Architecture Material: Oyster-shell

RESEARCH EXPOSITION

ARK258_matter space structure3
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Contents

Introduction

The idea is to reintroduce neglected organic materials and food waste into modern industrial techniques, with the aim of showing how natural resources like oyster shells can be incorporated into contemporary architectural practice and everyday use. In addition, the project aims to inspire and encourage further exploration of alternative materials by showing how architectural features can be generated from these materials.

Emphasis is placed on the variety of ways in which oyster shell materials are used, such as how they are used with wooden structures and how samples are made with different adhesives.

"Oyster shell houses are physical evidence of the cultural and living characteristics of the pearl River Delta region's architectural tradition for hundreds of years." The starting point for the modern Oyster Shell House was to explore this unique archive of cultural and architectural history and to use the past as a source of inspiration for contemporary architecture.

This is not a copy of the architectural style of the past, but inspired by the historical buildings of oyster shell. What is the possibility of the expression of modern oyster shell house? How to apply prefabricated oyster shells building modules?

In addition to restoring historic oyster shell buildings, a new and sustainable way of using oyster shells needs to be explored in accordance with modern technology and processes.

Research & MT question

The master thesis topic for the next semester (2021, spring) is about Rural Nature School of Food Cultural Spread in Teochew district, Guangdong, China, in where seafood cuisine is very distinctive. Jinxiang Town, the base of the project, is one of the largest oyster cultivation bases in the province.

In the design of this rural school, it is hoped to introduce oyster shell as one of the applied materials.

Method

Reflect on the application of oyster shells in history, and play with oyster shells as building materials.

By presenting the sample from different angles, such as changing combinations, arrangements, breaking and mixing different materials. These samples provide a space for reflection and manipulation, illuminating ideas of use in different situations. It's not about making perfect samples of materials that you can use right away, in fact most of the samples are at a superficial level, and it's this "fail-allowed" experimental process that allows me to list a wide variety of materials.

The material samples reflect the external features of the oyster shell, such as light and shadow, light transmission, color, texture, etc. Their most important function was to transform my initial view of the material into a more open view to discover new intersections and hidden potentials.

Sea shell waste or Architectural Material?

Tremendous volume of seashell waste in coastal area or restaurants.

Autumn and winter are the best seasons for oysters, which are served in restaurants and fish markets. Discarded oyster shells were also used as experimental materials for this study.

PART 1. History of Oyster-shell house

Oyster shells abounded in ancestral temples and dwellings in Lingnan region during the Ming and Qing dynasties

Oyster shell houses are a special part of guangdong pearl River Delta region and the global cultural heritage. Only a few oyster shell houses still exist as one of the few physical evidences of the culture and life that characterized the development of the Pearl River Delta region since the 15th century.

Oyster shell houses originated in the 15th century during the Ming Dynasty, when Zheng He's Voyages happened, large quantities of oyster shells were sent back to fill empty ship cabins to ensure maritime safety. Residents in the Pearl River Delta used them to build houses. As oyster shells are also readily available in the local region, they have become a common building material with long-term durability and protection against pests and corruption.

These preconditions have brought oyster shells back to our attention as a building material, especially given the current focus on the theme of sustainability.

Memorial Building made of oyster shells in Shawan Ancient Town in Guangzhou

The oyster houses mostly located in Pearl River Estuary in Guangdong province, China. (Guangzhou, Zhongshan, Foshan, Jiangmen, Dongguan, Shenzhen, Quanzhou, Jieyang and Zhanjiang etc.)

Ancient Cantonese people collected the shells and built them in walls with clay. Today a small amount of structures made of oyster shells are still standing in the ancient town as they were in olden days.

Each wall is decorated with tremendous pieces of oyster shells, presenting a peculiar texture in the house's facade. The use of oyster shells is believed to improve the wall' s resistance to temperature shifts and insect infestation, which is very necessary given the hot humid climate in the Lingnan region.

Different types of oyster shell architecture

Type 1: Family Templets_Well protected and repaired by government or prosperity

Oyster shell houses in the form of ancestral halls are valued by the villagers due to their unique nature and traditional Chinese cultural characteristics, and they are constantly being renovated to keep them intact

Ancestor Temple of Jiang clan, Shajing, Shenzhen

Ancestor Temple of Huang clan, , Xiangshan District in Zhongshan

Ancestor Temple of Jiang clan, Shajing, Shenzhen

Luyi Hall, Doumen district in Zhuhai

Luyi Family Temple was built in the fifth year of Mingjingtai (1454). It used nearly a million oyster shells and was glued with yellow mud mixed with brown sugar, glutinous rice, vinegar, and chaff. With an area of more than 500 square meters, this is the most complete preservation and the largest scale oyster shell architecture in China.

Different types of oyster shell architecture

Type 2: Residential house: Badly damaged

The most well-preserved oyster-shell house in Xiaozhou Village. It was built in the Qing Dynasty and recognized as one of the immovable cultural relics of Haizhu district, Guangzhou.

