SUSTAINABILITY IN COLD CLIMATES

A VERNACULAR STUDY OF ICELANDIC TURF HOUSES

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By

Taylor Kreps

McEwen School of Architecture, M.Arch

Faculty of Graduate Studies
Laurentian University
Sudbury, Ontario, Canada

UniversitéLaurentienne
LaurentianUniversity
McEWEN ÉCOLE D'ARCHITECTURE SCHOOL OF ARCHITECTURE

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Thesis Examiners/Examinateurs de thèse:

Dr. Emilie Pinard
(Thesis Advisor / Directeur(trice) de thèse)

Dr. William Crumplin
(Thesis Second Reader / Directeur(trice) de thèse deuxième)

Professor Brian Lilley
(External Examiner/Examinateur(trice) externe)

Approved for the Faculty of Graduate Studies
Approuvé pour la Faculté des études supérieures
Dr. David Lesbarrères
Monsieur David Lesbarrères
Dean, Faculty of Graduate Studies
Doyen, Faculté des études supérieures

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Íslenski Bræinn Turf House- Fish Drying Shed- Photo by Author

Abstract

This thesis investigates the principles of vernacular architecture in cold climates to inform sustainable design and building practices in the 21st Century. More specifically, the thesis aims at studying the building typology of Icelandic Turf Houses, to develop a series of informed architectural strategies for cold climates, that will support the environmental and culturally sustainable development and transformation of northern built environments. Through literature review and a material and spatial analysis of existing turf houses, this thesis sheds light on three key aspects of a cold climate sustainable architecture: 1) Passive and environmental strategies, ancient and new, as they relate to cold climate conditions; 2) material selection and expression; and 3) its relation to social structures and interactions. Observed principles are then further explored in the project Turf House Complex, a sustainable building complex addressing issues of the climate balanced protected indoor and outdoor spaces, farm to table food sustainability, as well as incorporating strategies of passive systems resulting in a sustainable occupation of the project.

Keywords: Sustainability
Cold Climates
Icelandic Turf Houses
Vernacular Architecture
Passive Design Strategies

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Introduction

This thesis investigates the vernacular building typology of Icelandic turf houses to uncover new ideas and strategic approaches to environmentally and culturally influenced building design strategies in cold climate regions of the world. Literature has shown that a better understanding of contemporary application of vernacular architecture principles, sets the foundation in reaching the four pillars of sustainability: environmental, cultural, social, and economic. These pillars of sustainability are rarely addressed together in the context of architecture, thus this thesis explores the integration of environmental and cultural sustainability in the built environment. The importance of this research stems from a need to develop more examples of sustainability principles derived from vernacular architecture, specifically in cold climate landscapes.

Paul Oliver, author of the Encyclopedia of Vernacular Architecture of the World,[1] explains that all vernacular cultures are largely shaped by their surrounding climate, and that the resulting architectural forms are an expression of the cultures that built them. While there are many case studies addressing hot, dry and humid climates, there is still a lot to learn from vernacular architecture about cold climate sustainability, since the extreme weather conditions present important challenges. This leads to research questions about how we address sustainability in cold environments, what methods or tools can be extracted from the vernacular architecture of a place, and how can those findings be applied in contemporary architecture? Norman Pressman, author of the book Northern Cityscape: Linking Design to Climate (1995),

[1] Oliver, Paul. "*Introduction*" *Encyclopedia of Vernacular Architecture of the World*. Vol. 2. 3 vols. Cambridge: Cambridge Univ. Press, 1998.

presents urban to protect outdoor spaces. Through an understanding of vernacular typologies, the author contributes to new strategies to achieve sustainable and comfortable outdoor environments at the human scale and to encourage more positive outdoor interactions in winter cities.[2] The desire or need to design sustainably is relatively new, only within the last 60 years has this paradigm emerged with the objective of the built environment having a lesser impact on the natural environment.[3] Architecture has a responsibility to be responsive to these issues of sustainability and start exploring new solutions technically and culturally for current and future architecture. As well as seeking environmental sustainability, the study of vernacular architecture is a fundamental part in the preservation of culture within the contemporary built environment. Different elements of cultural sustainable design are an integral part of vernacular architecture that has evolved over time with the use of local materials, tools, and construction methods which has emerged from the natural environment, improving relationships between people and their place.[4] Kenneth Frampton, an architect and theorist on the subject of regionalism and critical regionalism, articulates that approaches to regionalism can be applied in modern architecture through the importance of understanding and considering the culture in which a project is situated, acknowledging the specificities of the site, and developing a sense of place with a direct experience to the place and site.[5] It is through this understanding of the relation between place, people and culture that traditions of vernacular building can begin to play a role in the design of contemporary architecture of a place.

This thesis is structured in three chapters. The first chapter outlines the conceptual framework of the research, consisting of three areas of research and practice defined within the study of vernacular architecture (Figure 1). The first area includes explorations of well tempered environments or passive systems design comparing methods of mapping of vernacular strategies as well as climate balanced design methods, later applied in the project. The second area is material culture, exploring traditional building methods in relation to tools and

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[2] Pressman, Norman. *Northern Cityscape: Linking Design to Climate*. Yellowknife, NT: Winter Cities Association, 1995.

[3] Baweja, Vandana. *"Sustainability and the Architectural History Survey."* The ARCC vol.11 (2014): 40-51

[4] Salman, Maha. *Sustainability and Vernacular Architecture: Rethinking What Identity Is.* IntechOpen, 2018.

[5] Kenneth Frampton, "*Ten Points on an Architecture of Regionalism: A Provisional Polemic.*" In Center 3: New Regionalism, (University of Texas: The Center for American Architecture and Design, School of Architecture, 1987), 375-385.

naturally available materials, and their significance within a societies' culture and activities to evaluate the significance and meaning of materials. The third area is the social logic of space, which looks at house forms in connection with culture, making links between humans, their lifestyle and their social interactions with vernacular spaces. The second chapter of the thesis provides specific insight into the tradition of building and living in Icelandic turf houses. This research is completed through mapping and diagramming passive design strategies, case study analysis, turf material culture review, as well as spatial syntax maps outlining the spatial organizations of the turf house cases for this thesis. Finally, the third chapter of this thesis is the project Turf House Complex, which outlines in detail the project's parameters including site selection, climate conditions, environmental site analysis, the projects programming as well as design explorations. Furthermore, this thesis focuses on researching and identifying architectural design principles found within vernacular architecture to adapt and modify these strategies to begin addressing environmental and cultural sustainability in contemporary architecture within cold climate regions.

Figure 1: Vernacular architecture streams of study

Chapter 1

1. Conceptual Framework: Learning from Vernacular Architecture

Vernacular architecture encompasses the majority of the world's built environment, typically, including the study, exploration, documentation, and understanding of traditional and primitive building typologies of a particular place during a particular period in time. This field of study is quite recent, beginning in the second half of the 20th Century with the contributions of architectural theorists and scholars such as Bernard Rudofsky, educator and author of Architecture without Architects (1964), Amos Rapoport, academic and author of House Form and Culture (1969), Paul Oliver, architectural historian and author of Encyclopedia of Vernacular Architecture of the World (1997), and many others whose interest lie in the study of building traditions of the world. The term vernacular can be interpreted in various ways however this term is specific to a place or region with its own set of cultural, regional, and climatic relations. Oliver describes the term:

> "An architecture that is owner built or community built; where even if specialized skills are utilized, these skills are locally based; and where the architecture has a fairly direct correspondence with the immediate local contexts of cultural and social tradition, climate, and material resources. This stands in contrast to an architecture produced by formally trained architects in a society occupationally differentiated to a level where the design process is abstracted and distanced from the routines and experiences of everyday life, often relying on a philosophy that is more conceptual and abstract than experiential."[6]

Oliver's interpretation of the term vernacular is a useful one, in that

[6] Oliver, P. (ed.), 1997. *Encyclopedia of Vernacular Architecture of the World*, Cambridge: Cambridge University Press.

it speaks of the location and structure of society, their skills and traditions rather than focusing strictly on primitive structures or a fixed vision of tradition. Vernacular architecture can be seen as a specific knowledge of building that encompasses ways to address a specific climate, cultural practices, and an understanding of locally available materials suitable for conditions that are unique to the place:

"Vernacular architecture is an area of architectural theory that studies the structure made by empirical builders without the intervention of professional architects. There exists many area of non-professional architectural practice, from primitive shelter in the distant communities to urban adaptation of building types that are imported from one country to another."[7]

According to various authors, Bernard Rudofsky was the one initially responsible for bringing architects' interest and attention to the topic of primitive shelters.[8] With his book Architecture without Architects, Rudofsky shines a greater light on the history of vernacular buildings that have long often been dismissed by architects as accidental in their beauty.[9] Rudofsky also addresses in his opinion, what architects consider when using the term vernauclar: "Architecture without Architects attempts to break down our narrow concepts of the art of building by introducing the unfamiliar world of non-pedigreed architecture. It is so little known that we don't even have a name for it. For want of a generic label, we shall call it vernacular, anonymous, spontaneous, indigenous, rural, as the case may be."[10] In search of a continued understanding of how to describe what the vernacular embodies, Henry Glassie, a professor of folklore, in his publication Vernacular Architecture, explains that architects of the 21st century use the term vernacular to describe a construction that is unfamiliar to themselves, a built form alien to those that architects learn about in professional schools.[11] Glassie states that: "The study of vernacular architecture, through its urge towards the comprehensive, accommodates cultural diversity. It welcomes the neglected into study in order to acknowledge

[7] Paul Oliver, Source Unknown.
[8] Carlos, G.D., Mariana Correia. *Vernacular architecture?* Escola Superior Gallaecia, Vila Nova de Cervei ra, Portugal. 2015. 3
[9] Rudofsky, Bernard. *Architecture without Architects: A Short Introduction to Non-pedigreed Architecture*. Albuquerque: University of New Mexico Press, 2002. 1
[10] Rudofsky, *Architecture without Architects*, 2.
[11] Glassie, Henry. *Vernacular Architecture. Philadelphia: Material Culture*, 2000. 20.

the reality of difference and conflict."[12] This inclusive perspective was brought more consistently first by Rapoport in House Form & Culture. Rapoport intended to contribute to the recognition of architecture as a cultural expression, understanding the culture and the local building tradition as a repository of the cultural identity of specific communities.[13]

Historically, the study of vernacular architecture strictly explored stable traditions of primitive buildings, looking at peasant and rural architecture as inspirational and romantic ideologies of a place. Rapoport explains that previously, the study of the vernacular was understood as a category of natural history describing and documenting buildings, identifying their variety and classifying them.[14] Since the study of vernacular buildings became an area of academic and professional interest in the mid 20th Century, there has been as strong draw to the notion of the untouched, preserved and most "authentic" traditional building typologies.[15] According to Vellinga, the scholars and conservationists' perspective that the vernacular is only comprised of the primitive, pre-modern historical and traditional buildings, is restrictive. In his view, it is specifically the dynamic character of vernacular traditions that gives them relevance in the provision of sustainable architecture in the future.[16]

Today one of the focus in vernacular architecture studies is still the preservation of the oldest most traditional primitive buildings worldwide. However, more recently the visions shifted and vernacular architectures, old and more recent, are now recognized for their contribution to contemporary architectural issues. Many authors examine these buildings in search of solutions to climate, material use, cultural and environmental problems that the current generation of architects faces and will face in the future. In discussing learning from vernacular architecture, Rapoport explains how vernacular environments provide an unequalled, and only possible, "laboratory" with a vast range of human response to an equally vast range of programs; cultural, technological, material resources, site, climate and so on.[17] There is an overarching concern in today's society to address issues of sustainability, and it is Rapoport's view that vernacular buildings, studied in their whole context, hold the key to solutions

[12] Glassie, *Vernacular Architecture*, 20.
[13] Carlos, G.D., Mariana Correia. *Vernacular architecture?* Escola Superior Gallaecia, Vila Nova de Cervei ra, Portugal. 2015. 3
[14] Asquith, Lindsay, and Marcel Vellinga. *Vernacular Architecture in the 21st Century: Theory, Education and Practice.* New York: Routledge, 2006. 179.
[15] Asquith, Lindsay. *Vernacular Architecture in the 21st Century,* 2006. 82
[16] Ibid., 83.
[17] Asquith, Lindsay. *Vernacular Architecture in the 21st Century,* 2006. 181.

surrounding sustainable architecture in the future. Norman Pressman also sees the innovation and contemporary solutions which can be found through the study of vernacular buildings.[18] Pressman states that typologies of the commonplace in vernacular building uncover triumphant solutions for humans survival and comfortable living which can be found anywhere in the world: "Designs and ideas dictated by climatic and topographical concerns are genuine and authentic, as they must be if they are to respond meaningfully to human needs, local materials and natural forces."[19] Vellinga concurs and explains that much of the recent work in the field is to asses the extend to which specific vernacular traditions are environmentally sustainable.[20] He explains: "Most studies set out to evaluate the thermal properties of of a particular building type or to investigate the ways in which its layout, form and materials relate to local climate and geographic conditions."[21] Overall, in more recent years, in response to increasing concerns about environmental challenges, scholars have started to focus their attention on the sustainable character of vernacular buildings, due to the fact that they are tailored to their local environments.

The conceptual framework chapter of this thesis explores three areas of vernacular architecture research that contribute to address issues of environmental and cultural sustainability today. The first section, Well Tempered Environment: Passive Architecture Principles, focuses on the utilization of passive systems strategies for design in cold climates which are displayed throughout vernacular architecture, as well as studying these vernacular buildings to further understand their relationship between climate and site. The second section addresses Material Culture, which is a strongly defining aspect of the study of vernacular with the application of locally available materials, the materials impact on the environment, as well as the materials playing a significant role in expressing traditions and cultures of a place. The final section of this chapter is the Social Logics of Space, which looks at how vernacular dwellings and settlements are organized spatially, as well as how these spaces are a representation of the importance placed on different aspects of peoples lifestyles including expressions of culture,

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[18] Pressman, Norman. *Northern Cityscape: Linking Design to Climate*. Yellowknife, NT: Winter Cities Association, 1995. 62.
[19] Pressman, *Northern Cityscape*, 62.
[20] Vellinga, Marcel. "*The Noble Vernacular.*" The Journal of Architecture 18, no. 4 (2013): 570-90. 571.
[21] Vellinga, *The Noble Vernacular*, 571.

world views and identity. The objective of this conceptual framework is to extract relevant approaches and methods to study vernacular buildings in order to develop appropriate design principles for cold climates in the 21st Century.

Traditional Icelandic turf church at Arbær. Photo By Author

Village of Lofoten, Norway. https://expertvagabond.com/lofoten-islands-photography/

1.1 Well Tempered Environment
Passive Architecture Principles

This section focuses on the passive systems strategies for design which are displayed throughout variations of vernacular architecture and the buildings' relationship between climate and site. The mapping and documentation of site conditions including wind, sun and orientation diagrams are tools that researchers and architects often use to analyze a building typology or site's relationship with the surrounding climate conditions. Many historians and archeologists have studied the relationship between vernacular architecture and climate, by classifying and mapping the different typologies of buildings in function of their typical climate conditions.[22] In the Encyclopedia of Vernacular Architecture, Oliver explains that maps which correlated regional housetops identified primarily by the roofs based on slopes, led to the conclusion of a wet-tempered environment or cooler climatic

[22] Vellinga, Marcel. *Drawing Boundaries: Vernacular Architecture and Maps*. Traditional Dwelling and Settlements Review. Vol 14. (2003).

zone.[23] Analyzing the form of vernacular buildings can indicate the type of environmental conditions inhabitants and users dealt with and allow for the identification of climactic responses through the built form:

> "A building's performance is not only determined by local climate conditions and operation energy efficiency. Site location and urban design approaches also have a major impact. Rather than working against the urban grain, we need to work with it by using environmental site planning principles; we can then promote occupant comfort and heath as well as minimizing operational and transportation energy use."[24]

Overall, mapping is an important form of documentation for the analysis of site and it's relationship to surrounding environmental conditions. This in turn allows architects, designers, and planners to make more informed design decisions.

Another key aspect to further the understanding of a building's relationship to its site and to properly address human comfort is to analyze its indoor to outdoor relationship. Interpretations about what constitutes a well tempered or comfortable environment vary greatly. For example, Willi Weber, author of Lessons from Vernacular Architecture, define the well tempered as "achieving acceptable indoor environmental conditions for occupants with the least expenditure in energy and materials replacing non-renewable energy sources with renewable ones and doing away with environmentally unfriendly processes and materials."[25] Adressing the theme of human comfort, Victor Olgyay, poses that "the structure which in a given environment setting reduces undesirable stresses, and at the same time utilizes all natural resources favorable to human comfort, may be called "climate balanced."[26] According to Pressman, passive strategies such as ventilation, weather mitigation, and heat retention strategies are essential in achieving a climate balanced environments. These strategies will be essential for the successful outcome of the project proposed in this thesis (Figure 2).

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[23] Oliver, Paul. *"Introduction," Encyclopedia of Vernacular Architecture of the World.* Vol. 2. 3 vols. Cambridge: Cambridge Univ. Press, 1998. 127
[24] Pelsmakers, Sofie. *The Environmental Design Pocketbook.* London: RIBA Publishing, 2015. 47
[25] Weber, Willi, and Simos Yannas. *Part II Vernacular Architecture as Model, Lessons from Vernacular Architecture.* London: Routledge/Earthscan, 2014. 2
[26] Olgyay, Victor, and Aladár Olgyay. *Design with Climate: Bioclimatic Approach to Architectural Regionalism.* Princeton, NJ: Princeton University Press, 2015.10.

Starting from the outside and working towards the interior space, site orientation and the buildings relationship to the landscape and other buildings can allow for a more successful outdoor environmental experience where people feel protected yet outside in nature. Exploring the outdoor relationship between spaces and environmental elements, Pressman, has developed two fundamental approaches to elevate the relationship humans have with the outdoor environment in northern latitude regions.[27] The first principle is not to overprotect people from nature, implying that humans need to learn to co-exist with nature as symbiotically as possible to reduce humans sensitivity to the cold.[28] The second approach he takes is to offer as much protection as possible, proposing that the implementation of sheltering devices such as tunnels, skywalks and galleries should be incorporated within the existing urban fabric to allow for minimal contact with the extremes of winter such as snow ice and harsh winds (Figure 3).[29] Directing people to the outdoor environment is critical and the importance of protection through the utilization of strategically placed wind breaks, the existing buildings and topography and purposefully oriented shelter is the essence of comfortable outdoor living conditions. Critically analyzing

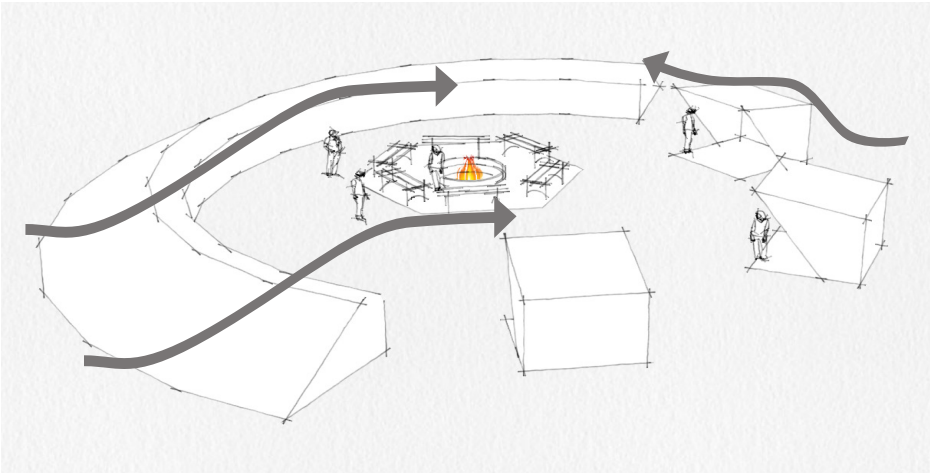

Figure 2: Using a landscaped berm and buildings positioned to protect from wind conditions and create a comfortable outdoor gathering area.

[27] Pressman, *Northern Cityscape*, 5.
[28] Pressman, *Northern Cityscape*, 9.
[29] Ibid., 9.

data on wind patterns and mitigation strategies is an integral part of designing for outdoor comfort, particularly in context where high winds are a daily occurrence. Due to the extreme weather conditions of Iceland, sun study and analysis of wind patterns will be particularly important. Buildings can have both positive and negative influences on the outdoor comfort condition at the pedestrian level, depending on building orientation, surrounding buildings and prevailing winds (Figure 4). Pressman outlines criteria for windbreaks that mitigate the forceful wind effects created in the area between buildings. He suggests that: 1) the place of wind breaks be perpendicular to prevailing winds; 2) the height of surrounding trees be used for protection; 3) the density of windbreaks is important for protection, as well as 4) utilizing vegetation as a wind barrier as it does not completely deflect wind but filters it to a lesser degree for a more comfortable environment.[30]

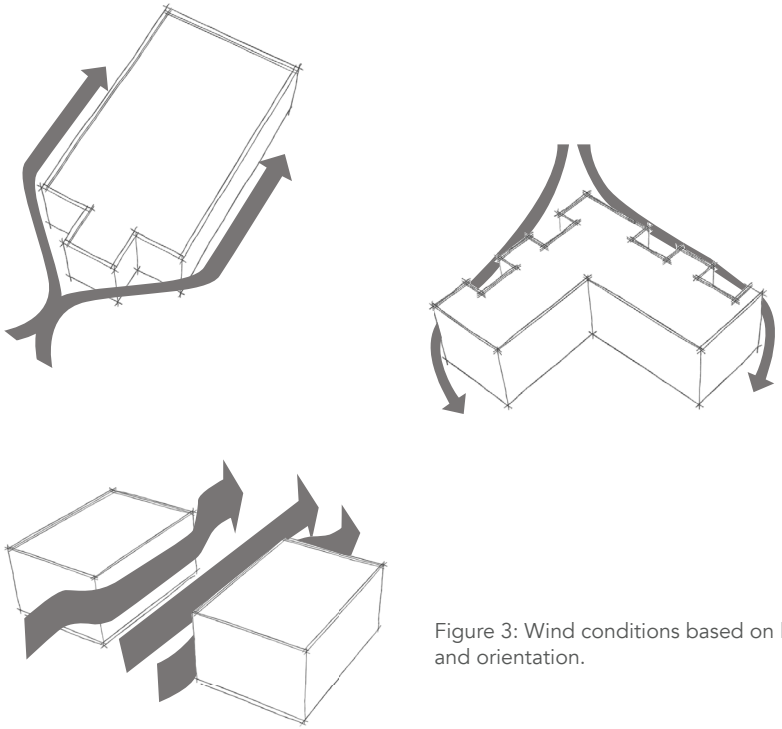

Figure 3: Wind conditions based on building shape and orientation.

[30] Pressman, *Northern Cityscape*, 168.

Moving the focus towards interior spatial comfort, the orientation of a building is a determinant factor in the overall outcome of human comfort within a particular building or space. Solar gain, for example, can be seen as having both a positive and a negative effect on human comfort within the built environment.[31] In cold climate regions, the sun is often at a lower angle, creating an undesirable visual obstruction typically later in the day. In some cases of the cold, arctic, and subarctic regions, there is no sun during winter. Olgyay presents a set of principles to deal with the sun's impacts on interior building conditions.[32] He states

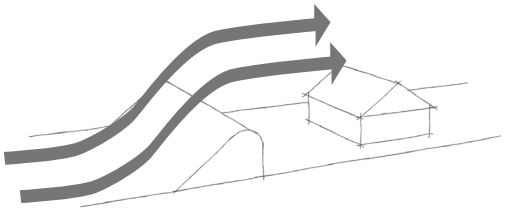

Figure 4: Natural landscaping protects buildings from high winds.

that for the best living conditions (warmth in winter and coolness in summer) the main facades of a building should face the south. Facades facing southwest and southeast have the advantage of regularity of insolation, however they are colder in winter and warmer in the summer. East and West exposures are warmer in the summer and cooler in the winter therefore determining that the East and West are not suitable for large areas of glazing (Figure 5).[33] Therefore, the goal in these locations is to optimize the warmth the sun provides while mitigating unwanted blinding and glare factors, orienting the buildings to achieve the most solar gain year round. To achieve this, calculations and sun studies can be made to orient the building based on the sun's intensity. To correlate the optimization of solar gain and appropriate space orientation, room orientation charts are often found in texts concerning the vernacular and passive systems design, which can be used as a recommendation tool for the organization of spaces (Figure 6).

