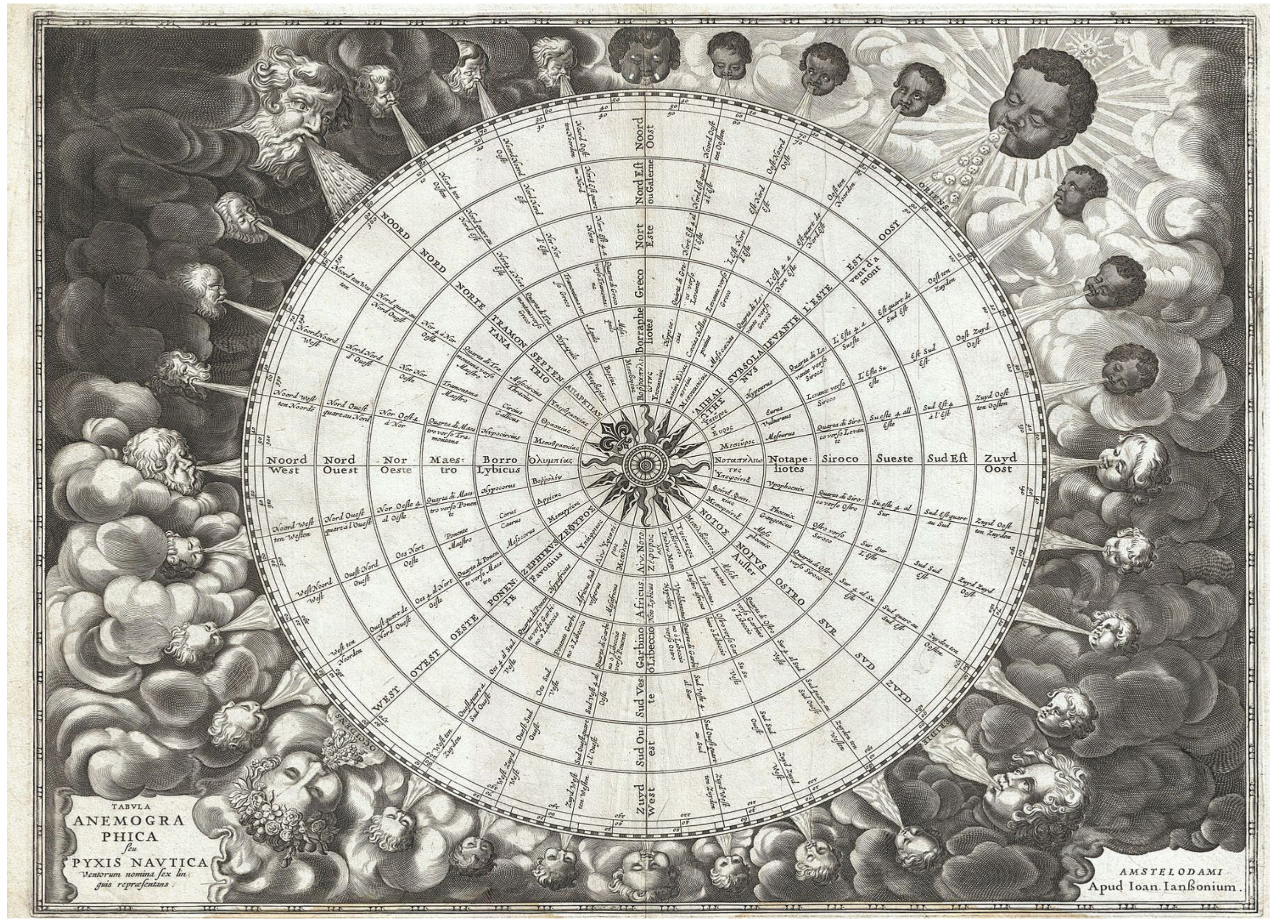


Figure 2.0 :

Windrose with surrounding imagery portraying the conceived attributes of directional wind.

By the sixteenth to eighteenth centuries society's relationship with air began to fundamentally shift in response to technological advances.[8] Rebecca Williamson notes that the documentation of winds evolved into a rigorous science of "systematic observation, measurement and analysis." As seen in 17th century meteorological maps, air began to be seen more as a single homogenous mass, classified only according to temperature and direction.[9] This systematic categorization of the elements and effects of wind, revealed its patterns of behavior allowing planning and protection from a previously unpredictable force. Jonathan Hill observes that the 16th century adoption of the Julian calendar, over the Gregorian one, provided further clarity for understanding the rhythm of the wind in relation to the seasons.[10] This early classification of patterns created the foundation for meteorology, a scientific field of study focused on extracting data from these documented phenomena, in order to predict, harness and guard against their effect.

[8] Knechtel, John. Air. Cambridge, Mass.: MIT, 2010. Alphabet City (Cambridge, Mass.); #15. Print. 190-194.
[9] Knechtel, Air, 10.
[10] Hill, Weather Architecture, 12.

Figure 2.1 :

(right) The painting 'Juno Asking Aeolus to Release the Winds' by François Boucher, c.1769.

Figure 2.2 :

(left) 'Snow Storm- Steam-Boat off a Harbour's Mouth Making Signals in Shallow Water' by J.M.W. Turner, c.1842.

Art of Wind

Alternately, wind also has historically been documented for its experiential qualities as portrayed in mythology and art. At the same time flows of air were being measured scientifically to assess their risk or gain, they were assigned distinct characteristics related to their impact on the human senses. [11]

Across multiple cultures, wind has been chronicled through mythology as a means of expression and explanation. As Kenda explains, "mythological winds have their origins in the etymology of the Greek word pneuma which derives from 'pnein', to blow, and means 'breath' or 'wind' as well as the vital spirit, the soul."[12] Greek myths portrayed the winds as untamable forces guarded by the god Aeolus. (Figure 2.1) He was responsible for the "cave of winds" on the island of Aeolia, releasing them as directed by the gods to favor or punish humanity.[13] Similarly, Native tribes in the Pacific Northwest attributed the winds to the mythical "thunderbird", an enormous bird that fed off killer whales. Sea winds were brought by the flapping of its massive wings as it flew out to sea to hunt. [14] This belief that the winds were deliberately controlled by the god(s) not only justified their outcomes but rationalized their unpredictability.

The poetic understanding of moving air is further reflected in the atmosphere becoming the focus of paintings, replacing its previous role as background.[15] These landscape paintings are categorized by a low horizon line with landscapes or people being the secondary focus of the scene. Instead the atmospheric effects of weather become the focus, evoking a sensory connection the viewer can relate to through personal experience. J.M.W Turner's work, Snow Storm- Steam-Boat off a Harbour's Mouth Making Signals in Shallow Water (Figure 2.2), consciously illustrates the massive scale at which the wind exists within the landscape and establishes its temperamental nature.[16] Barely visible at the center of the scene, the boat gives a sense of scale

[11] Knechtel, Air, 10.
[12] Kenda, Aeolian Winds and the Spirit in Renaissance Architecture, 06.
[13] Kenda, Aeolian Winds and the Spirit in Renaissance Architecture, 06.

[14] McShane, Dan. "Wind and the Washington Landscape via Cliff Mass." Reading the Washington Landscape:. N.p., 01 Jan. 1970. Web. 21 May 2015.
[15] Hill, Weather Architecture, 12.
[16] Hill, Weather Architecture, 12.

Figure 2.3 :

(left) Strandbeest by Theo Jansen ; (middle) Singing Ringing Tree by Tonkin Liu ; (right) photograph by Charlie Waite.

and reveals the physical effects of the storm.

The impact that wind has on the landscape is a theme that is evident in other kinds of artistic works that seek to capture its auditory, visual and sensory qualities. Engaged as an animator, this flowing air breathes life into sculptures that respond to the natural conditions of their specific site. For example, Strandbeests designed by Theo Jansen are self-propelling beach creatures that inhabit the windswept environment of the beaches on the coast of Holland. [17] (Figure 2.3) These kinetic sculptures are constructed of PVC pipes and are propelled by high wind, through the use of wing like sails. Jansen harnesses the wind as a life source for his creations, letting them be animated by this unlimited resource tied directly to the environment.[18] Another example located in East Lancashire, UK is the Singing Ringing Tree by Tonkin Liu, a musical sculpture on a remote hilltop.[19] (Figure 2.3) This piece emits different chords as prevailing winds pass through its stacked pipe construction, creating songs of wind.[20] While using different approaches, both these projects rely on the open landscape to harness moving air in its raw form.

The presence of wind in the environment has also been a source of inspiration in the field of photography. Landscape photographer, Charlie Waite creates images of the landscape that are characterized by "a sense of calm and clarity."[21] (Figure 2.3) In his photography, Waite seeks to document the absence of wind, creating images that are noticeably stagnant, almost void of atmosphere when the wind lulls.[22] This allows the images to focus on the resulting sculpted environment left behind by erosion and the redistribution of material. Waite states, "the wonderful thing about photography is that it allows that moment of perceived beauty to endure," recognizing that these environments are constantly being transformed by the elements.

[17] Jansen, Theo. " Wind Storage." STRANDBEEST. Theo Jansen, n.d. Web.
[18] Jansen, STRANDBEEST, Web.
[19] "The Singing Ringing Tree." The Singing Ringing Tree. RIBA, n.d. Web.

[20] Liu, Tonkin. "Singing Ringing Tree: Hill-Top Musical Sculpture." Singing Ringing Tree. Tonkin Liu, n.d. Web.
[21] Charlie Waite Photography. Charlie Waite, n.d. Web.
[22] Waite, Charlie Waite Photography, Web.

