TOWARD A NEW TECTONIC

by

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ABSTRACT

Architecture's role as the mediator between the environment and occupant has been discarded, handing off the roles of structure and environment to engineering, and leaving itself spatial planning and aesthetics. Simultaneously, standardization has further reduced the expressiveness of architecture. The tectonic traditions of architecture have been cast aside in favour of a pan-global style, and remain marginalized with the current trend toward the overly formalist design of the first digital era.

In opposition to the generic, thin architecture that has been produced through the use of climate control - digital simulation of environmental forces, materials, and construction, can allow for the generation of a thick architecture of specificity, tuned and expressive of its place through an expanded sense of the tectonic material basis of form. This associative architecture, formed by physical forces, with a basis of 'necessity' will allow for an attempt to reassert a more substantial architecture through digital means.

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To my family.

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INTRODUCTION

The current state of architecture leaves no room for architecture. Flexible floorplans and thin skins with the accompanying air conditioner leave no room for design. A building can exist with a flexible floorplan anywhere and with any curtain wall or standardized skin with any air conditioner. This generic architecture therefore does not need to respond directly to the environment in which it is situated, leading to an atectonic expression. According to architect James Marston Fitch "the ultimate task of architecture is to act in favor of man: to interpose itself between man and the natural environment in which he finds himself, in such a way as to remove the gross environmental load from his shoulders." (Fitch, 1972, p. 1) Architecture has succeeded at this task, at first with response to forces of the environment, as seen in vernacular architectures which largely managed to do so without mechanical intervention, and with the materials readily available on the site.

This vernacular architecture, meant to mediate the hostile environment for its occupant has been explored by many theorists in the concept of the primitive hut. Of course each of these huts is an invented one, an idealized construct to explain the origins of architecture, but it makes the concept no less potent. This un-complicated architecture of essentials began with survival – the creation of a stable environment for habitation in the face of one which was hostile and changing – and eventually turned to comfort, over time

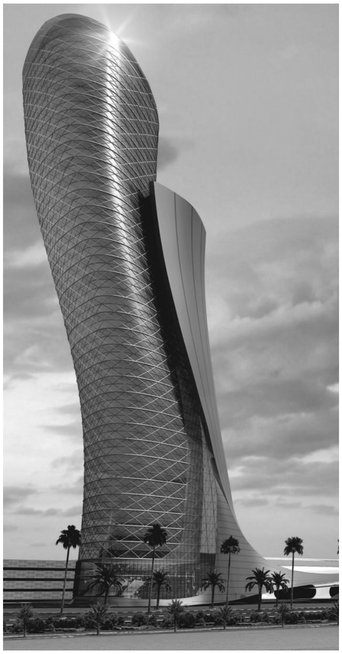


Figure 1 & 2: Elastic, ill fitting, for when the dealing with outside is not an issue.

tuned to the needs of its occupant, the specifics of its location, and thus the environmental forces acting upon it. This reaction to the environment would be acknowledged primarily through formal means.

With increasing technological advancement came increasing comfort for occupants, at which point it became not about resisting and responding to the forces, but creating and controlling the forces totally, with the eventual air conditioner and hermetically sealed interior as a modernist global response to all climate conditions. (Frampton, 2002)

Likewise, the structure of the buildings, once entwined with their adaptations to their locations, has become standardized by modes of production and the hand off of the role of the structure. What has commonly been pursued is the most efficient and economical mode according to standardized production techniques developed long ago. This stands in opposition to the potentials of effectiveness and expression – that of an architecture about the purpose of architecture, as opposed to an architecture about production. In Vitruvius' triad of firmness, commodity and delight, the former has been neglected in the prioritization of the latter, leaving us an architecture that is shallow, based upon aesthetics. The prioritization of the visual is a lazy architecture that can be quickly experienced, and does not demand the viewer to inhabit it, but experience it potentially solely through image. The thinning of architecture and the reduction of the potency of form from it leaves form as something purely aesthetic. In sacrificing these roles which were once tectonic in nature, and allowing them to become systems separate from the architecture of the building, architecture has been reduced in its scope, becoming concerned mainly with spatial arrangement and aesthetic concerns. The comfort and familiarity of these standardized approaches has made for a lazy approach to architecture; our profession's 'sweat pants.'

Though the forces that architecture responds to have, for the most part, remained the same, our response to them, the techniques we use to build our buildings and maintain them have become more advanced, and simultaneously more universal. The tools we have generated are not used to create an architecture of survival, as their predecessors had, but one of formal exuberance. Recent architectural production has retained its tendency toward the a-tectonic expression afforded by the advancements of mechanical climate control and the purely formal possibilities of the computer, neglecting the rich heritage of building traditions which evolved over time in response to their location. Where once there were definite formal implications to responding to these conditions, we are left with aesthetic or sculptural exercises maintained through the use of external systems. The architect's tool is form, and though it has been misappropriated with the onset of these technologies, it remains the most potent actor to substantiate architecture.

The continued allowance for these roles to remain outside of the realm of architecture allows for the enduring dominance of the scenographic. The preference for the scenographic, programmatic or spatial leads to an architecture that may have commodity and delight, but neglects firmness; in our ability to control the environmental forces which we once necessarily opposed, we lose the connection between architecture, the body and nature.

Though currently in a sort of self referential phase of form about form, digital modeling and simulation tools offer new approaches targeted at materials, atmospheres, and other architectural issues outside of those purely formal, which can also allow us to reclaim abandoned roles. The computer as a tool allows for a much greater range of exploration through simulation, allowing us to make a case for the reintegration of these issues in the tectonic, allowing for a reassertion of a more substantial architecture through digital means. In opposition to the generic, thin architecture that has been produced through the use of climate control, digital simulation of materials, construction and environmental forces allows for the generation of a thick architecture of specificity, tuned, and expressive of its place through an expanded sense of the tectonic material basis of form, allowing us to recapture this expressivity in a contemporary manner.

Figure 3: Frontispiece of Laugier`s Essai sur l'Architecture, showing the hut literally made of its surroundings, celebrating it's branchiness.

TECTONICS

The origin of the word tectonic is in the Greek tekton, meaning carpenter or builder, a definition later changed to refer to the art of construction. But the origin remains so that the tectonic is of the builder. Sometimes misunderstood, the tectonic is not necessarily the revelation of structure, but in the words of Kenneth Frampton, the material basis of form – or the visual clarification of the constructional aspects of a building. According to Laugier, the primitive hut was divided into two elements; the stereotomics, or earthwork, and the tectonic, or frame. The tectonic, in this vision of the primitive hut, was the lightweight, linear components to create a spatial matrix. (Frampton, Studies in Tectonic Culture, 1995) Here in the case of the primitive hut, the tectonic is not that the structure is revealed, but – at least in the frontispiece of Laugier's Essai sur l'Architecture – that the hut reveals and celebrates that it is made up of trees; it is formed by the surroundings and thus its construction material in the most literal sense, and it is allowed to remain evident. Furthermore, the shape of the roof is both about shelter, and thus about shedding; and the shape of the roof is something that can be intuitively read to understand its function – to protect the occupant and respond to the external forces in order to do so.

The tectonic frame is the method by which the volumetrics of the building are formed, and so there is a constant dialogue between space and structure, but especially between structure and the forces acting upon it.

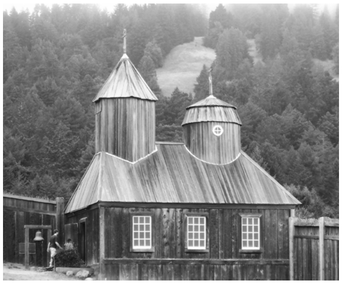


Figure 4: Chapel at Fort Ross

The frame is the beginning – the structure – of James Marston Fitch's 'third environment,' the mediator between the person and the environment; the interior space. If we look at the primitive hut as an idea of the first building, it would be the first iteration of development. Subsequent generations would, through trial and error, develop nuances to external forces that would become formally evident of their situation. In The Place of Houses, the example of the Chapel of Fort Ross emerges as an example of such adaptation. On an extremely windswept site, the small chapel has no overhangs or soffits, they have been pulled in tight with the skin of the chapel, so as to minimize the amount of stress that the structure will undergo from the intense wind. (Moore, Allen, & Lyndon, 1974) Small adaptations like this abound in vernacular architecture, so that the tectonic of one area is not the same as another.

The tectonic aspect of an edifice was an emergent and self-evident artifact that developed from the architectural response to the environmental forces acting upon it, and eventually became self-referential. In Northern European cities, such as Amsterdam, tall windows became an architectural response to the demands of a pre-artificially illuminated era; the low light levels paired with narrow frontages and deep lots demanded this so as to increase interior comfort.

Vittorio Gregotti, in discussing the tectonic, posits that the origins of architecture lie not in the primitive hut, or any such prototypical model, but in the act of "[placing] the stone on the ground to recognize a site in the midst of an unknown universe: in order to take account of it and modify it." (Frampton, Studies in Tectonic Culture, 1995, p. 8) It is the location of the building which is the primal generator for the tectonic and which emerges from it. Indeed, in vernacular architecture, this was especially true of the buildings which emerge from the materials of the site as well. But the tectonic expression of vernacular architectures did not emerge solely from the response to forces, but from methods of making. Close engagement with the material allowed for new methods of working to emerge; for the craftsperson to push the limits of what is possible. In the case of gothic churches for example, masons would often build to failure, demonstrating both the possibilities and the limits of the material in a way that is materially tested. With building to failure, the possibilities of the material would be examined over time. Thus inherent in craft is also the layers of history. The iterative development of methods over time is more valuable than constructed artifacts. There is inherent knowledge within each joint, each gothic arch, within the shape of the roof, or the orientation upon the site.

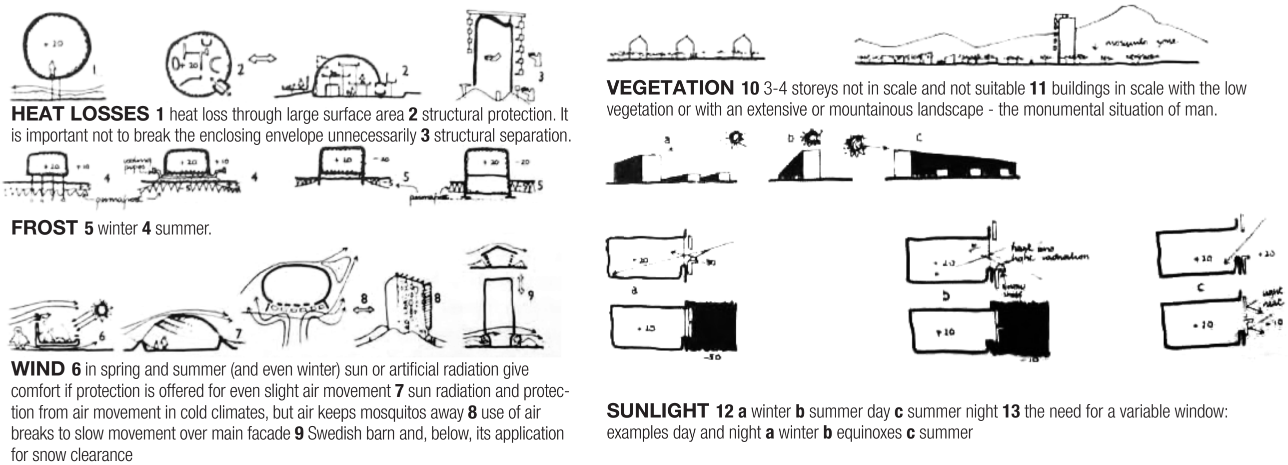


Figure 5: Ralph Erskine`s sketches of regional adaptations for working in the arctic.

In Ralph Erskine's diagrams of strategies for working in the arctic, the components of the building are broken down into smaller pieces, and worked through in such a way that the overall construct becomes expressive of the climate surrounding it. For example, in apartment buildings in a cold climate, where heat transfer would be an issue, the skin has rounded corners so as to minimize thermal stress points, and remains unbroken, contrasting with many exposed continuous slabs built contemporaneously found in cold climate areas throughout North America. The continuous slab penetrates the envelope, as well as serving as the balcony, and is left exposed. In contrast to this, Erskine hangs the balconies off the building so as to minimize the penetrations through the thermally protective skin. The tectonic form was expressive of all of the factors acting upon it, from the intuition of the designer, to its own making, to its own place in assembly, to the environment it was situated in.

THE LOSS OF THE TECTONIC

The tectonic richness of architecture has been greatly eroded by two major developments within the discipline. It began with the separation of craft and architecture, once inherently linked through the role of the architect as both designer and master craftsman. An architect was trained to understand and even work with materials, yet today they are far removed from the process of construction. Through this schism, craft has been lost through the separation of the roles of the architect and craftsperson, brought upon by the split between building and design during the Renaissance, with Alberti's assertion that the architect is "no Carpenter." (Alberti & Rykwert, 1991) As labour and intellect separated, so too did the fields of design and building. The engagement with the process of building, the 'art of making,' was supplanted by representation, and architecture was elevated to a profession, while craft carried on in labour and the vernacular.

Although John Ruskin argues that the synthesis between mind and body produces the most beautiful artwork, there is an inherent disconnect present in the field of architecture, existent since the time of this first major development. Where the architect draws the idea of the building, a disconnect occurs in the translation to built form, where a craftsman, with his own understanding and experience will influence the construction of it. This is not to say craftspersons were 'mindless,' but that in sacrificing the role of constructing, in allowing the execution to be carried out away from the 'intellectual,' there is a contradiction between the 'pure' intention of the architect and that of the craftsperson. This can lead to the dilution of the architectural concept of the building.

The larger and more significant division took place at the beginning of the industrial revolution. It was here that increasing mechanical complexity began to demand new specializations, and architecture lost control over the engineering of buildings. As architecture has become separated from its previous roles, it has become increasingly generic. With modernism and the so called machine aesthetic began with the eradication of cultural artefacts, and the rise of the international and the mass-produced. In Le Corbusier's The Pack-Donkey's Way, (Le Corbusier, 1929, p. 67) he discusses a new way of navigating the city, based on function, order, machinery and precision, and not the primitive ways that had come before it. This argument expanded from urban design to the construction of buildings.

Figures 6 & 7: Le Corbusier's Cite de Refuge pre and post-renovation. The brise soleils and more solid walls were meant to remediate the lack of a planned double skin and air-conditioner.

There had been previous attempts at worldwide styles, including neoclassical and gothic architecture, but the developments that were associated with modernism were especially influential, in their ability through the application of the aforementioned curtain wall and air conditioner to be situated anywhere in the world based on the premise of cheap energy. (Frampton, 2002) This was a time when the possibilities of the machine could solve any problem; air conditioning, televisions and automobiles to allow each their own piece of land.

In his seminal essay Architecture of the Well-Tempered Environment - Reyner Banham questions why have a house at all if we can just have the mechanical systems supporting us – a position reflected in Francois Dalligret's Environmental Bubble of 1969, in which a thin skin surrounds a fluid space, with a life-support system in the middle, as a sort of totem.

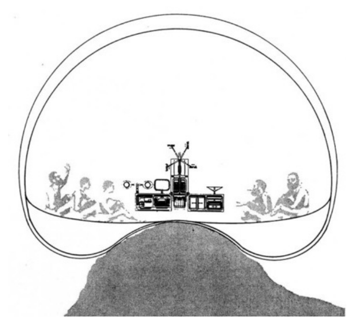


Figure 8: Francois Daligret, The Environmental Bubble, 1969

Banham goes so far as to propose a floating roof using a sort of propulsion system to float above, radiating down heat and light, surrounded by an air curtain - the complete removal of architecture and its replacement with system – an arrangement he goes on to compare with Philip Johnson's glasshouse in New Canaan, Connecticut.

Figure 9: Philip Johnson, Glass House, New Canaan, Connecticut.

Architecture and the vernacular developed in different streams, with one stagnating, while the other became fully adapted to the realities of modern production and consumption. K. Michael Hays writes about Miesian architecture as that which has been removed from "the forces that influence architecture – the conditions established by the market and by taste, the personal aspirations its author, its technical origins, even its own purpose as defined by its own tradition." (Hays, 1984, p. 22)

Today, a window frame is minimally climatically adapted, manufactured in a system approach that reduces localized adaptations out of the design entirely. The standardization of construction methods has meant that architecture is now designed from a catalog of standard components, arranged by the architect. Most components of contemporary buildings come from a standardized mode of production; from structural steel to wood to windows and doors, forcing architecture to remain outside of the potentials of production.

David Leatherbarrow argues that we design from a vast array of catalogs; a library in each office so extensive that it rivals the library of Alexandria; that architecture has become not the specifications of 'profiles and shapes' that the workers labour practices approximate, but the specification of the components that will be installed on the site. For Leatherbarrow, this is an issue that architects seem to not want to face, ignored as it seems to reduce architecture's or design's claim to originality. (Leatherbarrow, Uncommon Ground, 2000)

Leatherbarrow also states that it is no wonder that craftwork has disappeared, as the standardization of components has reduced builders to installers, "reducing both ingenuity and improvisation on the builder's part." (Leatherbarrow, Uncommon Ground, 2000, p. 125) But Leatherbarrow claims that this stems from the complexity of the system of architecture; that it is too complex for something to be improvised on site, or to deviate from these standardized systems.

These two fundamental splits in the discipline have led to a commodification of architecture, and the demise of regional building traditions. In its place is the global; a global construction industry and materiality, with global sensibilities, a global architecture. Our world is dominated by genericizing forms of construction that have largely superseded local methods of building, generating an atectonic expression. The construction method becomes that of a standard frame, with an applied surface, leaving the expression of the project to the variations of the surface, and neglecting the full tectonic potential of architecture.

Jean Nouvel argues that we use a sort of architectural Darwinism in which we remove useless matter and use our knowledge to increase performance in loading, lightness and insulation. (Leatherbarrow, Architecture Oriented Otherwise, 2009) And yet, is this a good use for our knowledge? Should our existence be predicated on the mechanical systems which can fail? On materials meant to seal us off from nature so that these mechanical systems can function? The creation and continued use of these systems separates us from the energy flows found in the natural world, leaving us to create our own systems to power the sealed buildings.

Does not using nature as a component of the architecture actually bring us closer to it than a piece of glass and the ability to look upon it does? This de-substantialization – the reduction of robust and integrated combinations of elements – into a systematized mode of component arrangement under the pretense of architecture has produced a thinning of architecture to that of a surface draped over a standardized frame.

THINNING

The development of this surface architecture has been exacerbated further by the first generation of digitally generated architecture. Although hand drafting remained the architects' tool for creating instructions for other people to build up until the late twentieth century, the advent of the computer transferred representation into digital space, disengaging from the act of drawing on paper, and leading to an even deeper schism and abstraction between the physical realm and the architects' manner of working. There was a fundamental shift with the advent of digital three-dimensional modelling, in which architects again began to build, albeit representationally, and at first, crudely. The increasing complexity of building demanded this shift in order to understand it more wholely. But what has emerged from this potential so far? What constitutes a digital tectonic?

Figure 10: One of Zaha Hadid's Nordpark stations under construction, showing the unique plates and their associated gaskets.

The first era of digital architecture was obsessed with surface, slavishly imitating the immaterial entities within modeling software. In the work of Zaha Hadid for example, renderings present smooth, white surfaces flowing around, becoming wall, floor and ceiling in complex continuous geometries. The Nordpark Cable Railway stations in Austria are a series of four canopies, each different in form. The complexity of the form and the image of these sculptural objects is alluring, no doubt. Alluring complexity or not, there is complexity in the service of what? Is it complexity, or just complication? Why is it positive to have each of these stations completely different formally, with the associated expense of engineering them, and fabricating each individual and unique component? Does the value of the architecture come from how difficult it is to produce?

This raises the questions: if we have these tools available to use, what is the right way to use them? Is pursuing form for the sake of creating a form useful? The onset of these digital technologies has led to another instance of 'modern-like' production, in which new construction methods, although mass customizable, are applied around the world in an undiscerning manner. This generates a form based, surface architecture, devoid of its entire meaning, replacing the tectonic with what stand as symbols of buildings, and especially

Figure 11: The sculptural form of one of Zaha Hadid's Nordpark stations.

Figure 12: Metropol Parasol by J Mayer H.

symbols of computer generated architecture. Although much current digitally developed architecture can in some ways be considered tectonic – at least with the sheer amount of material and effort – but in the propensity for surface over structure it cannot be. Digital tools run the risk of 'more of the same,' as in the case of the undiscerning application of modernism globally. Certain digital tropes – the blobbly form, the waffle grid and others – reappear repeatedly. Although we can manipulate the shapes of the building, they are not necessarily addressing tectonic issues. Neri Oxman argues that "a hierarchical approach tends to prevail where fabrication methods and material considerations are only brought into the design process as final design solutions in preference to promoting explorations which are generative in nature." (Oxman, 2007) One such example is the application of a waffle grid in J Mayer H's Metropol Parasol. In model making, it is one of the simplest methods of implying a complex surface such as that developed in three-dimensional modeling software. And yet, it stands as if built by an oversized student with an enormous laser-cutter, a project as studio model writ large. (Made even more absurd by the fact that the wood serves only to support itself; there is a concrete frame beneath.) It stands in opposition of the material basis of form as it appears to simulate sheet material at a grand scale, from which it has been cut and notched and attached together; of course this actual system couldn't be used, and instead it contains thousands of steel connections painted the same color as the 'sheet material' so as to reduce it further to an image. In the literal translation of digital model to form, albeit with some major detailing changes, it is symptomatic of the unrealized possibilities in some of these earlier works.

Furthermore, the current digital tectonic seems a continuation of the abstractive rigour of the modernist period, wherein references to architecture itself were removed. This architecture has been generated as a reaction to standardization, but has produced an architecture so far removed from architecture that it becomes merely sculpture. It does not encapsulate the complexity of the act of creating a building because it is so subsumed with the creation of a form. This mode of architectural production is more the exception than the rule – the past century has been dominated by it, but humans have been building shelter for much longer than that.

The schism that has developed between the physical and representational in architecture has produced a shift in the thinking of what architecture itself is, but its roots remain as the 'third environment,' rooted in the material world we inhabit.

THE CASE FOR A NEW TECTONIC

"Technical progress leads toward a non-technical goal: renewed contact with nature."

(Leatherbarrow, Architecture Oriented Otherwise, 2009, p. 84)

In a fundamentally changed world, the reality of the way architecture is produced has radically changed. A tectonic based on craft is no longer possible. The new standard is the assemblage of standard components to form a thin skinned, climate controlled, flexible space, meant to maximize the living space which is supported by mechanical equipment required to make it habitable.

But such an architecture can exist anywhere, generating a sameness of expression, and an inappropriateness that is a product of this system of mass production and energy intensive use. The use of standardized component systems generate an atectonic expression in that their making was done in a factory, untouched by the realities of the site, and lightly touched by the architect in his arrangement. If the tectonic is truly about revealing the method of making, or the material basis of form as it has been for architects such as Louis Kahn, why has the tectonic not evolved with the manner in which we design buildings? Increasingly we are able to develop and manipulate information in digital space before the building is built, and yet largely we remain within the realm of image and construct – a premeditated form, constructed through brute force. The reduction of architecture from a complex set of relationships to a series of standardised components and machines has left us with only spatial planning and aesthetics – a shallow architecture. Even our role as 'master builders,' oft romanticized as a role we still carry, has been extinct since the advent of representation as our new toolset during Alberti's time.

