Remote Control: Attuned Interventions in Mass Timber for Inuit Housing

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ABSTRACT: *This paper investigates the cultural and ecological resilience offered within prefabricated mass timber housing solutions for a small, remote Inuit village at the northernmost tip of the Canadian province of Quebec. Just below the Arctic Circle, the harbor is open for less than one month a year, with no roads connecting Ivujivik to other northern Quebec communities. Timing and prefabrication of design solutions are essential to providing building infrastructure to this remote part of the planet. Additionally, this underserved community is overcrowded and lacks the necessary means of constructing suitable dwellings to withstand the long, cold winters. A brief history of this society and a rationale for why mass timber and pre-fabrication are appropriate for this remote location, followed by several lessons learned during an exploration into ecology, environmental awareness, health and well-being, and cultural sustainability towards the ultimate design project of prefabricated mass timber eco-housing for the Arctic. The studio process was threefold; 1) explore local resources of Inuit and other indigenous populations, 2) research qualitative and quantitative understanding of low-carbon and renewable materials for sustainable architectural design futures, and 3) speculate on prefabrication possibilities of mass timber in contemporary design for architectural interventions within remote locations. This paper will present several design benefits of employing pre-fabrication for construction in remote areas – from reducing waste and time of on-site labor through construction processes to durability, while also relating to the phenomenological and cultural resonance that aims to reconnect indigenous peoples to more symbiotic and biogenic building practices through regenerative and durable materials.*

KEYWORDS: Ecological Resilience, Prefabrication, Mass Timber, Culture, Environmental Awareness.

INTRODUCTION

Ivujivik, like much of Upper Canada, is cut off from the rest of the world. It is an island, not in a geographic sense, but through its remoteness, placing it at an extreme distance from major population centers of North America. This separation isolates its community from much of the inhabited world. No roads link this community to the larger cities of Montreal and the extensive North American hard infrastructure of highway and rail networks, nor is this community connected by road to any neighboring communities. It is a distant, isolated, and unique region of the world.

It is estimated that this area was the initial landing spot of the ancient Thule tribe and the entry point from Baffin Island into the province of Quebec. It was a seasonal village and only formally established as a permanent settlement by creating a post for the Hudson Bay Company in 1947. Nomadic ancestors of these First Nations Inuit (Nunavummiut), 'Eskimo' in the United States, have seasonally populated this area for thousands of years. Historically, these peoples erected temporary structures and camps from naturally occurring materials readily available as they followed animal migration patterns, fishing near the sea, or gathering, farming, and trading during the summer months.

"A fundamental difference between our culture and Eskimo culture, which can be felt even today in certain situations, is that we have irrevocably separated ourselves from the world that animals occupy. We have turned all animals and elements of the natural world into objects. We manipulate them to serve the complicated ends of our destiny. Eskimos do not grasp this separation easily and have difficulty imagining themselves entirely removed from the world of animals. For many of them, to make this separation is analogous to cutting oneself off from light or water. It is hard to imagine how to do it." (López 1986)

The spring 2021 design studio was initially interested in exploring the pre-fabrication of housing modules and the benefits of using carbon-negative and renewable building materials for architectural ideation. During the research phase of the semester, which included interviews with people and experts from the community, the studio grappled with the humanitarian disaster of housing in Canada's Aboriginal region. Most of Canada's 60,000 Inuit live in small, typically underprivileged communities of less than 1,000 people. It is estimated that 53% of families in Nunavik live in overcrowded homes, coupled with the prevalence of deleterious health effects such as chronic lung disease, tuberculosis at 250 times, and suicide at four times the national average, caused for deeper investigations (Pepin et al. 2018). What is the relevance and importance of architectural design for these underserved communities, and how can material choices positively affect these underserved communities that were once self-reliant and migratory to the now sedentary and governmentally funded?