Overall, all vernacular buildings depend on and are often shaped by their relationship with the surrounding environment and climate conditions. It is by nature that humans look to the environment to inform building formations, material use and orientation. In the design of the

[31] Peacock, A. "Materials for Energy Efficiency and Thermal Comfort in Domestic Buildings." Materials for Energy Efficiency and Thermal Comfort in Buildings, 2010, 77-100.
[32] Olgyay, *Design with Climate*, 54.
[33] Ibid., 54.

built environment concerning well-tempered spaces, architects should turn their focus to the utilization of passive architecture principals for buildings such as orientation, site topography and conditions, wind breaks and sun optimization.

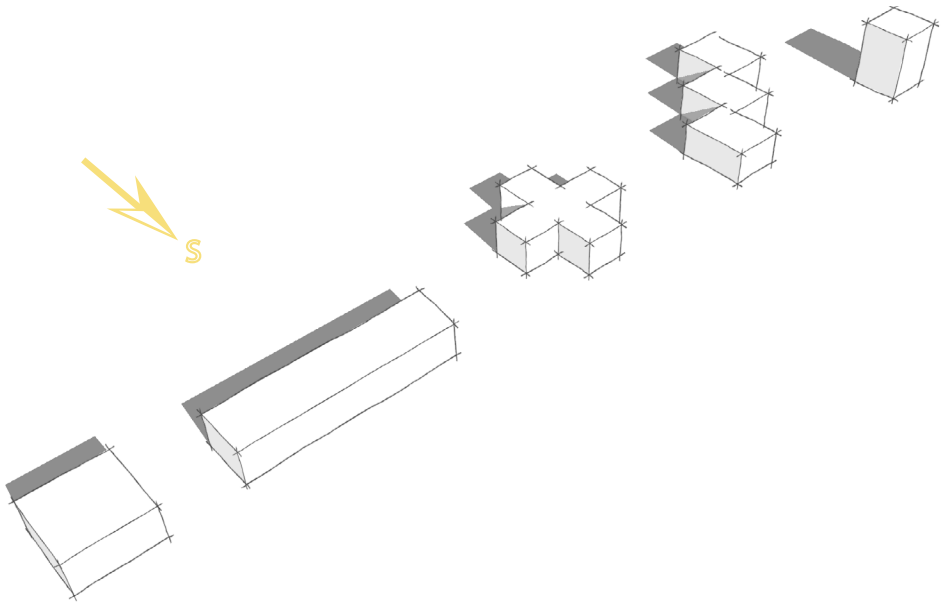

Figure 5: Building shapes for passive sun optimization.

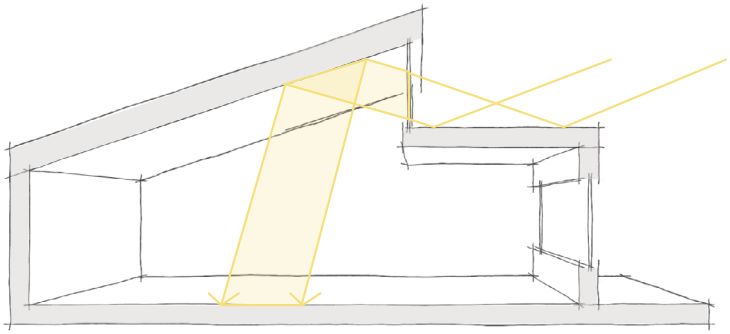

Figure 6: A skylight is an example of how to bring natural light into typically darker areas of a building.

Longhouse at Stong, Iceland. Photo by Author

1.2 Material Culture

One important characteristic of vernacular architecture is the choice to utilize locally available materials in the construction of buildings.[34] This is significant in vernacular buildings in two ways. First the use of locally available materials was limiting the negative impacts of construction on the environment. Second, the material choice plays a significant role in expressing traditions and cultures of a place. This section has three main focuses pertaining to the methods, identity, and choice of material used in vernacular buildings.

Traditional building methods originally developed as humans began experimenting with locally available natural materials. These experiments with different materials and methods originated to provide protection and shelter from their surrounding climate conditions. The landscape that these natural buildings reside in, varies widely across different regions, from the most appropriate construction materials,

[34] Rapoport, Amos. *House Form and Culture*. Englewood Cliffs, NJ: Prentice-Hall, 1991, 3.

techniques and details.[35] Investigations of vernacular architecture and traditional building are often looked at within a regional context, categorized by its physical, cultural, and functional features. In describing categories of studying primitive buildings, Oliver states that "Physical regions may be bounded by mountain ranges, cultural regions are defined by shared traits such as styles of ceramics and vernacular architecture, and functional regions may be defined in reference to the extent of political control or economic interaction."[36] Each region defined within these different boundaries have a set of traditional construction methods and locally available materials that also help to define them. Every building material in the vernacular style is treated or molded differently depending on region, weather, material properties, and traditional construction methods. Building with earth, for example, as noted by Joseph Kennedy in The Art of Natural Building, has been practiced for thousands of years in many regional styles, and still shelters more than one-third of the world's population.[37] The specific use of this material whether it be as rammed earth, sun fired brick, or compressed earth blocks have been developed specifically based on the earth properties as well as to meet the needs of the residents, therefore contributing to the identity of a place through the traditional use of materials in that location. The use of materials can also help define groups of people culturally, particularily in the case of nomadic and semi-nomadic peoples.[38] The Inuit for example, are not confined to a physical location in defining them as a group of people, they are however often characterized by their winter dwellings of igloos or their summer dwellings of tupiq. The igloos, built in winter consist of snow blocks stacked to built a dome, while the tupiq in the summer, is a tent-like form made from tree poles and animal hide outer skin.[39] The material, its use, and specific construction methods thus greatly contribute to defining groups of people or specific regional areas.

Understanding the elements of traditional buildings such as materials, cultures, and construction methods is necessary to better comprehend the identity of a place. Today, many architects use or mimic local materials in their projects to draw attention to a site's specific natural, environmental, and cultural history. Golden discusses that the act of

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[35] Kennedy, Joseph F. *The Art of Natural Building: Design, Construction, Technology.* N.M.: NetWorks Productions, 1999. 73.
[36] Oliver, Paul. *"Archeological" Encyclopedia of Vernacular Architecture of the World.* Vol. 2. 3 vols. Cambridge: Cambridge Univ. Press, 1998. 11.
[37] Kennedy, *The Art of Natural Building*, 146.
[38] Oliver, *"Archeological," Encyclopedia*, 11.
[39] Oliver, Paul. *Dwellings: The Vernacular House Worldwide.* Berlin: Phaidon, 2007. 22.

utilizing or mimicking traditional materials and building techniques can be successful, however, there are cases in which a building's authenticity in response to place can be questioned.[40] In this discussion, Golden points out that there are very specific and considerate ways in which to use or portray traditional materials and techniques, and without proper research or acknowledgment of the specific cultural context, the interpretation can fall short of its intended cultural significance. Golden explains that "incorporating the appearance of traditional materials in contemporary architecture can heighten our awareness of our immediate surroundings."[41] However, often the "copy and paste" solutions from the past no longer meet the social and cultural needs of the community.[42] Again Golden implies that directly applying solutions from traditional building will not meet the needs of contemporary society resulting again in a failed interpretation of a culture and their tradition as a dynamic process. Sandra Piesik, editor of the text Habitat; Vernacular Architecture for a Changing Planet states that "Replicated Western solutions are, in many cases, out of context and over scaled, alienating communities and ignoring not only the social structure but also local climate and characteristics."[43] Oliver discusses how Westernization of society and built environments today, is drastically different than that of traditional settlements, thus stripping away a sense of cultural identity and place. He explains: "Western culture represents for many traditional societies the most extreme divergence from the values of their own culture. Exponents of Westernization justify it on the ground of the replacement of superstition by rationalism, of oppression by freedom, of conservation by 'development' and of tradition by 'progress.'"[44] Frampton, in his text Towards a Critical Regionalism, would concur with Oliver in his discussion of progress versus culture and tradition in explaining that "Modern building is now so universally conditioned by optimized technology that the possibility of creating significant urban form has become extremely limited."[45] Overall, the specific use of locally available materials, as well as the traditions of a place expressed in vernacular architecture, is useful for contemporary architects to draw from to design in a culturally significant manner today.

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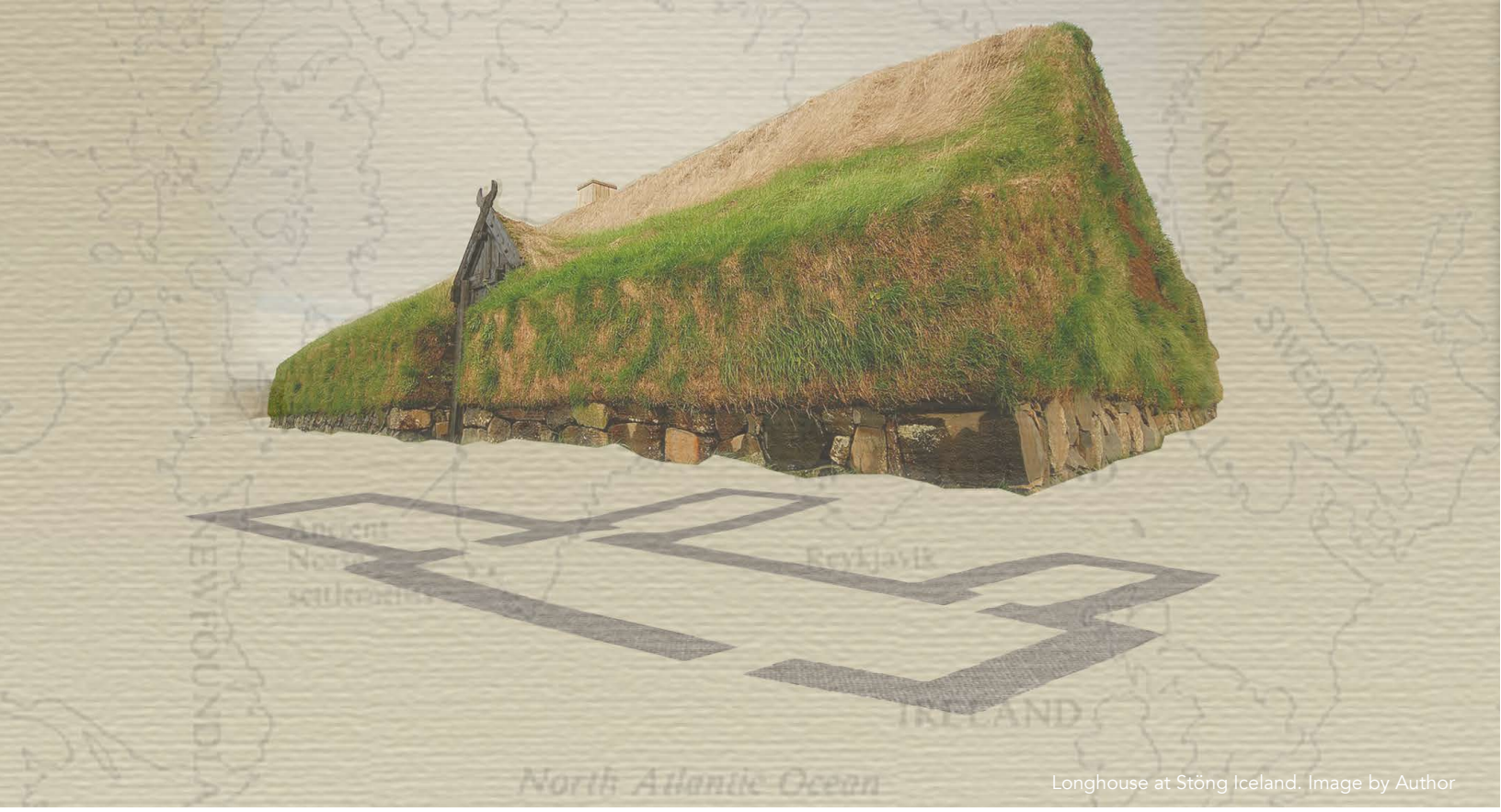
[40] Golden, Elizabeth M. *Building from Tradition: Local Materials and Methods in Contemporary Architecture*. London: Routledge, 2018.134.
[41] Ibid., 134.
[42] Piesik, Sandra. *Habitat: Vernacular Architecture for a Changing Planet*. New York: Abrams, 2017. 23.
[43] Piesik, *Habitat*, 23.
[44] Oliver, *"Introduction," Encyclopedia of Vernacular Architecture of the World*. 122.
[45] Frampton, *Towards a Critical Regionalism, Six Points for an Architecture of Resistance*, 16.

Figure 7: A Viking age longhouse excavation, downtown Reykjavík, Iceland. "*Viking Longhouse.*" Icelandmag. https://icelandmag.is/tags/viking-longhouse

Studying material choice, and methods of construction of the remains of early building types can inform details about social order, climate strategies and cultural organization of groups of people (Figure 7).[46] Historically, material choice and use found in the remains of vernacular dwellings were studied through the field of archeology solely to provide information about environmental conditions. Since the late 19th century, however, settlements have been investigated to study the evolution of vernacular buildings and the related changing social patterns and interactions. The analysis of additions to buildings, more specifically new or improved methods of construction as well as the type of space added, information about how society evolved socially and technically can be gathered. Oliver discusses the positive implications of archeological investigations on contemporary architecture and research today, stating that there is a growing appreciation of prehistoric vernacular architecture as a rich source of sociocultural information.[47] The material choices in a household are represented by a system of activity areas, which are in turn, spatially structured according to the household's participation in higher levels of social, symbolic and economic organization.[48] It thus becomes more clear how the use of that locally available material evolved over time. For example, an additional room or building to an existing structure could represent new strategies for construction, expansion of a household, or perhaps a shift in social status. As such, studying material culture in the context of vernacular architecture can provide greater insight not only into the climate mitigation strategies, but on a communities sense of place, cultural identity, and social dynamics.

[46] Oliver. Dwellings: The Vernacular House Worldwide. 2007. 44
[47] Oliver, *"Introduction," Encyclopedia of Vernacular Architecture of the World. 9.*
[48] Ibid., 9



Longhouse at Stöng Iceland. Image by Author

1.3 The Spatial Organization of Traditional Dwellings

Through the study of vernacular architecture, it can be perceived that buildings and settlements are spatial representations of the importance placed on different aspects of peoples lifestyles including culture, Ethos, world views, and national identity.[49] This chapter addresses principles behind interpreting spaces and forms based on their social and cultural logics.

Forces that shape vernacular architecture are not only the result of not only physical factors such as landscape, material availability and climate, but most importantly socio-cultural forces including social order and cultural activities.[50] Comparison between the house and settlement forms of different societies usually highlights the most significant cultural or religious activities of these groups. Relationships between people and what this group of people envisions as an ideal lifestyle are the main determinant in the form of a dwelling and the organization of spaces within that dwelling.[51] According to Oliver, the changing appearance and organization of built structures is often an indication of changes in climate or in social structure.[52] This means that, in addition to environmental

[49] Rapoport, *House Form and Culture*, 47.
[50] Ibid., 47.
[51] Ibid., 47.
[52] Oliver, Paul. *"Introduction," Encyclopedia of Vernacular Architecture of the World*,108.

adaptations, socio-cultural elements, and people identity and connection play a large role in the evolution of traditional dwellings. For architecture practice today, identifying these culturally significant spaces can support the translation of vernacular traditions into contemporary building. Oliver infers that in recognizing qualities of space, form, use of materials, detailing, proportion and other expressions of local sensibility, architecture can become more interpretive to recreate qualities of vernacular style.[53]

It is through the relations of definite spatial forms with each other, as well as patterns of movement between dwellings or structures in a settlement, that we can understand the occupation of space.[54] In discussing the relation of houses and settlements, Rapoport suggests that the house cannot be seen in isolation from the settlement, but must be viewed as part of an overall social and spatial system which considers the house, the settlement and the residents' ways of life.[55] Spatial order is one of the most striking means by which we recognize the existence of the cultural differences between one social formation and another.[56] It is through the analysis of spaceand understand, based on quantity and quality of spaces used for specific activities, which activities are given high importance within a society. Oliver explains, "Every culture has its particular exception of its dwellings, and arranges domestic spaces in ways that relate to its social structure, to its traditions and to the organization of date daily lives of its members."[57] If one were to only compare spaces and structures based on physical form, daily activities would be overlooked, neglecting the socio-cultural aspects of dwellings that help define forms. Overall, the social activities and cultural traditions of members of a particular settlement are defining contributors to house and settlements form, and through research it clear that socio-cultural factors are just as if not more significant in contributing to form than climate factors and material availability.

A method to analyze the form of settlements and study spatial order, the type and quality of spaces, is the use of syntax maps (Figure 8).[58] Bill Hillier and Julienne Hanson authors of The Social Logic of Space, state that spatial syntax maps have two different functions, first to distinguish the relationship between inhabitants and their activities, and the relations

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[53] Oliver, Paul. *Built to Meet Needs: Cultural Issues in Vernacular Architecture*. Amsterdam: Architectural Press, 2006, 10.
[54] Hillier, Bill, and Julienne Hanson. *The Social Logic of Space*. Cambridge: Cambridge Univ. Press, 2005. 26.
[55] Rapoport, *House Form and Culture*, 69.
[56] Ibid., 26
[57] Oliver, *Dwellings*, 166.
[58] Hillier, *The Social Logic of Space*, 82.

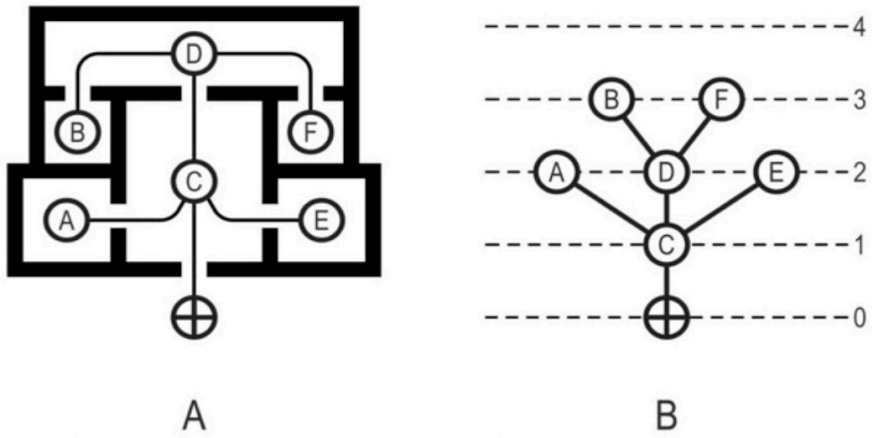


Figure 8: Syntax map- Justified access graph based on levels of privacy.Dawes, Michael, *Percise Locations in Space: An Alternative Approach to Space Syntax Analysis Using Intersection Points.* School of Architecture and Built Environment, University of Newcastle, NSW, Australia, 2013.

between inhabitants and strangers or guests.[59] This system is arranged to distinguish between primary and secondary spaces which are often developed in terms of privacy: "How societies regard the relationship of internal to external space is often a measure of the importance they place on privacy."[60] Primary buildings, for example, are houses, common areas, and buildings consisting of the main gathering or living functions. The secondary spaces are the more private spaces not for strangers or members outside of the home such as bedrooms, closets and private sitting rooms. These primary and secondary spaces are connected through carrier spaces which are more transitional rooms such as vestibules, or areas outside of the main settlement buildings. Hanson explains: "Houses are sensitive to social relations only insofar as they construct and constrain interfaces between different kinds of inhabitant, and different categories of visitor."[61] Space syntax maps not only distinguish between private and public spaces, they can also be used to extrapolate information about the social origins of spaces and settlements. In discussing decoding the home based on social relationships and hierarchy, Hanson explains:

> "Human spatial behaviours reflect the workings of rather fewer social forces than there are cultural phenomena to be accounted for. Such forces include differentiating individuals or groups with different statuses, roles or categories, and generating or controlling the possibility for encounter and avoidance among them."[62]

[59] Ibid., 82.
[60] Oliver, *Dwellings*,166.
[61] Hanson, Julienne. *Decoding Homes and Houses.* Cambridge. Cambridge University Press, 2003. 77.
[62] Hanson, *Decoding Homes and Houses.* 77.

Through the use of syntax maps, it becomes clear that the social relationships are visible based on how spaces are connected, as well as on which spaces are meant to be visible and which are meant to be concealed from guests or visitors. read aspects of theand of its occupants The investigation and comparative analysis of traditional vernacular buildings is essential in determining climate responses, material use, and most significantly information about social structures and cultural importance within a particular place and group of people.