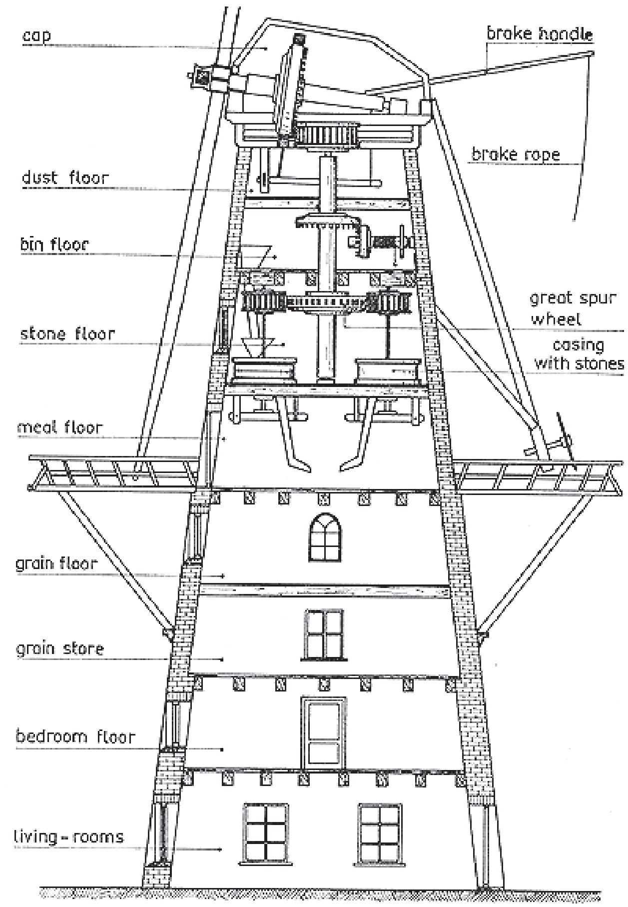


Figure 2.4 :

Tower mill section, labeling interior spaces of body created by machinery and sail scale.

Architecture of Wind

Beyond its role as a source of inspiration in art and science, wind has been a force in the built environment. This human built infrastructure has sought to capture wind as a source of energy, to resist it as a destructive power and interpret it as a natural force - thus suggesting the typology of the harvester, barrier and installation.

Harvester

Historically, windmills have played a substantial role in capturing and harnessing the energy of wind. As reflected in its name, the windmill began as a machine that captured the energy of the wind to mill grain and/or pump water. The structure consisted of a sail or blades that transfers the energy of moving air to a wheeled machine housed within the built form. While relatively consistent, the basic architectural features of windmills adapted to reflect regional variations in the wind.[23] The size of the sails that physically captured the force of the wind was the most important adaptation, having the largest resulting architectural impact on the scale of the mill. The structural framing of the body of the windmill was central to the design, constructed to shelter the machinery and act as an anchor to counteract the force wind exerts on the sails.[24] As sail lengths increased to optimize efficiency, the body of the structure correspondingly increased in scale.[25] This provided room for supplemental spaces, complementary to the function of the mill as a machine: including storage space, shop front and living quarters.[26] (Figure 2.4)

Some mills possessed rotating heads on which the sails were attached, that were then adjusted by the miller onsite to respond to the shifting directionality of local winds.[27] These minor variations allowed structures to develop their own regional characteristics to optimize functionality in relation to geographic forces.[28] Due to the need to exploit the natural resources of the wind and geography, windmills were often located as satellites in relation to towns and rural landscapes.

[23] Reynolds, John. Windmills & Watermills. New York: Praeger, 1970. Print.
[24] Beedell, Suzanne M. Windmills. New York: Scribner, 1975. Print.
[25] Stokhuyzen, Frederick. The Dutch Windmill. Merlin P in association with C.A.J. van Dishoeck, 1962. Print.

[26] Stokhuyzen, The Dutch Windmill, 62.
[27] Stokhuyzen, The Dutch Windmill, 62.
[28] Stokhuyzen, The Dutch Windmill, 62.

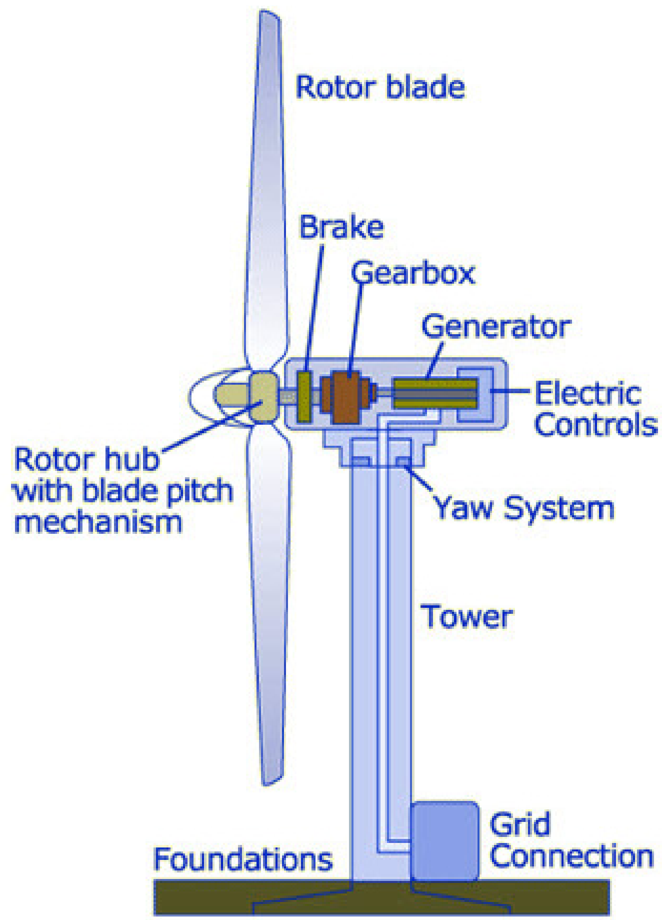


Figure 2.5 :

Modern wind turbine diagram, demonstrating the same elements of structure, body, machinery and sails.

Sprawling landscapes optimize the capturing of wind by the machine from all directions by reducing potential architectural impediments that might block or limit the rotational space of sails.[29]

The historic wind mill can be seen as the predecessor of the modern wind turbine that is dedicated to generating electricity.[30] Streamlined to the ultimate in functionality and efficiency, these current designs are driven by factors related to aerodynamic and acoustic performance and visual impact.[31] Their connection to a larger infrastructure is also important, as these structures rely on an unattended monitoring system, eliminating the need for the human occupant that historically was the miller.[32] Remote controlling is now possible due to the production of the invisible byproduct of electricity that is transmitted through the grid network and collected offsite.[33] Now composed of tubular steel towers, the support structures are tapered to reach heights of 200+ feet; while the height of the turbines capturing the wind is site specific, depending on wind velocity or frequency.[34] The widespread commercialization of wind technology in the early 1980s, along with the removal of onsite operation created a massive shift in the design of turbine technology.[35] (Figure 2.5) These advances allowed turbines to reach a physical scale that is functionally productive but lacks the former relationship to its environment, users or product. The construction of large scale wind farms has created an even greater distance between the familiar typology of a windmill and the current wind machines that dominate the landscape.

Barrier

The location of these built harvesters of wind continues to be strongly tied to the landscape that has a direct impact on the character of the wind. Prairie landscapes for example, are particularly strong environments for wind, having few obstacles for it to overcome. Yet these open landscapes where wind is at its strongest can also pose a potential risk to the urban infrastructure that

[29] Beedell, Suzanne M. Windmills. New York: Scribner, 1975. Print.
[30] European Wind Energy Association,. Wind Energy - The Facts: A Guide to the Technology, Economics and Future of Wind Power. London: Taylor and Francis, 2012. EBook Library. Web.
[31] European Wind Energy Association,. Wind Energy - The Facts, 12.
[33] European Wind Energy Association,. Wind Energy - The Facts, 12.
[34] European Wind Energy Association,. Wind Energy - The Facts, 12.
[35] European Wind Energy Association,. Wind Energy - The Facts, 12.

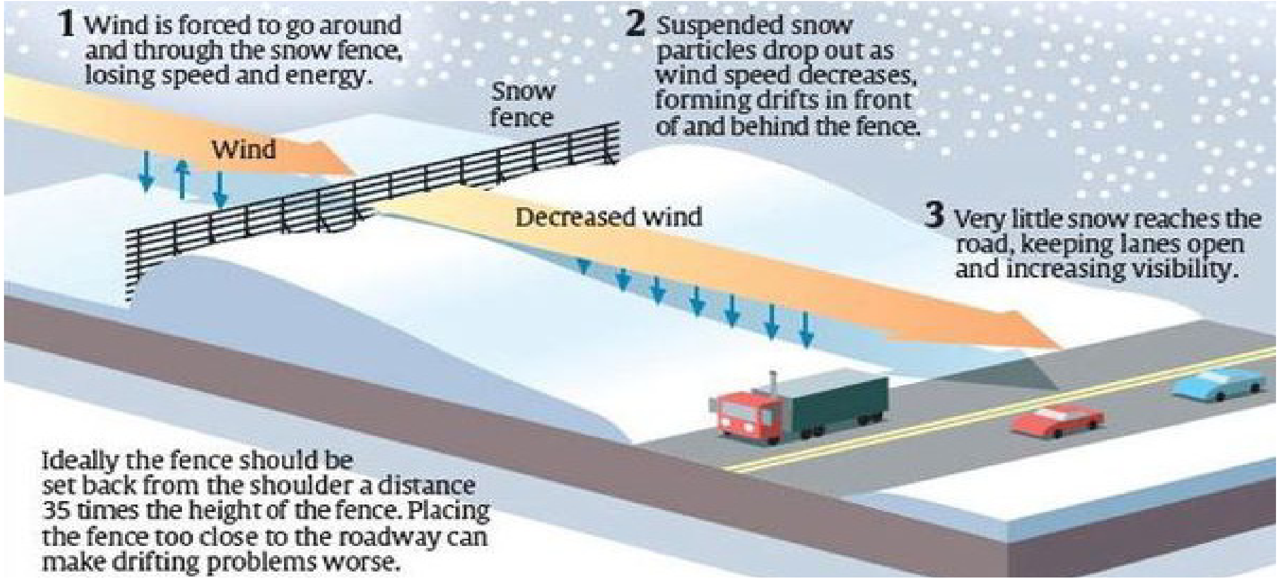


Figure 2.6 :

(left) Diagram of snow fence design and functions.

