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Weathering Architecture: A Study of Contingency And Entropy in Our Built Environment

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WEATHERING ARCHITECTURE:

A STUDY OF CONTINGENCY AND ENTROPY IN OUR BUILT ENVIRONMENT

by

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ABSTRACT

This thesis is about the architecture of change. Weather, in the context of this thesis, acts as the agent of change and contingencies in organizing and modifying the built environment. It is a study of weather as the energy and matter in the atmosphere that directly affects the external organizations of the building, as well as the internal organizations of the user's experience. These organizations define architecture as a process through time; a performance-based construct that evolves with the actions and events of its surroundings. This thesis argues that weather can be used to enhance the experience and awareness of architecture.

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For my grandmother

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CHAPTER 1

INTRODUCTION

The purpose of architecture is to provide shelter from external elements. Traditional structures were constructed as a means to mediate between the natural and architectural environment. As technologies advanced, the approach of mitigation was quickly replaced with the desire for separation. Weather was quickly seen as a force to be reckoned with in order to maintain order and stability within the architectural environment. In 1930, Le Corbusier proposed a universal climate for all architectural spaces, as he states,

> "At this moment of general diffusion of international scientific techniques, I propose: only one house for all countries, the house of exact breathing… In winter it is warm inside, in summer cool, which means that at all times there is clean air inside at exactly 18 degrees. The house is sealed fast!" (Banham, 1969, p. 30).

Today, the desire for **control**, **uniformity**, and **stasis**, still remains as the major driver in architectural designs.

This thesis revisits the notion of mediation between weather and architecture through open interactions between the natural and built environment. By focusing on weather and architecture as dependent entities, the building renders greater interpretations and opportunities. It is an approach based on **contingencies**, **conditions of flux**, and **process**.

CONTINGENCY& ENTROPY

The era of Modernism in architecture was about order and stability. It was a time marked by an act of liberating from the past and creating a fresh start into the future. The modern movement in architecture took flight during the post-war period and was predicated on the need to meet social demands with fast, cost-efficient, and easily produced architecture and designs. Technologies were utilized to create buildings that operated like machines – in a standardized, predictable, and moderated manner. In order to meet the growing demands of basic social needs, mass production and universal designs were adopted. As a result, buildings became internalized, focusing on the interior conditions of space, while having little regard for the specificities of its surroundings. Hermetic buildings and standardized construction became the symbols of modern architecture.

In 1984, Reyner Banham (1984) published *The Architecture of the Well-tempered Environment*, arguing for better control of interior environments through greater integrations of HVAC technologies with architectural spaces. He acknowledges the need for a diverse range of climatic conditions within a given building to allow for multiple experiences and functions of

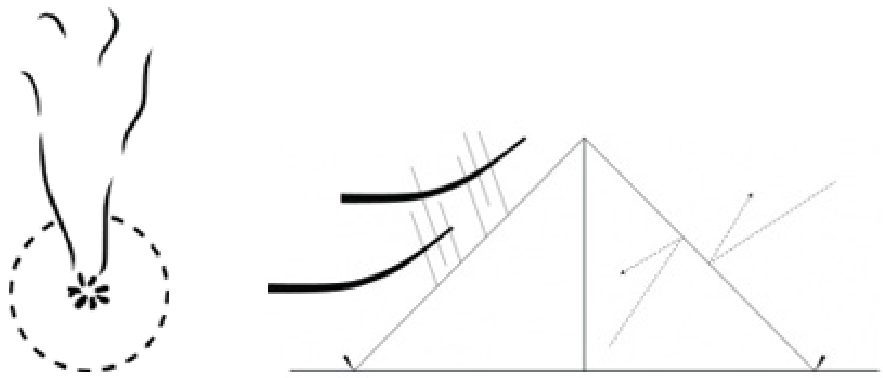


Fig 1-1. Environmental conditions of a Campfire and Tent

space, rather than a universal climate as was the case with many buildings of the time. Using two models of environmental management, the *tent* and the *campfire*, Banham illustrates the basic methods of conditioning space. He describes the tent as a structural solution where members tend to visualize space as they have lived in it – predetermined, bounded, and contained within a singular condition. The campfire, on the other hand, allows users to inhabit a space whose external boundaries are vague and adjustable to a variety of functional needs (p. 19). The campfire is effectively zoned by a range of temperatures and lighting conditions in concentric rings around the source of the fire. He argues that the construction of enclosed and massive buildings as a solution lacks a range of spatial experience and cultural responses that nomadic civilizations have always enjoyed. He believes that different climatic conditions are required to serve different functions and social organizations; hence the different zones based on varied environmental conditions and behaviours of the *campfire* model was critical in maintaining comfort within a given space.

Reyner Banham defined climatic variance and changeability within the context of environmental control. He believed that user control is critical in maintaining comfort within a given space. In his description of the campfire, he suggests that the downfall of this model is the impact of additional factors, i.e. wind and smoke, which render the fire as unappetising (p. 20). The environmental conditions of the given space are no longer driven by function and the need of its users, but by an external force that is beyond the control of its inhabitants as well as the architect. This unpredictable nature of weather that renders a lack of control within the architectural environment is the core of this thesis investigation. By challenging the notion of control and predictability, this study looks at architecture based on instability and vulnerability. It argues that only by letting go of control and architecture as a place of comfort and mitigation, can we begin to rethink the discourse of architecture and challenge old conceptions of habitation.

> "Where houses are no longer set in natural surroundings, the relationship between house and space becomes an artificial one"
>
> Gaston Bachelard
>
> (Bachelard, 1994)

In a similar manner, Banham's theory and this thesis are critical of the universal conditions in the *tent* model, a hermetic approach to interior conditioning, by establishing the need for variability and change. In Banham's study, however, variance is based on the users' control; while this thesis looks at variance based on contingency and unpredictability. For Banham, weather was a nuisance. He believed it is only through the means of environmental management carried out by the regulated energy of mechanical services was a space deemed habitable within comfort. With this description, can it not be argued that the *campfire* approach is simply a fire within the confines of a *tent*?

Weather, in the context of this thesis introduces an aspect of vulnerability that encourages greater awareness and understanding of architecture. By injecting a sense of vulnerability, users no longer rely on habits but rather; are encouraged to constantly establish new habits of occupying space. Interior conditions are no longer pre-determined by function and use but instead; use and social arrangements are determined by the changes of its immediate environment. This approach redefines the *tent* and *campfire* by breaking down the barriers between the interior and exterior environments.

By opening up to contingency and accepting vulnerability, architecture is recognised as a process – a process in motion, continually changing with the conditions of its surroundings and time. Such change is initiated through the interactions with its surroundings. In fact, the study of weather and architecture is a study of the interactions between architecture and energy. The word interaction implies that the relationships between weather and architecture are reciprocal; architecture consumes and responds to the forces acting on it from its surroundings; while altering the quality of the immediately adjacent environment. Derived from the Second Principle of Thermodynamics, entropy introduces the concepts of initial change, instability, and the notion of irreversible time. It suggests that over time, systems reach a steady state of equilibrium (Fernandez-Galiano, 2000, p.55). The system, at that point, has adapted to the patterns of change and disorder becomes predictable and regulated. This is particularly important as continual change is necessary to bring cognitive awareness to spatial surroundings. Psychologist, James J. Gibson (1966) suggests that cognitive awareness of light, heat, and sound are not of the environment, but of the behaviours in which the bodies are reacting to the environment (p.14). He argues that our senses activate only in the presence of change. In order to enhance the experience of one's surroundings, a constant state of change must be established.

In fact, parallels can be drawn from biology; like an organism, a building consumes energy in order to maintain its internal and eternal processes, while constantly reacting and adapting to external forces. French architect/designer, Mathieu Lehanneur believes architecture is an organism that is in a permanent state of adaptation to the energies and matters of its surroundings (Fernandez-Galiano, 2000, p. 64). He further argues, "Each change to any external parameter activates the function that enables [an organism] to adjust. We are continually in the state of hyper-reactivity" (TED, 2009). In this state of performance, a building is acting and reacting to the various forces of its surroundings. Performance Theorist, Doris Hannah, notes, "Architecture is in this sense intrinsically performative and no matter how seemingly still, is itself a slow performance: a spatial thing in perpetual motion – heating and cooling, contracting and expanding, and eroding and accruing" (Yates, 2012, p. 64).

SUBJECTIVITY & CREATIVITY

The experience of weather is subjective and personal. In the early eighteenth century, weather diaries were used as a means to record local weather conditions. The diarists did not record in the manner of empirical data, but through metaphors and analogies that reflected the moods, atmosphere, and experiences of a particular person and place. Following Francis Bacon's assumption that extraordinary weather events could be more revealing than everyday occurrences, weather diaries gradually became a common method of recording local as well as extraordinary weather conditions (Hill, 2011, p. 66). These diaries described weather as narratives that express the qualitative rather than the quantitative conditions of weather. In comparison to the detached weather records promoted by empirical science, these diarists offered an appreciation for the weather and its effects on the self.

The experience of architecture is subjective and personal. James J. Gibson's study (1966) on visual perception strongly advocates on what is known as "direct perception". This theory explains that the senses provide the observer with direct awareness of the external work or scene; placing great emphasis on the senses as the determining factor in understanding one's surroundings (p.14). The concept of human behaviour as a result of this understanding was further investigated in his 1966 publication, *The Senses Considered as Perceptual Systems*. He carefully differentiates between sensations and perceptions; the former relating to the objective realities acting on our senses, while the latter is a subjective reading of these responses (p. 14). In other words, perception relates to the feelings and moods formed by sensations. In his study of optical flow, Gibson explains that patterns in the apparent motion of objects, surfaces, and edges in a visual scene are caused by the relative motion between the observer and the scene. Over time, he argues, "It would be expected that an individual, could orient more exactly, listen more carefully, touch more acutely, smell and taste more precisely, and look more perceptively than he could before practice" (p. 14).

Our understanding of architectural scale and dimension are measured with the body and through the projection of the body into the space in question. In *The Architecture from the Inside Out: From the Body, the Senses, the Site and the Community*, authors, Karen A. Franck and Bianca Lepori (2007)believe the

"I am not interested in weather as a matter of science; I am not a meteorogist or a botanist. I'm interested in people: how people engage sensually with the qualities of weather - rain, mist, ice, snow, and humidity"

Olafur Eliasson

(Kimmelman, 2004)

Fig 1-2. The Weather Project by Olafur Eliasson. 2006

body is permeable, fluid and open to other objects, people, and its surroundings. It is through this interaction of the biological and cultural influences where places are remembered and made personal.

In explaining subjectivity, nuclear engineer and architect, Michelle Addington (2007), describes two different frames of references, the Eulerian and the Lagrangian model. In the Eulerian model, the point of reference is fixed on a particular object or point of origin. The Eulerian is an idealized frame based on pure geometries and fixed relationships. The Lagrangian frame, on the contrary, finds its origin not at a point fixed in space, but at the centre of the subject. As a result, the Lagrangian frame is premised on the experience of the subject. The Lagrangian frame, rather than being an idealized frame, is based on uncertainty and variability of the moving subject (pp. 40-41). It has been well established that awareness of architectural space is initiated through the interactions of the body to the variances of its immediate environment; where the senses are activated upon changes in the energy and matter of the atmosphere. At the spring 2012 lecture series, *Form and Energy* at the University of British Columbia, Addington (2012) argued, "all things that consume energy are for the body or consumed by the body – so we should be designing for how we feel and how our body reacts." This, she says, "should be the heart of architecture".

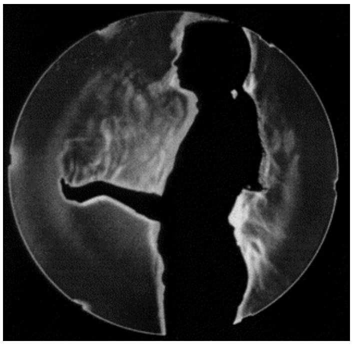


Fig. 1-3. Schlieren flow visualization of the thermal convection plume from the human body.

The introduction establishes that the experience of both weather and architecture is subjective. Architecture that opens up to vulnerability and contingency is one that deals with the body and the phenomenal experiences of the inhabitants under both weather and architectural conditions. Architecture is constructed as a means to house people; it is where actions and events unfold. These events are established by acknowledging the constant evolution of the building and the processes within it. Without the interactions between the users, the environment and the architecture, the building simply becomes an artifact in space. It is in this continuous flux of becoming that makes for a process that is inherently “creative”. By opening to uncertainties, the user’s experience and the building are enriched with new possibilities and discoveries.

THESIS STATEMENT

Weather in the context of this thesis, acts as the agent of change and contingencies in organizing and modifying architecture. Architecture is defined as a performance-based construct, shaped by the actions and the events of its users, as well as the energy and matter in the atmosphere. This research seeks to establish a relationship between weather and architecture through three concepts of investigation: **Architecture as Process**, **Boundary as Behaviours**, and **Spaces of Contingency**. This thesis approaches the subject through a series of small interventions and explorations. The following chapters are a documentation of the exploration process.

CHAPTER 2

ARCHITECTURE AS PROCESS

Entropic time works alongside the process of designing and continues long after the architect has left the scene. However, accepting this collaboration requires a shift in architectural priorities away from architecture as a moment of "completion" and towards an acceptance of the "unfinished". For American artist, Robert Smithson, entropy takes on both a negative and a positive connotation. The negative one follows the Second Law of Thermodynamics, which suggests a gradual decrease of energy until a condition of uniformity and order is reached through a equilibrium. Instead, what Smithson looks for in his designs, "is an engagement with the active aspects of entropy's inevitable disturbance of stability […] a positive reformulation that contributes to the continuous remaking of stuff over time" (Till, 2009, p. 106).

This sense of "unfinished" is not necessarily of the physical, but in accepting the possibility of appropriation and regeneration.

It is seen as an opportunity for spatial and material invention. Chemist Illya Prigogine and Isabelle Stengers (1984) suggest that entropy does not simply lead to disorder; rather a new system of order is derived through initial changes, fluctuations, and the imbalance of entropy (p.140). Like Smithson, they view entropy as an opportunity for new order and renewal over time. They define the development of this new order as follows,

> "In some cases the analysis leads to the conclusion that a state is 'unstable' – in such a state, certain fluctuations, instead of regressing, may be amplified and invade the entire system, compelling it to evolve toward a new regime that may be qualitatively quite different from the stationary states corresponding to minimum entropy production" (Prigogine & Stengers, 1984, p. 140)

This theory of renewal suggests that buildings are in a state of regeneration and renewal, rather than simply deterioration and degradation with time. With entropy, the reference frame of change is constantly shifting and redefined. Architecture that acknowledges the presence of energy identifies itself as a process that is continually evolving. As a result, successful designs must take into account entropy and contingency.

WEATHERING

For most of architectural practice, it was necessary not only to create habitable environments, but also to conserve them. Architecture came to be seen as a practice of creating permanent structures, devoid of uncertainties and change. In addition to maintaining a constant and stable interior environment, modern architects wanted to create order by designing and maintaining buildings in the state of which it was completed. Glass and steel construction were predominately used for its ability to maintain a constant level of cleanliness and aesthetic through time. In *Architecture Depends*, Jeremy Till (2009) argues that architects tend to focus too much on creating finite and fixed objects rather than allowing the architecture to take shape through the influence of external forces formed by uncertainties and contingencies.

A building acts as an information storage for the past and present, and at the same time has the capacity to foresee future tendencies. Materials weather with time, while the needs and functions of a building adapt to the constant change of its surroundings. For Juhani Pallasmaa (2006), natural materials express a structure's age and history as well as the tale of its origin and use (p. 4). David Leatherbarrow and Mohsen Mostafavi (1993) suggest that the most direct level of acceptance of time includes the idea of weathering as "a form of completion". They see weather as the agent of positive transformation toward completion. According to philosopher and sociologist, Edgar Morn, architecture can be put into the realm of transience, in the midst of the processes and transformation in the phenomena of irreversible time. He suggests,

> "It is in the context of irreversible decomposition of the organized, the inevitable degradation of the built, the sure ruin of buildings, that the bases of theory of rehabilitation must be established, one that takes into account the environments' need for a continuous supply of materials and energy to allow it to repair the damages of time and chance, reconstruct its form, regenerate its original confirmation or adapt it to new needs" (Fernandez-Galiano, 2000, p. 64).

