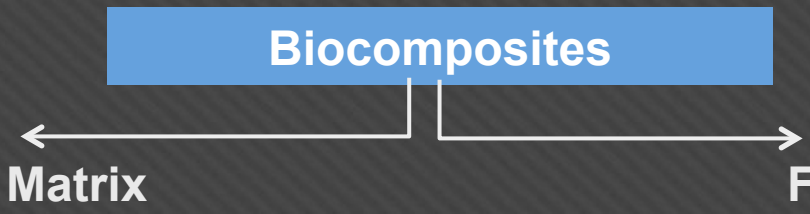
Das Bild kann nicht angezeigt werden. Dieser Computer verfügt möglicherweise über zu wenig Arbeitsspeicher, um das Bild zu öffnen, oder das Bild ist beschädigt. Starten Sie den Computer neu, und öffnen Sie dann erneut die Datei. Wenn weiterhin das rote x angezeigt wird, müssen Sie das Bild möglicherweise löschen und dann erneut einfügen.

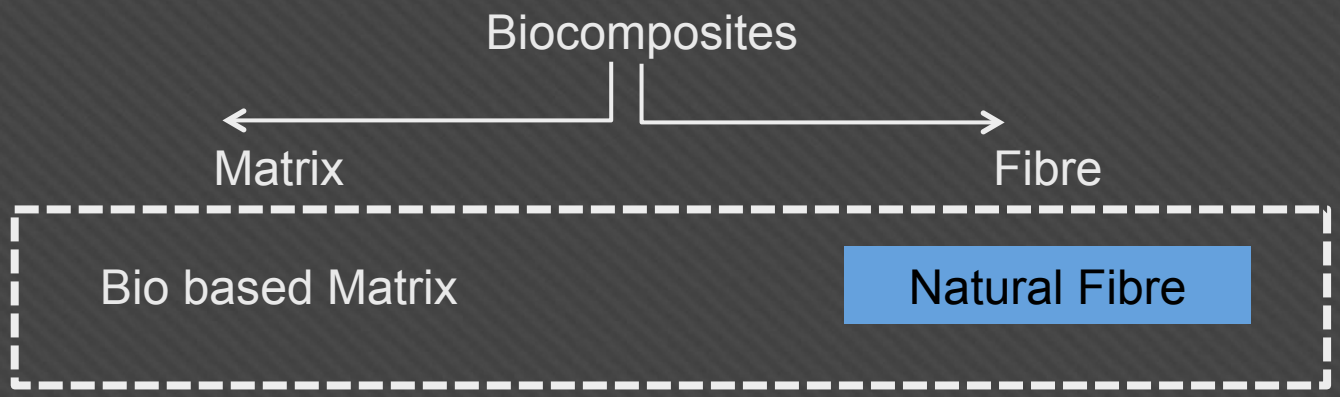
Product Design Aspects of Agro-fibers' Biocomposites for Architectural Applications

M.Sc. Eng. Hanaa Dahy

ITKE- University of Stuttgart- Germany
E.Mail:h.dahy@itke.uni-stuttgart.de



	Matrix	Fibre
1	Bio based Matrix	Natural Fibre
2	Bio based Matrix	Manmade Fibre
3	Fossil-based/Petro- Matrix	Natural Fibre


Biocomposites
Matrix
Fibre
Bio based Matrix
Natural Fibre

Natural Fibers

Plant Fibers

Animal Fibers

Mineral Fibers

Fibers- Renewable Resources

Fibre Crops

Agro-fibers

Natural Fibre source in Biocomposites

Agricultural Crops Quantities

Sugar Cane	Maize	Rice-paddy	Wheat	Potatoes	Sugar Beet	Soybean
1,794	883	722	704	374	268	261

Agricultural Crops Amounts in million tons, after FAO-2011 (Anon., 2013)

Agricultural crops consist mainly of grains, vegetables, fruits and others.

Agricultural residues are the materials left over from the production of crops whether cereal crops, fruits, vegetables or nuts. The main interest in such annual crops' agriculture is the seed/fruit itself and not the residues left over after harvesting.

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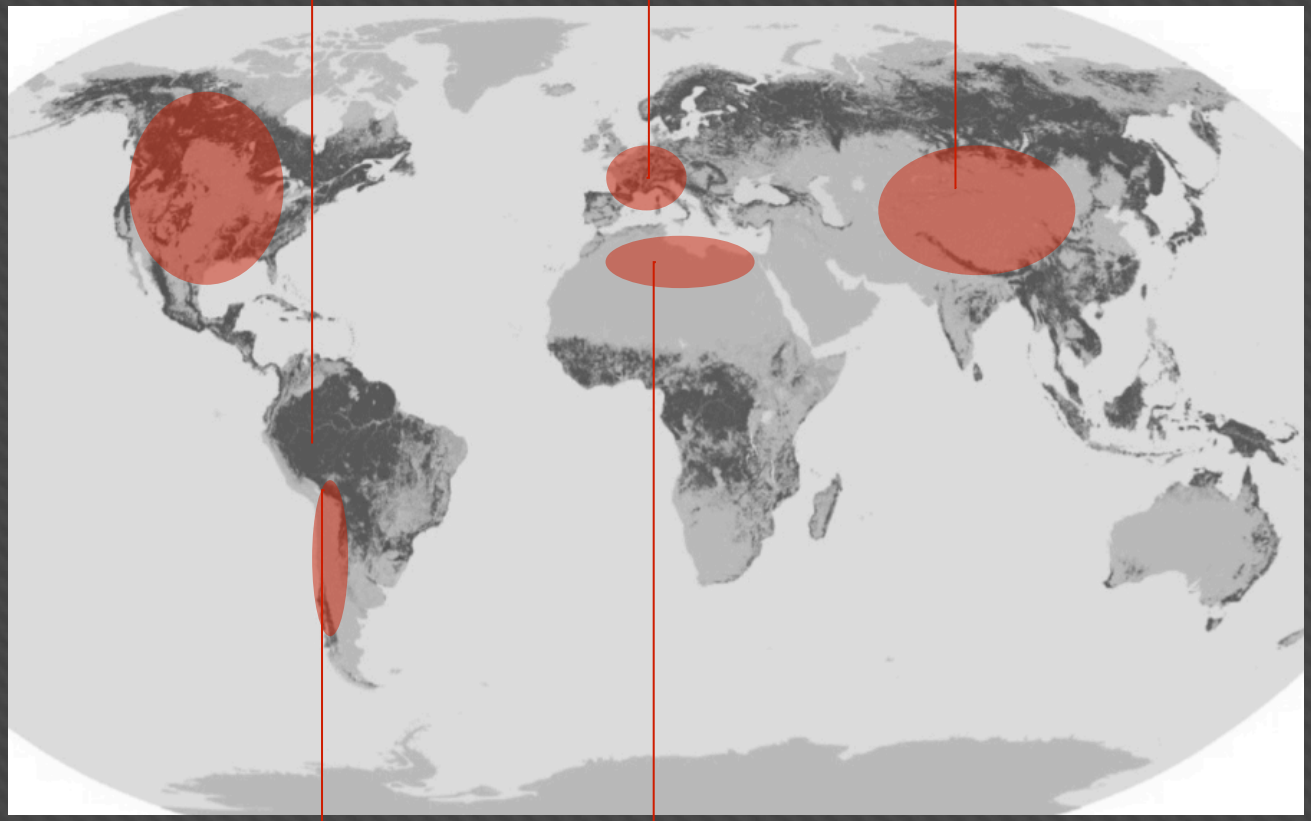
USA: 56,730.274
Canada: 13,385.100
Total: 70,115.374

EU: 56,436.820

Central Asia: 949,079.38,South Asia: 132,381.760,
East Asia and Pacific: 174,713.722 .
Total: 402,003.420