Figure 2.7 :

(right) The snow fence as an object on the landscape in off season.

supports human occupants. Particulates carried by wind in the form of dirt, sand and snow are two main causes of decreased visibility, safety and increased accidents in severe weather.[36] The construction of barriers along roadways and bridges is a means to block the accumulation of wind borne matter and sounds.[37] Drift fences for example are surface mounted, porous barriers that reduce the wind's velocity and collect traveling particles on the downwind side of the fence where there is less velocity.[38] Over time, material accumulates against the barrier, creating a dune away from the targeted protection zone. (Figure 2.6) Similar barriers exist to mitigate the damage of wind where particles are carried, such as beach conditions.[39]

Located along roadways and installed perpendicular to prevailing winds, fences can be constructed from different kinds of materials, including wood slats, metal rails, plastic netting, polymer and woven fabrics.[40] These structural frames are highly visible in the off season, usually appearing as abandoned skeletal structures in an open landscape. But at the same time they stand as markers of the larger seasonal infrastructure of wind that traces its paths across the landscape. (Figure 2.7) Effective drift fence design is determined through scientific calculations, correlating the height, porosity and length of the fence with the potential resulting dune or drift size.[41] These calculations are based on meteorological records of wind and material fall patterns. If material accumulates beyond its capacity, the fence ceases to perform its intended function, becoming a part of landscape rather than a barrier against it. Barrier typology is a unique utilitarian design response to wind, similar to the previously discussed wind turbines. These fences are a minimal infrastructure based on the study of the material behavior of wind justified by functional calculations over aesthetic design.

[36] Constantinescu, G, H Ho, M Muste, and K Basnet. "Method to Assess Efficiency and Improve Design of Snow Fences." Journal of Engineering Mechanics. 141.3 (2015). Print.
[37] Constantinescu, G, H Ho, M Muste, and K Basnet, Methods to Assess Efficiency, 15.
[38] Constantinescu, G, H Ho, M Muste, and K Basnet, Methods to Assess Efficiency, 15.
[39] Constantinescu, G, H Ho, M Muste, and K Basnet, Methods to Assess Efficiency, 15.
[40] Constantinescu, G, H Ho, M Muste, and K Basnet, Methods to Assess Efficiency, 15.
[41] Blanken, Peter D. "Designing a Living Snow Fence for Snow Drift Control." Arctic, Antarctic, and Alpine Research 41.4 (2009): 418-25. Web.

Figure 2.8 :

Spring Wind by AuW within its larger windscape of sweeping hills ; human interaction facilitated by passing through the instillation.

Installation

As seen in its artistic representations, wind has also informed interpretive built responses that seek to capture and reveal its untamed and invisible qualities. These types of projects initiate a dialogue of how wind and its related landscapes are interpreted in the built environment.

Located on the Hungarian plains, Spring Wind, built in 2013 by Architecture Uncomfortable Workshop (AuW), "highlights the natural effects of a sheltered environment" while responding to winds inherent properties of movement.[42] Using a structural frame and a textile that fluidly responds to gusting wind, an interactive envelope that reveals the moving air on this remote hilltop was created. (Figure 2.8) The designers, AuW state that, "this building is actually the contrary of the house in function, instead of closing the wind out, it lets it in, it is actually formed by the wind."[43] The design is a poetic interpretation of how wind is designed in modern architecture, drawing a stark juxtaposition between the traditional envelope form and untamed wind.

Similarly relying on textile movement, Breath Box, designed in La Grande Motte, France for the 2014 Festival des Architectures Vives by NAS architecture, consists of a reflective main wall, composed of individually hinged mirrors facing the waves.[44] The project inhabits the seam in the landscape where wind transitions from water to land, allowing the mirrors to react and recompose the surrounding environment. (Figure 2.9) This shift draws attention to the presence of this natural force and its surrounding elements as viewers follow the path of the fluctuating wind.[45] The architects stated they wanted to allow users, "to distinguish, to see the wind passage, not only feel but apprehend physically."[46] The supporting structure is composed of wooden slats that filter the residual air into a more refined sensory experience for users. The installation is both spatial and visual, providing

[42]Szabados, Karolina, and Lukács Szederkényi. Spring Wind House. AUWorkshop, 2013. Web. 13 June 2015.
[43]Szabados and Szederkényi, Spring Wind House. Web.

[44]"Breath Box." Breath Box. NAS Architecture, n.d. Web.
[45]NAS Architecture, Breath Box, Web.
[46]NAS Architecture, Breath Box, Web.

Figure 2.9 :

BreathBox by NAS Architecture along its windscape, capturing wind from the sea ; additionally the inhabitable interior space for user interaction.

an immediate change in experience for viewers as they pass by the edge of land and sea.[47]

In contrast, the 2011 project Windswept, by Charles Sower Studio, addresses wind in an urban environment. Designed for the Randall Museum in San Francisco, California, Windswept is an exterior installation, composed of 612 freely rotating weather vanes mounted to a wall.[48] (Figure 2.10) According to Sower, the design creates an "architectural scale instrument for observing the complex interaction between wind and the building."[49] The metal vanes rotate to reveal the shifting nature of the gusts of wind, allowing it to visibly react with the built environment.[50] The use of a neglected urban environment illustrates that wind is not simply an element that can only be captured remotely but which permeates our everyday environments.

The siting of all three of these architectural constructs plays a dominant role that is primary to the function and appearance of the designs. Each engages the wind through similar means by using mechanical or physical means to capture its fluctuating rhythms of movement. In doing so, installations make the ephemeral void of wind visible, allowing viewers to identify directly with this force of nature. However, they stop at the limits of experiential and do not engage the more utilitarian properties of wind that give it another layer of value or purpose.

47NAS Architecture, Breath Box, Web.
48Sowers, Charles. "Windswept." Windswept. N.p., n.d. Web.

49Sowers, Windswept, Web.
50Sowers, Windswept, Web.

Figure 2.10 :

Windswept by Charles Sower Studio in its urban windscape : purely visual interaction for users.

Architecture Typology Analysis

Each of these three typologies of wind infrastructure recognizes a relationship to the properties of moving air in order to harness, block or reveal it. Thus, landscapes tend to be remote, allowing wind to flow without a barrier, built or geographic, until it falls upon the fabricated structure that transforms it. The scale of wind architecture can be seen in its opposing extremes of scale-experiential works that are at human scale, making the concept of wind more relatable and, in contrast, massive utilitarian structures that are streamlined for efficiency. In their contrasting approaches, these typologies of wind infrastructure reveal the potential for a new kind of built intervention that bridges between science and art. This thesis proposes an architectural intervention that synthesizes the dual nature of the wind to render a more complete reading of its properties and its impact on the landscape.

Design considerations in wind infrastructure have been limited to mitigating damage or harnessing an energy source, disregarding its experiential connection to the landscape. In contrast, experientially focused wind installations have neglected the value of its scientific implications. This thesis argues for an architecture that willfully engages the shifting ground plane of extreme wind landscapes, to heighten visitors' understanding of the evolution of these landscapes over time and to enhance a personal experience with wind as a force. Denmark is one such place where wind is truly redefining the country, not only as a leader in wind energy but physically in the definition of its landmass. The selected site to test this proposition is located in Northern Jutland of Denmark which is home to the largest migratory sand dune in Northern Europe.[51] (Figure 3.0) The distinctive impact of the wind in this area is evident in its impact on existing built infrastructure, as well as the material landscape.

[51] "Planlæg Ferien." Toppenafdanmark. Danish Tourist Offices, n.d. Web.

Wind Erosion: Process and Product

The fluid character of wind has always been evident in visible patterns across the landscape. A.K. Lobeck emphasizes the power wind can have on the natural environment, stating that "wind can become an erosive agent, more constant than the rain, more potent than streams, and more persistent than the sea."[52] Moving air fundamentally shapes the landscape on a substantial scale, typically made visible in a secondary surface such as ripples on water, clouds moving through the sky or the rustling of leaves in a tree. Wind changes the landscape by transporting and depositing material elsewhere or through direct removal by abrasion.[53] The geological formation of the landscape, from fine sand to massive stones, influences the extent to which the wind shapes it. These direct traces are highly evident on the 6.2 mile long Lønstrup Cliff on the northwestern coast of Denmark.

[52] Lobeck, Geomorphology, 39.
[53] Lobeck, Geomorphology, 39.

Figure 3.0 :

Map of Denmark (right) highlighting areas of wind erosion along the coastline.
Underlay of highlighted strip of Northern Jutland in which the design intervention is focused.

Formed by the Scandinavian ice caps, this region of Denmark was originally compressed by the ice; after melting, the land rose from the water and created the cliff and plain like landscape of Vendsyssel.[54] Due to its formation, the cliff face, consisting mainly of clay and sand particles is now continuously eroded by an interaction of wind and precipitation, at a rate of four to seven feet per year.[55] As it rains, water seeps between the sand to the clay, where it then flows downhill towards the coast to trickle out in the middle of the cliff.[56] This process destabilizes the cliff face and facilitates landslides, while additionally loosening grains that are blown inland, over the cliff as sand.[57] Lobeck expands on this phenomena, noting that, "A strong wind behaves like a current", finer material will carry further, while larger sediment remains behind, smoothed by this constant abrasion.[58] He further notes that this behavior of wind can cause larger transformative events on the landscape:

[54] "Rubjerg Knude: Explore Rubjerg." Rubjerg Knude's Cultural and Natural History. Vendsyssel Historiske Museum, n.d. Web. 12 Sept. 2015.
[55] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[56] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[57] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[58] Lobeck, Geomorphology, 39.

… The atmosphere is filled with a driving mass of dust and sand, which hides the country under a mantle of impenetrable darkness and filters through every fabric; it often destroys life by suffocation and leaves in places a deposit of several feet deep.[59]

Wind is capable of carrying 10,000,000 to 100,000,000 tons of material in a single storm, up to 2,000 miles, resulting in geographic formations much like the dunes atop Lønstrup Cliff.[60] Steady flows of air blow sand in one direction over existing land, producing ridges either transverse or longitudinal to the orientation of the prevailing wind.[61] The directionality and force of the wind sculpts the sand into corresponding dune types classified by their shape and texture.[62] Furthermore, the wind continues to move settled sand, making Rubjerg Knude drift about 33 feet a year towards the northeast.[63] Below the cliff lies a 4 mile beach which can be accessed from the north in Lønstrup, as well as from the south in Nr. Lyngby. Alternately, in good weather it is possible

[59] Lobeck, Geomorphology, 39.
[60] Lobeck, Geomorphology, 39.
[61] Lobeck, Geomorphology, 39.
[62] Lobeck, Geomorphology, 39.
[63] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Today, Web.

Figure 3.1 :

Lønstrup Cliff in current condition, loooking south with created dune and lighthouse in the distance.

to access the beach through the gorge, Grønne Rende, just south of the lighthouse.[64] Unfortunately, this beach is consistently effected by coastal erosion and landslides, sometimes blocking access to entire sections.

