2018

Natural fibers insulation panels: an adaptive production

Savio, Lorenzo, Thiebat, Francesca, Bosia, Daniela and Pennacchio, Robe

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

CARTONLANA and FITNESs natural, low environmental stiff insulating Panels

RSD7 2018

CARTONLANA

100% Recycled Wool fibers

50% Recycled Wool fibers

50% Local Hemp fibers

FITNESs

Innovation Features

- **Stiffness**
- **Low environmental impact**

Piedmont Local Hemp

Cannabis Sativa

Cultivated Area: 30 ha

Harvesting: 2000 q

dati Regione Piemonte

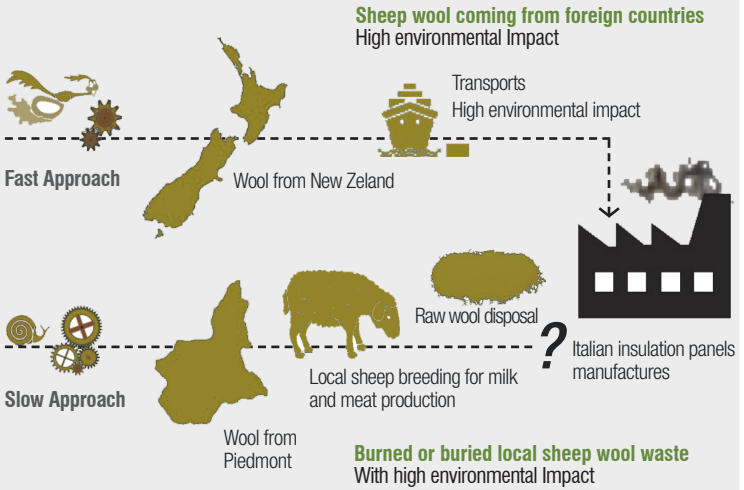
Impianto di prima trasformazione

Hemp shives: 75%

Technical fibres: 20%

Powder: 5%

THE SHEEP WOOL ISSUE



Traditional soft mats production process

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat

Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design

SYSTEMIC DESIGN RESEARCH NETWORK

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

CARTONLANA and FITNESs natural, low environmental stiff insulating Panels

RSD7 2018

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.