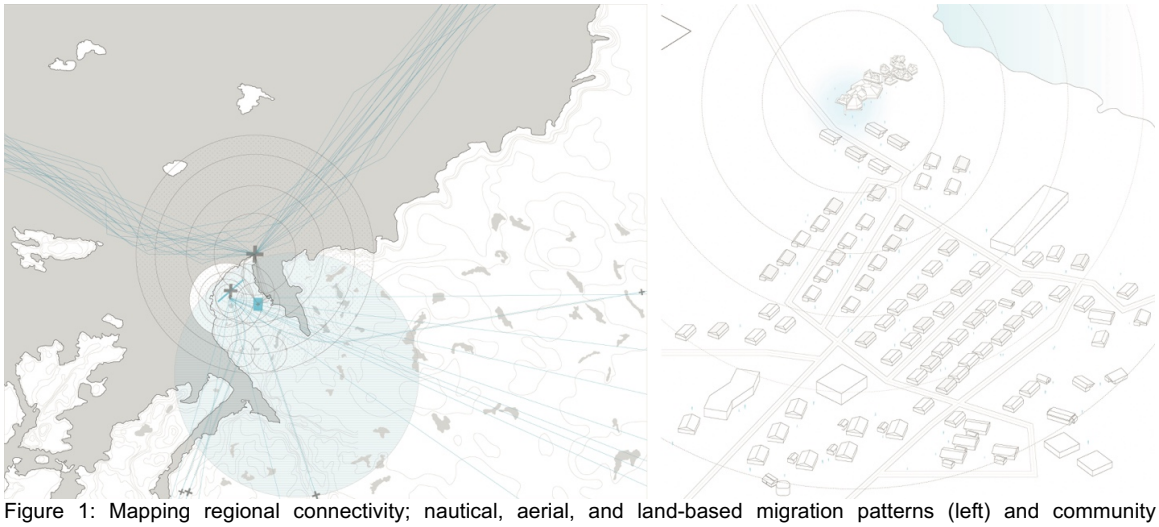

Figure 1: Mapping regional connectivity; nautical, aerial, and land-based migration patterns (left) and community connections and social spaces within Ivujivik (right). Source: Juliet Hollister, 2021

1. PROXIMITIES AND CULTURAL CONNECTIVITY

1.1 Remoteness as motivator for design innovation / necessity

Ivujivik translates to '*the place where ice accumulates because of strong currents',* where median temperatures range from −11 °F (−24 °C) in January to 52 °F (11 °C) in July. Ivujivik is the northernmost village of Quebec. Like almost all the communities within Nunavik, the small community is located along the coast. Surrounded by cliffs that plunge deep into the turbulent waters of Digges Sound, the strong tidal currents of the immense Hudson Bay and narrow Hudson Straight collide and churn, causing shards of ice to form. This town is 1,000 kilometers north of the 56th parallel. This numerical line of demarcation is important, as it is the liminal boundary where the landscape changes from a treeless Arctic tundra covered in lichen, mosses, and dispersed peat bogs to the boreal forest and taiga, which covers much of lower Canada. The Arctic is home to polar bears, foxes, hares, and the indigenous Inuit people This remote landscape is serviced daily by plane service Air Inuit, which brings in milk, dairy, bread, and staples to this community of less than 500 inhabitants. This area is under federal jurisdiction within Canada, yet several responsibilities are directed to the provincial government of Quebec to provide services for the Inuit population. One of the primary needs of these people is housing. With harsh climatic and important cultural considerations, design solutions require careful study of technological, environmental and social challenges latent within the landscape.

Materials other than stone, water, and any organic material that is brought to the area by the coastal currents are limited, and building materials suitable for such a harsh climate must be coordinated and shipped to this location during the brief 20 days that its port and harbor are ice-free. This greatly influences architectural projects as they must be planned well in advance - designed, constructed, and onboarded onto ships in late spring to make this narrow window. Upon arrival, workers install these prefabricated units onto above-ground foundations, which are pinned to the rocky surface. The permanently frozen ground is often colder than the air, creating structural settlement issues and thermal transmittance that may thaw the ground or invade the interior space. The lack of tools, materials, experienced labor, and building infrastructure invites prefabricated architectural solutions that can be deployed during the summer months to satisfy the local community's needs and a lack of housing. Transitions in growing younger populations must await a seasonal influx of housing that has to be planned well in advance, and the control is not local but remote.

