Aalborg Universitet



# Natural Materials - Materiality and construction of sustainable buildings - A one-to-one experience

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Materiality and construction of sustainable buildings









A one-to-one experience











# NATURAL MATERIALS



# MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

# THE POTENTIAL OF LOCAL NATURAL MATERIALS IN ARCHITECTURE

Natural materials are offered with a variety in almost every location. Using their potential in contemporary architecture diminishes the environmental impact of buildings. Distinct local architectural designs can be developed which are suited to the local building tradition and the local climate conditions

This brochure constitutes the practical outcome of an experimental construction process in the course, Materiality and Construction of Sustainable Buildings, which was conducted during the period March 12th – May 10th 2019. and constructing the 1:1 model included also to work out a material list, which served to order materials for the workshop. In the further reflection process after having ordered the materials and even during the workshop some groups concluded that their design could be further improved.

Therefore, the material used in these models are in some cases a simulation of the real material to be used. The exhibited 1:1 models therefore express the result of conducted experiments and are not to be regarded as final design solutions.

# **OBJECTIVES**

The aim of the course is to provide an understanding of the diverse and specific qualities of building materials and constructions and their use in contemporary buildings. The course aims at providing an advanced understanding of material experimental theory, methods of working with materials and practice in design and evaluation of sustainable buildings. This includes insight into material performance of selected materials, certification systems as well as appreciation of how materials may be applied and perceived within the architectural realm.

# LEARNINGS FROM THIS COURSE AND REMARKS ON THE 1:1 MODELS

Going from the design phase and detailed drawings to the construction phase and 1:1 modelling has brought awareness of the level of information embedded in the drawings, challenges related to material properties of real materials as opposed to general material characteristics, the importance of tolerances, etc. The process of designing Course module: 5 ECTS Coordinator: Runa T. Hellwig

Supervisors: Anne K. Bejder, Tine S. Larsen, Agathe Revil-Signorat, Camilla Brunsgaard, Dario Parigi, Runa T. Hellwig Lectures by: Tine S. Larsen, Anne K. Bejder, Runa T. Hellwig, Camilla Brunsgaard, Marwa Dabaieh, Dario Parigi, Mads B. Jensen

Special thanks to: Bjarne Johansen, Tækkemanden fra True, for an inspiring and instructive introduction to the craft of reed thatching

**Workshop team:** Poul Lund, Jens Munk Clemmensen & Peter Skotte. Many thanks for your great help and support during the workshop!

Exhibition team: Johanne Lyngklip Gaardbo, Emilie Hellerup, Mathias Flügel, Anne K. Bejder, Runa T. Hellwig Brochure design: Emilie Hellerup

**Photos:** Jens Munk Clemmensen, Anne K. Bejder, Inaam C. Ramløse

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# **EXPERIMENTAL PROCESS**

The course comprises of two phases, which strengthen the student's ability to analyse, design, experiment, construct and critically reflect on the choice and application of natural materials in sustainable buildings. The course has included a combination of theoretical studies, lectures, design development (Phase 1), testing and constructing in scale 1:1 (Phase 2).

During the first phase, the students were introduced to life cycle assessment (LCA) of materials, constructions and buildings. Each student had to evaluate variations of a wall construction using natural materials and comparing it to conventional wall constructions. Based on the learning from the evaluation result of each student the groups decided on a wall design.

The groups chose to work with one of the following natural construction materials: reeds, seaweed, hemp, cellulose, earth (rammed earth or dried clay bricks) or different timber products, and the construction was to be designed with an eye to future "disassembly".