Recycled Sheep wool
Washed and Combed

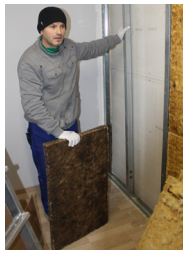
+

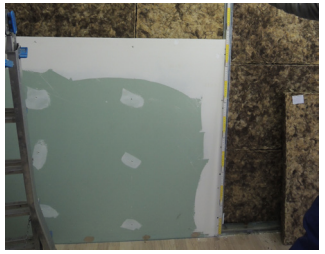
Local Hemp fibres
Macerated on field

Fibers Mixing

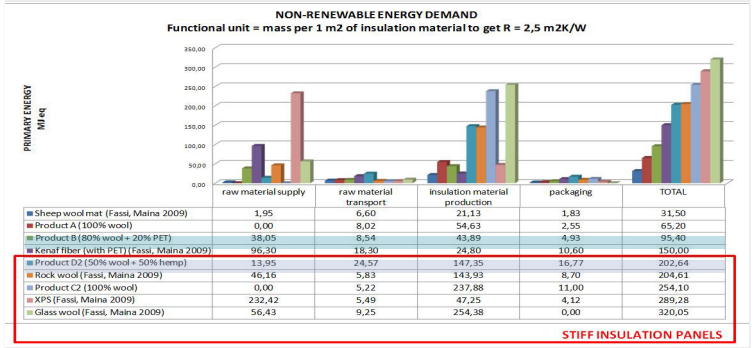
Chemical Treatment

PANELS WORKABILITY TESTS





LOW ENVIRONMENTAL IMPACT



	raw material supply	raw material transport	insulation material production	packaging	TOTAL
Sheep wool mat (Fassi, Maina 2009)	1,95	6,60	21,13	1,83	31,50
Product A (100% wool)	0,00	8,02	54,63	2,55	65,20
Product B (80% wool + 20% PET)	38,05	8,54	43,89	4,93	95,40
Kenaf fiber (with PET) (Fassi, Maina 2009)	96,30	18,30	24,80	10,60	150,00
Product D2 (50% wool + 50% hemp)	13,95	24,57	147,35	16,77	202,64
Rock wool (Fassi, Maina 2009)	46,16	5,83	143,93	8,70	204,61
Product C2 (100% wool)	0,00	5,22	237,88	11,00	254,10
XPS (Fassi, Maina 2009)	232,42	5,49	47,25	4,12	289,28
Glass wool (Fassi, Maina 2009)	56,43	9,25	254,38	0,00	320,05

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.

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design
SYSTEMIC DESIGN RESEARCH NETWORK

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION
CARTONLANA and FITNESs natural, low environmental stiff insulating Panels

RSD7 2018

THERMO-ACOUSTIC INSULATING PANELS PERFORMANCES

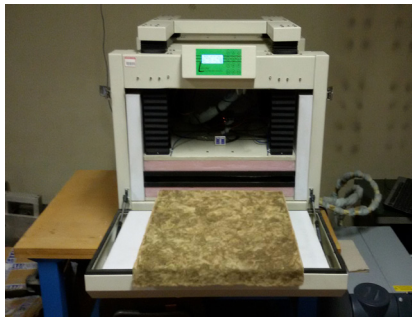
EXCELLENT SOUND ABSORPTION PERFORMANCES - Kundt's Tube and Reverberation Chamber Methods Tests results

FITNESs with acoustically transparent fabric α_w= 0.75 MH
FITNESs naked α_w= 0.65 MH
CARTONLANA naked α_w= 0.55 MH

OPTIMAL THERMAL INSULATION PERFORMANCES - Thermo fluximetric experimental apparatus tests results

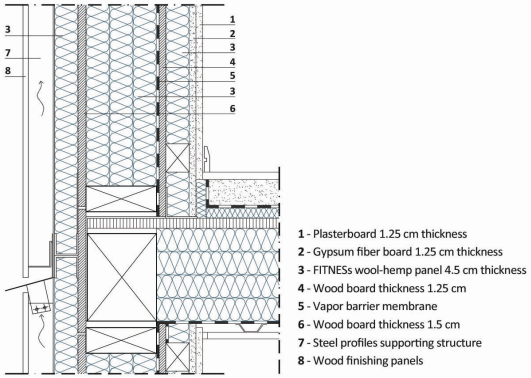
Sample	Density ρ	Water content	$\lambda_{eq\ 25°C}$	$\lambda_{eq\ 40°C}$
	[kg/m^3]	[%]	[W/mK]	[W/mK]
Cartonlana Sample 34d (standard)	142	8,6%	0.041	0.044
FITNESs Sample A (standard)	142	7%	0.041	0.044
FITNESs Sample B (standard)	142	8%	0.040	0.044

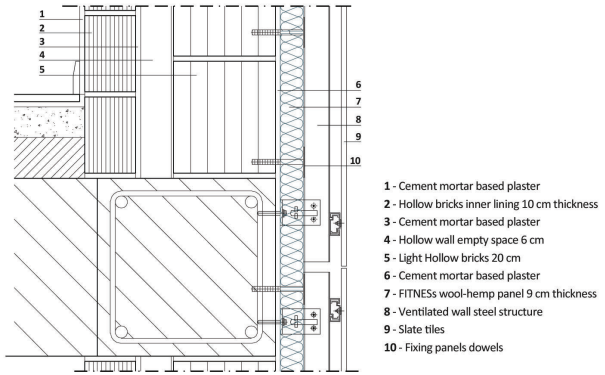




PANELS APPLICATION SCENARIOS in building envelopes

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

Wall Samples	s	f_a	Φ	Y_{ie}	U	C
	[cm]	-	[h]	[W/m^{2}K]	[W/m^{2}K]	[W/m^{2}K]
Wood-frame structure	34	0.08	16.22	0.013	0.16	0.17
Hollow brick wall Retrofit	57	0.08	15.53	0.025	0.30	0.30

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design
SYSTEMIC DESIGN RESEARCH NETWORK

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.