Chapter 2

2. Turf House Tradition

Turf or sod buildings are the traditional building typology of Iceland, originating in the 9th century when Vikings from Scandinavia and the British Isles settled along the coast of Iceland.[63] A traditional reading of the twelfth- to fourteenth-century written sources is that a large proportion of Icelandic society was made up of free 'householders' (b6ndi, pl. bcendr), farmers who owned and had control over an independent economic unit that included fields, meadows, upland pastures, and livestock.[64] This contributed to the large farm land plots seen today throughout Iceland, as farming is still a significant lifestyle. The Viking colonization is assumed to have lasted over sixty years, bringing in over 40,000 - 60,000 settlers.[65] "All individuals had to belong to a household and officially reside at a farmstead; however, the household was not the same as the social house. The Icelandic household was highly stratified and comprised landowners—who claimed descent from those who led the settlement expeditions, claimed land, and established the first farmsteads—dependent labourers without claims to land, and slaves."[66] The traditional characteristic of turf buildings were sod and turf walls and roof coverings to create an insulated envelope surrounding a thin wooden frame. Due to lack of building material on the island more specifically, a lack of wood, all dwellings, farm building, storage spaces, and churches consisted of this turf construction. Throughout history there are three main different types of turf houses that have been distinguished. The earliest from turf building was the longhouse, characterized as a long central hall and used for all types of actives including gathering and living. The second type developed was the corridor farmhouse defined by a central corridor leading off to secondary rooms or building such as parlours, living rooms and kitchens. The early 1800s brought the gabled farmhouse characterized

[63] Joost van Hoof, Froukje van Dijken."*Historic Turf Farms of Iceland: Architecture, Building Technology and the Interior Environment.*" Science Direct Building and Environment 43 (2008) 1023
[64] Milek, Karen B. *Houses and Households in Early Icelandic Society: Geoarcheology and the Interpretation of Social Space*. Newham College University of Cambridge, June 2006. 5
[65] Froukje van Dijken, *Historic Turf Farms of Iceland*, 1023
[66] Bolender, Douglas J. *House, Land, and Labor in a Frontier Landscape: The Norse Colonization of Iceland*. 405

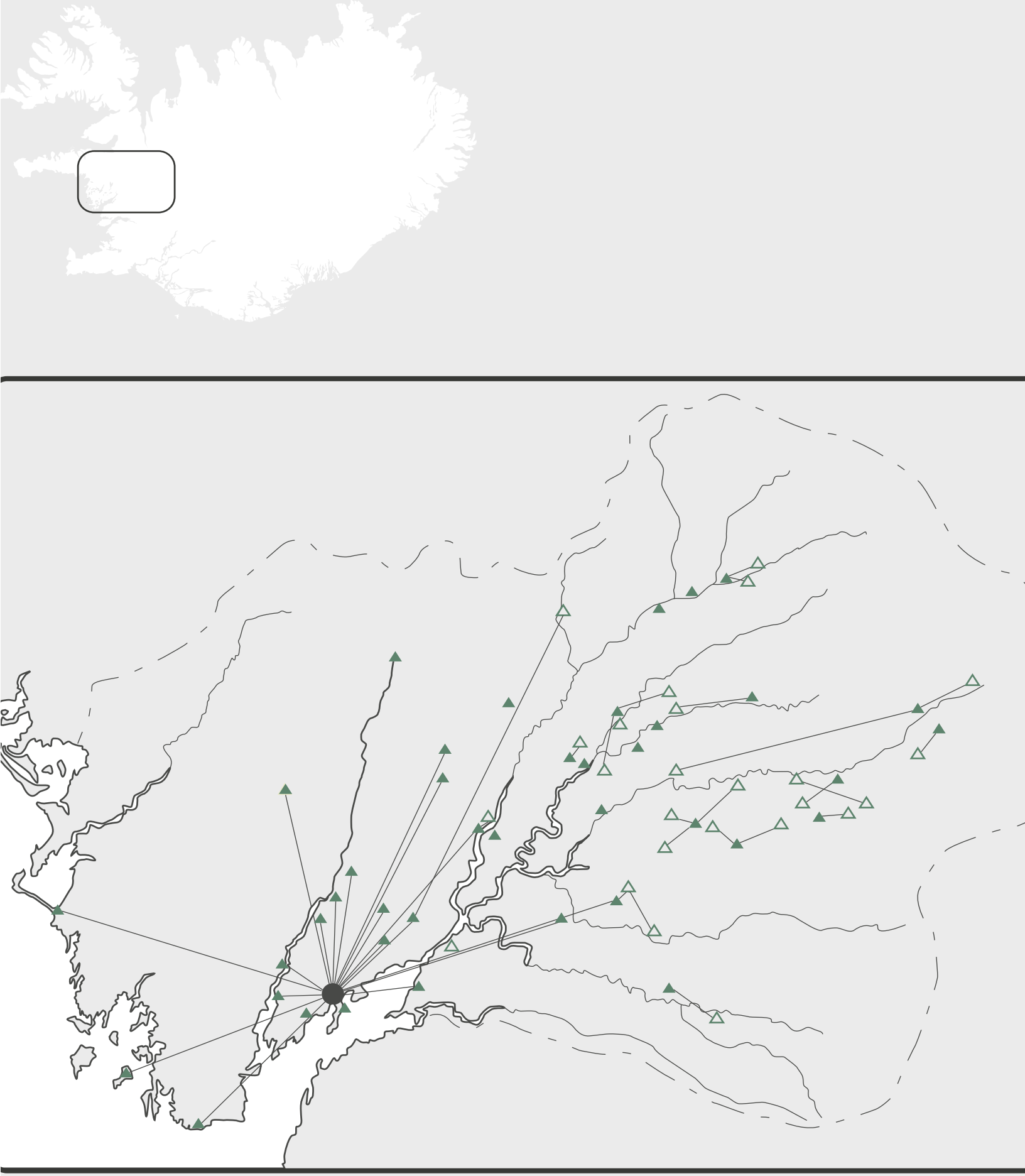


Figure 9: Filled triangles represent farms said to have been established during the first Norse colonization, then the open triangles represent farms established during the second generation of colonization.

as a series of turf buildings parallel to each other in a linear fashion, which is the most common typology seen across Iceland today.[67]

The objective of this chapter is to analyze in detail examples of Icelandic turf houses which exist today along the Southern coast of Iceland, to determine how they interpreted passive design and to understand their material culture and spatial logic. To provide greater insight into the specific typology of Icelandic Turf Houses, I conducted site visits across the South and South West Coast of Iceland. During this research trip, four farmsteads, three churches, one longhouse and various farm outbuildings were visited and documented to create an overview of the local vernacular typology and culture of Norse people. Many of the turf houses today are rebuilt or preserved and owned by the National Museum of Iceland. Most are UNESCO world heritage sites and have been legally protected under the National Museum since the 1930's as they represent a significant historical period in time for the Norse people.[68]

[67] Joost van Hoof, "*Historic Turf Farms of Iceland.*" 1026.

[68] UNESCO World Heritage Centre, "*The Turf House Tradition.*" https://whc.unesco.org/en/tentativelists/5589/

2.1 Understanding Tradition: A Case Study of Icelandic Turf Houses

Each of the following case studies were documented through methods of sketching, painting, scaled drawings of floor plans. Plans and wall sections were recreated to compare construction methods and material used, as the cases studied vary in style and method of construction. Each building will be presented with the objective of further understanding consistencies between styles and constructions as well as similarities between the organization of spaces between the turf house styles.

Church at Stöng, Iceland. Photo by Author

1 Arbær
2 Íslenski Bærinn
3 Stöng
4 Keldur
5 Skogar
6 Hofskirkja
7 Stokkseyri

Figure 10: Case Study Map of Iceland

Figure 11: Longhouse at Stöng

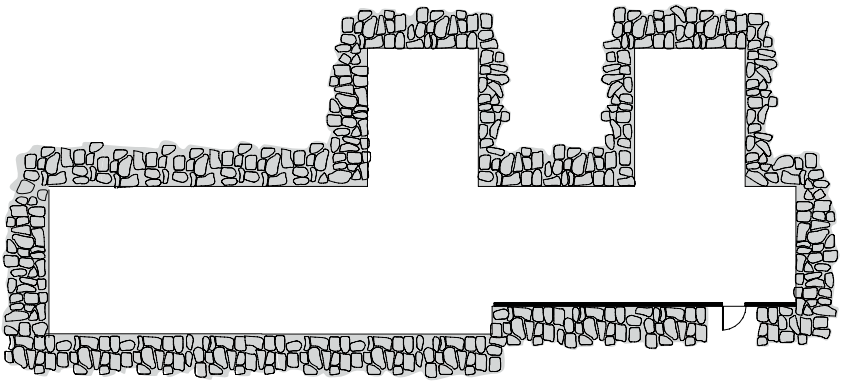


Figure 12: Floor Plan Scale 1:300

Figure 13: Longhouse End wall- Herringbone Pattern

Longhouse at Stöng

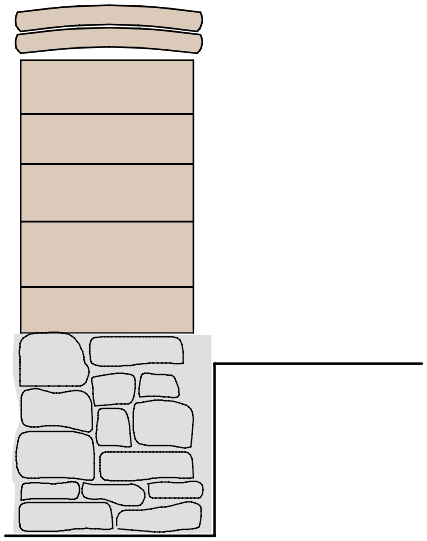


Figure 14: Wall Section Scale 1:50

The site that represents one of the oldest building styles in Iceland is the church and longhouse at Stöng. This commonwealth farm was based on the ruins of the former manor farm, which is considered to have been abandoned after its destruction during the Hekla volcano eruption of 1104.[69] The settlement was reconstructed in 1974 with every effort to replicate the farm as exactly as possible to the ruins left at Stöng (Figure 11 and 12). The longhouse uses a herringbone pattern for the stacking of the turf which is unique in that the different direction of layering with the turf site facing upward forms a watertight barrier (Figure 13 and 14) . The farm building is a museum piece in itself in its illustration of ancient craftsmanship and proof that the dwellings of the first people to inhabit Iceland were well built and majestic in construction.

[69] National Museum of Iceland, Information sign at Pvera.

Hofskirjka Church

The Hofskirjka Church is one of the most impressive case studies investigated as it is the oldest turf church still in use today. Constructed in 1884, it was the last turf church ever built in Iceland in the old style (Figure 15 and 16).[70] Today it is one of six turf churches still standing, and currently still in use as a Parish church.[71] The majority of the exterior and base uses stacked stone which develops the walls, and a thick slab of turf running along the stone up to the peak of the roofline (Figure 17 and 18).

[70] National Museum of Iceland, Information sign at Hofskirjka
[71] National Museum of Iceland, Information sign at Hofskirjka

Figure 15: Hofskirjka Church present day.

Figure 16: Hofskirjka Church with traditional wooden facade

This turf church is similar to the gabled farmstead in that the front facade uses only board and baton style wood, which leaves the front face uninsulated. Furthermore, this is a significantly impressive turf building in that although it has been preserved and kept up, it is still in use for its intended purpose after 135 years.

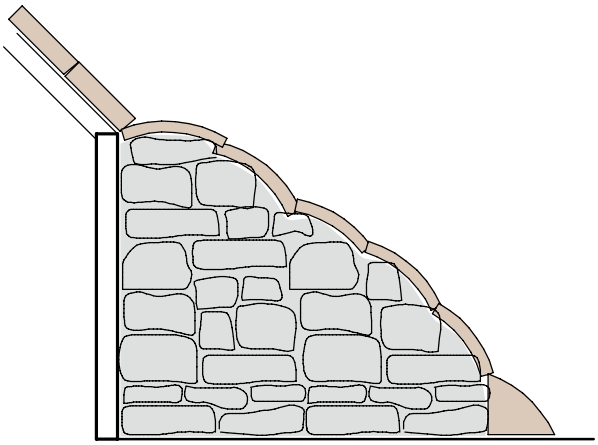


Figure 17: Wall Section 1:50

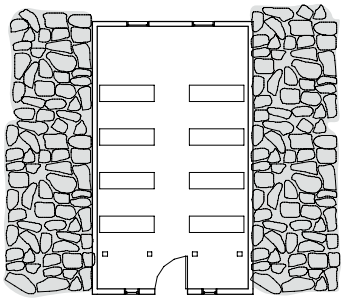


Figure 18: Hofskirjka Floor Plan scale 1:300

Skogar Turf Farm Museum

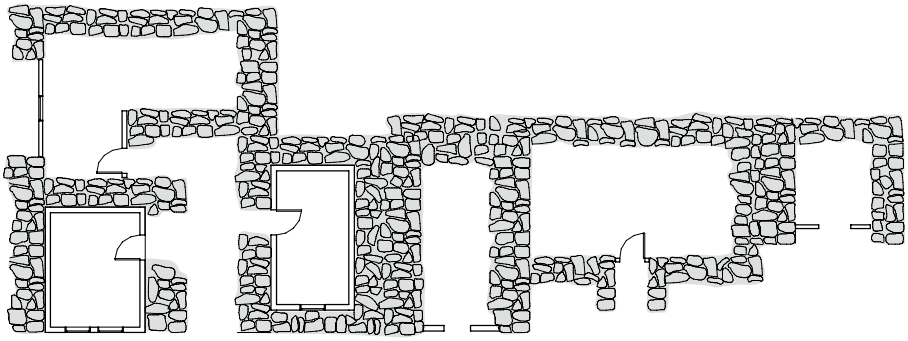


Figure 19: Floor Plan Scale 1:300

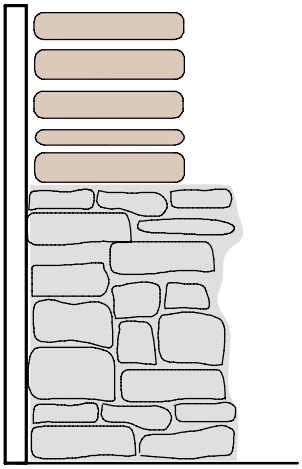


Figure 21: Wall Section Scale 1:50

Figure 20: Elevation of the farmstead at Skogar.

The most significant case studies for this project are the four turf farmsteads because they are the most diverse building typology representing the daily lifestyle of Norse settlers. These farmsteads were often built on farmland and contained several different buildings constructed in a linear cluster to serve many different functions of living and farming (Figure 19 and 20). The Skogar open air museum is a collective experience of turf farm living which includes turf buildings that date back to 1830, with later additions of parlour, kitchens and communal rooms in the early 20th century.[72] The storehouse was built in the early 1830s, the cattle shed in 1880, and the smithy is the most recent addition in the 1950s.[73] The construction of this turf site were noticeably characterized by its layers of turf and stone for approximately 5 feet in height, compared to other methods of strictly using stone for foundation and all turf stacked walls and roof (Figure 21 and 22).

[72] National Museum of Iceland, information pamphlet at Skogar
[73] National Museum of Iceland, information pamphlet at Skogar

Figure 22: Original Skogar turf farm buildings

Arbær Open Air Museum

The Arbær open air museum is a collective of relocated and rebuilt influential historic buildings from central Reykjavik, which illustrates the typical lifestyle of the Icelanders during the 19th and 20th century. The Turf Farm buildings at the Arbær open air museum are the only buildings on the site that are in their original location.[74] Arbær is assumed to have originated around the 15th century as this is the earliest documentation of the farms existence, and the farm was inhabited until the early 1900s and abandoned in 1948.[75] In comparison to the other farmstead case studies in this project, it is the most developed farm with multiple separate buildings including sheep sheds, stables (Figure 23 and 24) a church, additional vestry and a smithy (Figure 25 and 26) . The church was built in the old style similar to that of Hofskirjka with a wooden facade, however the rest of the buildings mainly consisted of turf walls and roofs, seemingly disappearing into the landscape of tall grasses (Figure 27 and 28).

[74] National Museum of Iceland, information pamphlet at Arbær
[75] National Museum of Iceland, information pamphlet at Arbær

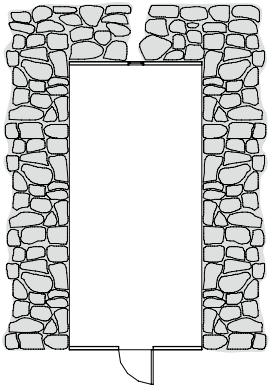


Figure 23: Floor Plan scale 1:300

Figure 24: Painting of the old stables at Arbær

Figure 25: Arbær farm buildings on their original site from the 15th Century

Figure 26: Kirkja (Church) at Arbær Museum built in 1960.

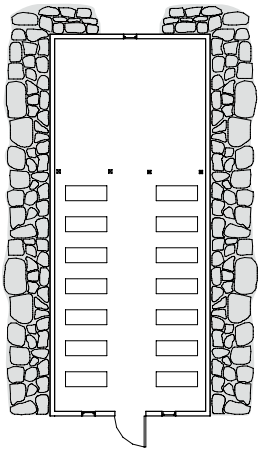


Figure 27: Floor Plan Scale 1:300

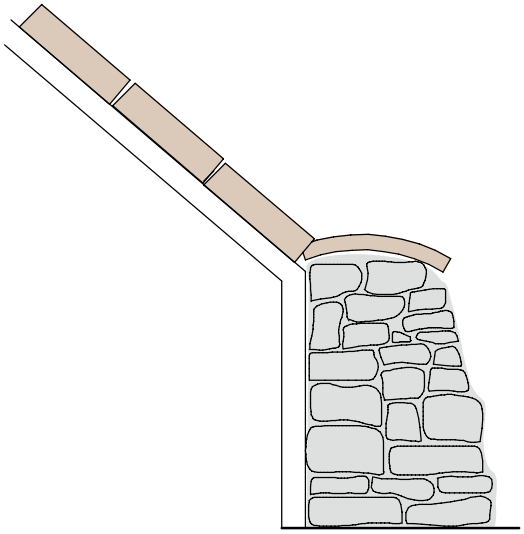


Figure 28: Wall Section Scale 1:50

Íslenski Bærinn Farmstead

Figure 29: Íslenski Bræinn farmstead

Figure 30: Fish Drying hut at Íslenski Bræinn

The only turf farm not owned by the Nation Museum of Iceland is Íslenski Bærinn. The term Íslenski Bærinn actually means Icelandic Turf Farm in Icelandic, and this farm is owned by the artist and turf house fanatic Hannes Lárusson, who built and maintains the turf farm himself (Figure 29 and 30). The main turf farm consists of four houses, a barn and stables, eight buildings in all which Lárusson continues to build upon with the goal of rebuilding the entire farmstead to its original glory (Figure 31). All of the turf buildings on this farm consistently use contrasting layers of lava stone and turf, back and forth to build up the walls, with the roofs using the typical style of an interior timber frame and exterior layers of turf and sod (Figure 32 and 33).

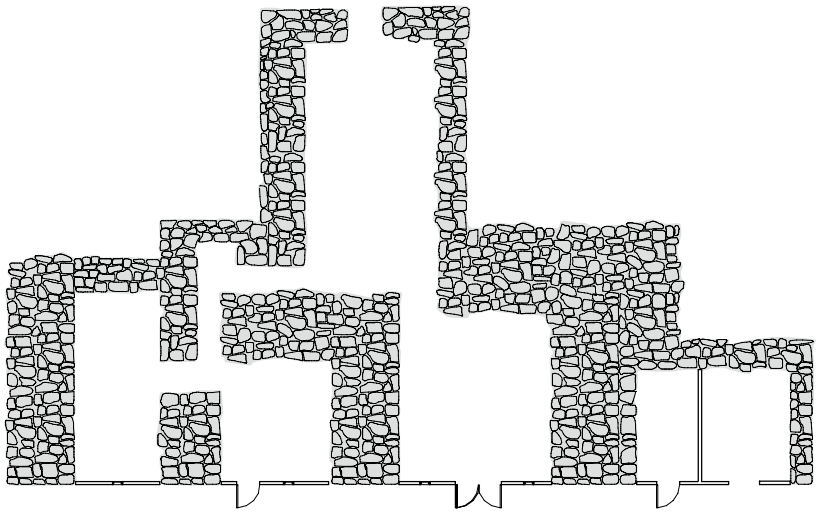


Figure 31: Floor Plan scale 1:300

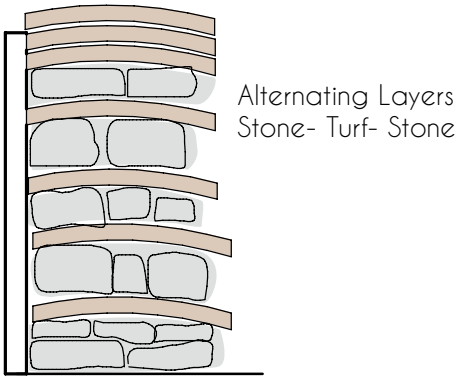


Figure 32: Wall Section 1:50

Figure 33: Painting of Íslenski Bræinn Farmstead

Keldur Farmstead

The turf farmstead at Keldur is one of few very well preserved turf settlements left in South Iceland, and was once the home of the of one of the most powerful clans in Iceland who lived in the turf houses until 1197.[76] The front building are parallel to the farm yard, facing a "newer" church with an adjacent cemetery facing the mountains beyond (Figure 34 and 36). The hall (skáli) of the turf houses is believed to be the oldest turf house hall in Iceland. (Figure35)The turf buildings have been rebuilt several times after large earthquakes between 1896 and 1912, and overall remains of 16-18 farmsteads have been found at the Keldur site (Figure 37 and 38).[77]

[76] Ragnarsdóttir, Regína Hrönn. "Keldur Turf House in South-Iceland - Is This the Oldest House in Iceland?" Guide to Iceland. June 18, 2014. https://guidetoiceland.is/connect-with-locals/regina/keldur-turf-houses-in-south-iceland.
[77] Ragnarsdóttir, Keldur Turf House in Southern-Iceland, 2014.

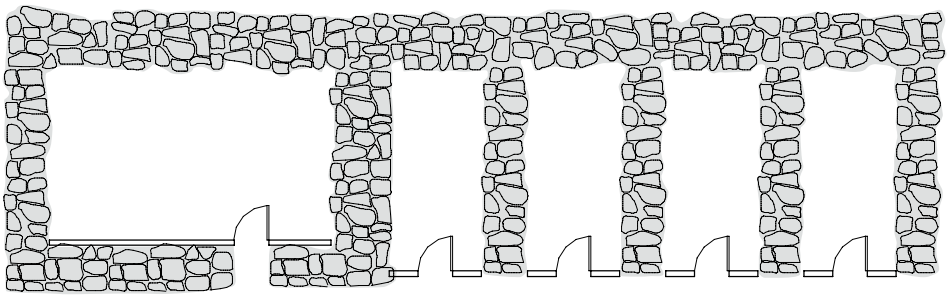


Figure 34: Floor Plan Scale 1:300

Figure 35: Hall at Keldur

Figure 36: Keldur Farmstead

Figure 37: Farm Building Interior

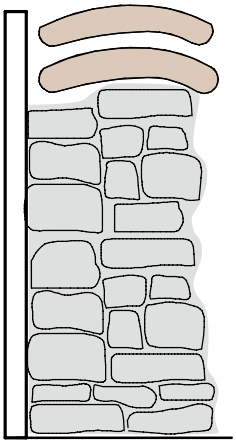


Figure 38: Wall Section Scale 1:50

2.2 Turf Material Performance

The natural mineral-based turf has been used as a building material in Iceland since the initial settlement of the Norse people in the 9th century.[78] The turf is often supported by a foundation base of lava stones and an interior thin timber structure if wood was available. This thick cut of sod typically removed from the top layer of wet Icelandic marshlands that were covered in tall grasses often at a dept of 10-20 centimetres that was dependent on how much land the farmer could spare for building.[79] Often the thinner the layers were, the greater they were in strength due to how deep the grass roots grow, which in essence is what keeps the sod and grass intact as one piece. Once the layers are dried out they become thin and flexible for easy layering and construction. Construction materials that derive from plants such as turf, have a lower embodied production energy than conventional non-renewable alternatives.[80] Seeking to extract information about the environmentally sustainable aspects of Turf Houses, this research examines the material of turf at levels of usage, thickness, thermal mass, heat retention and breathability to further inform the usage of turf as a renewable construction material (Figure 39). The thermal properties of turf vary as the numbers are dependent on the density of material. The greater amount of heat that a material can store, the slower that material will respond to thermal changes, therefore this "damping" effect will allow for a more stable internal room temperature.[81] The earth used in traditional Icelandic architecture is usually a mix of soil and turf and is always used in a combination of lava stone and turf.[82] Due

[78] Joost van Hoof, *"Historic Turf Farms of Iceland."* 1023.

[79] Ibid., 1026.

[80] Piesik, Sandra. *Habitat: Vernacular Architecture for a Changing Planet*. New York, NY: Abrams, 2017. 532.

[81] Piesik, *Habitat: Vernacular Architecture for a Changing Planet*. 532.

[82] Joost van Hoof, Froukje van Dijken. *"Historic Turf Farms of Iceland."* 1026.

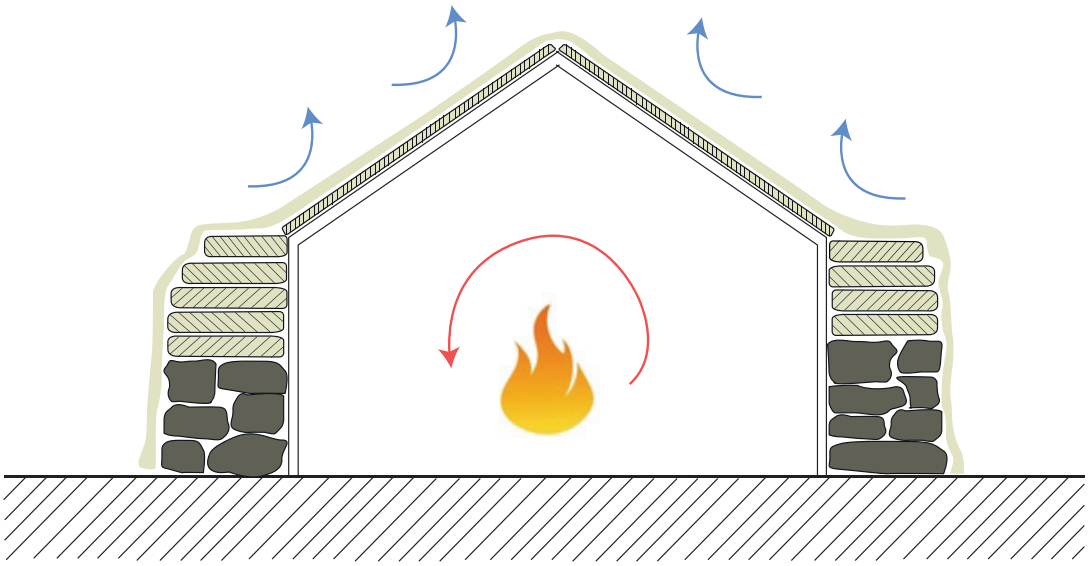


Figure 39: Traditional Icelandic turf house heat retention diagram

to the fact that turf is a mix of plant based material and mineral based, the specific heat capacity is between 1 kJ/kg.K(kilojoules per kilogram for unit temperate in Kelvin) to 2 kJ/kg.K. This means that turf has a greater thermal mass, given its avidity to absorb, store and release the sun's energy.[83] The use of turf is not only sustainable for the building but it also improves the surrounding environment, the grasses absorb carbon dioxide from the atmosphere, and provide cleaning air for the surrounding inhabitants. Overall, in the context of this thesis, one of the main streams of investigation is to deconstruct the building envelope of the Icelandic turf house, and to pursue further understanding of the links between construction methods, material use, and cultural impacts.