Sand Drift: Impacts

The impact of sand drift on this landscape can be further magnified by the existing infrastructure on the land that assists in keeping soil in place. The loss of the symbiotic relationship between the landscape and wind has historically led to catastrophic events. Specifically, the severe sand drift issues at Rubjerg Knude have two main causes: climate and human exploitation of nature.[65] Rubjerg Knude has unique vegetation that is very specific to the natural conditions created by the sand and wind. Local plant life was over-harvested for thatching, weaving, fodder, bedding, rope and fuel, while buckthorn thickets continued to be cleared for new grazing.[66] With the widespread removal of this protective plant cover that originally held the sand, the wind was able to sweep further inland. This caused a shift in how the area was utilized. In the mid 1500s, there were 18 farms in Rubjerg, however just 30 years later only 5 remained.[67] People began to tear down their homes, moving further inland, to escape the sand. By 1750, all the forests in Vendsyssel had been clear cut, leaving no remaining windbreaks.[68] Without breaks, the sand continued to drift, leading the community to relocate and use more area of the cliff for grazing, thus perpetuating the cycle.[69] Today, the landscape remains much the same, open grazing plains that provide a stark contrast to the growing dunes. (Figure 3.1)

Landscape Conservation

In 1792, after nearly 300 years of effects, the first fight against the sand drift was organized.[70] Helmet, a drought tolerant and long rooted plant, was the primary means of fighting the drifting dunes. Other means were also employed, 'using wattle (pine branches) and covering the flats with heather, turf or clay'.[71] In 1994, sand won

[64] Vendsyssel Historiske Museum, Rubjerg Knude: The Beach, Web.
[65] Vendsyssel Historiske Museum, Rubjerg Knude: The Sand Drift Catastrophe, Web.
[66] Vendsyssel Historiske Museum, Rubjerg Knude: The Sand Drift Catastrophe, Web.
[67] Vendsyssel Historiske Museum, Rubjerg Knude: The Sand Drift Catastrophe, Web.
[68] Vendsyssel Historiske Museum, Rubjerg Knude: The Sand Drift Catastrophe, Web.
[69] Vendsyssel Historiske Museum, Rubjerg Knude: The Sand Drift Catastrophe, Web.
[70] Vendsyssel Historiske Museum, Rubjerg Knude: The History of the Prevention of Sand Drift, Web.

1964 2002 2015

Figure 3.2 :

Aerial progression of Lonstrup Cliff, noting the shifting condition of the cliff line and sand as it spreads and condenses.

the battle when prevention techniques were resigned.[72] Today, the sand continues to accumulate from the cliff face to the dunes or into the air, facilitating its travel and fall throughout the surrounding landscape.[73] However, the dune is flattening out, reaching its peak height of 295 feet in 1990 and now down to 230 feet high.[74] (Figure 3.2)

This site has sparked tensions and a dialog, "between allowing nature to take its course on one side and protection of a landscape rich in monuments of the past and history on the other side".[75] Multiple ideas for addressing the coastal erosion have similarly been discussed, such as cliff draining, the use of groynes and breakwaters and supplemented yearly sand-feeding and using pressure equalizer pipes.[76] Both advantages and disadvantages can be argued for preventative techniques. One side argues for coastal erosion prevention noting it will preserve the cliff, threatened buildings and beach as seen today.[77] However, landslides from the cliff face would continue depositing material on the beach, leading others to argue that nature should take its course and eventually the cliff will reach its 'passive equilibrium's form', allowing it to stabilize and grow cliff plants at the cost of losing the dramatic landscape seen today.[78] This group notes most prominently that coast protection would be visually disfiguring to the local environment it aims to maintain.[79]

Terrain Typology Analysis

Through analyzing the existing material landscape, it became clear there were four distinct zones: water, sand, forest and plains. Water is the source of the wind that defines this site experience and its deterioration. The wind is driven off the sea, hitting Lønstrup cliff as its first obstacle, creating the corresponding loss of land and dune growth. As the cliff erodes it also falls to the beach, to be consumed again by the cycle of currents and rising tides that wash it into invisibility.

[71] Vendsyssel Historiske Museum, Rubjerg Knude: The History of the Prevention of Sand Drift, Web.
[72] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Today, Web.
[73] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Today, Web.
[74] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Today, Web.
[75] Vendsyssel Historiske Museum, Rubjerg Knude: The Future, Web.
[76] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[77] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[78] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.
[79] Vendsyssel Historiske Museum, Rubjerg Knude: Coastal Erosion, Web.

The 'sand zone' is determined by the product of the wind erosion, forming the migrating dune atop the land that consumes anything in its path. This formation is driven by wind, giving it the exclusive ability to consume and then reveal parts of the environment over time without resulting in as destructive an event as the actual cliff edge deterioration.

The smallest swath of land to the south, the 'forest zone', runs perpendicular to the cliff face. This is the only remnant of what the landscape used to be before it was destroyed by clear cutting, which permitted the wind and dune to overwhelm the site. It also demonstrates the natural ability of the landscape to resist the wind, allowing interior and leeward protection of the landscape from both the dune and wind.

The 'plains zone' is now the majority of the landscape in the area. It is the result of clear cutting and the opposite of the forest typology in its response to wind. The wind here has the ability to blow freely, without barriers, driving the sand further inland. Each terrain typology has a different interaction with the westerly wind in process and product that shape the identity of the [wind]scape.

Historically this area has been inhabited since before the Early Bronze Ages. This inhabitation is evident through multiple historic sites that remain as markers on the landscape. (Figure 4.0) Each site has a unique connection to this material landscape of wind that has caused their destruction, abandonment and formation.

Old Rubjerg Kirk (Church)

Built in 1180, Rubjerg Church was located in the most densely populated part of the local parish.[80] At the time, there was a large village north of the church, capitalizing on the rich agricultural soil in the area; however, by 1600, Rubjerg Church rested in a very different landscape created by the devastation of sand from Lønstrup Cliff.[81] The migration of sand became a huge obstacle, forcing the population to move, leaving the church abandoned in the sand until 1724.[82] In 1904, the church was taken apart, stone by stone, numbered, and reassembled 2 km further south and further inland.[83] This new location eliminated journeying through the dunes.

Today, the church site is marked by a turf wall, outlining the original floorplan and a small wall fragment from the western wall of the medieval churchyard.(Figure 4.1) Additionally, at the time of the move, the existing graves were left on the old grounds. A Romanesque granite cross is the most visible of these markers, dating from approximately 1180.[84]

Strandfogedgården (Wreck Master's Farm)

The original building was built in 1724 by a new parish clerk for Old Rubjerg Church and remained his residence until 1814.[85] The Wreck Master's Farm became home to the local wreck master from 1860 until 1992.[86] Wreck Master's collected wreckage on the beach, keeping meticulous records and daily logs of ship wrecks and their material goods.[87] Recovered items were returned to the surviving owner, however if the captain and all seamen aboard were drowned, the cargo value on board became property of the king and it was forbidden by law to collect washed ashore goods.[88] From 1864 to

80 Vendsyssel Historiske Museum, Rubjerg Knude: Rubjerg Old Church History, Web.
81 Vendsyssel Historiske Museum, Rubjerg Knude: Rubjerg Old Church History, Web.
82 Vendsyssel Historiske Museum, Rubjerg Knude: Rubjerg Old Church History, Web.
83 Vendsyssel Historiske Museum, Rubjerg Knude: Rubjerg Old Church History, Web.
84 Vendsyssel Historiske Museum, Rubjerg Knude: The Churchyard, Web.

85 Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Farm, Web.
86 Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Farm, Web.
87 Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Work, Web.
88 Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Work, Web.

Figure 4.0 :

Composite map of sites directly affected by wind, viewed in their original to current condition (left to right). Top to bottom : Mårup Kirk (Church), Rubjerg Knude Dune Plantation, Strandfogedgården (Wreck Master's Farm), Old Rubjerg Kirk (Church).

1922 a total of four wreck masters, all from the same family, lived on the farm.[89] This job was crucial in the area, named Jammerbugten (Bay of Lamentations), for its rough seas caused by westerly winds.[90]

In 2000, the buildings were leased by the Vendsyssel Historical Museum to tell about local natural conditions and historical living along Lønstrup Cliff.[91] The museum became a permanent fixture in 2007, with continually expanding exhibits displaying the natural and cultural history of Vendsyssel and its landscape.[92]

Rubjerg Knude Dune Plantation

Rubjerg Knude has unique vegetation that is very specific to the natural conditions created by the sand and wind. The ideal conditions of wind, sea fog and sandy soil have allowed Denmark's largest thicket of native Buckthorn to grow and thrive at the base of the dunes.[93] Buckthorn is indigenous to this area, however many other plants, such as helmet, broom, juniper, spruce and pines were brought to the area to fight against dune conditions.[94] In 1927, Hjørring Municipality purchased 177 acres of land south of Rubjerg Knude to begin planting a dune plantation of deciduous trees, in an effort to alleviate wind effects as well as relieve high unemployment in the community.[95] (Figure 4.2) This grove was planted around one of many Bronze Age burial mound, Mulshøje, which survives to this day.[96]

Today, the nature of the plantation varies. Closer to the coast, plants are shorter and show the effects of wind, while they grow taller and thicker to the East.[97] It provides relatively good shelter from harsh western winds and has been protected by the Environmental Ministry since 2002, to preserve it as "an important recreational area for the future."[98]

[89] Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Work, Web.
[90] Vendsyssel Historiske Museum, Rubjerg Knude: The Wrecks, Web.
[91] Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Farm, Web.
[92] Vendsyssel Historiske Museum, Rubjerg Knude: The Wreck Master's Farm, Web.

[93] Vendsyssel Historiske Museum, Rubjerg Knude: Plants in the Area, Web.
[95] Vendsyssel Historiske Museum, Rubjerg Knude: The Plantation, Web.
[96] Vendsyssel Historiske Museum, Rubjerg Knude: The Plantation, Web.
[97] Vendsyssel Historiske Museum, Rubjerg Knude: The Plantation, Web.
[98] Vendsyssel Historiske Museum, Rubjerg Knude: The Plantation, Web.

Figure 4.1 :

(left) Old Rubjerg Knude Kirk in its moved location at present day.
(right) Now buried relic from old church yard at present day.