Aggregated materials

RSD7 2018

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

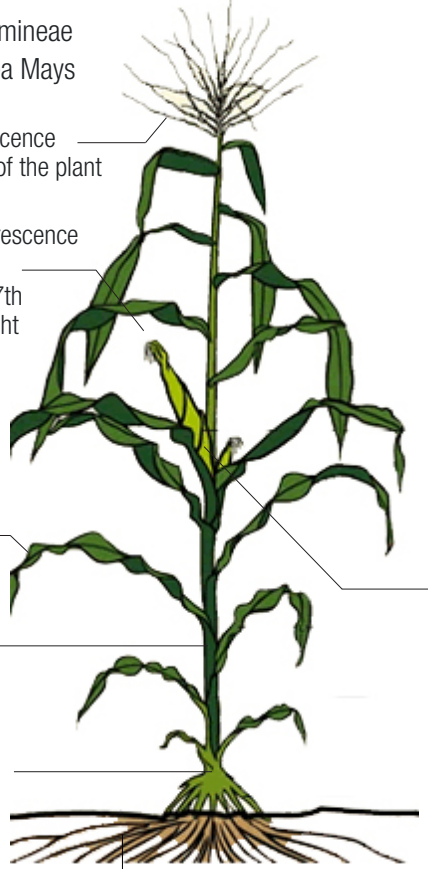
Aggregated materials: Corn Plant Bracts

RS D7 2018

CORN PLANT
BOTANICAL CHARACTERISTICS

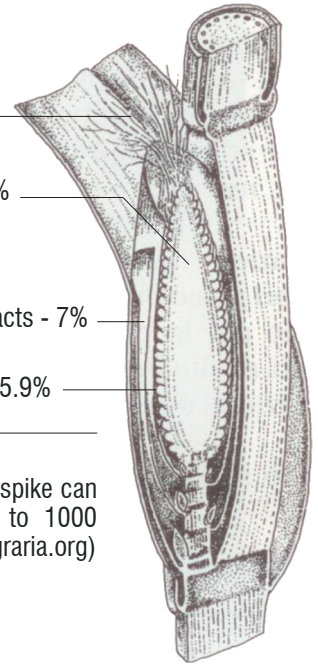
Family: Gramineae

Species: Zea Mays



Female Inflorescence

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



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

BRACTS
CORN CULTIVES BY- PRODUCTS

10% of a whole mature corn plant mass

Industrial Uses

Once:

Animal litter, Mattress infill

Nowadays:

Mainly used as boilers fuel,

Basically considered as a waste

(Dip. Agraria, Università di Sassari)

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

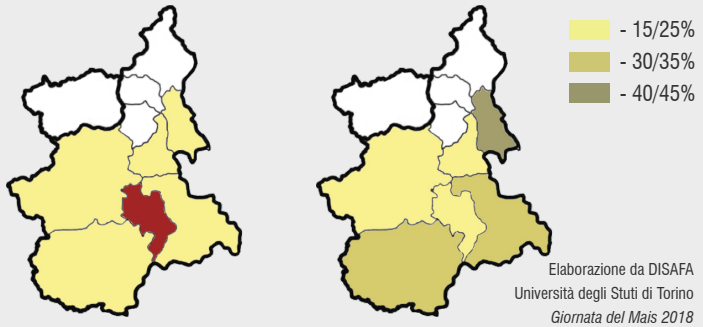
10% Human feed

5% Industrial applications

(Dip. Agraria, Università di Sassari)

Corn cultivated areas Piedmont 2016

Regional Corn cultivated area decrease 2016



Elaborazione da DISAFA
Università degli Stuti di Torino
Giornata del Mais 2018

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat

Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design

SYSTEMIC DESIGN RESEARCH NETWORK

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

Aggregated materials: Chestnut Bark

RSD7 2018

CHESTNUT CHARACTERISTICS

Family: Fagaceae
Species: Castanea sativa

Monoecious 25 - 30 m high plant, can live 500 - 800 years.

