2018

Natural fibers insulation panels: an adaptive production
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Suggested citation:
NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION
CARTONLANA and FITNESs natural, low environmental stiff insulating Panels

CARTONLANA

100% Recycled Wool fibers

Piedmont Local Hemp
Cannabis Sativa
Cultivated Area: 30 ha
Harvesting: 2000 q
datai Regione Piemonte

FITNESs

50% Recycled Wool fibers

50% Local Hemp fibers

50% Recycled Wool fibers

Hemp shives: 75%
Technical fibres: 20%
Powder: 5%

Innovation Features
- Stiffness
- Low environmental impact

THE SHEEP WOOL ISSUE

Fast Approach
Sheep wool coming from foreign countries
High environmental impact
Transports
High environmental impact

Slow Approach
Wool from New Zealand
Wool from Piedmont
Local sheep breeding for milk and meat production

Burned or buried local sheep wool waste
With high environmental impact

100% Recycled Wool fibers

50% Recycled Wool fibers

50% Local Hemp fibers

Impianto di prima trasformazione

THE SHEEP WOOL ISSUE

Wool from New Zealand
Wool from Piedmont
Local sheep breeding for milk and meat production

Burned or buried local sheep wool waste
With high environmental impact

Traditional soft mats production process

Washing and Drying
Beating
Combing and needling
Traditional soft mat
NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION
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PRODUCTION PROCESS
Innovative fully natural method, allows to exploit keratin inside wool fibers to keep both wool and hemp fibers linked together in a high density stiff mixture.

LOW ENVIRONMENTAL IMPACT

Canapa: dati associati alla coltivazione di 1Ha di canapa sul territorio della regione Piemonte
Lana di pecora: raccolta, trasporto e processamento lana di pecora.
La lana di pecora utilizzata non è adatta alla produzione tessile ed è considerata come rifiuto speciale.

Risultati
Cartonlana e FITNESs, nonostante l’alta densità, mostrano una bassa domanda di energia non rinnovabile rispetto ad altri pannelli rigidi sul mercato.

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RSD7 - RELATING SYSTEMS THINKING AND DESIGN 7
SYMPOSIUM - TURIN - OCTOBER 24-26 . 2018
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THERMO-ACOUSTIC INSULATING PANELS PERFORMANCES

EXCELLENT SOUND ABSORPTION PERFORMANCES - Kundt’s Tube and Reverberation Chamber Methods Tests results

FITNESs with acoustically transparent fabric $\alpha_w = 0.75$ MH
FITNESs naked $\alpha_w = 0.65$ MH
CARTONLANA naked $\alpha_w = 0.55$ MH

FITNESs $\alpha_w = 0.75$ MH
FITNESs naked $\alpha_w = 0.65$ MH
CARTONLANA naked $\alpha_w = 0.55$ MH

FITNESs with acoustically transparent fabric $\alpha_w = 0.75$ MH
FITNESs naked $\alpha_w = 0.65$ MH
CARTONLANA naked $\alpha_w = 0.55$ MH

OPTIMAL THERMAL INSULATION PERFORMANCES - Thermo fluximetric experimental apparatus tests results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Density $\rho$ $[\text{kg/m}^3]$</th>
<th>Water content $[%]$</th>
<th>$\lambda_{eq\ 25^\circ C}$ $[\text{W/mK}]$</th>
<th>$\lambda_{eq\ 40^\circ C}$ $[\text{W/mK}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartoniana Sample 34d (standard)</td>
<td>142</td>
<td>8.6%</td>
<td>0.041</td>
<td>0.044</td>
</tr>
<tr>
<td>FITNESs Sample A (standard)</td>
<td>142</td>
<td>7%</td>
<td>0.041</td>
<td>0.044</td>
</tr>
<tr>
<td>FITNESs Sample B (standard)</td>
<td>142</td>
<td>8%</td>
<td>0.040</td>
<td>0.044</td>
</tr>
</tbody>
</table>

PANELS APPLICATION SCENARIOS in building envelopes

New dry construction systems (a) - as an insulating infill and further insulating external coat.
Building heritage envelope energy retrofit (b) - as a natural alternative to synthetic insulation coatings