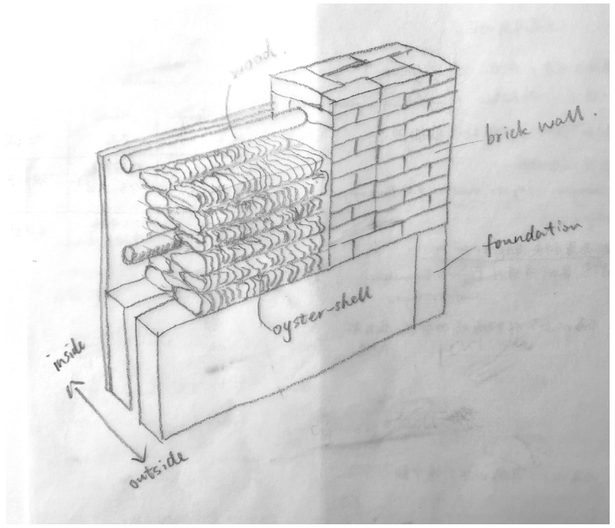
The oyster-shell houses in the Xunbu village of Quanzhou, Fujian province

As time changes, this kind of dwellings in Guangdong is less seen than before, with only a few of them left. In the Xunbu Village of Quanzhou, Fujian province, more than 100 oyster-shell houses have been listed as cultural sites under municipal protection. However, the houses are so old that they fail to meet the needs of modern living making them no longer inhabited. .

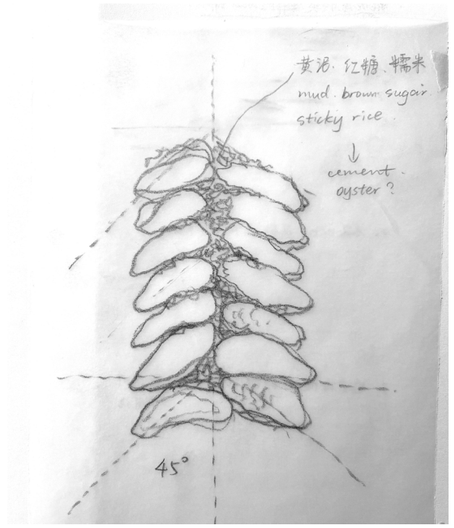
The oyster-shell houses in the Xunbu village of Quanzhou, Fujian province

The oyster shell houses in the form of residential or annex buildings have not received attention and financial support for a long time. If these dwellings lack attention and continue to deteriorate, they rarely survive.
Although some original oyster shell walls were repaired by the owners, the repair technique was very crude.

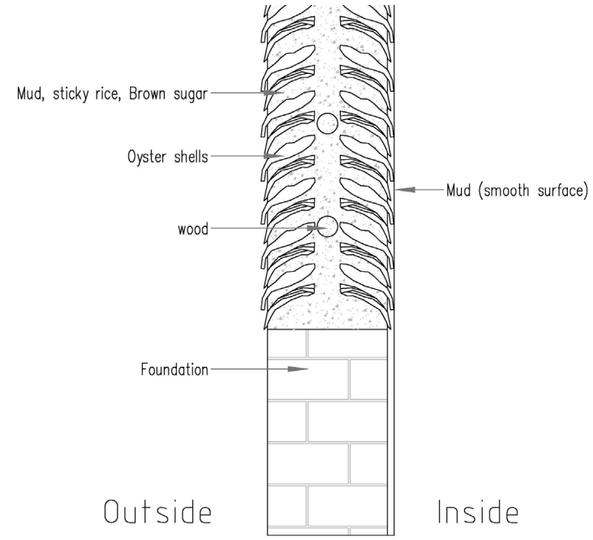
A wall of a Oyster shell house in Xiaozhou Village

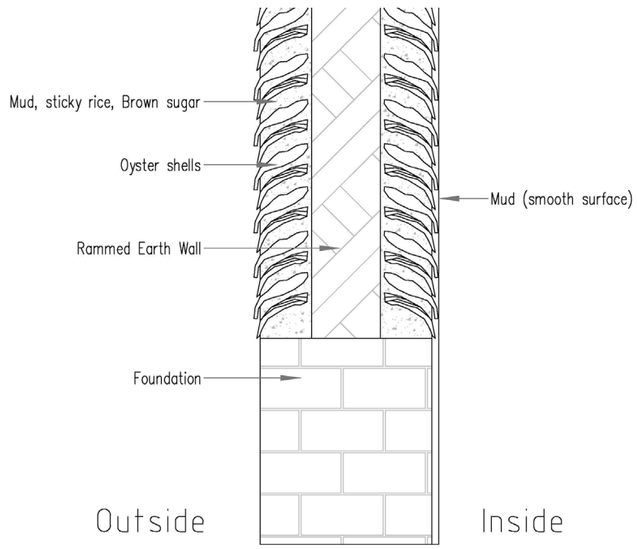


The surface of the oyster shell is uneven, which can form a large shadow of the oyster shell under the sun, which has the effect of heat insulation.