Kenneth Frampton argues that "The full tectonic potential of any building stems from its capacity to articulate both the poetic and cognitive aspects of its substance. This double articulation presupposes that one has to mediate between technology as a productive procedure and craft technique as an anachronistic but renewable capacity to reconcile different productive modes and levels of intentionality." (Frampton, Studies in Tectonic Culture, 1995, p. 26) Although there is portrayal of the poetics of space within the work of Mayer and Hadid, they still lack the complexity and substance of building. Though in their digitally derived forms there is potential to convey the structural effects of such decisions, or even the structural efficiency, in the case of the Nordpark stations, they are composed of steel structural fins, overlaid with a surface so as to obscure the construction of it. Thus, according to Frampton, "the tectonic stands in opposition to the current tendency to deprecate detailing in favour of the overall image." (Frampton, Studies in Tectonic Culture, 1995, p. 26)

The trend of digital architecture generated to simulate a mathematical surface in physical space disregards the physicality that we must consider. What we build exists not in the computer but in the physical world, and is exposed to environmental forces, and is made of materials, and is inhabited. In this regard, maybe the focus shouldn't be on what the possibilities of the computer are, but what the computer can do in the generation of architecture, that is; how is this autonomous system influenced by the new possibilities and information that arise from this separate system, rather than referencing solely the computer and making architecture subservient to it.

According to Kenneth Frampton, the tectonic remains between ontology and representation; when you have something of use, you also have a sign of its use - it is intuitive in its expression, drawing connections between what it does and in what manner it appears. One of the simplest examples of this is an Ionic column, meant to bear a load to the ground, it increases in diameter as it approaches the bottom, with a banding around the bottom that can also be read as rippling under the load it is to carry. The column begins to portray a dialogue between the force of gravity and the material out of which it is made. Where the tectonic has traditionally been concerned with material, and "the formal amplification of its presence in relation to the assembly of which it is part," (Frampton, Rappel a l'ordre: The Case for the Tectonic, 2002, p. 93) a new tectonic can emerge from this same thinking, with a larger idea of what we should consider the material world. This would allow for an architecture expressive of the entire milieu in which it is situated; a completely specific architecture generated to suit its place in the world physically, culturally and environmentally. Vittorio Gregotti argues that "the architectural project is charged with the task of revealing the essence of the geo-environmental context through the transformation of form. The environment is therefore not a system in which to dissolve architecture. On the contrary, it is the most important material from which to develop the project." (Gregotti, 1983)

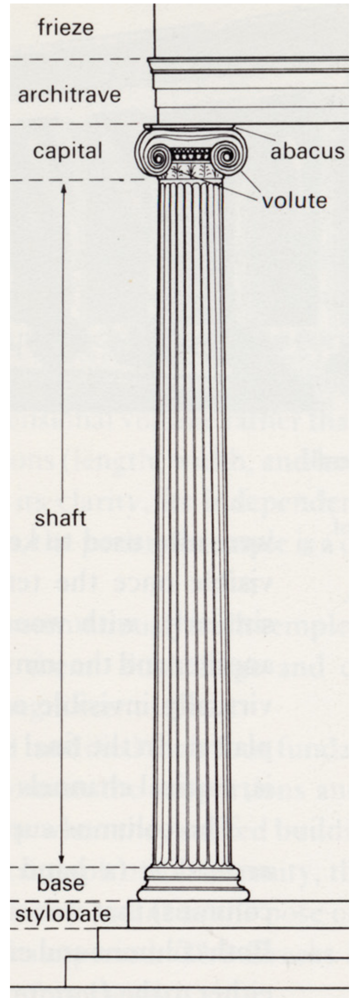


Figure 13: An Ionic column, which in itself represents the process of bearing a load to the ground.

The material basis of a building is both what it is made up of, and what it must resist; solar radiation, wind, thermal transfer; all matter, energy. That these materials can now be visualized and worked with in the digital realm can lead to a new mode of the making of architecture. If we begin to again reconsider materials in this manner, the definition of tectonics – the material basis of form – necessarily changes in tandem.

EXTENSIONS

The digital tools we use almost daily in architecture are just that, tools, extenders of both our perception, and of ourselves in the physical world. They allow for both cognitive and physical extension, allowing us to do more, more quickly. Whereas, for example, vernacular architecture developed over centuries through series of trial and error responses to problems or situations at hand, today such development can be accelerated through iterating and perfecting variations digitally before building, allowing for a more nuanced development, and greater architectural possibilities. The move towards an integrated mode of digital modeling and production offers the possibility of having a deeper level of control over the project in order to maintain intentions, and more deeply influence the architecture. The data generated in a three dimensional model of the project can be translated through the computer into code that will allow for the machine, acting as the extension of the architect, to create.

In the same sense that the architect works with an abstracted input method in their mode of creation, John Ruskin – a writer from the time of the industrial revolution – refers to a musician, who works in materials in an abstract way as well – the tool, the harp, is manipulated to generate notes – that is, the musician, through synthesis of mind and repetitive motion, creates vibration in the string which generates the notes. Although the mouse and keyboard lack the same tactility of the physical world and interaction with materials, there remains an underlying technique driving the generation of the model. Lars Spuybroek argues that the "the two handed dexterity, the coordinated left- and right-mouse-button clicking, combined with keyboard maneouvering, and moreover scripting and programming, go far beyond the dexterity required in any hand drawing technique." (Spuybroek, 2008, p. 73) The mental dexterity is also much greater; it allows for the user to think in three dimensions, allowing for the exploration at a much earlier stage when compared with hand drawing.

The skilful manipulation of data and machine operation realigns us with the craftsmen of the past. Craft has traditionally been a form of work that has been iteratively perfected and passed down through apprenticeship and training. Rotheroe argues that “craft is associated with the slight adjustments and subtle changes to the parameters that define processes of design and production in search of such an outcome.” (Kolarevic, 2003, p. 73) Similarly, rapid prototyping, digital simulation and iterative design allow us to explore processes, materiality, and other factors that allow us to produce an outcome that has been more thoroughly thought about and explored, as opposed to specification with the hope that it works, leading to a closer understanding of material as akin to the craftsmen of the past.

FABRICATION

In his design for the Imperial Hotel in Tokyo, Frank Lloyd Wright expressed his ambitions for the hotel; to not only create the spatial arrangement, but “to realize genuine new forms true to the spirit of the great tradition and found I should have to make them; not only make forms appropriate to the old (natural) and to new (synthetic) materials, but I should have to so design them that the machine (or process) that must make them could and would make them better than anything possibly could be made by hand.” (Leatherbarrow, Uncommon Ground, 2000, p. 147)

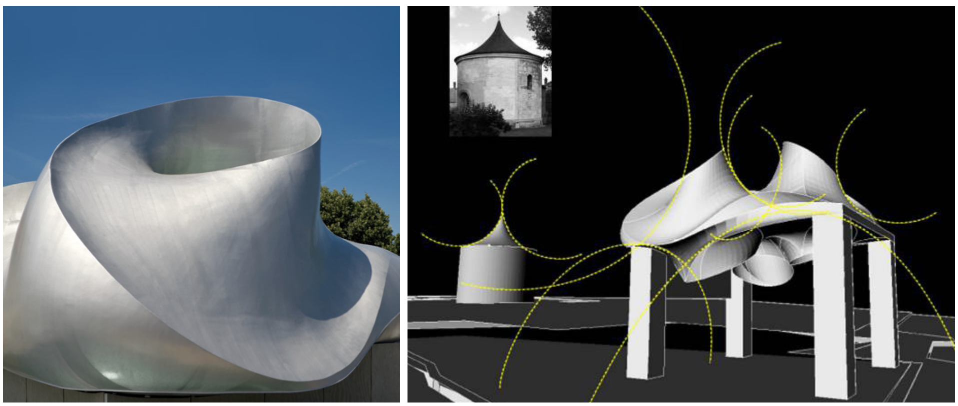
The idea of expressing the technological possibilities of architecture through the ages has not weakened; from the gothic to Frank Lloyd Wright to today, the production of architecture has evolved with the ideas that it is formed out of. In our own time, mass customization and digital fabrication will allow us to create an architecture that is individual to its unique situation. The process by which production and representation have become separate, is also leading to its reintegration. The instrumentalization of numbers, as posited by Alberto Perez-Gomez, has led to a reconvergence of the act of designing and building through languages that are newly compatible, through the binary code of the computer, in both Computer Aided Design and Computer Aided Manufacturing. Representation evolved from physical drawings, to digital drawings, to digital models; which now generate the information for construction.

This is made possible by the computer, and its ability to simulate some aspects of the engineering of systems and structure, as well as the construction of buildings, and then even generate the information for their physical realization. This is not to say that we could completely reclaim this role, as the complexity of architecture demands consultants to aid in the development, but that we can begin to work more collaboratively so that these systems seen as outside of architecture begin to become intrinsic once again. This can allow for us to re-substantiate architecture, by engaging again with the tectonic aspects of the work through digital simulation.

Discussing the value that John Ruskin placed on the 'marks made by the hands of an individual artisan,' Stanley Rotheroe argues that "Digital fabrication, too, places supreme value on its capacity to generate unique output; the only difference is the absence of direct intervention of the human hand." (Rotheroe, 2010, p. 79) However, as architects begin to develop the information that drives the machines, and the machine-operator operates the machines, the machine becomes the tool that is held by the 'thinking hand,' Ruskin's construct of a craftsman's synthesis between labour and design. (Rotheroe, 2010, p. 79) Sennet argues that "the disaster ushered in by Fordism was that this kind of lateral knowledge transfer ceased to occur." (Sennet, 2011, p. 44) Where architects were once 'master' craftsmen, we now have limited knowledge of the methodologies used in erecting a building.

The possibilities of parametric programs such as grasshopper and generative components are that a technique worked out by one user can be transferred to another to be used as a base and evolved. This brings to mind the techniques passed down over time and perfected iteratively by the craftsperson. The possibilities of simulation make this likeness even more so; newer developments in the work of researchers such as Achim Menges have led to the integration of material characteristics to be modeled in digital space, allowing for them to be worked within a hypothetical environment and thus pushed to their limits, much in the way that close engagement with materials over time led to development of techniques specific to material. The new and deep-seated connection between 'model space' and physical space, with data that can be translated into a physical object, "and not the complex curving forms, is what defines the most profound aspect of much of the contemporary architecture." (Kolarevic, 2003, p.57) In designing something digitally, we have generated the information to control the machines that will produce it, creating an inherent link between ourselves and the machine, and making the machine an extension of our own hand in the construction process.

SIMULATION AND THE EXPANDED MATERIAL BASIS



Figures 14 and 15: Left; the completed Martin Luther Church, a simulation of the digital model at right.

Architectural production already works within the realm of simulation through the creation of models both physical and digital. These models serve to test ideas of construction and form during the design process.

Fabrication, and especially digital fabrication in a prototyping context serves much the same role, as a method of quickly outputting into a physical artifact, in some cases allowing for material testing. The Tectonic expresses the method by which something was built, and as such, the digital has a distinct expression to now. The fact that the forms of the buildings are generated within the computer have led to surface based 'blobs' etc. In these cases, a sort of reverse simulation occurs, in which we begin to attempt to simulate these digital forms physically. The Martin Luther Church by Coop Himmelb(l)au for example, consists of a complex geometry rendered in bent steel plates, welded together and ground down to deny their construction and enhance their reading as form. The mathematically generated construct is forced to be rendered in a material other than mathematical representation, making it a sort of reverse simulation.

This reverse-simulation seems to be exacerbated by the idea of the 'responsive environment,' that of a building which actively functions as an apparatus for the purpose of inhabitation. Environmental controls such as air conditioning are replaced and 'enhanced' through the addition of flapping shutters responsive to light, lights to respond to the darkness caused by them, and other stimulants used to simulate some other environment through electronic means that would in no significant way reduce our energy dependence, serving to reflect the dynamism that exists in the environment in ourselves. Is the static state operation of architecture such a disadvantage? The increasing attempt to appeal to all of our senses through these blinking, moving images creates just a further thinning of architecture, and greater dependence on apparatus.

But digital simulation offers even more potential with specialized tools that have been developed to test other physical phenomena, creating a deeper link to the real world. Within these environments, a digital approximation of our own environment can be generated, allowing for us to test and evaluate a wider range of effects. With this in mind, the notion of efficiency in construction transforms to a model of effectiveness instead, with a more comprehensive development based not on how fast or easily something can be built, but how it can be pushed to its limits, allowing for new expressions. Where previous generations had to work within the physical realm to build and test, the lower energy outputs of simulation can allow for a much wider variety of exploration. The continuous testing that can thus be achieved allows for a better understanding of material, using the simulation process to drive the formal and material expression of architecture in a way that can become dynamic not through the addition of apparatuses, but through the same material understanding that drove vernacular expression, leading to a reengagement with the idea of the tectonic form through expression driven by their digital simulation and making.

Peter Rice argues that there is a feeling that there is a solution to technical problems, and that we can feel trapped by them. But we are not; if we only allow for the calculation of loads and the selection of a column from a chart in a formulaic manner we are. (Frampton, Studies in Tectonic Culture, 1995) However, if we use the calculations to generate a form that can be expressive of the load, we can have intentions that will generate different solutions from someone else doing it. Digital tools don't solely allow for the computer to design, but allow for a greater and deeper exploration of the formal implications of what we do. Recent publications such as Softspace and Thermally Active Surfaces in Architecture explore the thermal possibilities of material in some cases through digital simulation, expanding architecture's material palette to airflows and heat and energy. (Moe, 2011) Because the flows of energy and air can be visualized and understood in some sense, their formal potentials on architecture can more readily be realized and made evident; integrated into architecture, the reliance on systems and apparatuses can be reduced. (Lally & Young, 2007)

Neri Oxman talks about design informed by fabrication, as opposed to simply being formed by fabrication. (Oxman, 2007) In these cases, the tools and methods of fabrication, as well as material form and behavior are prioritized over concerns which are purely formal. Within the realm of simulation, the idea of informing resonates. As opposed to generating a form based on the material unit of a brick in the Kahnian tradition, for example, the simulation of solar raditation can allow for new formal possibilities driven by the optimization of flows of energy and heat, or the stresses and strains through members, so that the material is in dialogue with the form, as opposed to being forced to fit.

One such project developed through simulation of material behavior was the 2010 ICD/ITKE Research pavilion by Achim Menges and Jan Kippers. This project explores the physical qualities of materials; specifically that of Birch plywood strips. Through extensive physical testing a reliable computational model was developed so as to then generate the behaviours of the strips in the model of the roof structure. The interlocking components provide each other with tension and compression, which was accurately simulated through the model developed following material testing.

Figure 16: The completed ICD/ITKE Research Pavilion at Stuttgart University.

The project developed explored "understanding of form, material and structure not as separate elements, but rather as complex interrelations." (Menges, Schleicher, & Fleischmann, 2011, p. 22) This understanding of behavior generates a unique skin-structure hybrid that would have been very expensive and time consuming to develop through traditional means. Out of the ability to test these materials new formal possibilities were generated.

The idea of such an architecture that is optimized to necessarily resist the forces they must endure every day through optimization seemingly would stand in opposition to the current preference given to preconceived forms made to work through brute force. Though we talk about the elements of architecture which resist external forces and conditions having a behavior we attempt to anticipate, the tectonic expression does often not coincide.

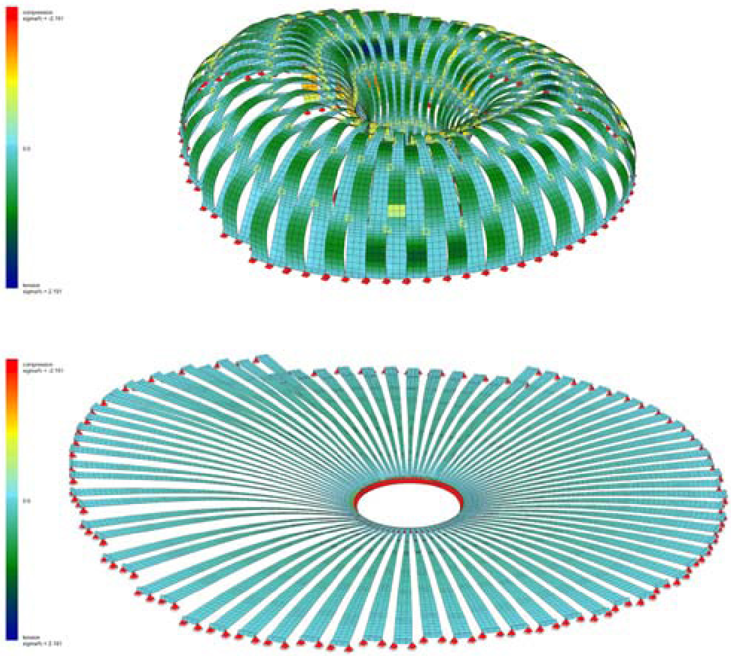


Figure 17: A finite element analysis of the ICD/ITKE Research Pavilion, showing the tension and compression forces working through the panels.

‘THICK’ ARCHITECTURE

Mark Rakatansky uses the analogy of Christopher Walken, an actor who prepares for the aspects of a character that will emerge as he acts, rather than immersing himself in the role in the tradition of method actors. Why method act if it is not something that will come through in the performance? What purpose does it serve? This is much the same as the example of Zaha Hadid’s 2,500 unique, individual panels for the Nordpark station. How does it the project benefit? In this sense, Christopher Walken is a tectonic actor. Rakatansky further elucidates, returning to architectural production and the fetishization of the explanatory images accompanying these projects by questioning “who cares what your diagram is or my diagram is if it doesn’t make it into your act or my act, into the act of your design or my design, in a way that is legible, perceptible, perceivable?” (Rakatansky, 2012, p. 161)

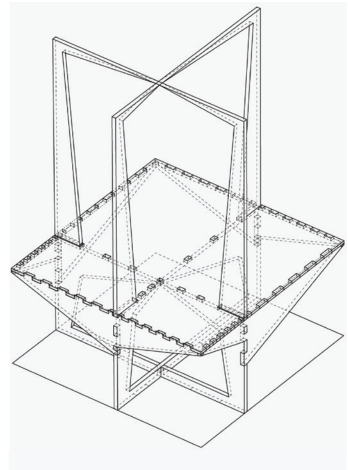
Which brings us back to the potentials of digital architecture; it is sometimes the case that these diagrams of structure, or airflow, or sun penetration, or shadowing, or anything that can be simulated in digital space, are generated from the programs we use. And yet with all of the information they contain, they are used as solely diagrams, and not necessarily to influence the architecture. The information contained within them can be incredibly valuable in this regard. For example, in the diagram of a structure, we have moment and shear diagrams which can be simulated within the computer.


Figure 18: A fabric formed concrete beam by Mark West at the University of Manitoba.

And yet with these tools to fabricate shapes more accurately, the depth of beams remains constant throughout when some of the material is simply not needed. A good example of this, though using a sort-of physical computer as opposed to a digital one, is the concrete work by Mark West at the University of Manitoba. By using fabric formwork, the concrete is allowed to shape itself to some degree, deforming to match the bending moment diagram of the beam, simultaneously saving 20% of the concrete that would have been used if it had been cast uniform in cross section. (Allen & Zalewski, 2009)

In my own work, an attempt at revealing the information found within such a structure was carried out in the design of the Tectonic Bench. As its name implies, the bench focuses on the idea of the tectonic, and the craft by which it can be achieved; specifically through digital tools. Meant as a first responce to the tendency toward the treatment of surface over the tectonic in many instances in recent years, this project aims to reintroduce prominence to the tectonic using tools which have in the past lead to its marginalization.

The project was developed through digital modelling, with parametric joints and a simple definition meant to optimize the depth and shape of the structural members found under the seating surface. A Grasshopper definition was written in which the number of finger joints on each side remains the same, but lengthens and contracts depending on the length of the associated side. The constructional method was kept in mind during the entire process in order to have it inform the design, and the current use of parametrics was questioned. Is it necessary to create a number of small unique pieces just because we can? Currently, parametric software is in a sort of self referential loop, where the complexity of the software is used to make the construct more complex and make objects that are more complicated to assemble. We currently use parametrics as a tool to complicate an already complex process, usually for minimal benefit.



Figures 19 & 20: Left; the cantilevers demonstrating the forces moving through the planar elements. Above; axonometric of the bench.

The bench itself was inspired by Kenneth Frampton's discussion of the tectonic in relation to space in Studies in Tectonic Culture. In it, he states that the emphasis of architecture has been on the creation of space, and recently we have neglected "the constructional and structural modes by which, of necessity, it has to be achieved." The bench remains between what Frampton calls the ontological and representational role of the tectonic; that is that it has both a use, or purpose of being, as well as being a corresponding sign of that use. In this case, the bench bears the gravitational load of the user. Because it was developed with the use of a simple parametric definition based on a simple formula for the minimum depth of a cantilever, the minimum amount of material is used, allowing for the load transfer through what would ordinarily be a rectangular member to be revealed. The structure is meant to act as a built diagram of the forces moving through planar members. The unnecessary extra material is removed, leaving only the essentials, resulting in an economy of material. The force from the end of the cantilever increases as it reaches the legs, making visible the force exerted by the user. The legs continue upwards to enclose a space, but without a force to respond to; they fail to meet and engage any loads, and so they begin to disappear at their ends. As the bench engages the loads exerted by the user, the vertical extensions shift due to the bending horizontal surface of the bench, slightly distorting the implied space between them, and making the forces even more highly visible as they act as a sort of seismograph.

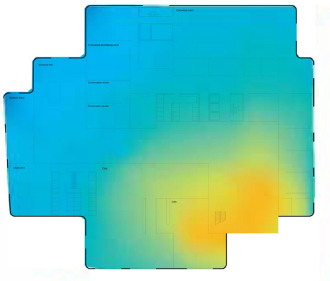


Figure 21: Phillipe Rahm's Convective Museum, showing the two poles of extreme temperature.

Through simulation, not only can the structure become tectonic again, but as in the work of Sean Lally and Phillipe Rahm, so too can the environmental systems. The conditioning of our buildings can become integrated, poetic even, through understanding how we can manipulate them, by understanding their behavior as presented within the computer simulations. Phillipe Rahm presents us with the example of the Convective Museum, a proposal for Wroclaw, Poland. Responding to two different climatic conditions required for storage and offices, the temperatures were set as poles, diametrically opposed to each other in the plan of the building, allowing the temperatures of each of them to flow between each other in the main gallery space. This allows for the creation of new environmental gradients and atmospheres within the building. (Rahm, 2008) In this way, the simulations of interior climate are being used to influence the experience of the space. However, it remains a modification of the hermetically sealed interior environment, and is still controlled strictly through the use of mechanical systems.

Rather than using the computer to pursue form, or to pursue new models of interior climate in what have become divergent streams of architecture, there should exist a dialog between them, allowing the knowledge we gain from each of them to inform each other. In The Sympathy of Things, Lars Spuybroek's presents his theory of the sympathy of the gothic; that things become and inform each other. For example. the ribs of a vault flow together into a column, or through a window forming the tracery, making the continuity between the design considerations visible. (Spuybroek, The Sympathy of Things, 13) Likewise, Rakatansky invites the reader to investigate sympathy through their own body, asking them to "take a look at the back of your hand to see the montage of veins, muscles, tendons, bones, joints, ligaments, bursa, nerves and nails appear as inflective and inflected systems, emerging and disappearing;" (Rakatansky, 2012, p. 73) in other words, the complexity of the system and their interactions between each other is made evident.

An early exploration was done through the design of the roof for an extension to an early 20th century bungalow in the Lakeview neighbourhood in Mississauga. Because of the limited budget in place for this project, the material system of a wood platform frame had to be maintained. The contractors who would be building the lower part of the house would also be constructing the roof, and so the system of construction had to remain similar.