There can be issues when working with prefabricated housing units. Tools, labor, and materials are employed outside a community, and only the finished product is brought to the community. Issues arise when these units are poorly constructed of non-durable materials that cannot be easily mended, painted, or sealed due to the lack of access to building materials or trades. Building with more durable, solid materials, such as mass timber, can not only provide a healthier interior environment, especially in nail laminated timber eliminates the harsh glues associated with other composite wood products, but also reduce the need to repair less durable drywall or foam panels. With limited access to these sheet materials, it may take several months to source, and many such deliveries are limited to the summer. Solidly constructed, easily repairable, and durable materials such as mass timber and structurally insulated panels are highly practical solutions for building infrastructure.

1.2 Boreal forests and renewable resources

The construction industry has been turning towards renewable resources since the invention of mass timber and readily available manufacturers of this new technique. The ability to utilize younger, faster-growing trees such as pine, fir, spruce, and even some grasses in glue-laminated bamboo has created an ability for architects to design large panel prefabricated walls, roofs, and primary structures using mass timber. With similar material properties to heavy timber, mass timber is fire-resistant and comparable to concrete and steel for structural strength. Additionally, by growing building materials, timber can also serve as a carbon sink by storing carbon within its cells, providing a reprieve from typical carbon-intensive building materials. When insulated and protected from the elements, wood can last generations. Additionally, mass timber offers the potential to be recycled if the connections and assemblies are designed for future convertibility.

Canada is home to 9% of the world's forests, covering over 347 hectares and 38% of the country's land mass. With over 90% of these forests on publicly owned land, the government has implemented silviculture practices for sustainable management of these areas. Sustainable harvesting seeks to maintain residual forest structures dispersed evenly throughout and grouped into islands of intact pieces of forest that are left to maintain diversity and protect wildlife habitat. (Pitt, 2009). Sustainably harvesting certifications such as FSC "must be paired with legal protection of intact forests if biodiversity and ecological services are to be maintained over time." (Grant, 2012) Sustainable forestry practices aim to promote new growth to preserve renewable resources while conserving invaluable ecological zones of biodiverse areas.

1.3 Multitude of benefits of mass timber

Pairing local, natural, and renewable resources for housing is important for multiple reasons. First, the cultural significance of using bio-based, organic, and locally sourced materials has a veritable connection to the locale and indigenous culture of the Inuit people. Through the study of historic indigenous structures, many employed wood, bone, or other naturally occurring materials which washed onshore as primary structural components of their dwellings. In the summers, these materials would be lightweight and allow for transport to more remote areas that offered superior hunting, fresh water, and security. In the winter, animal skins, oil for heating, and other resources would be used to create warm and comfortable interior environments for the long, dark winters. Utilizing wood within contemporary housing allows for a veritable connection to the natural world while using a material with a lower thermal diffusivity than stone or earth. Second, timber is a renewable resource that can be sustainably harvested and is readily available within the province of Quebec. The major Quebec ports that service Ivujivik are Montreal and Quebec City. These cities have several mass timber processing plants that can provide regionally sourced materials to the remote community by boat. Lastly, cross-laminated timber (CLT) and nail-laminated timber (NLT), and dowel-laminated timber (DLT) are structurally stable, thermally massive, and easily assembled for modular housing applications. The benefits of using mass timber for housing offer a robust yet lightweight material that can withstand the environmental impacts of the Canadian Arctic while creating a livable space that better connects these people to their land.

While industrialization has dramatically impacted the construction industry since the late 19th century, timber has only played a "subordinate role." (Huß, 2019, 9) The 2015 International Building Code (IBC) approved using CLT in exterior/interior walls, floors, and roofs for Type IV Construction and as a structural system if manufactured to the Standard for Performance Rated Cross-Laminated Timber (ANSI/APA PRG-320:2012). This has triggered several advances in the design and construction of mass timber buildings. While this has been published extensively recently, it is important to state that mass timber has lower embodied carbon and produces lower greenhouse gas emissions during manufacturing than alternate assemblies. Advancements in life-cost analysis and the "shift from a prescriptive approach to sustainable design toward systematic, performance-based considerations" allows users to make informed decisions about what products designers specify and use. (Dangel, 2017, 62)

Pre-fabrication for construction in remote areas has several sustainable design benefits, as discussed above. In addition, the prefabricated mass timber panels also reduce waste and time of on-site labor for construction. The ability to decrease time in these harsh weather conditions almost precludes other means of building while also ensuring tight-fitting envelopes and highly resilient connections.