# PARTICIPATING STUDENTS

Mette Sletting Jensen, Mathilde Vig Benfeldt, Tine Bredahl Terkelsen, Andreas Nygaard Mathiesen, Christine Damlund, Luna Nørgaard, Gevitz, Even Årsland Anderssen, Cecilie Bruun Jensen, Benjamin Rusch, Tanja Krogh Andersen, Morten Høgh Larsen, Mikkel Jong, Lykkegaard Pedersen, Gülay Eryüce, Søren Peter Nørgaard Mikkelsen, Christian Rejkjær Bülow, Clara Kirstine Simonsen, Rebecca Butler, Camilla Bjørcklund, Clarissa Nazzaro, Emilie Grønborg Rønnow Nielsen, Julie Melchior Skov, Camilla Hyttel, Luisa Vitolo, Barbara Høyer Johansen, Patrick Jørgensen, Kirstine Tone Hylleberg Beyer, Louise Bagge Mikkelsen, Maria Engelund, Abhay Kumar Kandula, Drashti Shantiv Mehta, Eleni Iro Papadopoulou, Natalia Maria Glapiak

During the second - experimental construction - phase, eight groups of 1 to 5 students have further improved their design, worked out a material order list, evaluated and constructed a 1:1 section of an exterior wall, focusing, among others, on the:

- Materials' environmental impact (through Life Cycle Analysis)
- Materiality of materials (how the materials are perceived)

• Technical performance of the materials regarding thermal conductivity and water vapour diffusion

• Meeting between materials

• Design for disassembly

# MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

MSC02 ARCH-SUS, GROUP 3: BENJAMIN RUSCH, GÜLAY ERYUCE, MIKKEL JONG LYKKEGAARD PEDERSEN, MORTEN HØGH LARSEN, TANJA KROGH ANDERSEN

# DETAIL



DISASSEMBLY

As a solution on how to design a wall that can easily be put together but also easily advancembled, insea and is built in these secti-advancembled, inseas walls built in these secti-as sandwich elements. It uses strate as insi-biliton contained in a wooden construction of i-profiles and closed of with a soft wood behaviour of the section or and CSB-plates on the interior. These modules are connected upge added in the mest step. The CSB-board will be airtightly sealed.

using the toxic... ding added in the net step. i.e ..., will be arrightly isaids. When the main consistent is is standing the exter-or facate plates are applied with strews, to they can easily be encomed or enchanged. These modules can both be predistruined the enclaimed words found. In the retriev the taking are able found. In the retriev the taking are built up using words that must be hadd them place. This way, there is no use for motion and they can be remo-wed easily and reused in other projects.

VALL CONSTRUCTION	
ladding, recycled wood ywood ir gap (Wooden crossbars 30x50 mm) df wood Bireboard raw (-profiles, wood 400x60 mm) SB board, airtightly sealed am bricks (Bathy sealed am bricks (Bathy sealed am bricks (Bathy By plaster me paint	20-40 mm 16 mm 30 mm 22 mm 400 mm 15 mm 54 mm 16 mm 10 mm 3 mm
	Total 606 mm

101

CONSTRUCTION

# RECYCLED WOOD

Uses wood otherwise intended as waste Gives a diverse facade expression Linhtweight Biodegradable

## VENTILATED AIR GAP

Wooden battens hold the outer cladding, and are oriented vertically in case of any water needing to run down. The air gap ensures ventilation from the inner layer in case of excess moisture

## STRAW TIMBER CONSTRUCTION

Lightweight, strong and durable Has a low thermal conductivity making it a natural insulation material Straw is a waste product, which means the only energy needed when using them for construction is for the bailing process and the transportation to the worksite.

Fire retardant and mold resistand when pressed tightly to-oether

# CLAY BRICKS

High Thermal mass minimising temperature variastions Regulating temperature, absorbing moisture and odours Sound absorbing qualities

## CLAY PLASTER

Strong, durable and flexible Easy to repair and cost effective High thermal mass making it warm to touch in winter and cool to touch in summer Breathable ensuring the properties of the layers underneath to be exploited Recyclable, reusable

PLYWOOD BOARDS

Used for applying the recycle wood in an easy way Can be premade as a modules Protection for water

# SOFT WOOD FIBRE BOARD

Homogeneous, no grain direction Easy to work with and quick to install Made of recycled wood

Breathable making excess moisture in the insulation e Direct exposure to water can cause swell, so it needs to be protected from direct rain

## OSB BOARD

High performance, structural, wood particle board When sealed correctly in all openings it works as a natural vapor barrier Stabilising the structural elements, making the wall stabil Suitable for external and internal use

# SOFT CLAY PLATE

Consisting of natural materials as clay, reed and hessian High thermal mass minimising temperature variastions Regulating temperature, absorbing moisture and odours Sound absorbing qualities

# LIME PAINT

Natural product without any chemicals Sustainable and carbon neutral

Moisture regulating

Breathable making it a mould and bacteria resistant paint. This also ensure the properties of the layers underneath can be exploited.