By allowing the building to deteriorate and regenerate with the conditions of its surroundings, the architecture acknowledges, represents, and reconsiders time. It is through this process that new possibilities and relationships emerge. The unpredictability of decay and weathering acknowledges that the process of weather not only subtracts through deterioration but also adds to the building through accumulation of debris or markings on a surface. Peter Zumthor (2006) describes materials as having enless possibilities, "Materials react with one another and have their radiance, so that the material composition gives rise to something unique" (p.24). Edges and qualities of differing materials begin to merge through staining, while multi-layered and complex materials will deteriorate, revealing new characteristics and aesthetics. The openness and lack of control in weathering offers a subjective reading of the building through a sense of ambiguity in terms of both its material rendering and its meaning.

> "Take a stone: you can saw it, grind it, drill into it, split it, or polish it – it will become a different thing each time. Then take tiny amounts of the same stone, or huge amounts, and it will turn into something else again. Then hold it up to the light- different again. There are thousands of possibilities in one material alone.""
>
> Peter Zumthor
>
> (Zumthor, 2006)

As the building evolves with time, the objective and subjective perspectives change; the architecture is then understood as an expression of time – the process of designing, constructing, and the life of the building. Fred Matter, a professor at the Arizona University, believes that in order for a building to be understood as an expression of time, it must provide a means of recording the passage of time (Buntrock, 2010, p. 34). Similarly, Christopher Woodward (2001), author of *In Ruins*, suggests that our fascination with ancient relics is in its ability to capture history and remind us of our past. These relics are temporal and consist of layers of information that tell us how a particular place came to be.

When the process of weathering is allowed to continue uninterrupted, the original surface can be covered so completely that it disappears altogether under a patina; a time-bound “growth of skin” that covers the new surface with an accumulation that represents the relationships between the building and the conditions of its surroundings. These surface modifications are a result of the actions of natural elements taking on the qualities of the place over time, and in return, modifying its surroundings to create a sense of harmony. Kengo Kuma once wrote, “That’s what I’ve always wanted to do, I want to erase Architecture”, as he expressed the idea that architecture should not be restricted to the isolated object, but blended in to become a part of the whole environment (Brownwell, 2011, pp. 38-39).

RASPBERRY FIELDS
by Jason Payne

Fig 2-2. Conceptual Model of the re-cladded design illustrating the effects of weathering. 2010.

This 2010 design is a full renovation and restoration of an existing, one-room schoolhouse built in northern Utah in the early 1900's. The building is a simple and symmetrical geometry oriented in the east-west direction such that its southwest façade faces directly into the prevailing winter storms and southerly solar exposure. Over the years, the Southwest façade has weathered significantly while the northeast side of the building has remained perfectly intact. When the two are compared, the effects of weathering are captured in the shape, texture, and colour of the original wood cladding and shingles. This demonstrates that this formally symmetrical structure has, over time and through the exposure to weather, evolved into something quite different in terms of material dynamic (Hirsuta, 2012).

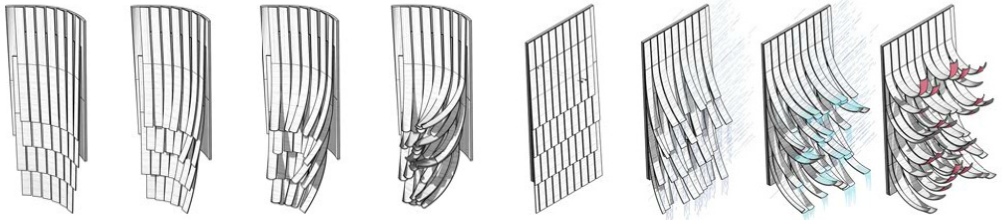


Fig 2-3. Diagrams illustrate that the concave surface encourages shingles to over lap, while shingles on the flat elevation simply curl over time. 2010.

The renovation project involves the re-cladding of wood shingles that emphasize the pre-existing dichotomy present in the original project. The building looks to encourage various degrees of weathering through the articulation of long slender shingles intentionally attached improperly, with the bottom ends unfixed and the grain oriented to encourage warping. Upon completion, the building will appear relatively flat and consistent with evenly distributed and dimensioned components. Over many years, however, the shingles on the exposed side will curl and become fuller with each season, while the sheltered side will remain reasonably flat and composed.

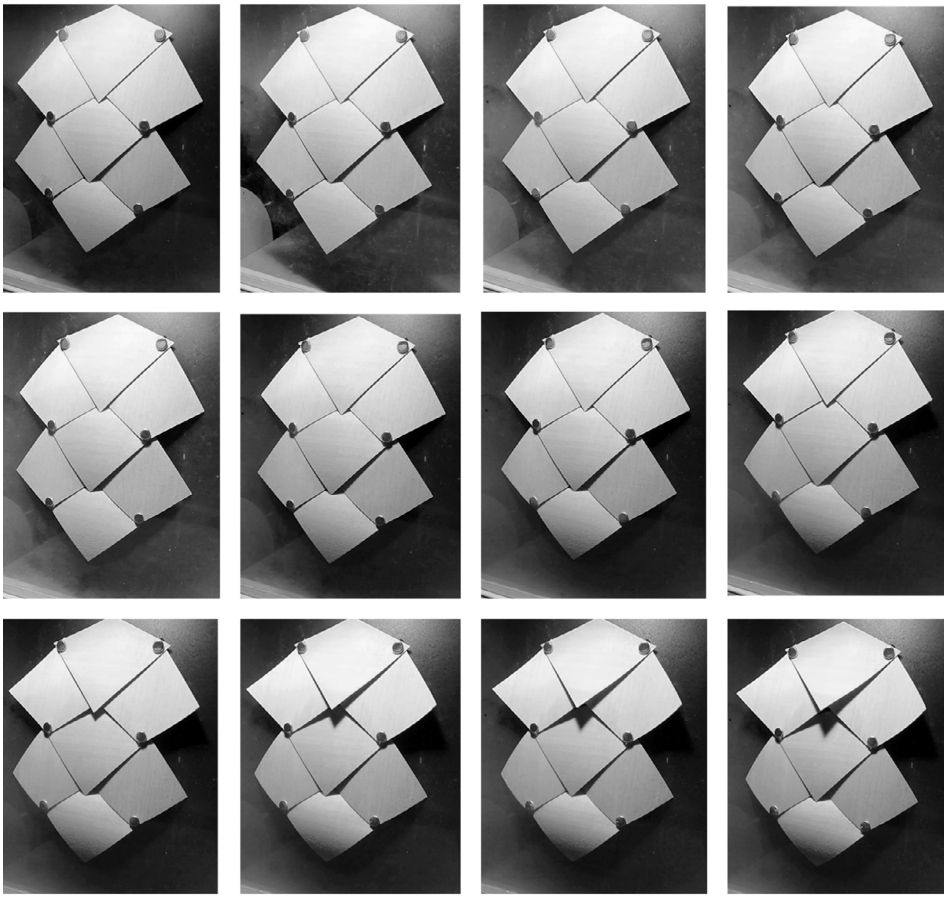


Fig 2-4. Stills taken at every 3 seconds demonstrating the process of transformation

BIRCH VENEER & HUMIDITY

Wood Exploration 1

A series of explorations were conducted throughout the process of the thesis to investigate the various effects of weather on materials and the qualities of architectural spaces. This first study looks at the effects of humidity and moisture on seven equally dimensioned sheets of birch veneer. Captured in real time, a 36 second video demonstrates the articulation and strategic overlapping of the pieces, as well as the placement of the pin connections in governing the direction and the degree of transformation.

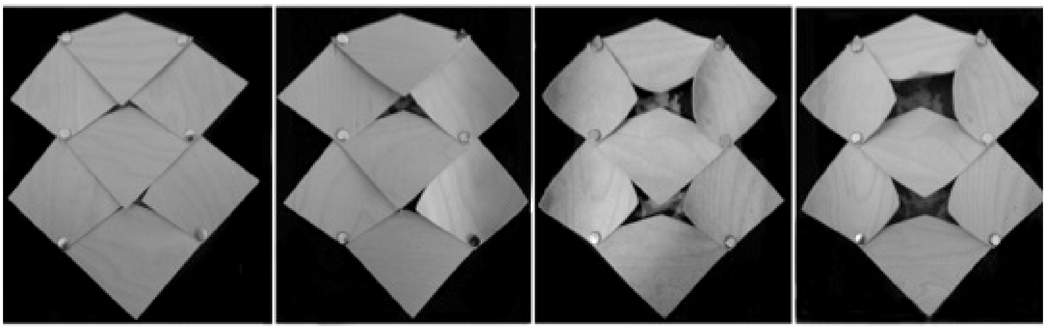


Fig 2-5. Representation of the interactions between wood and copper

WOOD & COPPER

Wood Exploration 2

This study builds on the first exploration by looking at the weathering effects of wood when placed in conjunction with a material of different properties and behaviours. The images represent the interaction between copper and wood. The two materials were selected for their dichotomous reaction to weathering. Wood deteriorates and fades, while copper strengthens and regenerates with time. The changes in the dimension and warping of the wood directly affect the exposure of the copper to create a varying pattern of oxidation. As the wood veneer deteriorates, a fresh and bright patina coated copper is exposed.

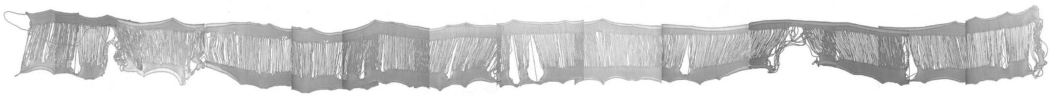


Fig 2-6. Textile Studies, Candice Fempel, University of Manitoba

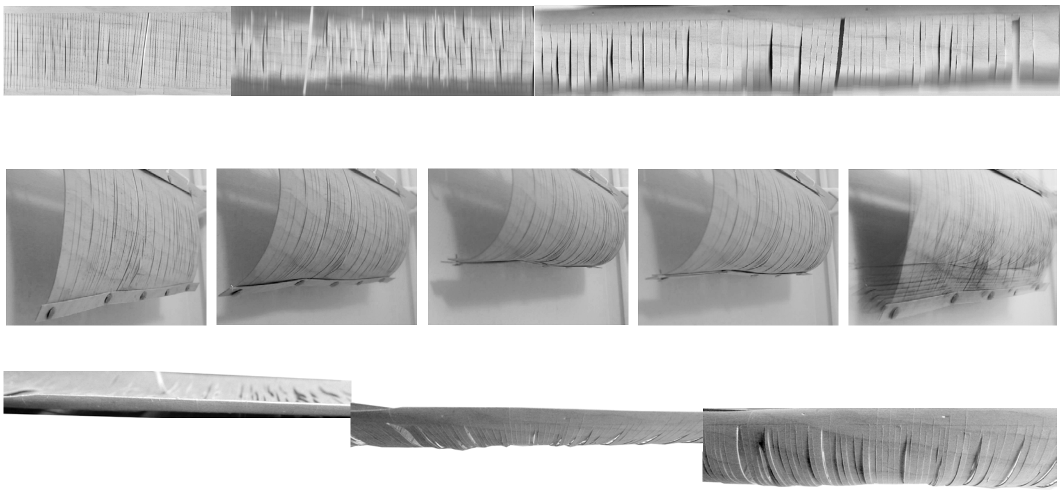


Fig 2-7. Time-lapse showing the process of transformation

WOOD TEXTILE

Wood Exploration 3

This third study utilizes the effects of weathering to create a wood veneer that adopts the characteristics of textiles. Reiko Sudo, co-founder and art director of Nuno, a Japanese textile research company, believes, “fabric is like water. It constantly responds to different forces – It’s never static. Fabric isn’t a rigid thing” (Brownell, 2011). In 2009, Candice Fempel, a student at the University of Manitoba conducted a series of textile studies that look at the makeup of the fabric in determining the weakness and strength of the material. Her analysis looks at the strength of fabrics in correlation to the consistency of the knit; the looser the knit, the greater the capacity of the fabric to sag and flex (Fempel, 2007). These ideas were translated to the design of a wood textile. By creating slits along the wood veneer, the aim is to create a surface that is more pliable to ambient moisture and air movement in the atmosphere. The study demonstrates the warping of the wood as it curls and sags upon exposure to humidity over time.

WEATHER SENSING

Recent technologies and material studies aim to bring awareness to the immediate presence of energy and matter in architecture. As previously defined, weathering is the deterioration and renewal of materials that showcase the process of buildings over long periods of time. However, the building not only acts as storage for the passage of time, but also acts as a sensing mechanism that responds to the immediate changes in the atmosphere. These studies are characterized into three main approaches; first, the use of architecture to process the elements of weather into empirical information; second, the direct amplification of weather phenomenon to enhance sensory awareness; third, showcasing the effects of weather on material properties.

The first approach uses architectural interventions to communicate weather information through the translation of atmospheric phenomenon into accurate statistical data. This is the most common approach in current practice of showcasing weather through visual representations. In 1986, Toyo Ito's proposal for the *Tower of the Winds* was an electronic system that recognized the changes in wind speed and sound waves by translating the collected data into a colour coded display of LED lights. The structure is installed around the original tower, measuring nine by six meters in section and twenty-one meters in height. The tower is covered with acrylic mirrors and lined with a perforated aluminium coating to reflect the sky during the day (Floornature, 2006). Designed as the landmark for visitors entering the city from the Yokohama bus terminal, the building functions as a weather beacon; an isolated entity that signals weather information to the rest of the city.

Fig 2-8. Tower of the Winds by Toyo Ito. 1986

Another notable project that has taken a similar approach as Ito's representation of weather is Studio Lab [au]'s *Weather Tower* (2012) in Brussels. This project also transforms the building façade into a light-based weather forecast installation. The coloured pixels of the façade vary in accordance to temperature change. In both cases, the façade uses real time data to project the temperature, as well as wind patterns and the intensities of these weather conditions through the display of different lights and colours. Ito's proposal, however, is more successful as it demonstrates the gradual flow and dynamic nature of energies with multiple levels of reading through the changes in not only colour, but also opacity and movement, while Lab [au]'s *Weather Tower* represents the flow of energies as binary light pixels.

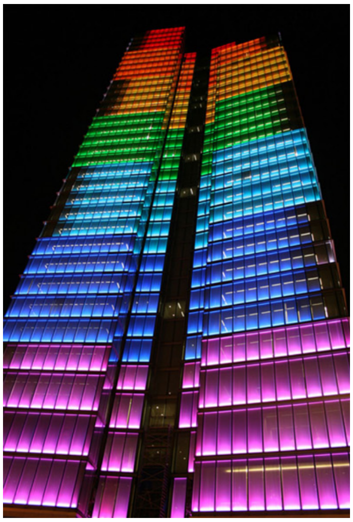


Fig 2-9. Weather Tower by Studio Lab [au]. 2010

With this approach, the understanding of weather is reduced to a visual representation with little participation of the users. These installation projects focus on demonstrating the technological advancement of new materials and mechanized systems, rather than the experience of the users within the given space. As previously noted, the experience of both weather and architecture requires a direct experience through its interactions with the body and all of the senses.

> "As buildings lose their plasticity and their connection with the language and wisdom of the body, they become isolated in the cool and distant realm of vision. With the loss of tactility and the scale and details crafted for the human body and hand, our structures become repulsively flat, sharp-edged, immaterial and unreal."
>
> Juhani Pallasmaa
>
> (Pallasmaa, 2006)

The second approach looks at the subjective readings of space through the amplification of weather phenomena. By amplifying the transient nature of weather, the architecture becomes a space of performance driven by events and actions of both the adjacent environment and its users. In dealing with sensory awareness, subjectivity becomes the core of the discussion. It is through this exposure to change where past and new experiences are developed.

Fig 2-10. Interior of Nakagawa - machi Bato Hiroshige Museum of Art. 2000

The *Nakagawa-machi Bato Hiroshige Museum of Art* by Kengo Kuma is an example of a building where the interior spaces are conditioned by the exterior weather. The museum design was inspired by one of Ando Hiroshige's paintings, *Sudden Shower over Skin-Ohashi at Ataka*. The layers and the depth of the rain that was captured in Hiroshige's painting inspired Kengo Kuma to design a space where the enclosure is formed by a series of permeable and translucent surfaces. Kuma's design was a permeable structure that allowed open interactions between the interior and exterior. As light permeates through the various surfaces of the wood lattices, louvers, glass, and Japanese paper, the character of these surfaces is highlighted through the interplay of light and shadow, as well as the quality of light within the space. In addition, the museum's outer walls are set back beyond the low eaves to dynamically change the perception of space as light changes. The volume of space can be determined by the intensity of light as well as the length and patterns of the shadows within.