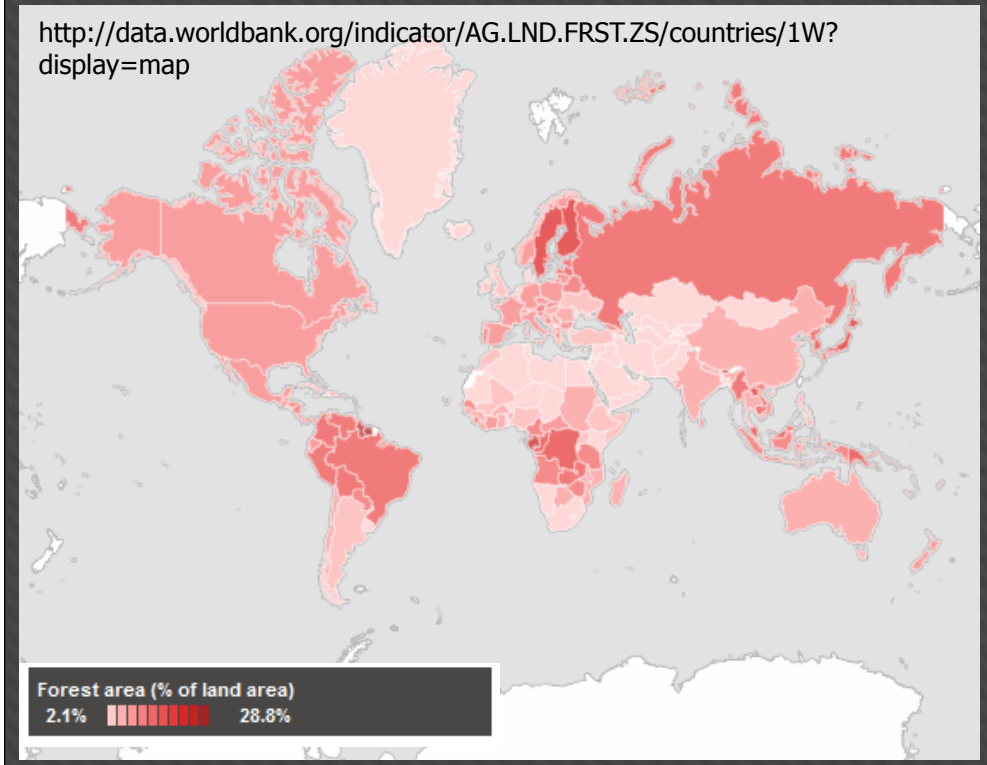
Latin America
&Caribbean :
51,034.470

Middle East and North
Africa 28,329.907

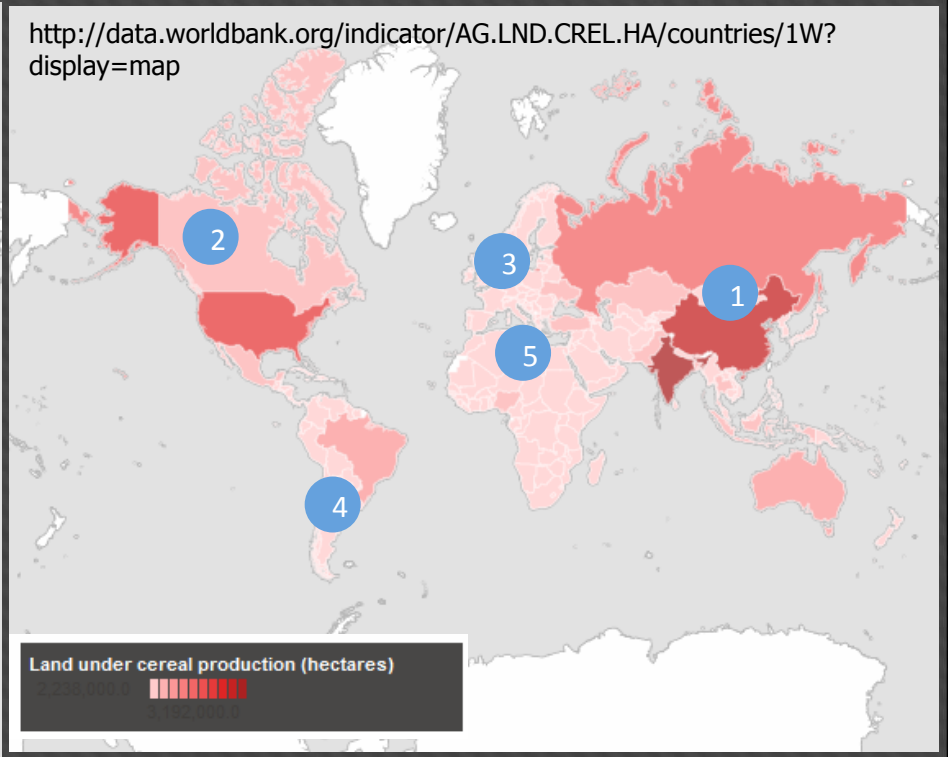
Land under cereal production (hectares)- Derived from available digital data of FAO+World Bank 2011 (all income levels)
Map Photo credit: FAO©-2006

Wood fibre shortage verses Agro-fibres Availability:

http://data.worldbank.org/indicator/AG.LND.FRST.ZS/countries/1W?display=map



http://data.worldbank.org/indicator/AG.LND.CREL.HA/countries/1W?display=map



- Wood supply- Forests
- Shortage of Wood Supply

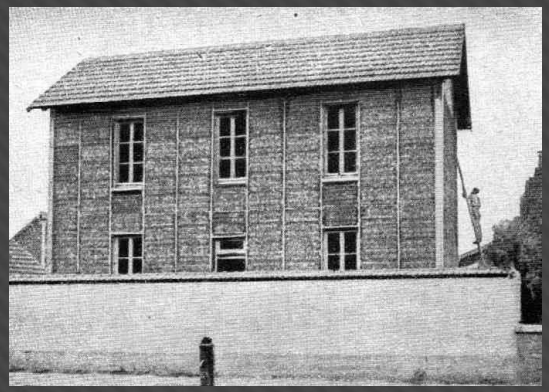
- High Cereal Crop Production
- Medium to low Cereal Crop Production

Agro-fibers Classical Applications in Architecture- Straw Bale Housing

Agro-fibers Reuse: ex. Straw Bale- Construction

H I S T O R Y

First straw bale construction in Nebraska in 1908 (Hammer, et al., 2012)



Oldest two-story straw bale construction in Europe- France since 1921 (Scharmer, 2012)