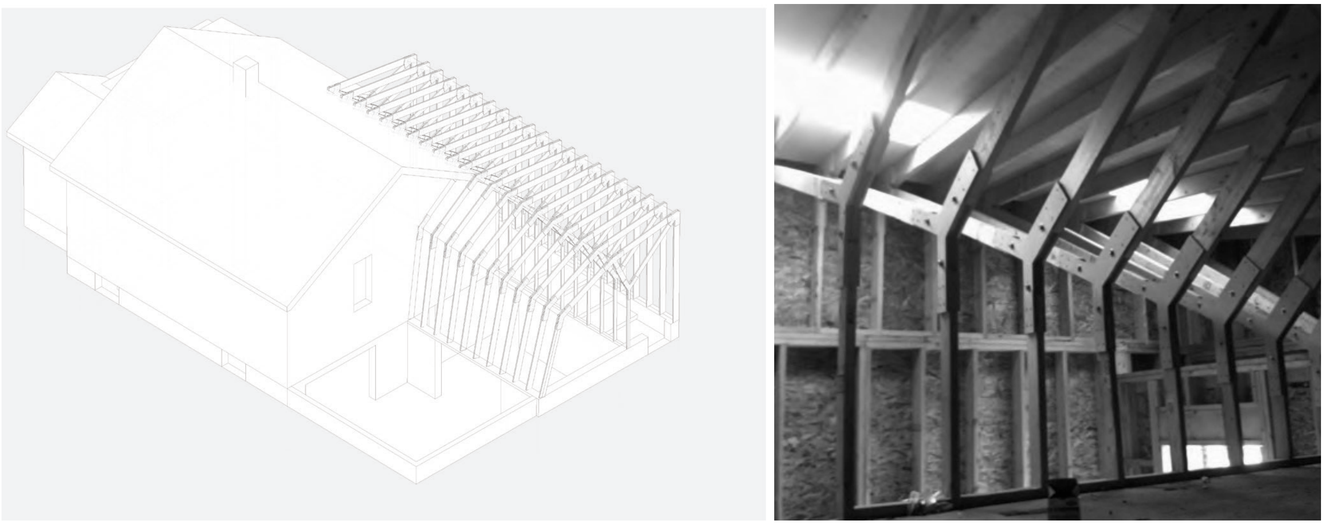


Figure 22 & 23: Left; an axonometric drawing showing the variable truss shapes. Above; an interior view under construction.

The roof was meant to both respond to the occupants' movement through the space, as well as drainage requirements for a planned water feature. The project emerged from a dialog between the spatio-graviational requirements of structure, climatic response to drainage, and a response to human movement on the interior of the space. The roof of the addition connects to the roof of the existing house, and the structure of it lines up with the existing wall. The water collected upon the roof is shed to the addition, and then to a point at the North-West corner, falling over the edge. All the while, the roof slopes down to this direction from both the South to the North and the East to the West, creating a double curved surface demonstrating the flow. Simultaneously, on the interior, one rises from the driveway level to the level of the existing house within the entrance hall, built alongside the existing house. The Y-shaped trusses are based along a wall in line with one existing wall, rising with the occupant as they ascend to the living area. Although these concerns are not as demanding as what has been outlined

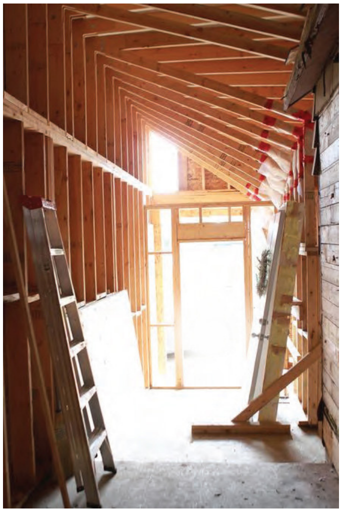


Figure 24: The interior hallway, showing the sloping rafters associated with the rise in the floor.

in the preceding paragraphs, it did allow for both of them to become quite evident in the finished design. The form becomes a spatial movement that attempts to reconcile a response to the environment as well as a response to the movement of the occupants within the space. Because of the geometry generated for these requirements, the intersections of the lumber members would have been different for each case, and thus extremely time consuming and expensive to build. So a supplementary component was added, with the underlying principles of mortise and tenon joints, in order to make the project buildable. These components were created through the use of Grasshopper, Rhino and AutoCAD, and then machined out of plywood and stacked. The truss forms were allowed to remain exposed, creating a link between the interior and exterior through an understanding of the slope of the roof to a single point for the water feature, as well as demonstrating the load transfer acting through them. This was further enhanced with the collaboration with an engineer who indicated that there could be a 'step down' in member sizes as the forces collected, which was itself reflected in the 'mortises' which connected them. This project attempted to take complex factors and put them into a formal dialog, compounding and substantiating them into an architecture of formal evidence.

This complex architecture could realize the dialog between design factors and celebrate them rather than reducing them in the design. And so we arrive at another potential, the recognition of architecture as a complex entity, not to be "three dimensionally printed" as a solid mass in the way some digital works seem to desire to be portrayed, but to be composed of constructional elements that begin to express the method by which it has been achieved. By taking advantage of the possibilities of the digital; material optimization, unique production, and simulation, we can pursue expressive complexity.

A NEW TECTONIC

The first idea for the project associated with a 'new tectonic' was a small cabin in Tobermory. On the interior was a small cube of program – the kitchen, bathroom, closets, and sleeping area. Surrounding this was the frame and covering. The enclosure, from the exterior, appeared as two planes per side, a sloped lower wall and a roof. These planes were framed by two members, hinging about the point where they met, and resisted by a flexible panel. The intention was to allow for the seasonal change, and the snow that would build up on the roof, to temporarily reshape the space by providing the pressure necessary to bend the panel.

Figure 25 & 26: Left, the Cottage deformed in the winter, and above, in the summer.

Where the tectonic has traditionally been concerned with material, and "the formal amplification of its presence in relation to the assembly of which it is part," (Frampton, Rappel a l'ordre: The Case for the Tectonic, 2002, p. 93) a new, dual tectonic can emerge from this same thinking, with a larger idea of what we should consider the material world. This would allow for architecture expressive of the entire milieu in which it is situated; a completely specific architecture generated to suit its place in the world physically, culturally and environmentally. Vittorio Gregotti argues that "the architectural project is charged with the task of revealing the essence of the geo-environmental context through the transformation of form. The environment is therefore not a system in which to dissolve architecture. On the contrary, it is the most important material from which to develop the project." (Gregotti, 1983)

The material basis of a building is not only what it is formally composed of, but also what it must resist; solar radiation, wind, and thermal transfer. That these materials can now be visualized and worked with in the digital realm can lead to a new mode of the making of architecture. If we begin to again reconsider materials in this manner, the definition of tectonics – the material basis of form – necessarily changes in tandem.

But the realm of our craft is not truly the site, and hasn't been for many years; it became the drafting table, and now the computer – we can shape information as a representation of physical objects. We cannot craft in the same manner that crafts persons can, so we use craft as an analogy for the way we exert out own level of influence on the project.

The New tectonic emerges from the possibilities of digital craft; Craft can be viewed as a built up knowledge of a certain technique – such as cutting stone, or wood. By iteratively designing, we are achieving the same kind of built up knowledge, but in a shorter time span through simulation. Digital Simulation increasingly allows us to engage materially with architecture – having to build the model in three dimensions first allowed us to experience it spatially before it is built. This in a sense is a form of craft in that the architect is able to spatially work with the building in a simulated form. In the same way, the newer generation of simulation tools beyond simply modeling in 3D, allows for further material information to be encoded – heat flows, light, air flow, gravity, allowing for a deeper understanding of the implications of our work – though currently these simulations are predominantly used to verify designs.

In a new approach, an attempt is made to use these simulation tools as design tools, to iteratively build and test light access and heat absorption as well as air flows to engage with the atmosphere materially as we would engage with what we normally think of as materials, in order to craft the space that we inhabit. There are three principles of this approach:

1. An Expanded Material Basis – In addition to the standard considerations of material, the material basis of form takes into consideration the forces which the building must resist as formative actors – wind, snow, sun, and heat all have a role to play, as they can be worked with through simulation.

2. Formal Amplification/Formal Potential – there is potential to be expressive in what we currently think of as immaterial –their translation into approximations of their behaviour in the digital allow for us to work with them as material in their own right, and they can in some way shape the space, making their presence evident.

3. Behaviour – That since we can now work through some of these other materials in some ways, that their effect becomes not only visual, but affects it in a deeper way - that the tectonic becomes not just about visual clarification, but experiential. Springing from Simondon's idea of concretization, the object takes on formal characteristics through the synthesization of discrete elements into coherent interrelated wholes, that enhance its behaviour. The formal amplification is therefore not only aesthetic, but as Frampton says, suspended between ontology and representation. Though impossible to neglect the experience of the designer and their influence on the project, the form should be primarily driven through behaviours in the building as opposed to formal considerations trumping all else. computer.

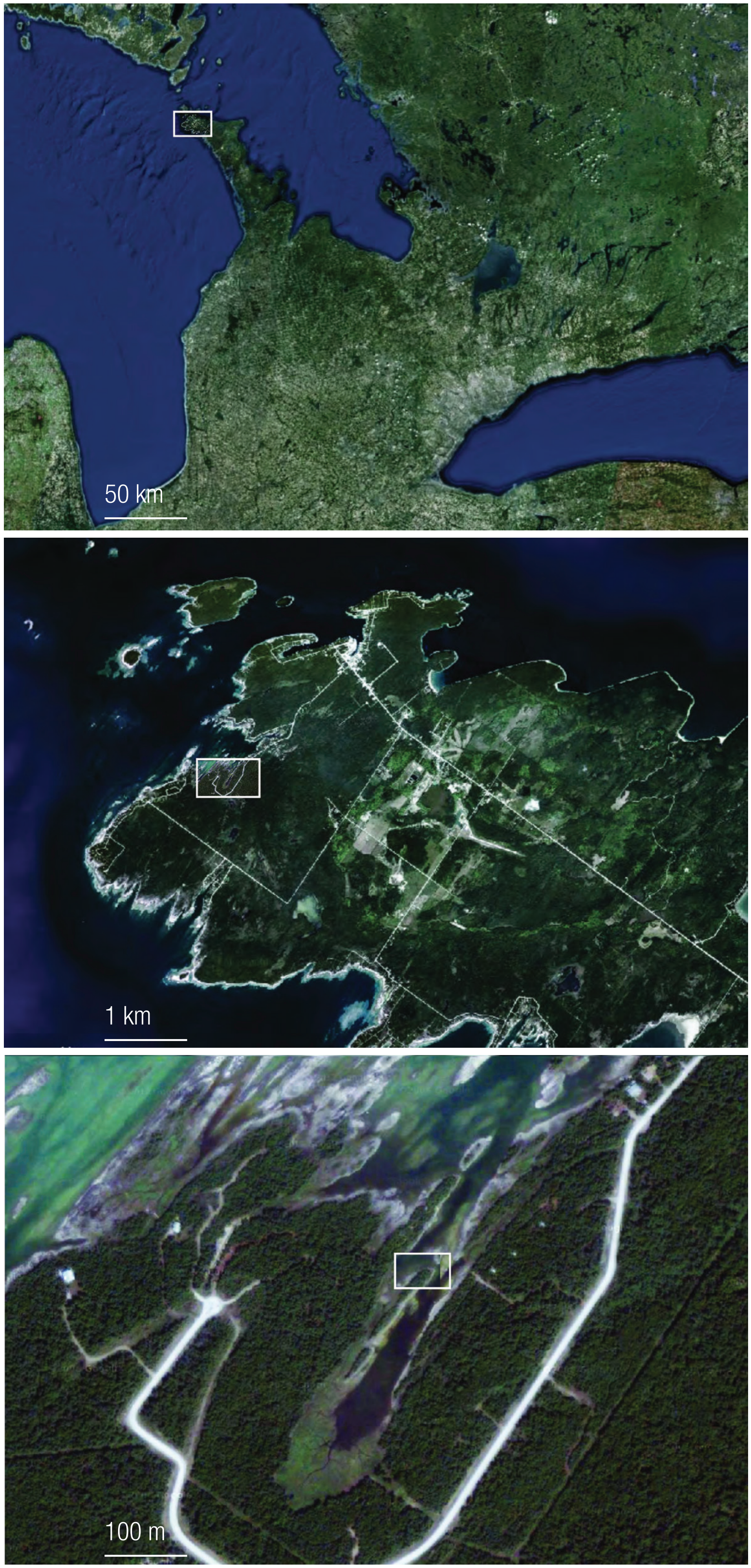


Figure 27, 28 & 29: From top to bottom, an aerial view of Southern Ontario with the Northern tip of the Bruce Peninsula highlighted; The Bruce Peninsula with Hay Bay highlighted; Hay Bay, with the site highlighted.

A MODEST COTTAGE

If the complex interplay of forces and their tectonic manifestation are to be fully examined, it is necessary to choose a site with complexity. The Bruce Peninsula forms part of the Niagara Escarpment, extending out between Lake Huron and Georgian Bay. The climate of this area is moderated by these two bodies of water, but it receives large amounts of rain, snow, and wind coming off the water.

The site itself is in a small cove off of Hay Bay, off of Corey Crescent, about 5km west of Tobermory. It is especially fitting due to the strong cottage culture of Southern Ontario. The trend of cottage living, meant to get city-dwellers back in touch with nature, is often contradicted by the construction of massive lakefront mansions that approximate the conditions of the city transported to a bucolic setting. What began – and for the purported intentions should have remained – as minimal accommodation has given way to another excess. This project aims to explore a modest dwelling influenced by the site in order to develop tectonic responses to human comfort. This is intended to be approached through a nested intervention; the 'mediator,' James Marston Fitch's idea of the third environment, and the 'machine,' a fourth environment to provide human comfort such as a place to sleep, sit, cook, eat, bathe and relax.

Figure 30: A view of the site overlooking Hay Bay

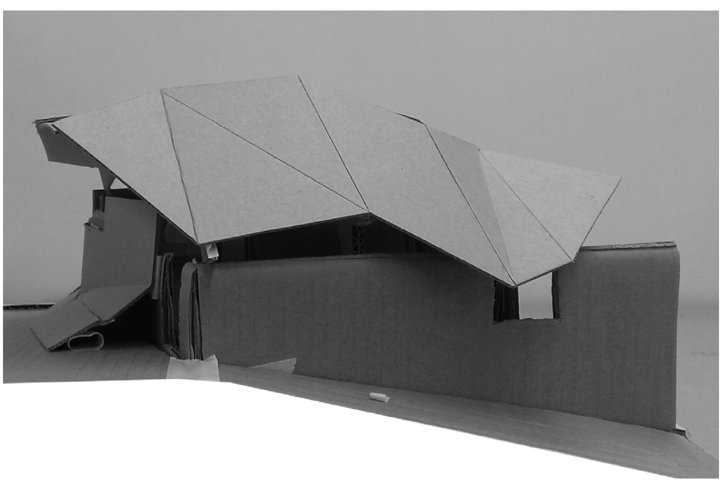
Figures 31 & 32: Below, a view of the South side of the cottage; right, a view from the water.

Though initial concepts began with the five cornered pitched roof frame house archetype, later explorations deviated from this, starting from a blank slate to respond to the interior and exterior conditions. Located at the edge of a cove, at the bottom of a valley, the building is oriented out to view the water. The roof deforms to allow for entrance to the second level from a bridge on higher ground, and the floor steps down to deepen the dialog with the landscape.

The second iteration turned into a 'folded plate' articulated to respond to the space requirements in the second story bedroom, and entrance stair, and extending out to create an overhang for the south facing thermal mass in the summer. The third iteration of the house dealt more with simulation, after having allowed some of the formal ideas to crystallize through physically modeling them for the previous iteration. Using grasshopper, ecotect and Galapagos, an associative component of the design was generated, consisting of a thermal mass collecting wall, roof soffit, and an undulating roof.

The thermal wall was made of two arcs which were allowed to deform through their centre point variably between themselves. They formed into a tilted arc of sorts, optimized to face the sun as efficiently as possible. The overhang of the roof was based on sun angles between the summer, where the mass wall would not be as exposed, and the winter, when it would be

Figures 33 & 34: Below left, view of a model of a folded plate roof; Below, a view of the curving thermal collecting wall bending around the West side of the model.

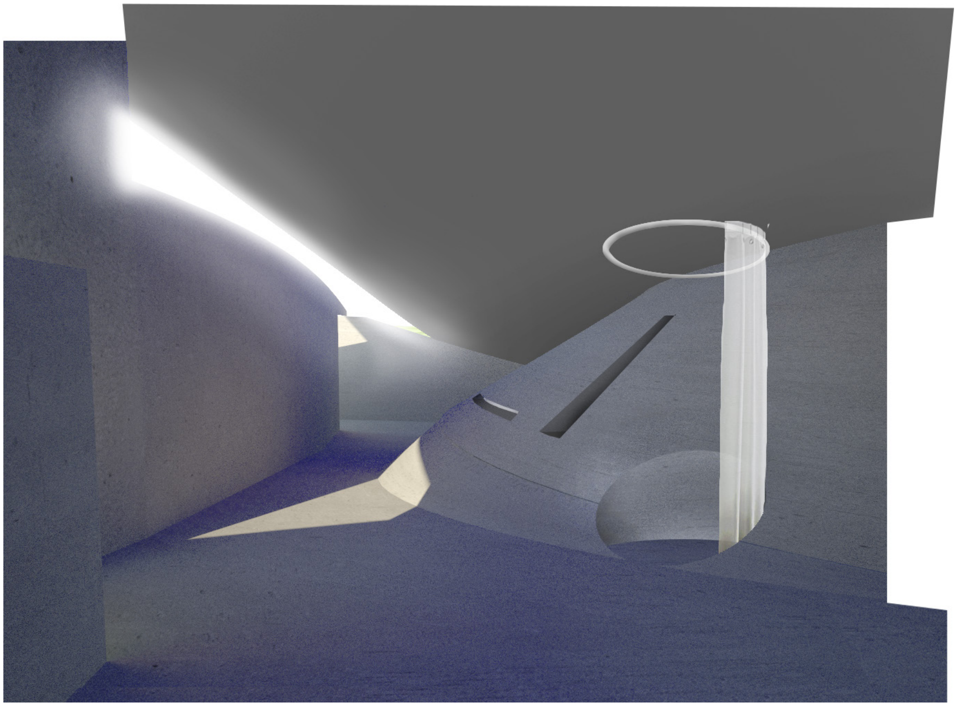


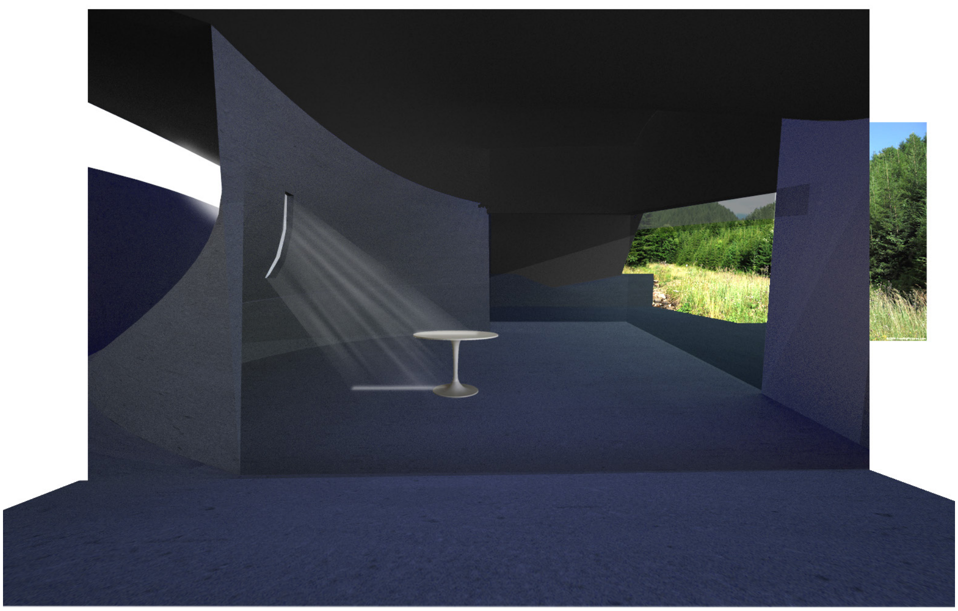
optimized to receive as much solar energy as possible. Likewise the undulating roof was optimized through control points along two curves to deform in order to self shade and receive as little solar radiation as possible.

The solar mass wall itself becomes the support system for the entire house, and this was intended to be taken further with the absorption and release of heat at various times throughout the day. As it tracked the sun around the concave form, the moments that were being heated would be related to what would typically be taking place at that time. For example, a shower would be placed so that in the morning the sunlight would warm the body and the concrete surround, and as the sun moves, it allows for the comfort of more activities, for example, falling through the penetrations in the wall as you eat your meal, then to the desk as one works. The thermal wall and its perforations was to pace the activities of the day.

The thermal mass wall was developed using the simulation program to divide the created surface into a grid, and analyzing the amount of thermal energy falling on the surface for pre-determined times. Further development could have contributed to the use of this data to determine the thickness of the wall to optimize heat absorption and distribution. The house thus would have been intrinsically connected with the forces which surround it, appropriating them for use as opposed to rejecting them.

The dynamism of the house extended to the ability for the activities to extend to the out of doors on warm days, so that the kitchen could extend onto the north facing patio, expanding the living space in the summer, shrinking and tightening in during the cold winter months. The project continued to evolve with the same spatial and programmatic requirements – a bedroom, kitchen and dining room, washroom, living room, office, and summer kitchen or outdoor area. This project aims to explore a dwelling influenced by the site in order to develop tectonic responses to human comfort.





Figures 35 & 36: Top, a view of the thermal space, showing the convex wall exterior, with moments, such as the shower cut into it. Bottom, the effect of these perforations on the space.

Although previous iterations had two components – the mediator and the machine – the integration of the two through the use of simulation tools became the desired outcome. Where before there was an expressive skin to resist with a sort of neutral interior space, an attempt was made to link them through their use, and so began an exploration of an alternate model in which the thermal mass wall was used to set out how the spaces would function, and sort of act as a time keeper or machine for carrying out the tasks of the day.

The idea of tracking the sun for various activities took on a more formative role in this iteration, with the mass wall transforming from a curving element literally tracking the sun into smaller elements directly related with their activities and set along a linear path in the east-west direction of the site, allowing for the association of time, solar position and thermal comfort, among others.

The organizational framework for the house was to track the tasks of the day in a linear progression – following the sun to some extent from the eastern side of the site to the western side. This led to the placement of the bedroom on the East side of the house, allowing for access to morning sun, with the adjacent washroom and shower having access to the sun slightly later in the day. Following that are functions which needed a more prolonged exposure to sunlight – the kitchen and dining room, office, and living room, with a covered outdoor area at the West end of the building.

Each of the spaces are connected along a spine running along the North edge of the building, as well as a continuous massive wall that is cut into and broken apart to allow for different situations to take place for each individual space. This basic initial form was ascribed certain parameters related to occupant comfort. The narrow and rectangular plan was adopted so as to allow deep light penetration in the winter and cross ventilation in the summer, while allowing for differing conditions in each space.

Figures 37 & 38: Opposite Page; Top, a program diagram showing the progession of the day with corresponding spaces. Bottom, the site plan showing the east-west orientation of the long rectangular plan.