Unlike Toyo Ito and StudioLab[au]'s approach of showcasing weather phenomena through the translation of empirical data, Keno Kuma's "Hiroshige Museum of Art" is a direct expression of these events. In all three projects, the event of weather is showcased through visual stimulation. Where Kuma's project differs is that it not only highlights the visual awareness of exterior conditions, but also creates a space in which users are immersed in the direct experience of these conditions by creating a permeable structure that allows light to enter freely. In this instance, the users become active sensors within the given space.

The third approach looks at immediate material changes upon contact with the energy and matter in the atmosphere. The study of architecture focuses heavily on material innovations and construction techniques. In recent years, weather responsive materials have become the forefront of these investigations. These innovations have expanded beyond a simple aesthetic approach towards a focus on material performances and its direct impact on the quality and organization of spaces.

In a recent study at the University of California in Los Angeles, Architect Doris Kim Sung examined the responsive properties of bimetallic metals to temperature fluctuations. These metal alloys, known as *thermobimetal*, consist of two laminated sheets of metal with different coefficients of thermal expansion. Each metal expands at a different rate when heated, causing it to curl or flatten in response to changes in temperature. These studies were put to the test in *Bloom*, a structure that served as a canopy between two buildings along Silver Lake Boulevard in Los Angeles. The installation is made up of 14, 000 pieces of thermobimetal that curl open when the temperature rises, allowing for natural ventilation as well as providing shade from direct sun exposure (Furuto, 2012). This system not only directly impacts the formal quality of the structure, but also encourages the potential of different spatial experiences. In this instance, the change in material geometry enhances the performance of the sheltered space by encouraging the natural ventilation of hot air during times of high temperature, while maximizing the exposure to daylight. By creating a porous boundary, the interior space is contingent on the behaviour of the exterior environment.

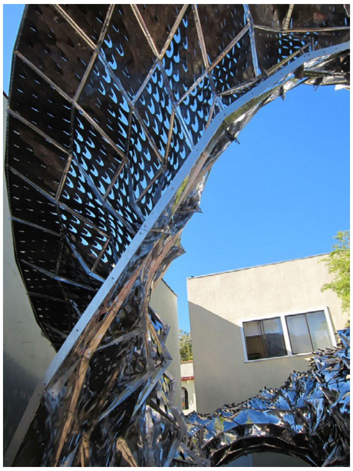


Fig 2-11. Bloom by Doris Kim Sung 2012

The canopy installation by Doris Kim Sung explores the use of weather-responsive materials to establish a relationship of mediation between the inside and outside environments. This next example demonstrates the use of these materials as an instigator to various social organizations and uses of space. *Open Column* by Omar Khan, is an installation consisting of a series of composite urethane elastomer structures that detect the levels of carbon dioxide present within a space. These column structures are programmed to expand and contract to the changes in the atmosphere as well as its users (Khan, 2008). As carbon dioxide levels rise, the columns expand and drop down, affecting the activity of those beneath the structure. In this case, users are dispersed into smaller groups. As the carbon dioxide levels decrease, the columns retract towards the ceiling, opening up the space for larger groups to gather. As the space becomes populated, carbon dioxide levels fluctuate, creating a constant shift of varying social organizations. In *Open Column*, the material systems demonstrate a high level of engagement between the inhabitants' experience and the architectural space. The study of architecture as a sensing mechanism should encourage a renewed phenomenological experience of spaces, rather than simply a visual and formal exploration. The amplification of weather phenomenon is used as a tactic to encourage multiple interpretations and the formation of new habits.

Fig 2-12. Open Column by Omar Khan 2008

CHAPTER 3

BOUNDARY AS BEHAVIOURS

"The building envelope represents the ultimate manifestation of the omni-functional surface boundary, while traditional architecture was capable of providing shelter from the environment, the advent of HVAC (Heating, Ventilating, and Air Conditioning) systems at the beginning of the twentieth century established the building envelope as a cocoon in which an alterative universe was maintained"

Michelle Addington

(Addington, 2010, p. 68)

Despite a clear shift in recent architectural discourses that begin to understand architecture as a process shaped by entropy and contingencies of the immediate surroundings; many contemporaries still follow Reyner Banham's approach towards a power-based solution of environmental control. Michelle Addington (2010) argues that the approaches of highly engineered systems that are strictly optimized for a variety of performance criteria are predicated on the maintenance of the homogenous interior. Its primary role is to separate and preserve a uniform, unchanging environment. In addition, the approach of these systems presumes the envelope as the definitive location for the interactions between the interior and exterior environment (p. 70).

To allow interior spaces to be conditioned by weather, a new approach to the architectural boundary is required. The boundary can no longer be viewed as a hermetic enclosure that differentiates the natural environment from the architectural environment. Architect Amanda Yates (2012) suggests, “Making architecture that intentionally enacts temporal flow requires an eroding of foundational thought and a liquefying of hermetic boundaries, both spatial and discursive” (p. 63). To understand her approach, it is necessary to reinterpret the notion of boundaries as behaviours rather than physical entities. These behaviours relate to the phenomenon and events that take place within a space and the interactions with its immediate surroundings. If boundaries are defined by the active zone of energy exchange, then these boundaries become transient rather than rigid to allow for multiple interpretations that open up to subjective readings and experiences of the users.

Unlike the static boundary of the building envelope, the energy boundary does not create a barrier of separation; rather, it emerges to establish a relationship between the different systems of exchange. In this instance, the layer comes into being only when there is an energy difference. Addington (2010) suggests, “this energy difference can be due to temperature, pressure, density, phase, height, momentum or concentration, and a unique boundary layer will appear for each difference and each magnitude of difference, and disappear when equilibrium is reached” (p. 71).

Fig 3-1. Conceptual Sketch of Fountaines d'eau et de toit de feu by Yves Klein. 1959

Fig 3-2. Stills from Yves Klein's 1958 short film desmonstrating air roof experimentation

An example of this energy exchange as described by Addington is demonstrated when a person moves through a room. A person walking through a room will create numerous shifts in conditions: the temperature difference between the person and the surrounding air will produce an exchange of heat between the body and the air; this exchange of heat will create a density difference; the density difference will then produce convective movement of air; moving air will affect the humidity immediately adjacent to the body, thereby setting up a mass of transfer of moisture from the body to its surroundings. This not only illustrates that conditions are constantly adapting with the introduction of new parameters, but also demonstrates the interactions between the space, atmosphere and users.

In the 1960's, Yves Klein (2004) built several installations exploring the theme of immateriality in architecture. His *Air Architecture* collection established spatial boundaries based on the flow of energies, i.e. air, fire, and water. In 1958, Yves Klein presented a short film demonstrating the prototype tests he developed for his concept of a roof surface generated by the movement of air. His experiments illustrate the effectiveness of a jet of air blowing water sideways where most of the water is dispersed horizontally as mist, creating a surface layer between the water from the faucet and the space below. This concept was later adopted into his 1959 design, *Fountaines d'eau et de toit de feu*, where the five enclosing surfaces were defined by jets of water and air (Dwell, 2010). The interest in Klein's project is not only in his use of energies to create a physical boundary, but more importantly, his studies on the changeability of these boundaries as they interact with external forces.

This notion of a multiple governing system of interactions is also present in Reyner Banham's *Campfire* model. In his description, the first order is established by the capacity of the fire to produce different temperature and light gradients. These gradients define the social arrangements within the space. He suggests that sleeping is an outer-ring activity, while pursuits requiring vision belong closer to the inner-ring (Banham, 1969, p. 20). However, this arrangement assumes that the only factor at play is the fire located in the centre of the space. Two more orders are established when the actions and influences of the users' and the conditions of the atmosphere are taken into account. The movement of air in the atmosphere alters the direction and the intensity of the fire and as a result, significantly alters the way space is inhabited. These interactions between multiple variables change substantially from one instance to another, perpetuating contingent behaviours.

In the discourse of energy and architecture, Reyner Banham's Campfire approach to environmental management became the precedent for many contemporary theories and projects. Philippe Rahm is a prominent figure in this field of study who has adopted Banham's approach to his designs of residential,

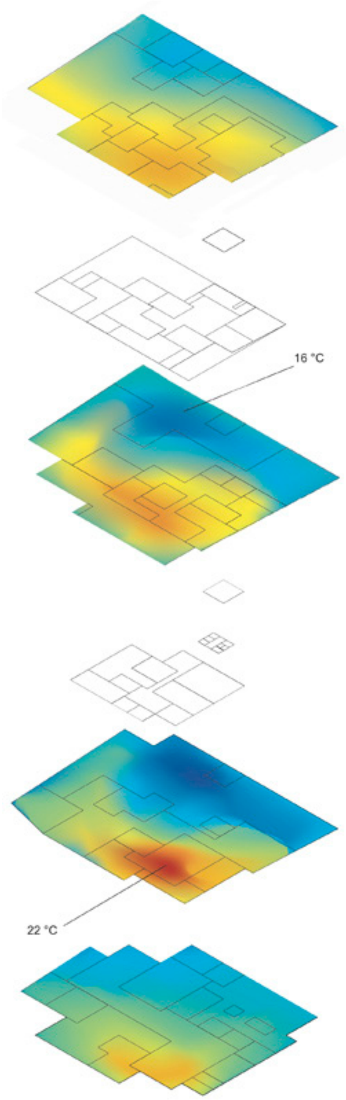


Fig 3-3. Convective Museum concept by Philippe Rahm

museum, and gallery spaces. Using the fluctuating conditions of the atmosphere to create diverse experiences of interior spaces, he argues that unpredictability is established by variances and differentials in the transition from one zone to another. In 2008, Philippe Rahm (2012) proposed "an architecture as meteorology and atmosphere" for the Museum of Contemporary Art in Wroclaw, Poland.

The architectural spaces of this design are defined by polar temperature zones at opposing ends of the building. The two ends of the building are set at exactly 16 degrees Celsius and 22 degrees Celsius; the temperatures, he explains, as the maximum and minimum standard for comfort. The premise of the design is to compose a multitude of climatic conditions based on the flow of heat between the highest and lowest temperatures to create a gradient for individuals to move freely and migrate through different atmospheric zones. This approach establishes different qualities of space for various activities without the use of physical walls and barriers.

However, as previously mentioned, this approach defines weather variance within the confines of an enclosed space, pre-determined by the fixed temperatures of the two poles. To design a building of complete vulnerability to weather, the enclosing surface must have the same degree of transience and vulnerability.

The architectural boundary is the most significant component of a building that is used to mediate between the natural and architectural environment. For this reason, the design of the boundary condition is critical in establishing connections and interactions between the inhabitants, the building, and its surroundings. This thesis advocates for the replacement of the static boundary of conventional buildings, for an ephemeral boundary condition based on a range of variances. The boundaries include both physical constructions of walls and surfaces that alter and reshape with the conditions of weather and time, as well as the ephemeral boundaries formed by atmospheric differentials. These conditions are constantly in the process of becoming or dissipating and in doing so, encourage diverse organizations of space based on moments and the events of contingency.

NOUN 1. UNAVAILABILITY

by Gartnerfuglen

Fig 3-4. Exterior of winter condition of Noun 1. Unavailability by Gartnerfuglen 2012

Fig 3-5. winter and summer conditions of Noun 1. Unavailability by Gartnerfuglen 2012

The traditional igloo is an example of an ephemeral structure that is constantly reshaping in response to weather conditions. The transition is gradual and allows for multiple readings of the building enclosure as it transitions with temperature changes.

In 2012, the Norwegian architecture studio, Gartnerfuglen, designed a temporary fisherman's hut from this concept of freeze and thaw during the different seasonal temperatures. The hut is built from chicken wire-clad walls and roof. In the winter, the walls are filled with lake water to create an ice enclosure; while in the summer, the ice melts away, leaving a light frame for plants to grow. In the winter, evenly distributed lighting conditions and warmth within the space is provided by the physical enclosure of the ice walls. In the summer, the plants provide shade and fresh smells as winds permeate into the space.

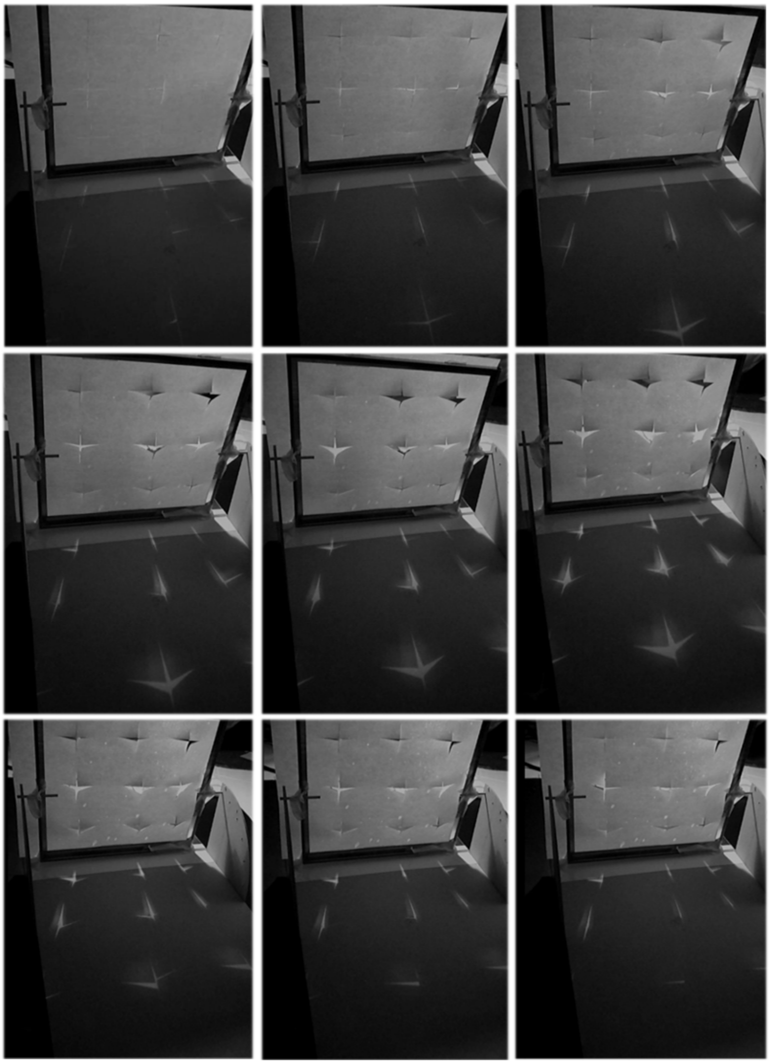


Fig. 3-6. Time-lapse of an initial prototype exploring the simple open and close functions of a perforated surface

POROSITY & LIGHT

Wind Exploration

The following two studies represent a boundary condition in which the surfaces are reacting to a wind source to create a porous surface that enhance the dynamics of the adjacent space. The light and shadows directly correlate to the conditions of the atmosphere.