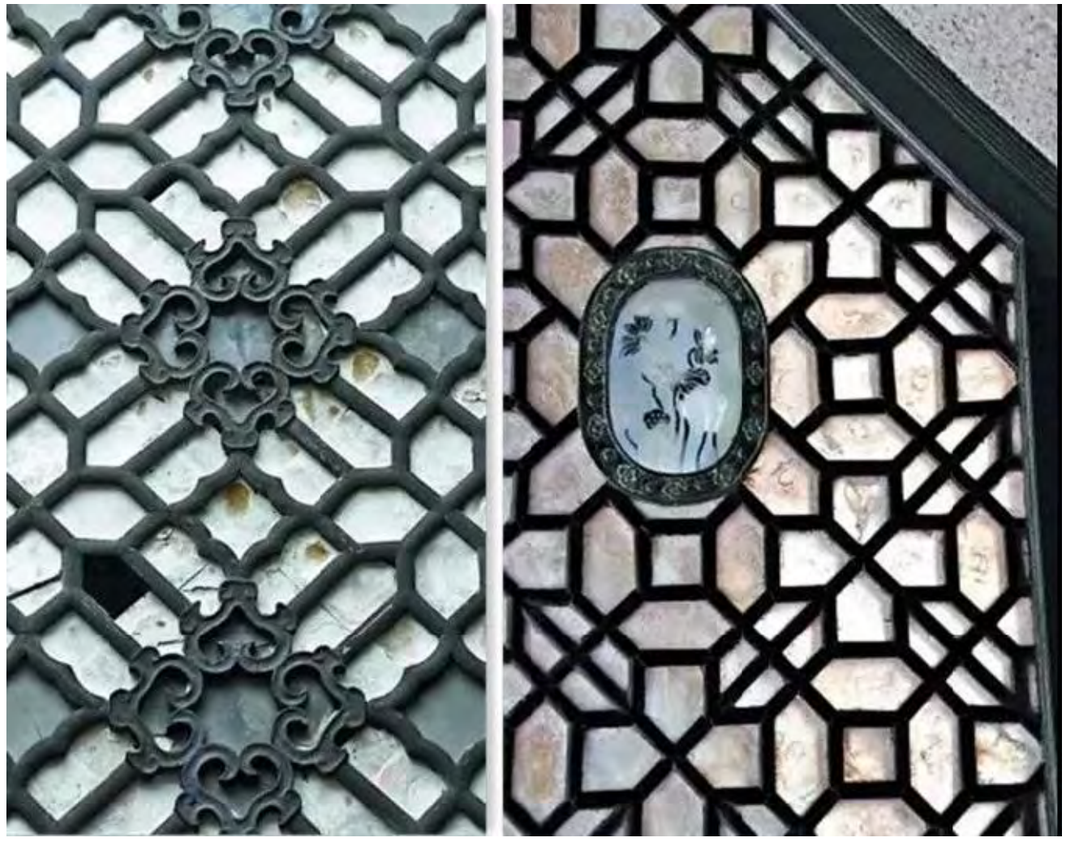
The oyster shells are scaly and neatly laid in a 45-degree downward manner, which can facilitate the drainage of rainwater, avoid rainwater from entering the inner wall, and keep the room dry.





Other types of shell architecture

Yuyin Garden
Corridor window under the shelter



Various patterns

The windows and doors were decorated by a paticular kind of seashell, Placuna placenta.

The semi-transparent shells reduce and soften the sunlight. However the production technique is complicated and basically lost now.

PART 2. Oyster shell as Natural Aggregate

1. Chemical composition of oyster shell

Chemical Properties of Sea Shells

Table 1. *The chemical properties of sea shells [41, 43]*

Chemical components	Ordinary Portland cement	Oyster Shell	Mussel Shell	Peruvian Scallop Shell	Cockle Shell	Queen Scallop Shell	Coral Reef Sand	Clam Shell	Snail shell
$CaCO_3$	62-67	95.99	94.6	53.70	51.5	50	50.46	67.70	61.95
SiO_2	17-25	0.69	2.58	0.10	1.37	0.2	0.42	0.39	10.20
Al_2O_3	3-8	0.41	<0.01	0.10	0.14	0.06	0.17	0.28	4.81
Fe_2O_3	3-4	-	<0.05	0.03	1.55	0.09	-	0.02	3.15
MgO	1-3	0.64	0.27	0.18	0.18	0.1	3.1	-	0.18
Na_2O	0.5-2	0.98	0.5	0.50	0.46	0.2	-	-	0.25
K_2O	0.5-2	-	<0.06	0.01	0.08	0.04	0.35	-	0.20
SO_3	1-3	0.72	0.308	0.32	0.14	0.02	0.43	-	0.03

Table 1 indicates the chemical properties of sea shells in percentages and comparatively oyster shells, mussel shell, clam shell and Peruvian shells are higher than the conventional cement matrix.