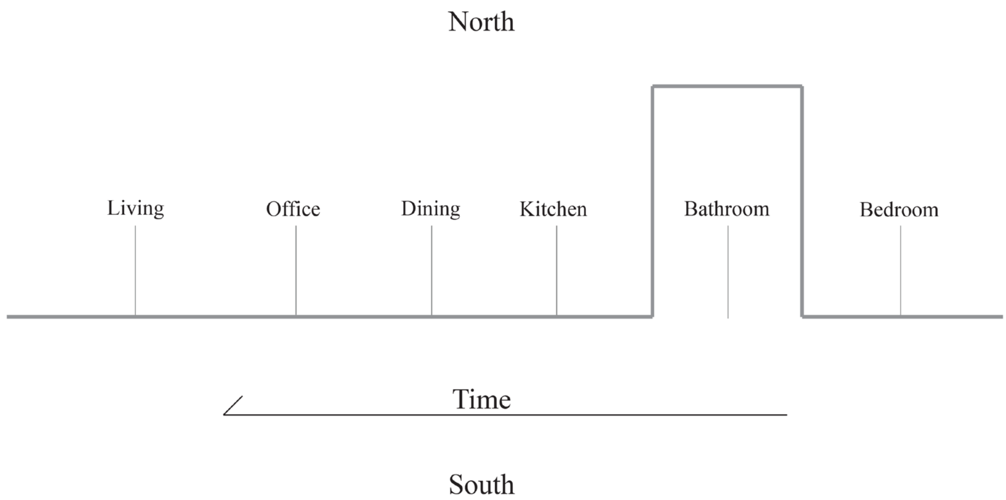

North
Living
Office
Dining
Kitchen
Bathroom
Bedroom
Time
South

Figure 39: A chart demonstrating the conditions to be designed for in each room, according to season.

SPACE	SUMMER		WINTER	
	ACTIVITY	COOLING	ACTIVITY	HEAT REQ.
Bedroom	LOW HEAVILY CLOTHED	HIGH	LOW HEAVILY CLOTHED	LOW
Bathroom + Shower	N/A	N/A	LOW UN-CLOTHED	HIGH
Kitchen + Dining Room	MEDIUM CLOTHED	MEDIUM	MEDIUM CLOTHED	MEDIUM
Office	LOW CLOTHED	MEDIUM	LOW CLOTHED	MEDIUM
Living Room	LOW CLOTHED	MID-HIGH	LOW CLOTHED	MID-HIGH
Outdoor Area	MEDIUM CLOTHED	HIGH	N/A	N/A

Inspired by Phillipe Rahm's use of the Swiss Society of Engineers and Architects' (SIA) standards for ambient temperature, as seen in the Interior Gulf Stream project and the associated chart, the Tobermory house was designed to achieve these conditions in a more passive way than usual. In the Interior Gulf Stream project, Rahm uses two thermal sources – one cold and one hot – in order to generate convective air movement in the space, allowing for temperature gradients, and thus the placement of various activities according to their desired temperature. (Rahm P. , 2008) In this thesis project however, two modes were addressed, and not necessarily based on temperature. Summer and winter were each addressed through their own different modes of creating thermal comfort, through the use of ventilation in the summer and solar absorption in the winter.

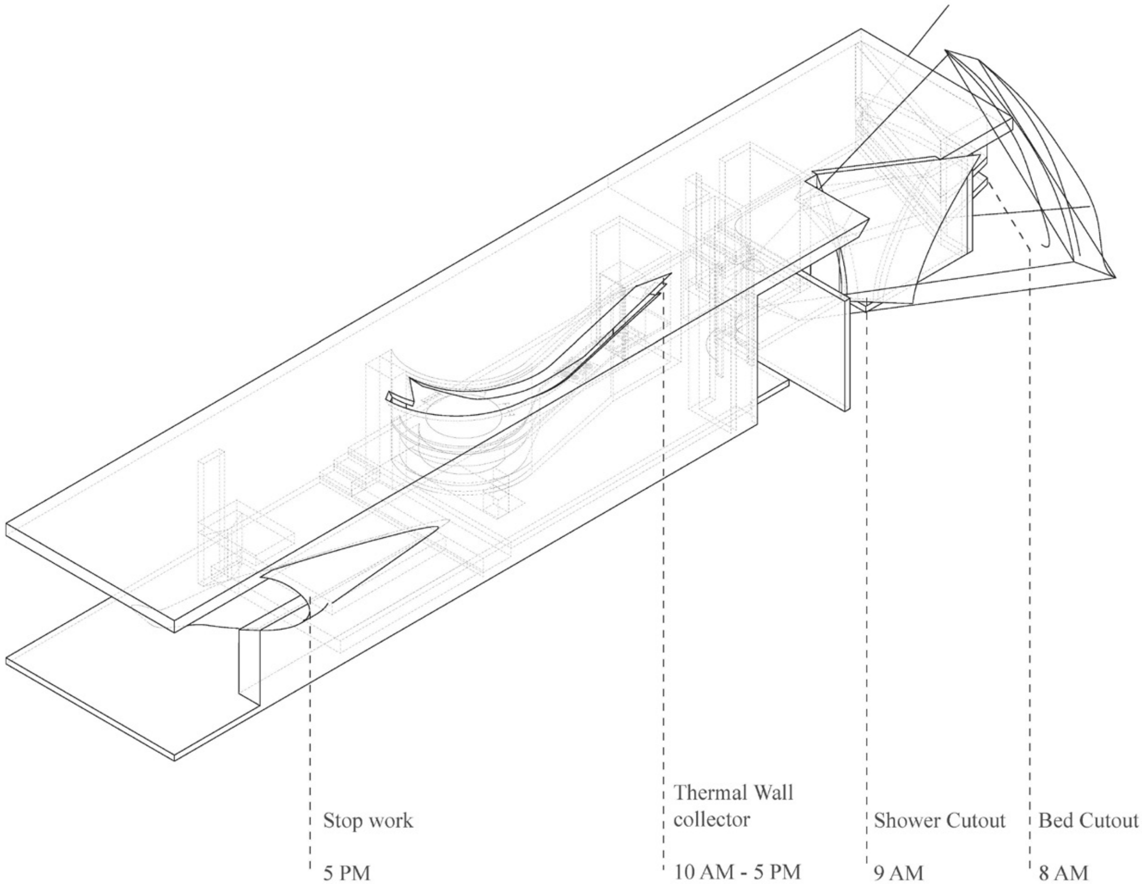


Figure 40: Axonometric showing an early iteration in which solid geometry related to the sun path was developed and subtracted from the overall form.

The first iteration of the project focused solely on solar absorption. Within a cuboid form, the differing solar conditions are allowed to generate formal responses through the use of surfaces and vectors derived from the sun-path in Tobermory. Rather than arbitrarily placing windows, the generation of specific geometries allows for a more precise approach wherein the sun is tracked for certain purposes, such as waking you up, warming the shower, or heating the kitchen while providing light for the office. In the development of solar the wall and roof as solar control, Grasshopper and Ecotect were used to generate geometries directly from the linear movement of light – that is the selection of appropriate times of the day and year to allow for the access of light into the space, their associated vector and the geometry generated from their spatial requirements. In this iteration, the

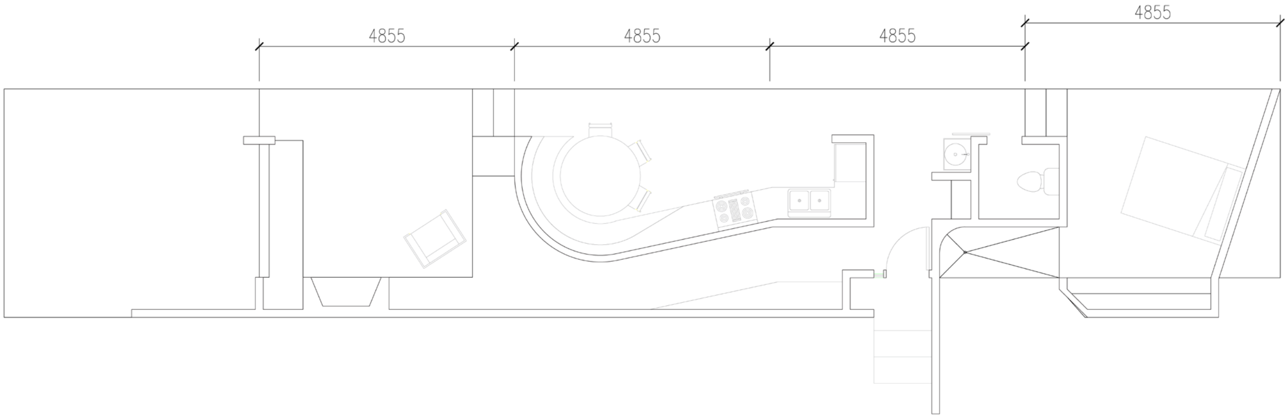


Figure 41: A plan of an early iteration showing the demising mass wall between office and kitchen.

mass wall served as a reflector for light into the office, and absorbing heat for a bench on the other side. This also demanded that the wall be shaped by the path of the sun, as well as a skylight to allow for access to light. The skylight, however, due to the nature of this approach, was a highly irregular form and required a cowl to keep the sun out when it was higher during the summer. A similar protuberance was required at the West end of the building to allow for light to fall on the desk at the end of the work day.

Conversely, on the East end of the house, the cuboid was carved out for early morning access to the shower and the bedroom, controlling access for a limited amount of time throughout the year. For example, in succeeding iterations, the mass wall surrounding the dining table seating area was instead transformed into the table itself.(Figure 40) The time period of late September to mid-April were used as the boundary dates, and 10-am to 4pm as the primary times for solar collection, as it would have minimal use during that period. The vectors extruded along the far edge of the table fan out in the direction of the sun, along which the surface itself is extruded, allowing for a solid geometry – the spatio-solar requirement for the table to cut itself out of the thickened south wall.

As you can see in the images of the project over the year, and the associated simulations, the table is showered with light during the design times, receiving minimal sunlight at later points, when the table would

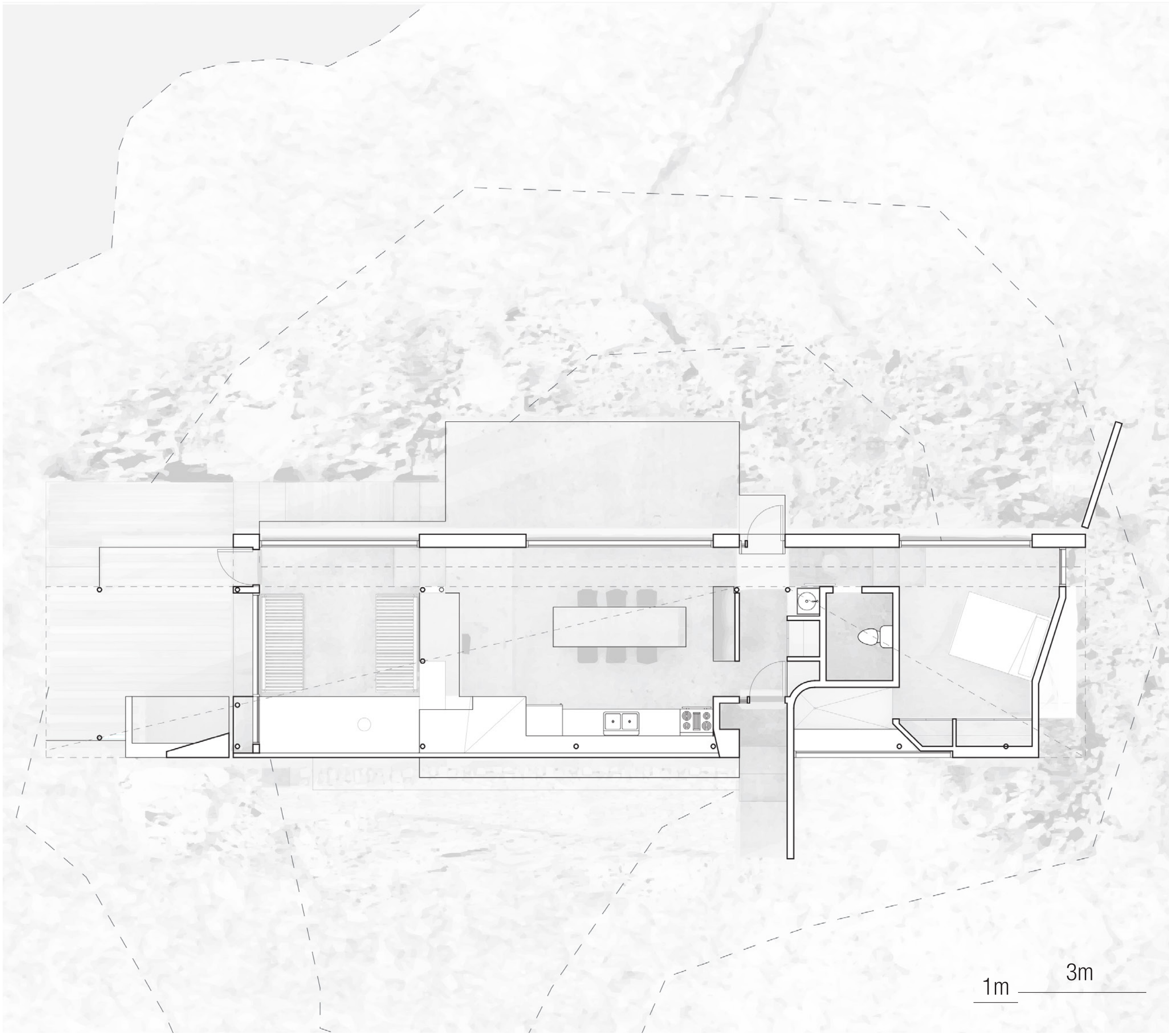
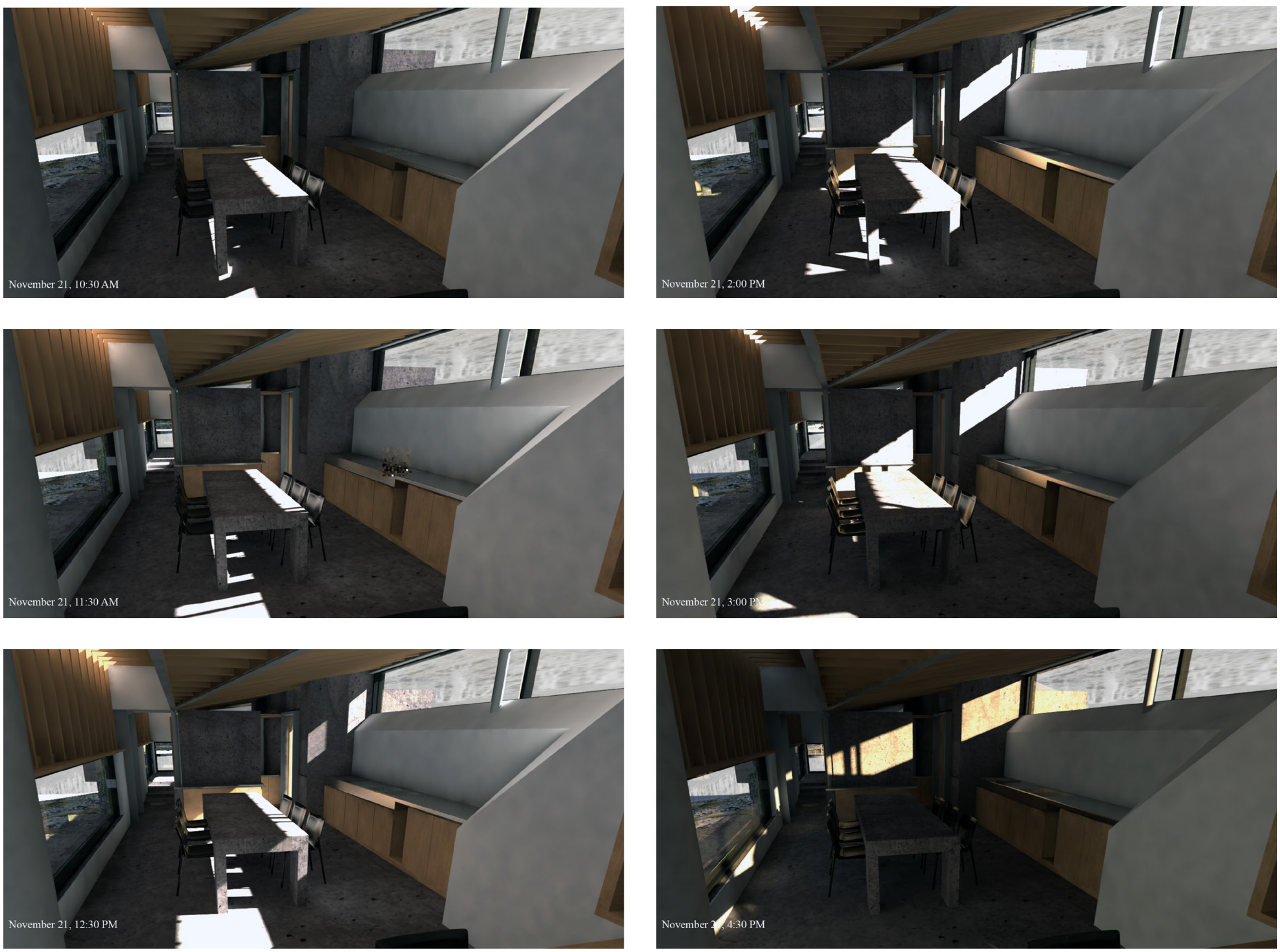


Figure 42: The final plan of the cottage, showing the mass having transformed into the table, as well as dashed lines related to the the angle of the sun in various components of the plan.

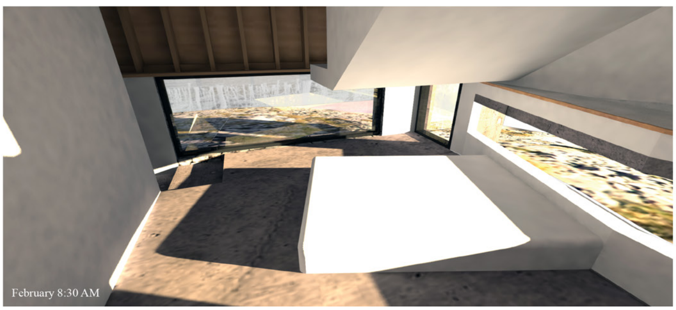
likely be occupied. This same approach was undertaken with each of the spaces and their associated conditions.

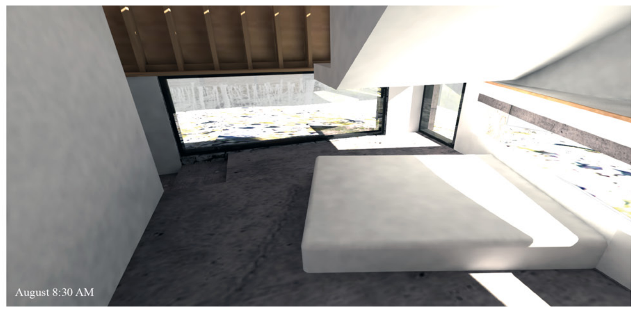
Within the bedroom, the design times were 7:30 am to 8:30 am, generating a parabolic form on the East wall over the bed. The intention in this case was to have sunlight fall on the bed during that period, waking the occupant up by warming them with the sun's rays slowly tracking across the bed. The form of the window makes the seasonal and diurnal movement of the sun evident through the form subtracted in order to allow for solar access.

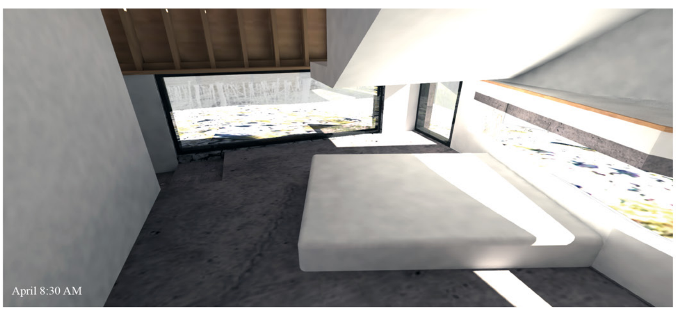
Figure 43 & 44: Below, images demonstrating the diurnal sun cycle over one day in the kitchen. Opposite, six periods within a year demonstrating the consistency of the locating of the sun during that time of the day.

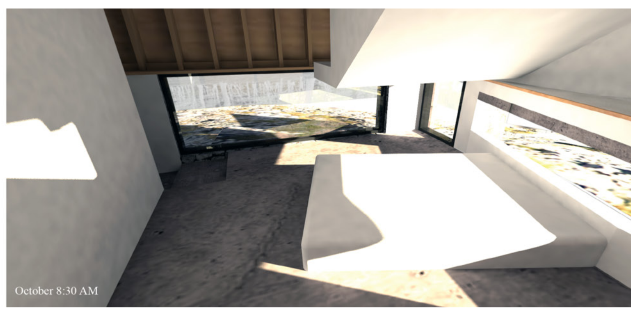


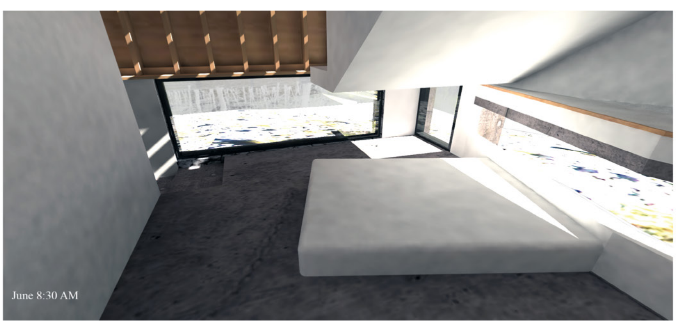
Likewise, in the South-facing shower, a design time of 8:30 am to 9:30 am leads to another instance of a highly formal subtraction from the block housing the closet, as well as a portion of the ceiling for a skylight. Again, the diurnal and seasonal change is producing this variable form due to the changing azimuth and altitude of the sun. This allows for the sun to fall on the body as one showers, every morning, tying the experience of showering to a specific time, as well as to the specifics of the site. These two conditions are very much tied to the diurnal cycle and the progress of one's day, generating a somewhat inflexible approach in order to gain the intended experience of the place.

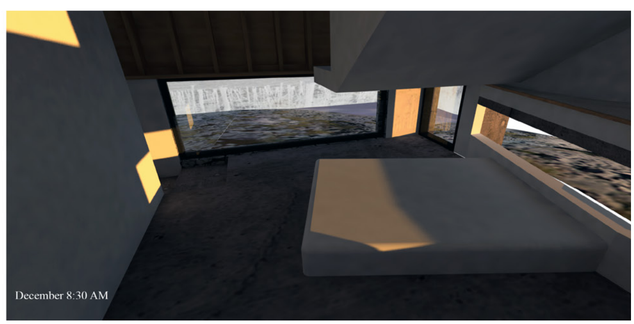












In opposition to this, from the hall westward, the remainder of the house is primarily designed to deal with seasonal changes, as the activities that take place within them take place over longer periods of the day. As in the earlier iteration where the curving mass wall, skylight and cowl demanded a large intervention to be effective, the same requirements remain in terms of the time of thermal exposure during the winter. However, in an effort to 'concretize' the experience of eating at a table, the table became not just a movable piece of furniture, but an essential element of the space that also serves as the solar collector – a concrete top sits in the centre of the room, in the winter collecting the warmth of the sun, allowed for by the geometry generated and subtracted from the thick wall. The gathering point of the room also becomes the heat source, warming the people that surround it. In this case the design times were between October 15 and April 15, from 10:00 am to 4:00 pm each day. These generated a sort of low, flat, box geometry which flared out significantly to the South. This necessitated the high south clerestory, but also aided in the development of the roofline. Since access to the summer sun would cause overheating within the space, the same geometry was used to help set how far the eave should extend past the wall.

