[SEAWEED] FARM TO TABLE

Research Plan

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01/01/2022

PROBLEM STATEMENT

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 QUESTION

"How can we use seaweed, seagrass and mussel shell waste as resources in the Dutch built environment?"

Fig 1: canal bike with mussel shells and algae growing together

BACKGROUND

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.

Fig 2: traditional Danish "seaweed farmer", Kurt Schierup from Møn Tang, processes dry eelgrass into bales for construction. Eelgrass is a type of seagrass native to the northern hemisphere.

BACKGROUND

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).

Fig 3: Traditional Læsø "Seaweed House". Like many historical references to "seaweed", the seaweed in this case is actually the seagrass known as eelgrass (Zostera marina).

BACKGROUND

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.

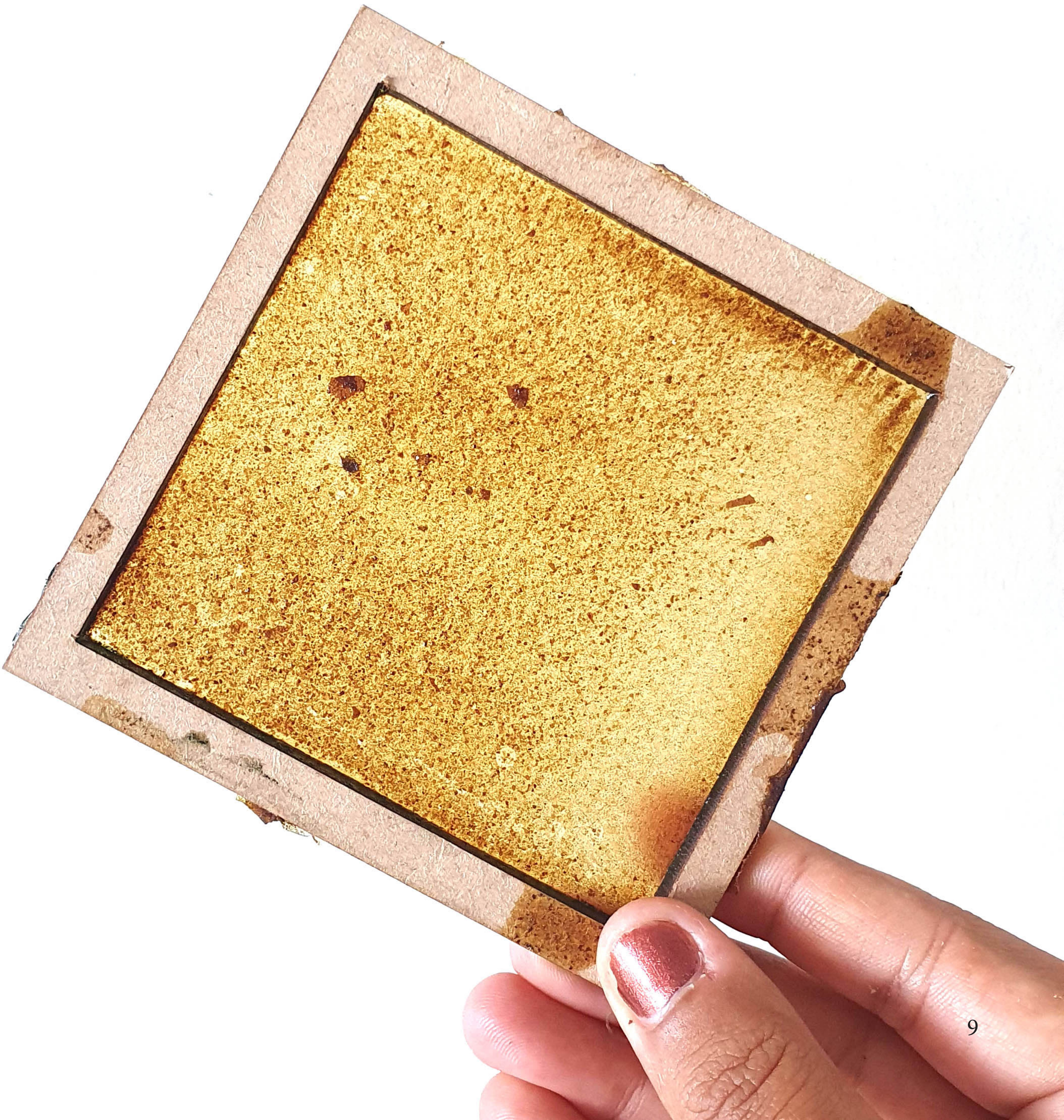

Fig 4: Seaweed bioplastic test with dulse seaweed, gelatine, and glycerol

METHODOLOGY

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.