Straw Reuse: Straw Bale- Construction

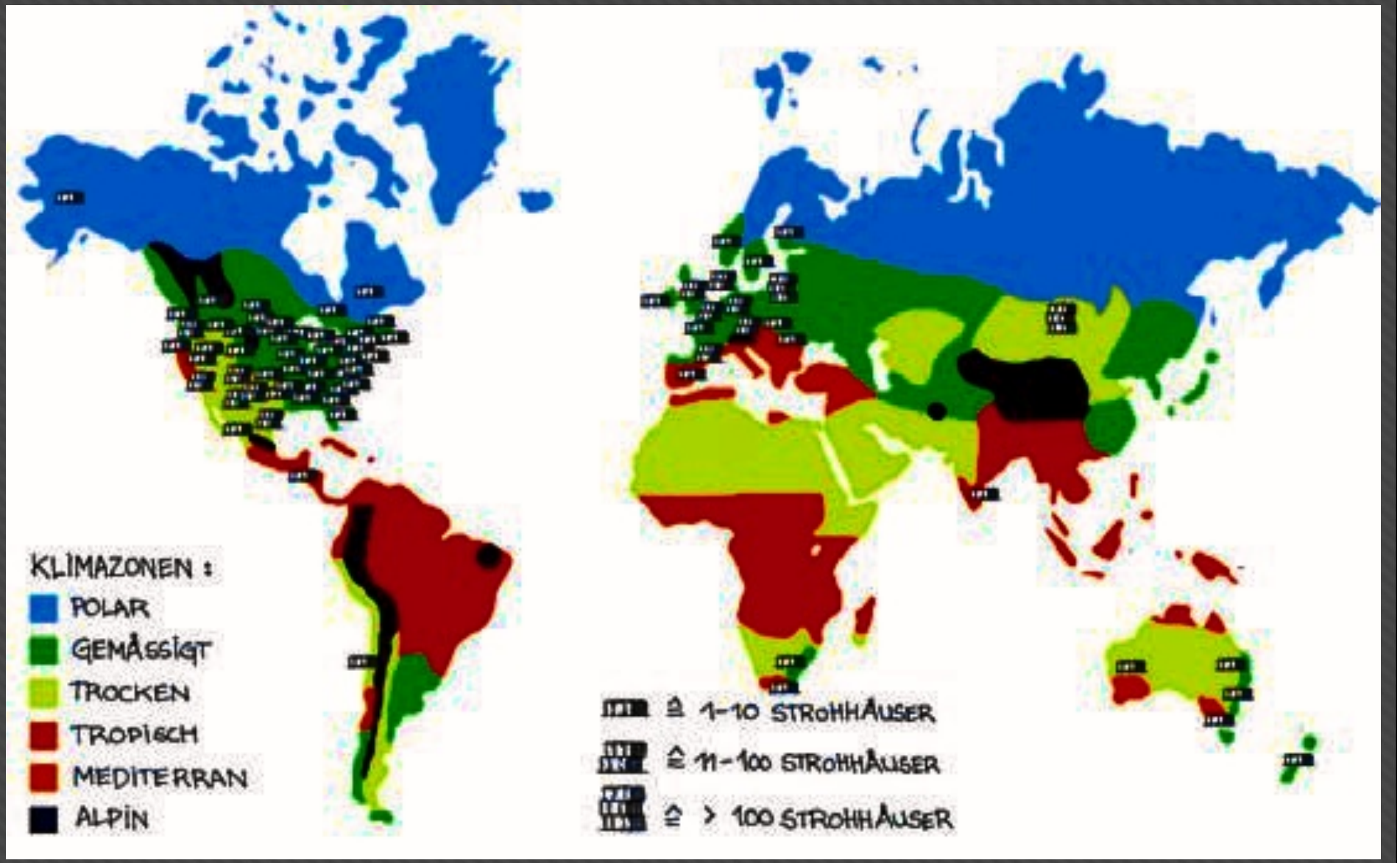

© Bernd Vogl/Bernd Vogl


http://www.baubiologie.at

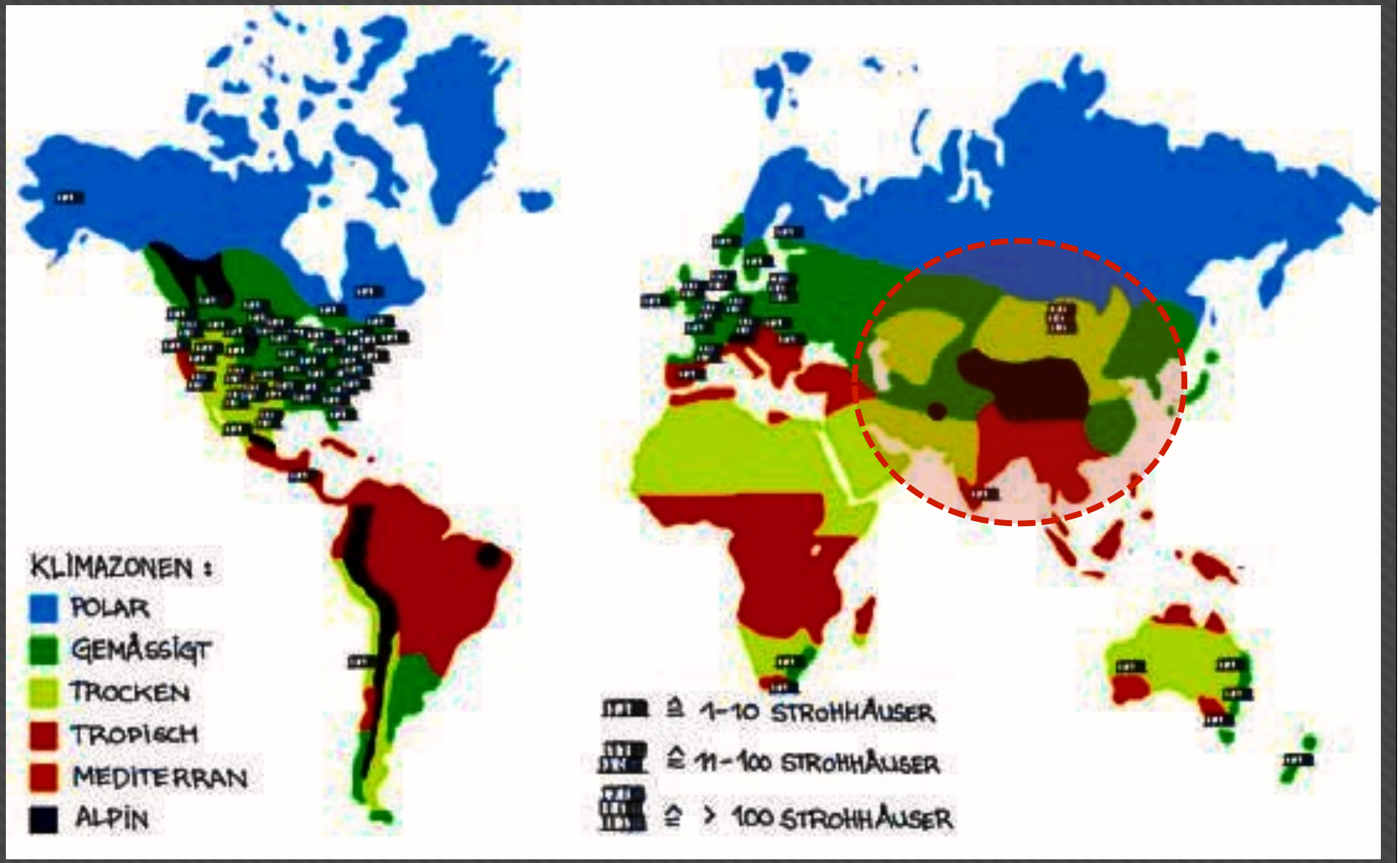
In S-Haus Böheimkirchen , the straw bales were applied externally as an insulating system. "Building for the future program"- Austria -2005

Architect: Mag. Georg Scheicher.
Consultaion and Energy Planning: TU-Wien- Gruppe Angepasste Technologie, Dr. Robert Wimmer

Are these classic applications successful enough?



The distribution of strawbale constructions worldwide and in different climatic zones. (Wimmer, et al., 2004)



The distribution of strawbale constructions worldwide and in different climatic zones. (Wimmer, et al., 2004)

Agro-fibers‘ Biocomposites- Another Potential for Agro-fibers Applications in Architecture

Mud brick from Thebes, Egypt, 19th Dynasty, 1250 BC. Stamped with the name of RamessesII,
Photo credit: www.britishmuseum.org

Photo: Hemmings.com

A car made from hemp- Ford- 1941

Ford's using wheat straw in a 2010 Flex component

FUTURE

Agro-fibers thermoplastic biocomposites for building industry: Examples from Market

Rice husk (60%wt) + Mineral oil (18% wt) + Rock salts- additives (22%wt)

http://www.resysta.com/de/fassade.html

Rice Husk	ca. 60%
Rock Salts	ca. 22%
Mineraloil	ca. 18%

http://www.resysta.com/de/eigenschaften.html

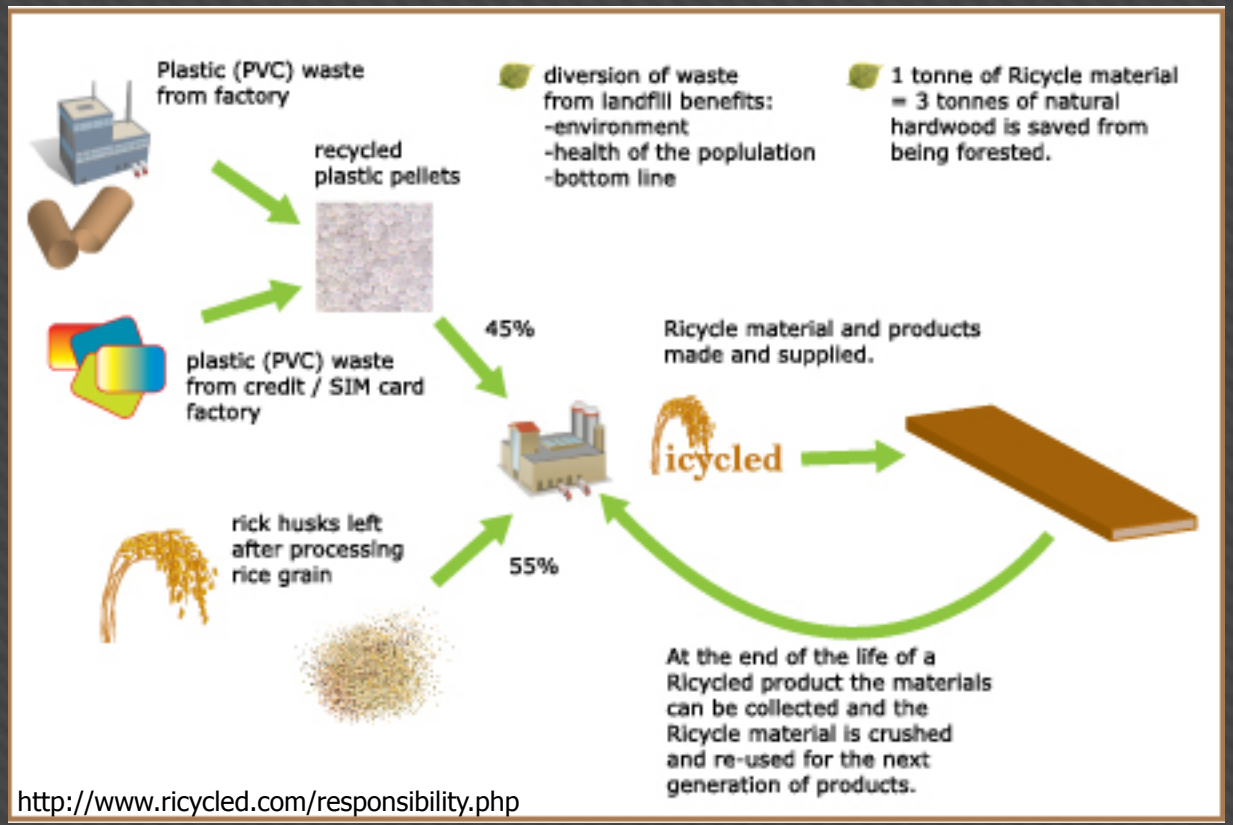
German owned Company based in Malaysia

Resysta® THE BETTER WOOD

Agro-fibers thermoplastic biocomposites for building industry: Examples from Market

Rice husk (55%wt) + PVC (recycled-45%)

Product life-time: Ricycled, Ricycled rice husks based composite, Rice Husks, looks like wood outperform wood, lowers your cost and carbon footprint



British owned company, based in Malaysia

Agro-fibers thermoplastic biocomposites for building industry: Examples from Market

Wheat Straw + recycled HDPE

TerraDeck™: wheat straw and HDPE

USA Company, based in USA

NATURES COMPOSITES
organic building products

Agro-fibers thermoset biocomposites for building industry: Examples from Market

Almond shells flour + Conventional Resin

http://www.decke-wand-boden.de/wandverkleidungen/duralmond/duralmond-wandmodule/index.php