1.4 Wood and thermal diffusivity

Wood is distinctive as a natural material that can accumulate energy by heat transfer, as an isolating material, and one that can equilibrate different temperatures more slowly than other materials. The R-Value of softwood is 1.41 per inch (2.54 cm). Therefore, a 3-ply CLT panel used for exterior wall and structure can already have an R-Value between 6.35 and 9.87 (see Table 1 below). The required envelope design for thermal resistance (RSI/R-Value) found in the Housing Construction Guide to Good Practices published in 2017 is high and requires careful planning to ensure tight envelopes. This is assisted by increased control of prefabrication, where air tightness and continuity of insulation can be closely monitored and tested before deployment. With the addition of thermal resistance associated with mass timber, it is possible to use natural fiber, such as

recycled denim insulation, while limiting rigid insulation to satisfy the recommended thermal resistance values for this Arctic climate.

Table 1: Thermal Resistance Factors for Arctic Climate Zone

Recommended Values			
		R-Value	***RSI***
	Roof	51.0	9.00
	Wall (above grade)	29.0	5.11
	Wall (foundation)	17.0	2.99
	Floor	29.5	5.20
Insulative Design Values*			
		R-Value	***Inch***
	Denim Batt	21.0	5.5”
		30.0	8.0”
	Compressed Straw	21.0	10”
		41.0	17.5”
	Rigid	7.5	1.0”
	CLT Wall Panel	6.35	4.5”
		8.46	6”
		9.87	7.5”

**Numbers above do not consider windows, doors, and mechanical service penetrations.*
Students were given these insulative values to design their prefabricated panels to satisfy the thermal resistive requirements.
Source: (Société d'habitation du Québec, 2017)

2. CLIMATE AND CULTURAL CONNECTIVITY

2.1. Colonialization and cultural resilience

As an embodiment of culture, architectural artifacts can connect us to our heritage. Inserting architectural forms that ignore the indigenous culture or the vernacular rooted in climate specificity, local materials, and the place is a form of colonialization. Architecture has long been used to establish dominance over native populations by directly embodying power structures and distant cultures they represent. The Canadian government during the 19th and 20th centuries used formal settlements to fix indigenous populations of northern Canada to lay claim to extensive lands to the north. However, this hampered indigenous histories of migration to follow the caribou herds while relying on fishing and whaling to sustain their livelihood. Climate change, overfishing, and the European whaling industry that began in the mid-1800s have decimated the once extensive local food supply and caused local populations to rely on more contemporary means of living. This lifestyle shift requires the importation of food, clothing, and even buildings to survive.

It could be argued that any architecture designed and constructed without the input of local people and culture would continue to reinforce colonialization structures already in place. This topic could be an entire paper unto itself. While the studio researched the local community and indigenous vernacular structures to attempt to reconsider building practices that can reconnect the Inuit people with their natural surroundings through architecture rooted in phenomenology and culture. The studio itself was speculative, using technical with ecological and environmental knowledge within a single, sixteen-week semester. Ultimately, the best remedy would be working with the Inuit population directly as the client to get their input for the designs of their homes. The current housing stock is both inadequate in number and isolates occupants from the environment while not allowing for easy manipulation or mending of the structures once deployed. Employing a more reflexive model of educating both the designer of the culture and utilizing more resilient architectural materials can foster more emphasis on self-reliance while dismantling the existent power structures that have been in place since first contact.

As outlined within Lola Shepperd and Mason White's book “Many Norths,” understanding this expansive territory is multivalent. Architectural and social solutions go beyond solar geometry, building science and understanding geographic conditions as we attempt to comprehend the complexity and vastness of Canada’s Nordic region. Shepperd and White expounded on Louis-Edmond Hamelin’s “Many Norths” to present ten different factors for defining regions from the economic, northern extent of roadways, boreal zone limited by mean July temperatures not reaching 10°C, permafrost and 10,000 Heating Degree Days Line – all which Ivujivik is beyond. Its northness is unquestioned. How can architectural design create thermal comfort within a treeless, permanently frozen ground with nearly sunless winters and nightless summers? How can architects reconsider foundations and connections to the ground within the Canadian Shield encircling Hudson Bay, which is the largest area of exposed Precambrian rock in the world?