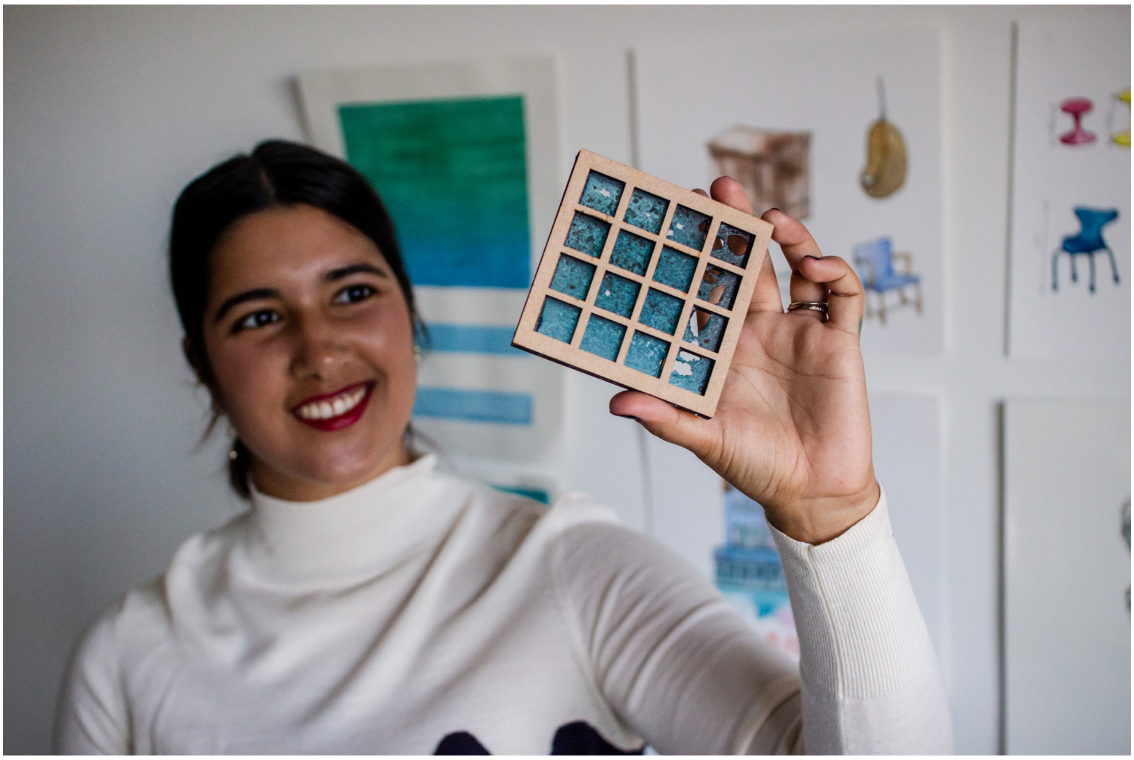

Fig 5: Making process. Photographed by Sarah Tulej.

LIMITATIONS

Material Driven Design has some drawbacks. When a material is used in an improper fashion or not fully realized, it can cheapen the perceived value of the final result, according to Danish researcher Mette Bak-Andersen (2018, 14). Thus, the limitations of materials should be respected.

As the research conducted for this thesis is done in the architecture faculty, access to testing the strength and performance of materials or constructions is limited. Because of this, for the time being, the results will remain speculative, as further testing on longevity and strength is necessary to confirm their full potential as materials for the building industry

Ethical questions can be raised with Material Driven Design, especially when experimenting for sustainable reasons (Bak-Andersen, 2018). Raw materials might be locally limited, or unsustainably sourced. For example, with regards to wild seaweed in the Netherlands, it is not permitted to harvest any without a license (Verhaege, 2020).

Therefore I have made the decision to source my seaweed and seaweed-based materials from seaweed farmers and suppliers here in the Netherlands, using endemic species, such as Dulse (Palmaria palmata), Irish moss (Chondrus crispus), and Sea Lettuce (Ulva), and I have also arranged for a visit to learn more about a land-farming seaweed practice.

My seagrass comes from Denmark, from a licensed traditional Danish eelgrass farmer. Despite the energy required to ship the eelgrass, harvesting eelgrass in the Netherlands ethically is currently not possible. In the 1930s, the construction of the Afsluitdijk destroyed the conditions necessary for eelgrass to flourish in the Dutch Wadden Sea (van Eerbeek, 6, 2010). There is an ongoing preservation effort by Laura Govers, who believes there is not enough healthy eelgrass in the Netherlands to supply the construction industry (Tekath, 2020).

Fig 7: Fresh sea lettuce, from Amsterdam-based "Seaweed Tech" grow tanks. By sourcing seaweed from licensed farmers for material experiments, ethical harvesting can be ensured.

OUTCOME

A guide of wall finishes made from seagrass, seaweed, and mussel shells. In particular, looking at plastic, paint, clay plaster and mussel-based concrete.