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Cementitious material and additive for cement

Fig. 2. (a) Surface of oyster shell, (b) Crushed oyster shell, (c) Powdered shell using electric furnace about 1000 ºC

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It was showed that the mechanical properties and the physical properties containing 10 -30% seashells are similar to the conventional materials.

2. Advantages and characteristics of oyster shell

easy distribution in complex sites,

no settlement,

strength,

duration,

flexibility,

the ability to combine with nontraditional materials.

shell waste gives high compressive strength, porosity and workability

3. Crushed oyster shell as filler and aggregate

Figure 3 Composite of Concrete mortar (a) Green mussels; (b) Scallops mortar; (c). Blood clamps

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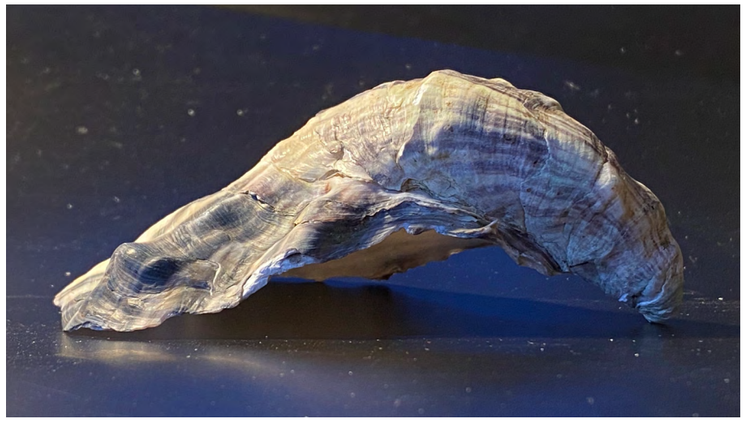
Oyster shell mortar can be used as building materials, such as: terazzo, wall and ceramics. For an example, mix design of terazzo might have a composition materials, white cement: water: shell powder: coarse shell as 2.00: 1.00: 3.00 : 0.75