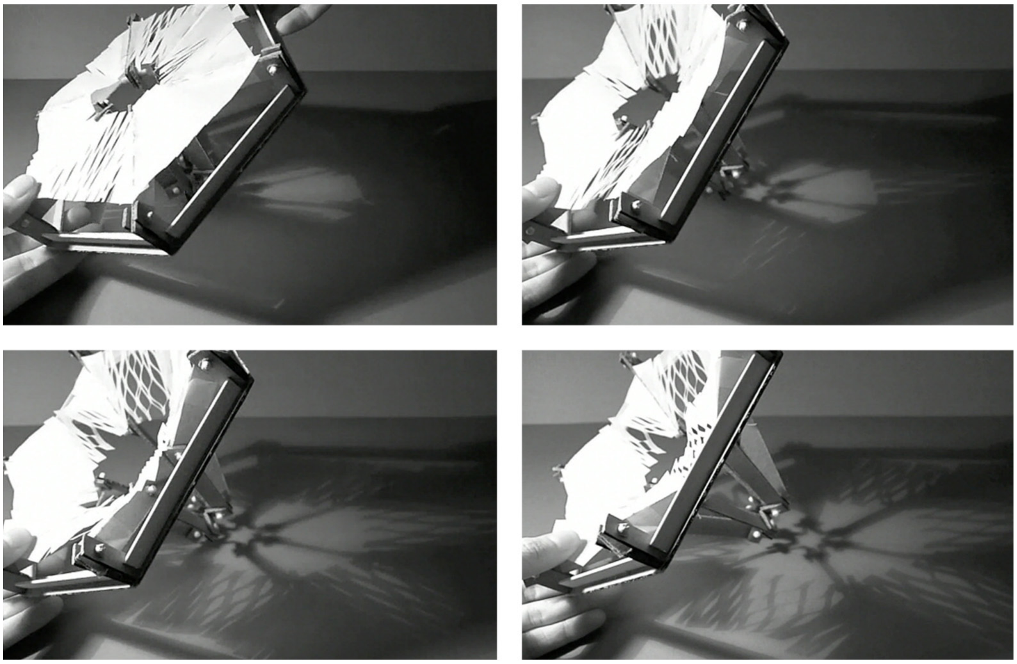


Fig. 3-7. Time-lapse of a second prototype exploring the effects of geomtry in creating a varying pattern of light and shadow

In this second prototype, a more complex geometry and system was put in place to investigate the effects of materiality, shape, textures, and form on the dynamics of light and shadow.

CHAPTER 4

SPACES OF CONTINGENCY

In an environment based on change and variance, the space becomes a learning environment for multiple interactions and interpretations. Two ways of interacting with the atmosphere and the weather is through direct exposure or the translation and expression of weather through the architecture. In a contingent space, users are exposed to multiple conditions and effects that are in a state of continuous adaptation. These conditions overlap to create multiple readings and sensory awareness.

Contingent behaviours are influenced by scale. The scale of the receiving entity and the magnitude of the force determine these responses. When designing at the scale of a building, Michelle Addington (2007) argues that assumptions and generalizations are often made in order to accommodate for the complex interactions between different energy systems (p. 43). However, weather is based on the aggregation of small variations to a larger outcome. As a result, it is critical to work with ambient conditions at a small scale.

When dealing with the scale of the interactions between architecture and the atmosphere, the difference between climate and weather must first be established. Climate is defined by the changes in the atmospheric conditions of a given region based on averages typically collected over a thirty-year period. Current sustainable designs primarily focus on climatic conditions; dealing specifically with regional types classified by the Koppen-Geiger Climate System, i.e. tropical, dry, temperate, continental and polar climates (World Meteorological Organization, 2012). Weather, on the other hand, deals with the immediate and local changes in the atmosphere. It is not defined by averages or statistical information, but instead, by the immediate variance and fluctuations of the atmosphere. As a result, designs that deal with the interactions of weather require a shift from the approach of climate-based designs.

A structural design defined entirely by the processes of weather is Diller+Scofidio's *Blur Pavilion* at the Swiss National Expo in Yverdon-les-Bains. The pavilion consists of 31, 400 jets that generate a cloud-like mass over Lake Neuchatel. The water droplets are so small that most of them remain suspended in the air, establishing a vague notion of an enclosure. Computers are then used to adjust the strength of the spray according to changing weather conditions. These conditions include the speed and direction of winds, the temperature, and the atmospheric humidity. The mist in the atmosphere moves in response to the direction of the wind as well as the movement of the visitors, creating a boundary based on the behaviours of the mist as it interacts with the energies present in the natural environment. As visitors move through the space, their eyes, ears, nose, skin and movement of the body are used to measure the qualities of the atmosphere as well as the architectural space.

Fig 4-1. Blur Pavilion by Diller+Scofidio 2002

A contingent space defined by weather is a space of multi-sensory experiences; where the qualities of matter, space, and scale are measured by the interactions of the body with the architecture and weather. The space becomes a learning environment that allows its users to recognize the event and phenomenon taking place at a particular moment in time. It also encourages multiple readings of spaces that are constantly being reinterpreted. Memories felt and experienced are those that remain most vividly in our minds, long after the moment has ceased. For Juhani Pallasmaa (2006), a childhood-image of the countryside is recollected in his depiction of the changing seasons. “I can vividly recall walls against the angle of the sun,” he writes, “walls which intensifies the heat of radiation and melted the snow, allowing the first smell of pregnant soil to announce the approach of summer. These pockets of spring were identified by the skin and the nose as much as by the eye” (p. 3). It is in the atmosphere where an architectural space is felt and experienced. This idea is also prominent in the work of Peter Zumthor. He believes that how a building responds to its context and to the senses is what gives the building a character that can only be experienced (Zumthor, 2006).

These experiences are constantly changing from one instance to another. An architecture that is ever changing like weather requires constant re-evaluation of the use and organizations within the space. Innovative uses do not necessarily deviate from habit, but can establish, affirm or develop new habits that are in themselves creative. The users’ responses to the environment can be characterised as biological responses as well as socio-cultural responses. Biological responses pertain to the inherent sensory response of the body to its surrounding context. Socio-culture responses, on the other hand, are not inherent but actively sought-after. To give an example of such socio-cultural responses, Galiano quotes Lewis Mumford in saying, “Instead of a physiological adaptation to the cold, like the growth of hair or the habits of hibernation, there is an environmental adaptation, such as that made possible by the use of clothes and the erection of shelters” (Fernandez-Galiano, 2000, p. 197). It is in socio-cultural adaptations where diverse organizations and functions of space are formed.

These socio-cultural adaptations to the environment were a major consideration in the design of traditional Japanese dwellings. In Japan, houses are designed for summer conditions, as it is believed that winter conditions are much easier to accommodate. Simply wearing multiple layers of clothes or setting up a fire can be sufficient in providing heat within the living space. Author of *Place, Time, and Being in Japanese Architecture*, Kevin Nute (2004) suggests, “The need for the household to gather around this central heat source may well have a positive effect on the Japanese family cohesion” (p. 25).

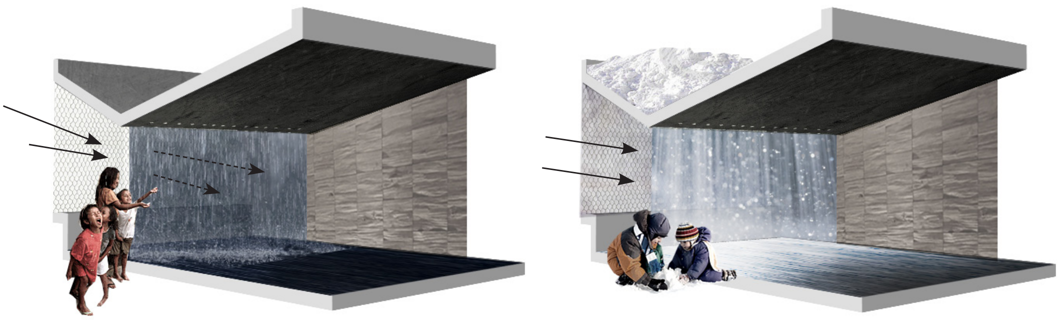
Working with contingent behaviours requires designers to recognize that the relationships between weather, architecture and its users are not singular actions, but rather, complex systems formed by the interactions between the different layers of information and responses. By working with multiple variables present in the atmosphere and architecture, multiple temporal outcomes are established to provide new opportunities for creative uses. These possibilities constantly emerge and renew the objective and subjective readings of architecture.

SENSORY EXPERIENCES

Design Exploration

In a contingent space, users are exposed to multiple conditions and effects that are in a state of continuous adaptation and change. These conditions overlap to create multiple readings and sensory awareness. This particular study explores the impact of rain, snow, and ice on the auditory, visual, and tactile experiences of the users. The roof is designed to allow precipitation to filter into the interior space to immerse its users in a weather active zone that encourages a range of sensory stimulations.

The introduction of precipitation creates a screen that cascades into the interior space, creating an ephemeral boundary that alters the degree of light entering the space. During cold temperatures, the screen freezes into a wall of ice that evenly diffuses light passing through; while during warmer temperatures, the rain creates a scattered lighting effect.



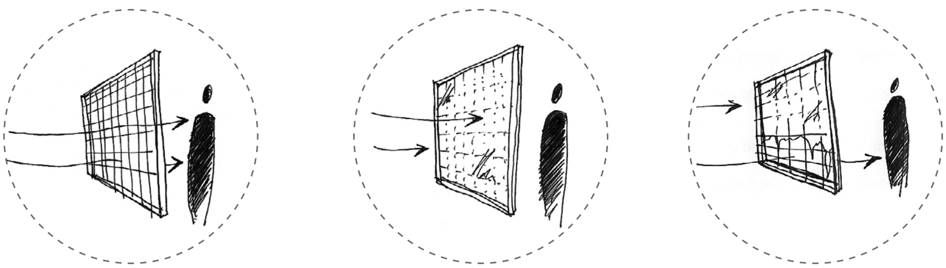


Fig 4-2. (Top) Conceptual renders indicating the transient wall to allow light, air, and rain to enter.
Fig 4-3. (Bottom) Conceptual sketches illustrating the transitions of a wall based on changes in state

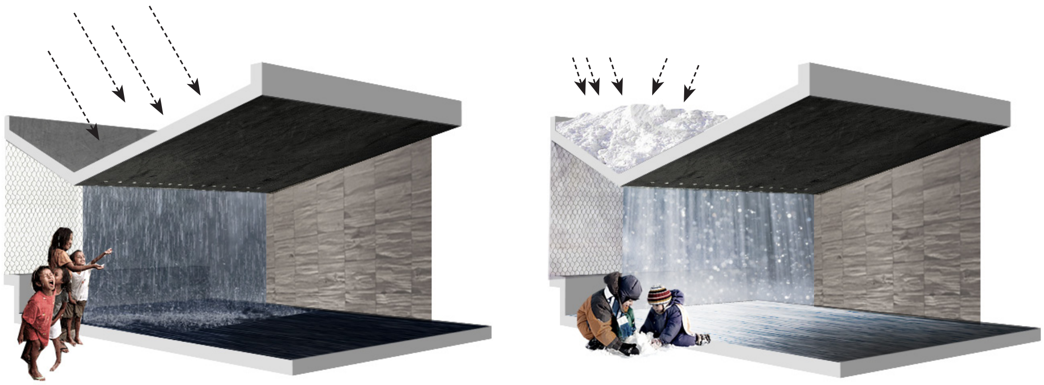


Fig 4-3. Conceptual renders indicating the acoustical and thermal effects of snow and rain as falls and settles on the roof surface

During the warm seasons, the sound of rain is heightened as it falls and drips off the various material surfaces. While during the colder seasons, precipitation is much denser, falling in the form of ice or snow. As a result, there is a greater possibility of build-up and accumulation that create a layer of sound and thermal insulation – damping the sounds within the space and creating a sense of warmth and stillness.

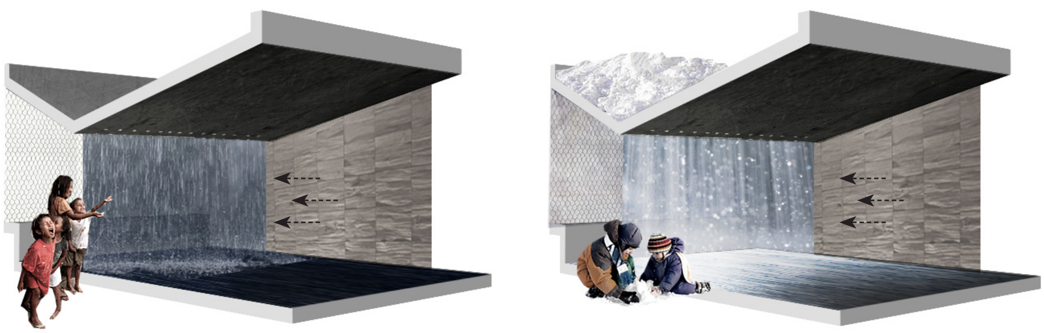


Fig 4-4. Conceptual renders indicating the role of materials in stimulating sensory responses

Temperature changes of the materials and even the dampness of the material create an overall aura of smells and touch within the space.

CHAPTER 5

DESIGNING FOR WEATHER

In 1984, Cedric Price and Joan Littlewood designed the *Fun Palace* as an experimental project exploring interactive spaces. The floor, ceiling, and wall surfaces were designed in such a way that they could be moved and reassembled based on the changing needs of its users. The intention of the project was to create a learning environment based on instability and change. It kept the users in continual anticipation and encouraged different functions and organizations of the space. In a discussion on responsive architecture with Omar Khan and Philip Beesley, Khan suggests,

> "What remains provocative about the Fun Palace is that its technologies are deliberately wild and dangerous, ripe with creative potential", in which Beesley responds, "The fragility of the structure was, of course, part of the point – it didn't try to resist. Instead, it seems to have been framed as lightly as possible, so that it could give way to action"
>
> (Khan, Scholz and Shepard, 2009)

When designing for weather, the same ideas of interactivity and openness are applicable. Similarly, it is important that the building is framed as lightly as possible to allow open interactions between the exterior weather and interior environment. This sense of openness and lack of a definitive enclosure can be achieved by making the building porous and permeable. The designs should encourage interactions between the architecture, weather and their users by embracing contingency and entropy in both the natural and built space. When designing for weather, the architecture becomes a learning environment for both the natural and built context.

SITE

Based on the three concepts previously established, the ideal location would have an ever-changing and dynamic range of weather conditions. To avoid falling into expectant behaviours and habits, the interactions between architecture, weather, and the users must be constantly redefined. On a static site, the sun always rises and sets in the same location of the space. Whereas, on a dynamic site, such that the building shifts and reorients with the conditions of its surroundings, the direction of the sunrise and sunset is ever-changing. By selecting a site on water, the building is entirely governed by the conditions of weather. The movement of air in the atmosphere drives the building's foundation as it directs the orientation and displacement of the building. The architecture becomes an object in transition; defined by multiple vectors, flows and movement. Similar to a weather vane, the building responds to the weather by following the directions of the wind and the currents of the water.

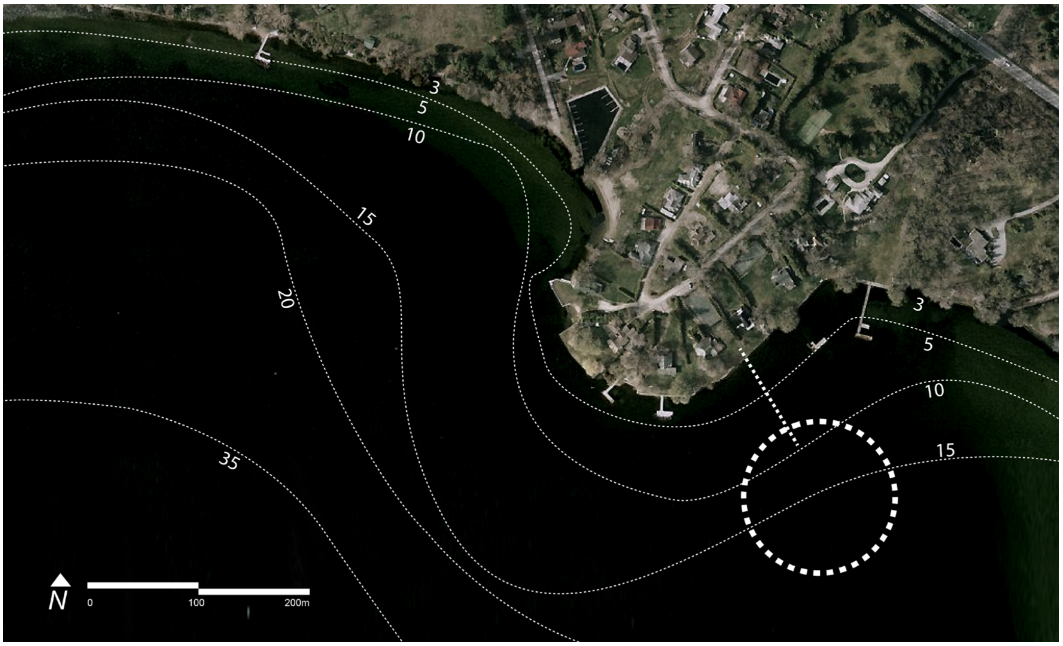


Fig 5-1. Diagram of Cook's Bay, Lake Simcoe, the site of exploration

The northern shore of Cook's Bay in Lake Simcoe was chosen as the site of the design exploration. This site was chosen for its range of weather conditions and seasonal variations. Lake Simcoe is well known for its ice fishing activities as the lake freezes into a thick surface of ice during the winter months. In selecting this site, the experience of freeze and thaw effects are reinforced by the transition of the ground plane. In the winter, the structure is pulled to shore and docked in a fixed location, while in the summer; the structure is free to move in accordance to the currents of the water.