Next to the kitchen is the office, which was conceived as a more calm and stable space to be able to carry out work, and which was developed with a light shelf as opposed to a cutout, so that the thick south wall maintains its thickness and height here, with storage built into the wall for the office. Adjacent is the living room, where like the family room and the development of the table as the essential element, the seating areas in this space were developed to work with the sun. The sofas are leather straps on a metal frame, hung from the structure of the building, over a thermal mass floor. In this space, the thermal mass wall is heavily cut into, as the space steps down as the site descends down toward the lake. The clerestory is maintained to allow for sun to reach the more northerly portions of the room, and another cut allows for the integration of the fireplace into the wall, as well as for

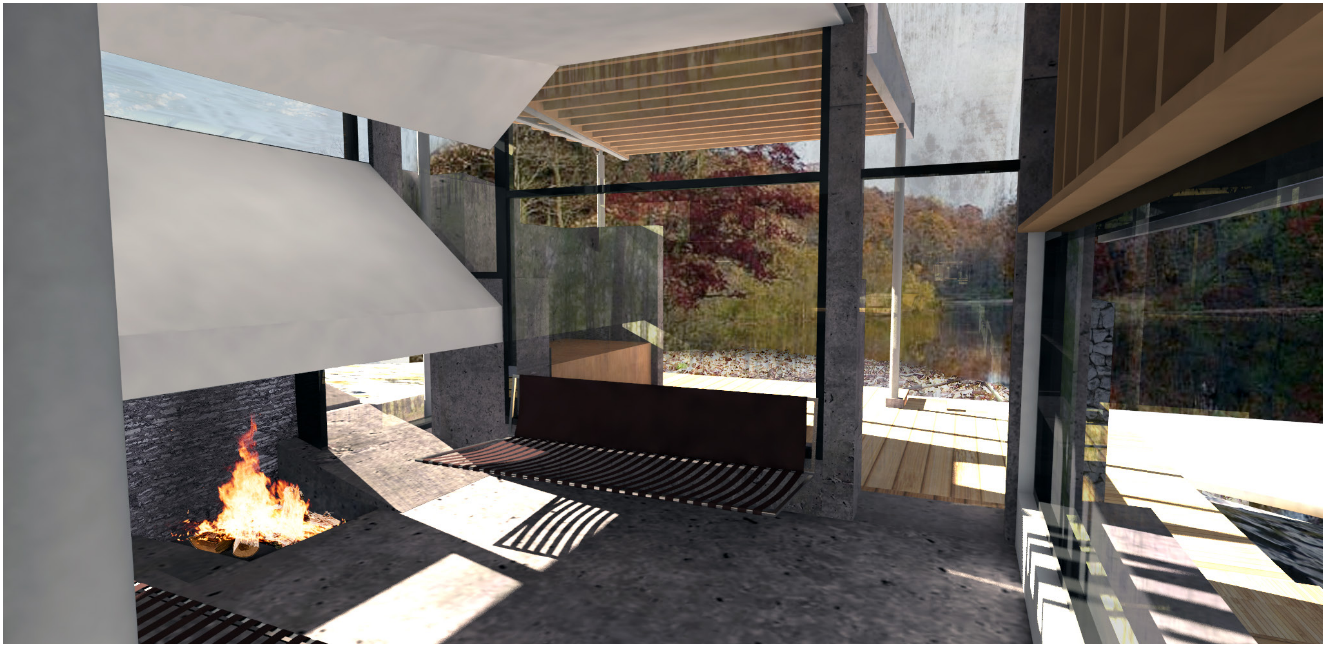
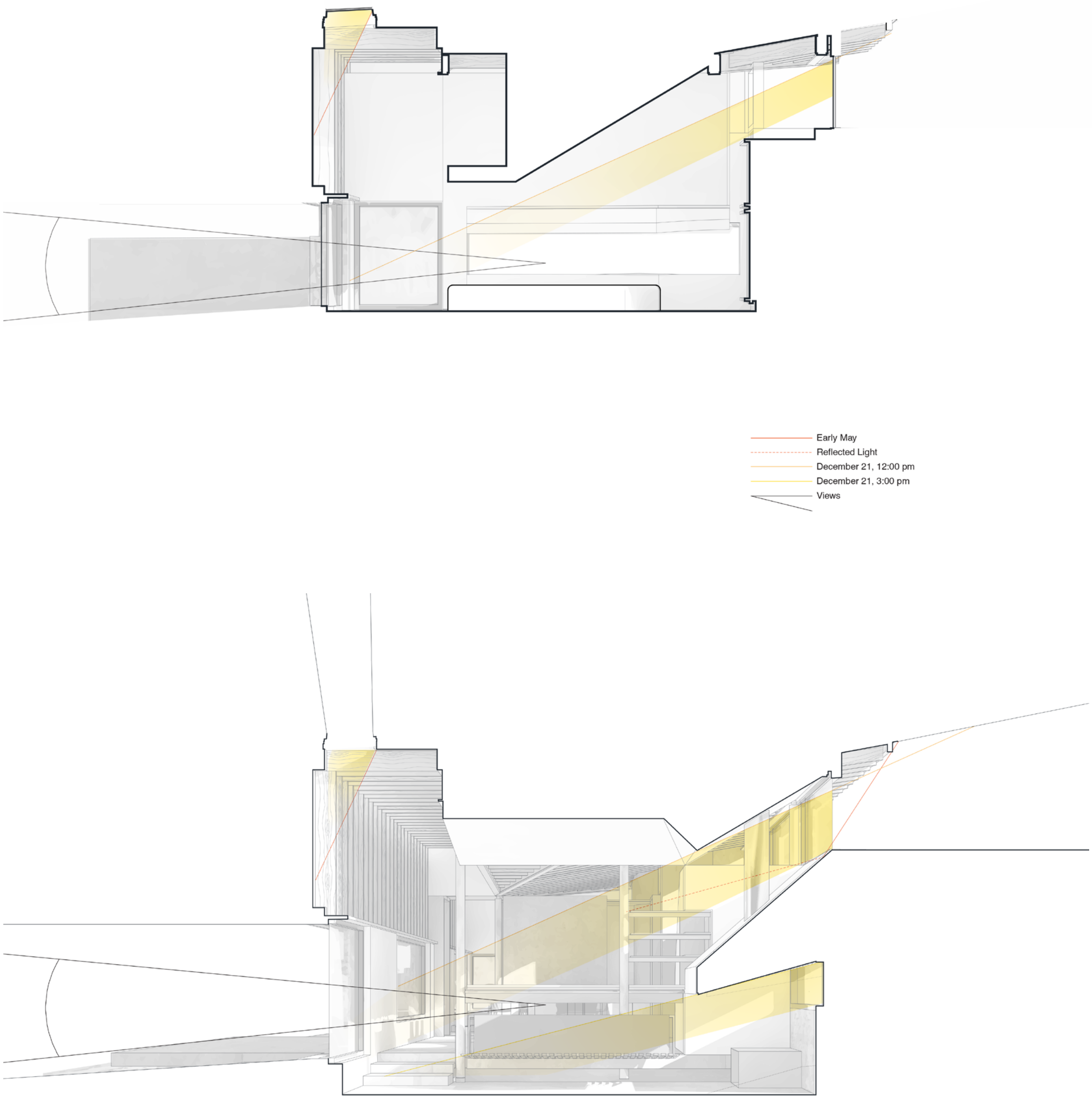
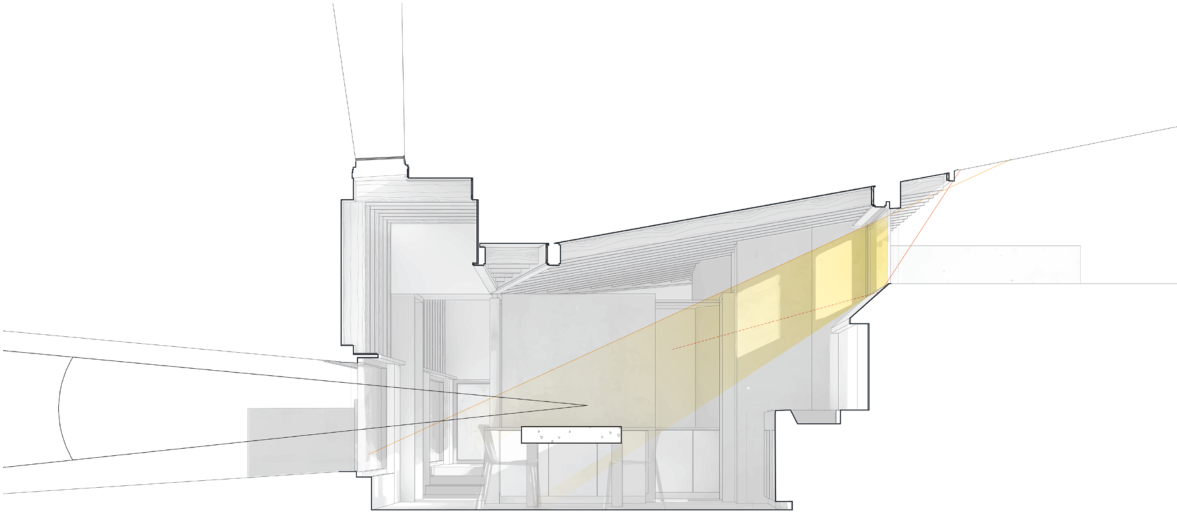


Figure 45: A view of the family room, showing the concrete floor beneath the sofas having access to sunlight, and with the summer kitchen beyond overlooking the lake.

sun on the floor beneath the sofas in the southern portion of the room. The design times for this space were 12:00 pm to 4:00 pm, generating low flat forms flaring to the southwest.

The variation created by such an approach can readily be seen in the sections of the project, in which from one space to another the thick south wall begins to demonstrate the variation in the sun angles that aided in forming it, generating diverse expression across the building. Likewise, in the plan, the azimuth created a subtle radial pattern from each of the areas that can be seen in the south wall, the west outdoor area, and the east wall. But as with Frampton's explanation of the tectonic, it exists between ontology and representation; though we can intuitively understand the solar angles and their implication on the form of the walls, they also serve to allow access to the thermal mass of the floor in the winter, reflecting light into the space in the summer due to their width. The geometry that was developed through Ecotect was also verified, as can be seen in the axonometric drawings showing the amount of thermal absorption over their design times. As can be seen, each of the addressed areas – the bed, the shower floor and wall,


Early May
Reflected Light
December 21, 12:00 pm
December 21, 3:00 pm
Views



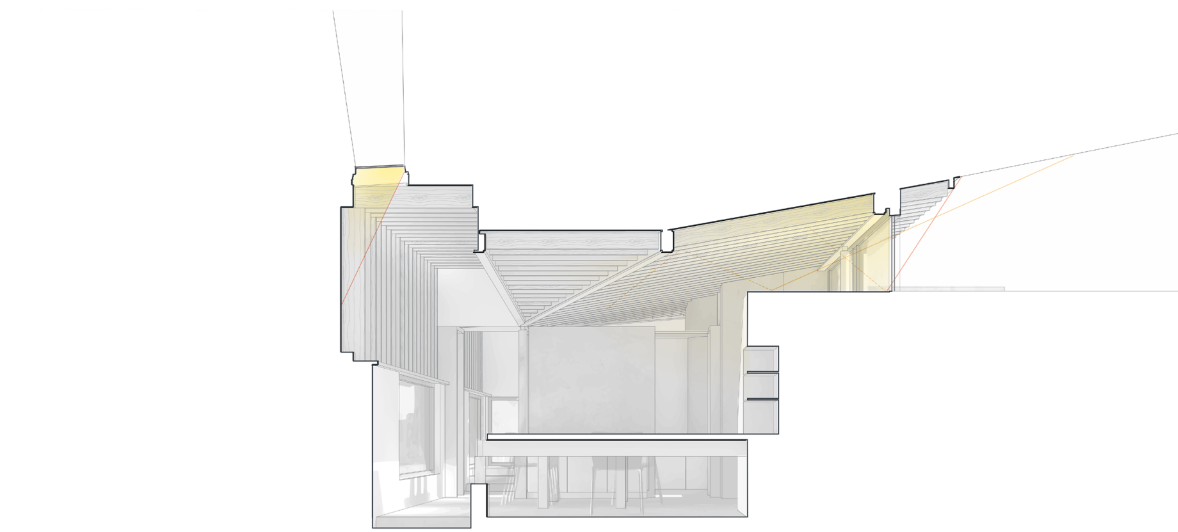
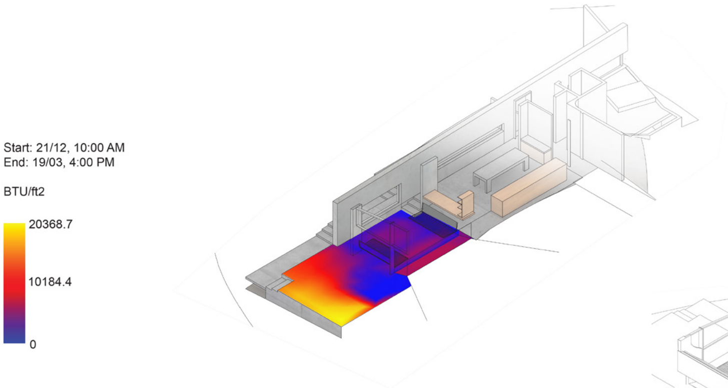


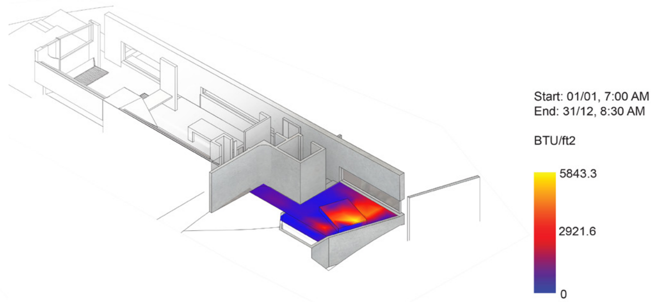
Figure 46: Sectional perspectives demonstrating the allowance and denial of light according to times of the year. Clockwise from top left; bedroom, kitchen, office, living room.

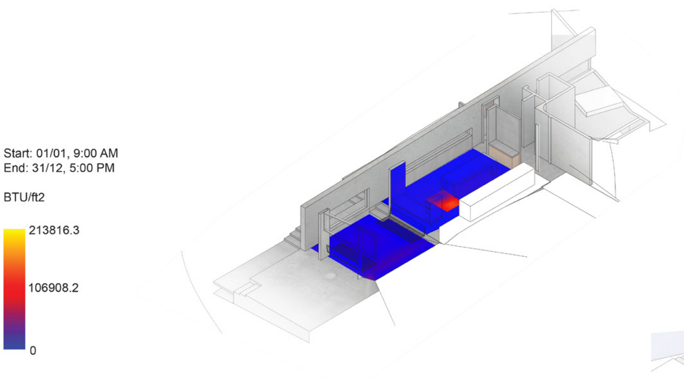
the kitchen table, and the area beneath and in front of the sofas have higher incidences of solar absorption when compared with the surrounding areas. In the office, the reflection of the light shelf can also be seen, and the desk remains without direct solar gain during the use times.

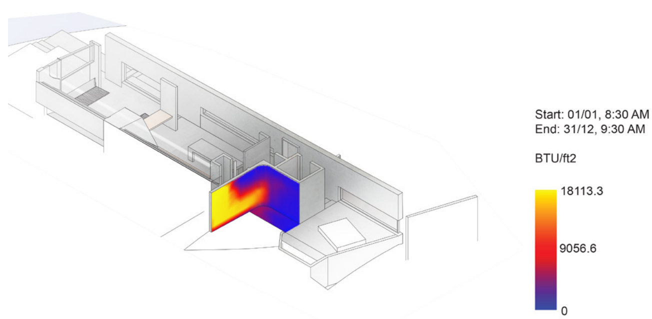
Within the sections, to the North side of the building there are also low windows as well as a skylight. The windows themselves were another effort to 'concretize' the activities taking place within the room; in the bedroom, the window is set low at floor height, so that laying in the bed one has a view out over the lake. In the dining area, the window height is set not so that when walking through there is a view, but so that when seated, the view opens up at that level. Likewise, in the living room, the window dropping down lower allows for views when seated on the sofa. On the exterior of the house, this leads to the generation of a strong datum on the North elevation, which in turn emphasizes the section of the house as it descends toward the lake at the West end.

Figure 47: The North view of the house showing the strong datum carried across the house generated by the demands on the windows and the sectional change from East to West.









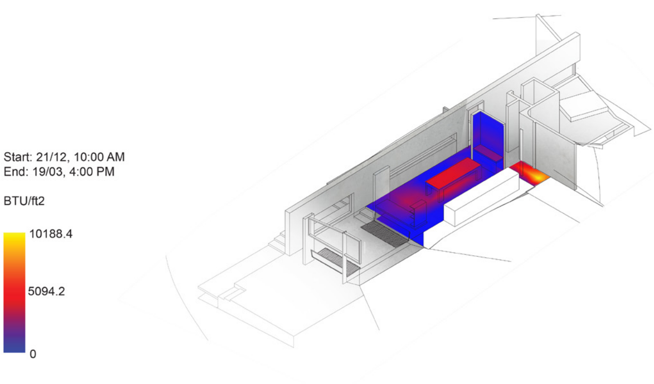
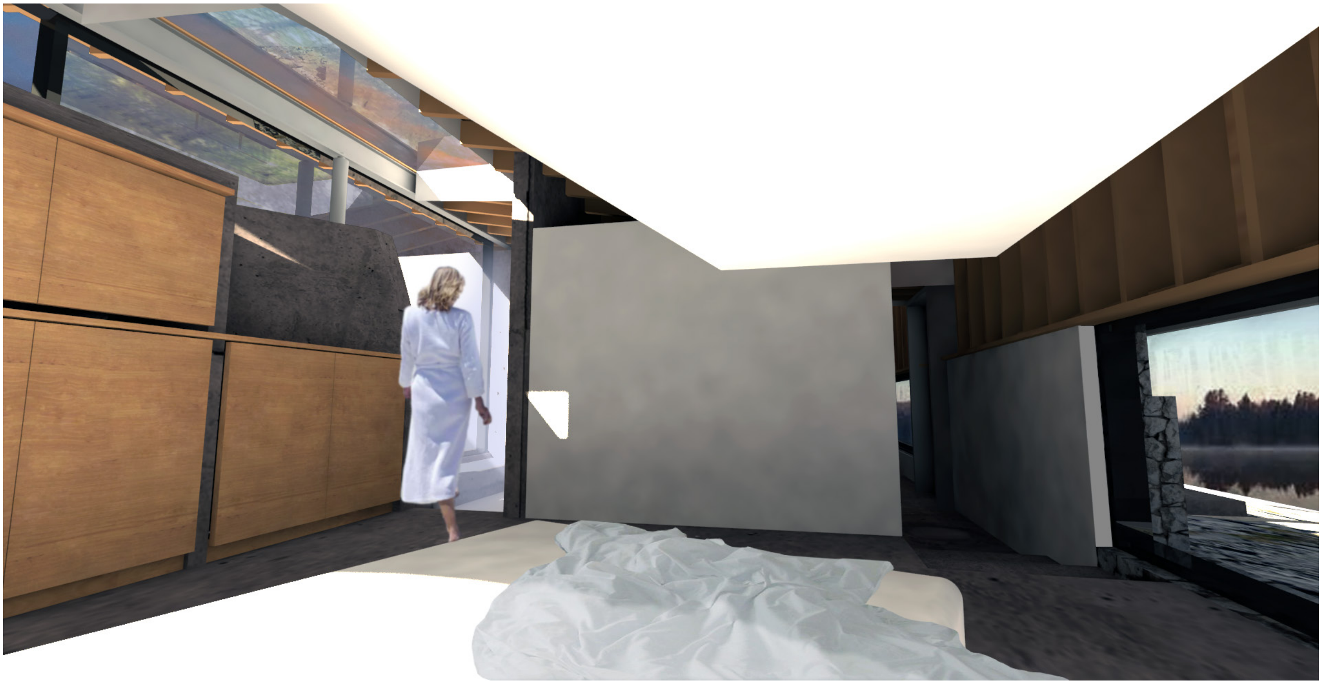


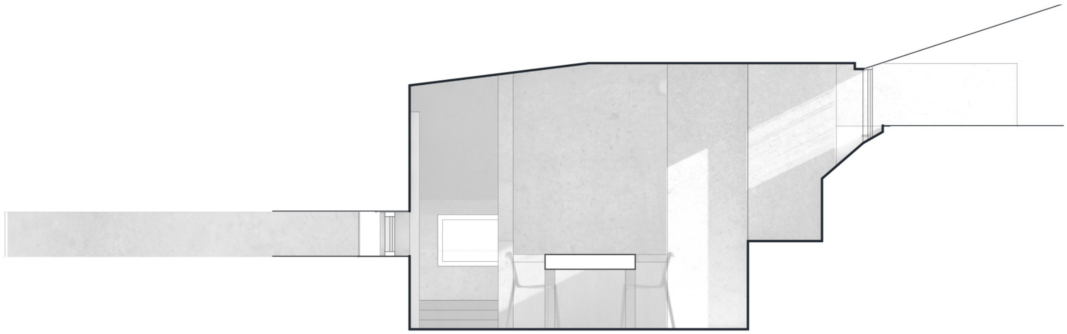
Figure 48: Verification images from Vasari demonstrating the amount of light at the point of interest for the design times. Note that images on the left are designed for the winter, whereas the images on the right correspond with a year round design time.