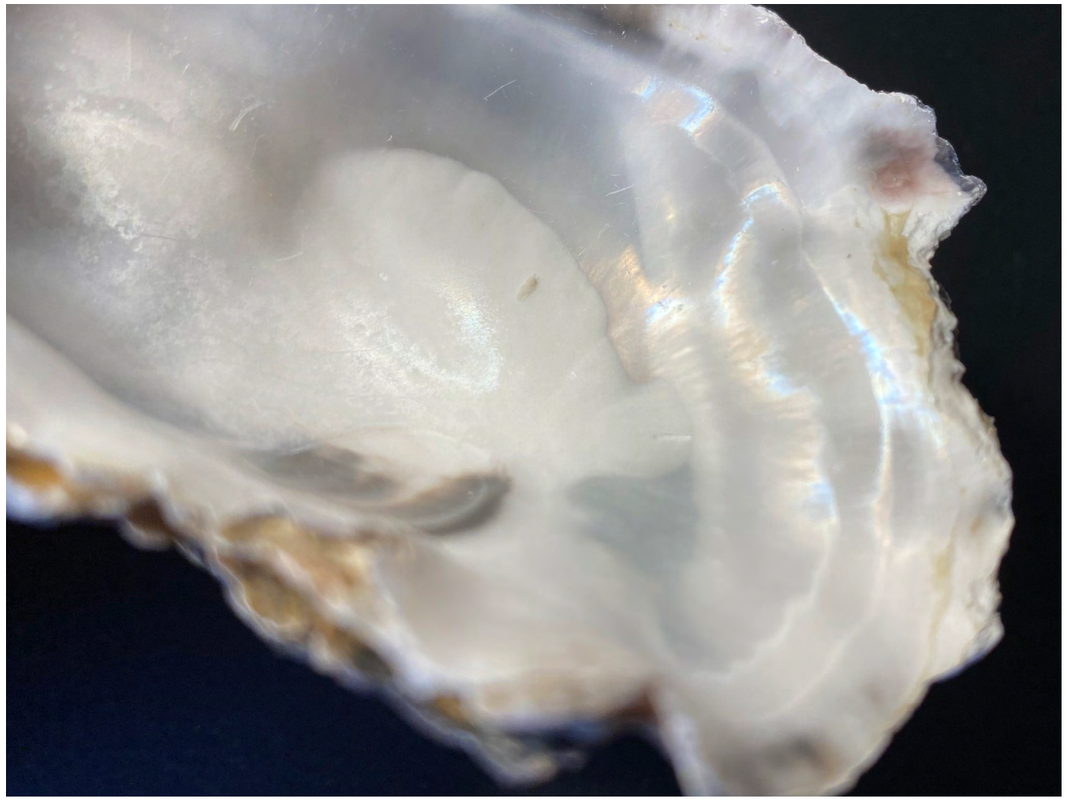
PART 3. Play with Oyster shell

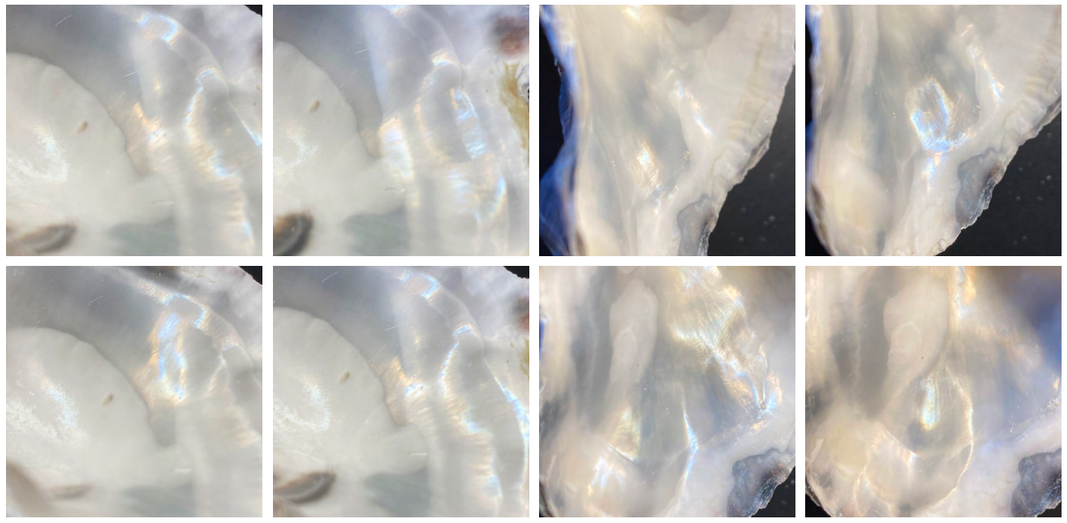
Oyster shells appearance



Oyster shell shape

Oyster shell texture



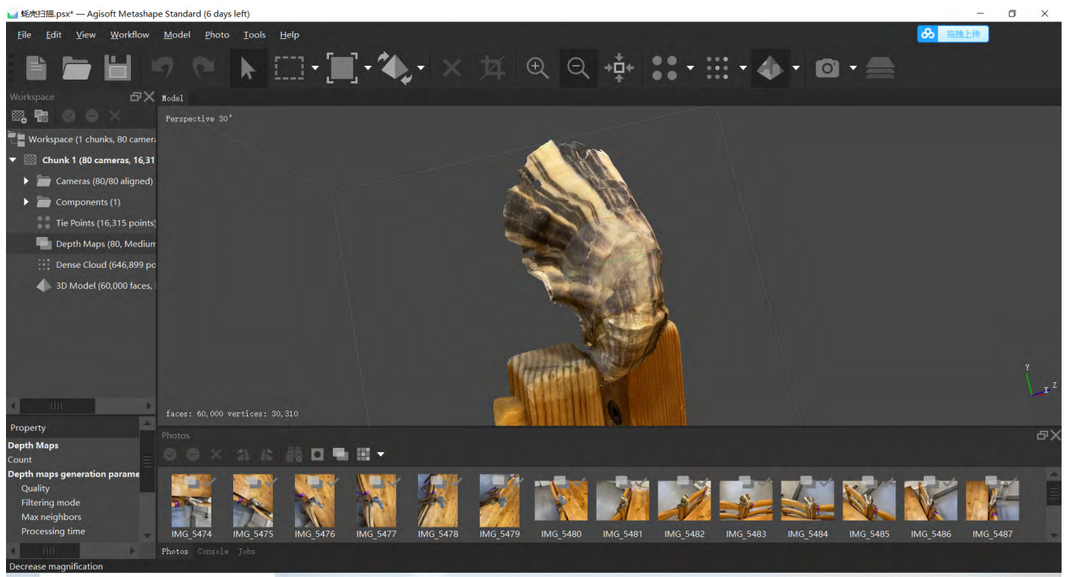


Inerside of oyster shells

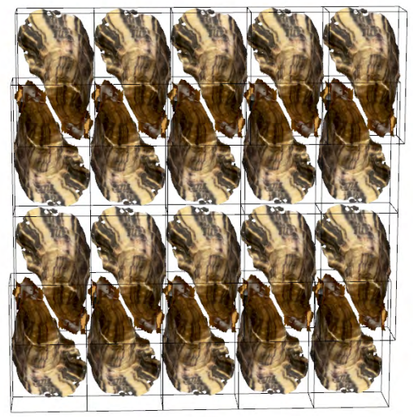
Different colors depending on the Angle

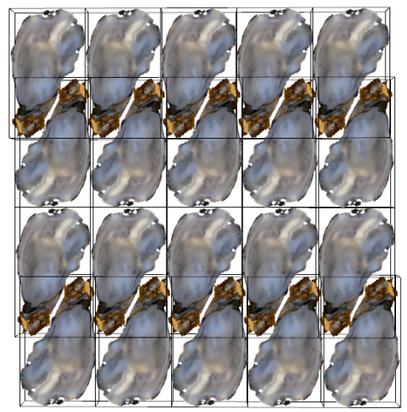