Application Scenarios thermal performances

<table>
<thead>
<tr>
<th>Wall Samples</th>
<th>$s$ $[\text{cm}]$</th>
<th>$f_b$</th>
<th>$\Phi$</th>
<th>$Y_w$ $[\text{W/mK}]$</th>
<th>$U$ $[\text{W/mK}]$</th>
<th>$C$ $[\text{W/mK}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-frame structure</td>
<td>34</td>
<td>0.08</td>
<td>16.22</td>
<td>0.013</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>Hollow brick wall Retrofit</td>
<td>57</td>
<td>0.08</td>
<td>15.53</td>
<td>0.025</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>

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**NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION**

The “adaptive panel” concept

Objective:
- to create and test an “open recipe” for insulation panels production, able to keep as low as possible the environmental impact, thanks to the adaptive use of natural fibers available in a specific context and time.
- improve the degree of **adaptability** to the real availability of wasted natural fibers and other products from local agri-food systems

New panels, as those already tested by the research group, consist of two main components:
- a “matrix” based on sheep’s wool chemically treated according to a process patented by the research group capable of constituting the rigid keratin structure of the insulating panel;
- a “charge”, made up of waste materials and by-products of textile and agri-food chains; natural fibers that are not used on the market, but also artificial waste materials.
NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

Aggregated materials: Corn Plant Bracts

CORN PLANT
BOTANICAL CHARACTERISTICS

Family: Gramineae
Species: Zea Mays

Main spike: 10 - 20 cm length, 3-5 cm diameter (Assomais).

Female Inflorescence

Main traits:
- Cob 8.2%
- Bristles
- Husk/Bracts - 7%
- Grain - 45.9%

A single spike can host up to 1000 grain (Agraria.org)

Industrial Uses

Once: Animal litter, Mattress infill

Nowadays: Mainly used as boilers fuel, basically considered as a waste (Dip. Agraria, Università di Sassari)

BRACTS
CORN CULTIVES BY-PRODUCTS

10% of a whole mature corn plant mass

Regional Corn cultivated areas decrease 2016
- 15/25%
- 30/35%
- 40/45%

Corn cultivated areas Piedmont 2016

Elaborazione da DISAFA, Università degli Studi di Torino Giornata del Mais 2018

CORN PRODUCTION IN PIEDMONT REGION

Production surface: 192.922 ha
Harvesting: 1.8411 thousands of tonns
Production value: 409 millions € (dati ISTAT 2012).

Main uses:
- 85% Animal feed
- 10% Human feed
- 5% Industrial applications (Dip. Agraria, Università di Sassari)

CORN PRODUCTION

In Piedmont Region

Regional Corn cultivated area decrease 2016

- 15/25%
- 30/35%
- 40/45%

Elaborazione da DISAFA, Università degli Studi di Torino Giornata del Mais 2018
CHESTNUT CHARACTERISTICS
Family: Fagaceae
Species: Castanea sativa
Monoecious 25 - 30 m high plant, can live 500 - 800 years.

Volumetric mass: 580kg/m³, Hardness: 19 N/mm²
Compressive strength: 50 N/mm²
Bending strength: 110 N/mm²

CHESTNUT PIEDMONT INDUSTRIAL PRODUCTS
- Poles for vineyard or greenhouse
- Trusses and boards for buildings
- Carpentry: parquet, furniture, sound-absorbing barriers
- Chipped timber as boilers fuel
- Tannin from the Bark

CHESTNUT BARK AND CHIPS FOR PANELS PRODUCTION
- Smooth shaped, brown-reddish colored, tends to slit longitudinally
- Basically considered as a waste, excluding the low employment for tannin extraction

Composition:
- sugars, lipids, protein,
- mineral salts, vitamins B1-B2,
- tannin

Val Susa Chestnut Industrial production
A - Travatura e tavolati
B - Paleria da vigna
C - Paleria da serra
D - Legname da triturazione e da tannino

CHESNUT SPREAD IN ITALY AND PIEDMONT REGION
- Piedmont Chesnut Production surface: 204,000 ha
- Altitude limits: 1,000 msl (south Italy) - 600 msl (Piedmont)
- Harvesting: 220 m³/ha fruits
  (dati Masterplan Castagno Piemontese 2015).