Figure 4.2 :

(left) Sediment settling on vegetation within the Plantation during high winds, present day
(right) Walking path and Plantation at present day.

Figure 4.3 :

Most immenently doomed site due to shifting landmass by wind, Rubjerg Knude Fyr (Lighthouse) in its original and current forms.

Rubjerg Knude Fyr (Lighthouse)

The Rubjerg Knude Lighthouse was lit for the first time on the 27th of December, 1900.[99] Constructed 197 feet above sea level, on the coasts highest point, the 75 foot tall lighthouse was originally built 656 feet inland.[100] (Figure 4.3) The lighthouse was occupied by three men and their families, filling the following positions: lighthouse master, lighthouse assistant and lighthouse attendant.[101] The watch room of the structure was continuously manned at night to maintain gas power, the lens apparatus and winding of the clock every three hours.[102] At the time of construction, there were no dunes in existence. However, with the continually growing dunes, the sand became so high that at times it obstructed the light and thus the lighthouse function was terminated in 1968, leaving the buildings abandoned.[103] In 1971 the buildings were acquired by the Ministry of Cultural Affairs who used them for the original Sand Drift Museum which was opened to the public in 1980.[104] The original museum told of the Lighthouse's history, construction and operation, as well as its technical elements, while neighboring buildings held exhibits describing the fight against the sand.[105] However, the consistent migration of the sand buried the lighthouse buildings in 1992, forcing the museum to close by 2002.[106] (Figure 4.4)

Today the dune has blown further inland, past the lighthouse, making it increasingly isolated. As of 2008, there were approximately 65 feet to the cliff's edge, predicting its crumble to the beach in the early 2020's.[107]

Mårup Kirk (Church)

Mårup Church was built in 1250, over half a mile from the sea.[108] A new church was built to the north in Lønstrup in 1928, leaving Mårup unused.[109] The National Museum took possession of the site in 1952, working to preserve it. However, efforts were terminated in 2005 by The Forest and Nature Agency which had taken possession in 1988.[110] Over the last 300 years, the cliff has eroded

[99] Vendsyssel Historiske Museum, Rubjerg Knude: The Lighthouse's History, Web.
[100] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Museum, Web.
[101] Vendsyssel Historiske Museum, Rubjerg Knude: Daily Life at the Lighthouse, Web.
[102] Vendsyssel Historiske Museum, Rubjerg Knude: Daily Life at the Lighthouse, Web.
[103] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Museum, Web.
[104] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Museum, Web.
[105] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Museum, Web.
[106] Vendsyssel Historiske Museum, Rubjerg Knude: Sand Drift Museum, Web.
[107] Vendsyssel Historiske Museum, Rubjerg Knude: The Future, Web.
[108] Vendsyssel Historiske Museum, Rubjerg Knude: Mårup Church's History, Web.
[109] Vendsyssel Historiske Museum, Rubjerg Knude: Mårup Church's History, Web.
[110] Vendsyssel Historiske Museum, Rubjerg Knude: Mårup Church's History, Web.
[111] Vendsyssel Historiske Museum, Rubjerg Knude: Mårup Church's History, Web.
[112] Vendsyssel Historiske Museum, Rubjerg Knude: The Future, Web.
[113] Vendsyssel Historiske Museum, Rubjerg Knude: The Future, Web.
[114] Vendsyssel Historiske Museum, Rubjerg Knude: The Future, Web.

Figure 4.4 :

(left) Rubjerg Knude Fyr in its current condition.
(right) Remanents of surrounding buildings in lighthouse complex at present day.

Figure 4.5 :

(left) Mårup Kirk gravestones and anchor relic.
(right) Mårup Kirk's location prior to dismantling due to cliff erosion (present day).

at an average of four to seven feet per year, placing the church 30 feet from the sea in 2008.[111] (Figure 4.5) This site has sparked tensions and a dialog, "between allowing nature to take its course on one side and protection of a landscape rich in monuments of the past and history on the other side".[112] Some argue for the geologically unique qualities of the cliff, stating the importance of no coastal protection for the church; while the alternate parties argue that the site should be protected since it is a religious ground and that it is immoral to fail to save a churchyard.[113] In 2008, an action plan to prevent the church from falling into the sea was executed. The church was taken down to a controlled height of 6.5 feet, with further coastal protection methods added if needed.[114]

Site Analysis

Each of the main zones of site have been uniquely effected by the wind driven sand. Additionally, the architectural artifacts that remain throughout the larger landscape demonstrate distinct typologies that correspond to these previously analyzed terrain zones. (Figure 4.6)

Most prevalent is the 'object on the landscape' demonstrated by Mårup Kirk, Rubjerg Knude Lighthouse, the Wreck Master's Farm and Old Rubjerg Kirk. This plains zone architecture is the simple response of placing a structure on top of the ground plane as a singular object, making it an obstacle for the wind and sand. These buildings do not engage the ground plane, thus when it shifts or disappears their existence is completely wiped from the rich history of the site, leaving no remains. This is most evident in Mårup Kirk's rapid disappearance at the cliff's edge to the sea below and the Lighthouse's near future demise.

Distinctively different, the 'landform' typology demonstrated by the burial mound at the center of the plantation is the most successful in its engagement with the environment. Not only does it have the benefit of

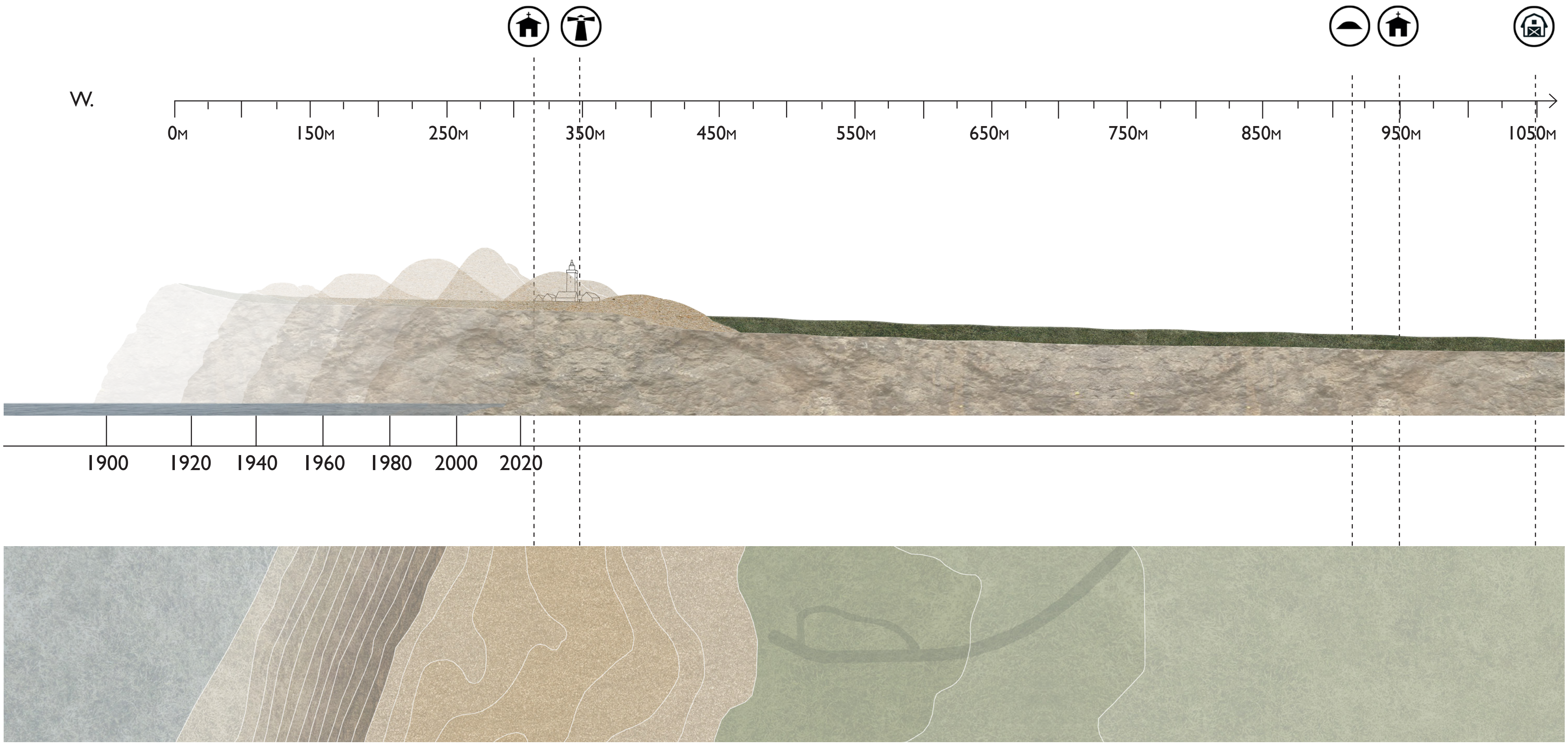


Figure 4.6 :

Visual timeline of the decaying site since 1900 and into the near future, demonstrating the significant amount of land being lost every year.

being within a natural wind buffer of the forest zone, but it also engages the ground plane by using it as an additional means of protection. By burrowing into the earth and becoming part of the landscape, the landform typology does not create an obstacle for the wind to hit but rather becomes part of the earth. These variations in the architectural typologies demonstrate that some are more successful in their engagement of the environment based upon how they are reacting to the migrating dune and unstable landscape. They also indicate the potential for a longer lifetime of the architecture and site.