Volumetric mass: 580kg/m^3, Hardness: 19 N/mm^2
Compressive strenght: 50 N/mm^2
Bending strenght: 110 N/mm^2

CHESTNUT PIEDMONT INDUSTRIAL PRODUCTS

until 15% (Nosenzo 2006)

Poles for vineyard or greenhouse

Trusses and boards for buildings

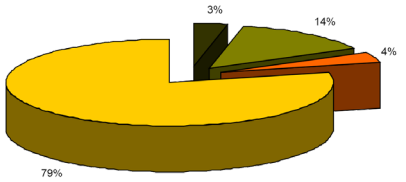
Carpentry:
parquet
furniture
sound-absorbing barriers

~ 85%

Chipped timber as boilers fuel

Tannin from the **Bark**

Val Susa Chestnut Industrial production



- A - Travatura e tavolati
- B - Paleria da vigna
- C - Paleria da serra
- D - Legname da triturazione e da tannino

CHESTNUT BARK AND CHIPS FOR PANELS PRODUCTION

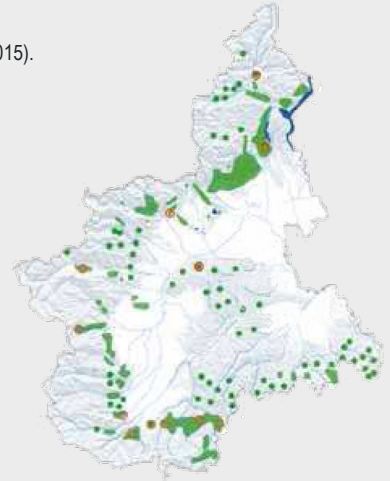
Chestnut Bark Characteristics

- 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

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 m^3/ha fruits
(dati Masterplan Castagno Piemontese 2015).



chesnut covers 22,1% of entire regional forestal area

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

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design
SYSTEMIC DESIGN RESEARCH NETWORK