[83] Piesik, *Habitat: Vernacular Architecture for a Changing Planet.* 532.

2.3 Turf Material Culture

One of the mains streams of investigation in this thesis is to deconstruct the building envelope of Icelandic turf houses to pursue a greater understanding of the links between construction methods, material use and cultural impacts. As shown previously in the case studies of turf houses across South Iceland, diagrammatic wall sections were developed to begin documenting various style of turf construction, layering techniques, and material choice. This material study through the use of sections identified four different methods of building that provides insight into the environmental conditions at the period in time they were built or reconstructed, as well as the material availability in a particular location. The different layering techniques are dependent on factors such as the availability of turf, the amount of stone accessible, the thickness of the earth on site for the turf layers, as well as how much land a farmer could afford to use for the construction. Through the process of modeling and drawings, four patterns were developed that represent the various building methods to help identify different features in turf houses. Different methods of stacking also emerged across different building uses or functions. Farm stables or storage buildings for example typically used more basic structures and consisted of less wood structure or nice material often built with a much rougher finished interior. The Arbaer stable was one construction that was very typical of the other farm buildings, a gable style farm building, the entrance was constructed of thin wood, the foundation consists of short layers of stone, and thick layers of roughly cut turf form the walls and roof on a thin wood stick frame. The buildings designed for the living quarters and gathering spaces used higher quality materials, larger more square rock formations to strategically stack the foundations, thick even slabs

Figure 40: Turf house layering- stone- turf- stone

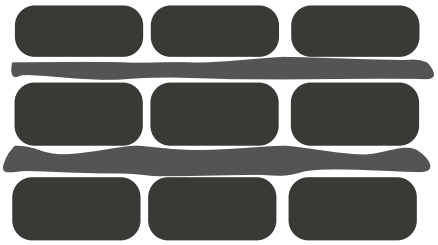
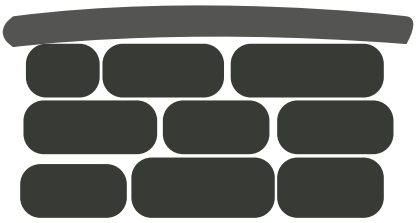


Figure 41: Turf house layering- rock walls finished with turf



of turf to form the walls, larger interior structures as well as some wood lining the walls or floors for interior finishes. Across the cases studied for this thesis, the buildings used for living quarters were often constructed using two patterns, the first being the stone foundation and then thick layers of turf, the second uses layers of stone, turf, stone, turf and so on. The most sophisticated stacking method was the herringbone pattern, constructed of very thick slabs cut out at 45-degree angles most commonly used to build end walls of gable style house forms. The herringbone pattern is significant in its aesthetic, therefore creating a visual reference to turf houses, which has been translated into the final project. Overall, the use of Icelandic turf as a construction material, its sustainable properties, as well as its reference to local culture, play a significant role in my thesis objective of developing design principles for environmental and culturally sustainable building practice in cold climates.

Figure 42: Turf house layering- horizontally stacked turf

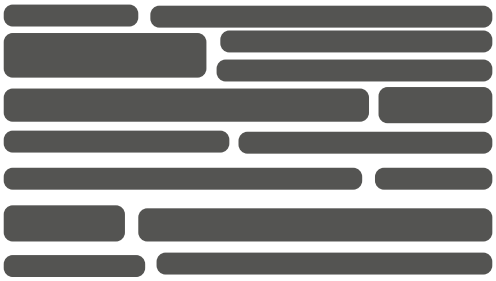
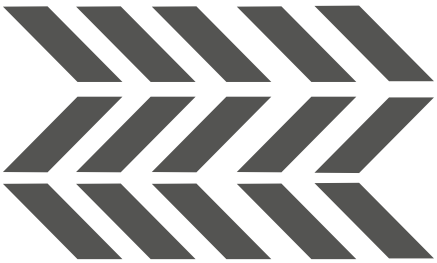


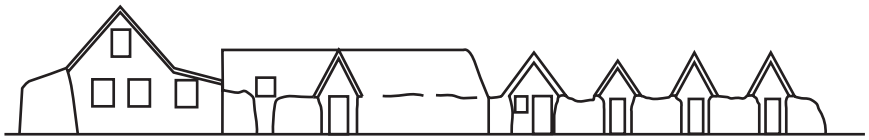
Figure 43: Turf house layering- stacked turf herringbone pattern

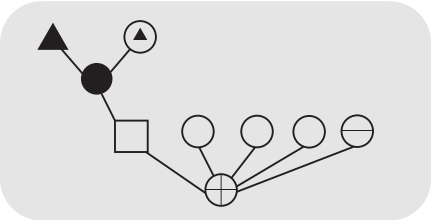


2.4 Spatial Logic of Traditional Turf Dwellings

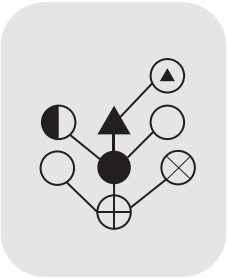
Through studying the typology of the Icelandic Turf Farmsteads, elements of daily lifestyle and traditional activities helped develop a sense of public versus private spatial organization and coined individual theories as to the building methodologies and strategies implemented. To further this study in plan, spatial syntax maps were created to analyze the various levels of spatial use in terms of levels of privacy and movement throughout the buildings. Through the comparative analysis of spaces, it was determined that across the different farmsteads studied, there were three main common spaces. The first being the sleeping quarters, the second being the farm building such as stables, smithies, and storage for equipment, and then the central hearth designed as a gathering space for cooking and spending time together often located at the center of the farmstead. These three key aspects are the main spaces chosen to pursue through the modern interpretation of turf house culture in the final proposed project. Once the comparative analysis of spaces was completed through the syntax maps, the farm buildings or farmsteads were the most interesting typology as they consisted of many different spaces or rooms all in various configurations often developing a small complex. The turf farm at Keldur, for example, was very linear, with many of the rooms accessed only from its exterior individual door this type is known as a gable farmstead typology. The Islenski Bærinn turf farmstead, on the other hand, was a more corridor style farmstead, with several exterior doors, however with interior corridors that lead to the other spaces within the building. Furthermore, the logics of turf house farmsteads were determined through the use of syntax maps and concluded by identifying three key spatial organizations which contribute to the final buildings programming.

Figure 44: Syntax map legend

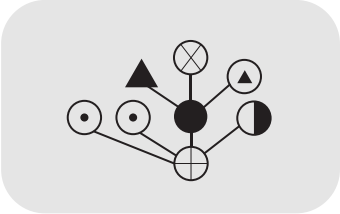




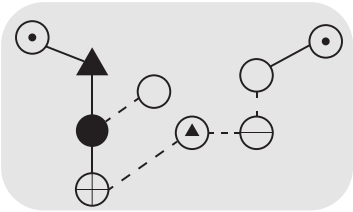
The Turf Farm at Keldur is a gable style farm building which has multiple entrances to individual farming buildings. The main hall is a gathering space that provides access to the living quarters such as bedrooms and cooking area.



The Arbær turf farm is also gable style and it's evolution of turf building is shown through the differences between the old and the new styles. The main access point is through the front door of the newer farm buildings, which allows access to the living and cooking spaces, which further leads to the sleeping quarters. The older style building is a farming storage building only accessed from it's own door.



The Íslenski Bærinn turf farmstead contains many buildings most with access through separate exterior doors. The main buildings with multiple access points would be the living quarters, which contains a cooking area and access to bedrooms.The end of the corridor allows access to a cellar/ storage room, following to an additional farming building adjacent to the front gabled buildings.



The Skogar farmstead was slightly different in that it was the only building of the case studies that used a small court yard to access three of the buildings, and they did not all sit in a perfectly linear fashion. Each building was accessed individually with the exception of the living quarters which brought you to the cooking area and bedrooms.

Figure 45: Farmstead spatial comparison elevations.

Figure 46: Farmstead spatial syntax maps.

Traditionally, there were three main styles of Icelandic turf farmsteads that have been distinguished through Norse history. The earliest form from the Viking Age was the longhouse mainly consisting of wood and sod (Figure 47), from the 1800s the gabled farmhouse was introduced, characterized by buildings parallel in elevation with shared walls of turf connecting them and impressive wooden facades (Figure 48).[84] After the gabled farmhouse, came the corridor style which is similar to the gabled however with an interior corridor in plan

Figure 47: Traditional viking longhouse
"*Turf Houses in the Viking Age.*" Hurstwic. http://www.hurstwic.org/history/articles/daily_living/text/Turf_Houses.htm

that connects to a number of other buildings (Figure 49). The gabled farmhouse became the most popular in the warmer areas such as the south coast due to the fact that the front wooden façade lacked the thermal insulation of turf.[85] The overall method of moving through these farmhouses or farmsteads as they are often referred to, was to begin through a main door that led to a transitional space, which fed often directly to the kitchen and cooking hearth typically in the centre of the turf house. The transitional spaces often fed other living areas such as sleeping quarters, lavatories, pantries and storage. This very specific vernacular style of program and building layout led to the exploration of a program that integrated several uses of the original way the turf farmsteads were inhabited. Examining these different styles provided insight into which spaces I assumed only needed to be accessed from

[84] Hoof, Joost Van "*The Historical Turf Farms of Iceland.*" 1026.
[85] Ibid., 1026.

Figure 48: Gabled Farmstead

the outside such as stables, whereas other rooms such as living spaces, some storage rooms, workshop spaces, and gathering spaces were often accessible from both interior and exterior doors or just interior doors. Analyzing these spaces also provided a sense of public versus private spaces, which ones were more likely to have guests or visitors, and which ones such as the gathering spaces, were more open and accessible to all. Finally, the spatial organization analysis of farmsteads informed three key spatial elements which began the development of the program for the thesis project and this information also continually informed how each space in my final project is accessed and oriented based on tradition turf spatial logic.

Figure 49: Corridor Style Farmstead

Chapter 3

3. Site Analysis

The project Turf House Complex seeks to address modern day issues of sustainability in cold climates through integrations of principles derived from the previous documentation and exploration of vernacular architecture and Icelandic turf houses. The objective of this project is thus to explore new environmentally and culturally sustainable architectural forms and building solutions in the context of Iceland.

The third chapter of this thesis presents the final project's site in Stokkseyri, Iceland and includes details about site selection, site analysis and program development. The site selection section presents information about Iceland, the site's location in the small fishing village, as well as the village's situation in relation to tourism and local activities. The site analysis section looks more closely at the site in relation to its surroundings, covering climatic, material and cultural aspects. Finally, the program development section describes the spatial requirements for each function of the building's initial programming, and explain how the program culturally and environmentally reinterprets traditional turf houses.

Figure 50: Site Stokkseyri, Iceland

Fish Hut Turf building, Stokkseyri. Photo by Author.

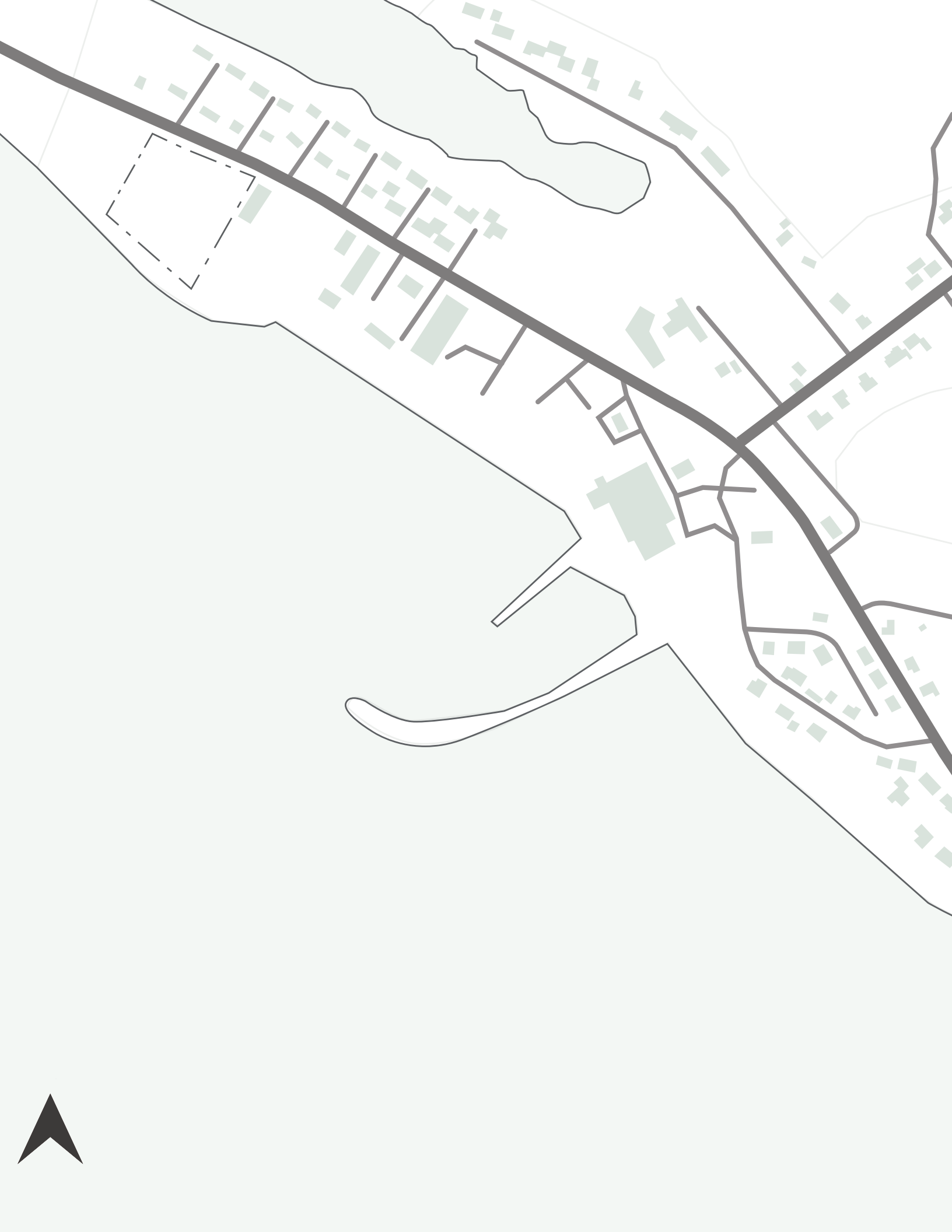
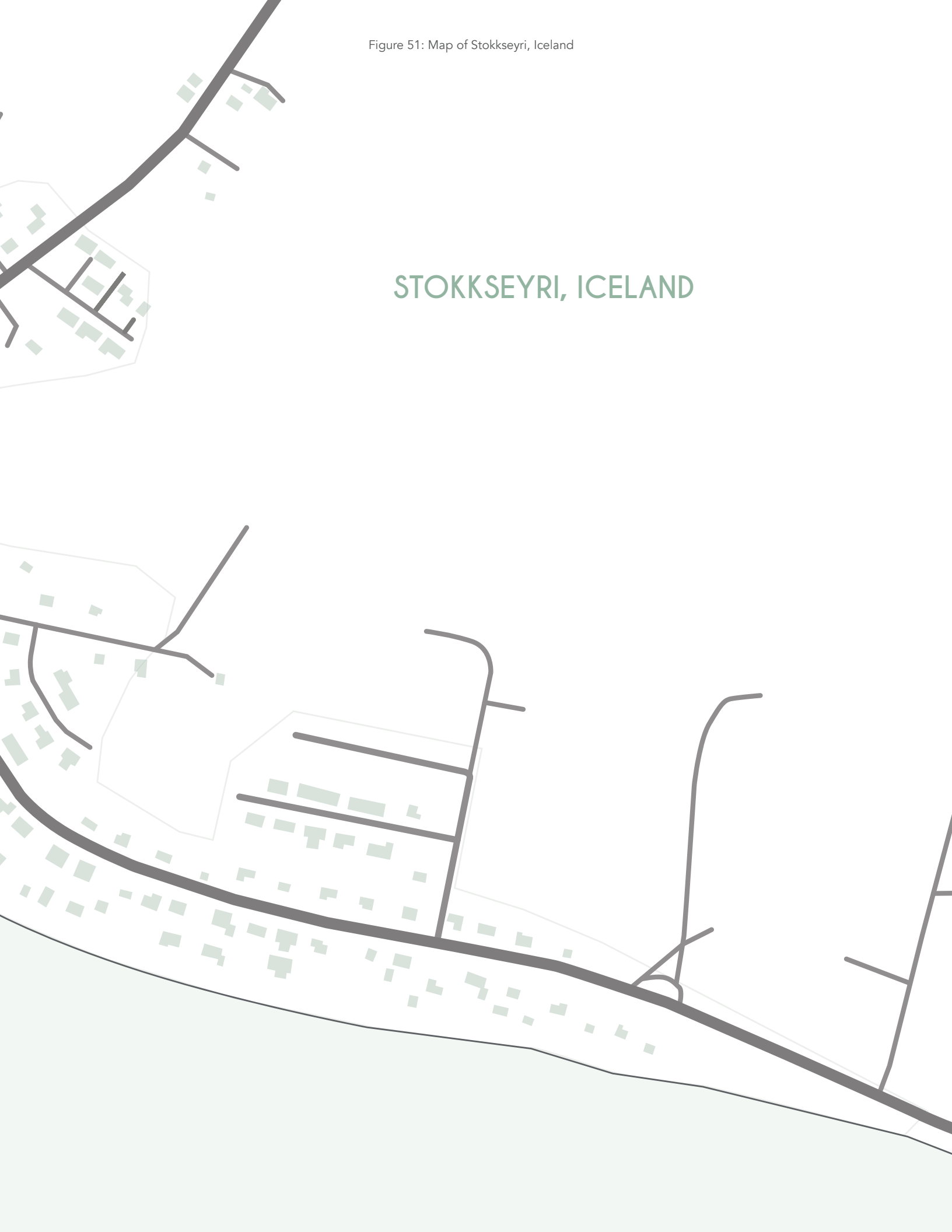


Figure 51: Map of Stokkseyri, Iceland

STOKKSEYRI, ICELAND



3.1 Site Selection: Stokkseyri, Iceland

The chosen site for this thesis project sits on the southern edge of small costal town in the South of Iceland called Stokkseyri. This small town of approximately 400 people originated as a successful fishing village along the coast and today its primary means of support is the growing tourism industry.[86] In Stokkseyri, the main street runs East to West parallel to the coast line, with mostly residential buildings, public buildings and various tourism attractions (Figure 52 and 53). Today the majority of the town consists of locals hosting their homes as AirBnB's as means of income, along with one Seafood Restaurant, a Hunting and Fishing tourism information centre, and a Cultural House with displays of the Northern Lights, Elves and Trolls as well as Ghosts.

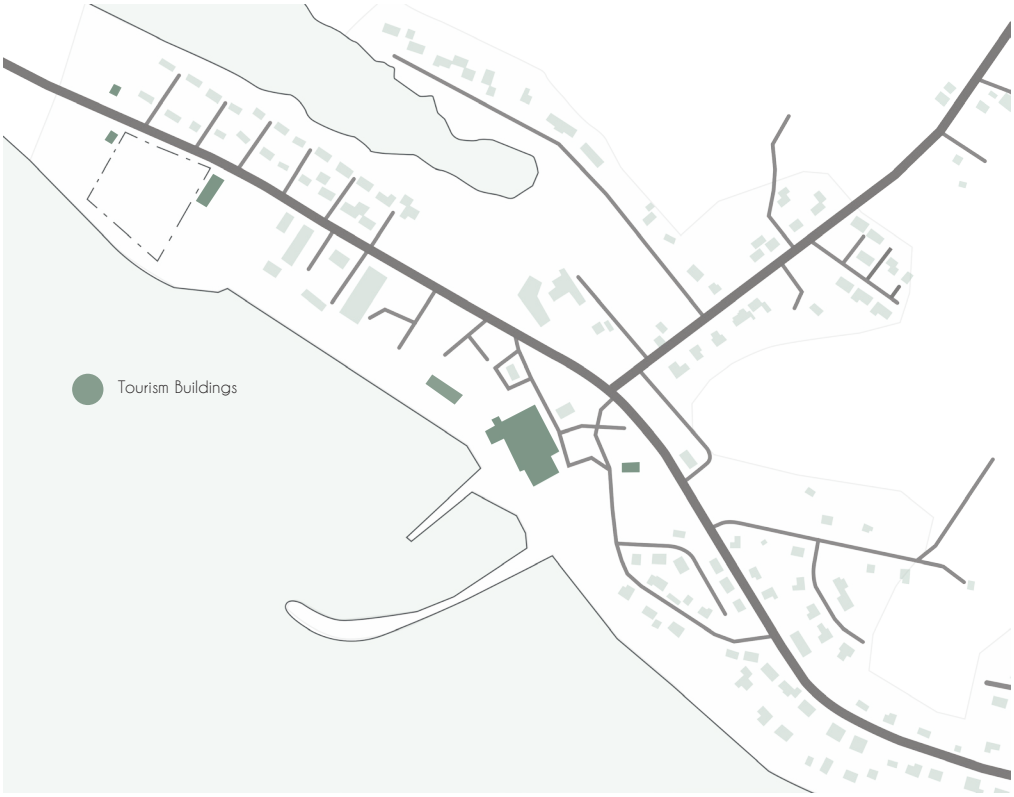


Figure 52: Map of Stokkseyri showing tourism buildings

[86] Visit South Iceland. "STOKKSEYRI." Upplifðu Suðurland. https://www.south.is/en/inspiration/towns/stokkseyri.

To serve the locals, the town contains a public school, several soccer fields, a community pool/ office building, and little else in the way of public building. While travelling through the South of Iceland, many documented and some undocumented Icelandic Turf houses were studied either at National Museum locations or independent lovers of turf houses. Through this exploration, the town of Stokkseyri had an abundance (comparatively to the population) of turf houses that are either still utilized today, are for tourism purposes, or as existing and deteriorating reminders of the past. Many residents of Stokkseyri still utilize turf today as building material for the construction of farm buildings, sheds or green roofs on their homes. In the heart of the town facing the coastline, lies a small fisherman's hut which was inaugurated in 1949, and has been preserved by the National Museum and the locals as a reminder of the towns history.[87]

Figure 53: Map of Stokkseyri showing public/ community buildings

[87] National Museum of Iceland, Fisherman's Hut sign.

Figure 54: Site facing West in the evening

Figure 55: Typical homes in Stokkseyri.

Figure 56: Abandoned turf building, Stokkseyri.

Figure 57: Site facing South- East

This location offers great potential to integrate Icelandic culture with tourism and passive design through the development of the site which sits on the Western entrance of the town. In the pursuit of the deep relationship between the Icelandic vernacular architecture of turf houses and modern building practices of passive systems, Stokkseyri has demonstrated the significance of the turf house tradition in the small town, and provides an optimal site location facing the coast, for this thesis project (Figures 54-57).

