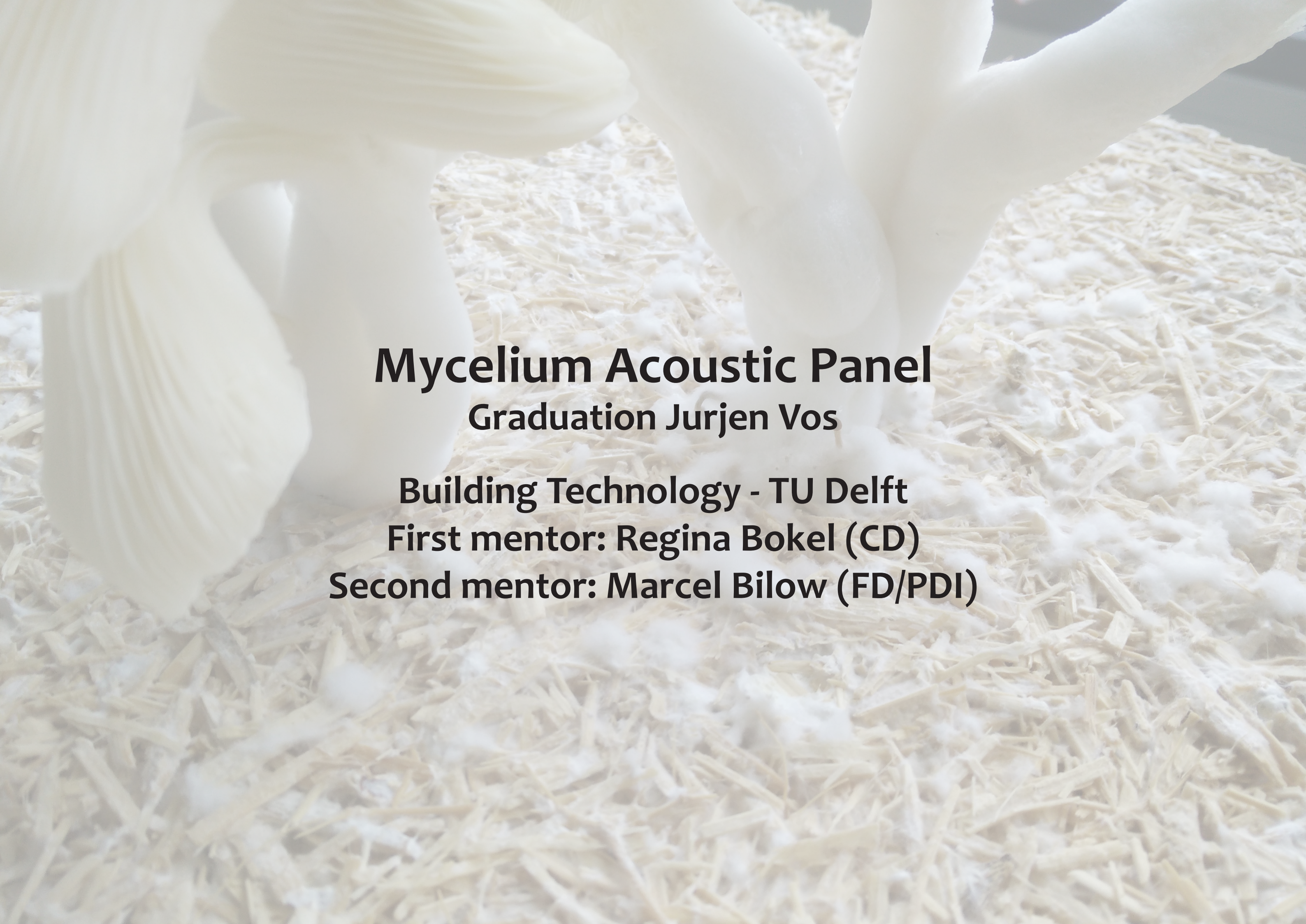


The background image shows a close-up of a mycelium acoustic panel. The panel is a light cream color with a series of vertical, ribbed ridges. It is resting on a substrate of light-colored straw or wood shavings. Patches of white, fuzzy mycelium are visible growing on the substrate and the base of the panel. The lighting is soft and even.

Mycelium Acoustic Panel

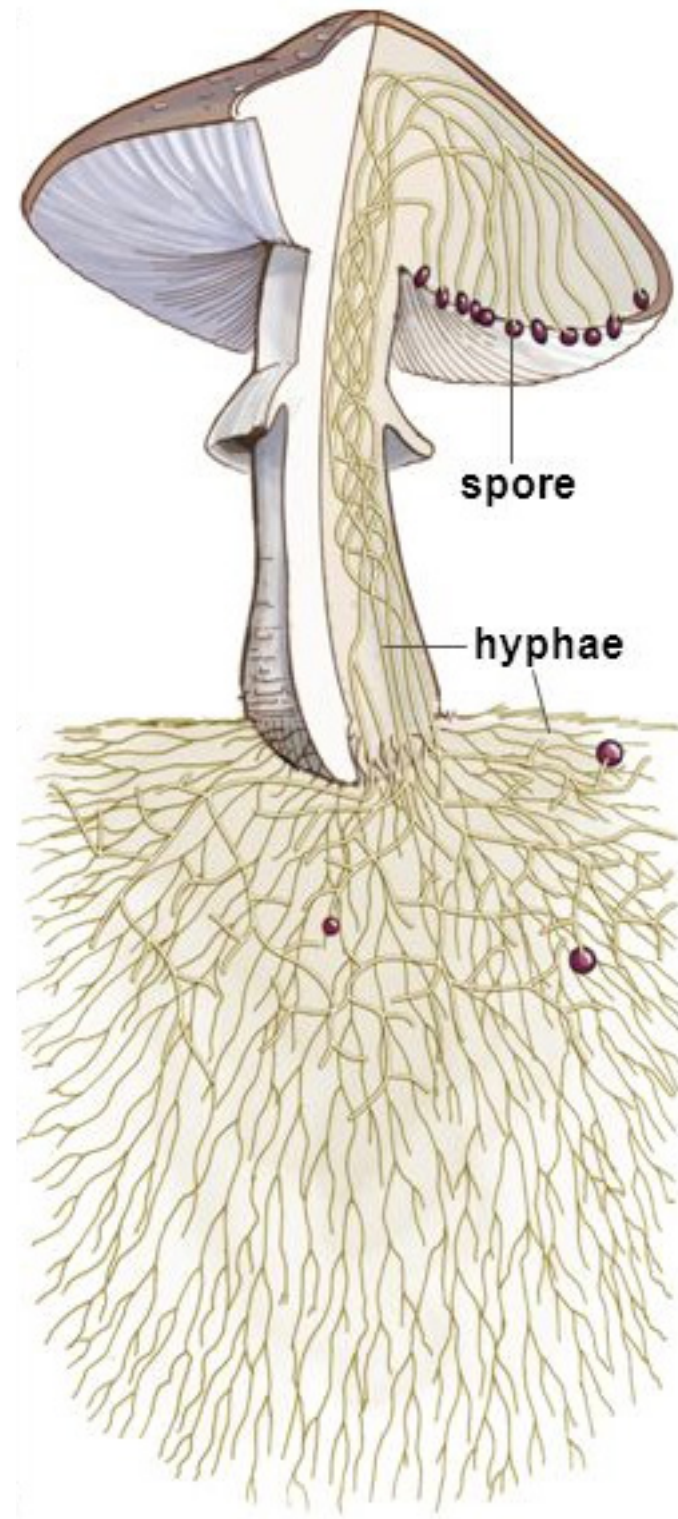
Graduation Jurjen Vos

Building Technology - TU Delft

First mentor: Regina Bokel (CD)

