Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Kathryn Larsen
Student number	5341264

Studio		
Name / Theme	Explore Lab	
Main mentor	Roel Van de Pas	Architecture
Second mentor	Marcel Bilow	Building Technology
Argumentation of choice of the studio	The Explore Lab is a self-structured lab for students obsessed with a singular topic. I am obsessed with seaweed and natural building materials, and structured my own study trips and material research.	

Graduation project	
Title of the graduation project	[Seaweed] Farm to Table
Goal	
Location:	Oosterschelde, The Netherlands
The posed problem,	In 2021, the IPCC released a report stating that ongoing sea rise level due to climate change, would be irreversible for potentially hundreds of years (IPCC, 2021). However, they also stated that by reducing carbon dioxide emissions, it is possible to still limit the effects of climate change (IPCC, 2021). In recent years, seaweed farming, and seagrass meadow restorations have emerged as a possible solutions to help capture and embody carbon emissions. When combined with mussel farming, they help the environment further by filtering the water of heavy metals and pollutants (Zeewar, 2021).

	As the building industry is responsible for up to 39% of global carbon dioxide emissions (World GBC, 2019), companies like The Seaweed Company have invested in the possibility of using seaweed as building materials, to sequester the carbon for longer term (The Seaweed Company, 2021). The issue is, there is no written comprehensive guide as to how these materials can be applied in a built environment, despite a historical precedent for their use. Furthermore, many resources confuse seaweed and seagrass, which makes possible construction applications even more difficult to research.
research questions and	"How can we use seaweed, seagrass and mussel shell waste as resources in the Dutch built environment?"
design assignment in which these result.	"How can a housing project be created in direct response to the landscape and natural materials of the Oosterschelde, should flooding and storm surges become more commonplace?"

This thesis is a study of how seaweed, seagrass and mussel shells can be used in the Dutch built environment. In this case, the speculative design project imagines a future building as a showcase is made from seaweed and mussel shells, to support a new community of "sea pioneers" around the Oosterschelde. This building will serve as a symbol of hope and innovation for a future resilient from climate change.

Process

Method description

The primary methodology for this research will be a Material Driven Design (MDD) methodology, which is based in Research Through Design (RtD). Material Driven Design is a newer methodology, that involves designing from the materials as the starting point (Karana, Barati, Rognoli, Zeeuw van der Laan, 1, 2015). In order to design with seaweed, seagrass, and mussel shells, it is necessary to inherently understand and experiment with the materials, by prototyping and letting the materials speak for their use. Only then can one begin to explore the possibilities and potential applications of these materials, as well as their architectonic potential.

Using this research methodology, a material's perceived weakness can become its strength. For example, most seaweed-based glues are very weak, making them unsuitable for resin-composite based applications. However, this weak glue provides an even consistency and workability to traditional Japanese plasters (Holzhueter, 2014), and traditional wood and ceiling paints (Vadstrup, 3, 2010).

Using this methodology, I will produce a range of prototypes and material experiments. From these prototypes, I will develop material applications for use in the built environment, and explore the strengths and weaknesses they have.

I am specifically looking at developing a seaweed-derived bioplastic, seaweed-derived paints, a mussel biobased concrete, and a mud plaster with seaweed glue.

Literature and general practical preference

For my thesis at the Copenhagen School of Design and Technology, I investigated the role of eelgrass (a common type of seagrass) in the Danish construction industry, and experimented with creating a prototype of prefabricated seagrass thatching. My previous research did not distinguish clearly between the role of seagrass versus seaweed in construction. Thus, for this thesis, I will focus more on the role of seaweed and mussel shells as materials in combination with eelgrass, as well as the Dutch context for such a construction to be utilized.

Historical precedent of these materials and their uses provides a roadmap of what to test, and where to begin. As previously stated, seaweed was historically used as a binder in construction applications around the world. Seagrass has historically been used as insulation, mattress stuffing, and upholstery (Vandkunsten, 2013).