STRATEGIES & EXPLORATIONS

This thesis re-examines the relationship between weather and architecture and demonstrates that weather can enrich the experience of architecture. The investigation has outlined several critical issues to be addressed in the experience of architecture. First, architectural spaces are often designed and experienced in isolation from external forces and the presence of time. Second, habitation is pre-determined by the architect and governed by the initial function and conditioning of the space. Third, solutions that deal with the external environment are usually grand gestures that respond to the conditions of climate rather than the immediate conditions of weather.

Several strategies and concepts were explored in an initial design. These strategies include: designing a porous and permeable structure to allow open interactions between the external forces and the interior conditions; acknowledging time by encouraging the effects of weathering to enhance material properties and their relationships; promoting creative use and new habitation by introducing a range of socio-cultural responses based on contingency and unpredictability; and designing for the body and sensory responses by focusing on the interactions between the atmosphere and the users.

The act of constructing a building establishes two distinct environments. This thesis is not about establishing an interior space that is identical to that of the exterior environment; but rather, it is about the utilization of weather to enhance the experience of these interior spaces. This research argues that when designing for weather, the building should act as a mediator between two environments that enriches the experience of three conditions of spaces – the exterior, interior, and the threshold between. The experience of weather is separated into direct exposure and indirect translation through the building. The exterior weather is experienced through direct exposure, while the interior weather is experienced through the architectural translation.

Weather is a complex interaction of multiple atmospheric conditions; it is the layering of actions to create momentary events. In architecture, this is applied to the layering of spaces and material systems to encourage multiple uses and readings of spaces. The initial design is a small fifteen square meter structure (5x3 meters), with two volumes of space. The spatial organization of the building adopts a simple open plan to give way to open interpretations. The building design is framed as lightly as possible with various perforations and openings to allow momentary floods of light, air, and precipitation into the interior spaces. The design incorporates a range of materials and spatial qualities that encourage different sensory responses. These include varying the texture and colours of materials, as well as different scales and dimensions of spaces.

MATERIAL SYSTEMS

The structure consists of different surface materials and textures to encourage a range of sensory responses. The material character is expressed through its ability to retain moisture and heat during different weather conditions and its transformations over time.

A combination of copper, wood, steel, and concrete were used to enrich the architectural experience of the users and the process of weathering. These materials were selected for their specific tactile, visual, and thermal properties. Metal surfaces are great conductors that cause a significant contrast between hot and cold sensations in accordance to the atmospheric temperatures. Wood, in contrast, is a better insulator, which provides a warm sensation throughout the seasons. Concrete surfaces retain and radiate heat throughout the day, to provide a gradual transition between cool and warm sensations throughout the day.

The roof structure is designed with copper. This encourages the process of weathering to record and showcase the effects of time. By enclosing the roof with copper, the acoustical impact of rain, wind, and other external forces on the surface is amplified. A combination of white cedar panels and shingles are used for the enclosing wall surfaces and decking on the second level space. The wood panels are evenly distributed with a small spacing between each panel to allow for open interactions between the inside and outside. Within the space, steel is used for the structural system and stairs, while a hollow concrete pontoon is used for the base of the structure.

In addition, elements such as elastomer membranes, fabrics and metal chains were incorporated in the design for their ability to stretch, sway and billow in response to movement in the atmosphere.

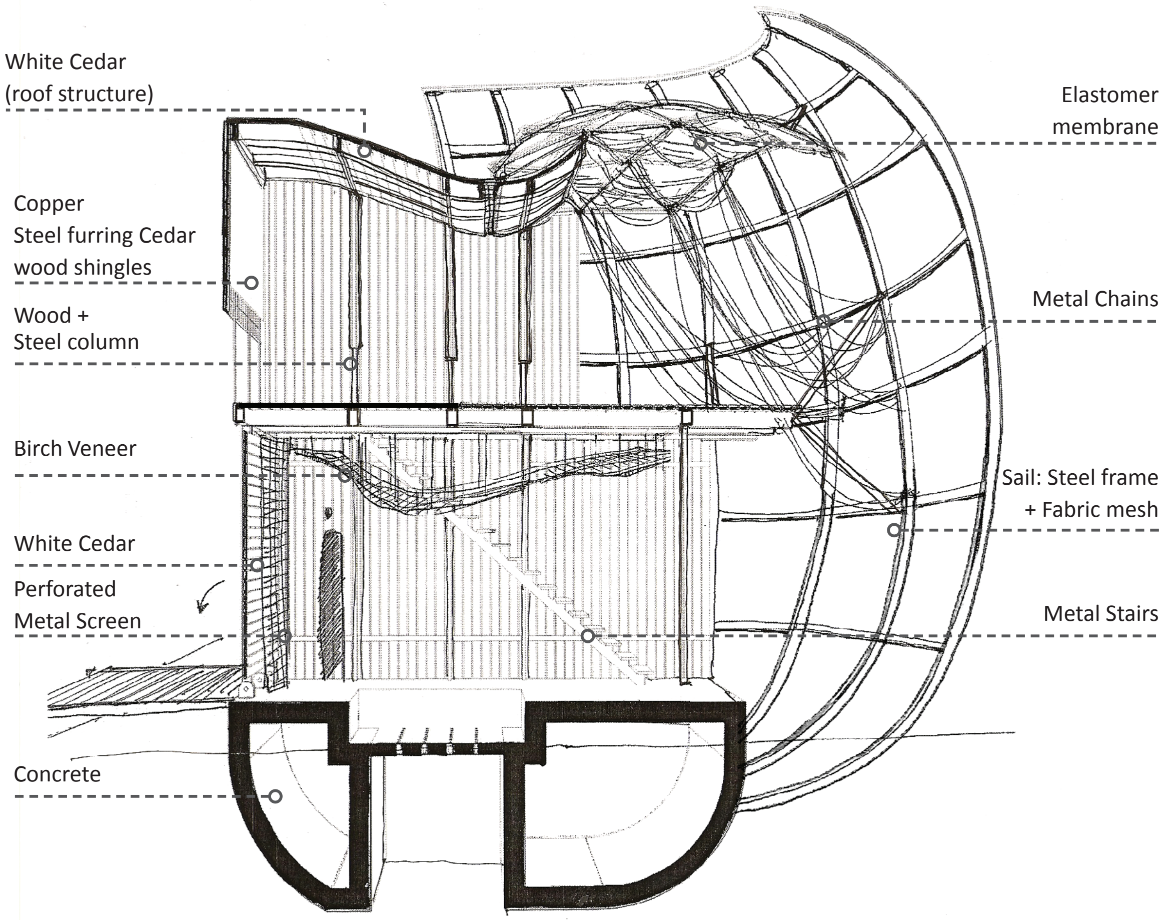


Fig 5-2. Building Section illustrating the various material systems

ORIENTATION AND WEATHER PATTERNS

The process of weathering has the ability to showcase the conditions of a particular location through the emergence of specific patterns. A greater degree of degradation, discolouration, and warping of wood shingles indicate the prominant direction of weather. In a building where orientation is defined by weather, particular sides of the building will always be propelled towards the dominant direction of weather. As a result, in this particular design, the contrast of weathering is magnified.

MATERIAL RELATIONSHIPS (Copper, steel, and wood)

Patterns also emerge to indicate the relationships between various material properties and material compositions.

Copper Roof & Wood Panels/shingle: streaks of patina stains on the wood surfaces indicate the relationship between the wood surfaces and the copper roof above, while the colour and length of the stain indicates not only the presence of copper, but the depth, the weathered properties of copper, and its composition with the wood surface.

Copper & Wood Veneer: Adopted from a former study (refer to "Wood Exploration 2" p. 28) the wall system consists of layers of copper, exposed steel furring, and wood shingles to encourage the staining of the various materials and varying the effects of oxidation on the copper surface.

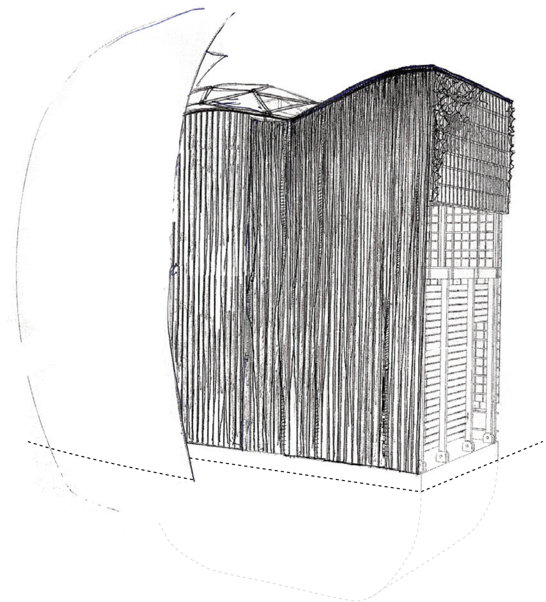


Fig 5-3. Exterior perpective illustrating the effects of weathering

STRUCTURAL INTEGRITY

Some materials degrade overtime, while others are renewed and strengthened. The polymer membrane is an example of a material that loses its elasticity with time. As a result, larger openings are created as the membrane expands and sags; creating greater porosity and vulnerability to the outside environment over time.

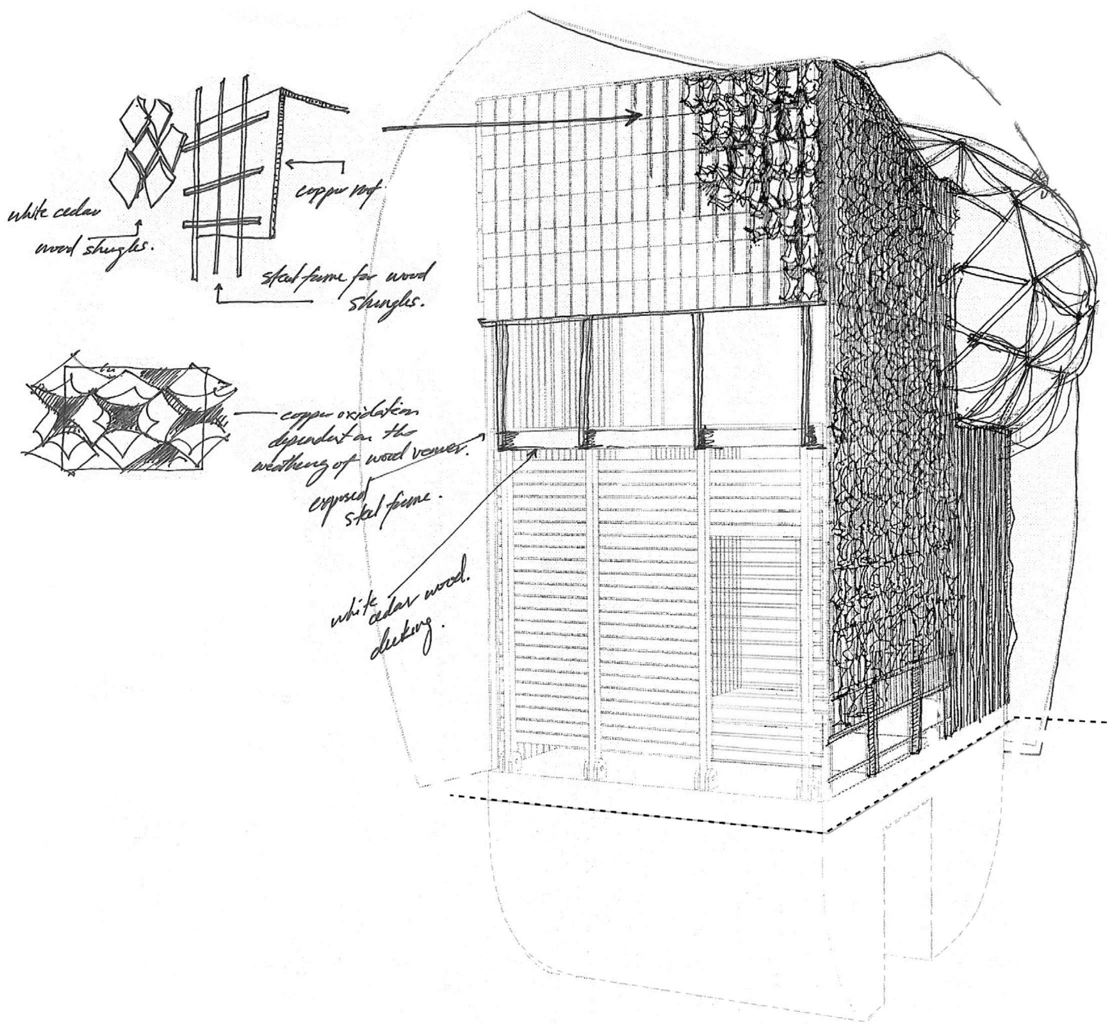
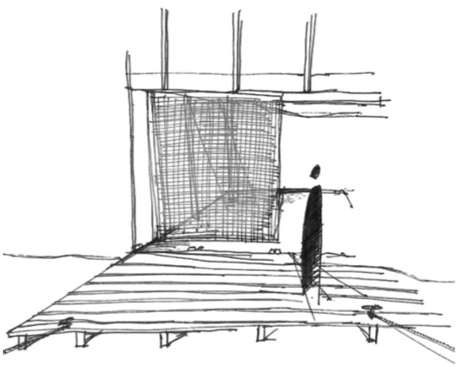


Fig 5-4. Exterior perspective facing dominant winds

ACCESS & ENTRY

The entrance is articulated in such a way tha prior to entering the architectural space, visitor are enveloped by the various surfaces an components of the structure. These moment of encounter with the architecture creat unique experiences that express the qualitie of the natural and architectural environmen simultaneously.



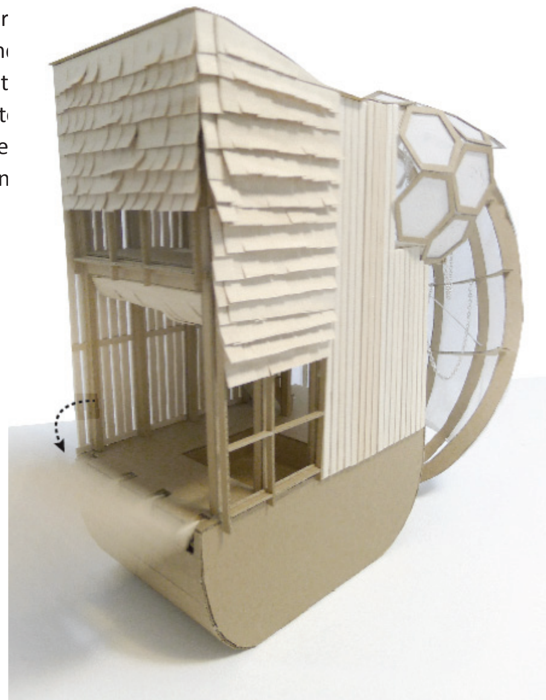


Fig 5-5 (Sketch) & Fig 5-6 (Model) illustrating the winter access

Due to the uniqueness of the site, two entrances were designed for the warm and cold seasons with very different experiences. During the colder weather, the structure is docked on shore where the enclosing wall drops down to create a docking platform. This entrance is very direct, and formed by a simple orthogonal formal expression.

The floating entrance on the other hand, takes advantage of the movement of the building to create a more dynamic and complex experience of entry. Users are swept into the sail as they enter the structure. The sail pivots and rotates on the horizontal axis with the movement of the wind, -- altering the location and the width of the entranceway. In addition, chains hang loosely from above, swaying with the motion of the building and the sail.