Second mentor: Marcel Bilow (FD/PDI)

Mycelium



Fungi



Mycelium



Novel material



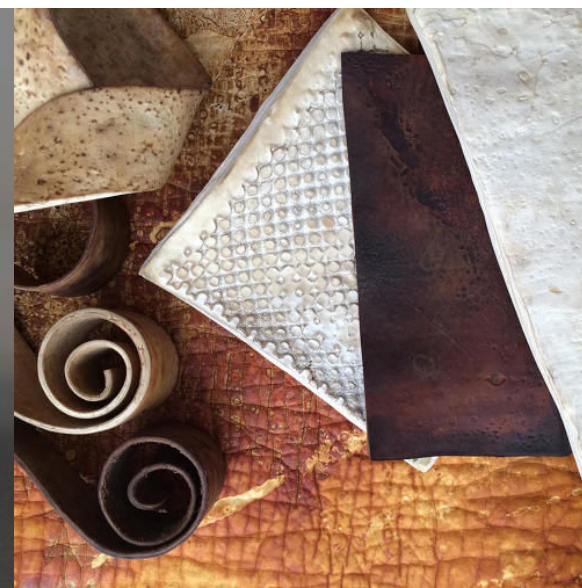
Mycelium

Problem statement

Novel building material with unknown performance and application

Relevance

Mycelium companies interested in building construction



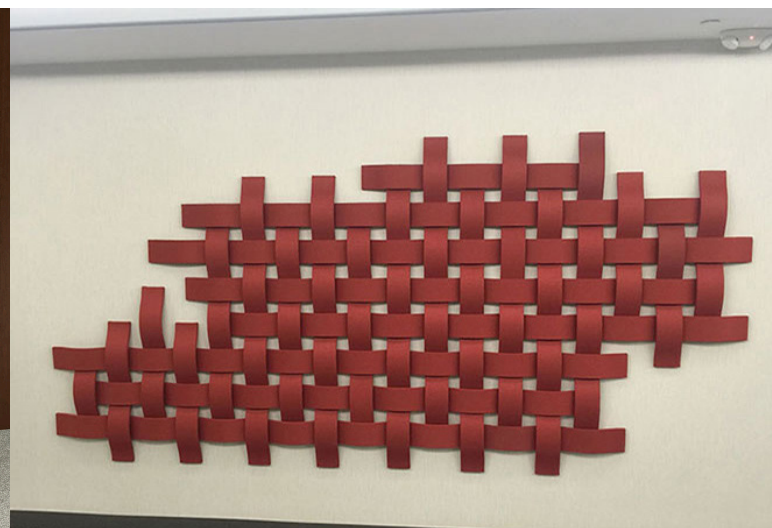
Mycelium

Problem statement

Novel building material with unknown performance and application

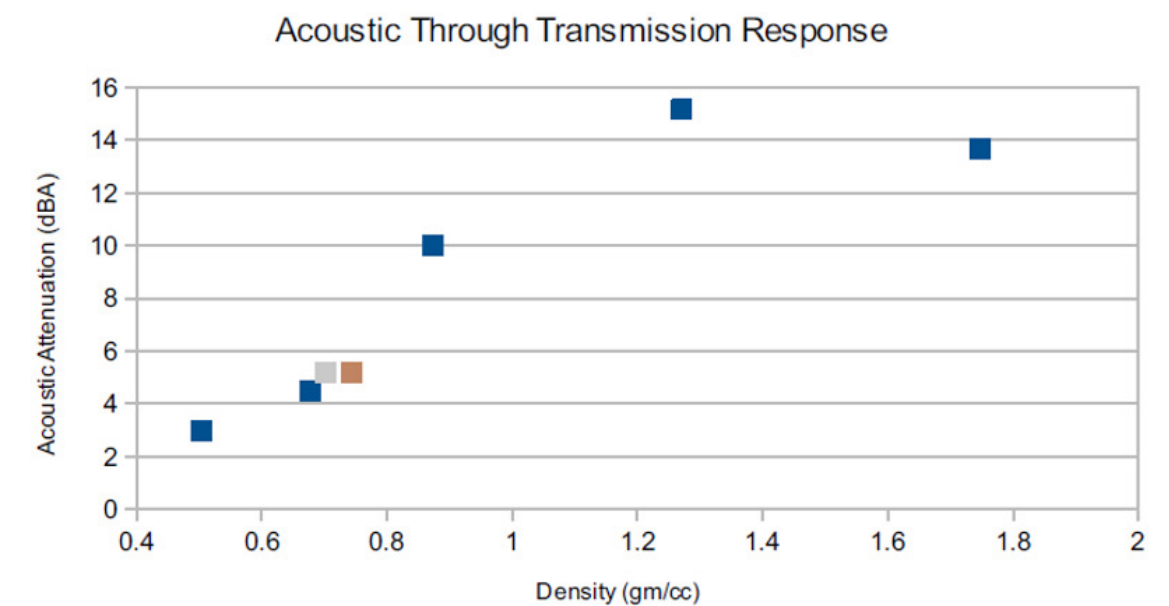
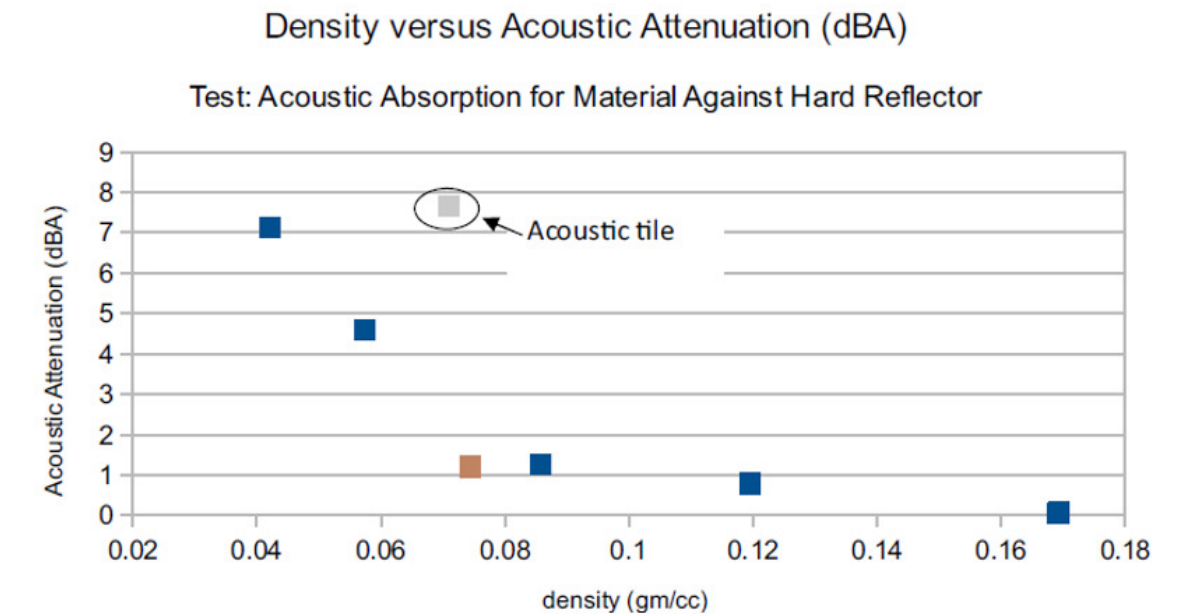
Relevance