EME Fusion Hotel
Seville | Spanien | Realisiert 2008

Mandelschalen Verbundwerkstoffe-Fassadelemente

Fotograf: Fernando Alda

Spanien Company DECORATIVE ARCHITECTURAL INNOVATIONS S.L. Duralmond

Duralmond Wandmodule

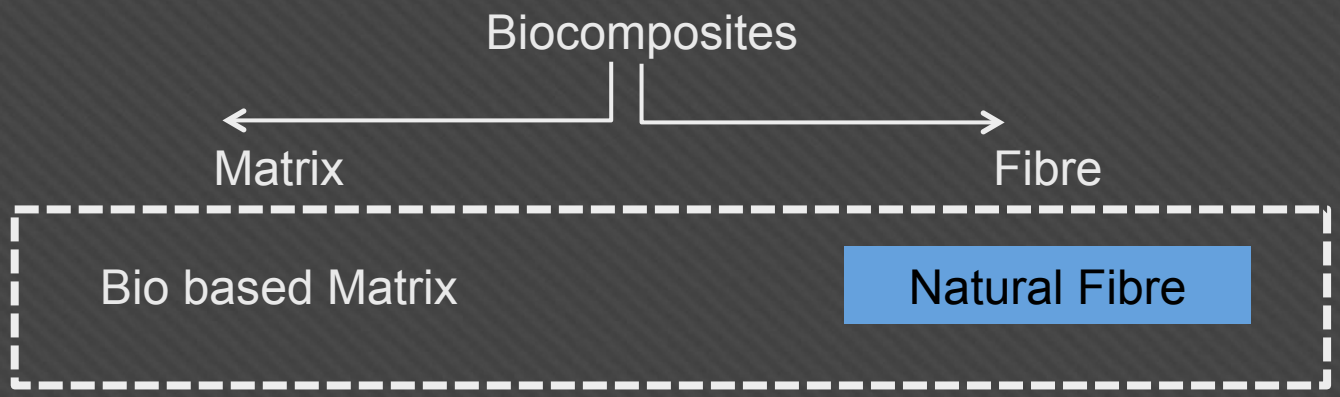
Agro-fibers thermoset biocomposites for building industry: Examples from Market

Agro-fibers (till 80% wt.) + Conventional acrylic Resin

http://www.organoids.com

Austrian Company Organoid Technologies GmBH

CASE STUDIES


Biocomposites
Matrix
Fibre
Bio based Matrix
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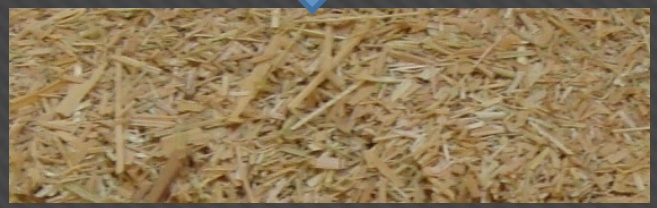
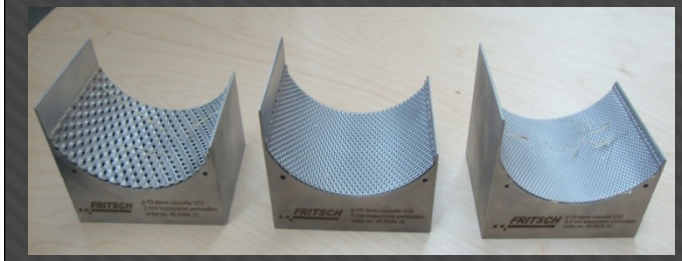
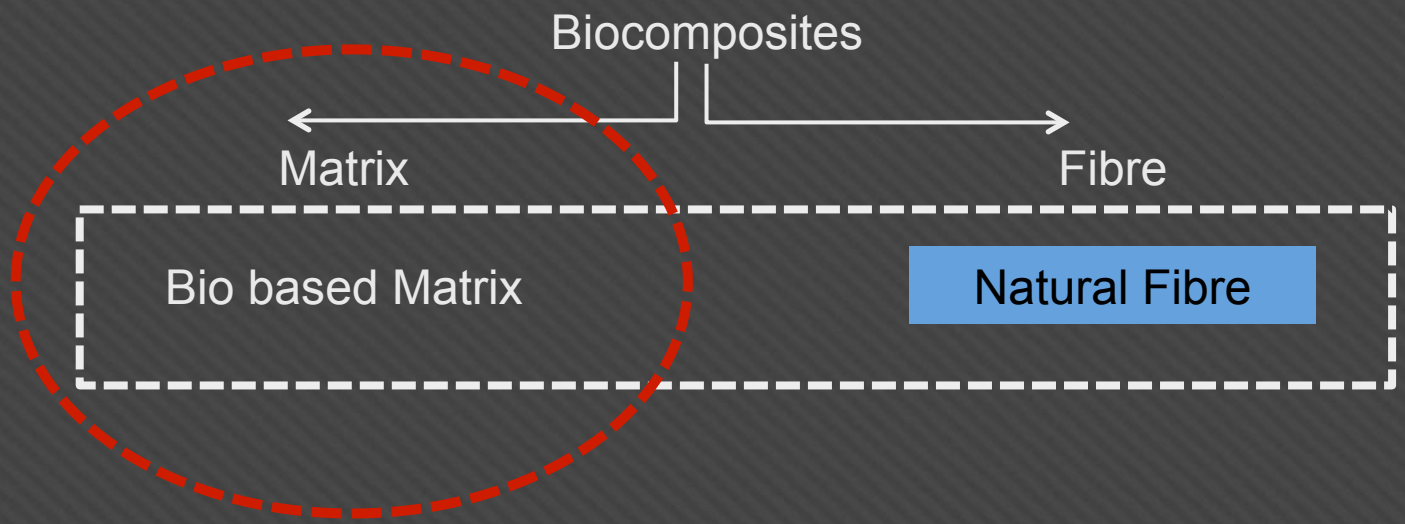




Agratechnik Instiut- Uni Hohenheim

Cutting Mill Combination PULVERISETTE 25/19, the chopping machine is integrated with the collector and dust absorber, supported from FRITSCH GmbH


Biocomposites
Matrix
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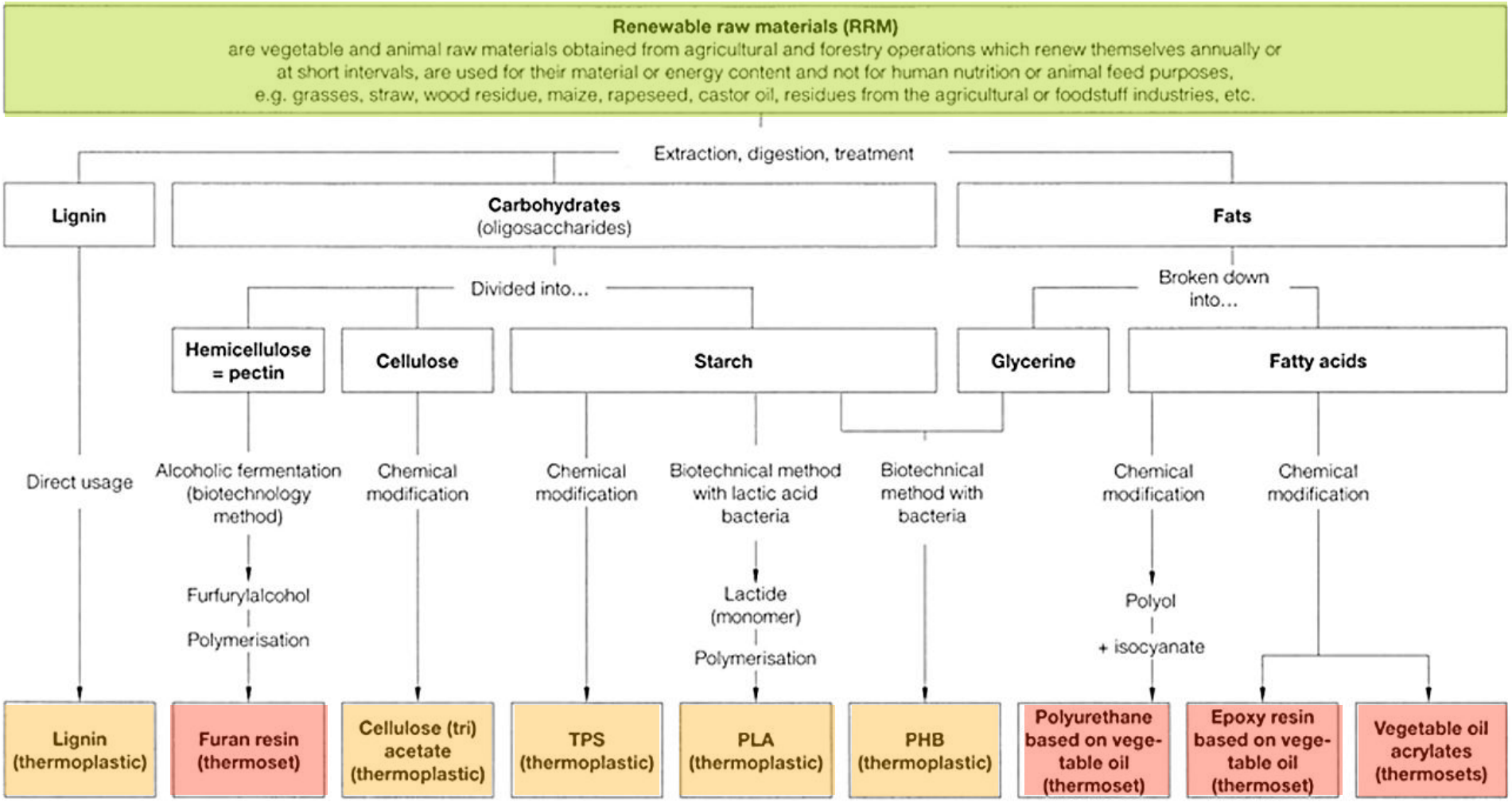