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

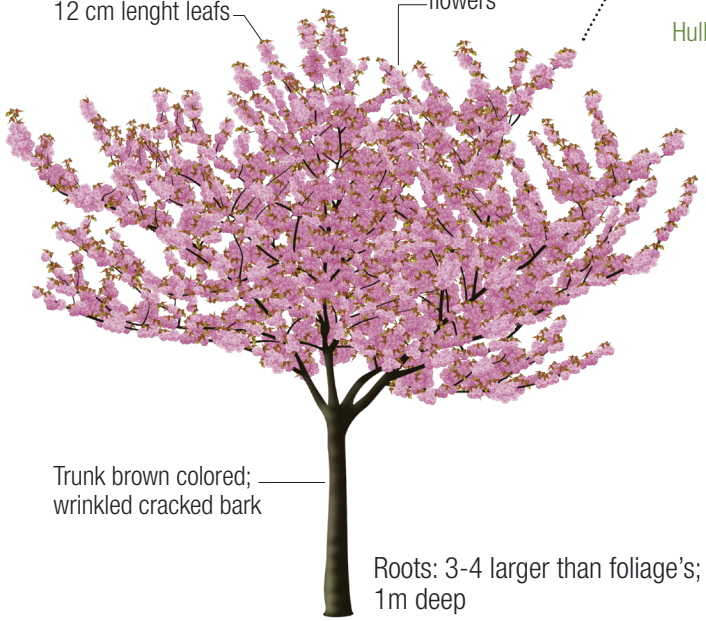
Aggregated materials: Almond Shell

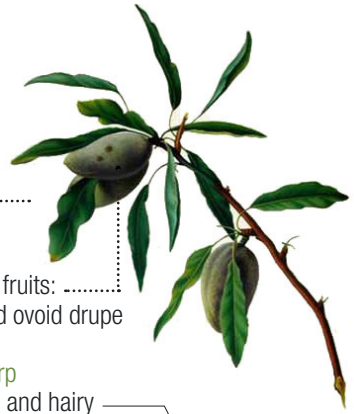
RSD7 2018

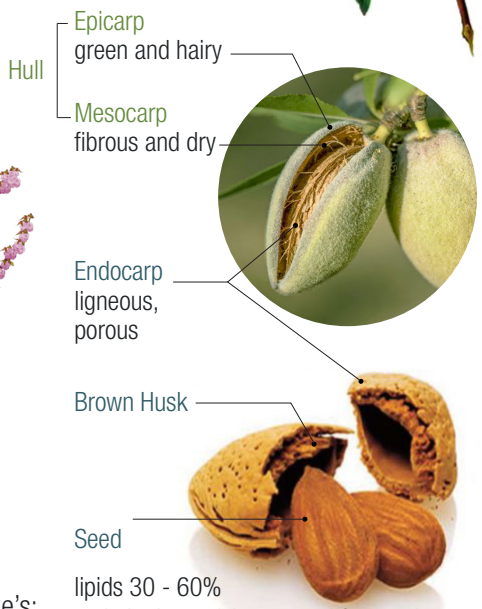
ALMOND
BOTANICAL CHARACTERISTICS

Family: Rosaceaee
Species: Prunus - Prunoidee

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







lipids 30 - 60%
carbohydrates (glucose and fructose) 40%
proteins, Minerals, Vitamins 18%

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 - Storge

INDUSTRIAL USES

Hull: used for animal feeding

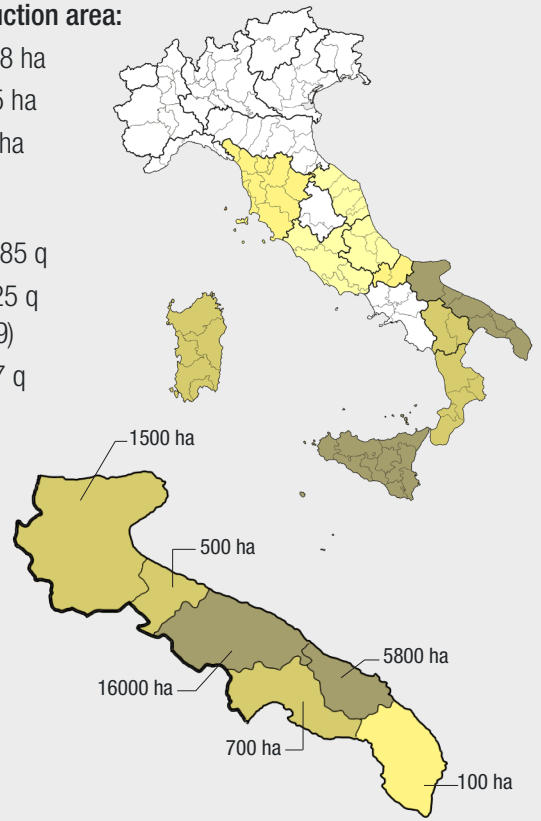
Ligneous Shell
Pharmaceutic and cosmetics industry
Biomass and Combustible for chemneys
Bakery wood

Seed
Fresh fruit before lignification
Food industry, once dry
Oil for herbalist and cosmetics industry

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
(74.595 in 2009)
Italy - 795.987 q
(dati ISTAT 2017)



Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

POLITECNICO DI TORINO Department of Architecture and Design
SYSTEMIC DESIGN RESEARCH NETWORK

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

Aggregated materials: Dry beans plant

RSD7 2018

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 - differet 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 plat and used in pharmaceutical industry