Mycelium companies interested in building construction



Literature research material properties

- Mechanical +
- Fire resistance +++
- Acoustic insulation +++
- Thermal insulation +++
- Water resistance ++



Research question

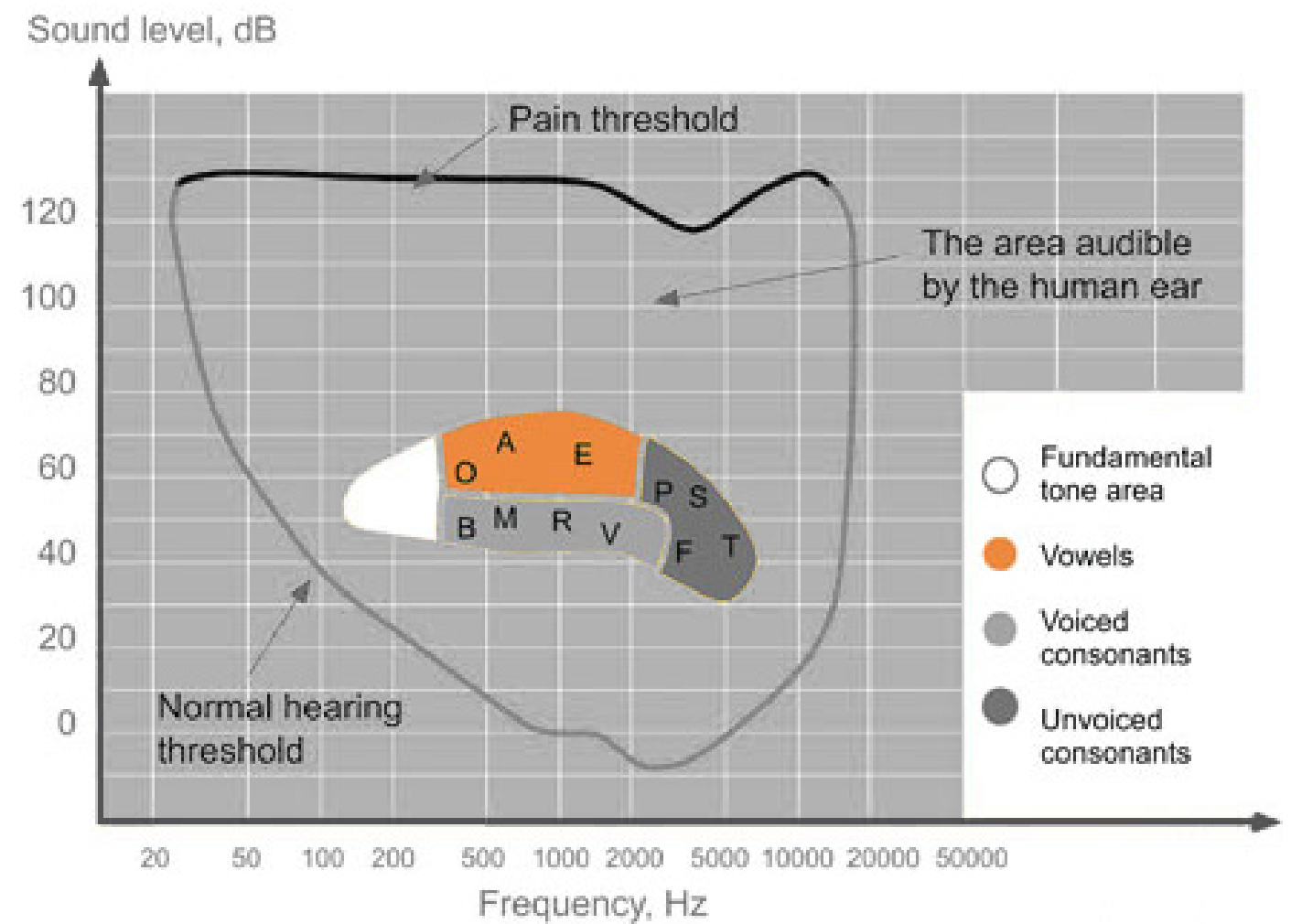
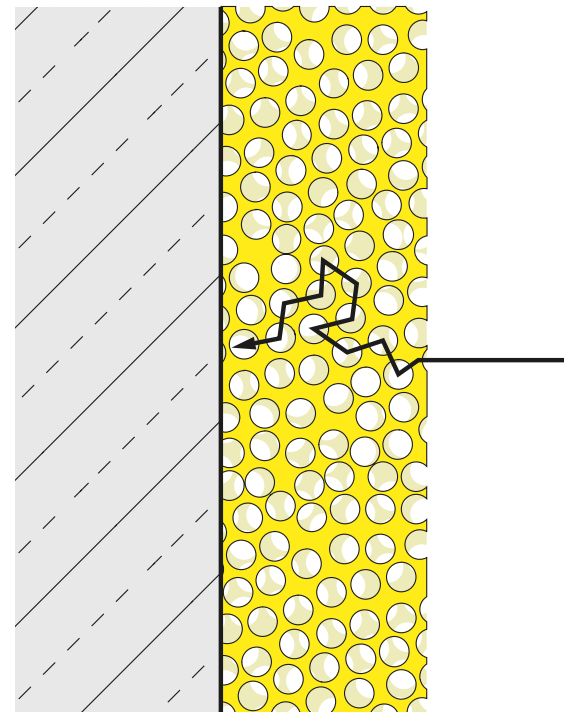
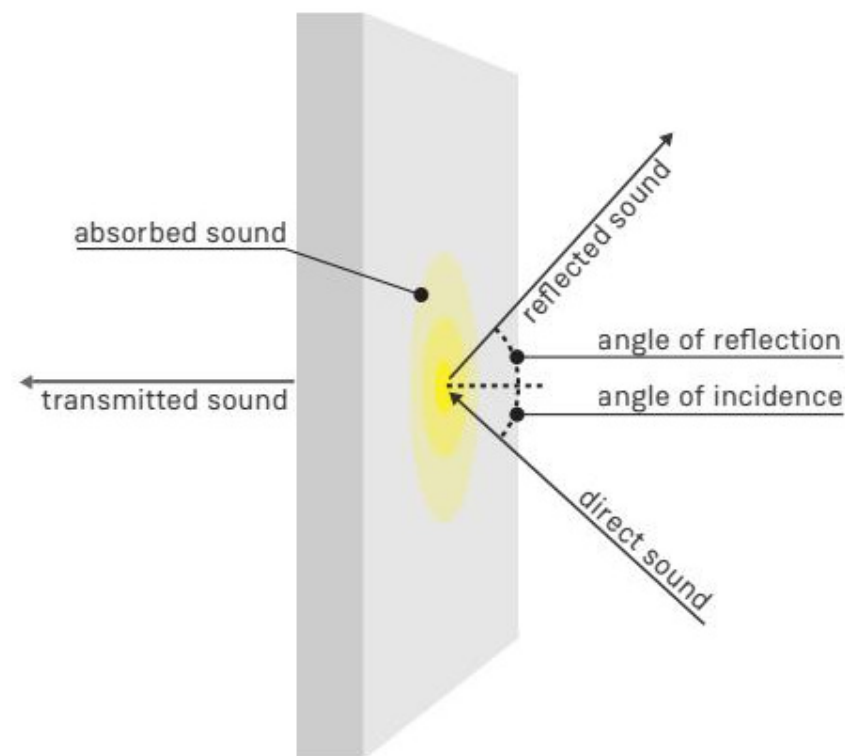
*“What are the **specific qualities** of this material and how can it be used in an **acoustic building product**?”*