DESIGN IDEA

The material experiments will inform the material choice and tectonic design for a housing complex, situated in relation to water in the Dutch landscape. This landscaping and relation of architectural infrastructure to water, and farming is integral to the design idea.

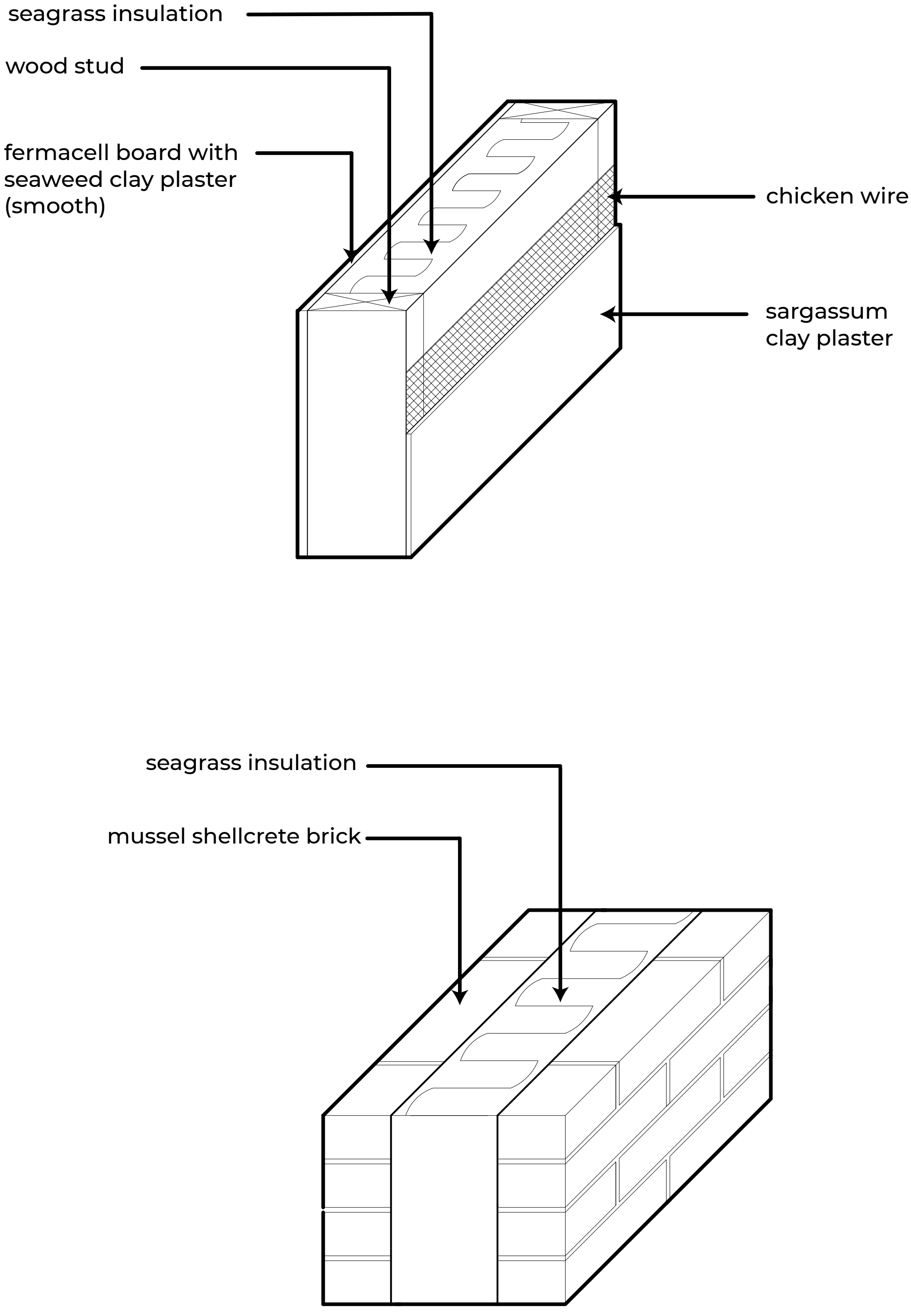

Fig 8: Designs of 1:1 scale mock-ups, using the developed materials.

TIMELINE

P1: October 2021

Preliminary Research presentation
Material ratio samples (1:1 scale, small)
Research plan

P2: January 2021

Research results presentation Tectonic models (1:1 scale)
Research plan
Graduation plan
Design Brief
Design draft (plans & sketches)

P3

Preliminary design presentation
Design (plans, sections, elevations)
Preliminary detail drawings 1:5/1:10
Facade fragment 1:20

P4
Formal presentation
Site 1:2000
Plans: 1:50/1:100
Elevations: 1:100
Sections: 1:100
Facade fragment 1:20
Detail drawings 1:5/1:10
Reflection

P5
Final formal presentation

Fig 9: Collage mapping of research applications and observational inspirations

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