Masterplan Castagno Piemonte
Messa a punto di modelli organizzativi di filiera
Valorizzazione di prodotti del castagno
Reti di sinergia con altri Enti/Istituti di ricerca

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION
Aggregated materials: Chestnut Bark

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**ALMOND**

**BOTANICAL CHARACTERISTICS**

**Family:** Rosaceae  
**Species:** Prunus - Prunoidee  

Deciduous, 5-7 m high plant, can live 500 - 800 years.

Grey colored, 12 cm length leaves  
White or pink flowers

Trunk brown colored; wrinkled cracked bark  
Roots: 3-4 larger than foliage's; 1m deep

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**ALMOND PROCESSING**

1 - **Harvesting:** (Aug - mid Sept) manually or mechanically  
2 - **First Drying:** air exposition on waterproof pitches  
3 - **Hulling:** the shell is released from the hull  
4 - **Shell Drying:** shells are kept exposed to the sun on pitches  
5 - **Shelling:**  
6 - **Storage**

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**INDUSTRIAL USES**

**Hull:** used for animal feeding  
**Lignous Shell:**  
Pharmaceutical and cosmetics industry  
Biomass and Combustible for chimneys  
Bakery wood  
**Seed:**  
Fresh fruit before lignification  
Food industry, once dry  
Oil for herbalist and cosmetics industry

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**ALMONDS GROWING AREA IN ITALY, PUGLIA AND SICILY REGIONS**

Almond production area:
- **Puglia:** 19,558 ha  
- **Sicily:** 31,215 ha  
- **Italy:** 57,598 ha

Harvesting:
- **Puglia:** 266,385 q  
- **Sicily:** 473,325 q  
- **Italy:** 795,987 q (74.595 in 2009)  
- **Italy:** 795,987 q (dati ISTAT 2017)

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**NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION**

Aggregated materials: Almond Shell

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NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

Aggregated materials: Dry beans plant

BEANS
BEANS: HARVESTED DRY OR FRESH
CLIMBING BEANS / DWARF BEANS

DRY BEANS
PROCESSING

1 - Harvesting: (from May to November) mainly mechanically
- removal of the sticks (manually);
- threshing: the bean is separated from the plant

2 - after drying process, the beans are stored;

3 - the dry plant lie in the field;

4 - different scenarios:

- it can be turned upside down in the field, in order to fertilize it (risk of risk of contamination due to the presence of pests or plant diseases)
- it can be collected in bales and used as animal litter floor (mainly cattle)
- it can be collected in bales and used in heating plants powered by biomass
- part of beans pod is separated from the plant and used in pharmaceutical industry

DRY BEANS CULTIVATION AREA
IN ITALY AND PIEDMONT REGION

Dry beans production area (dati ISTAT 2010):

Piemonte - 880,45 ha
Calabria - 592,24 ha
Italy - 3,283,52 ha

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In the “open recipe” the binding matrix (sheep wool) is mixed with different quantities and proportions of the “charge”, fixing the appropriate rules and variables to keep the thermal and acoustic performances suitable for the use in building sector as insulations.

With the aim of keeping the environmental impact related to the production of the panels low and with a view to circular economy, it has been suggested the use, as “charge”, of various materials available on the Piedmont region territory, chosen with the intent to explore the possibility of obtaining panels with different performances, depending on the characteristics of the charge;

a recipe therefore that allows to respond to different needs of the building market.
NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCT

The “adaptive panel” concept - test with bean dry plant

Thickness: 25.40mm
Area: 0.3716m²
Mass: 1.3000kg

Temperature Average: 40.02 °C
Results Average: 0.05322 W/mK
Resistance Avg : 0.6092 m²K/W

Temperature Average: 25.02 °C
Results Average: 0.0519 W/mK
Resistance Avg : 0.6247 m²K/W

Recycled Sheep wool
Washed and Combed

Dry Bean Plant
from dry bean cultivations

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