Acoustics

Absorption

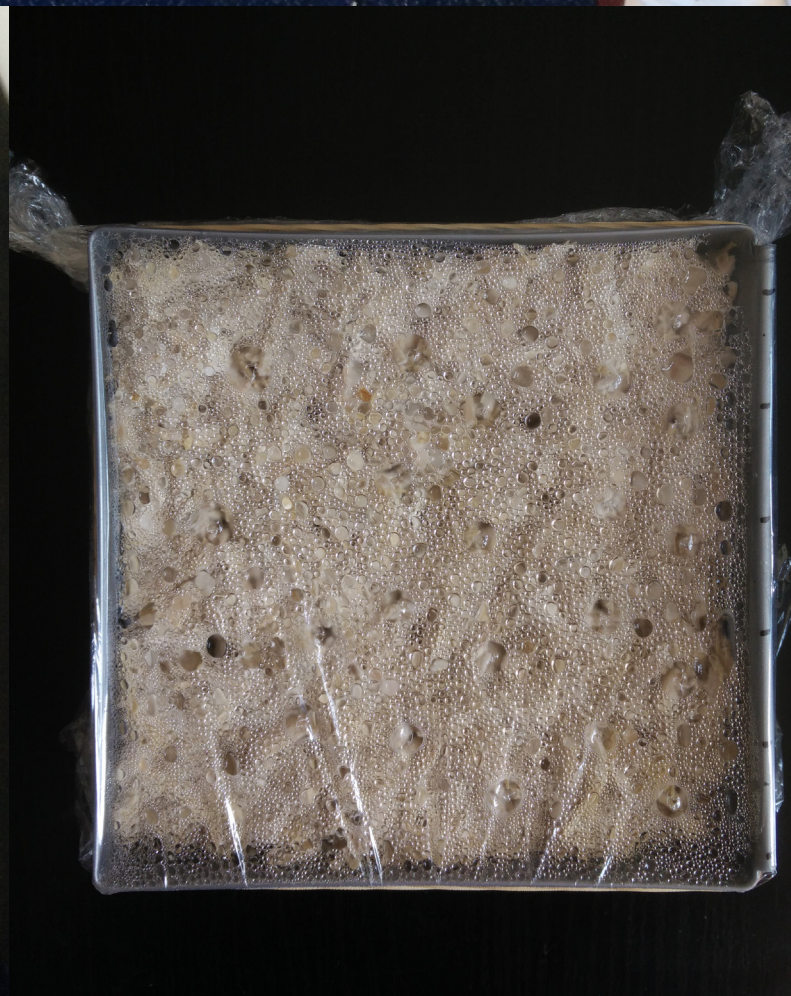
- Compared to transmission, reflection
- Porous absorber
- Speech: 100 to 5000 Hz