3. STUDENT OUTCOMES

3.1 Studio Methodology and Delivery

This studio was offered during the spring 2021 semester amid the Covid-19 pandemic and therefore was entirely virtual. The studio prompt of 'Remote Control' was born from the idea of remoteness and attempted to recreate connectedness through a virtual, synchronous studio format using platforms such as Zoom for audio and video connections and Miro as a virtual studio 'pin-up' space to record the ongoing and iterative student work. With two semesters of virtual studios previously completed, the format was embraced by inviting several experts to present virtually to the studio to present their ongoing work and expertise in environmental design, mass timber fabrication and implementation, cultural connectivity, and Arctic design via remote interviews and presentations. Since travel was cost-prohibitive and disallowed due to the ongoing Covid-19 pandemic, experts from the University of Montreal, Arctic Design Lab, and Canadian architects who deal with the climate complexities and native communities regularly via Zoom. Climate specialists and mass timber engineers joined virtually for design reviews and discussions essential to the studio's success.

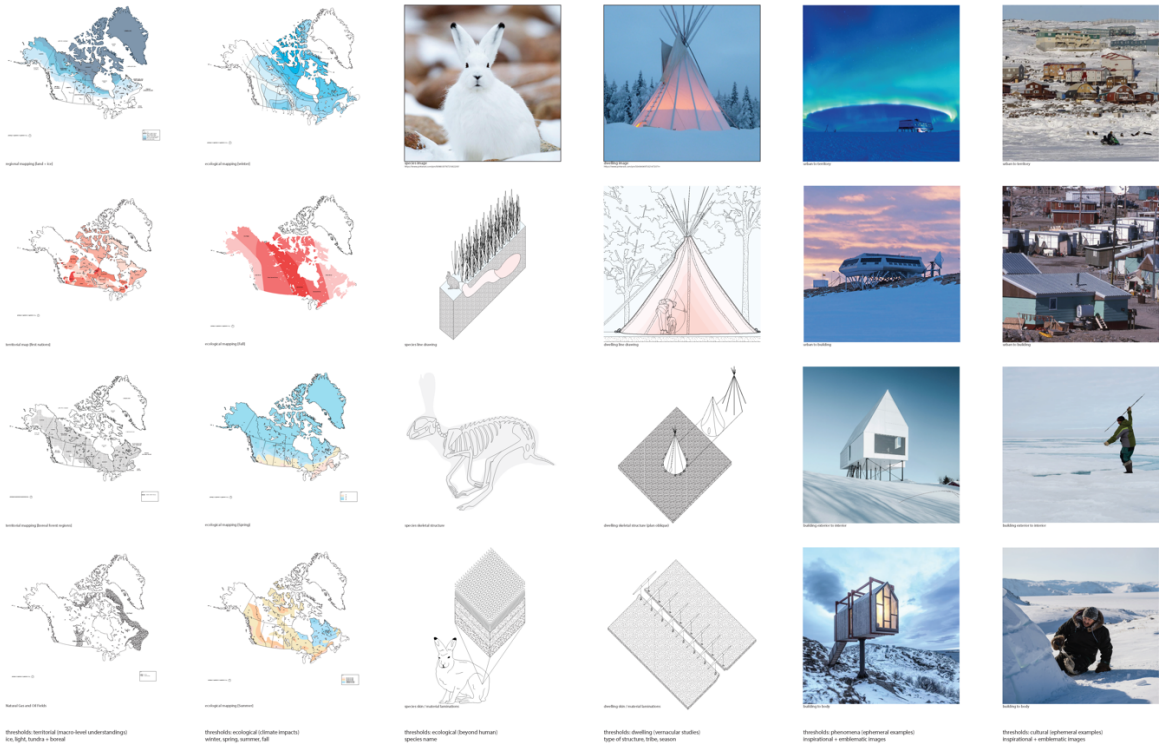

Figure 2: DNA Matrix drawing describing the territory, climate issues, thresholds of biological and vernacular architectural systems, and current cultural situations within the region. Source: (Colton Grieger, 2021)

The specificity of choosing a remote location such as Ivujivik premeditates some design decisions, such as prefabrication and climate-based design strategies that deal directly with the severity of the site. The realities of the place were presented as the precursor for design decisions.