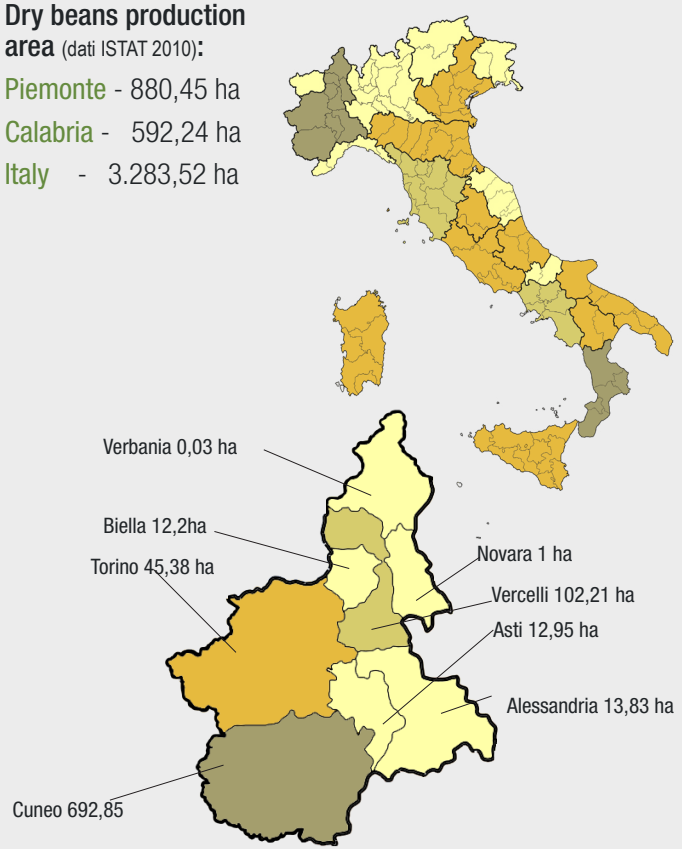
DRY BEANS CULTIVATION AREA
IN ITALY AND PIEDMONT REGION

Dry beans production area (dati ISTAT 2010)**:**

Piemonte - 880,45 ha

Calabria - 592,24 ha

Italy - 3.283,52 ha



Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat

Dipartimento di Architettura e Design - Politecnico di Torino

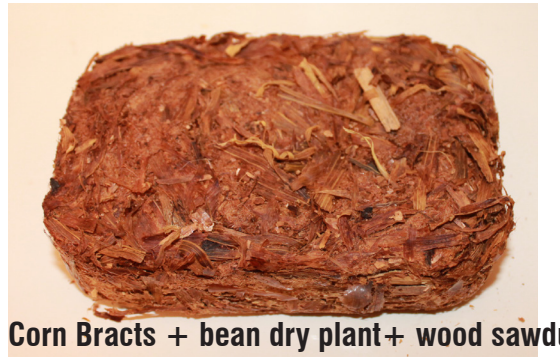
NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTION

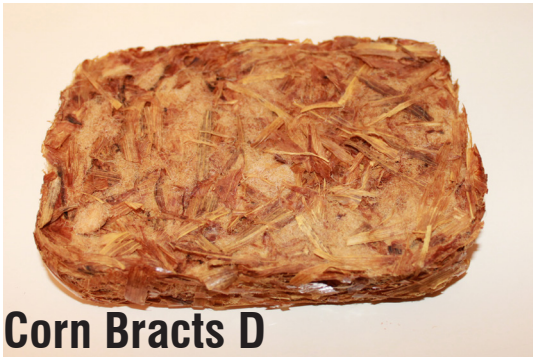
The “adaptive panel” concept

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.





Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino

NATURAL FIBERS INSULATION PANELS: AN ADAPTIVE PRODUCTI

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

Recycled Sheep wool
Washed and Combed

Dry Bean Plant
from dry bean cultivations

RS D7 2018

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

Lorenzo Savio, Daniela Bosia, Valentino Manni, Alessia Patrucco, Roberto Pennacchio, Francesca Thiebat
Dipartimento di Architettura e Design - Politecnico di Torino