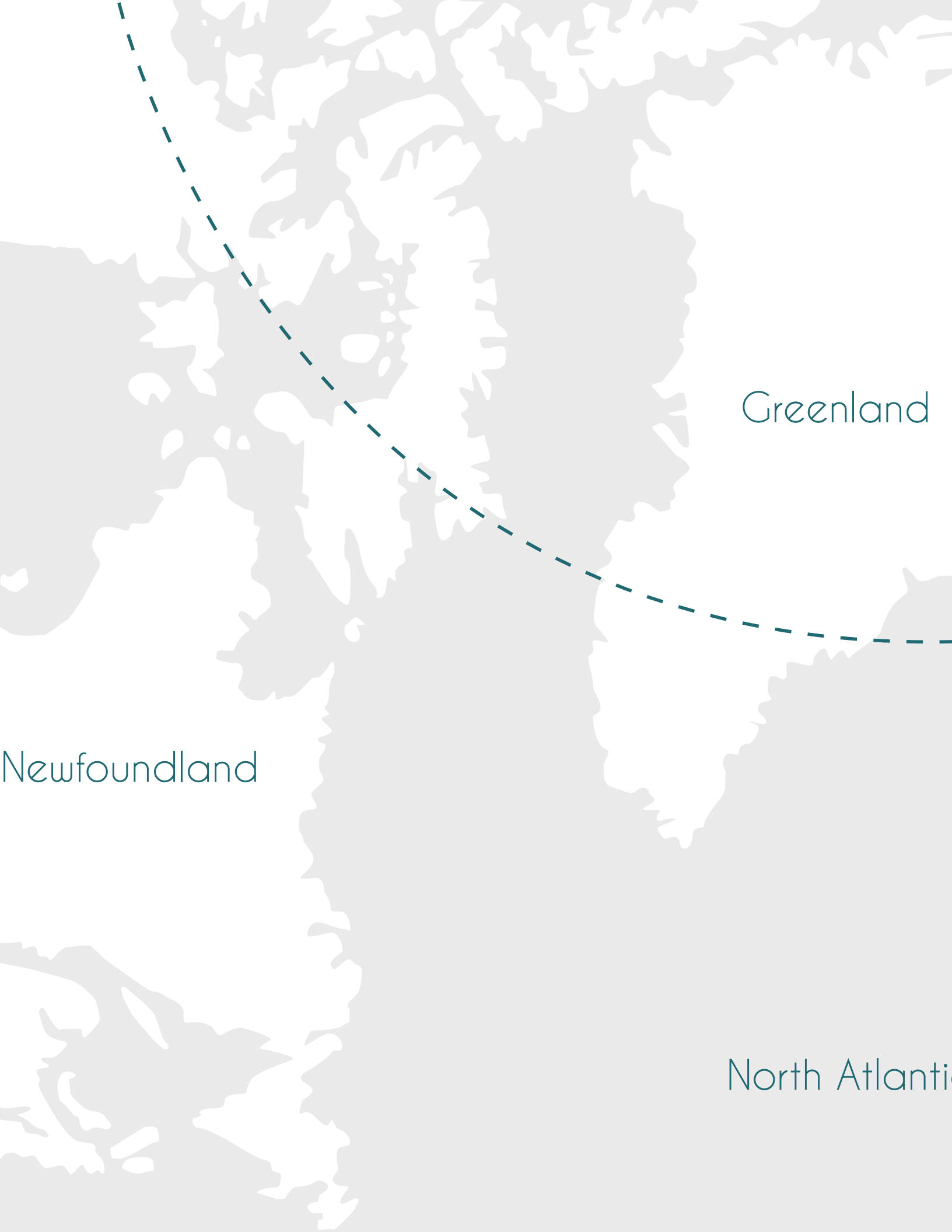

Greenland
Newfoundland
North Atlanti

Figure 58: Map of the North World

3.2 Site Analysis

Taking into consideration many factors for the site location including relevance, material use, cultural significance, and weather elements, one point of contention comes from truly defining the climate conditions that Iceland faces year round. The issue with the terms North and Winter are that they suggest locations of the world that lie above the 66 degree line, locations which are assumed to have copious amounts of snow accumulation, have a hindered mobility in the winter, and where the temperature during the winter months sits around -30 degrees Celsius.[88] Iceland's average annual temperate is approximately 5 degrees Celsius, and deals with a milder snow accumulation. However, Iceland does have extreme winds, rain and ice, blowing snow conditions, and poor mobility throughout the estimated seven months of winter (Figure 59 and 60).[89] Locals in Iceland often associate their climate with five months of a mildly warm summer and seven months of an immense lack of sunlight and extremely violent weather systems.[90] Due to the varying conditions between Iceland's local climate and that of say Northern Canada, the best term to describe Iceland's climate for the purpose of this thesis is "Cold". This term will represent the conditions outlined above that Icelanders experience during their dark winter, and will help to negate other perceptions of what the location's climate is on this isolated island country.

[88] Pressman, *Northern Cityscape*, 15.
[89] Ibid., 29.
[90] Ibid., 29.

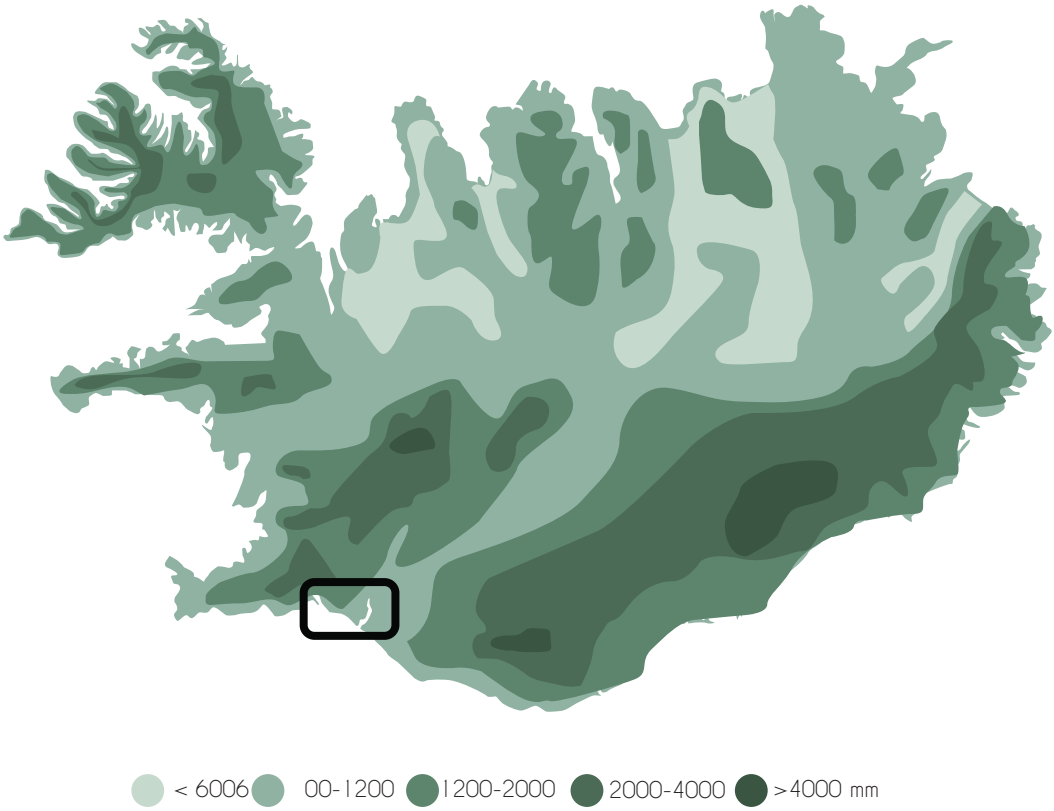


Figure 59: Annual Precipitation Map of Iceland

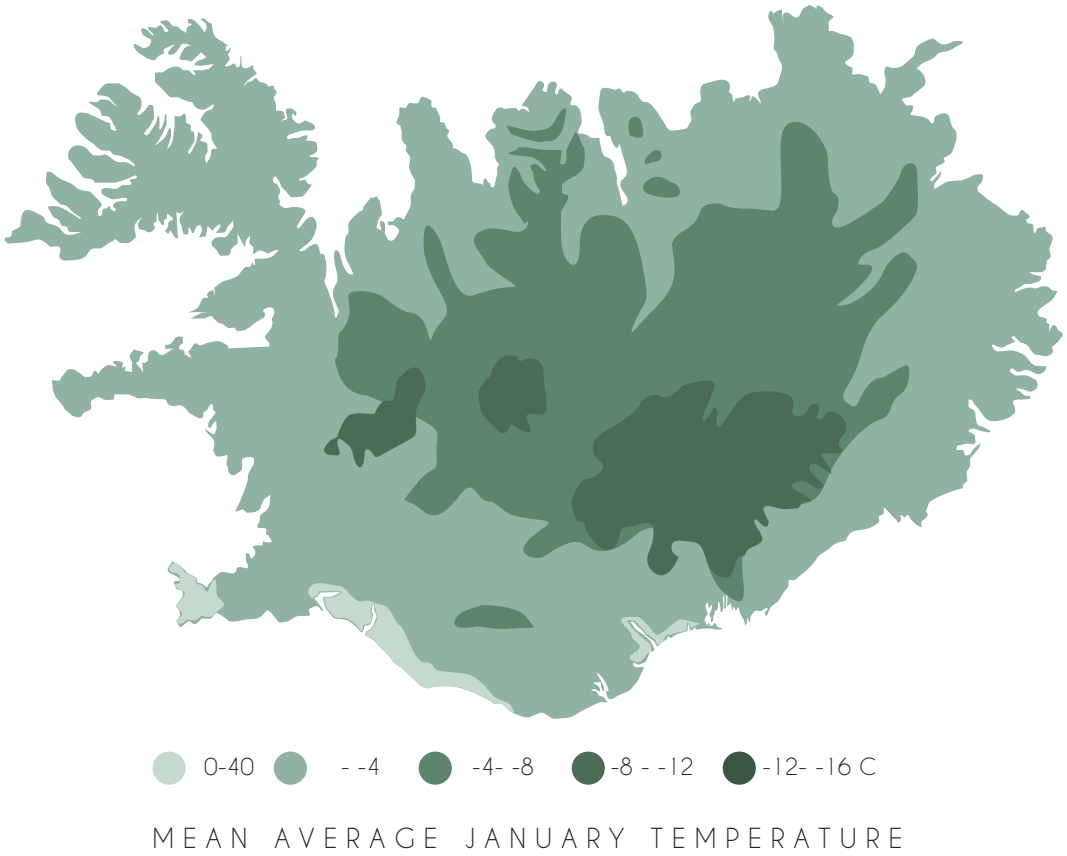


Figure 60: Mean Average January Temperature in Iceland

As part of the investigation into the Iceland's climate and local environmental conditions, wind, sun, and precipitation calculative studies were conducted. The characterisitics of the site itself are very flat with an 8-10' lava stone berm positioned along the South of the site. The site is positioned well in terms of the other public buildings, as the residential areas are mainly on the North side of the main street and the larger public or tourism buildings sit along the South side of the street. The use of a wind rose which produces rays of data representing the kilometers per hour the wind is blowing, in the specified direction, allowed for a better understanding of the forces acting on the site. This data was then translated into a model that communicates visually the wind's direction on the site and the surrounding buildings (Refer to Appendix E: Models) (Figure 61 and 62). To further inform the site conditions and develop a better understanding of the summer and winter sun availible, a sun study was conducted through the use of a sun calculator. Although Iceland typically experiences very little sunlight during the winter months in the highland regions, the South and South-East coasts do experience some sunlight which is optimized in the overall design. Considerations for the design which originated from the sun study include orienting the hotel glazing to the East and South for maximum sunlight and warmth throughout the morning and early afternoon, neglecting the West facade of windows due to the low angle of the sun in the late afternoon becoming a visual nuisance, and providing ample wall insulation in the North direction as it will receive the least amount of sun year round.

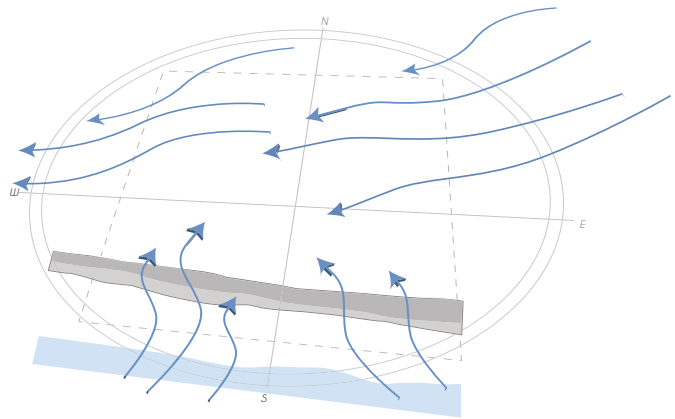


Figure 61: Wind mapping site diagram.

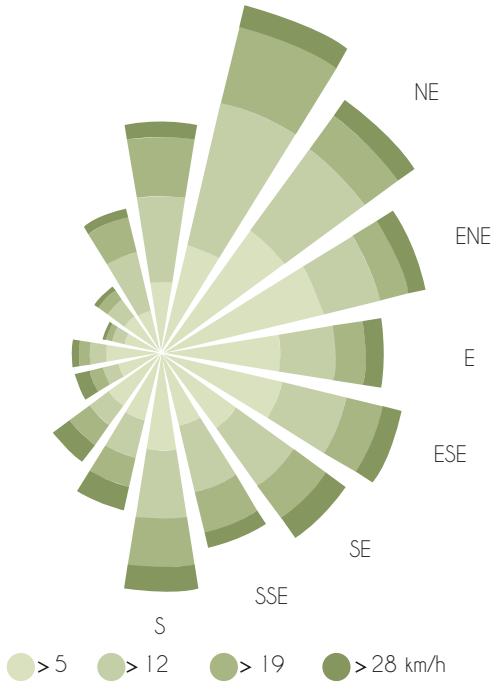


Figure 62: Wind rose representing direction and force of wind in Iceland average.

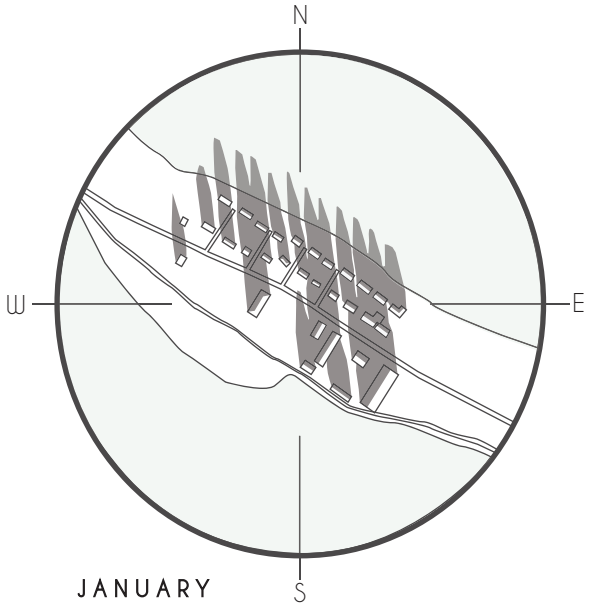


Figure 63: January sun diagram, Stokkseyri site.

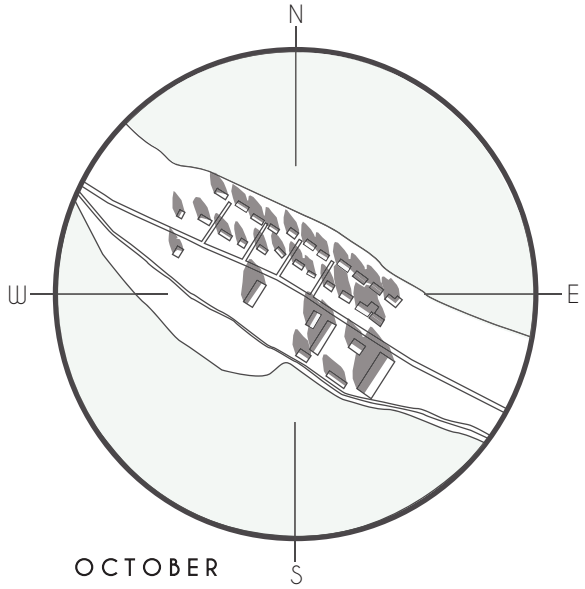


Figure 64: October sun diagram, Stokkseyri site.

Figure 65: Site map in Stokkseyri, Iceland

3.3 Program Development

Since the thesis focus on Icelandic Turf as a primitive building typology in cold climate regions, and study variations of turf buildings, the program for the project aims at reflecting the lifestyle and cultural activities surrounding the turf house tradition. The program consists of a mixed-use complex including a farmer's market, an hotel and a greenhouse, which focus on pushing principles of environmental, cultural and food sustainability. This program emerged through the farmstead building typology study conducted to analyze spatial use between different categories of turf buildings (Figure 66). Through the comparative analysis of spaces completed in the initial research stage, it was determined that, across the different turf farmsteads studied, there were three main common spaces: the sleeping and living quarters, the farm buildings and the central hearth designed as a gathering space for cooking and spending time together (see section 2.2 for more details). These three mains spaces inspired the main elements of program to pursue in a modern interpretation of turf house culture.

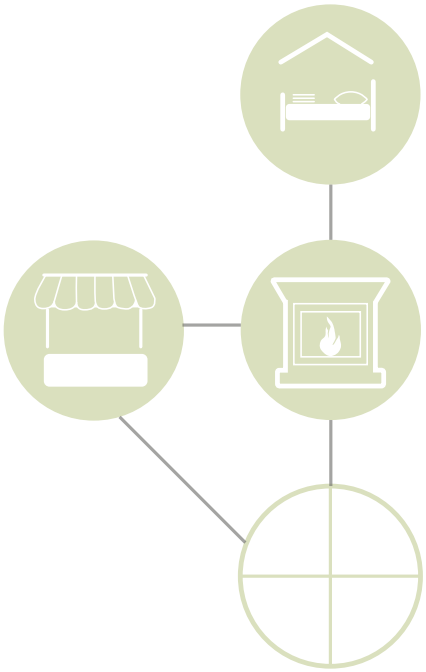


Figure 66: Three key spaces- Market - Central Gathering - Hotel

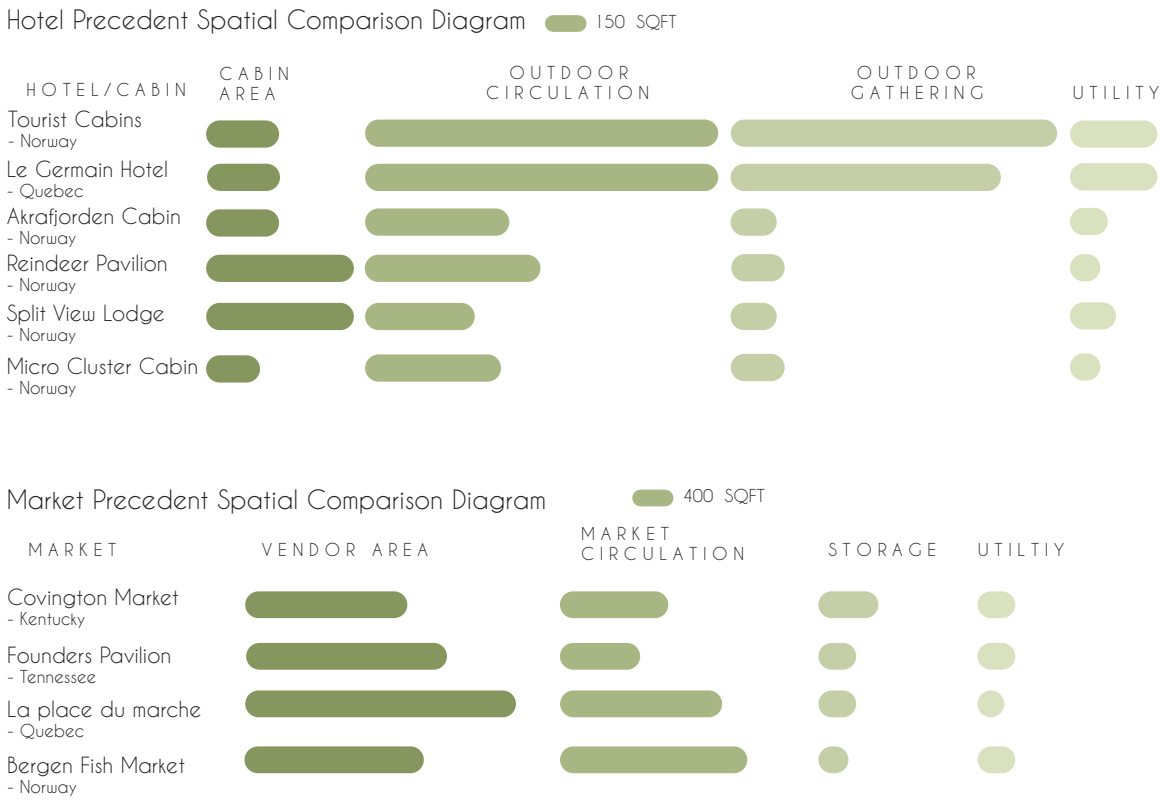


Figure 67: Hotel and Market Spatial Comparison Diagrams

As part of the initial research into the spatial requirements necessary to bring these key elements together, several case studies of hotels and markets were looked at to compare square footage and determine the areas necessary for this project (Figure 67). A detailed version of this is available in Appendix A+B. The conclusion of the case study comparisons allowed me to begin developing space relationship diagrams that could represent the relationship between spaces and their square footages, and to organize the final programming as part of the schematic design (Figure 68).

The hotel portion of the programming consists of two cabin styles representing the experience of turf house living with a modern level of comfort, providing one larger cabin to accommodate larger groups or families, and one smaller cabin to accommodate couples or small families. The Farmers Market programming plays with the indoor and outdoor relationships of turf buildings by creating a protected outdoor area from the elements. With an area for six outdoor vendor stalls, as well as an indoor platform to accommodate four more permanent vendor stalls, the total market provides an area for ten vendors to meet different production needs for a comfortable indoor/outdoor market

experience.Additional spaces necessary to achieve the hotel program are the utility rooms such as mechanical and electrical room, hotel storage, laundry, utility, and staff room (Figure 69).

Overall, through the organization of these three main spaces, the goal of this program is to create a lively public space to support interactions between locals and tourists, contribute to the economic sustainability of the community through both touristic and agricultural activities, as well as to provide food sustainability in this small town.