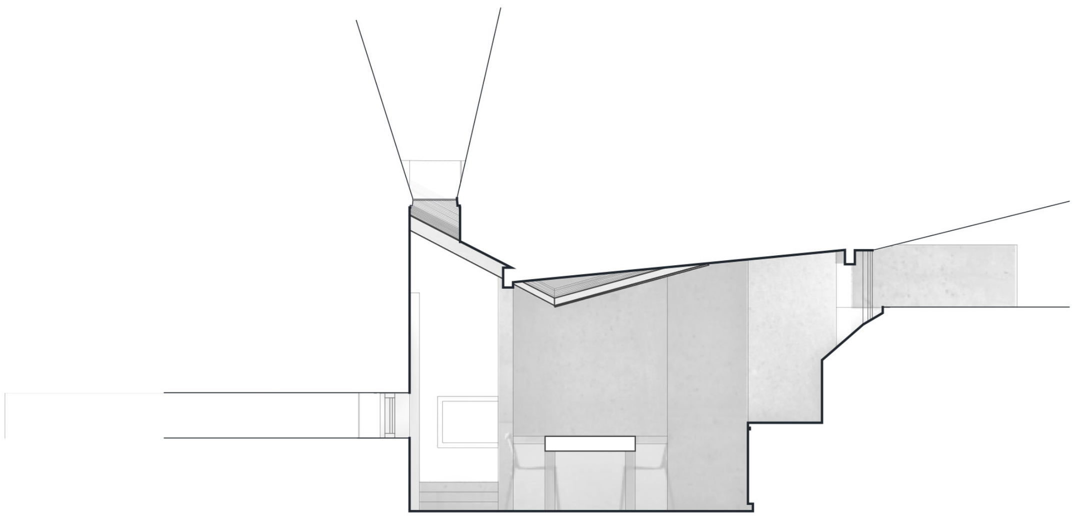


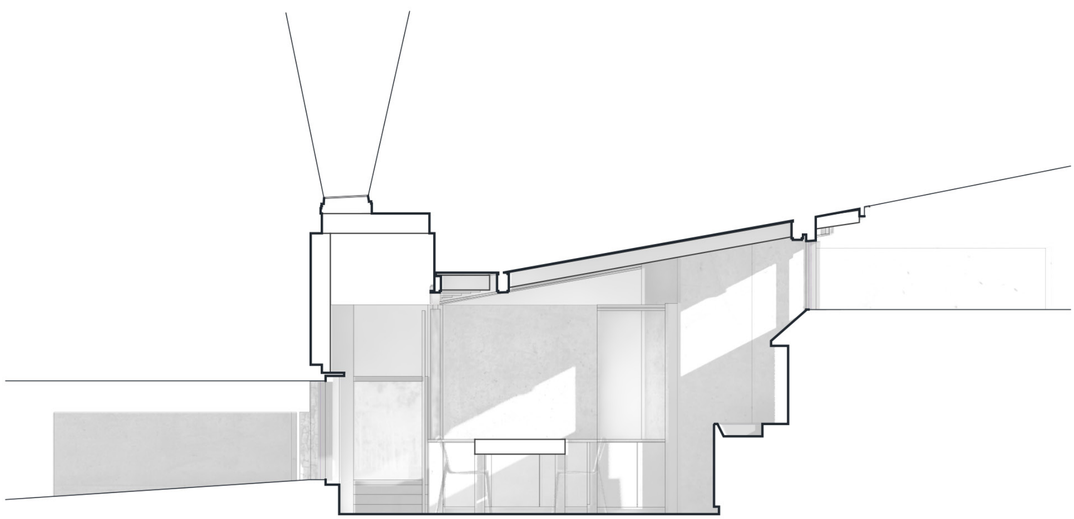
The second mode of the house which was considered was the warmer months, in which passive cooling would be used. This presented another interesting set of variables to work with, allowing for the sections of the house to develop more formally. Because the wind in the area is somewhat unpredictable, there were two sub-modes which needed to be developed – one for breezes from the North, and one from the South. In the case of wind coming from the North, it is quite simple, as the low windows which serve to provide views also allow for the wind to enter low, while the clerestory on the South side allows it to be pulled out higher in the room. Conversely, when the wind is coming from the south, the high clerestory window makes it difficult for the breeze to be exhausted from the North side without much turbulence. Through iterative design and simulation of the airflow through the building, the demands of the activities taking place within the spaces led to further development of the building section beyond the demands of solar control.

Figure 49 & 50: Opposite page, top, a view of the bedroom with the shower to the left, and the spine to the right. Bottom. a view of the kitchen, thickened mass wall, table and the office beyond.

As opposed to a software program designed specifically for iterative design, the computational fluid dynamics simulation was designed more as a mode of verification for building designs. This demanded a different work flow, in which basic models were built, tested, and then modified to test different overall formal changes, with certain iterations being developed further from the best performing results. Here we can see three sections – from the first design of this linear form to the final state of the design. At first, there is a relatively flat roof that serves only to block the sun – but as demands are added to it – for example that of ventilation – the form necessarily changes, so we see it dip in the centre for a high skylight, as well as a deflector hanging from the ceiling to push down incoming air. If we move to the bottom section, the demand for drainage dialoging with the demand for air deflection means that the roof 'concretizes' into a new form – performing multiple functions at once more efficiently than the generation preceding it. Where the second major generation of airflow tests demanded deflectors to the North side of the dining area and South side







of the living room, the original Western drainage demands competed with the direction of the roof slope, leading to a more complex geometry which was still compromised. Allowing for the dialog between these two demands allowed for the generation of a new form for the roof in which it drops down from the outer edges to the low point over the North door, allowing it to drain off over the canopy and into the lake.

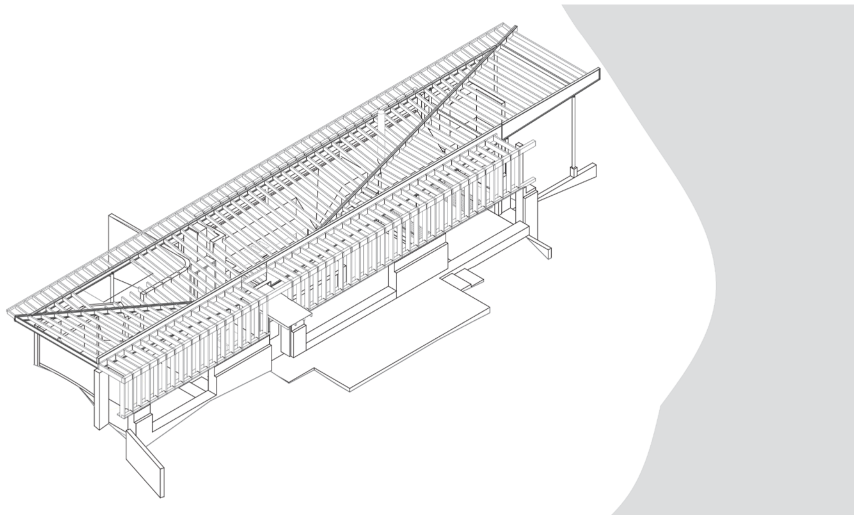
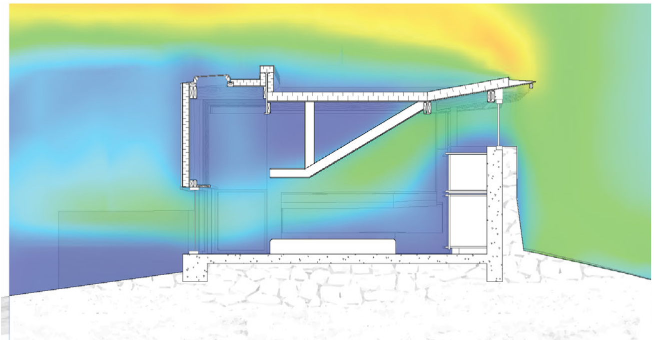
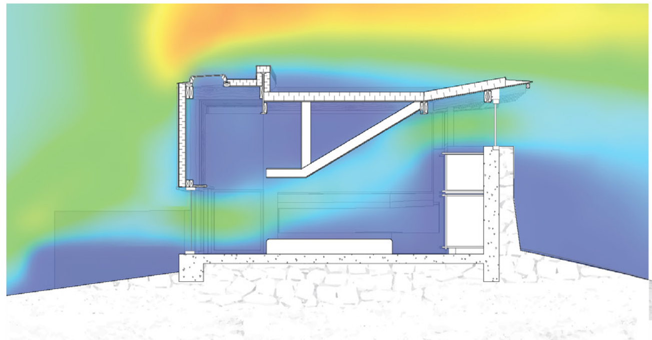
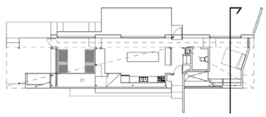
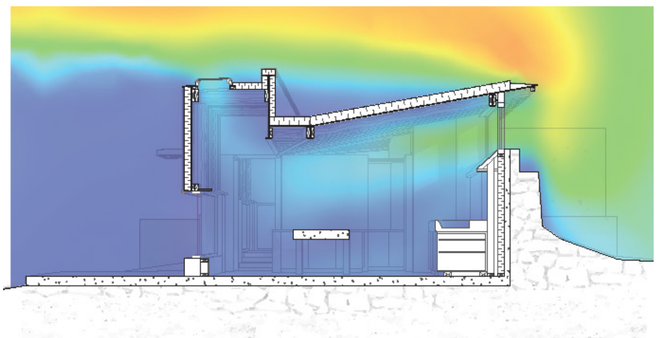
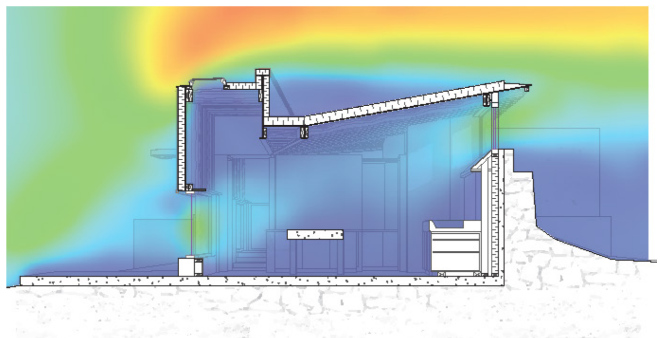
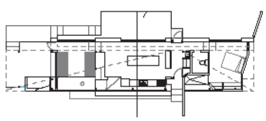
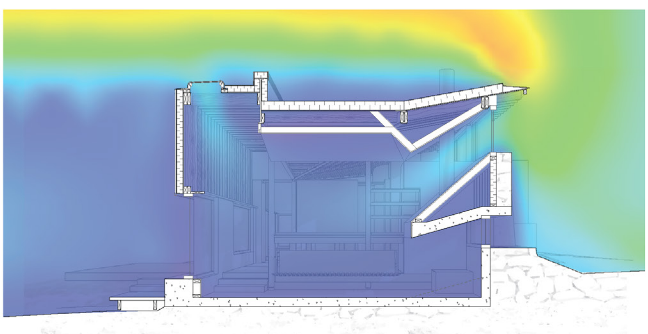
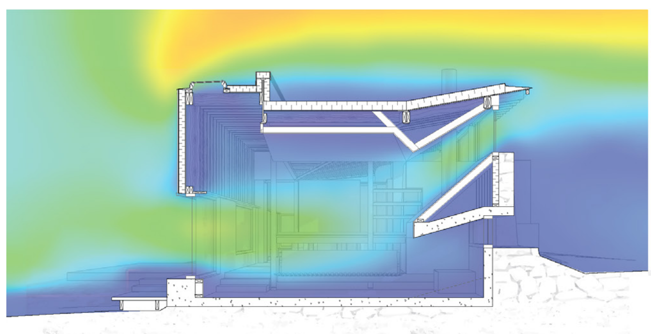
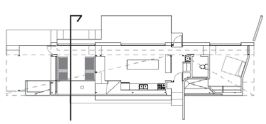


Figure 51: Opposite page; three sections showing the spatial evolution resulting from the iterative testing with the computational dynamic program, as well as other demands, concretizing the skin of the building into an integral whole.
Figure 52: Left; The structural frame of the cottage showing the form of the roof - engaging the demands of the ventilation on the underside and drainage above.

As has been previously stated, the project aims to explore the spatial implications beyond the generic reactions of hermetically sealing and conditioning air to counter these forces. In this house, the skin of the building becomes not just a container for conditioned air, but becomes performative in the making and the experience of the space. The frame does not just contain the space, but literally creates the space from a dialog between site and the material it is made of. The influence that these demands have had on the space itself become obvious – the competing demands have manifested as spatial deformations and higher expressivity of what the space is composed of.

Within the sections shown at left, cut through the dining area and kitchen, the transformation becomes evident; from flat roof, to the addition of the North skylight and the deflector, to a section in which all of these parts become integral to the overall structure of the building.

Within the bedroom, the deflector is much deeper to allow for the flow of air to pass directly over the bed, cooling the occupant as they remain sleeping. This depth of the deflector, and the constriction of space over the bed, coupled with the low window to the North create higher breeze speeds, more effectively cooling the space. The empty space above is cut into to allow for more storage on the windward side of the deflector.

Figure 53: Opposite page; From top to bottom, Three sections at the bedroom, kitchen and family room showing the breeze coming from the South and the North and their effects on the space.

In the kitchen, the deflector aims to simply create a downward movement of air behind the table and then up through the higher North skylight, pulling cool air through the space. This also prevents highly turbulent air from interrupting the office space next to the kitchen.

In the living room, the deflector is much deeper and aggressive, with the intent of having the air coming in through the clerestory, descend to the floor where the sofas allow for the breeze to surround you, and then be pulled up by the negative pressure created over the skylight at the North wall.

Although the house is about the idea of infringing upon the idea of 'pure space' supported by machines, there is more than the definite physical manifestations of the demands that the forces make upon the space. There is an attempt for the space to become expressive of what it is composed of – light, air, heat as well as the materials the building is constructed of. The spatiality of the envelope exists as an ontological device, shaping the air movement and excluding certain light and heat, while representing these very same processes, giving form to the intangible; the other materials of architecture.

Figure 54: Above; a view of the summer kitchen.
Figure 55: Opposite page; A view of the South facade.

CONCLUSION

In the allowance for architecture's roles to be reduced from it, we are only left with the vestiges of the potency of form. On one hand, architecture has become the arrangement of predesigned components into discrete compositions maximizing pure, generic interior space, and on the other, formal possibilities are flouted in favour of easily digestible, scenographic compositions. In both of these cases, architecture is reduced to an aesthetic add on, or to spatial arrangement in the most basic sense.

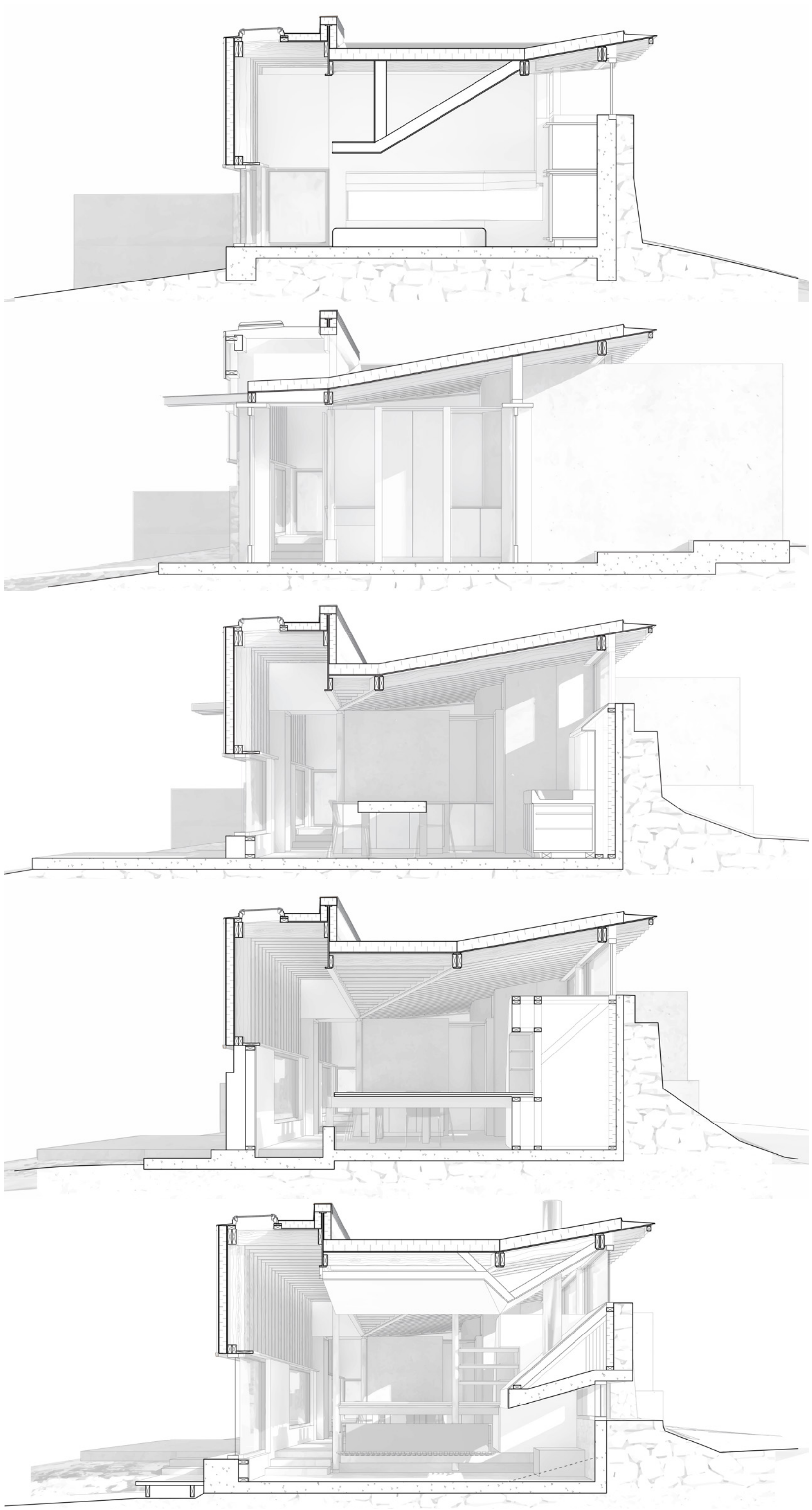
Standardisation and the hand off of building design roles have reduced the expressiveness of architecture, yet we use a tool on a daily basis which can allow us to return in some manner to the tectonic traditions generated with these roles. The technological advancement that began with Alberti's use of representation tools, leading to what Perez-Gomez refers to as the 'instrumentalization' of numbers (Perez-Gomez, 1983) has led us to the point of both the computer, and the accompanying tools that allow for digital fabrication and simulation of environmental forces. The separation of representation from construction led to these advancements, theoretically allowing us to partake more deeply in a more robust sense of design.

And so again, the architect's workshop becomes not the material workshop as it had in the past, but the digital workshop in which the palette

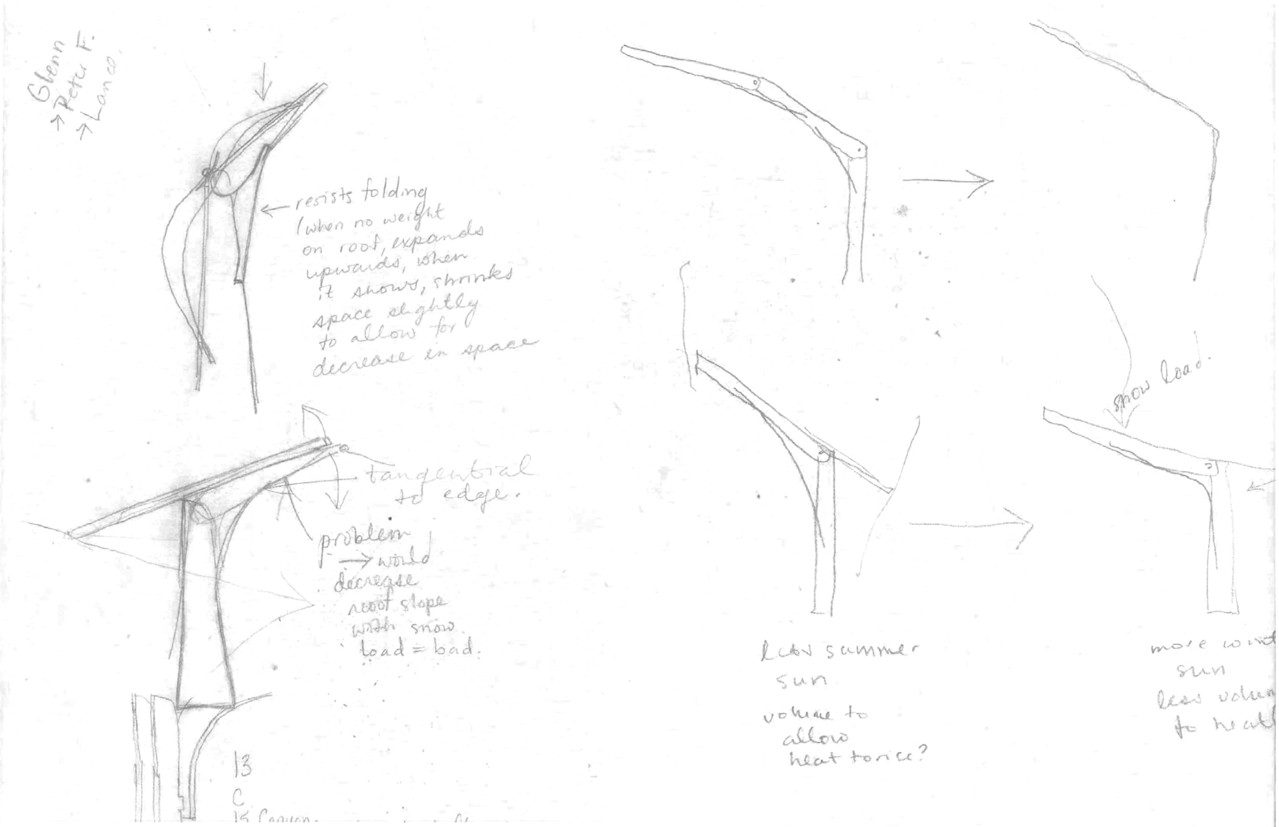
Figure 56: Opposite Page; from top to bottom, sectional perspectives cut through the bedroom, hallway, kitchen, office and living room.

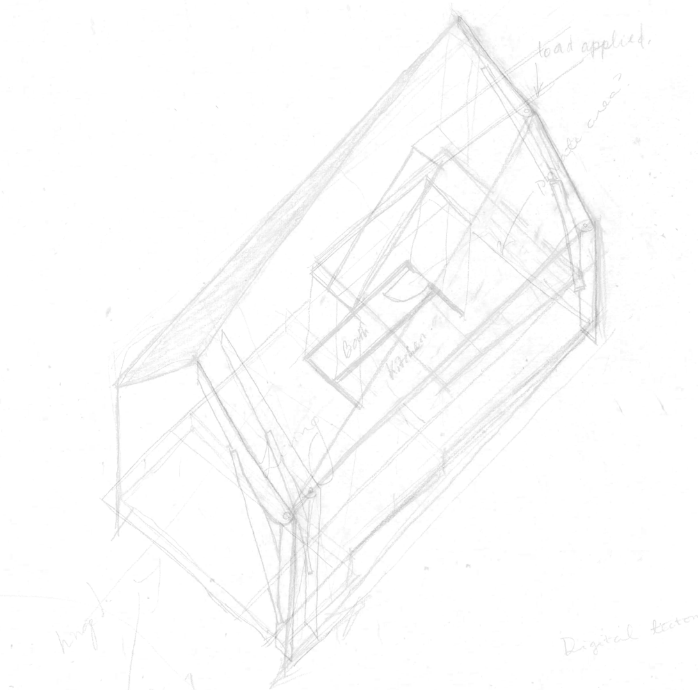
expands through the potentials of simulation. The materials are no longer brick and mortar, but energy and paths forming the spaces more directly, and re-purposing form as the most potent tool.

In opposition to the generic, thin architecture that has been produced through the use of climate control, digital simulation of environmental forces, materials, and construction, can allow for the generation of a thick architecture of specificity, tuned, and expressive of its place through an expanded sense of the tectonic material basis of form, allowing us to recapture this expressivity in a contemporary manner. By giving the envelope a spatiality and infringing upon the idea of pure space supported by machines, the space is allowed to take on effects, and give form to the intangible other materials of architecture.