Transparency of oyster shells

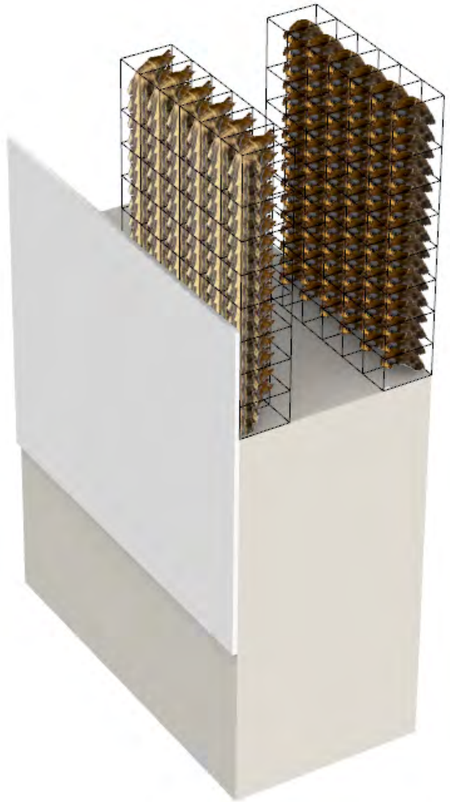
Oyster shell in digital models



Oyster shell scanning in Metashape







Different arrangement ways of oyster shells in Rhino

Material experimenting on oyster shells





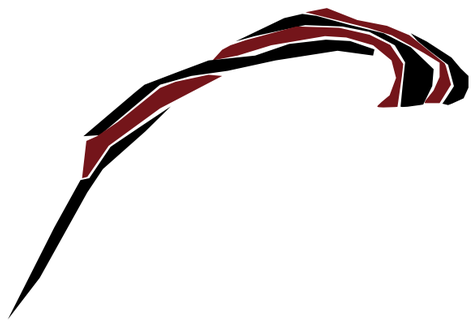

Polishing oyster shells

By polishing and cutting the shells, it created some linear boundaries and gaps.