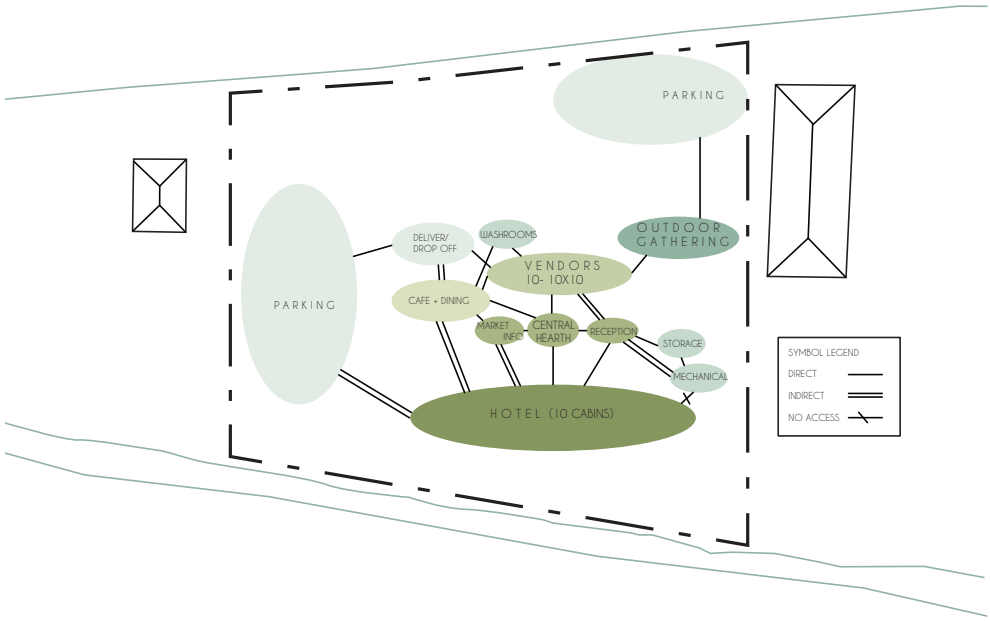
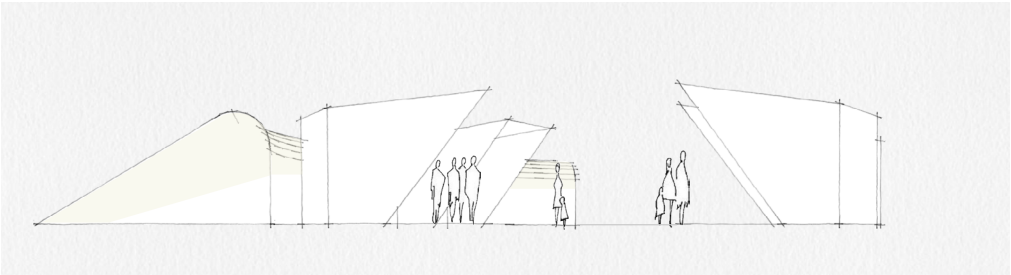


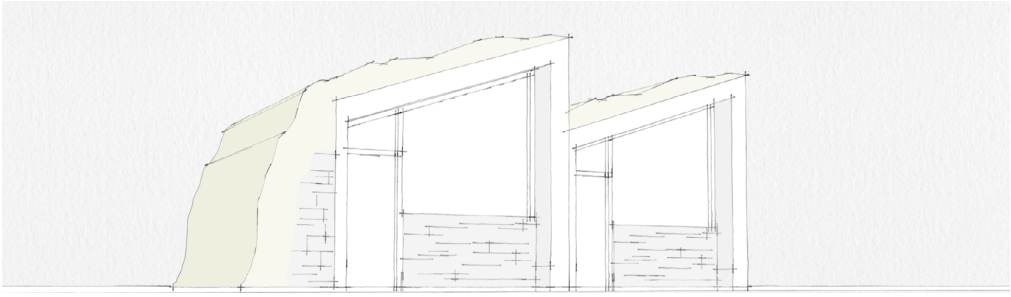
Figure 68: Initial space relationship diagram representing the relationships between spaces.

Figure 69: Intial Concept images representing the three main spaces



Farmers market example, integrating the berm as part of the vendor structure for protection.

Central Fire/ Reception area, using local materials to represent place and create a central lounge for social interaction.



Cabin example, utilizing local materials in a modern interpretation of turf houses.

Chapter 4

4. The Turf House Complex

The last chapter of this thesis presents the final project, a mixed-used complex that combines tourism and food production through a public market, a greenhouse and an hotel (Figure 70). Firstly, the building climate analysis section presents information about the different wind and sun patterns throughout the year and how the building responds to these changes. The building program section describes in detail the spatial requirements of each function of the building, as well as a description of the building's parti, circulation, and building analysis to provide a clear visual understanding of the habitation of the whole complex. Finally, the material selection part of this chapter addresses the use of rammed earth as a sustainable building material in its role as a custom designed block used in the construction of various feature walls throughout the project's design. Overall, the final chapter of this thesis provides detailed insight into the project, from the context of habitation and activity to the wall construction details.

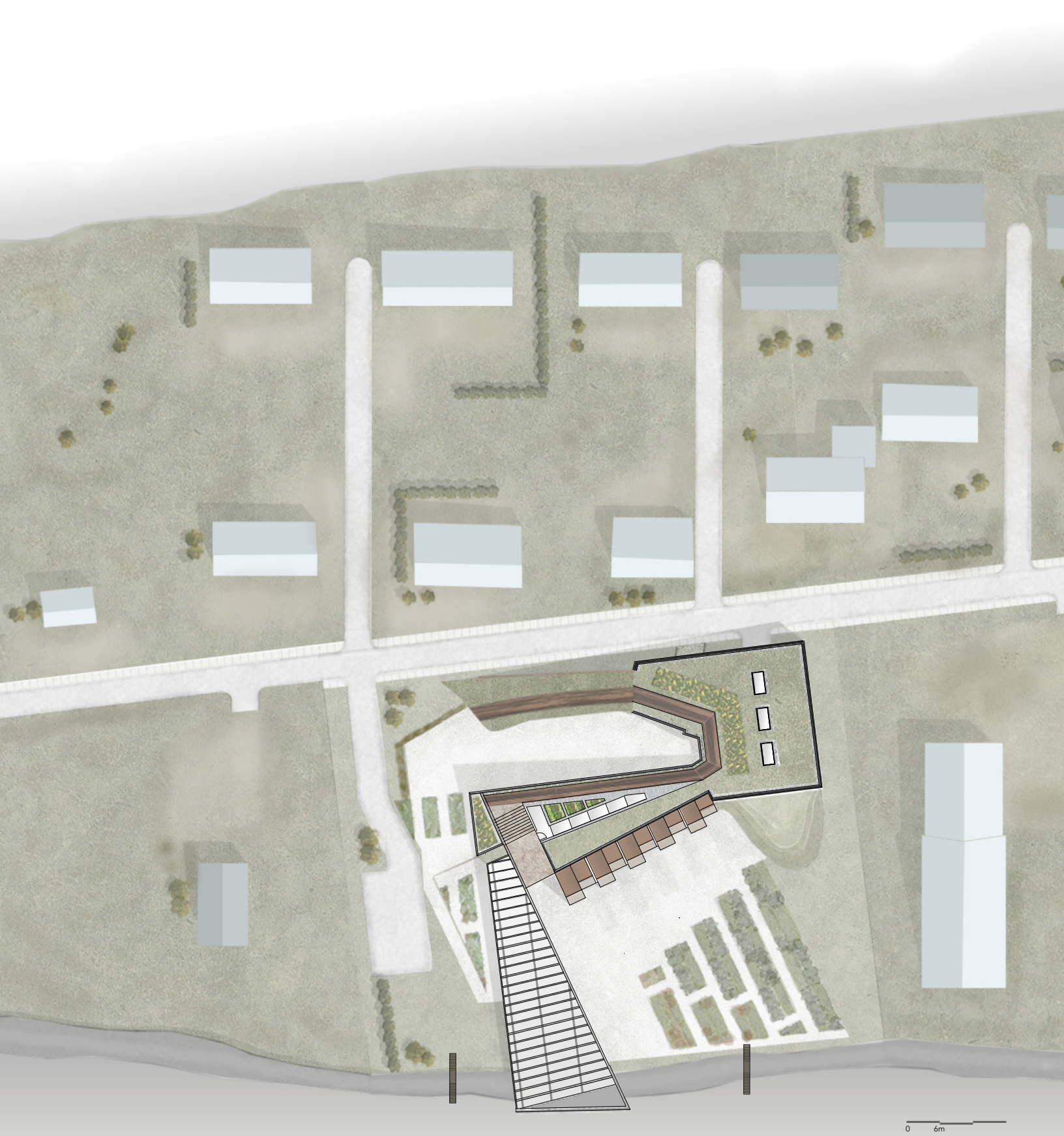


Figure 70: Final Project Site/ Roof Plan

4.1 At the Scale of the Site: Designing a Topography

One of my inital objectives for this thesis was to develop a building that people could really interact with, the notion of walking on or inhabiting the whole building and site was an experience that I wanted to achieve. This flat site in Stokkseyi that is completely covered in turf gave me the opportunity to really develop it and design with these objective in mind. The parti of my building plays off of these objectives, and in researching construction methods of turf, my parti developed as this gesture of lifting a thick layer of turf out of the ground as if you were collecting the slabs to construct a turf house.

This one move really began to align with those experiential objectives, first of all, this lifting motion gave me this gentle slope which I could utilize for an experiential path up to the top of the building (Figure 71). This large corner curve on the North- East part of the site originated from the wind analysis which allowed me to use this large mass of building to create a comfortable micro-climate for public space as well as optimizing sun for the main functions of the building.

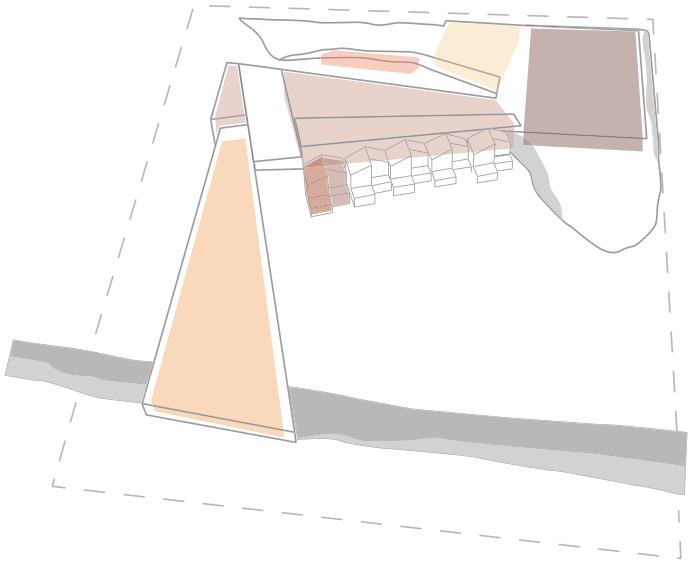


Figure 71: Building Program Diagram

The sun analysis conducted during the building design process concluded that during the winter months due to the low position of the sun, some of the main programming that requires direct sunlight such as the greenhouse and the cabins, would need to be positioned facing South. The location of the greenhouse facing linearly North- South, will allow for the optimization of sunlight throughout the year (Figure 72). The shape of the building particularly the outdoor Farmer's Market space and cafe public area allows the sun to reach this populated area throughout the day particularly during the late morning and late afternoon when temperatures are typically lower as shown in the Summer Site Analysis diagrams (Figure 73).

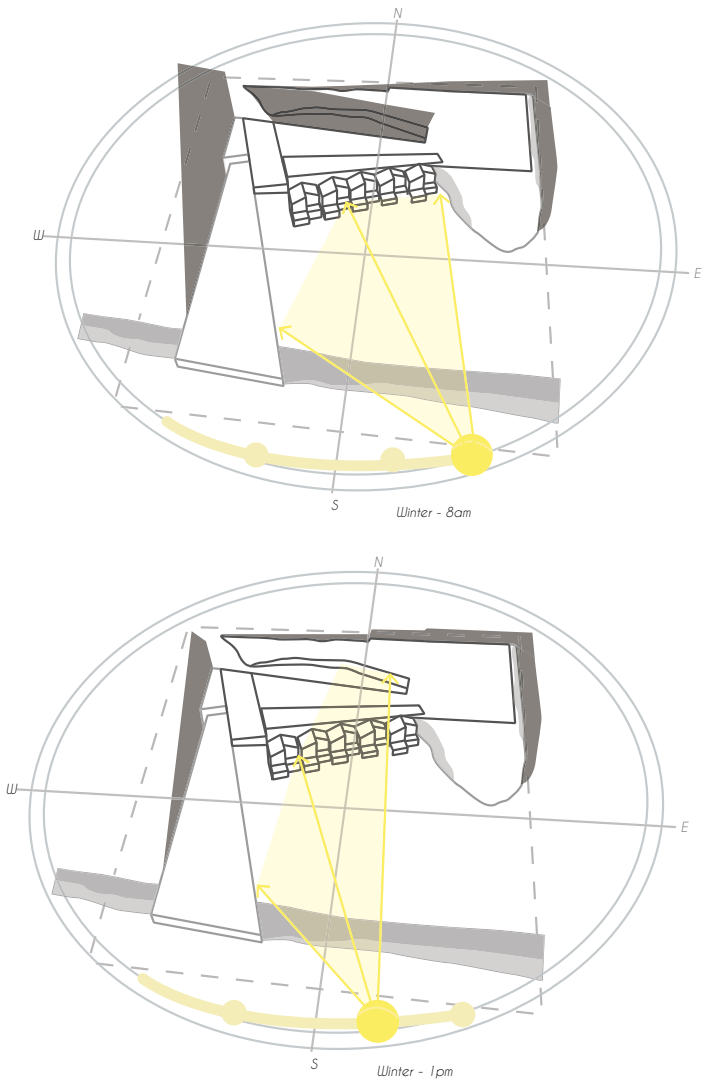


Figure 72: Winter Site Analysis

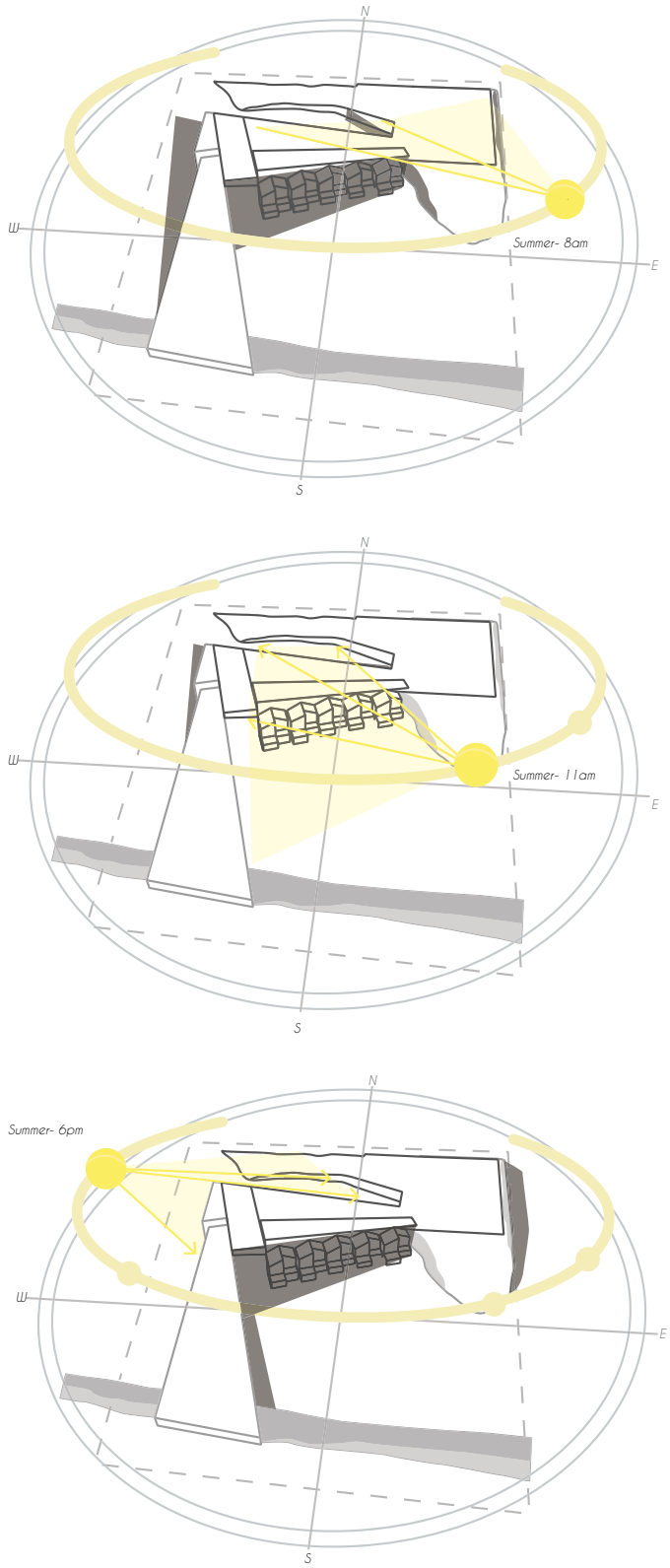


Figure 73: Summer Site Analysis

The wind analysis completed prior to the building's design development, concluded that the winds from the North-East corner of the site are the most dominant winds, therefore allowing myself to begin developing solutions such as berms, topography or using a portion of the building to protect an outdoor area from that dominant wind (Figure 74). Through the design of the building, I was able to use the parking structure portion of the building to protect the outdoor market, as well as take advantage of the sites existing berm along the coast to create a protected private outdoor area for the hotel guests along the South-East of the site. The position of the greenhouse sitting linearly North-South protects the West side of the building programming from harsh winds and environmental elements protecting the circulation and planted areas positioned on the West side of the greenhouse (Figure 75).

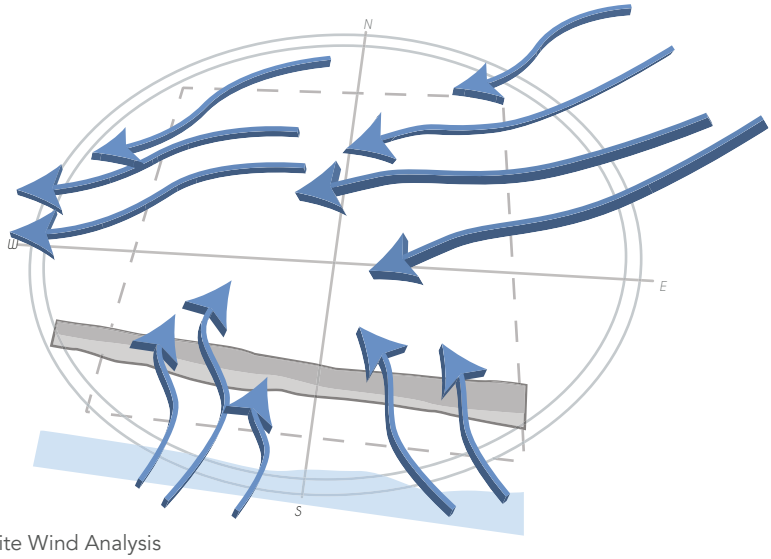


Figure 74: Site Wind Analysis

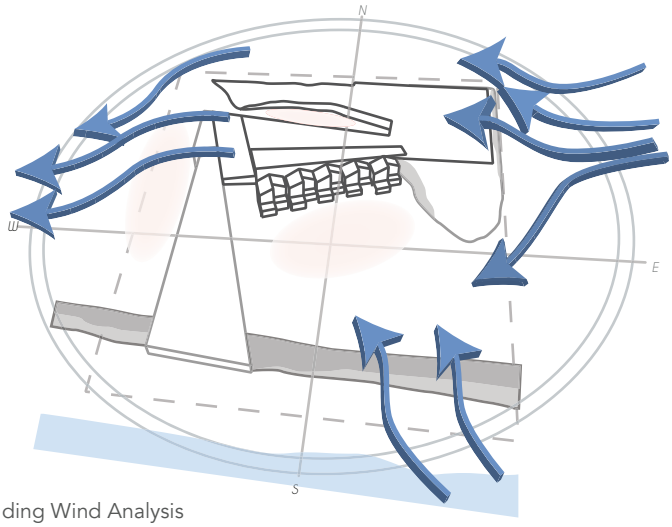
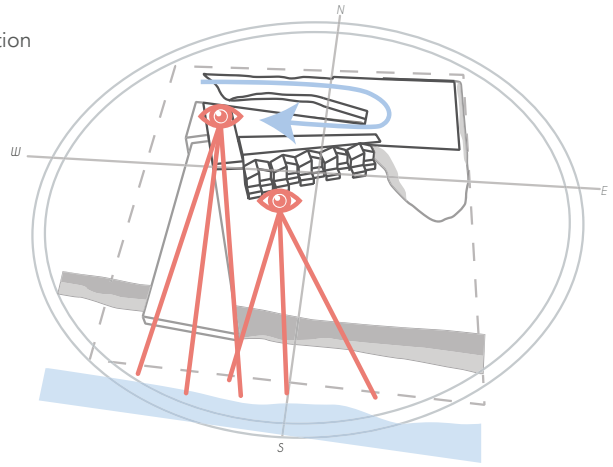


Figure 75: Building Wind Analysis

To experience the whole building and the site, as a guest you begin your experience at ground level and begin by walking up the path near the North entrance of the site. The path brings you up around the outdoor market vendors and over the cafe and then above the parking structure to an area of planted local berries and vegetation for harvesting including blueberries, arctic thyme, bramberries, rubarb, and lupines. This curved gesture in the North-East corner which protects the outdoor market and public space from dominant winds also allowed me to take advantage of the large mass and hide elements of the programming under the green roof such as the parking structure and mechanical room.

As you continue up the slope of the main building, you walk along the extensive green roof system up to the main viewing platform where you can eat your lunch from the market, rest and take in the view of the ocean as well as the entire sites food production (Figure 76). As a tourist just stopping by or as a local going for a walk, this green roof path gives the guest a real sense of all of the different programmatic elements which contribute to the environmental and cultural sustainability of the site. From the viewing platform you can either take the staircase down into the centre of the main reception building, or travel back down the path to ground level. Once at ground level you can continue the path by descending down to the path to the entrance of the reception, greenhouse and cabins, which sits four feet down into the ground. When you head down the path to the main building you would feel this large

Figure 76: Building Orientation Diagram



mass of building sitting above you which is a very similar experience one would have of entering a traditional turf house. The cabins also sit four feet into the ground again creating that experience of entering turf houses, however once inside guests can go up to the loft of their cabins which brings you above the level of the sites existing berm to provide guests with an ocean view from their cabin (Figure 77).

Figure 77: Final Project Floor Plan

4.2 At the Scale of the Building: Key Programming

The key programmatic elements for my thesis are derived from the comparison of spatial syntax maps completed of the turf farmstead buildings studied in Chapter 2. The conclusion of that comparison led to the three key spaces of turf farmsteads, the living and sleeping spaces, the farming buildings, and the central hearth or gathering space. These spaces have translated into my final programs organization which includes a farmer's market, hotel, and a greenhouse which seeks to address issues of environmental and cultural sustainability in the cold climate region of Southern Iceland (Figure 78). This section explores these three key programming elements to understand in detail the function and design of the public life programming which addresses the microclimates created for the social spaces, the food production programming, looks at food sustainability addressing issues of food security in cold harsh climates, as well as the eco-tourism element, which implements existing and new solutions to tackle issues of environmental sustainability within the tourism industry.

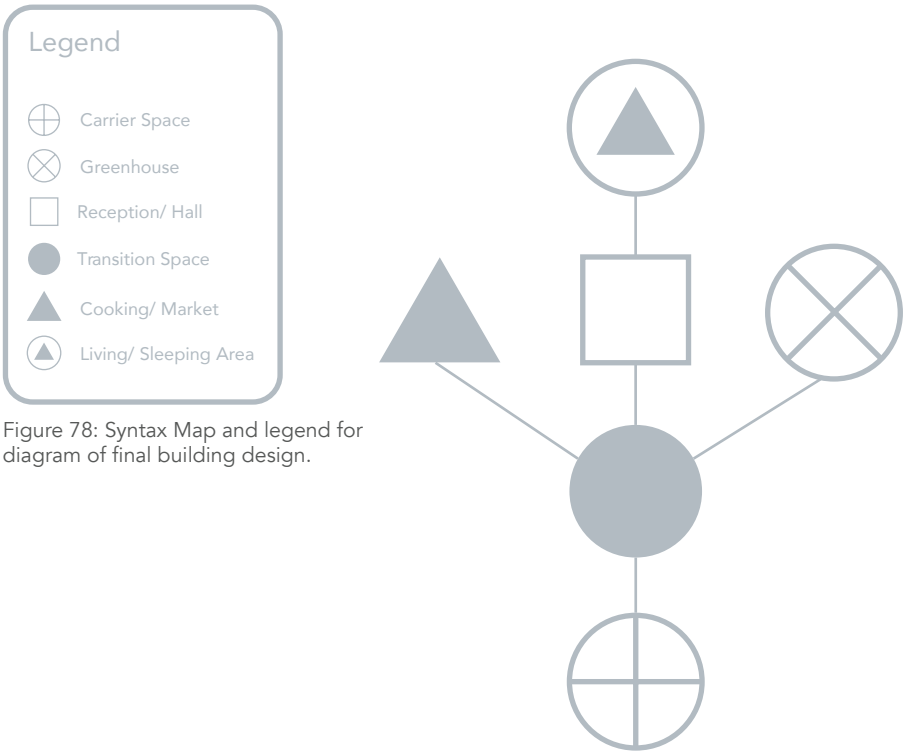


Figure 78: Syntax Map and legend for diagram of final building design.