Growing the samples



Grow-It-Yourself kit



Growing the samples



Pasteurisation



Growing the samples



After initial growth phase



Growing the samples



After growth in shapes



Growing the samples



Drying



Impedance tube tests

Impedance tube

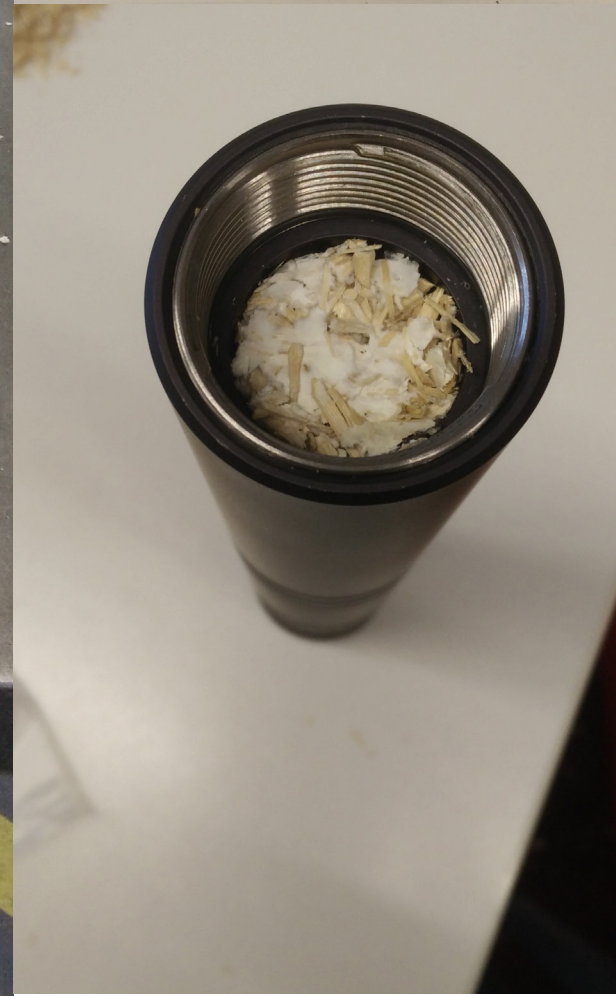
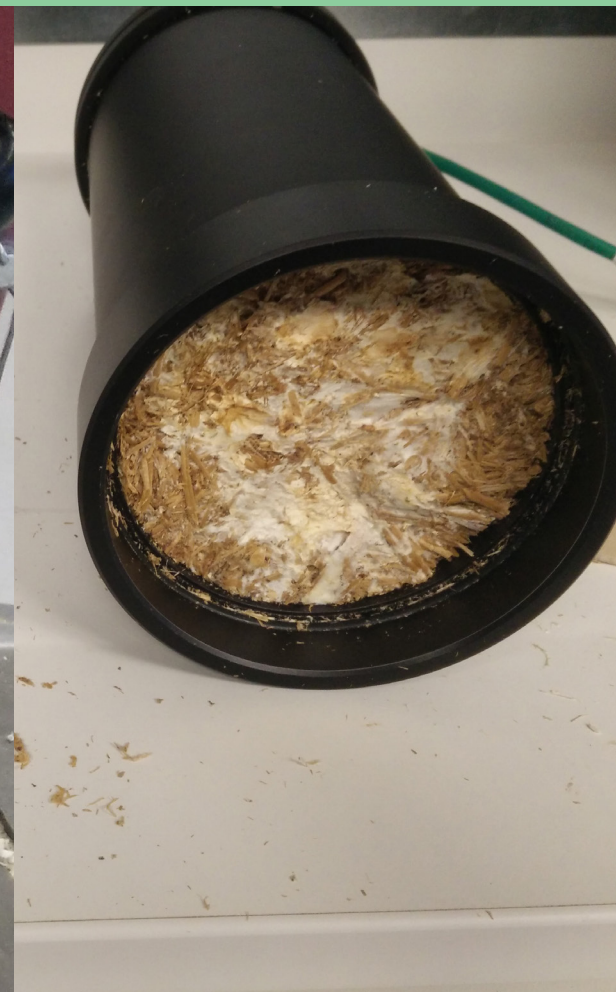
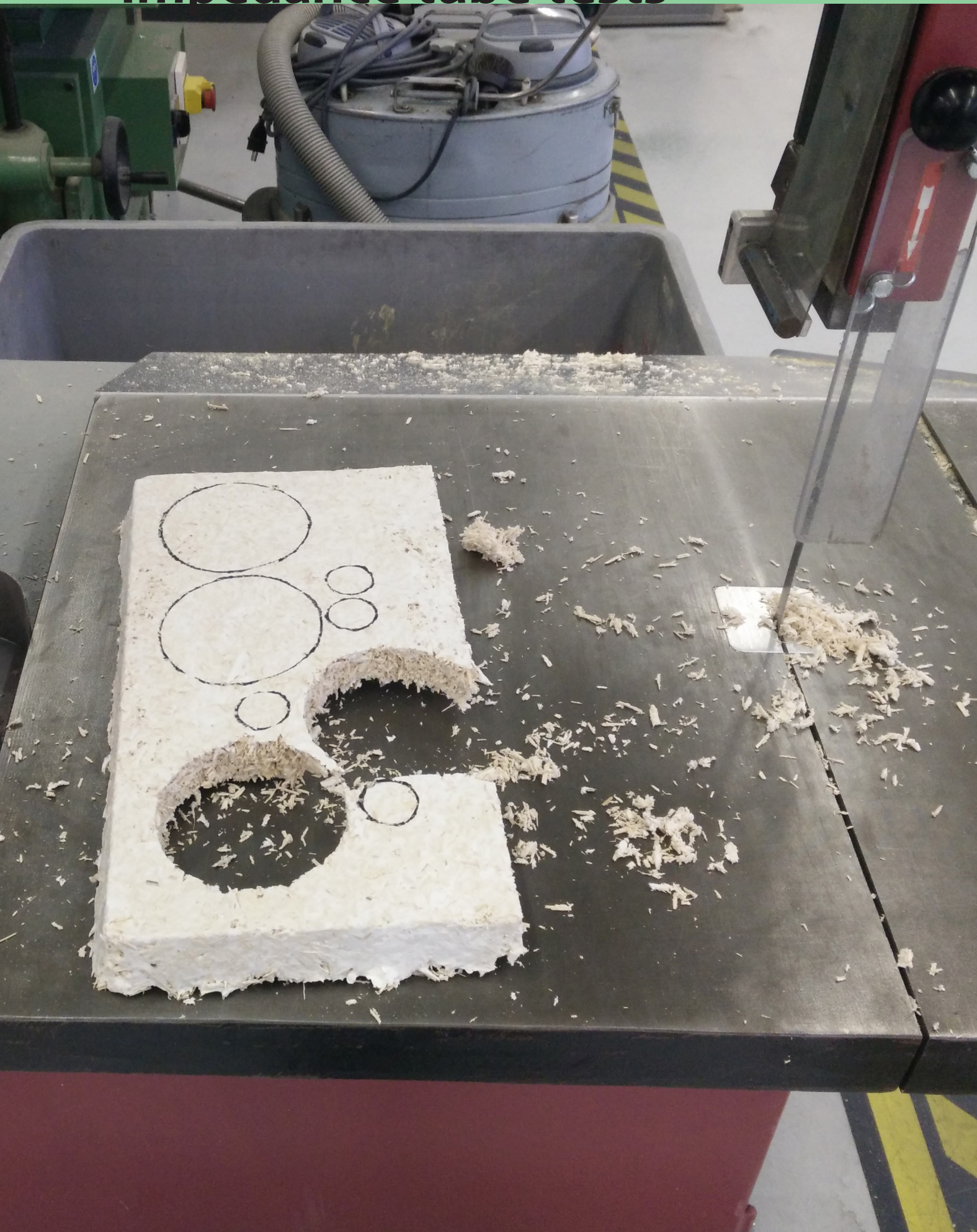
- Absorption spectrum
- Sound perpendicular
- 10 cm and 2,9 cm samples

Sample types:

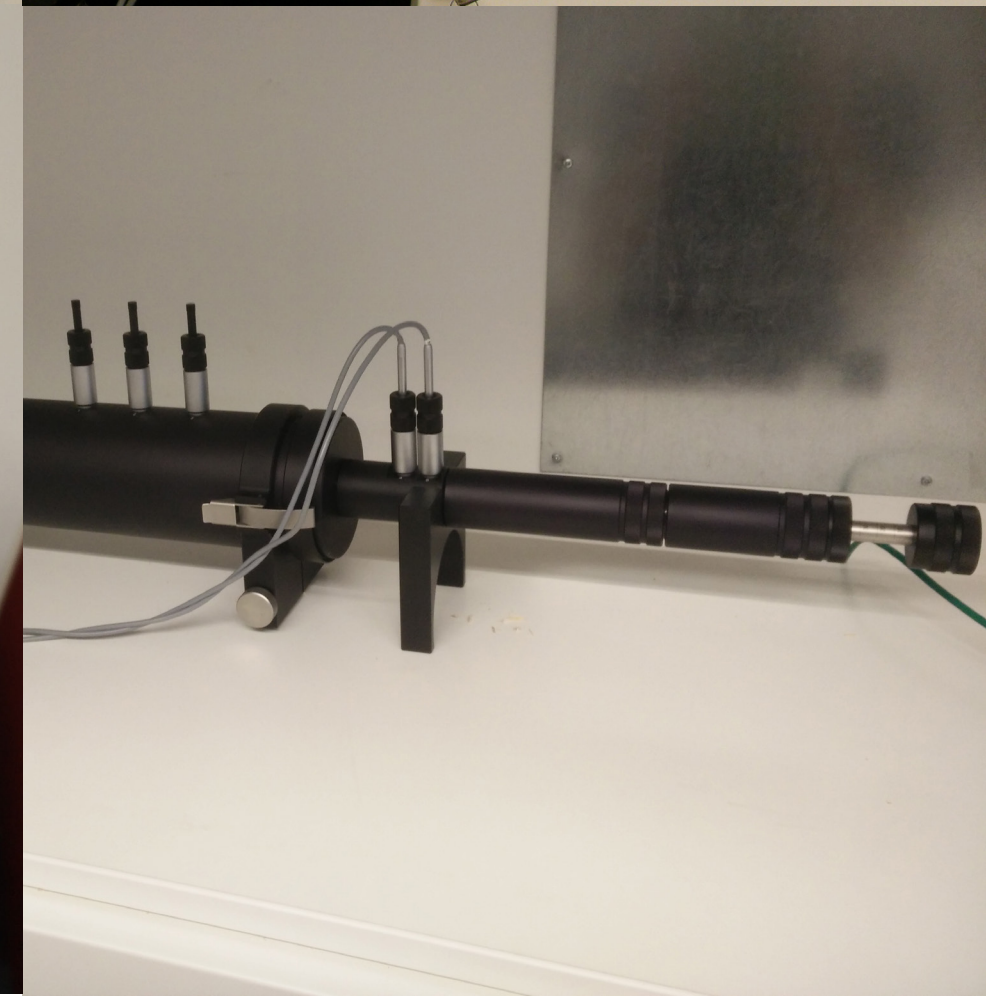
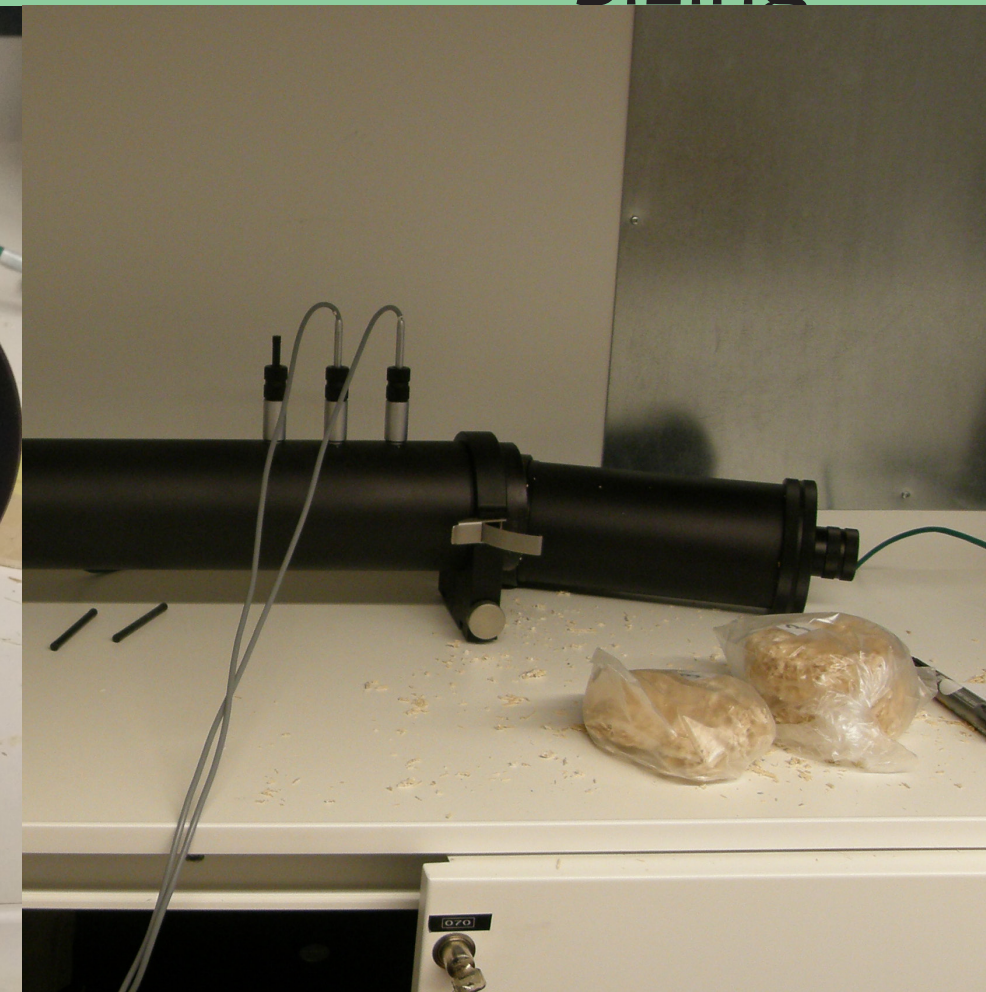
- Substrates
- Density
- Thickness
- Surface effects
- Existing products