# FINISH



EXTERNAL CLADDING As outdoor final's regided wood is used. This could be offset take entrains or other wood read-use that are not used base entrains or other wood read-use that are not used base there wood read-use that are not used base there wood read-use that are not used there there wood r

PHYSICAL MODEL

1,016 kg CO<sub>2</sub> equiv. = 12 % 3,32E\* kg R-11 equiv. = 7 % POCP Ph. 6,60E<sup>-1</sup> kg ethene equiv. 3,56E<sup>-2</sup> SO<sub>2</sub> equi = 17 % 



# EXAMPLE OF PROJECT POSTER

LCA

environmental firend material, clay. Clay has also been cho-sen for its great purposed as it can both regulate temperature due to its thermal mass, as well as it can regulate the level of moisture. It is also very sound absorbing and as a plus, clay is found directly on site as well, giving the interior a more natural correlation to the surroundings.

LCA & A TOOL
nature insterial, itsue, has been choren. This is found directly
backing a value to a great impact on the environment is easily product otherwise used for feeding is
outer to issen this, a more ex-of-rendry will have been convoice to issen the insterior of the environment is easily product otherwise used for feeding is
and to be environment is easily a set of the set issen of the set of the set of the environment is easily a set of the set of CHOOSING MATERIALS By doing organg analyses, the impact of each material been evaluated. If a specific material performed poor in several Offer alternatives such as interior clading have also been in-categories, alternative metargates are meetingated. For instan-vestigated. Due to the registre impact regular groups will be instand of using regular interial void a tradicion, arrite-tive in the entity of the registre impact of a single entities of the registre impact of the registre impact regular groups will be instand of using regular interial void a instance. The there is the registre impact regular groups will be instand of using regular interial void a instance. The there is the registre impact registre is the registre impact registre is the specific of the registre instance. The registre impact registre is the registre impact registre is the specific of the registre instance. The registre impact registre is the registre impact registre is the specific of the registre is the registre impact of the registre impact registre is the registre impact registre is the registre impact registre is the specific of the registre impact of the registre impact registre is the registre impact registre impact registre is the registre impact registre impact registre is the registre impact registre imp

PERCENTEAGE OF DGNB REFERENCE VALUES GWP ODP





# **MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS**

GROUP 2 - MSC\_02 ARCH SUSTAINABILITY

### DESIGN AND QUALITIES

Egholm is an oasis in the middle of Lim, fjorden, yet still connected to the busy metropol, Aalborg. On Egholm you can feel isolated from the city life and feel re-connected with nature, by the sound of the waves from the fjord hitting the shore and the sound of the reeds wavering in the wind, stuning out the sound of cars. The coning the sound of cars and ecco from hard surfaces. The con-struction site includes long views over a







he LCA



INSTALLATION LAYER





SPACKLE THE CLAYTEC BOARD WITH MOTOR

THATCHING THE REEDS ON THE FACADE







		el. International be reused as n compose
WALL A	WITH AIRGAPS	WALL B: WITHOUT AIRGAPS

PROS
U-value of reads counts in the overall u-value     Thiner valid 550 mm     Less use of material     Joints of facades needs no air gap
CONS
Higher use of plywood     Construction behind reeds dif- fers from the one behind wood     (project)     Reeds are a part of the heated     area and all 550 mm are heated

U-VALUE FOR BOTH WALLS: 0,095 W/m2+1











EXPLODED AXONOMETRIC DRAWING WALL B



EXAMPLE OF PROJECT POSTER

# MATERIALITY AND CONSTRUCTION OF SUSTAINABLE BUILDINGS

ARCHITECTURE | MASTER OF SCIENCE & ENGINEERING

# CONTACT

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