4.2.1 Public Life

The Public Life programming of the project refers to the gathering space or central hearth element of the spatial syntax comparison completed as part of the initial turf farmstead research. The design plays with the indoor / outdoor relationships of turf building by creating protected areas from the harsh climate for a comfortable outdoor market experience. The cafe, as well as the indoor and outdoor market vendor spaces, create a central outdoor gathering space for both tourists and locals to become social and have interactions that positively support both the towns own economic status as well as increasing tourism in the small town of Stokkseyri (Figure 79). The cafe is the public façade of the building, with views to both sides of the site including addressing the street to draw both locals and tourists alike into the market vendor area.

Figure 79: View of Outdoor Market, Cafe, Greenhouse, and experiential path.

4.2.2 Food Production

The food production aspect of the programming speaks to the farm buildings element of the initial spatial diagram, as one of the objectives of this thesis is to implement environmental strategies within the built environment, therefore one important aspect of this program is sustainable food production and consumption with minimal impact on the environment. These programmatic elements consist of the greenhouse, planted areas of local berries and vegetation, as well as the cafe serving food directly from the site, enforcing the sustainable practice of farm to table (Figure 80). Greenhouses are very popular and widely used particularly in Southern Iceland, as it is hard to grow a variety of fruits and vegetables in their harsh climate. As well as providing food sustainability for the residents, all greenhouses in Iceland take advantage of the local geothermal resource to heat and provide energy for the production, therefore the greenhouse program for this thesis follows suit making the food production environmentally sustainable as part of this sustainable complex. The greenhouse is a public area of the building, and is positioned to help create privacy in the hotel courtyard, and provide people with access to the other side of the berm. The end of the greenhouse cuts through the berm and a thick glass window provides a view of the ocean and its varying water levels.

Figure 80: Interior Market and Reception View

4.2.3 Eco-Toursim

The hotel portion of the programming consists of two cabin styles representing the experience of turf house living with a modern level of comfort. Along with sustainable food production, the hotel portion of my program addresses several issues of sustainability within tourism. On the detail scale of the building design, the cabins utilize the grey water from the rainwater collection system on site to provide water for the toilets in the cabins and the main reception washrooms, as well as utilizing grey water for the cabins laundry facility. In the context of the town, there are only ten cabins in this program which means that the small population in Stokkseyri can sustain the limited number of cabins. The cabins also contribute to sustaining the town's own tourism through attracting people with lodging, food and a unique tourist activity expressing the turf house tradition, along with the other museum, culture house, and seafood restaurant, these programs contribute to maintaining the communities permanence (Figure 81). Each cabin is designed on two floors, the first floor with a kitchenette, washroom, and small living area, and the second level designed as a sleeping area, each with a semi-private terrace and clear views of the ocean. The hotel guests also have access to the semi-private courtyard, positioned between the cabins, berm and greenhouse, filled with planted area of local vegetation.

Figure 81: View of cabins and private courtyard in winter

4.3 At the Scale of the Material: Rammed Earth Exploration

A defining aspect of this thesis is exploring the material culture of Icelandic turf, through principles laid out in the exploration of vernacular architecture. There are many approaches to categorizing vernacular buildings, whether based on form, roof slope or location. However, the specific materials are a significant category on its own, speaking about place, climate factors, and building traditions. Icelandic turf as a building material is culturally significant in many ways, through methods of cutting, removing the turf from the ground, its varying methods of stacking, as well as its flexibility as an insulator and structural component. A defining cultural feature of my thesis design is the construction of the custom modular rammed earth blocks. The block designed specifically for this thesis is shaped similarly to a parallelogram, resembling the traditional herringbone pattern found in the turf stacking of end walls of traditional turf houses (Figure 82). This modular block is used throughout the design of my building in two different capacities, the first is as a retaining wall along the street façade, and the second is as part of the exterior wall assembly of the main reception building and market building. The block is constructed of rammed earth to closer resemble the visua aesthetic of earth, as well as to introduce a more sustainable construction material as opposed to concrete or brick.

Figure 82: Custom Rammed Earth Block

Although the method of rammed earth construction is not new, the method of using rammed earth in a modular capacity is becoming popular across Europe as well as in hot and humid climates for its ease of construction and layered aesthetics. One interesting example studied for the development of this custom modular block is the Ricola Factory in Switzerland. Using a mixture of clay and soils from the local mine and queries, this building was constructed of prefabricated blocks stacked to complete the exterior walls, with an interior concrete structure (Figure 83).[91]

Figure 83: Ricola Factory Construction & Completion - Aguilar, Cristian. "*Ricola Kräuterzentrum / Herzog & De Meuron.*" ArchDaily. May 28, 2015.

Another example is the Visitors' Centre at the Swiss Ornithological Institute, completed in 2015 by MLZD architects. The building's self-supporting outer shell is comprised of solid walls made of rammed earth.[92] With the addition of simple timber construction, the building meets the targeted sustainable values as part of the initial concept (Figure 84).

Figure 84: Interior & Exterior of the Visitor Centre at the Swiss Ornithological Insitute- Valenzuela, Karen. "*Visitor Centre at the Swiss Ornithological Institute* / :mlzd." ArchDaily. June 25, 2015.

[91] Aguilar, Cristian. "Ricola Kräuterzentrum / Herzog & De Meuron." ArchDaily. May 28, 2015.
[92] Valenzuela, Karen. "Visitor Centre at the Swiss Ornithological Institute / :mlzd." ArchDaily. June 25, 2015.

A final example of the use of modular rammed earth is the Archeological Heritage Interpretation Centre, designed by nunc architects in Dehlingen, France. Completed in 2014, this building uses a modular stacking method of rammed earth blocks for a double rammed earth self-supporting exterior wall combined with light timber construction for the roof and exterior glazing (Figure 85).[93]

Figure 85: Construction & Completed Interpretation Centre. Gauzin-Müller, Dominique, *Architecture en Terre D'Aujourd'hui.* Museo / CRAterre *en partenariat avec amàco, 2019. 46.*

For the purpose of this thesis project, my design intentions for the block was to develop a construction that both visually and thermally represented turf. Therefore, initially, I explored developing a concrete block with the same shape, however using a combination of organic materials such as straw and organic carbonatite to air entrain the concrete and give it a greater thermal mass to match that of traditional Icelandic turf (Figure 86). Through this exploration, however, it became clear that the process of making concrete and is very unsustainable no matter how I tried to improve it, which was the turning point in exploring other earth materials for this block. The rammed earth concept really began to align much more clearly with the sustainable objectives placed on this thesis,

Figure 86: Construction of Rammed Earth Block

[93] Gauzin-Müller, Dominique, *Architecture en Terre D'Aujourd'hui.* Museo / CRAterre *en partenariat avec amàco, 2019. 46.*

and from this point, I began experimenting different combinations of clay, sand and crushed rock to develop this rammed earth block (Figure 87). The base for the rammed earth recipe originated from a previous student project, and I adjusted the proportions to develop the block. For the purpose of this project, I developed a 1:5 scale wall construction using a final recipe of:

1 Part Clay
1 Part Pink Crusher Dust
1 Part Sand
1 Part Portland Cement
1/2 Part Sisal Fibres
1/4 Part Water

Figure 87: Construction of Rammed Earth Block

This recipe was then individually tampered into plywood forms and set to dry out over the course of three days. Although this recipe for the purpose of this small scale model does contain 1 part portland cement, further experimentation is possible to develop a full-scale block that neglects the use of cement all together as seen in the project examples. Overall, one of the main objectives of my thesis is to seek new solutions for environmental and cultural sustainability through principles found within vernacular architecture, therefore the custom modular rammed earth block acts as one potential solution to addressing these issues within the cold climate region of Iceland (Figure 88).

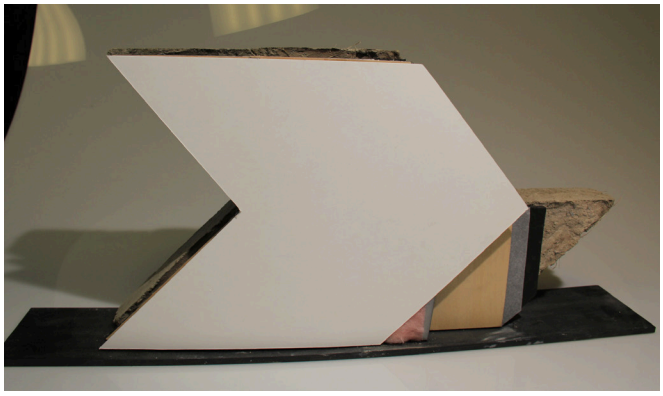


Figure 88: Final Rammed Earth Block Model Wall Construction

Conclusion

Overall, the goal of this thesis was to investigate principles found in the study of vernacular architecture in cold climates, to develop strategies for improved environmental and cultural sustainability in cold climate regions of the world. Through research into vernacular architecture studies, this thesis aimed at investigating the building typology of Icelandic Turf Houses to develop a series of informed architectural strategies for cold climates, specifically in Southern Iceland. As discussed in the conceptual framework of this thesis, key aspects of this research on vernacular architecture include 1) well-tempered environments and passive design, which informed wall systems and building massing and program orientation, 2) the material culture, also informing wall systems including the material selection, and assemblies and developed patterns and 3) the spatial interpretations of traditional turf farmsteads' logic of space to inform program organization and layout. Through the use of different methods of analysis such as wind patterns, sun studies, comparison of spaces, as well as research into traditions and cultural activities, this research contributed to a well-informed design addressing specific issues of sustainability. The final project, the Turf House Complex, is a result of this research on and experimentation with the principles found in traditional vernacular buildings in cold climates, specifically Icelandic Turf houses.

This thesis acts as an example of translating principles of vernacular architecture in cold climates into contemporary architecture. This also allowed me to go further and speculate on the future endeavours of some of these principles. The rammed earth block, for example, has the potential to be further developed into a larger modular system that could be used for the entire wall composition compared to the current application in this thesis, which is as an exterior cladding and retaining wall. The use of this material for the full wall however, would potentially require a framework for a group of the modules to be contained in to increase its structural stability. If the continued use of this material was as a full wall system, a structural member would be necessary for this project to run under the rammed earth facade above the curtain wall, to support it structurally. One of the greatest challenges in designing for climates such as Iceland's is dealing with long cold winters, and extreme winds. Therefore, although the use of rammed earth is not a typical method in Iceland, this modular block wall composition looked

at addressing these climate factors by being a natural, highly insulated wall to create comfortable indoor and outdoor spaces.

In my view, the traditional turf house was the original green roof that we see today on contemporary flat roof buildings. Today green roofs are used to create public spaces and relaxing outdoor areas that also contribute environmentally through rainwater management and thermal insulation properties. In this thesis project, I pushed this idea of using an extensive green roof as a public space, to develop an entire building that people can interact with, compared to the vernacular building in which turf is used strictly as a construction material. By exploiting the potential of green roof systems, I was able to create an interactive topography, and create micro climate conditions so that people taking advantage of the outdoor spaces will spend more time outside in Iceland. In conclusion, the Icelandic climate poses a lot of challenges for designing sustainably, with extreme cold, high winds, and very little sunlight during winter. However these challenges present opportunities now and in the future to continue addressing issues of both environmental and cultural sustainability within the built environment, particularly in cold climate regions of the world.

Appendix A - Market Case Studies

To begin to understanding the funtional requirements of a farmer's market program, various permanent market structures and pavilions were analyzed to determine different spatial organizations of markets.

Covington Market, Kentucky

The first case study is the Covington Market, a prefabricated outdoor pavilion developed as part of a design/ build project by third year Virginia Tech students.[92] The project sourced only locally availible and reclaimed materials as well as focusing their efforts on rainwater collection for the pavilions washroom facilities.

Figure 89: Covington Market- Meinhold, Bridgette. "*VA Tech Architecture Students Complete Prefabricated Covington Farmer's Market.*" Inhabitat Green Design Innovation Architecture Green Building. September 08, 2011

Founder's Pavilion, Tennessee

Founder's Pavilion is a 7000 sqft outdoor covered area designed by Thomas Weems Architect in Johnson City, Tennessee.[93] The intention of the design was to reflect on the history of the site which was originally two train depots at the heart of the city.

Figure 90: Founder's Pavilion- "*Farmers Market.*" Thomas Weems Architect. http://www.thomasweemsarchitect.com/wcjc-animal-shelter-1/.

[92] Meinhold, Bridgette. "*VA Tech Architecture Students Complete Prefabricated Covington Farmer's Market.*" Inhabitat Green Design Innovation Architecture Green Building. September 08, 2011. https://inhabitat.com/va-tech-architecture-students-complete-prefabricated-covington-farmers-market/?variation=a.

[93] "*Farmers Market.*" Thomas Weems Architect. http://www.thomasweemsarchitect.com/wcjc-animal-shelter-1/.

La place du marché, Quebec

La place du marché is a proposed public market by a Master's of Architecture student from Laval University. The project's aim was to develop a permanent space for the existing Sainte-Foy market in Quebec, while addressing multiple stages of food processing and looking at the different stages from production to consumption through architectural intervention.[94]

Figure 91: Proposed public market- Plamondon, Marielle, *La place du marché Une architecture nourricière par la reconnexion avec l'agriculture,* Masters Thesis., École d'architecture de l'Université Laval Printemps 2018.

Bergen Fish Market, Norway

The Bergen Fish Market designed by Eder Biesel Arkitekter, is an enclosed market hall along the waters edge in Bergen, Norway.[95] With the market on the street level and a tourist information centre above as well as it's large variety of locally caught seafood, the fish market is a hot spot for locals and a popular tourist location.

Figure 92: Bergen fish market interior- "*Fish Market, the Norwegian Way.*" Mr. Wolf Magazine. http://mrwolfmagazine.com/fish-market-the-norwegian-way/.

[94] Plamondon, Marielle, *La place du marché Une architecture nourricière par la reconnexion avec l'agriculture,* Masters Thesis., École d'architecture de l'Université Laval Printemps 2018.
[95] "*Fish Market, the Norwegian Way.*" Mr. Wolf Magazine. http://mrwolfmagazine.com/fish-market-the-norwegian-way/.

Appendix B - Hotel Case Studies

To provide greater insight into the spatial requirements and organization of small hotels and cabin style programs, six cabins or hotel style establishments were studied focusing on regions of Scandinavia and Quebec to position the precedents in a similar climate and cultural regions of the world.

New Tungestølen Tourist Cabin

The first case study is the New Tungestølen Tourist Cabin by Snøhetta, an ongoing development in Luster, Norway that acts as a cluster of larger cabins situated between the mountains on a plateau, that allows for the improved interaction between architecture and nature, inspiring moments of reflection and being present for the guests.

Figure 93: New Tungestølen Tourist Cabin, by Snøhetta- "*New Tungestølen Tourist Cabin.*" Snøhetta. https://snohetta.com/projects/243-new-tungestolen-tourist-cabin

La Ferme, Le Germain Hotel

The second case study is Le Germain Hotel at La Ferme, on the site of an old farm, La Ferme is a large complex of five pavilions inspired by the history of the place designed by CoArchitecture. The buildings are set up in such a way that they create functional space between them and offer a unique experience for visitors to explore the inside of the buildings as well as inhabit the entire site.[96]

Figure 94: Le Germain Hotel at La Ferme by CoArchitecture- "*Coarchitecture Le Massif - La Ferme.*" Coarchitecture. https://www.coarchitecture.com/le-massif-la-ferme.

[96] "*Hôtel Le Germain.*" Official Site - Le Germain Hotel Calgary | Downtown Luxury. https://www.legermainhotels.com/en/charlevoix/bedrooms/#compare

Åkrafjorden Cabin

Åkrafjorden Cabin is a small hunting shelter in Etne, Hordaland, Norway which acts a landscape integrated case study for the purpose of this thesis. The integration of this building into the landscape is an essential element of the design with the surrounding characteristics of the terrain being short grasses, heather, and rocks, which dictate the orientation and shape of the built form.[97]

Figure 95: Åkrafjorden Cabin by Snøhetta "*Bjellandsbu - Åkrafjorden Cabin.*" Snøhetta. https://snohetta.com/projects/180-bjellandsbu-akrafjorden-cabin

Tverrfjellhytta, Norwegian Wild Reindeer Pavilion

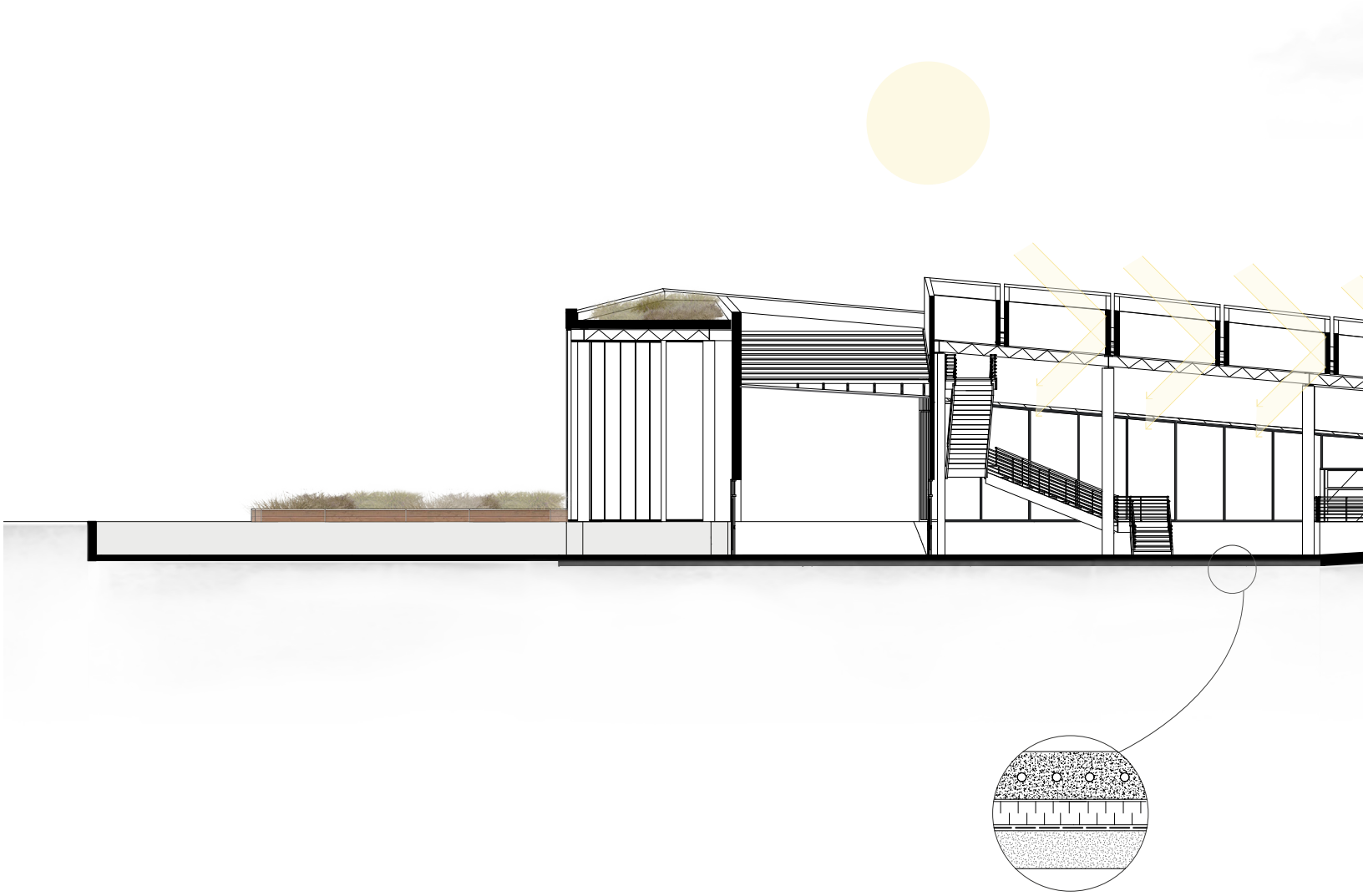
The Reindeer Pavilion in Hjerkinn, Dovre, Norway, while not specifically a cabin or hotel, is an excellent example of a gathering space surrounding a central fire which acts as an observation area to view wild reindeer. The interior of this design uses expertly carved wood for comfortable seating and viewing area, while a black steel fire is suspended from the ceiling, providing unobstructed views to the surrounding terrain.[98]

Figure 96: Tverrfjellhytta, Norwegian Wild Reindeer Pavilion by Snøhetta–"*Tverrfjellhytta, Norwegian Wild Reindeer Pavilion.*" Snøhetta. https://snohetta.com/projects/2-tverrfjellhytta-norwegian-wild-reindeer-pavilion.