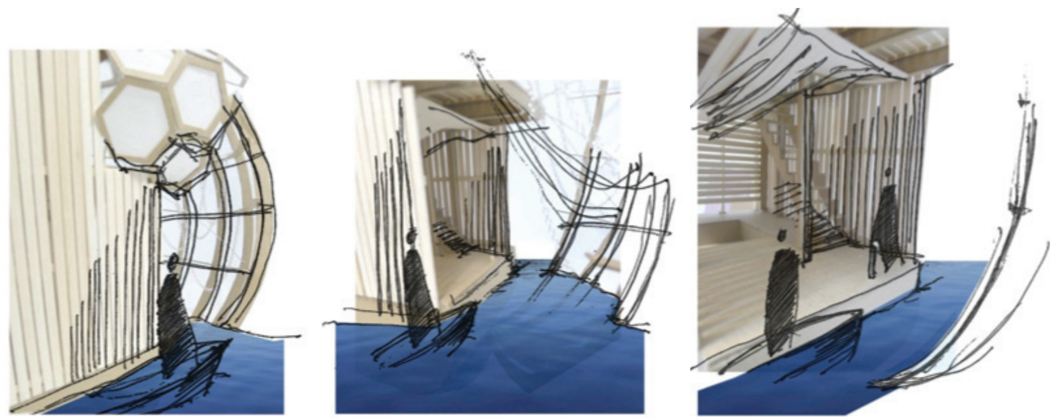


Fig 5-6. Conceptual renders of the summer access

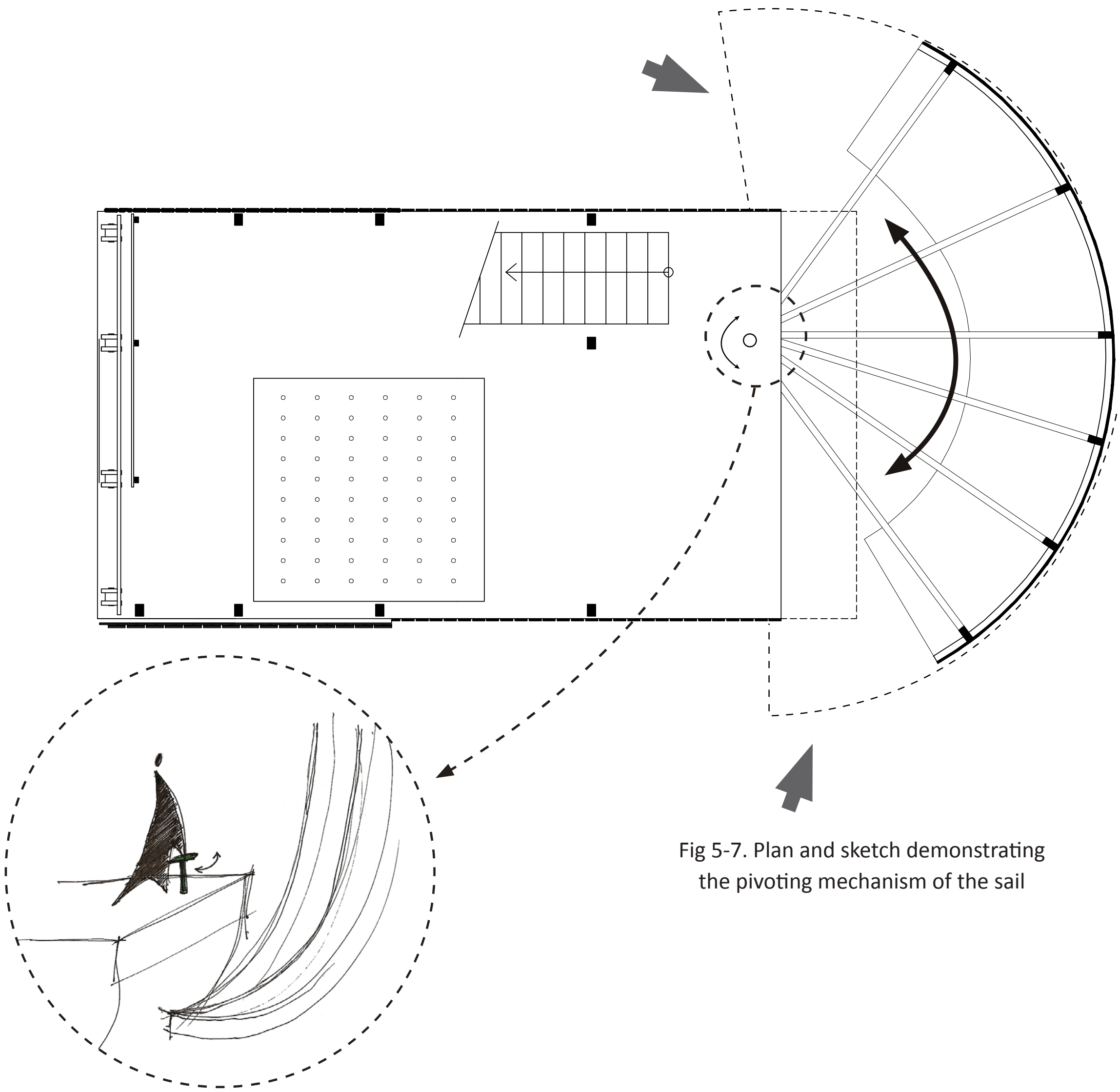


Fig 5-7. Plan and sketch demonstrating the pivoting mechanism of the sail

The sail of the floating structure not only plays a crucial role in the orientation and displacement of the building, but also influences the experience of the entry. The sail is attached at a pivot point to the hull of the boat and reinforced with steel rods to the steel frame of the upper deck. Attached at a single point, the sail is free to move laterally in the direction of the winds, changing the course of the building's movement and dynamically altering the location, dimensions and geometry of the entrance.

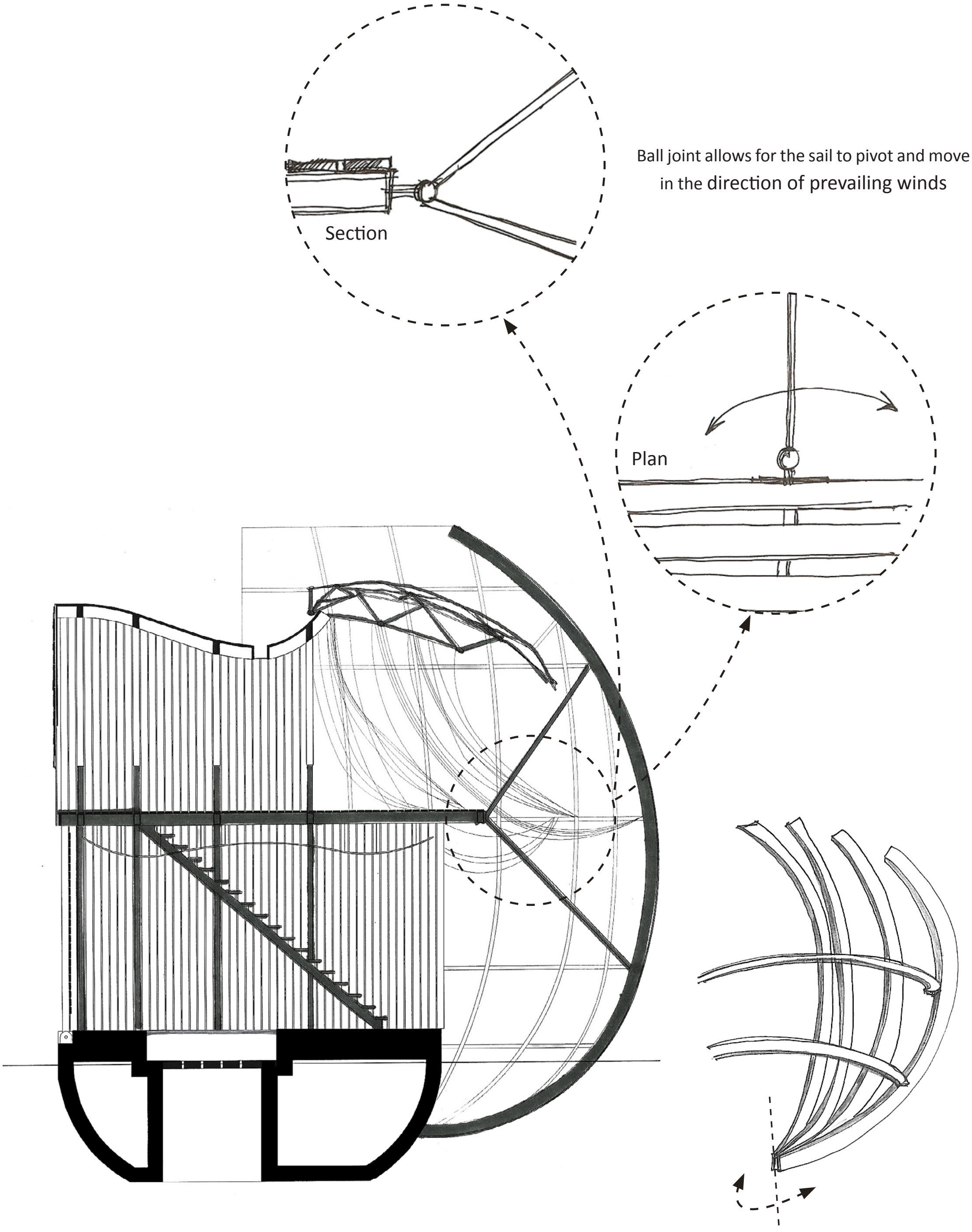


Fig 5-8. Section and sketches demonstrating the pivoting mechanism of the sail

SYSTEMS & EFFECTS

Old conceptions of comfort and habitation are challenged by the vulnerability of the architecture and the users. The dripping rain and ice formations, along with the howling winds and the flooding of spaces through the many perforations in the building instigate a sense of fear that is not common in our current conception of habitation. It is through this sense of vulnerability where a greater awareness of architecture is developed and new approaches to design and habitation are introduced.

Many components of the building extend continuously from the interior to the exterior. As a result, the architectural components simultaneously showcase the different weathering effects as rendered by the exterior and interior conditions. These moments of encounter with the architecture create unique experiences that express the qualities of the natural and architectural environment simultaneously. By introducing weather as a participant in the architectural process, it not only allows users to better understand the architecture, but also the phenomenon of weather.

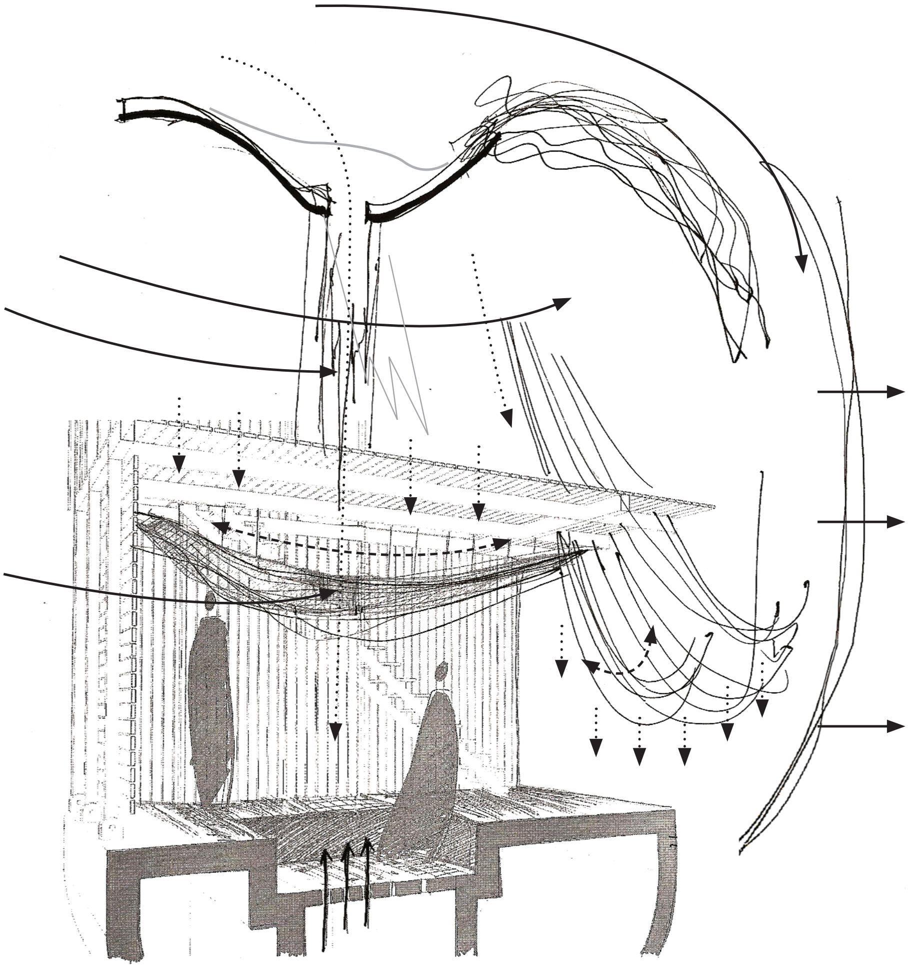
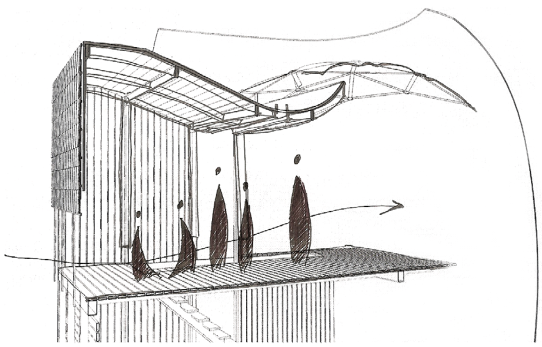


Fig 5-9. Building Section illustrating the different energy transfers within the space

Once inside, the users are immersed in a range of experiences. Something as simple as rain and wind interact with the different elements of the building and the spaces between each other.

Light, sounds, winds, smells, and sights filter through the many layers of the architecture - the gaps between the wood panels and shingles, the spacing of the floor decking, the porous concrete pontoon, porous roof membrane and the fabric mesh screen. The interplay of these various openings create greater variations and conditions to unfold.

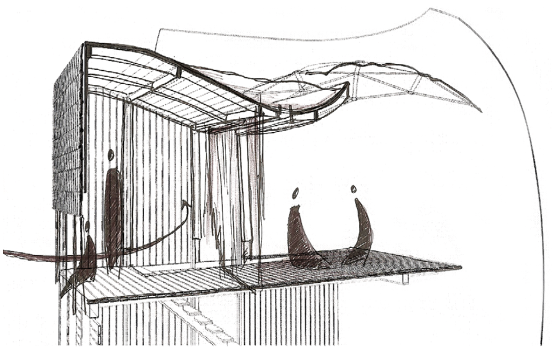


In its neutral state, the building assumes an open plan

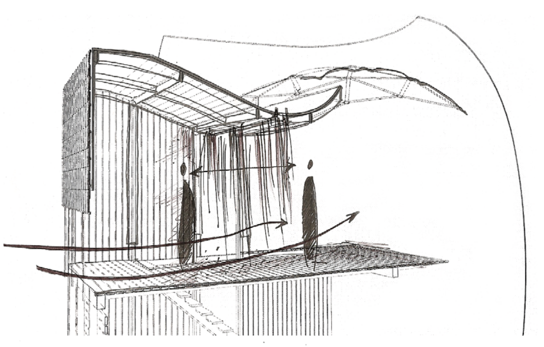
SOCIAL ORGANIZATIONS

Through an opening in the roof, rain, snow and ice are filtered to the interior space. Adapting the ideas of a former design exploration (refer to *Design Exploration: On Sensory Experiences* p. 46), the conditions of rain and snow within the interior space create a range of acoustical, tactile and visual experiences. The introduction of the weather into the building creates an ephemeral boundary condition that also encourages different uses of the space.