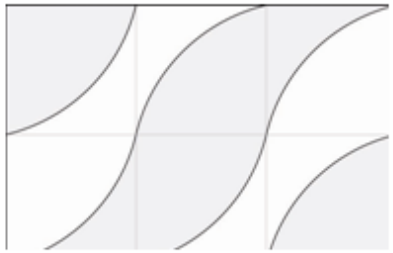
Thermoplastic Biopolymers
Thermoset Biopolymers

Atlas Kunststoffe + Membranen

Organic polymers from renewable resources

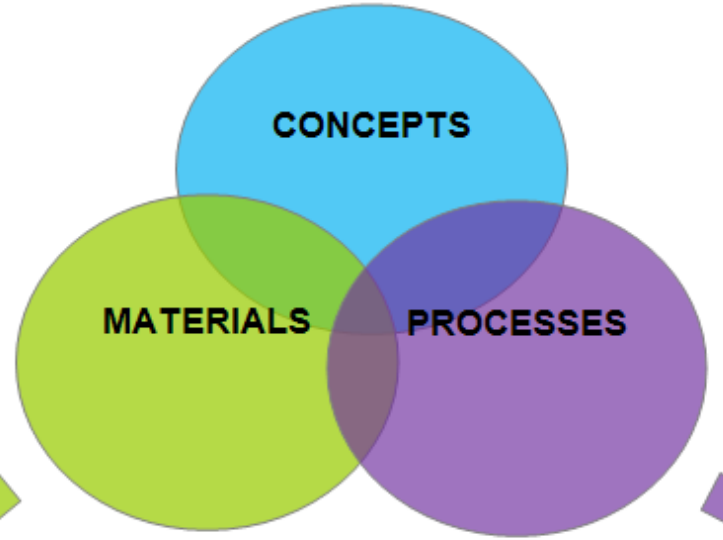
CONCEPT

- Composite type and architecture: sandwich panel, particle board, …etc
- Form: Free-form, flat, pro-filed,…etc
- Colour
- Texture
- Transparency
- …



Design + Application

- Inner Cladding
- Partitions
- False-ceiling tiles
- …



Natural fibre from Agricultural residues

Linseed oil thermoset epoxy matrix

Natural Fibre + Matrix

Processing

Physical Processing:

- Fibre was chopped with Mill Combination PULVERISETTE 25/19 from FRITSCH GmbH

- Mould was created through carving required design with a roboter machine
- Open and closed press molding technique were applied

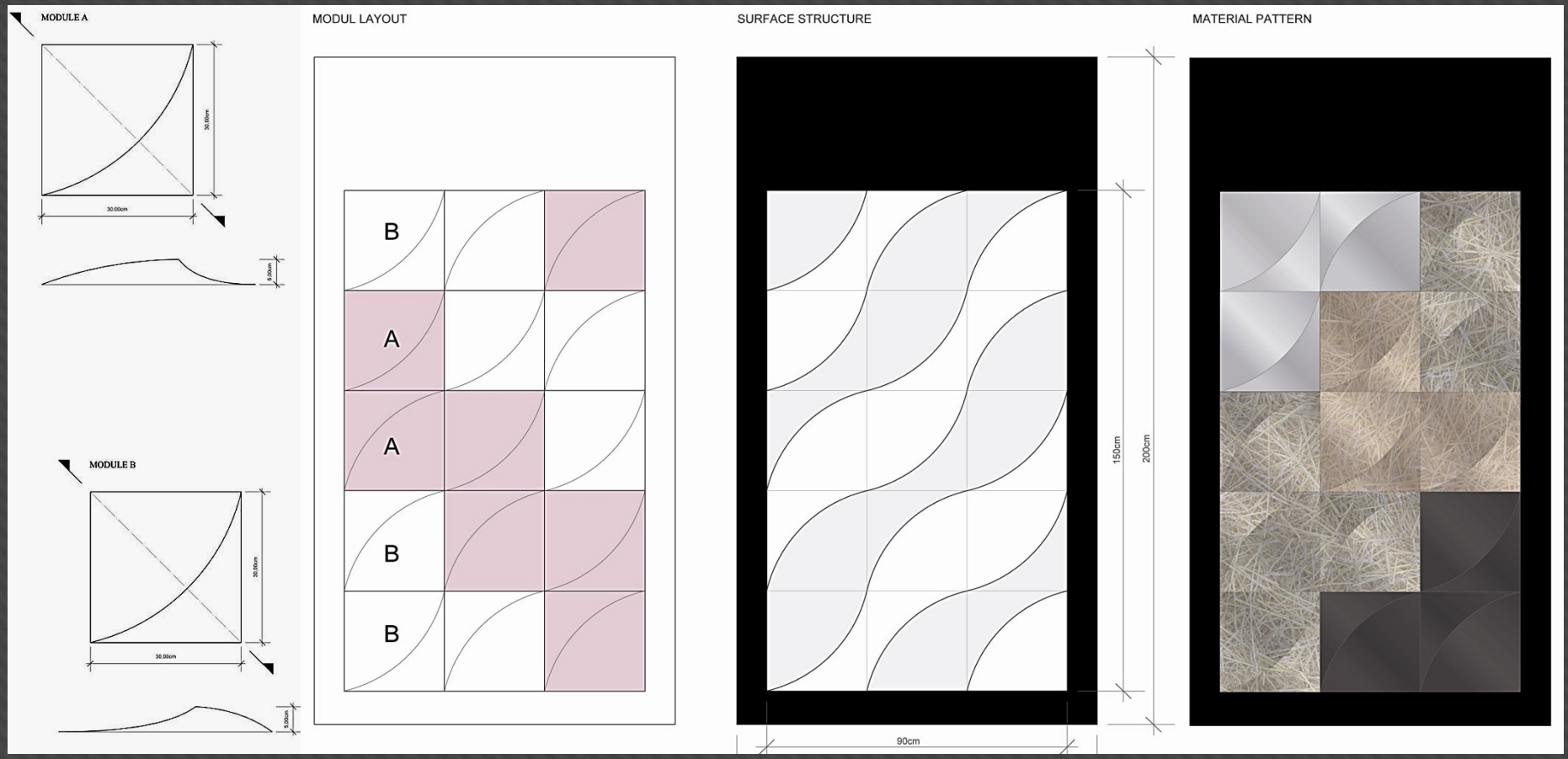
Chemical Processing: chemical reaction activities combining resin components within molding with the free-oriented short fibres

Sketch illustrating the intersection between materials selection, processing possibilities to meet the desired design fitting into the required application

Case Study- 1:TRAshell

Free-form Facade panel- Closed Press-Molding Process

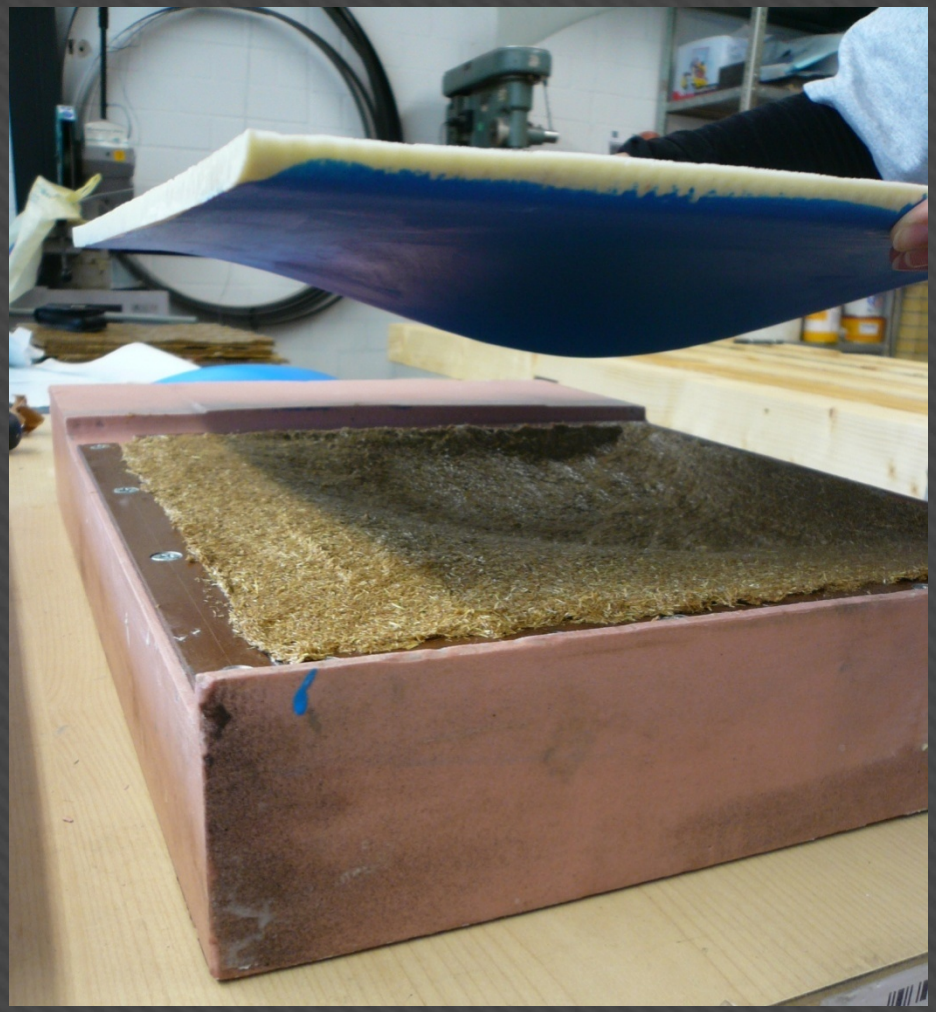
1- Product Design:



Susanne Hügel, Lousia Scherer, Kerstin Meyer

2- Mould Making (putting matrix and fibre types into consideration)

3- Choosing matrix, Recipy making and mixture application
4- Press Moulding after applying releasing agents



5- End Product

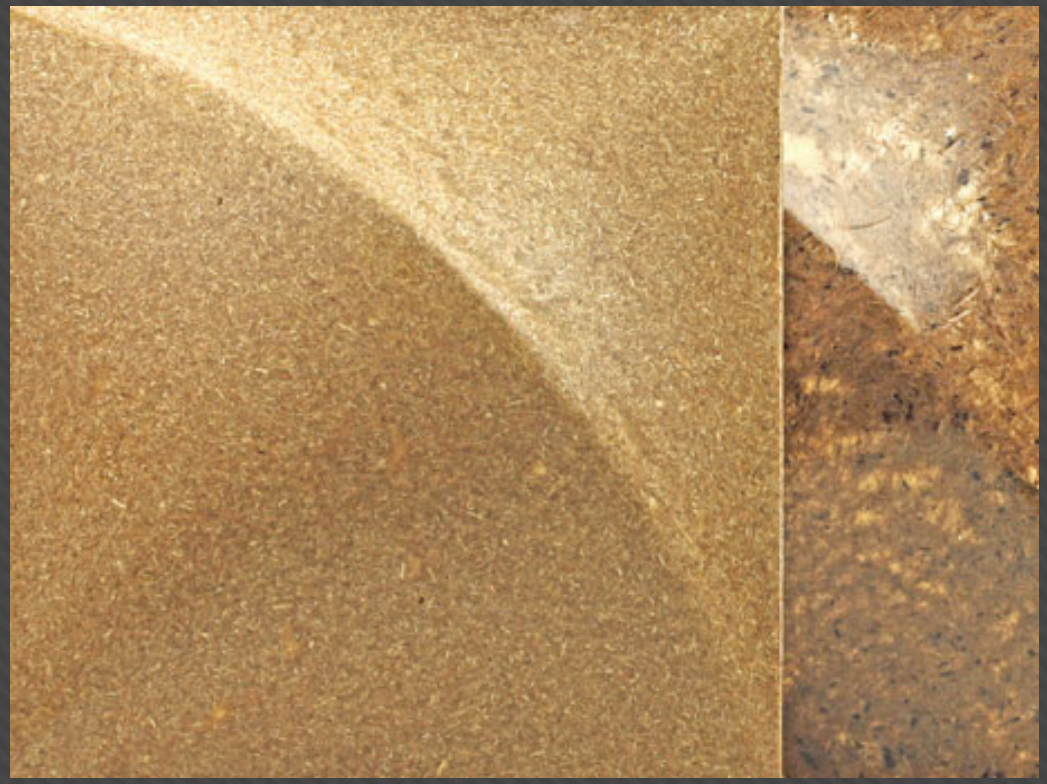


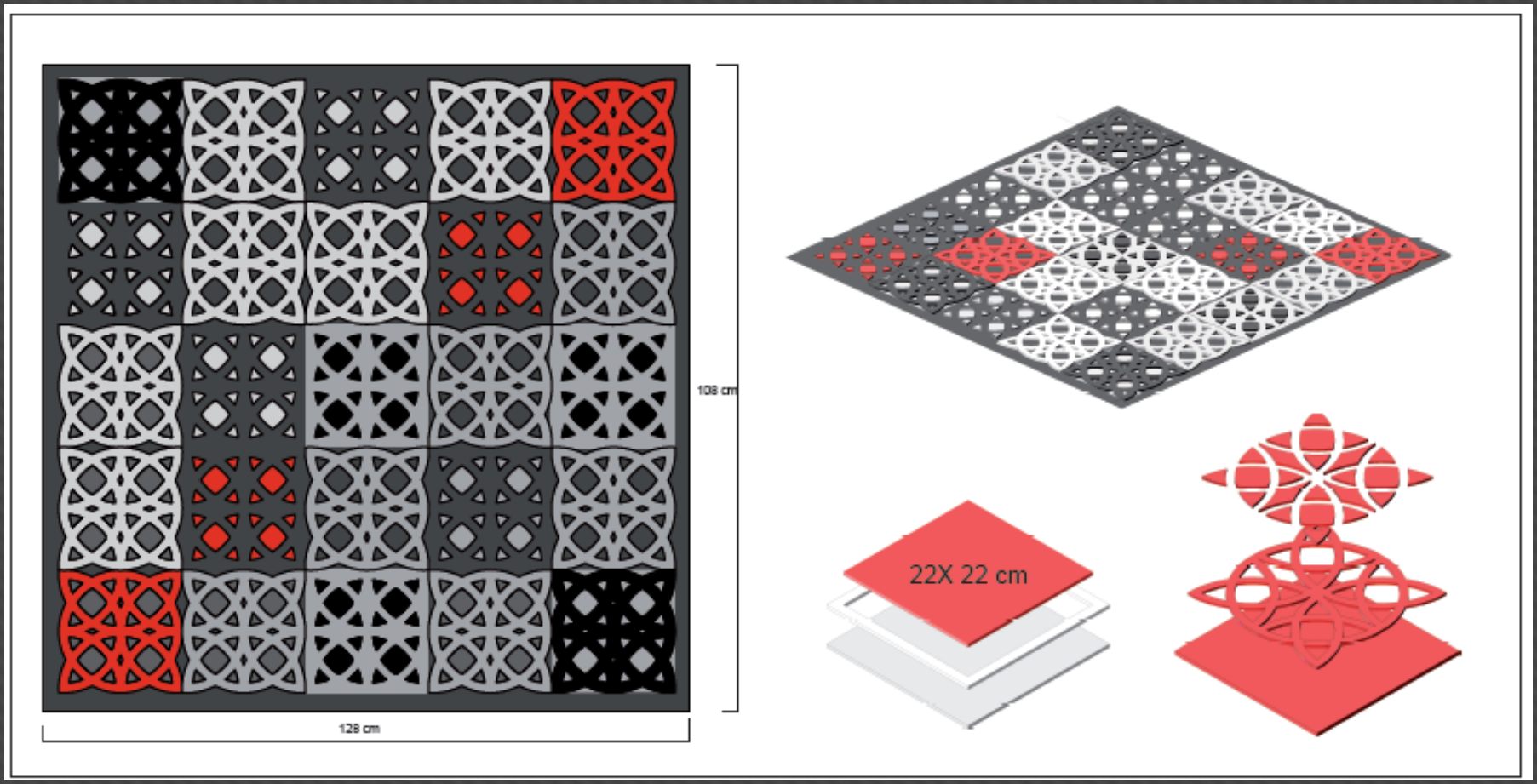
Photo: raumProbe

Photo: Boris Miklautsch

Case Study- 2: BIOrnament

Oriental panel- Open Molding Process

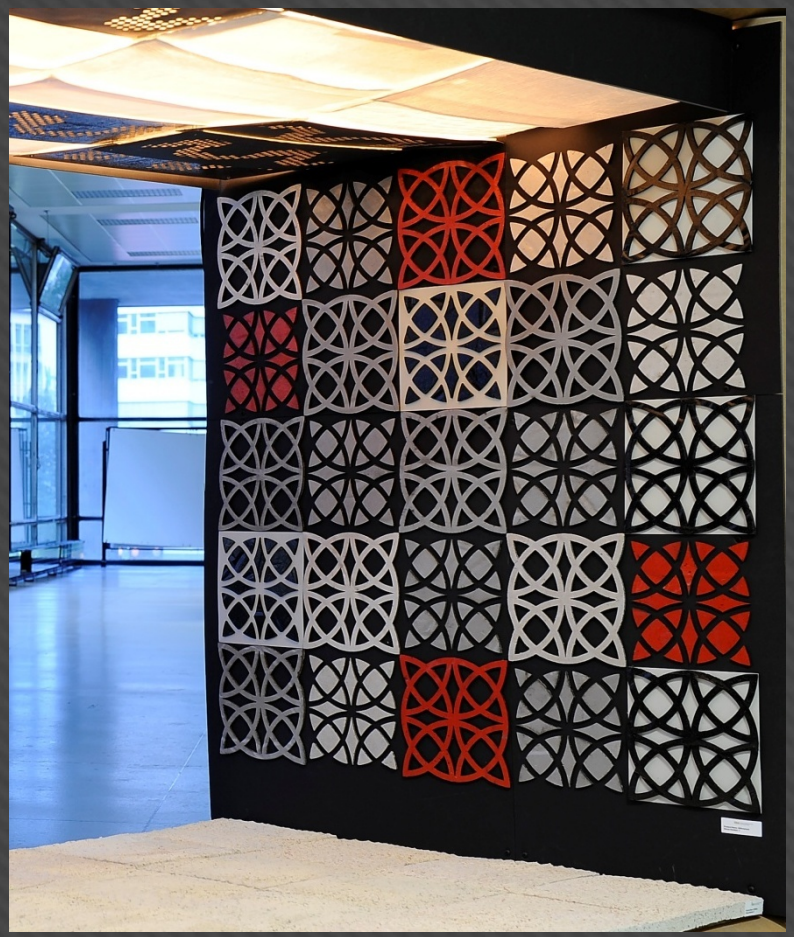
1- Product Design:



Students participated: Anke März, Gregory Tarkhounian, Nora Woborny

2- Mould Making , applying matrix with pigments and fibers according to recipes

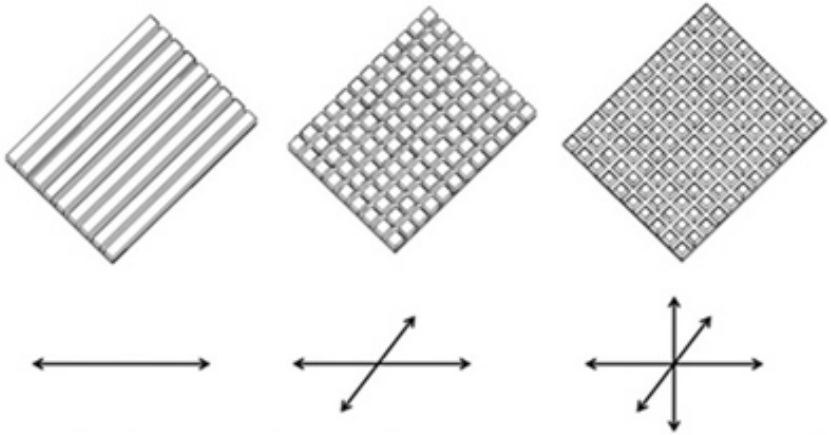
3- End Product

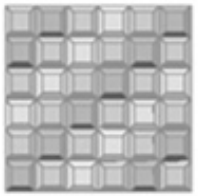


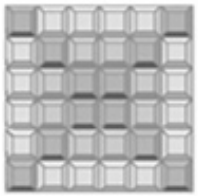
Case Study- 3: FLEXI Panel

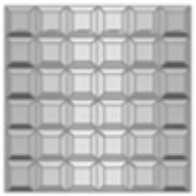
Biocomposite cubicals on a flexible panel- Molding Process

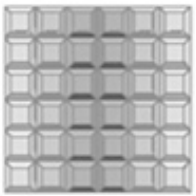
CONCEPT & FINAL PRODUCT

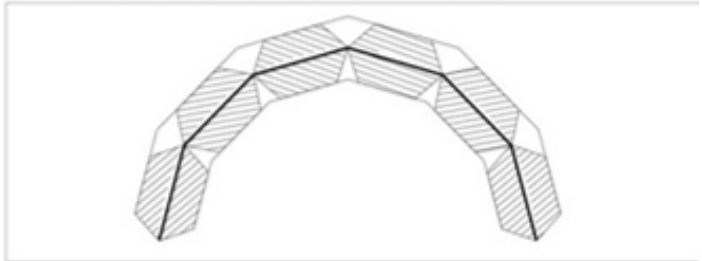


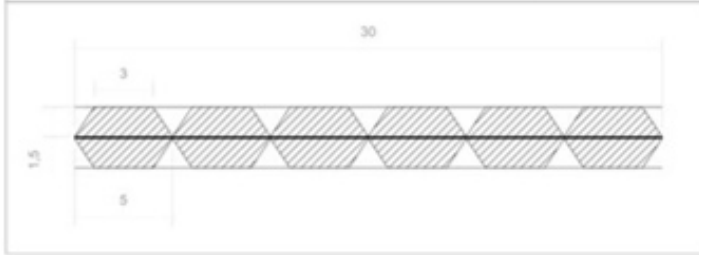






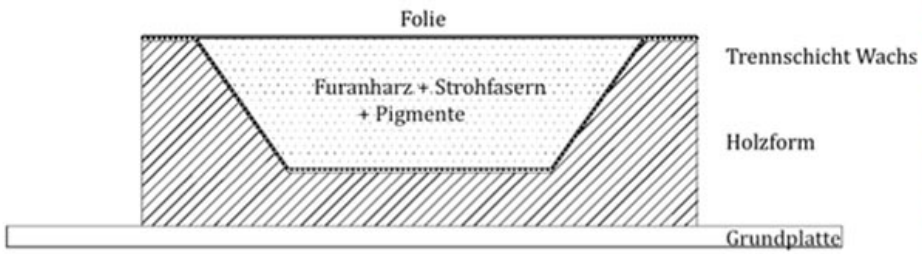






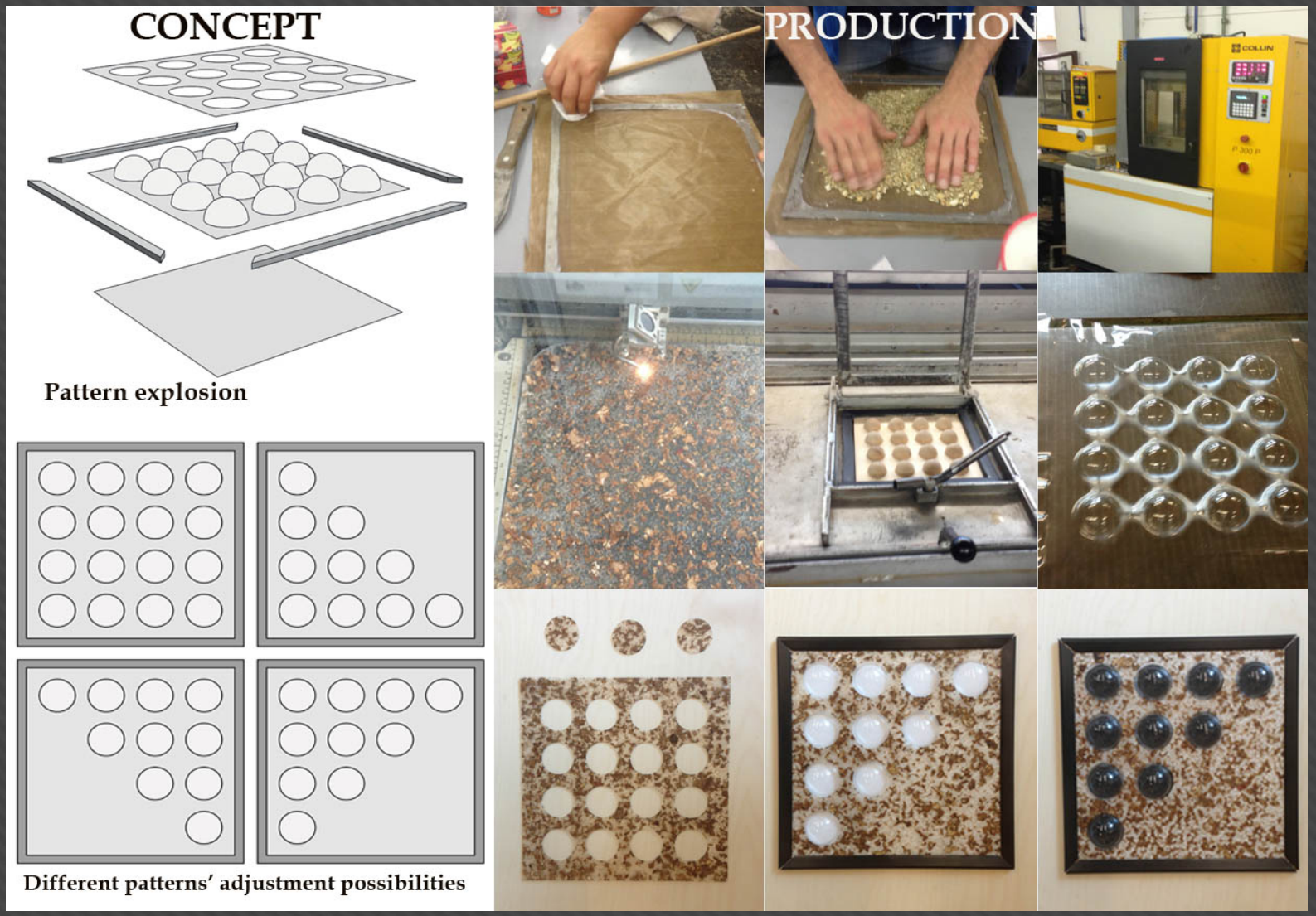
Students participated : Calleigh Freece, Pilar Gordillo, Anne Harmuth

CUBICALS' PRODUCTION



Case Study- 4: INOPLAST

Green thermoplastic Biocomposite of Peanut shells- PLA composite (pressed and lasered) and thermoformed CTA sheets



Students participated : Maximilian Fichter , Luca Menghini , Eugen Grass


APPLICATION

Case Study- 5: Light 24

Green thermoset Biocomposite of palm fibers and linseed epoxy resin with black light pigment

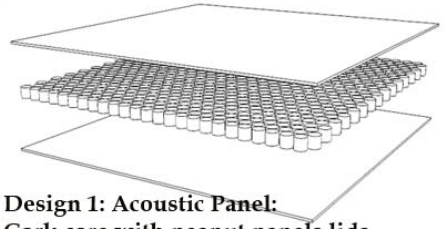
Students participated : Alice Grazzina ,Mirjam Müller , Reyhan Toraman


Final Product

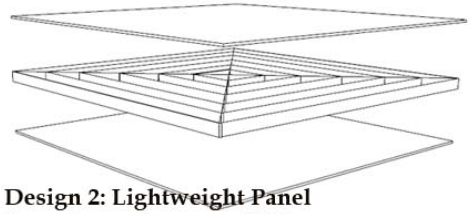
Case Study- 6: Peanut Panel

Sandwich Panel: Green thermoplastic Biocomposite of peanut shells and PLA. 2 designs and applications