Cutting oyster shells

Section of oyster shells



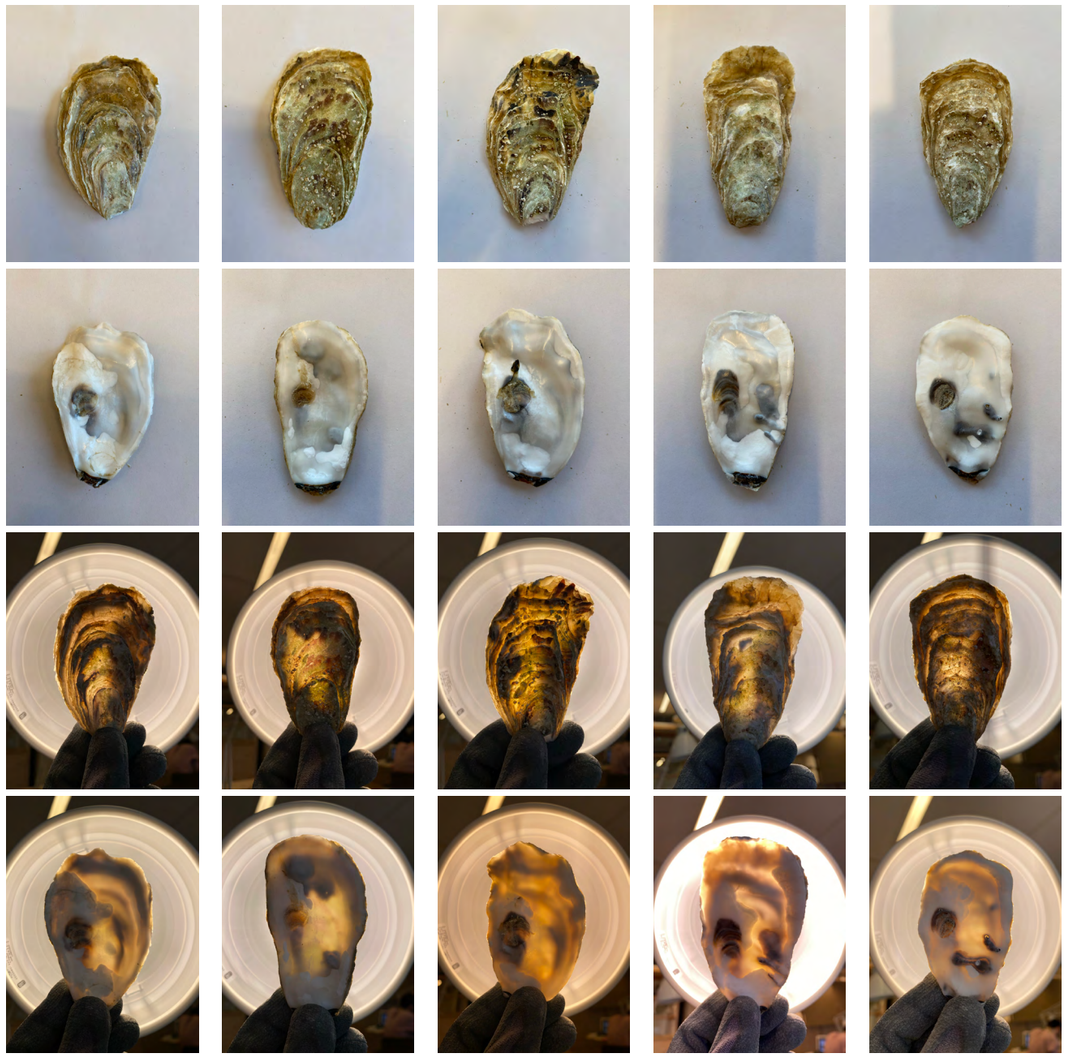
Assembling oyster shells with slice

The horizontal cross section allows the oyster shell to be laid out on a flat surface, making connections and forming regular geometric shapes.

Casting oyster shells with plaster

Shadow under the oyster shells

Other than placing the shells in this parallel way, we can also change the angle of the oyster shell to create different lighting effects. one thing should be noted, under different use conditions indoor and outdoor, is that when the mouth of the bowl is up, it will cause problems like water storage. However, if the oyster shell is large enough, it can also be used as a planter to grow plants and become an element of landscape space.



Documenting different oyster shells

Cutting oyster shells: 3.5cm*5.5cm

Comparing color of oyster shells

texture & sort order (outdide & inside)

The edge of the cut shells are not completely linear lines. So when fixing these materials, it is necessary to determine the width and depth of the frame slot according to the width difference of the shells.

oyster shells with wooden frame, front

oyster shells with wooden frame, back

oyster shells with wooden frame, front (transmition of light)

oyster shells with wooden frame, back (transmition of light)

Drilling oyster shells

To make the repairing or replacement of a damaged wall easier, Modulize a oyster shell wall facade could be a way.

In addition to using adhesives between materials, steel wires can be used to aligning oyster shells which can strengthen the connection of the materials. However, this kind of connection will make the wall lose the randomness like those old residential house had.

Aligning oyster shells by steel wire

First layer-Sand

Second layer-oyster shell pieces

Third layer-plaster

The brown part of the oyster shell fragment forms an irregular boundary in the centre of the tile. If we multiply the tile, it might create a pattern.

Crushing oyster shells

oyster shell powder

1mm~5mm

5mm~12mm

50ml 5mm~12mm Crushed shells
30ml sticky rice powder
20ml Water

50ml 1mm~5mm Crushed shells
15ml sticky rice powder
15ml cement
20ml Water

50ml oyster shell powder
30ml cement
30ml water

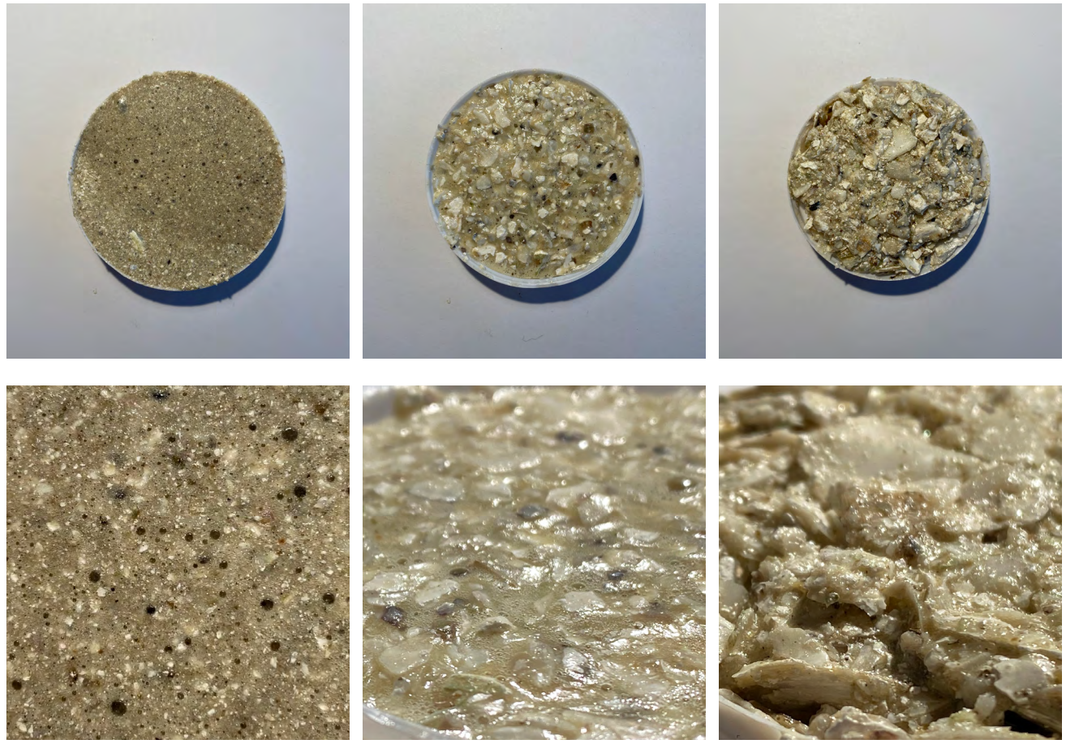
Subtraction

Cement, concrete, plastic, sticky rice were used as materials of making oyster shell tiles.