Fig 5-10. Sketches illustrating the different social arrangements based on different weather conditions



The formation of ice creates a physical barrier that divides the space into various zones



Rain creates a momentary barrier that oscillates with the intensity of rainfall

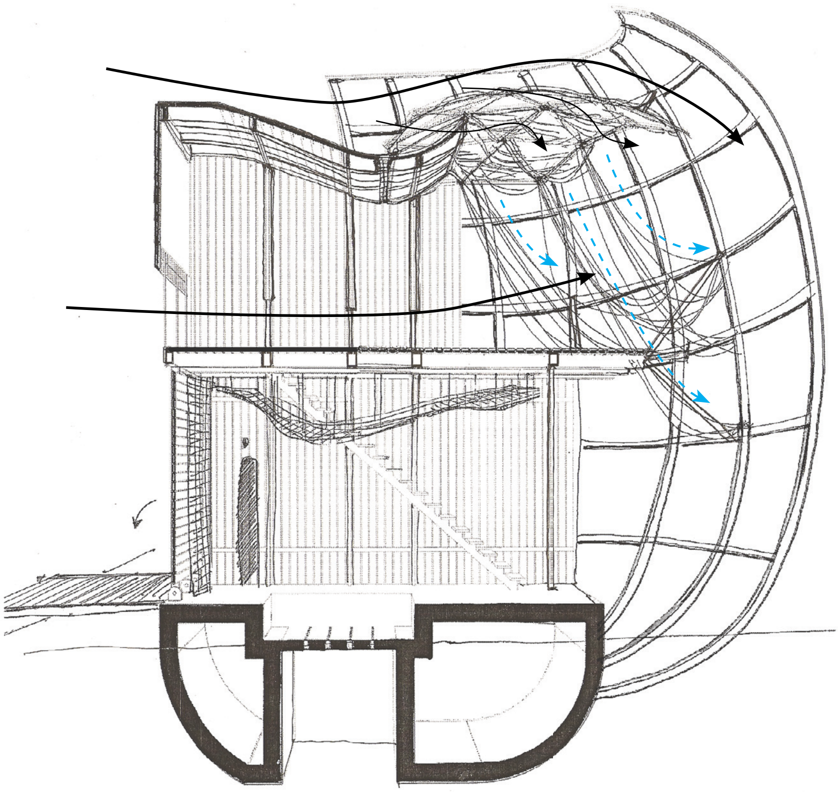


Fig 5-12. Sectional Sketch of the porous envelope and chain system

POROUS ENVELOPE

The porous roof surface allows air to filter through into the interior space. Along with the flow of air, light permeates and filters through the surface. This light is reflected off the ground and large fabric surface of the sail to create a dynamic display of shadows and light.

The curved roof encourages the movement of air towards the sail, propelling the building to move in response to changing weather conditions.

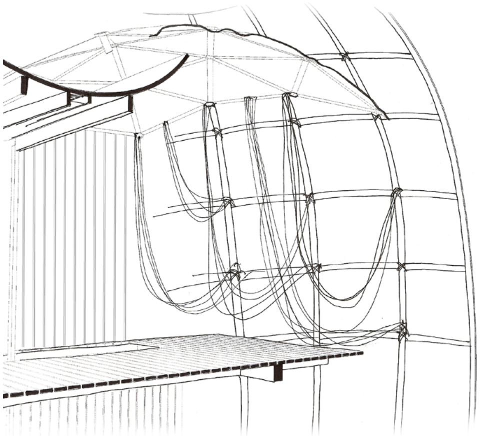


Fig 5-11. Upper level sketch of the porous envelope and chain system

Light chains were incorporated into the design to detect minutiae changes in the atmosphere. Like wind chimes, the sounds are directly reflective of the surrounding – the stillness of the frozen conditions of winter, a contrast to the calm dripping of water after a storm, or the clanking of chains in the presence of wind. Visually, the chains cast shadows that reflect the rhythm of the wind.

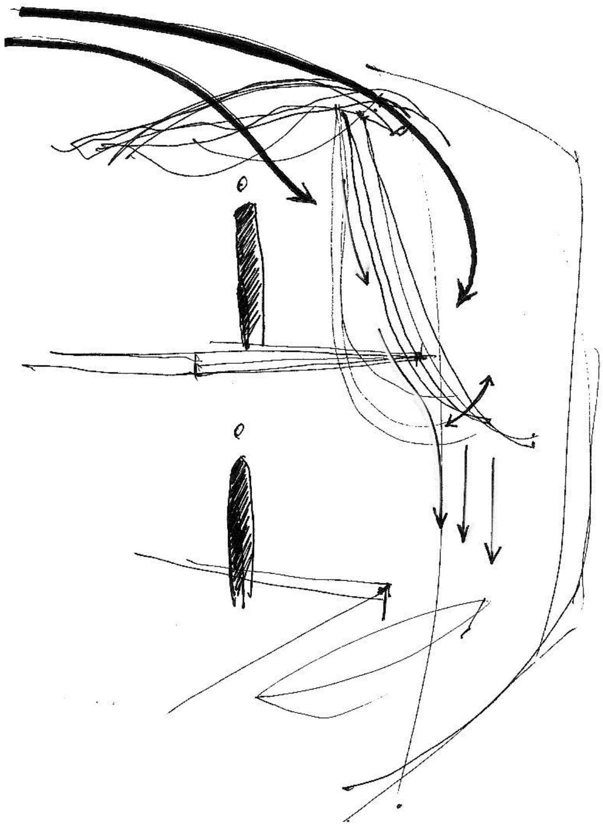
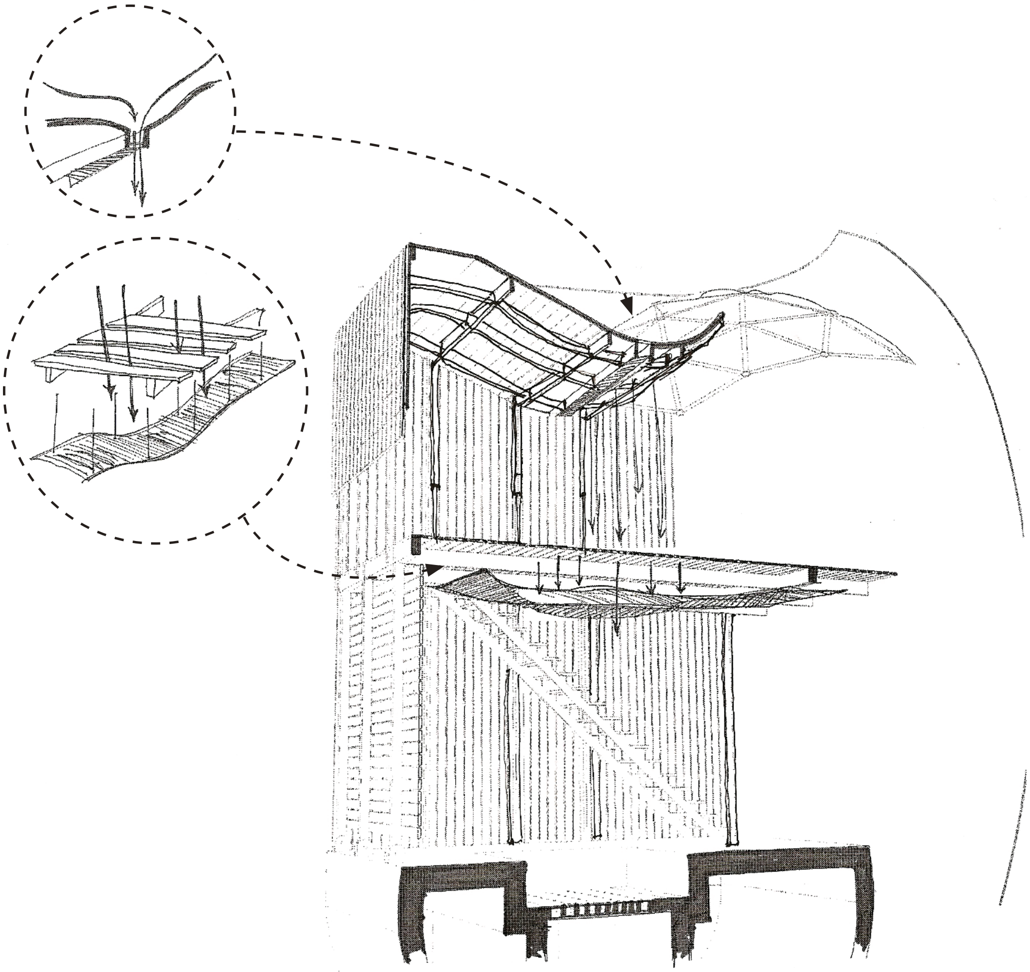


Fig 5-13. Conceptual sketch of the effects of wind and precipitation

These two systems work in tandem with each other to amplify the material and sensory responses. Physically, the two systems are connected through their similar materiality and structural system.



As water is brought into the building from the roof opening, water seeping through the wood decking encourages warping and sagging of the wood veneer below. With a low ceiling height, the sagging of the wood forces the users to adjust as they move through the confined space.

Overtime, the moist interior atmosphere encourages the growth of moss and other forms of life. The structure gradually becomes a habitat not only for its intended users, but a space for different organisms to coexist. (refer to *Wood Exploration 3: Wood Textile* p. 29)

Fig 5-15. Lower level interior perspective

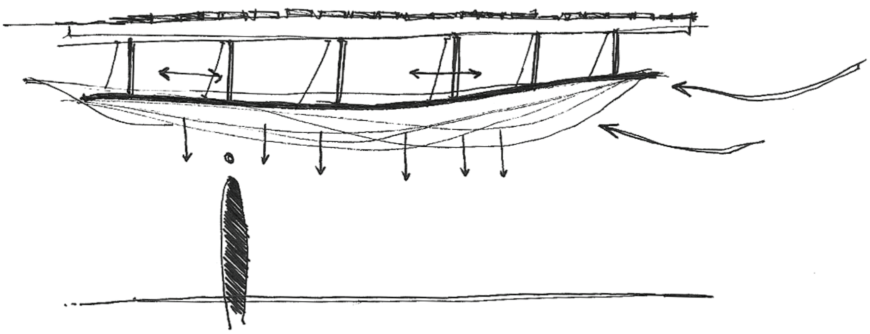


Fig 5-16. Conceptual sketch of the effects of wind

Wind seeping through the gaps and openings of the enclosing surfaces encourage the hanging wood ceiling to sway, shift, and warp to a different rhythm than the rocking of the floating concrete structure.

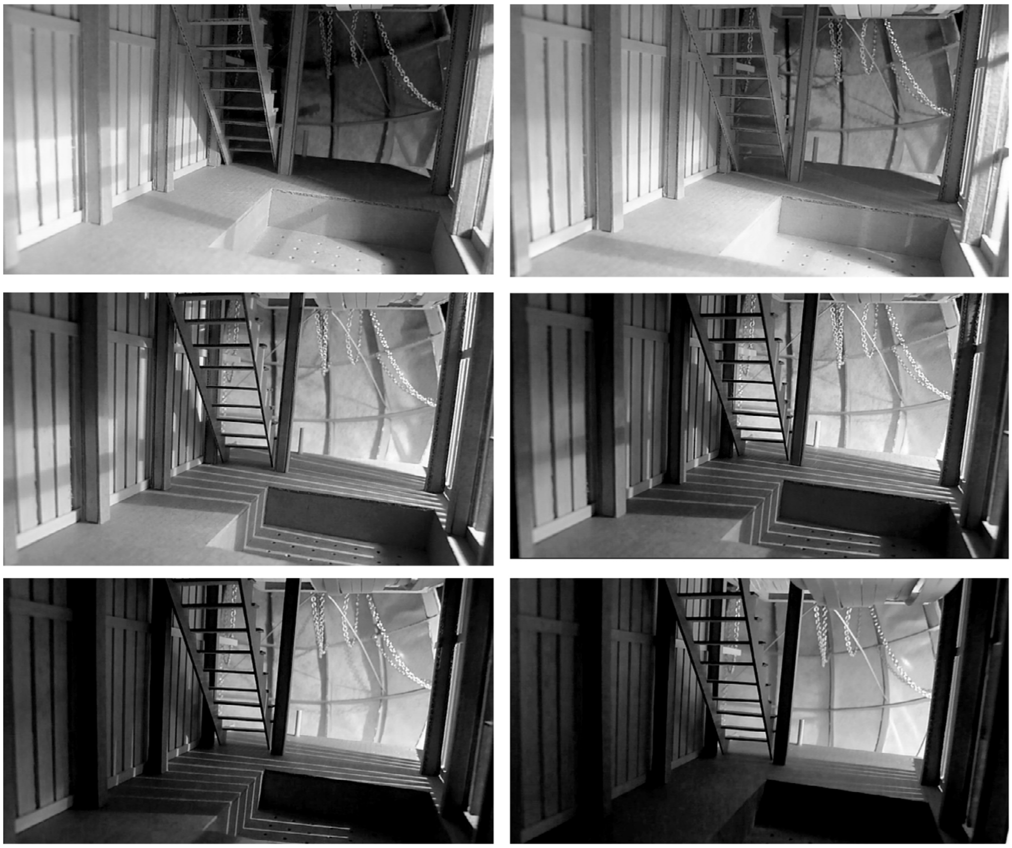


Fig 5-17A. Interior Shadow Studies

LIGHT & SHADOW

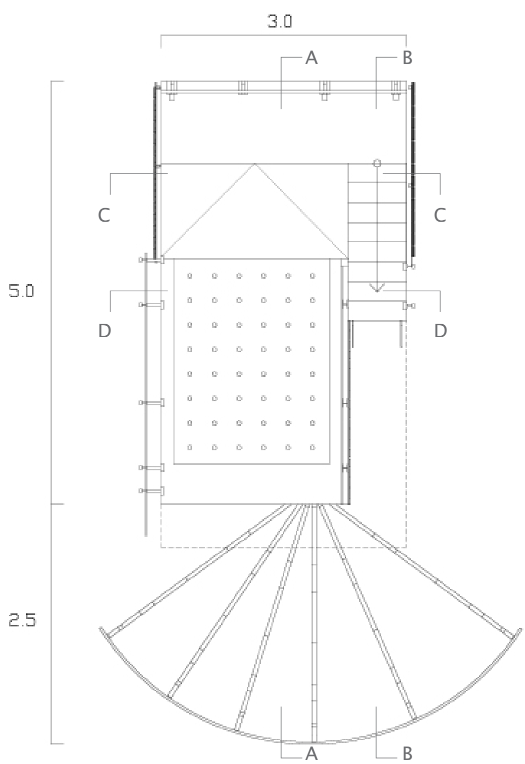
The framing, perforations and openings of the building create momentary floods and patterns of light and shadow. The long cedar barn boards and wood decking create a striated pattern of lights and shadows in contrast to the small breaks between the wood shingles. These patterns of light are incrementally changing as the wood shingles gradually warp and bend with time.

Fig 5-17B. Interior Shadow Studies

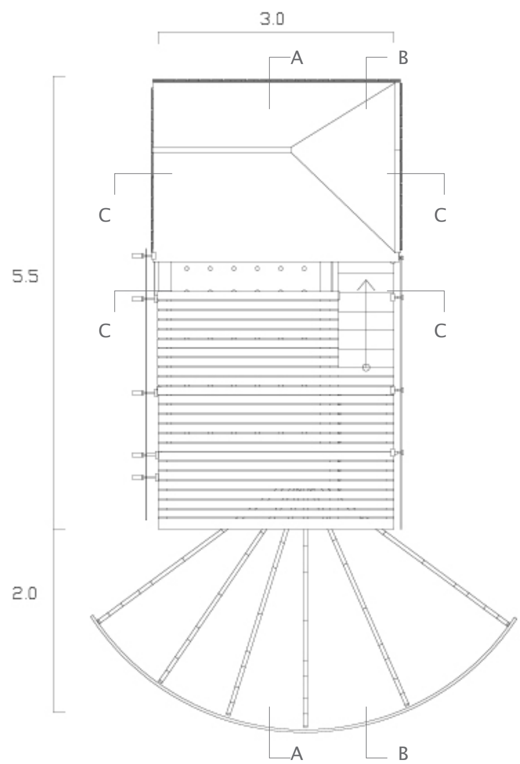
Fig 5-18. Exterior view illustrating the porosity of the structure

THE WEATHERING HUT

These ideas all showcase how weather can be better incorporated into the design of buildings to encourage a greater awareness of not only the architecture, but also the surrounding environment. In this intial design exploration, weathering effects, concepts and ideas have been applied in more or less segregated zones of spaces. A final design looks at how these ideas come together in a holistic architectural experience.