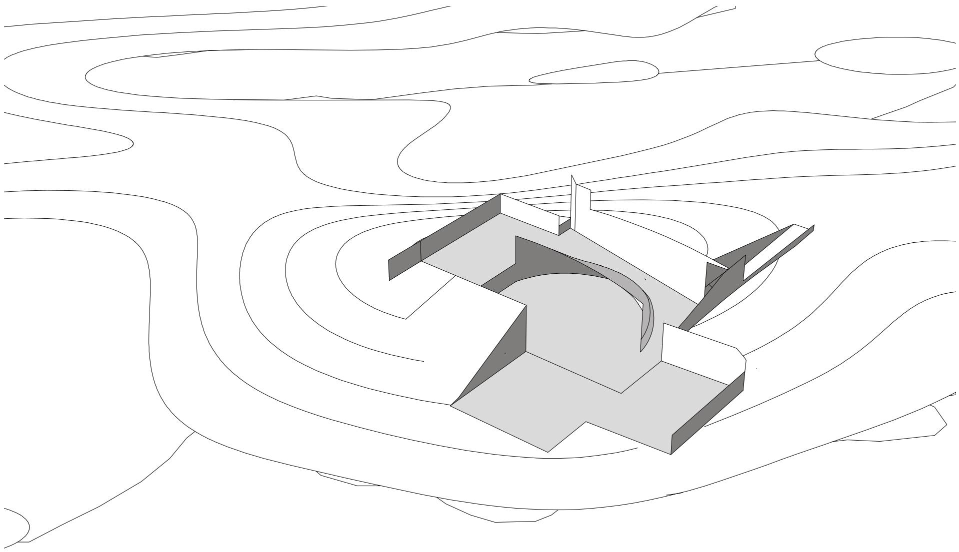


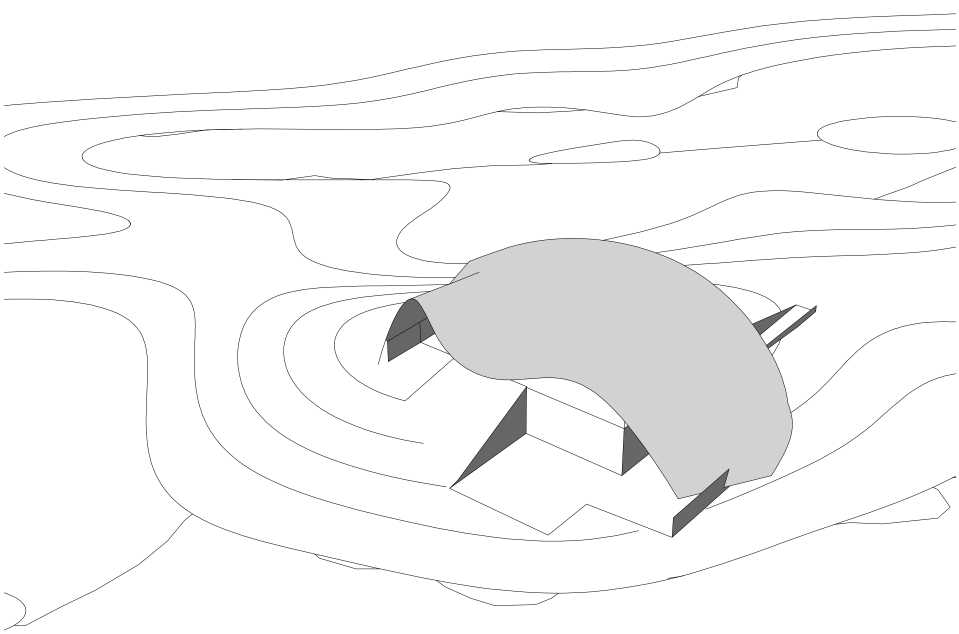
APPENDIX A: EARLY CONCEPTS

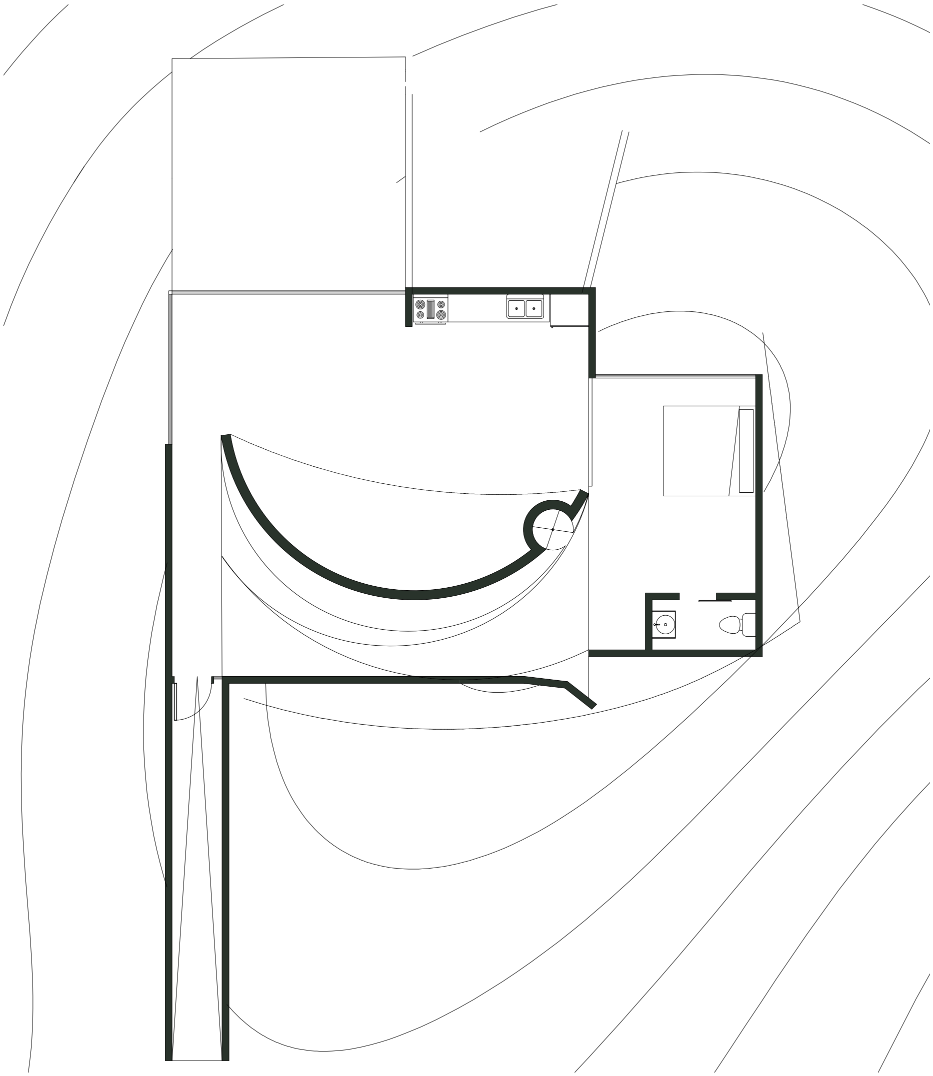




Refer to figure 25 & 26. This page: Sketches of the mechanisms for allowing the cottage to transform.

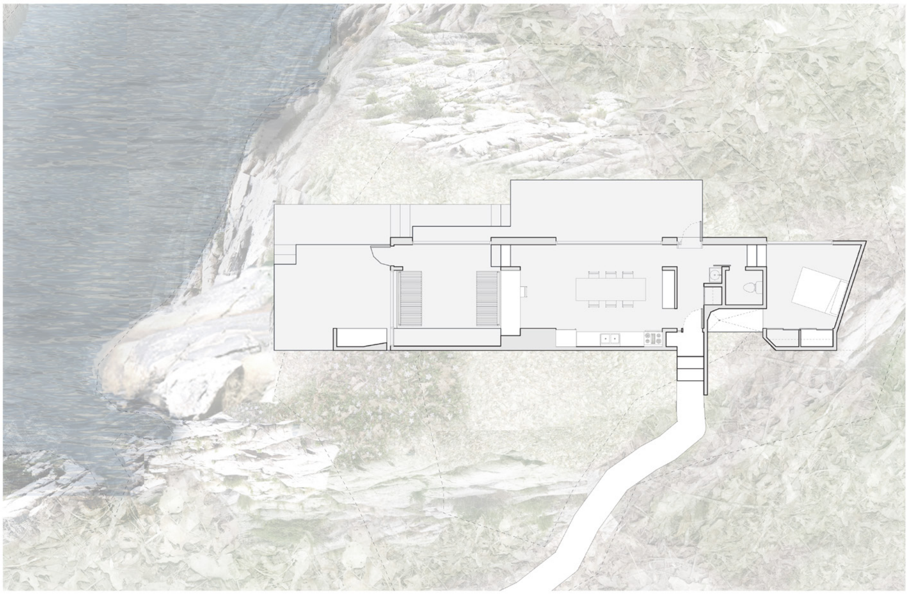


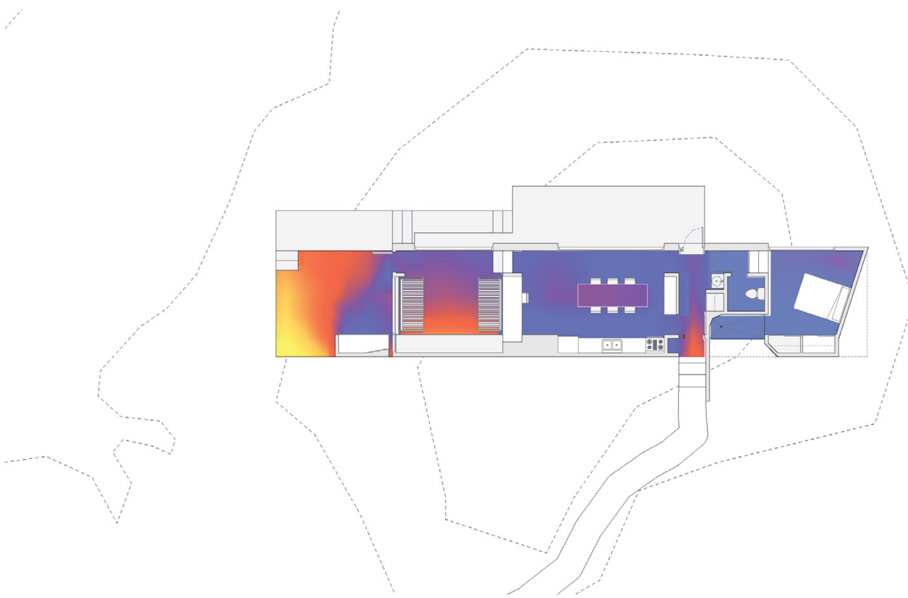




Refer to figures 31-36. Opposite Page: Axonometrics. This Page, Plan

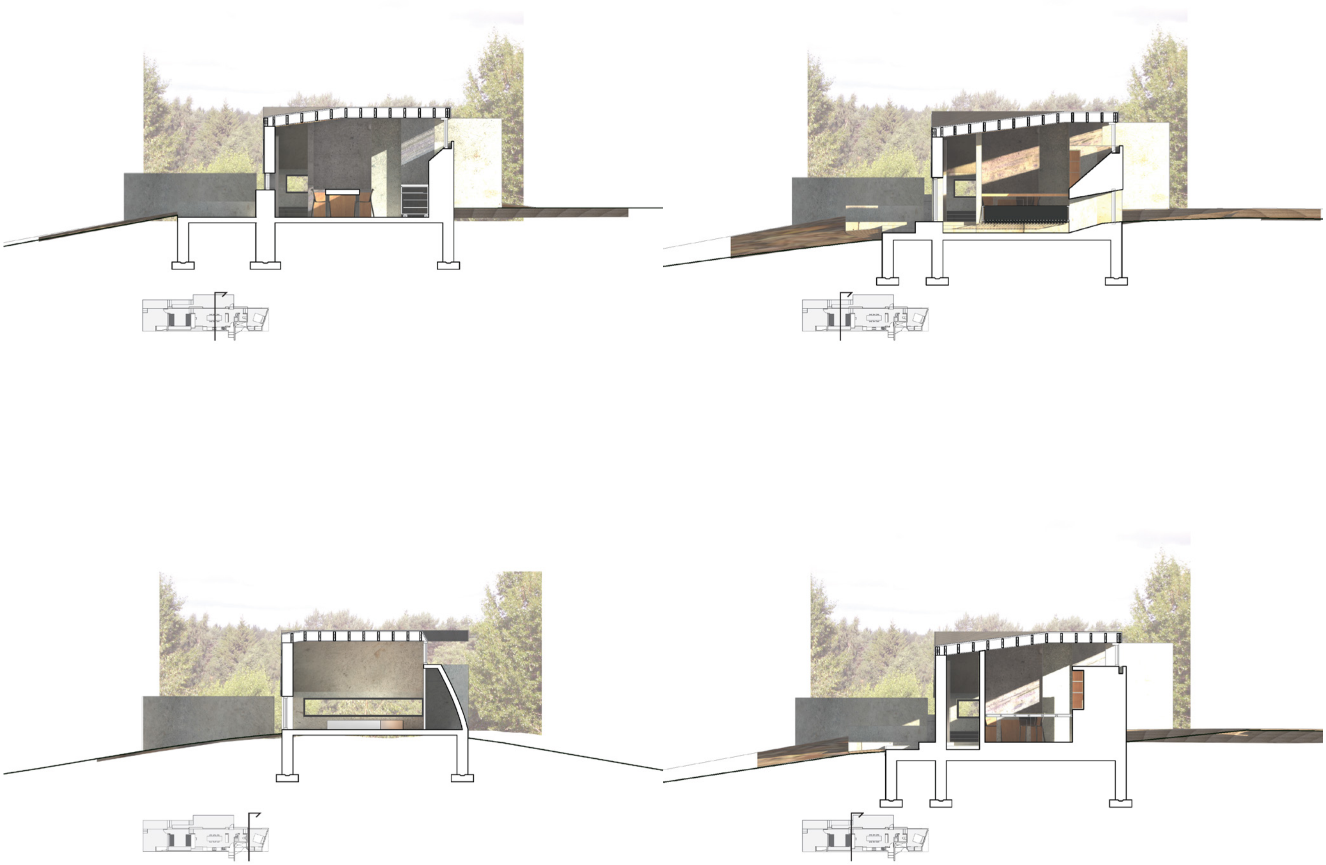
APPENDIX B: INTERIM



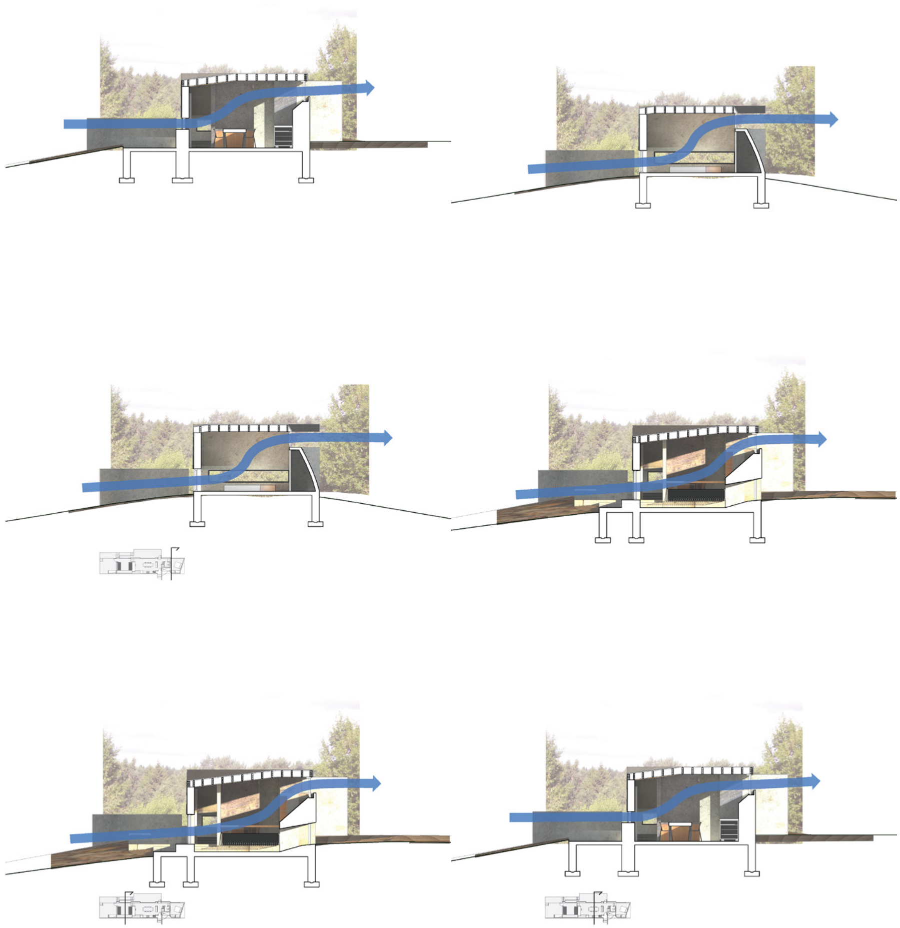


Top: Plan

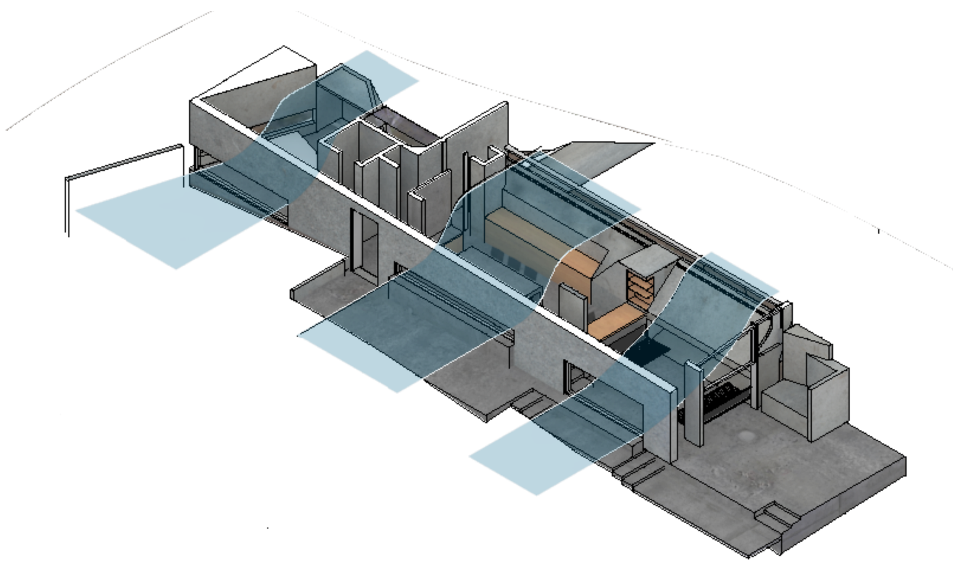
Bottom: Thermal Plan, arranging the spaces by warmth

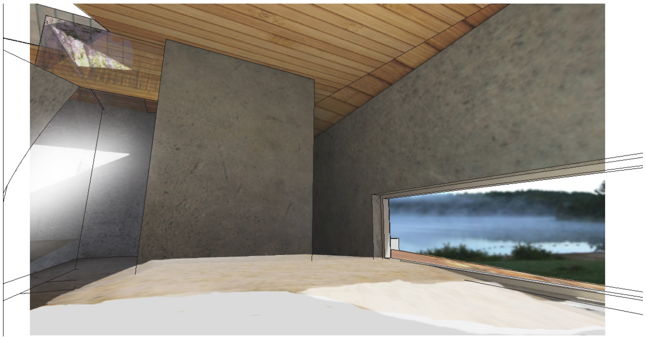


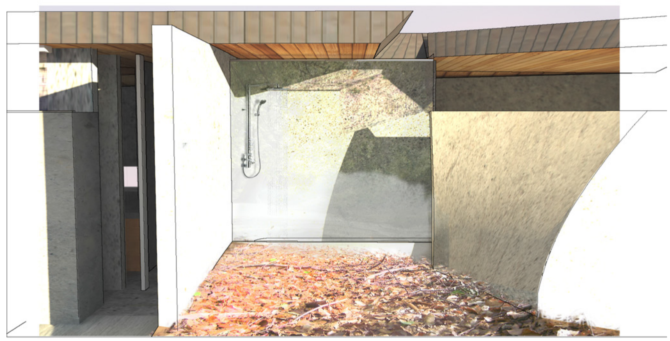
Above: Preliminary
Project sections



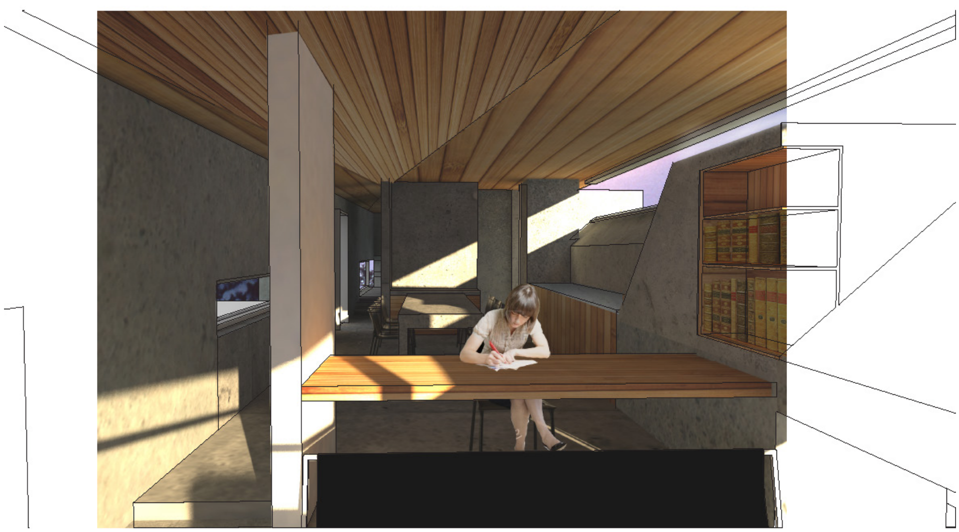
Left: Ventilation Diagrams before the computational fluid dynamics stage