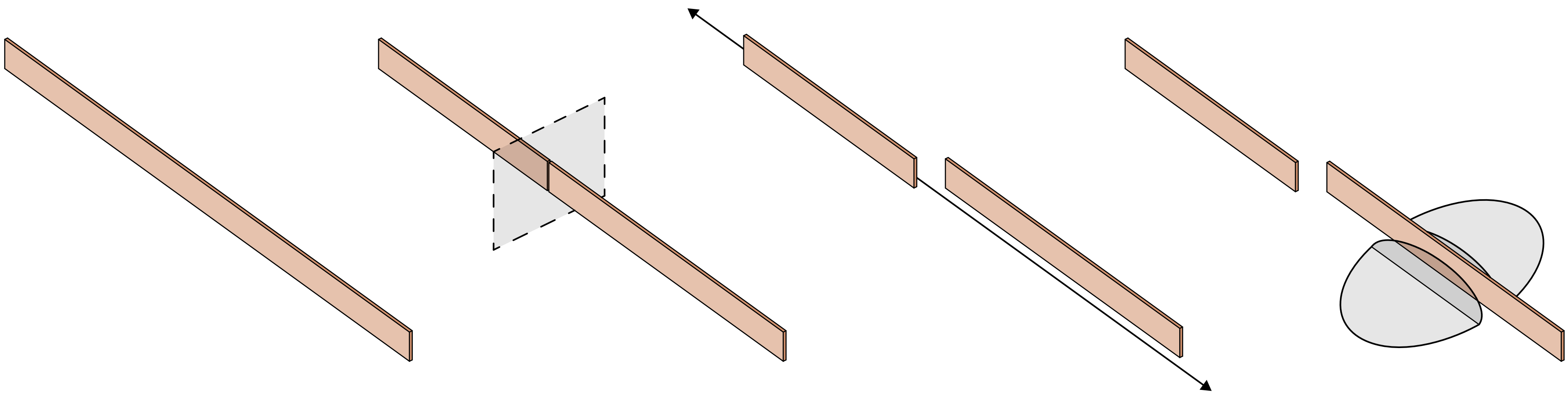


Figure 5.0 :

Four fundamental moves made in creating design intervention: Line, Split, Expand, Redistribute.

MARKING THE LANDSCAPE

The Inhabitable Datum

This thesis proposes an architecture that is more intimately tied to the shifting environment and ground plane that is inherent of the extreme [wind]scape of Rubjerg Knude. Through an intense site analysis of the terrain, the eroding cliff face of Lønstrup Cliff reveals the progression of the landscape. Over time the wind has eroded the cliff side, creating a massive dune landscape that has encroached upon the significant architectural fabric of the area. Analyzing this historic infrastructure has exposed a rich history but a lack of response in architectural design to the unstable environment that further fuels their obliteration from the site. Therein, this thesis intervention capitalizes on architecture's stationary nature by using it as a physical datum to measure and reveal the progression of the landscape by wind, both on a long term geological scale as well as more immediately in its daily fluctuations. Using the lighthouse as an existing reference point, while allowing its natural decay, a line is extended across the landscape creating a stable datum to measure the physical progression of the cliff. The line is then split, allowing cross migration of visitors, wind and sand so as not to create a barrier within the landscape. Expansion of the line allows for circulation and inhabitation, but results in the removal of landmass. This material is then redistributed to create a new landform within the larger, flat landscape. (Figure 5.0)

The physical intervention becomes a constant in this shifting landscape, connecting the topographical high point at the lighthouse, to the lower point inland, giving it a slight slope over approximately 2,885ft, that interacts with the ground plane in varied ways. The path flows into the earth and remerges above ground, eventually being consumed by the dune, no longer allowing a physical connection but rather an implied one, before remerging at the cliff edge to emphasize it as a continuum. These varied interactions with the ground plane shape visitors' experiences of the site by where the body is in relation to path and plane. (Figure 5.1)

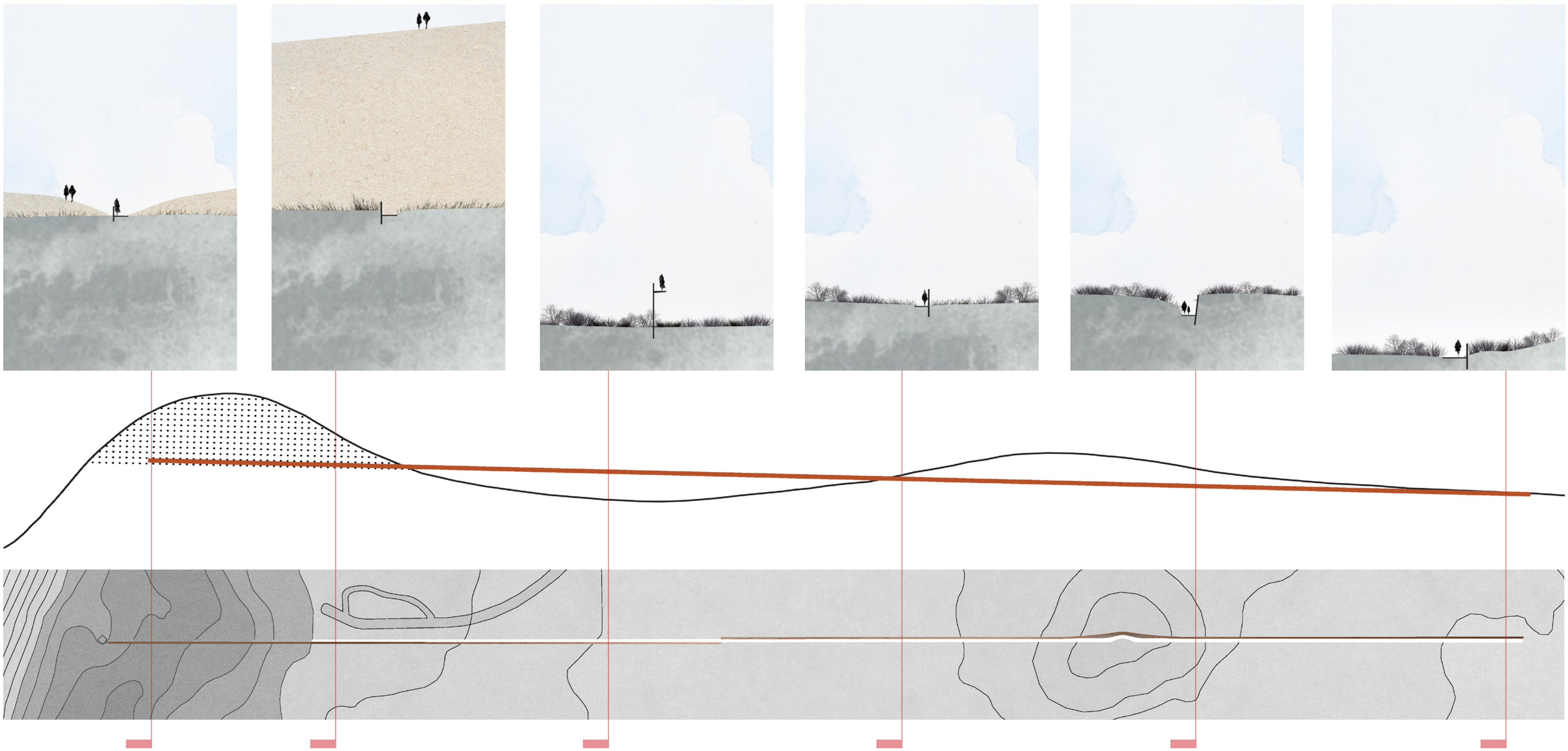


Figure 5.1 :

Plan and sectional diagram corresponding with where the human body is in relation to the shifting ground plane as user progress along the designed path.

As visitors move along the path, its width changes from 9' wide to 4', emphasizing a sense of compression with progression. Similarly, the datum walls shift in scale, ranging from 5'6" upon entry to 15' at its tallest. The fluctuating heights accentuate the scale of the site and further emphasize one's position in relation to the ground plane which visitors experience on, below, above and back on again. Key moments throughout the path heighten awareness to these extreme variations in relation to the landscape, wind and corresponding land forms. (Figure 5.2 / Figure 5.3)

The experience of the datum within the mound is characterized by the distinct absence of wind in this usually frenetic environment. Here space is carved out of the earth, using the landscape as a means of protection. (Figure 5.4) The curve of the path ensures a static atmosphere by never allowing the shifting wind a direct path through this space. The contrast of isolating visitors from a connection to the wind that drives this landscape, heightens awareness of its constant presence.

Here the path has both a soft and hard edge. The soft edge is defined by an earth mound that is sculpted into large tiers, indicating its deliberate human formation in a natural environment while also allowing space for visitors to pause and reflect while sheltered from the driving element. (Figure 5.5) Alternately the hard edge is indicated by the wall panels which turn into a retaining wall that holds back the natural mound formation, revealing the sky as a way to witness the wind through secondary sources of clouds or plants above.

As the wind shifts, the sand has the potential to move over any part of the datum. (Figure 5.5) Thus, the mound is designed to be filled or partially covered, at which point it would simply return to the landscape. If the dune moved over it and continued on, remnant of its path would be left behind, marking its progression through the environment.

Figure 5.2 :

View of the intervention from the entry at the furthest end, where visitors are set on the path, experiencing the open landscape and uninhibited inland wind.

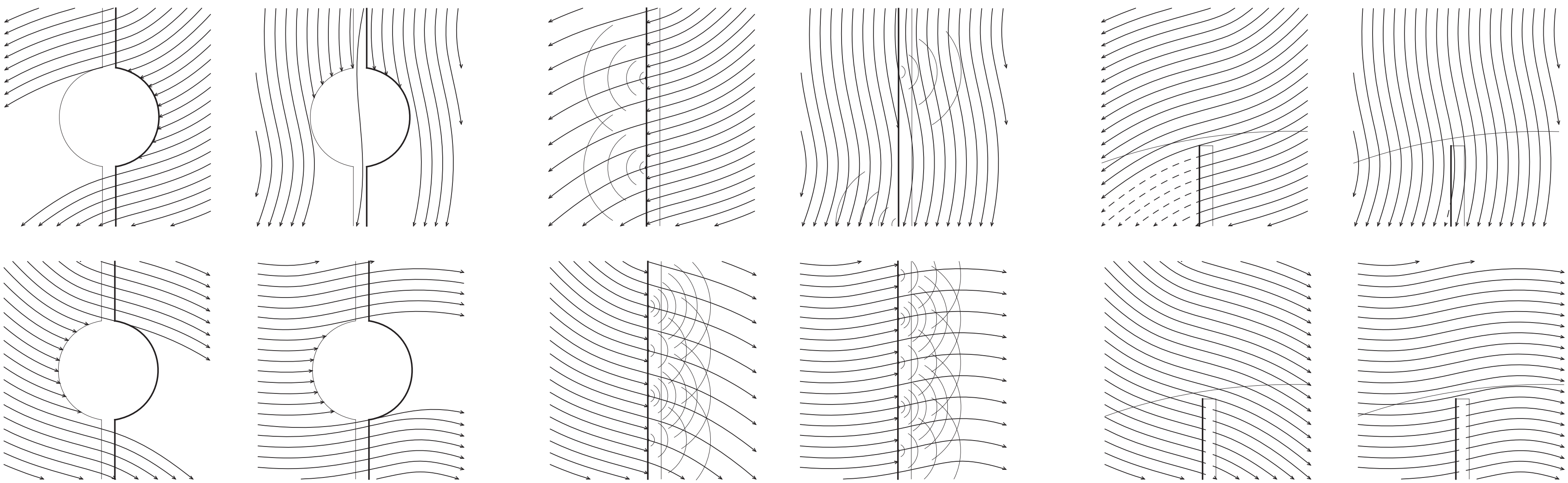


Figure 5.3 :

Abstactions of how the fluxuating wind may interact with the three extremes of the intervention: the mound (left), the bridge (middle) and the edge (right).