The appearance, hardness and cracking of the tiles can be affected by the amount of material used and the size of aggregate. In the experiment, the more rice paste was used, the more fragile the sample was.

Rinse the cement on the surface while the bricks are not completely dry, exposing the oyster shell so that the resulting surface can feel rough and grainy. (picture-middle.)

If using sand paper to remove the cement, the resulting surface would be smooth with oyster white spots. (picture-right.)



50ml oyster shell powder
50ml Fish bone glue

50ml 1~5mm crushed shell
50ml Fish bone glue

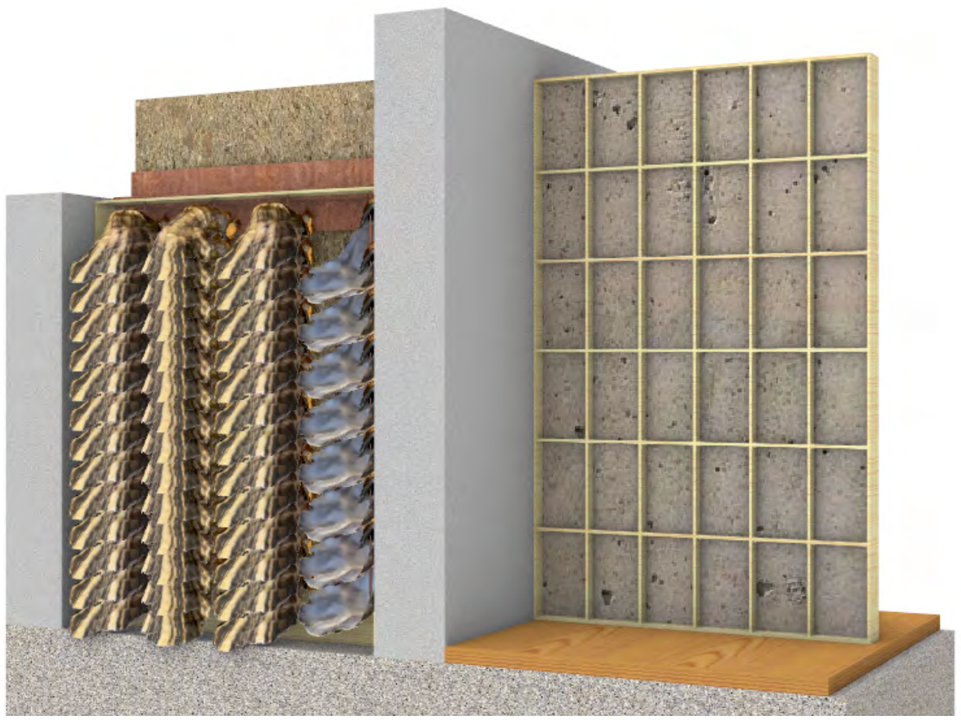
50ml 5~12mm crushed shell
40ml Fish bone glue

Addition

In this experiment, fish glue (made of fish bones) was used as materials of making oyster shell tiles.

The surface concavity depends on aggregate size. Here the larger the aggregate size, the more uneven the sample surface was.

To make the tile smoother, fish glue-shell mixture with smaller aggregate can be applied on the sample to fufill the the uneven surface.



3d modeling, Assembling oyster shells material in a wall

Reflection

This project has studied oyster shells as building materials, but there are still many possibilities to explore, leaving a lot of imaginative space for material application, such as different cutting and arrangement ways of oyster shells, different applications in furniture, interior decoration and outdoor materials, etc.

The joint style and connection method of modular oyster shell material can be further improved. For the large amount of copy of module materials, the effect applied to the facade is not deep enough.

The crushed oyster shell samples are now only limited to the appearance and style, and the structural characteristics (compression, tensile, bending, waterproof, sound insulation, heat preservation, etc.) are not studied. Second, try mixing other food scraps (seaweed, fish bones, etc.) or adhesives.

At the same time, the history of oyster shell houses can be dug out deeper, such as doing field visits, mapping their location distribution, construction methods and detail drawings, and reflect on how to integrate old construction methods and new construction methods, and how to repair and innovate, which is conducive to the application of oyster shell materials in future projects.

Last but not the least, exploring the story and vitality about the food culture is important. When Peter asked if there are any poetry and story about oysters, I said no. Actually, there are a few of poems describing people's happy life and express gratitude for food and nature. This is the vibe that could be represent other than the material itself.

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