3.2 Natural processes and learning from the environment

Students began researching existing climate and weather patterns within the area. Solar angles, wind direction, speed, the relative dryness of the frozen air, and dry bulb temperatures throughout the year. This empirically rich study was coupled with each student choosing an indigenous population and investigating their vernacular structures. Questions such as how they mitigate climate, source materials, construct dwellings, and deal with seasonal fluctuations through their architectures were addressed. Not all indigenous precedents were located within the Arctic region. However, specific discussions of place, space, and connections to the land were interrogated and compared to determine why one form of architecture prevailed or became repeated. Students were also asked to find exemplary images of contemporary buildings that embodied the region to address preconceived notions of image and place-making. The final aspect explored within the semester's initial research phase was for each student to pick an animal from the Arctic region of Canada to study. These studies explored skeletal structures, thermal resistance through skins, furs, and fat tissue, and how each animal burrowed, hibernated, or migrated throughout the year. Each of these studies was shared with the class and offered a toolkit of vernacular and biomimetic structures rooted in place.

3.3 Program plus

During the second phase, as students grappled with the environmental and site contexts such as the sloping permafrost, existing rural community, and the sea, the architectural program was introduced. Accompanied by a series of readings, film screenings, and lectures from outside experts, students developed ‘wildcard’ spaces that introduced a specific need or amenity that was either lacking or required attention. For example, some students determined that a community meat locker and kitchen would be beneficial, others a community library or café, and others still thought an indigenous heritage center or greenhouse would be most appropriate. This offered a diverse array of architectural solutions that were tied to the people and designed with the larger community in mind. By introducing a community component, students were required to investigate existing conditions, map the rural community, and determine what could be beneficial to the larger community and the individual success of their project. Also, having a larger spatial component within the program allowed for the investigation of why, how, and where to differentiate the small housing modules with a larger communal space within the envelope.

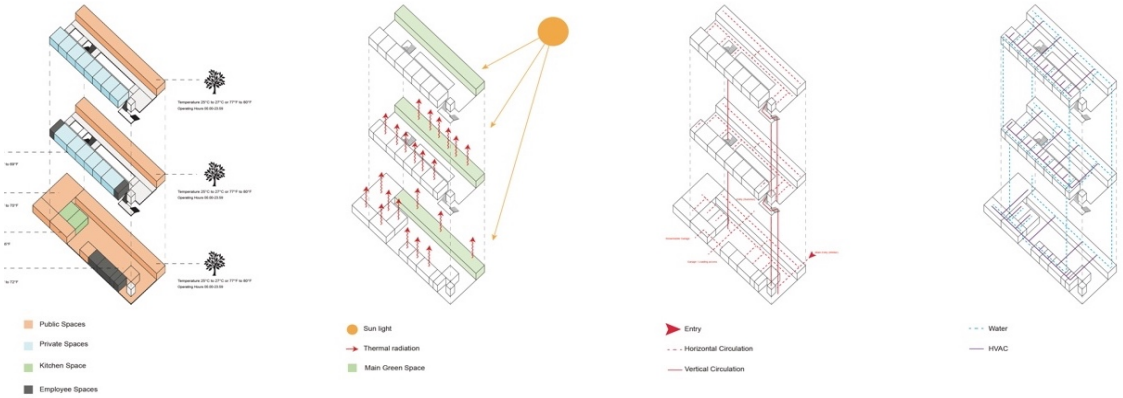

Figure 3: Systems diagrams investigating open and closed systems that exchange with the larger environment. Source: (Timothy Tipparch, 2021)

3.4 Biophilic design and health

With the massive housing shortage in the northern territories of Canada, finding a more sustainably derived solution can benefit the material and resource issues and create comforting interior environments for their occupants. The visual warmth of a wooden interior, coupled with adequately sized and thermally broken windows to provide views and light during the day, can allow for a more comfortable space. Solving the current overcrowding issue and truly designing spaces that are enjoyable to live in during the long, dark winter months.