[97] "*Bjellandsbu - Åkrafjorden Cabin.*" Snøhetta. https://snohetta.com/projects/180-bjellandsbu-akrafjorden-cabin

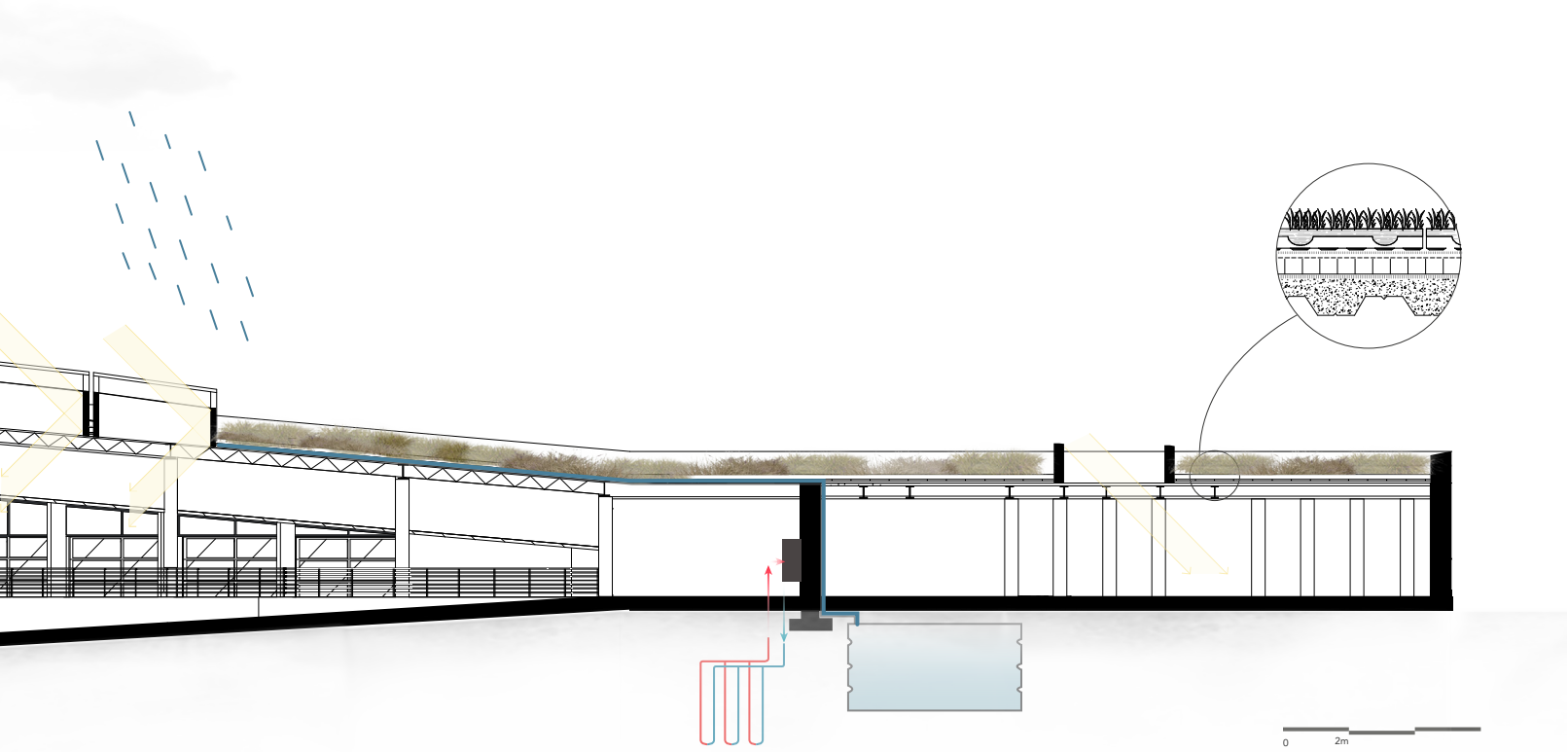
[98] "*New Tungestølen Tourist Cabin.*" Snøhetta. https://snohetta.com/projects/243-new-tungestolen-tourist-cabin

Appendix C - Construction Details & Sections



Long Section

Systems Section showing extensive green roof, geothermal in-floor heating, rainwater collection system, and the skylights bringing light down into the main building and a similar opening in the roof of the parking structure to provide light and ventilation.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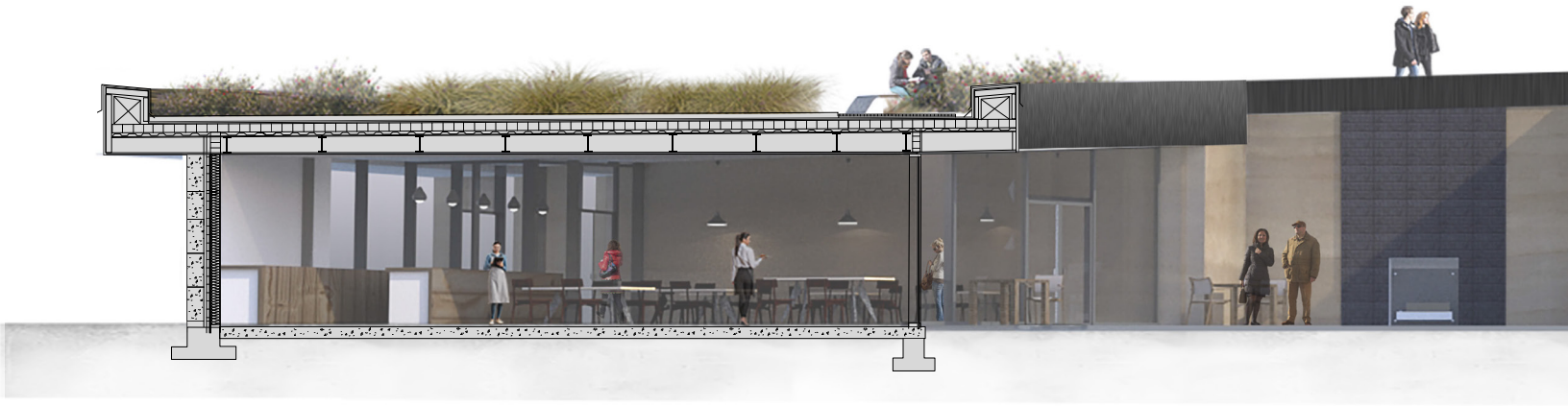

Construction and Habitation Section

This section displays the social interaction between locals and tourists through the cafe, outdoor and indoor market place, as well as the habitated path and cabins.

Rammed Earth Wall Section
Scale 1:50

This wall section is taken from the main reception building on the North Facade, showing the rammed earth modular block positioned over the curtain wall system, and supported by the steel structure.


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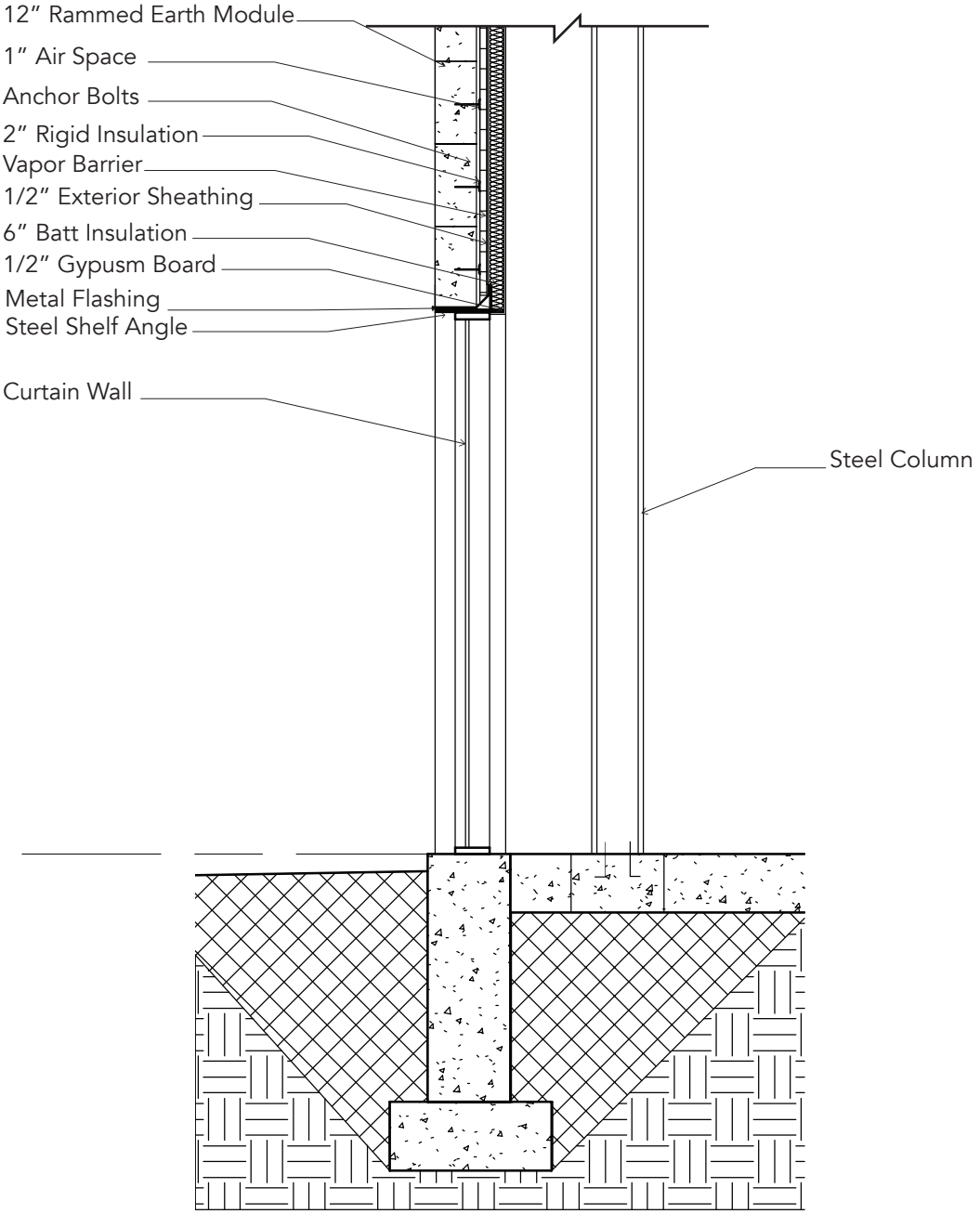
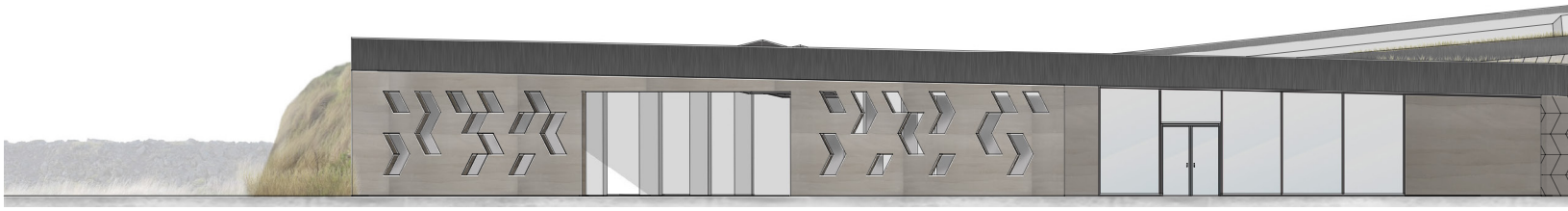

12" Rammed Earth Module
1" Air Space
Anchor Bolts
2" Rigid Insulation
Vapor Barrier
1/2" Exterior Sheathing
6" Batt Insulation
1/2" Gypusm Board
Metal Flashing
Steel Shelf Angle
Curtain Wall
Steel Column

Appendix D - Building Elevations

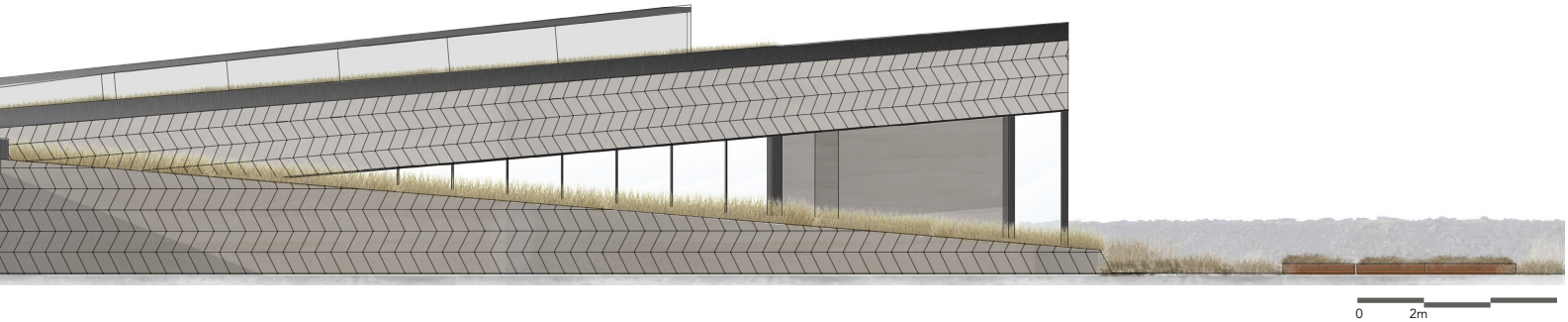


North Elevation

Showing the street view, the parking structure entrance, cafe entrance, and use of the custom rammed earth block as a retaining wall in front, and as part of the envelope beyond.

West Elevation

The West elevation highlights the Greenhouse, outdoor farmer's market and cafe gathering area, as well as the beginning of the experiential path at ground level.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South Elevation

The South Elevation highlights the cabins and viewing platform facing the ocean, with the greenhouse running along the West side of the site.


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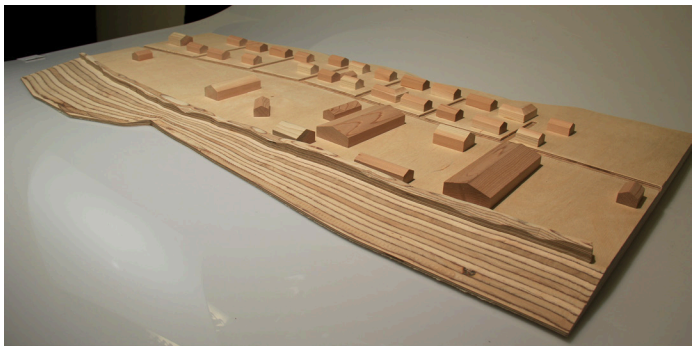
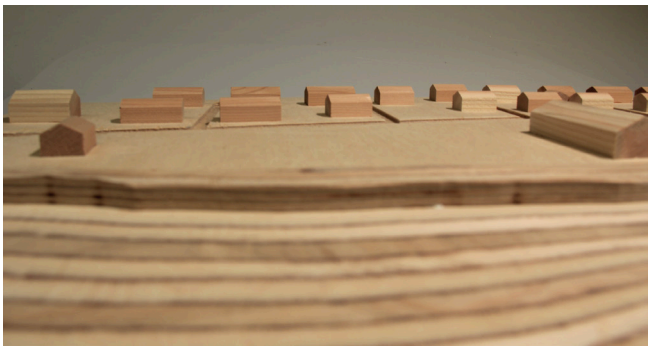
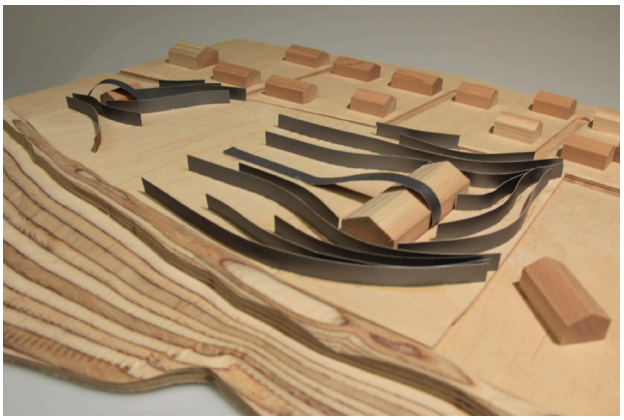
Appendix E-
Models



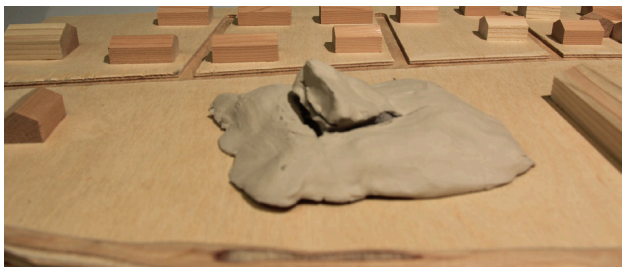


Site Model : Built at 1:500 scale, this site model shows the chosen site for this thesis project along the South Coast in Stokkseyri, as well as the closest surrounding town buildings including tourism, public and residential buildings. The model was constructed using 3/4" birch plywood, using the CNC to carve out the roadways and the gradual slope to the ocean on the South side and a river on the North.

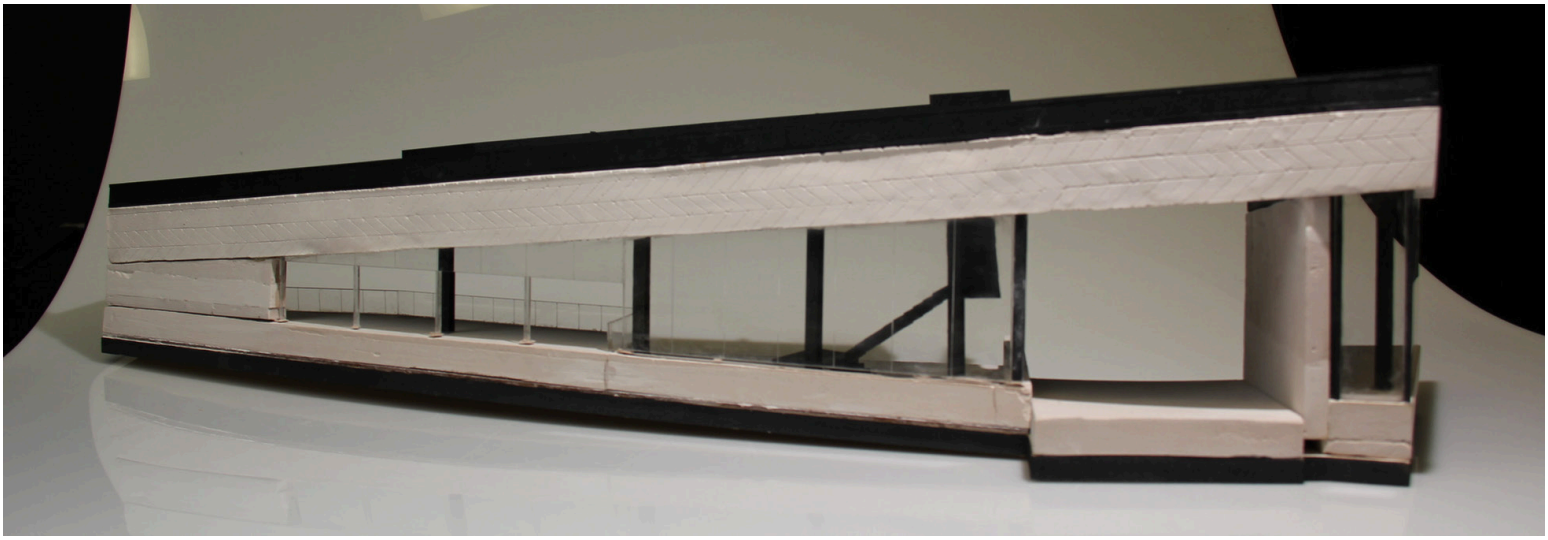


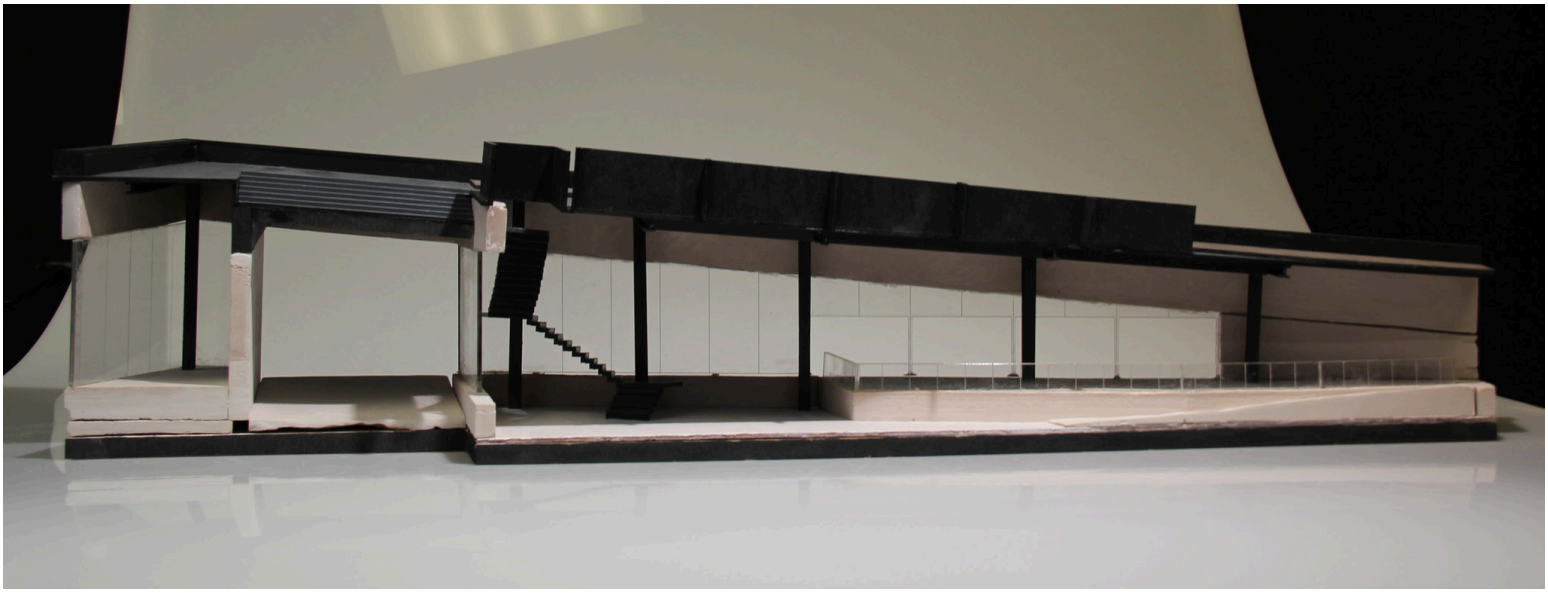
Wind Model : The insert represents an intial study into wind conditions on the existing site including strong North-East winds, as well as how these winds created certain conditions based on the position of the buildings surrounding the site.

Clay Models : In the initial stages of design I began to experiment with clay forms at the 1:500 scale to work on design a building form that was semi organic, and took into consideration the current research such as wind patterns and sun studies.

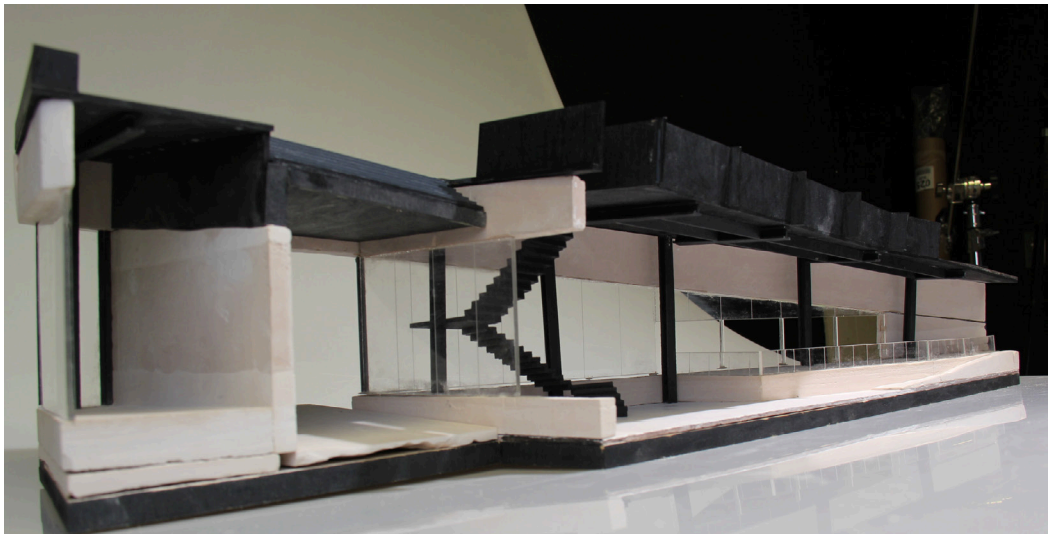


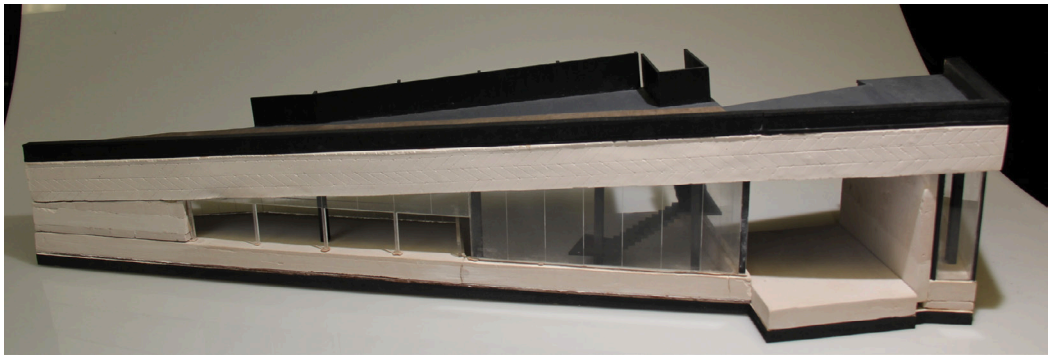
Clay Parti Model : During my clay experimentation, I developed the parti of my building which refers to the act of lifting a block of turf out of the earth during the construction of a turf house. This clay model represents that motion of lifting the turf out of the ground and became a critical design move in the final form of my building.





Section Model: Showing a similar section to the systems section in Appendix C, this model is a physical representation of a section through the Reception, Indoor Market, and Greenhouse shop area of the building. The majority of the models components use coloured and poured plaster to represent the use of rammed earth throughout the building, including ramps, floors, some walls as well as the wall consisting of the custom module designed in a herringbone pattern for use as exterior thermal cladding.





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