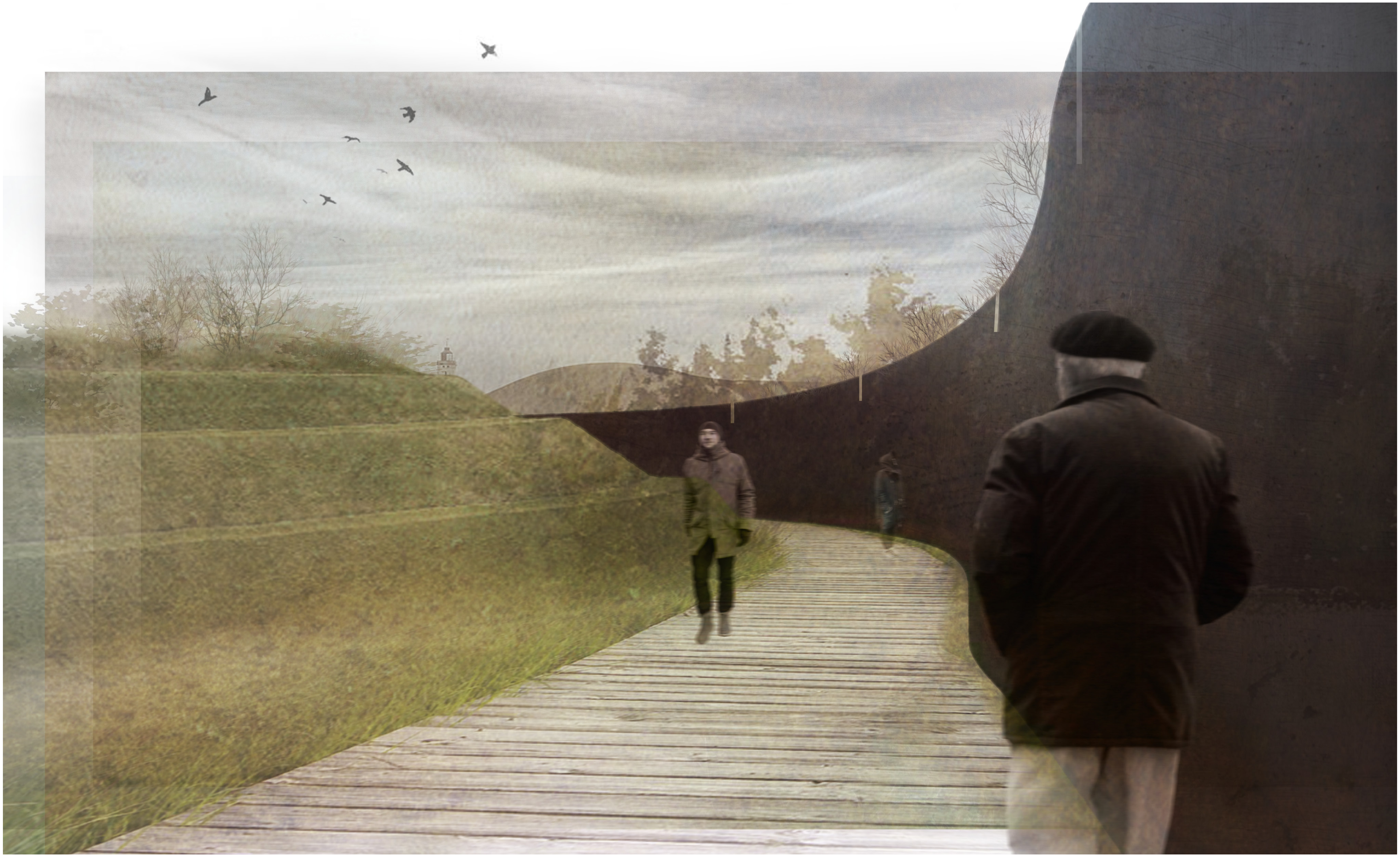
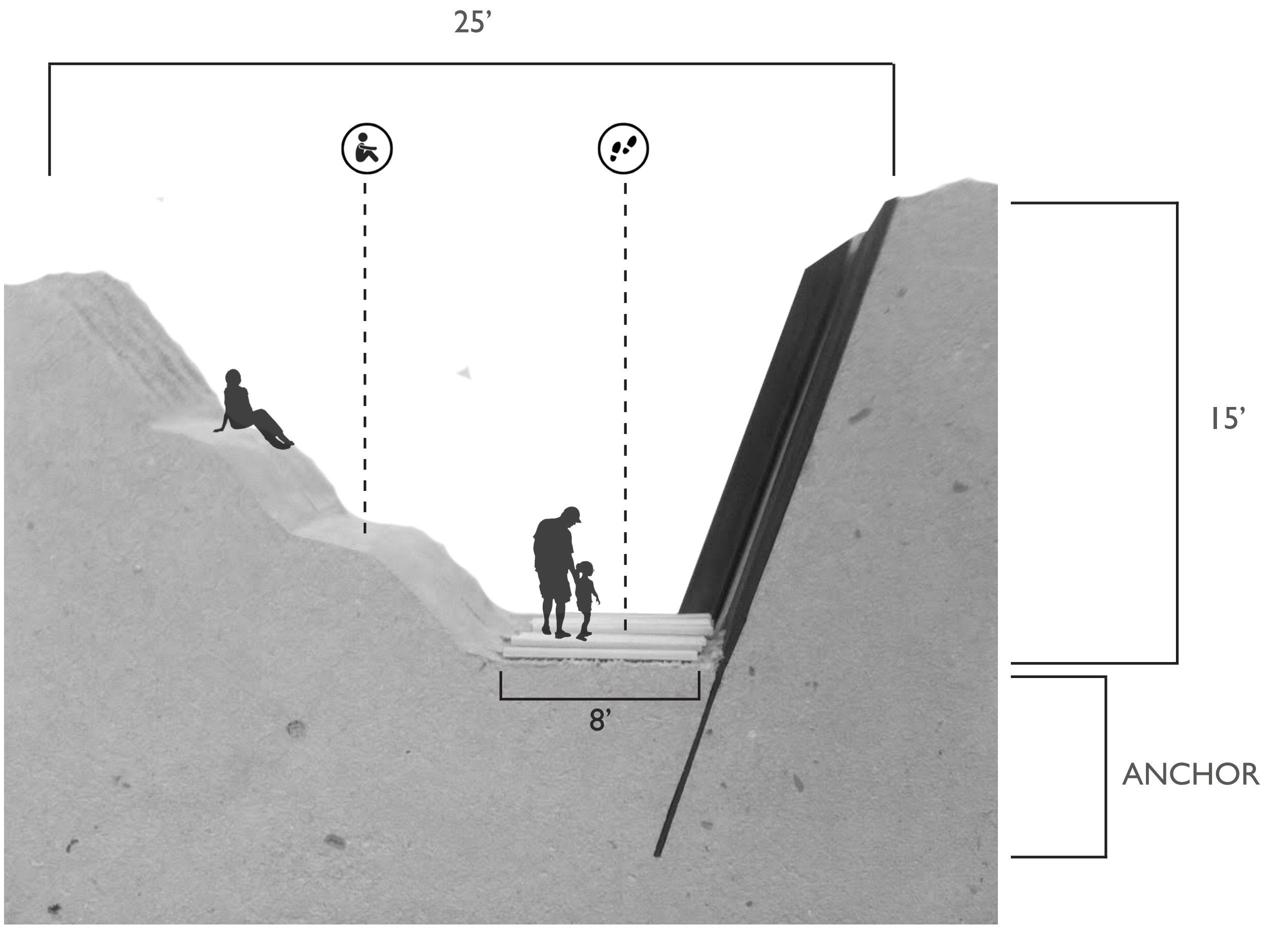


Figure 5.4 :

View from within the mound where users are protected from the wind, creating a stark contrast within this frenetic wind environment.



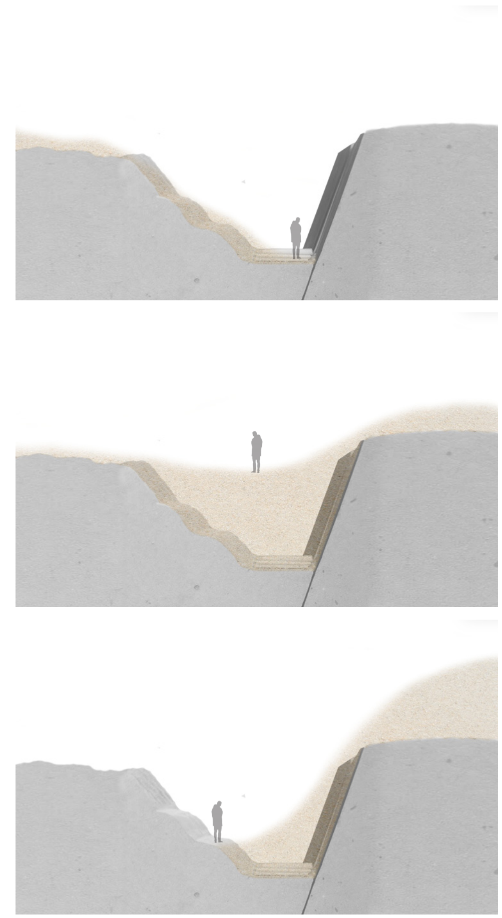


Figure 5.5 :

Study model of mound experience and dimensions; further examining how shifting sand would move over and through site thus altering the experience dependent on time (right).

Figure 5.6:

View from the bridge, where users are reintroduced to the presence of wind physically as well as acoustically as they near the base of the dune.