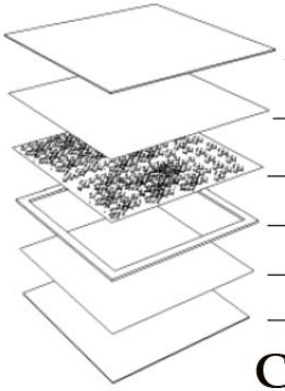
Students participated: Ines Wulfert, Gonzalo Canales, Veronika Schubach



Design 1: Acoustic Panel:
Cork core with peanut panels lids



Design 2: Lightweight Panel
Peanut panels core and lids



CONCEPT

Peanut panel production method

FINAL PRODUCT

Technical Properties of the produced Agro-fiber Biocomposites

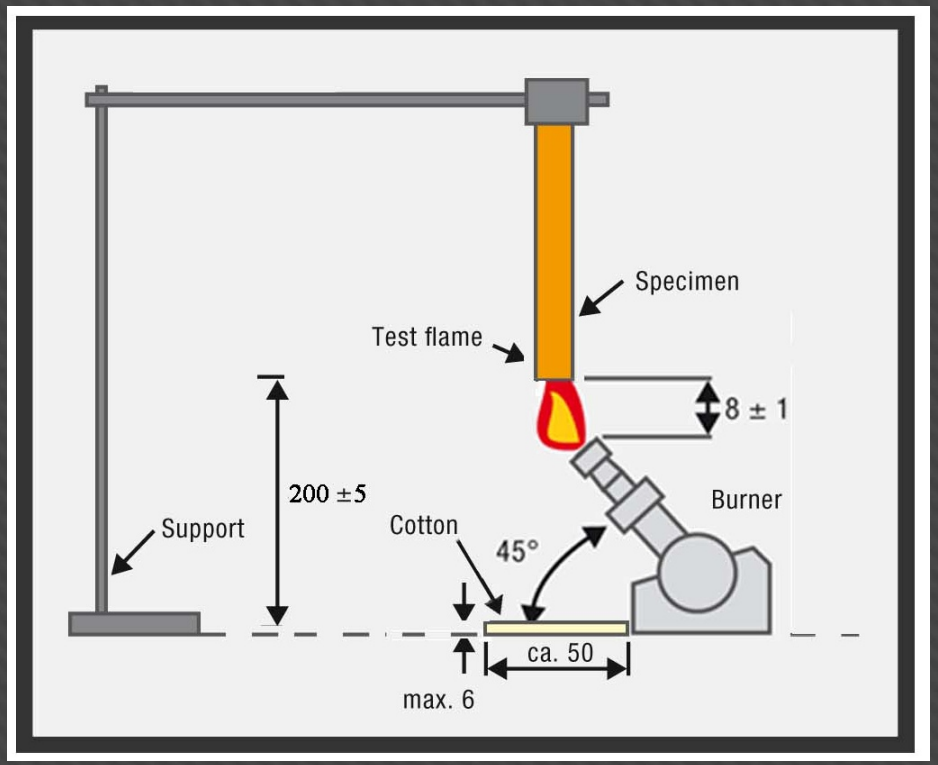
Chemical Composition

Straw/Plant	Cellulose	Hemi-cellulose	Lignin	Silica	Ash
Rice straw	28-36 [a]	18–25 [c]	12-16 [a]	9-14[a],[d]	15-20 [a]
Wheat straw	38-46 [a]	20–32 [c]	16-21[a]	3-7[a]/4-10 [d]	5-9 [a]
Soft wood	40-45 [a]	7-12 [e]	26-34 [a]	-[a]/<1[d]	<1 [a]
Hard wood	38-48 [a]	20-25 [e]	23-30 [a]	-[a]/<1[d]	<1 [a]

[a] Tappi, 1983. [b] Roxas et al (1984). [c] Galletti A. et al.2011 [d] Pekarovic et al 2008. [e] Chander et al 2007.

Chemical composition of rice and wheat straw in comparison to wood , in percent of dry matter

Burnt for 3 times, 20 seconds each



Illustrating diagram showing the burner's positioning in respect to the sample (edge position) and indicator according to the applied UL 1694 testing standard. Dimensions are in mm

UL 94- V1 ≡ B2

Normal combustibility, like wood

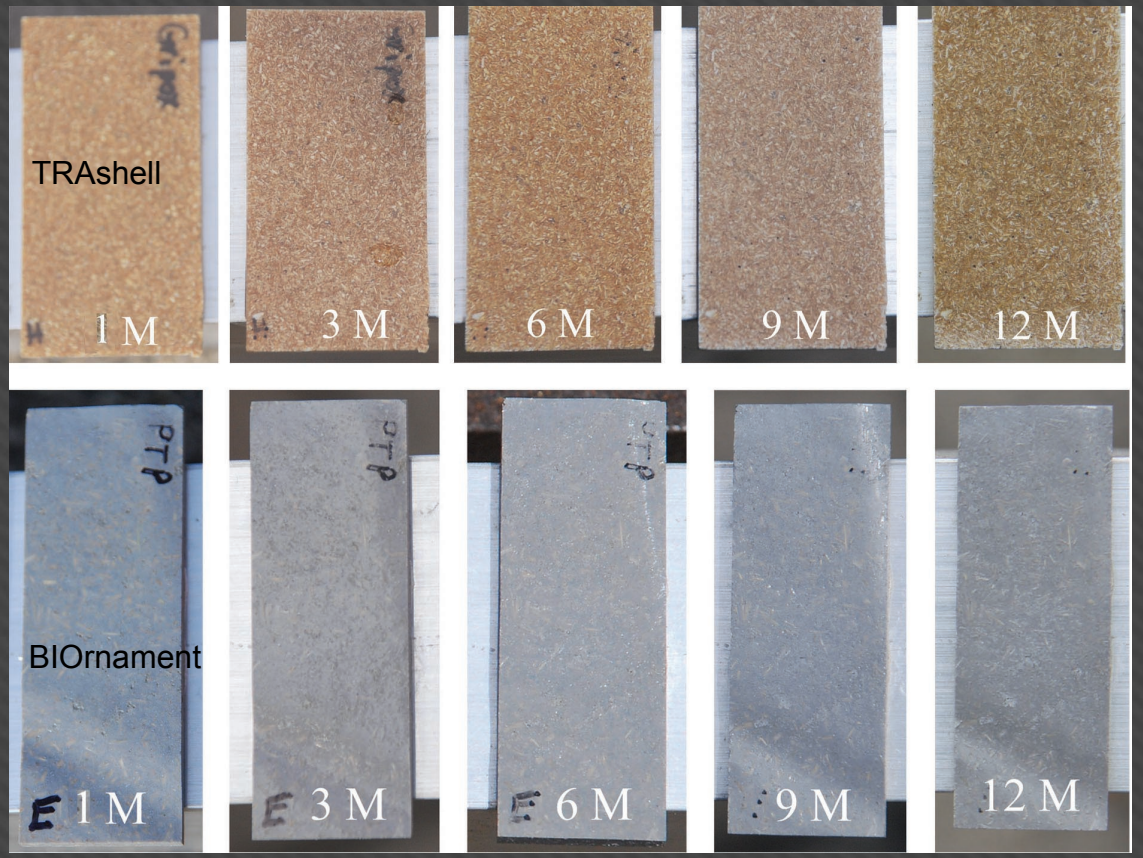
RSF instead of CF

UL 94- V0 ≡ B1

Difficult to ignite

Outcome of Weathering Test: (DIN EN ISO 877) for 12 months

This exposure test was applied to provide an indication of the relative outdoor performance of the samples and not as a pure performance indicator method in outdoors. The results were satisfactory and have shown high stability of the material against UV rays and weathering conditions.



Integration of Agro-fibers Biocomposites with other recycled products

ECO-PAVILION (c) Dahy, itke-2011

www.grossearchitektur.de

HOFFMANN
www.hoffmann-schwalbe.de

Grizzly Leim

FABRiNO

WACKER

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1818

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www.huelsen-mueller.de
Hartpapierrohre u. -ringe • Versandhülsen
Displayrohre • Kantenschutzwinkel u. -profile
Spulen • Behälter u. Trommeln
MÜLLER WÖRTH

RECKLI

GEHR

MOMENTIVE

Hochschule für Technik
Stuttgart

STAATLICHE AKADEMIE BILDENDEN KÜNSTE STUTTGART

IAC

Summary and Conclusions

1- Current applications of **straw-based biocomposites** and boards **are still in the early stages of development.**

2- Straw and other agro-fibers should be **given a second chance as main ingredients in biocomposites,** optimized by appropriate coupling agents instead of chemical modifications , that releases toxic wastes and increase the final product's price.

3- Inner natural components of agro-fibers, like the **high silica contents** should be more studied as a valuable natural non-toxic **flame-retardant** source. Raw rice straw with high silica content (till aound 15% wt.) has changed alone the material class of one of the developed biocomposites, which is of crucial importance in architectural applications.

3- **Colouring, textures and forms** are very important keys in the architectural design of the products. With the help of natural pigments, laser cutting, free-form panels' manufacturing **much more attractive products** could be reached replacing the conventional wood and plastic ones available contemporary in the market.

THANK YOU!

FOR YOUR ATTENTION

 Phone :+49- 711 685 832 74

 Email : h.dahy@itke.uni-stuttgart.de

 www.itke.uni-stuttgart.de