The realities of limited daylight hours, a total of only five hours during the winter, coupled with nearly twenty during the summer months, students investigated territorial climates and weather patterns of freeze and thaw and geographic conditions, followed by an extensive understanding of how animals and people have adapted and mediated their environments to survive. A deep and thorough investigation to better understand the realities of this remote location also coincided with documentation through reading and film of the area a people who live there. Givens in our more temperate climates, such as sun angles, diurnal temperature swings, and the relative notion of hot summers and seasonality and even when and where the sun rises and sets created interesting considerations throughout the semester set in this extreme environment. The importance of airtight thresholds between interior conditions and innovative solutions towards pre-fabrication and constructability were important modes of operation for the studio. As we continue to consider the real effects of climate change on future architectural solutions, students participating in courses such as this will be better prepared to tackle such questions.

3.5 Building technology and design

Purely technical rationale, solving only issues of acclimatizing the interior space without considering connecting the people to the land ignored the indigenous culture and history of colonization embedded within the architecture. Throughout the semester, students grappled with fanciful design ideations and the harsh reality of climate, culture, and construction, ultimately balancing the imaginative with the pragmatic. Many students desired to engage the sky, stars, and distinct landscape features throughout the year with minimal envelope penetrations to the all-important insulative envelope. This differs somewhat from more traditional architecture studios that employ fully glazed floor-to-ceiling façade solutions for more nuanced and purposeful

strategies. While others wanted to address the lack of fresh food by incorporating space for agricultural production within the public spaces to increase the self-sufficiency of the local population and embrace the long and sunny days of summer (Figure 3).

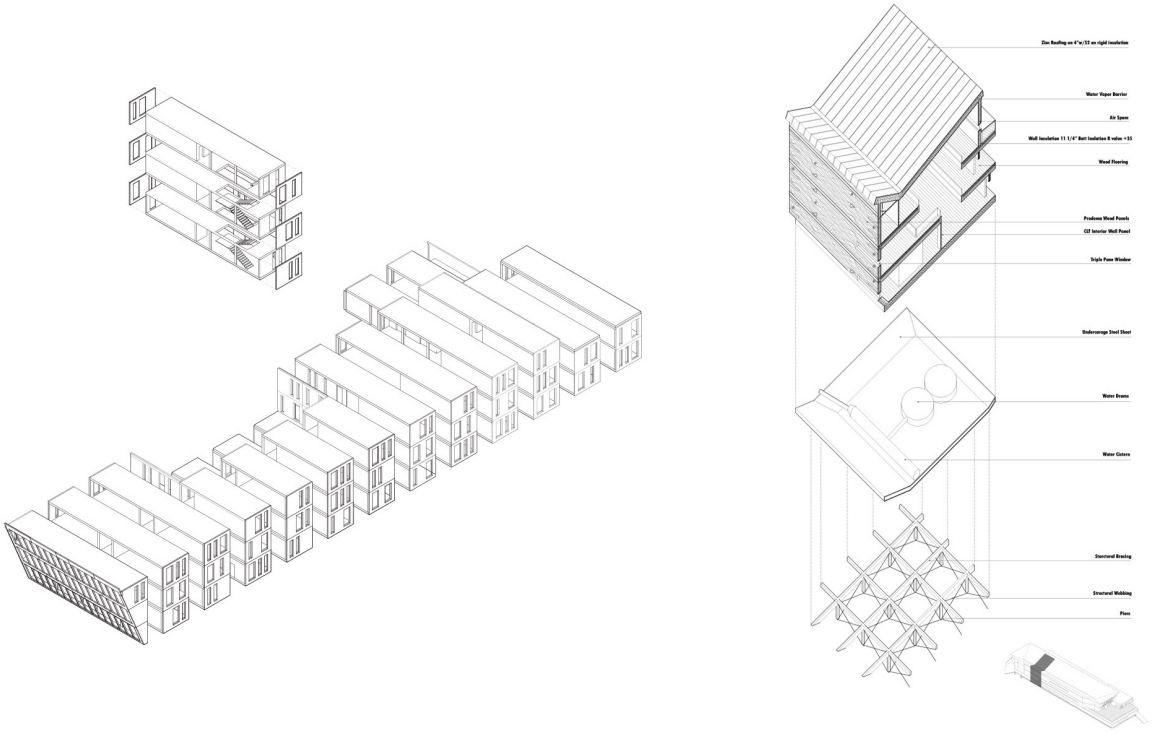

Figure 4: Building module drawing and exploded isometric drawing demonstrating constructability and assemblage of students' design for prefabrication. Source: (Joseph Garcia, left, and Robin Hatherill, right, 2021)