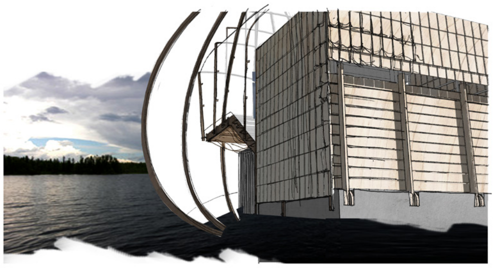
First Floor



Mezzanine

Fig 5-19. Plan

The final design is fifteen square meter (5x3 meters), with a mezzanine creating three different volumes of spaces.



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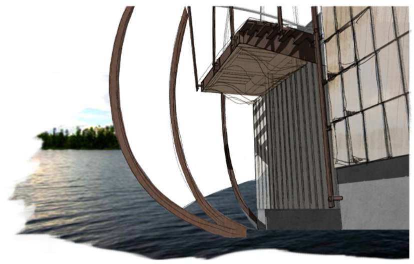

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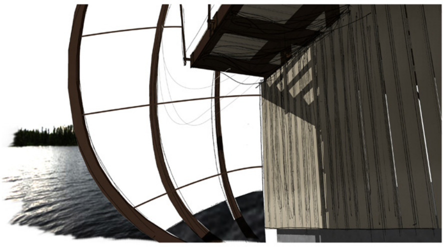

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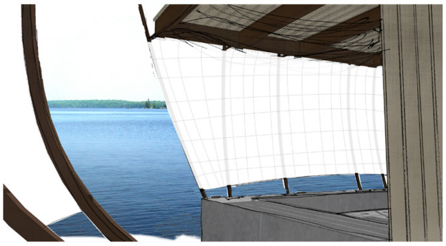

4

Fig. 5-20. Sequence of renderings that narrate the entry progression into the building

The entrance is articulated in such a way that prior to entering the architectural space, visitors are enveloped by the various surfaces and components of the structure. Upon entering, visitors are taken under the overhanging portion of the mezzanine and then swept between a large sail and the main enclosure.

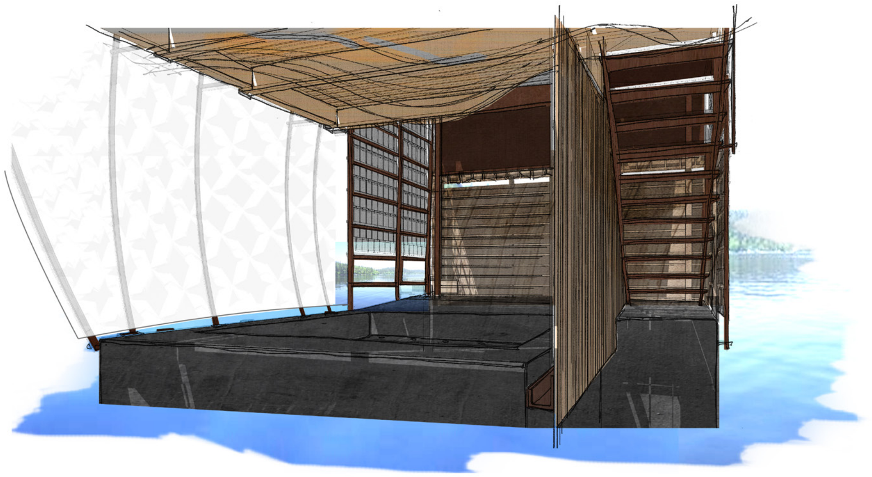

Fig. 5-21. Illustration showing the threshold between the interior and exterior

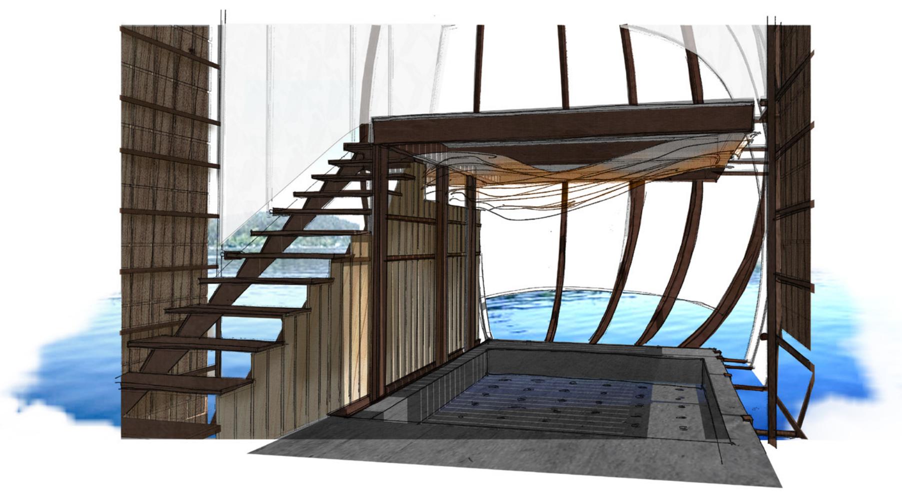

Fig. 5-22. Interior perspective illustrating the connections to the outside and the interactions of various material systems

Fig 5-23. Section A

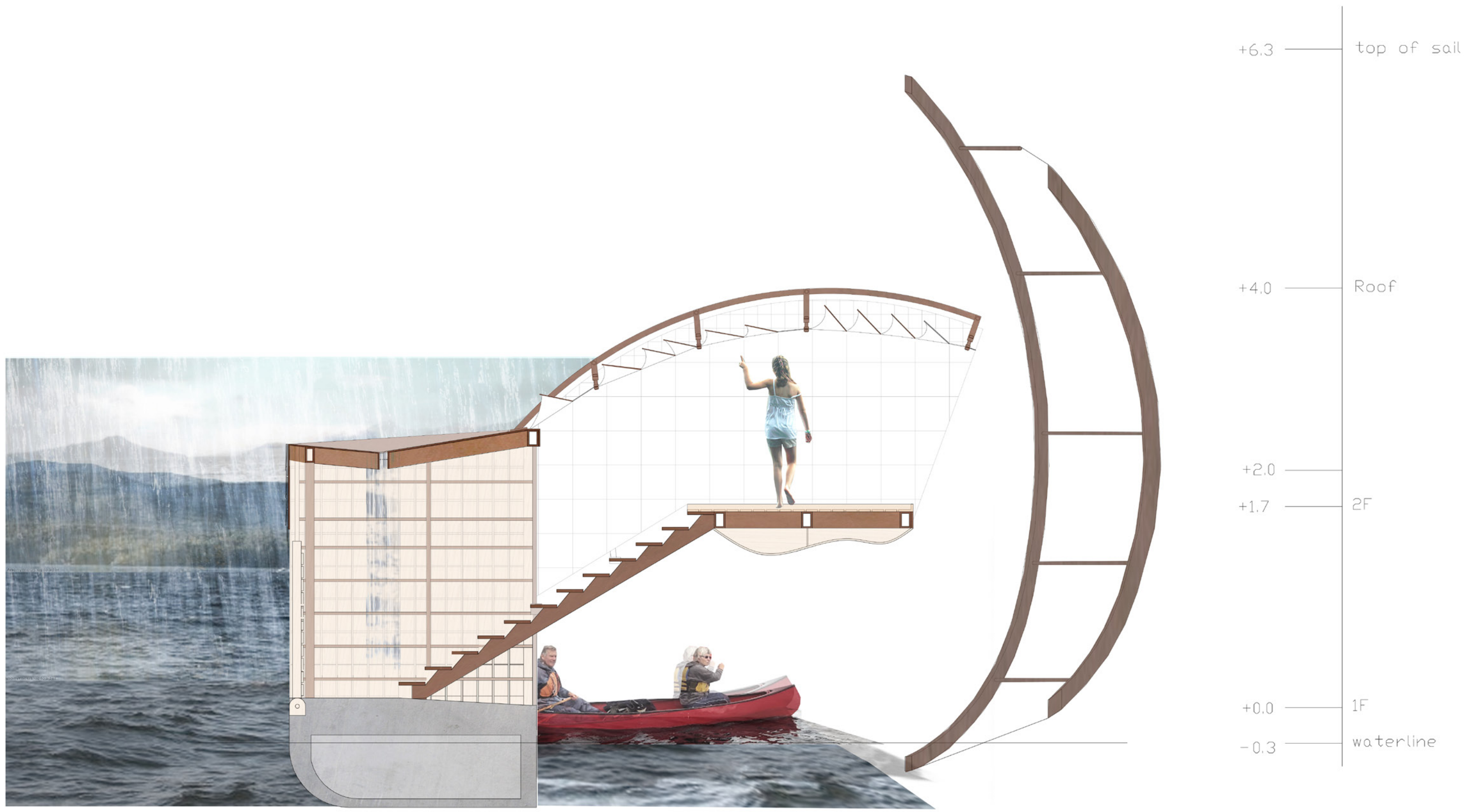

Fig 5-24. Section B

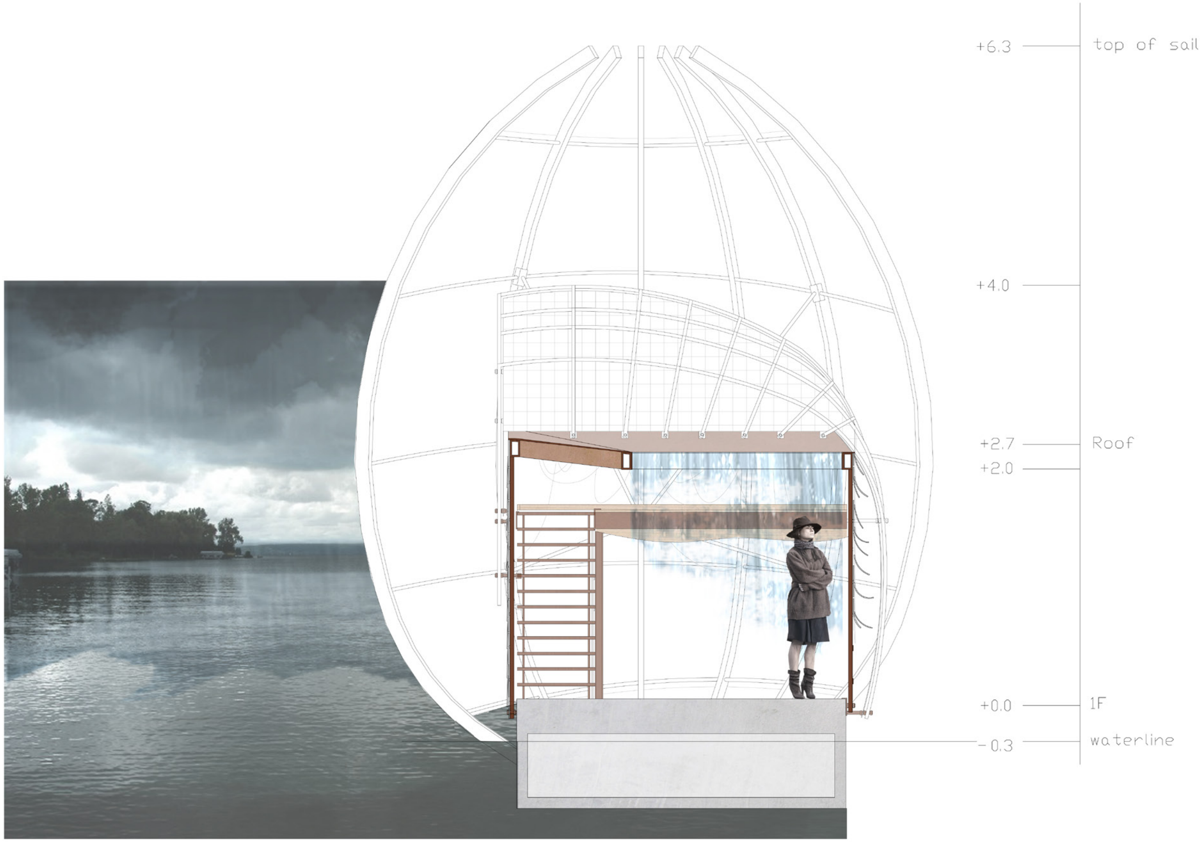

Fig 5-25. Section C

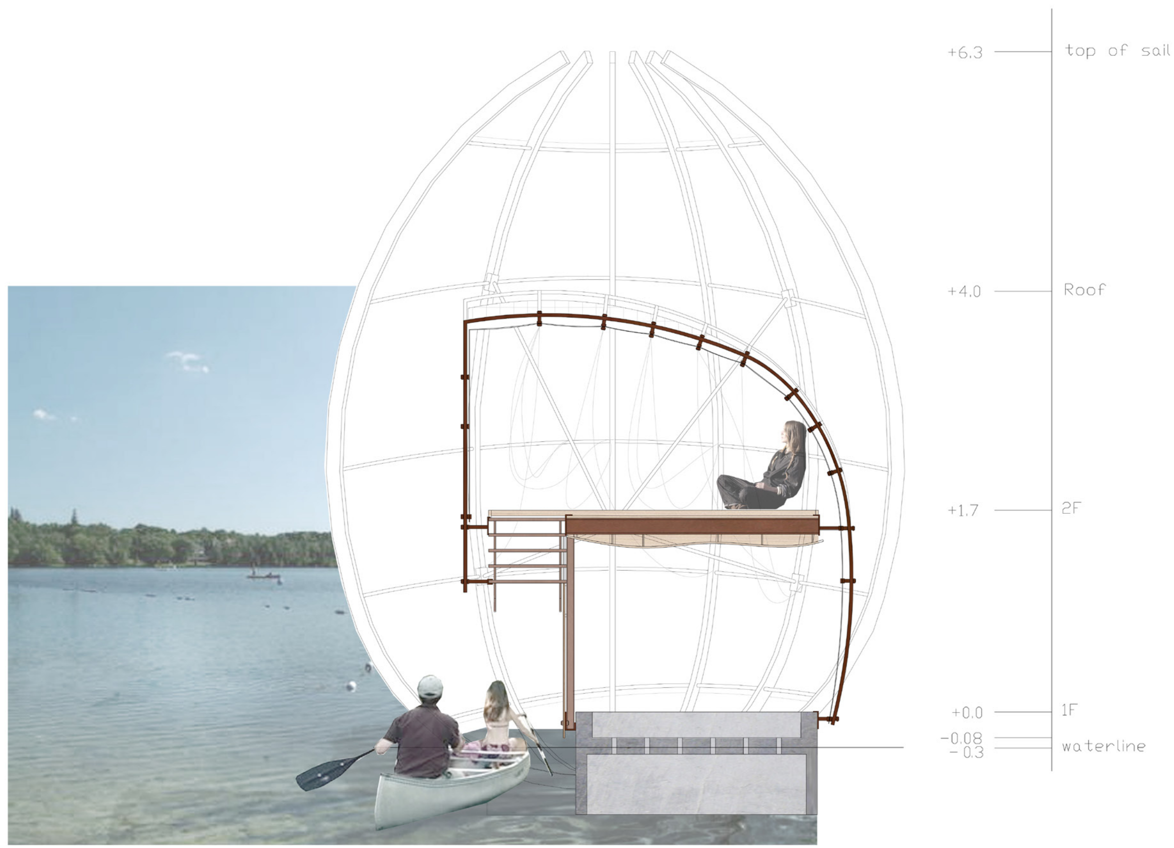

Fig 5-26. Section D

CHAPTER 6

CONTINUING THE DIALOGUE

The research demonstrates that for successful designs, a dialogue must be established between weather and architecture. Contingency and entropy need to become collaborators in shaping the architecture as well as the architectural experiences. In *The Architecture of a Well-tempered Environment*, Banham suggests the campfire as the ideal model for architectural conditioning, however, this research argues that in order to fully experience and understand our environment, we must let go of control and allow ourselves to be vulnerable.

Unlike Banham's *tent* and *campfire* model, the research and design illustrate a new approach based on the mediation between the natural and architectural environment. It recognizes architecture as a process that evolves with the conditions of its surroundings and acts as an indicator of time. When designing for weather, a deconstruction of the spatial and discursive boundary is required for an architecture based on behaviours and temporal flows. This approach promotes open interactions between the architecture, weather and its users by adapting weathering effects to enhance material character and relationships and to encourage diverse biological and socio-cultural responses. By designing for weather, the building's organization and processes are shaped by conditions of flux and change. This sense of unpredictability challenges the notion of comfort and begins to redefine the meaning of habitation.

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