Calcium carbonate, which can be found in egg shells, was also added to Japanese seaweed lime plaster (Shikkui, 2021). Mussel shells are also composed of 95-99%

calcium carbonate, so this provides a basis for experimenting with plaster mixtures (Murphy, Hawbolt, and Kerton, 2, 2018).

In the Netherlands, in the province of Wieringen, seagrass was used to build wierdijken, or so-called "seaweed dikes" during the Middle Ages (Keeton, 2014). Here, the seagrass was applied to the inside of the dike, towards the land-side, and kept in place with wooden poles. This prevented soil erosion of the dike.

Seagrass was also used to thatch roofs in China for centuries in the Jiaodong Peninsula, yet a recent English-language news article from China Today incorrectly refers to the seagrass construction as kelp, likely due to the fact that locals sometimes call them "kelp houses" (Zhidong, 2019). Other articles, such as one by ChinaDaily, refer to the roofs again, mistakenly as a seaweed construction (2020). The tale-tell sign of a seagrass roof construction are the swaying silvery seagrass blades on photos of the construction, as opposed to large, leafy fronds from kelp, or small vesicular fronds from brown seaweeds.

This example highlights the challenges of researching seaweed versus seagrass in construction applications. In the past, seagrass was commonly referred to as a seaweed in various countries, and mistakenly classified as such. Seagrass, however, is a plant, and seaweed is not. Seagrass has roots, and grows from seeds. Seaweed is a form of algae, and has a holdfast, similar to a barnacle (Norris, 1, 2019). Similarly, blue-green algae, although called algae, is not, in fact related to seaweed. Rather, it is classified as cyanobacteria, a type of bacteria, defined by their strong pigmentation (M.D. Guiry, 2000). The confusion between these three distinct groups and their applications often requires one to understand their biological appearances, in order to distinguish between them, while researching.

This is because despite their similar names, these groups all have vastly different material properties. For example, seaweed tends to rot with repeat exposure to moisture, and will even rot in storage if humidity is above 40% (McHugh, 57, 2003). For this reason, it is prudent to not use it as an insulation material. However seagrass will turn silver, harden, and last for many more years. There are instances of seagrass insulation lasting in wall cavities after over a century (Archipedia New England, 2020).

This is also why on the Danish island of Læsø, a properly thatched seagrass house will last for up to three hundred years (Gardiner, 2020). Cyanobacteria like Spirulina, on the other hand, is sometimes used as a nutritional supplement for iron (Sp2Life, 2021). Its strong green and blue coloring lends itself as a natural dye in material explorations.

There are some newer, more experimental material applications, such as seaweed in bioplastics (Hahn, 2021) and mussel shells in ceramic 3D Printing (Sauerwein, 9, 2020). These could have potential applications in interior architecture, for replacing glass or concrete materials.

Reflection

1. The Explore Lab is a lab for students that are, driven at their core by an obsession that they follow. My obsession is seaweed materials, and their construction applications. I believe in focusing on local building, using context-driven solutions and applications, rather than creating a model that can be copied exactly around the world. The applications I create can be tweaked and learned from around the world, however, due to the similar properties between species and natural materials. Like an artist that mixes his own paints and pigments, the architecture I create for my thesis will be from a palette of materials I have created and studied carefully tectonically.

2. Biobased design in the Netherlands is currently on-trend for sustainable solutions due to the low carbon footprint. However biobased designers largely focus on ahistorical applications, and have not always worked in the building industry, which sometimes causes issues, as the focus is sometimes impractical. By focusing on vernacular applications first, and using this as a primary inspiration, the research will be grounded in practical building solutions. For example, a common misconception here by young designers is that dry kelp or seaweed is a suitable insulation, due to the confusion between it and seagrass. However, seaweed rots in humidity, and this can create a potentially dangerous solution for a wall cavity. Vernacular seaweed applications are largely unstudied and untested, yet there is a demand for solutions that utilize invasive and farmed seaweed species, due to the popularity of carbon sequestration. As climate change becomes more apparent, we will need to combine building for disaster mitigation, as well as address the impact that the building industry has on CO2 emissions.

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