In preparation for the mid-term review, students were asked to break down their prefabricated modular systems into their component parts. This translated initial room modules based on the structural and manufacturing limits of building with timber through to the aggregated building designs (Figure 4). For the final phase of the semester, students were required to create animations to show the construction process of how these individual components would be brought to the site, staged, and assembled for the final built project. These simple exercises required an understanding of the construction processes as well as regard to dimensional limits posed by the material. Minimum egress requirements for bedrooms were provided, coupled with environmental and health considerations that helped to inform window location. Larger programmatic concerns demanded that students address the local community through a shared amenity space(s) to better connect designs with the larger context.

CONCLUSION

There are many complexities embedded within architectural constructs, including technological, material, and social. Designers could benefit from reframing environmental design through the lens of culture and meaning. The Inuit people have gone through an incredible shift from nomadic to urbanized in the past fifty years. These changes have massively affected the population's mental health and well-being. This studio's investigative work offered a learning opportunity for the faculty, students, and critics involved throughout the process. The connections forged with scholars, architects, and technological specialists left a lasting impression on the students enrolled in the class. Even today, faculty and students often reference the overwhelming success of the studio as it asked important questions and elicited novel solutions that were both practical and inventive. If provided the context to offer this studio again in the future, is to dialogue more with the Inuit community directly, to integrate more indigenous knowledge into the design process. Only through involving indigenous voices early in the design process can we truly ensure that their culture is respected and demonstrated within building designs. The true success of this studio would be to find better housing solutions that are both climatically attuned and representative of the cultures of these unique communities to influence the health and well-being of current populations for a more sustainable future.

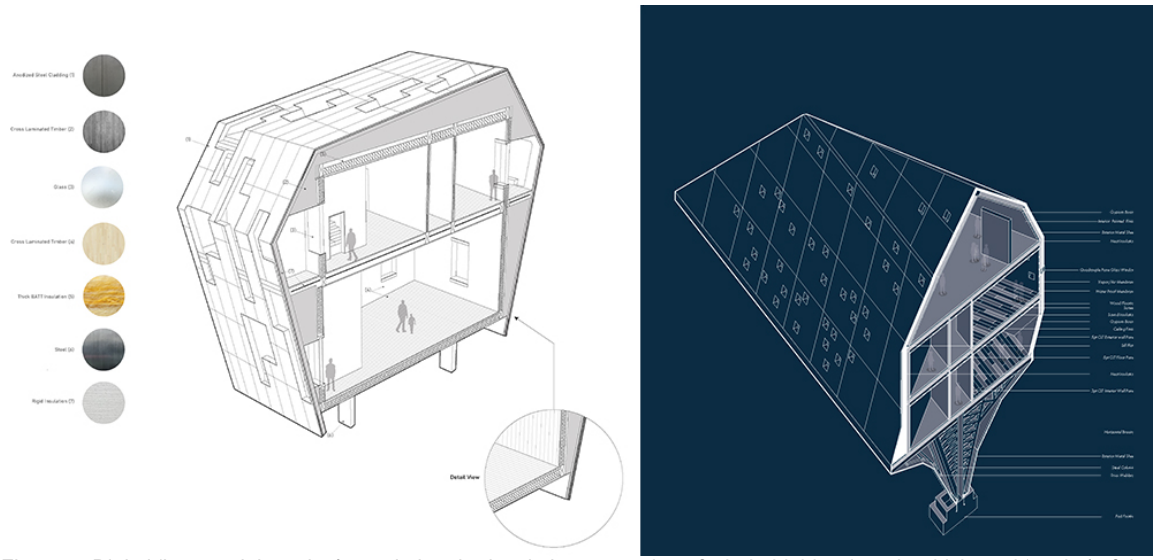

Figure 5: Digital ‘bay model section’ translating the insulative properties of whale blubber into the thickened ‘poche’ of the architectural envelope and the specifying of materials for the assembly. Source: David Nelson (left), Colton Greiger (right).

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