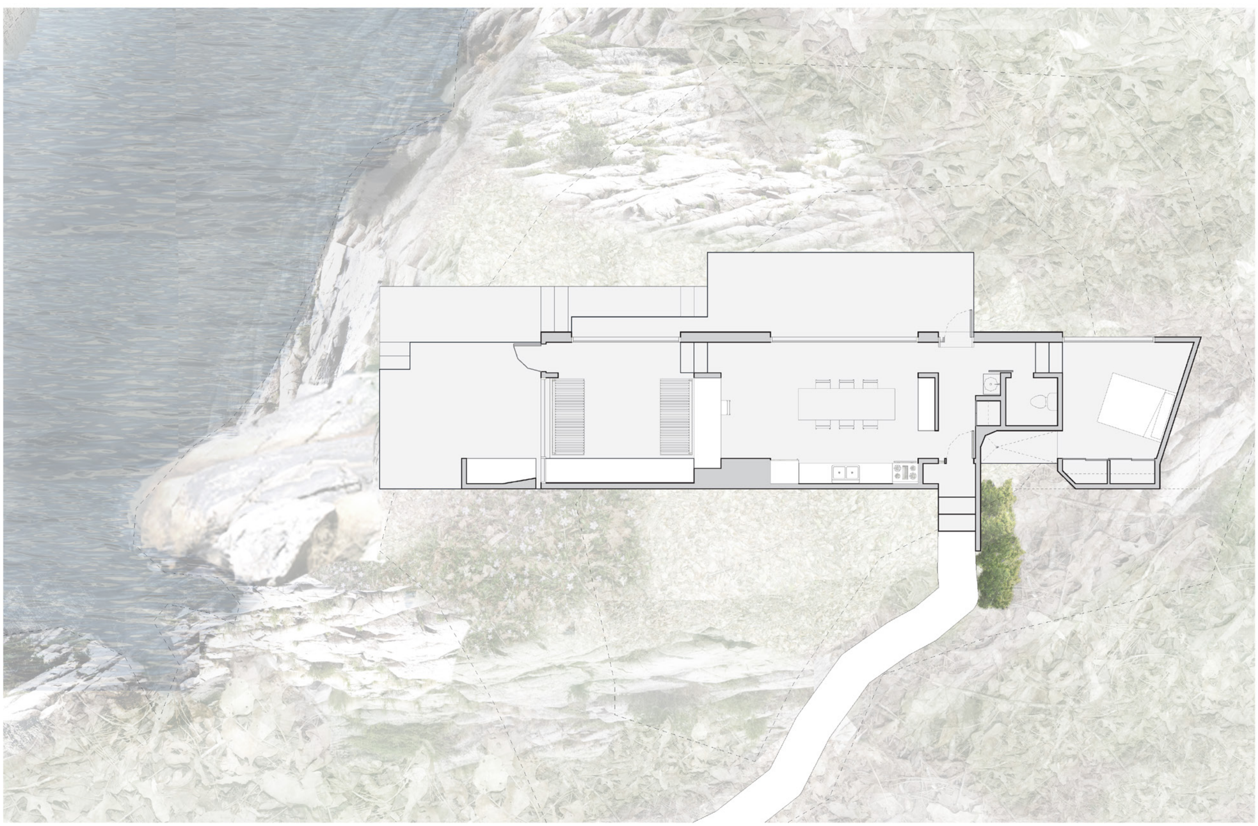
Interior Views

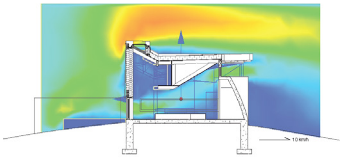
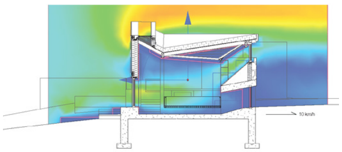
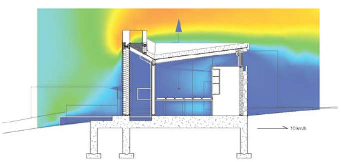
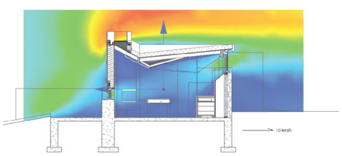


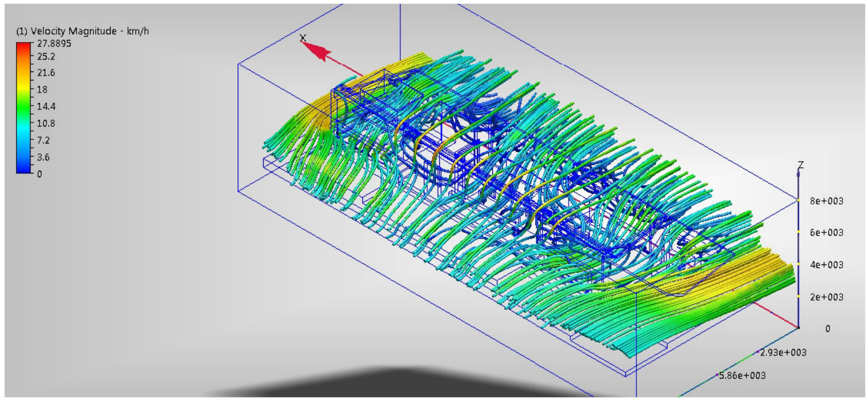
Top: North Facade
Middle: South Facade
Bottom: Summer Kitchen

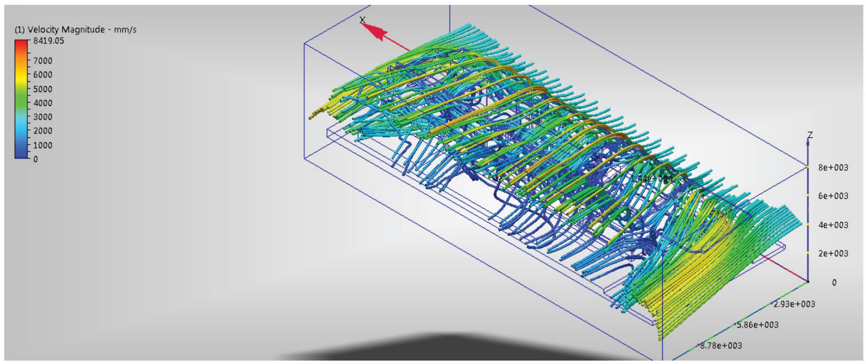
APPENDIX C: INTERIM B

Top: Site Plan
Bottom: Plan

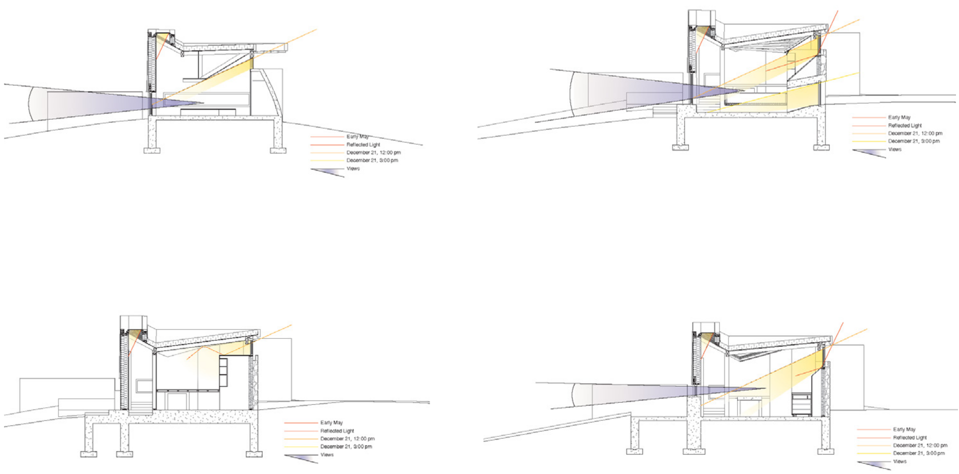


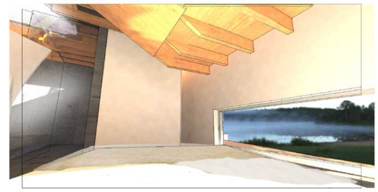




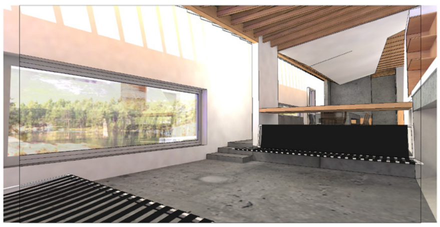
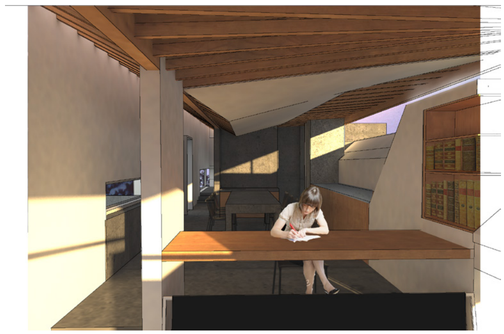
Preliminary CFD and solar sections

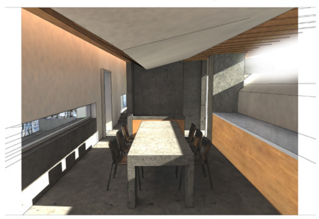




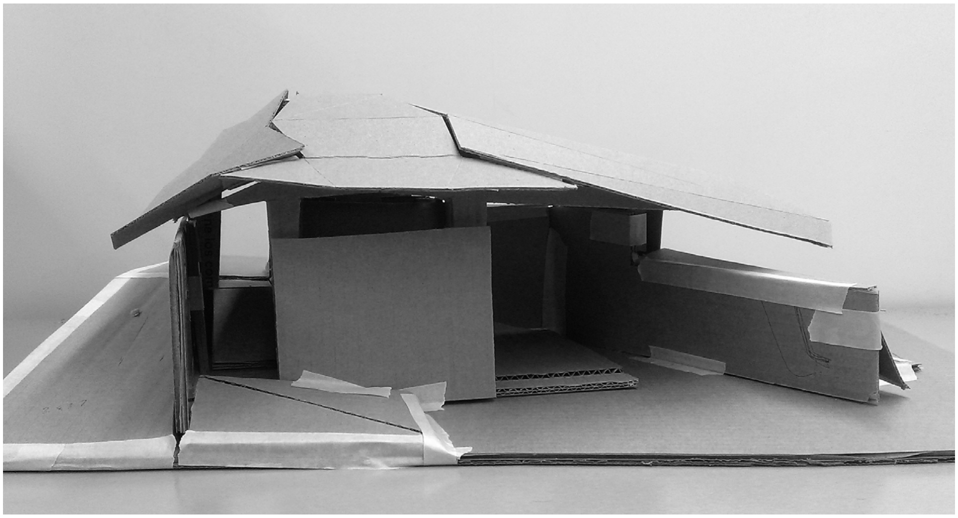


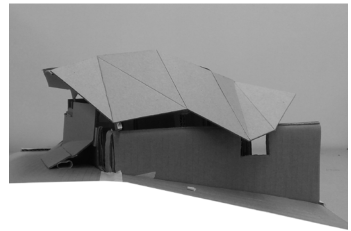
Project renderings

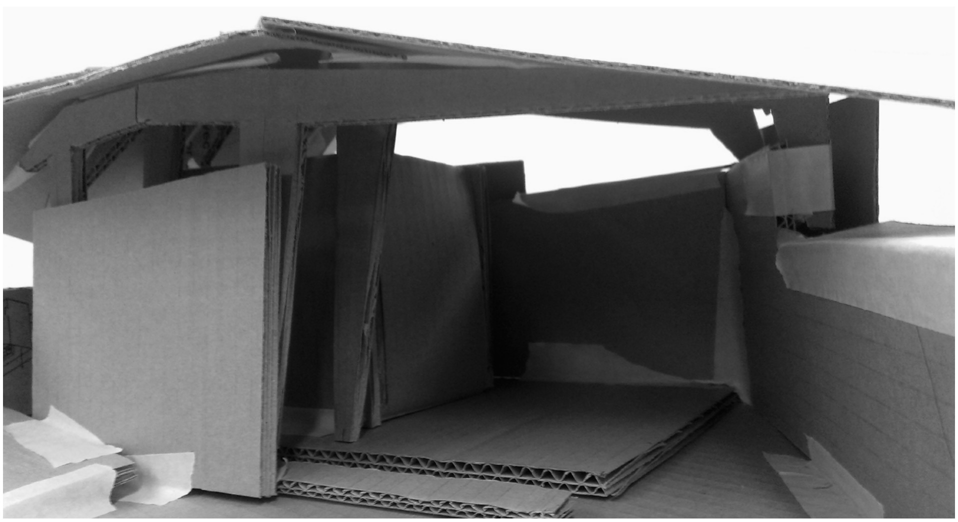



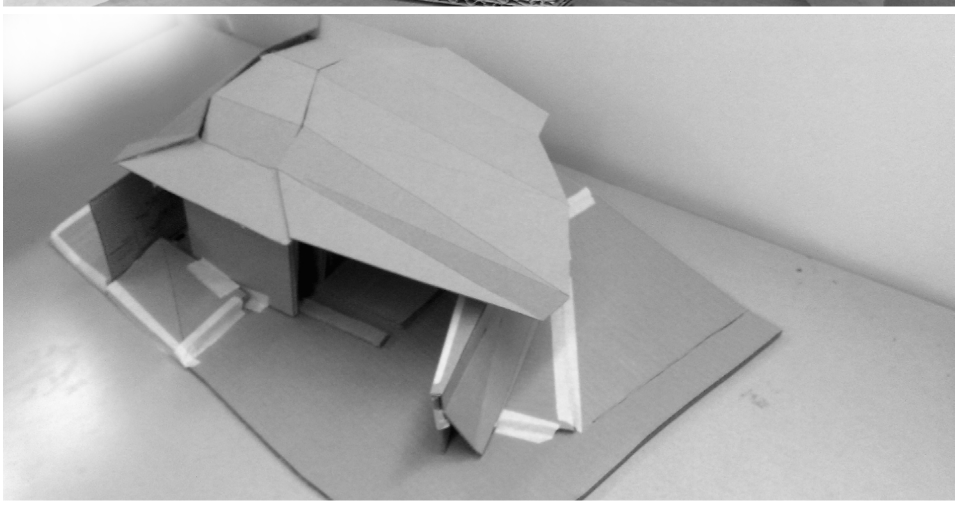


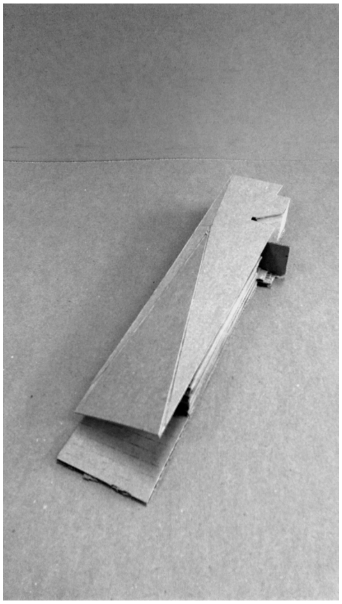

APPENDIX D: RESEARCH MODELS

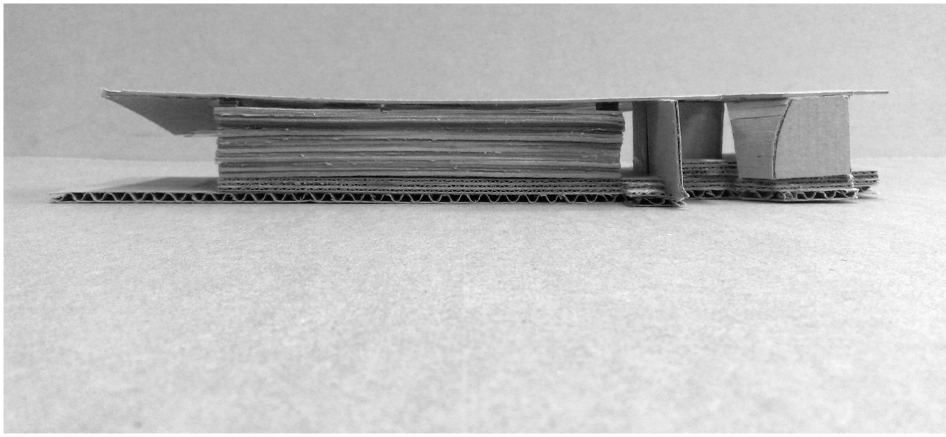


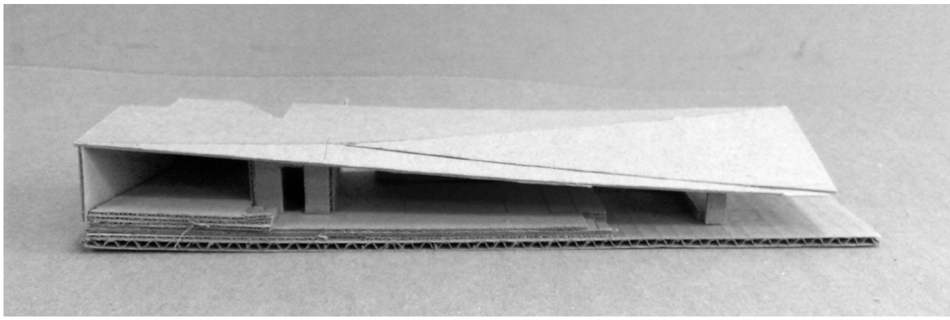


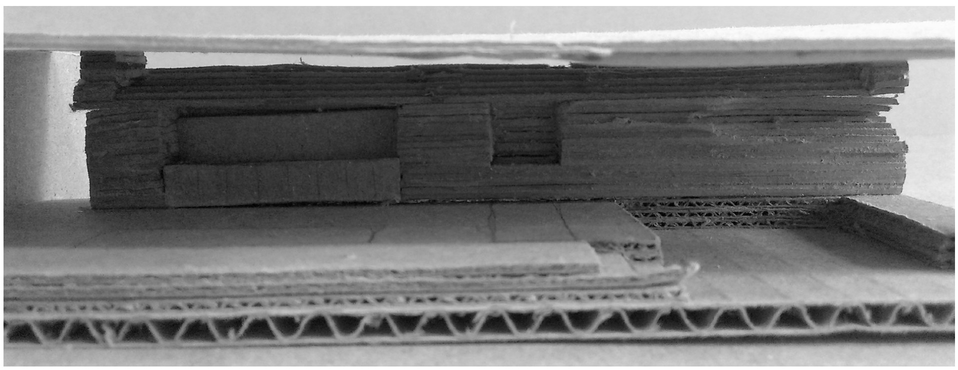


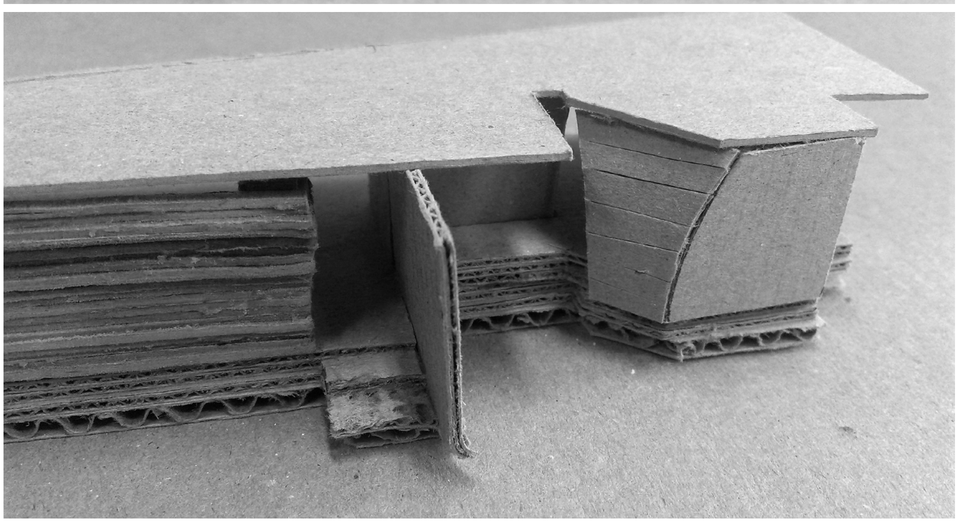


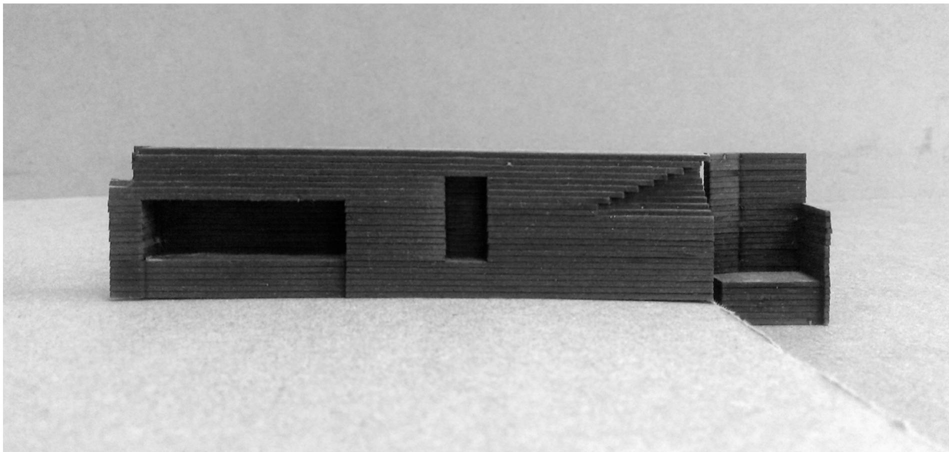
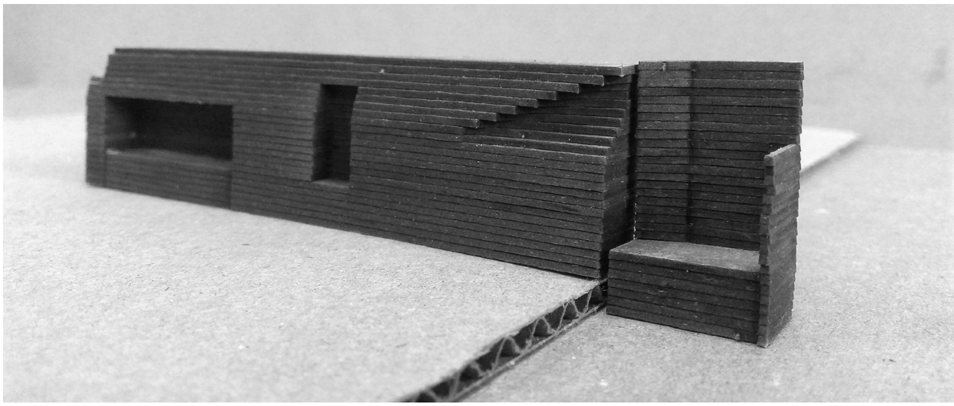
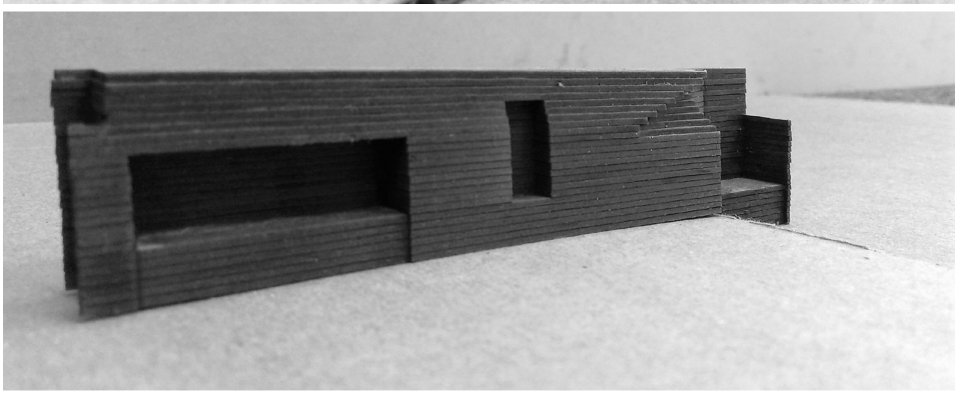
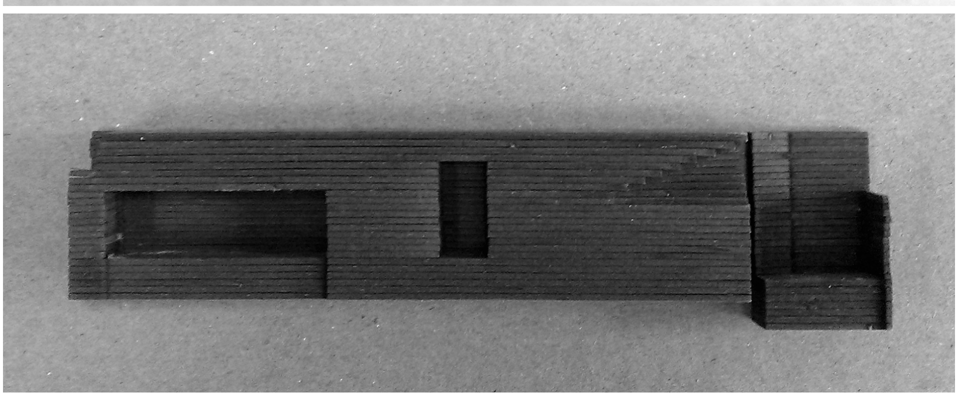










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