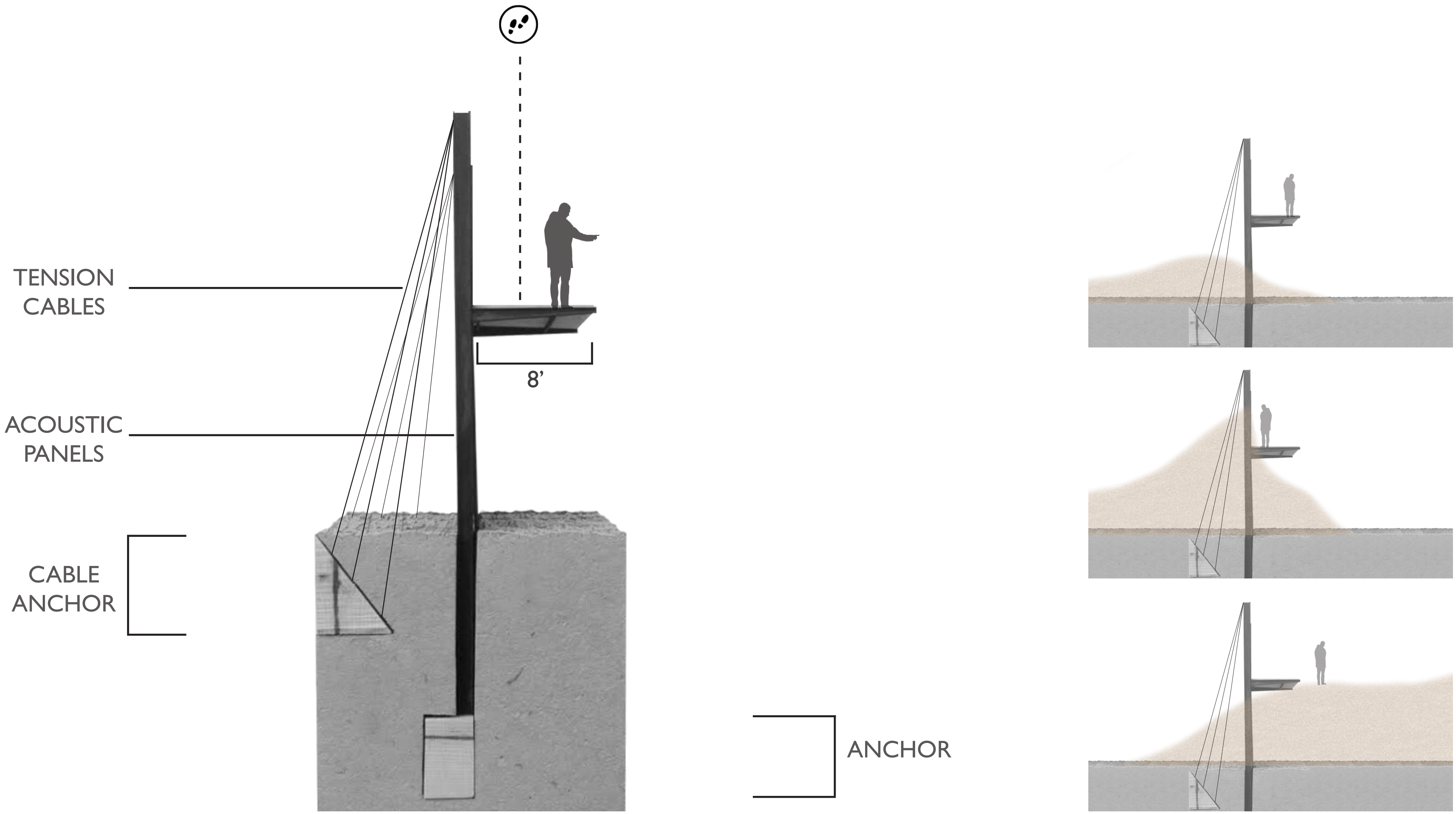


Figure 5.7 :

Study model of the bridge; further examining how shifting sand would move over and through site thus altering the experience dependent on time (right).

Figure 5.8:

View from the terminus of the design at cliffs edge where visitors experience the full force of the driving wind that is so influential in this andscape.

The bridge condition is a visitor's reintroduction to wind. The path becomes elevated as it emerges from the mound condition, using the panels for structural support with the addition of cable tiebacks. (Figure 5.6) These cables not only anchor the structure but additionally allow the bridge to become an Aeolian harp that indicates the fluctuations in wind through acoustic variations. At this point the wind is filtered through the panels that have dissolved into perforated screens. Sound varies depending on the intensity or directionality of the wind. This is another way the datum is measuring wind on a shorter, more immediate scale. Further, the porous nature of the panels ensures the bridge does not act as a barrier that blocks the environmental conditions of wind and sand completely. The shifting sand can move through the structure, burry it and move on, maintaining the path connection. As this sand moves, it will also lead to a modification in the perception of the ground plane to the viewer, potentially becoming an extension of the bridge. (Figure 5.7)

The edge condition of the datum is characterized by full exposure to wind. Here the panels are not tall enough to provide any protection from the wind but reappear from the dune and cliff face, completing the continuum. (Figure 5.8) The regular decay of the cliff, at four to seven feet per year, determines the size of structural panels that create the datum walls. Each segment is 14ft of thin, plated steel with a cutout every 7ft. The cutout marks the annual progression of the cliff by casting a shadow or light, visibly dependent on daily site conditions. Each panel is anchored in the earth allowing for the datum to react to the deteriorating ground plane. Thus, as the cliff disappears, every 2 years, the corresponding panel disconnects from the datum wall and falls to the beach below, where it begins to decay. This decay is further expedited by the wind driven ocean waves until it has dissolved, leaving behind a physical stain on the material landscape as an indication of this cycle. (Figure 5.9)

Understanding the long term existence of the datum further drove the material palette selection. (Figure 5.10) Steel was selected as the material for the wall panels. This was optimal for the desired thin profile that

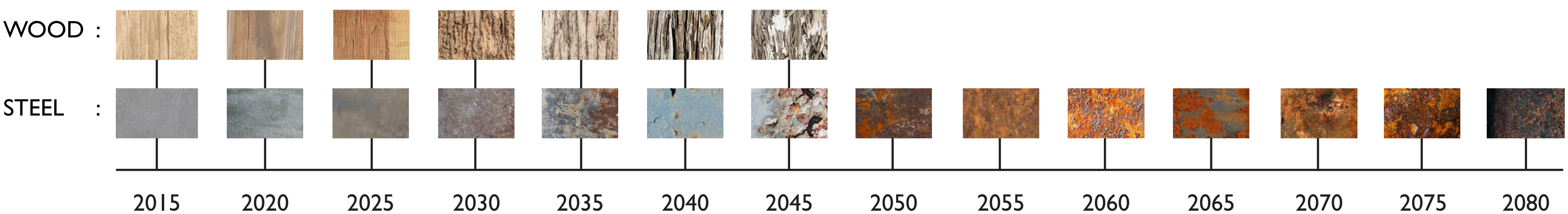


Figure 5.9:

(top) View from the beach of how the decay of the wall is intended to further concept of the timeline, leaving a physical stain on the landscape as panels fall off and dissolve.

Figure 5.10:

(bottom) Material timeline of both wood and steal, showing their correlation as they decay back into the environment.

allows the walls to disappear and reappear depending upon orientation. Furthermore, metal's natural ability to reverberate and perform acoustically made it optimal for the bridge portion of the intervention. Most prominently, its natural aging process gave another layer to the timeline of the datum. In response to its specific environmental conditions, steel shows a particularly visible shift in color and texture over time that can leach into its surrounding, leaving a visible reminder of its presence after it has eroded.

Alternately wood was selected for the path material, relating more to the existing material landscape. Its segmented nature shifts seamlessly from being embedded in the ground plane to infilling the structural frame of the bridge. Furthermore, the reaction of wood to the subtle shifts in the ground plane creates the potential for varied experiences on the path, depending upon when you visited the site; changing from a flat path, to settled planks or lifted with roots and sand. Due to its organic composition, wood has an exceedingly different life cycle than steel, making it break down and be reclaimed by its environment. The different material timelines indicate the physical pathway will break down and be consumed back into the environment but the wall will remain as an instrument of measurement. (Figure 5.10)

In the future it is projected that the cliff will stabilize, reaching an equilibrium in which the erosion ends and the dunes growth halts; at which point the existing dune will continue to roam with the shifting winds.[115] A wider variation in the wind's directionality across the site has begun to be indicated, most likely due to climate change. There is no way to know when this will happen or to predict the extent that the dune will roam. However when it does, the datum then has the ability to become a device that measures the migration of the dune and directionality of the wind instead of the deterioration of the landscape. (Figure 5.11)

[115] Coastal Erosion. Vendsyssel Historiske Museum. Web. 12 September 2015. http://rubjergknude.dk/engelsk/net-exhibit/explore-rubjerg/the-sea/coastal-erosion/

Figure 5.11 :

Constrasting views of how the design intervention changes over time further deomstrating the passage of time and the landscapes shifting nature.

DESIGN IMPLICATIONS

Opportunities for Expansion

This thesis attempts to establish a relationship between wind landscapes and the architecture placed within them. What emerged was a methodology that uses architectures key components of structure, material and physical experience to reveal the invisible force of wind. The resulting design is an inhabitable datum against which the evolution of the landscape will register. The erosion and physical progression of the landscape is measured by the corresponding decay of the intervention. Further material decay of the wall and path heighten visitors awareness of time and environmental conditions. Physical experiences along the datum record fluctuations in winds daily patterns through deliberate isolation and exposure to its driving force.

The process for the design of this thesis relies on an in-depth analysis of the environments in which wind thrives and its corresponding landforms. Additional analysis of architecture's engagement of these unstable ground planes reveals a connection to the lifespan and decay of built form. This conceptual approach to how architecture can engage its environment has the potential to influence designs across similarly unstable environments.

Although it is not possible to accurately predict future outcomes of the decay of the project, nevertheless, it is important to consider the full life span of architecture in wind environments. This thesis is acknowledging that by inserting this intervention into the landscape, it will inherently result in changes to the patterns of the site, such as dune migration or accumulation of sand. However, the possibilities of how the environment will respond to human intervention is equally compelling because it gives the design the potential to register unforeseen experiences and interpretations of wind.

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