Impedance tube tests



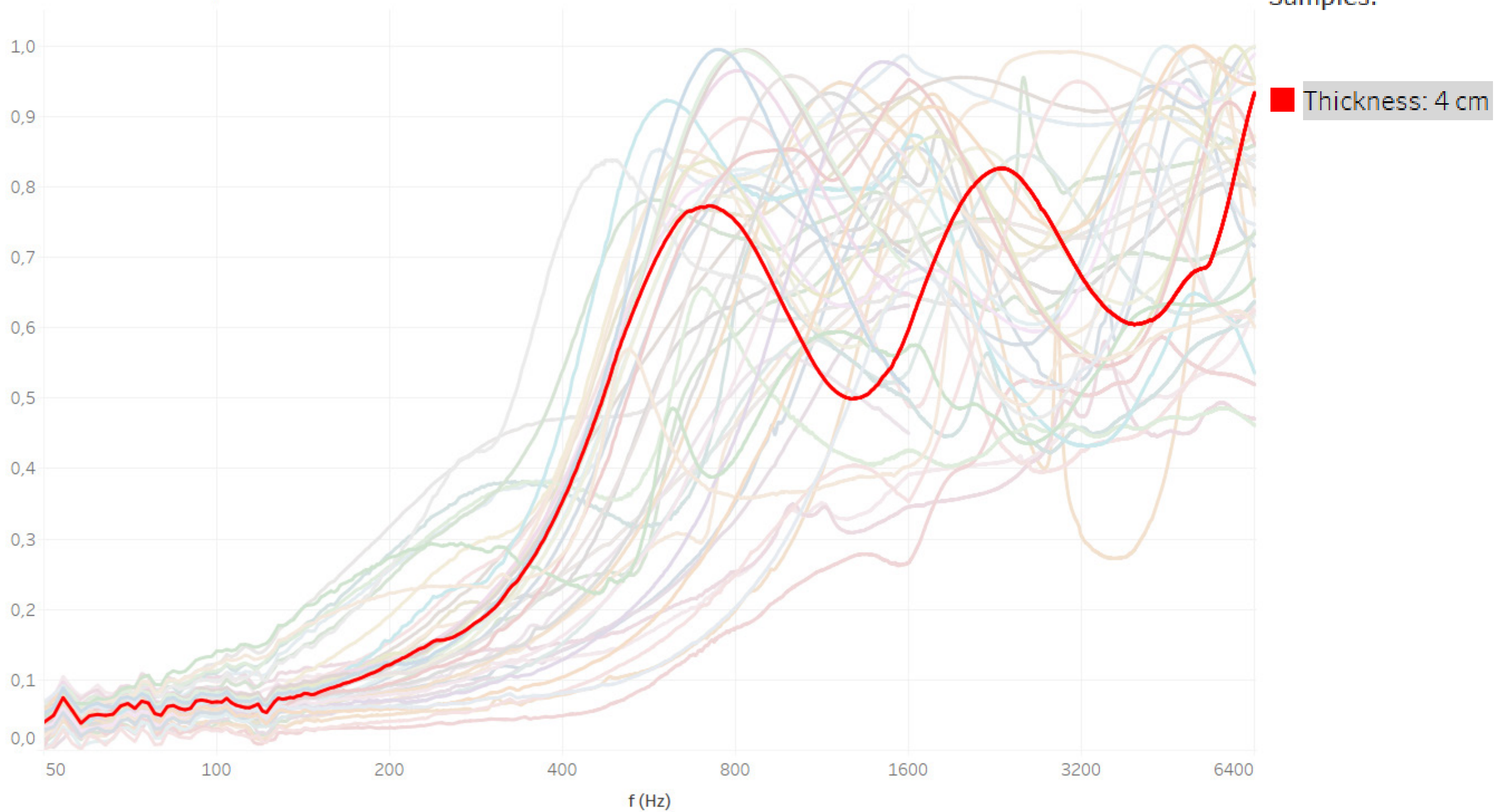
Sizing



Impedance tube tests

Overview

Acoustic Absorption



Impedance tube tests

Overview: 4cm Hemp/Straw



Impedance tube tests

Substrates: Cacao



Impedance tube tests

Substrates: Cattail



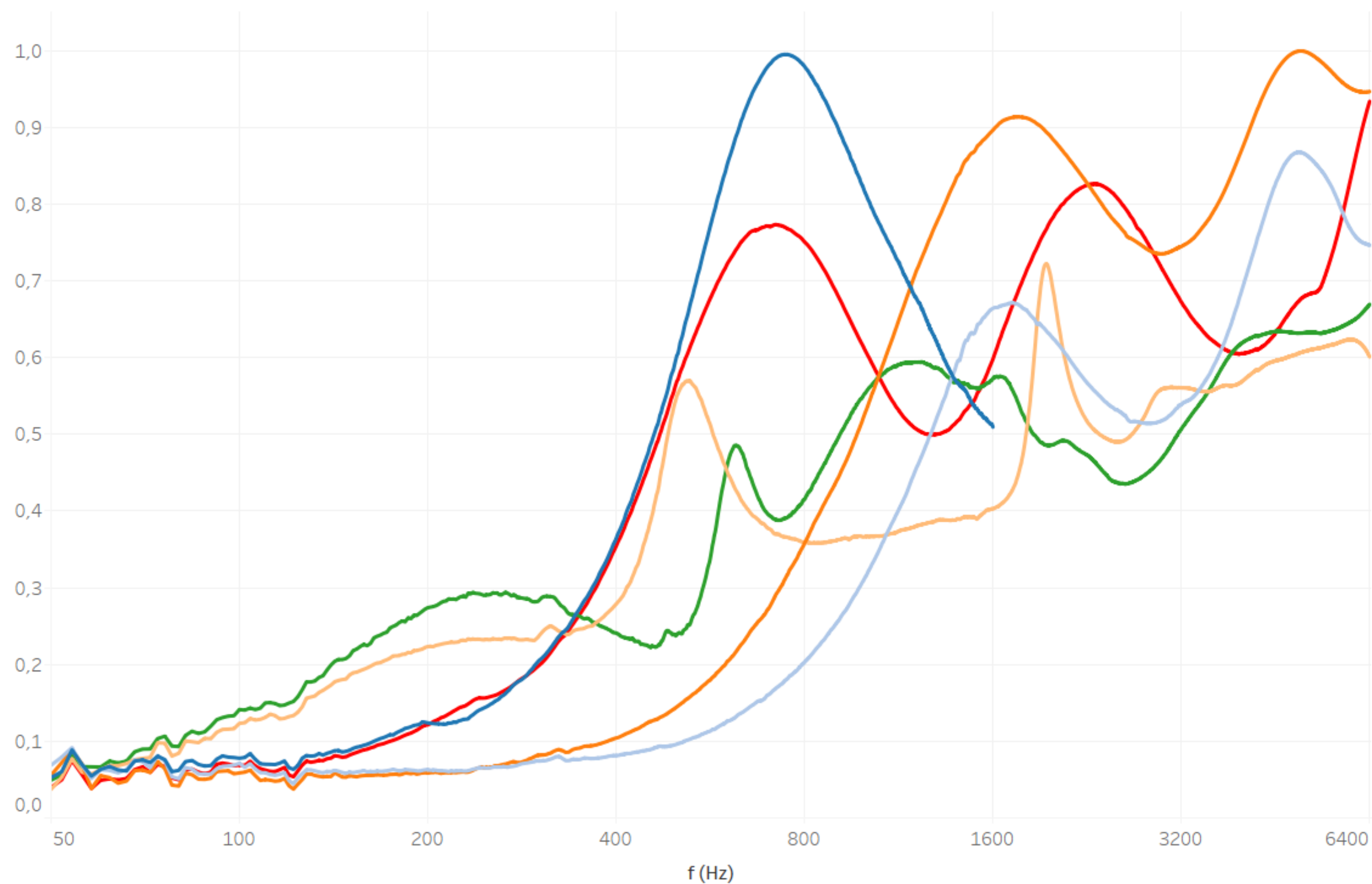
Impedance tube tests

Substrates

Acoustic Absorption

Samples:

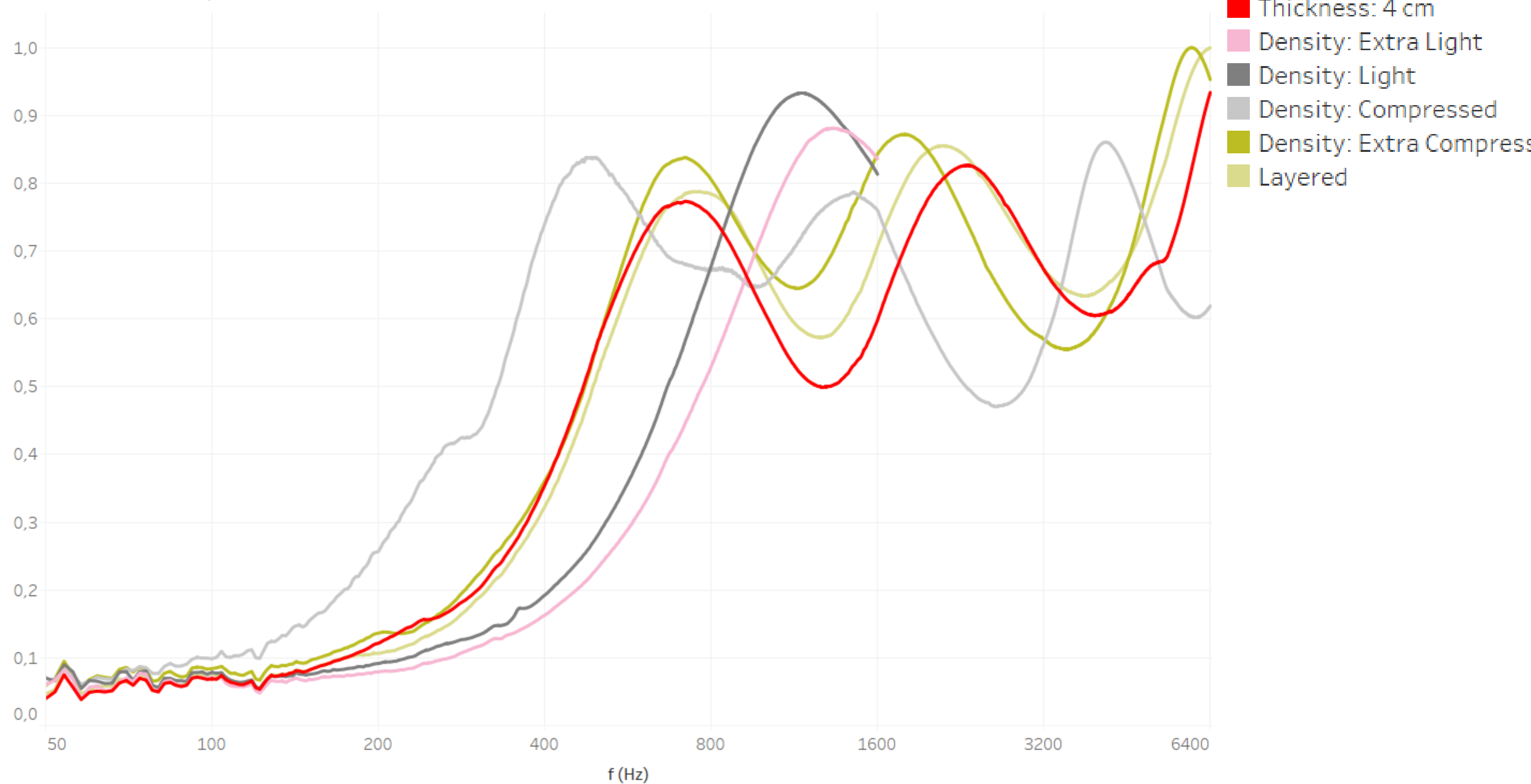
- Hemp
- Straw
- Woodcurls
- Cattail
- Cacao
- Thickness: 4 cm



Impedance tube tests

Density

Acoustic Absorption



Impedance tube tests

Surface shapes: extra growth



Impedance tube tests

Surface shapes: squares



Impedance tube tests

Surface shapes: triangles



Impedance tube tests

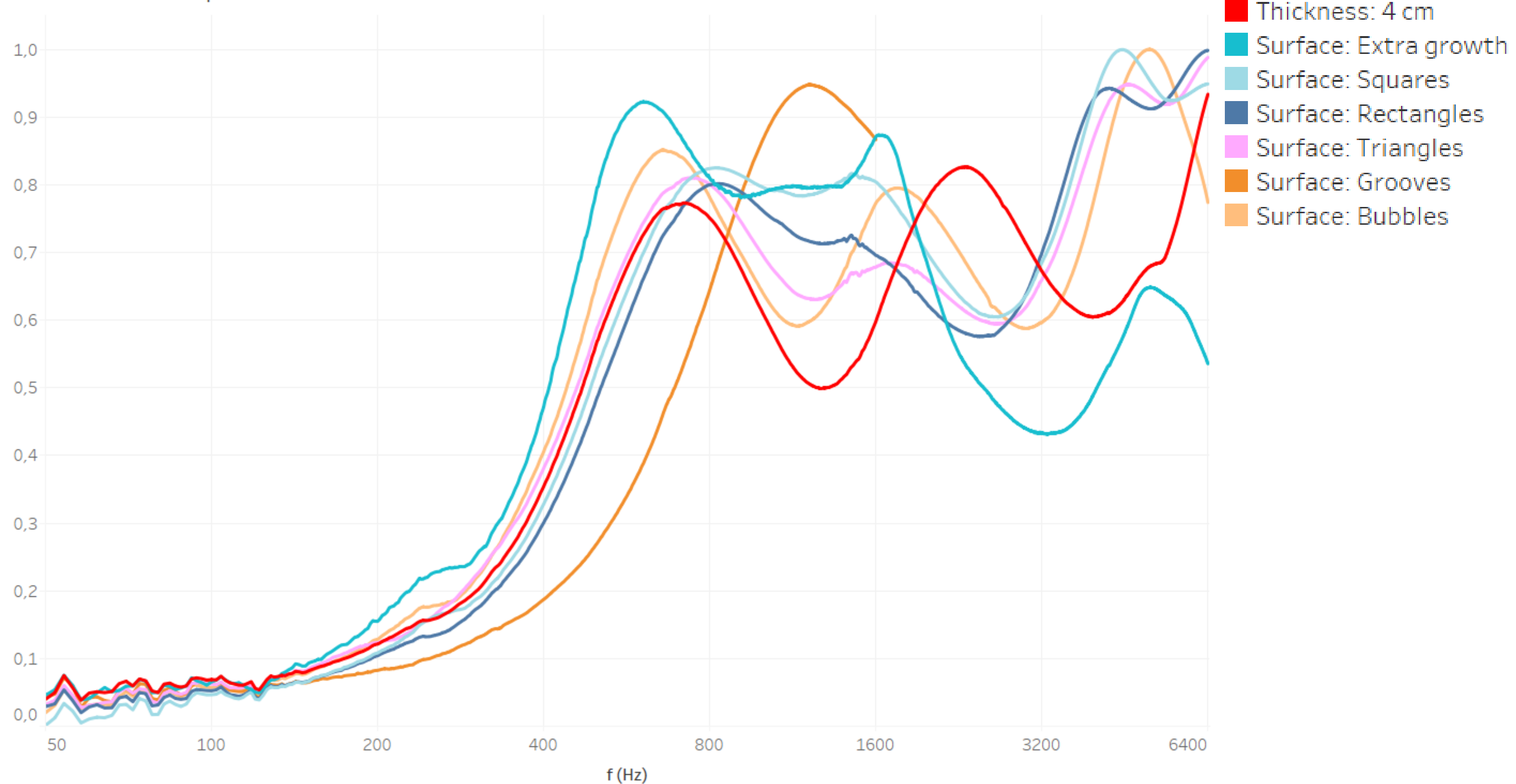
Surface shapes: bubblewrap



Impedance tube tests

Surface shapes

Acoustic Absorption



Impedance tube tests

Products: Ecovative



Impedance tube tests

Products: GreenSulate closed



Impedance tube tests

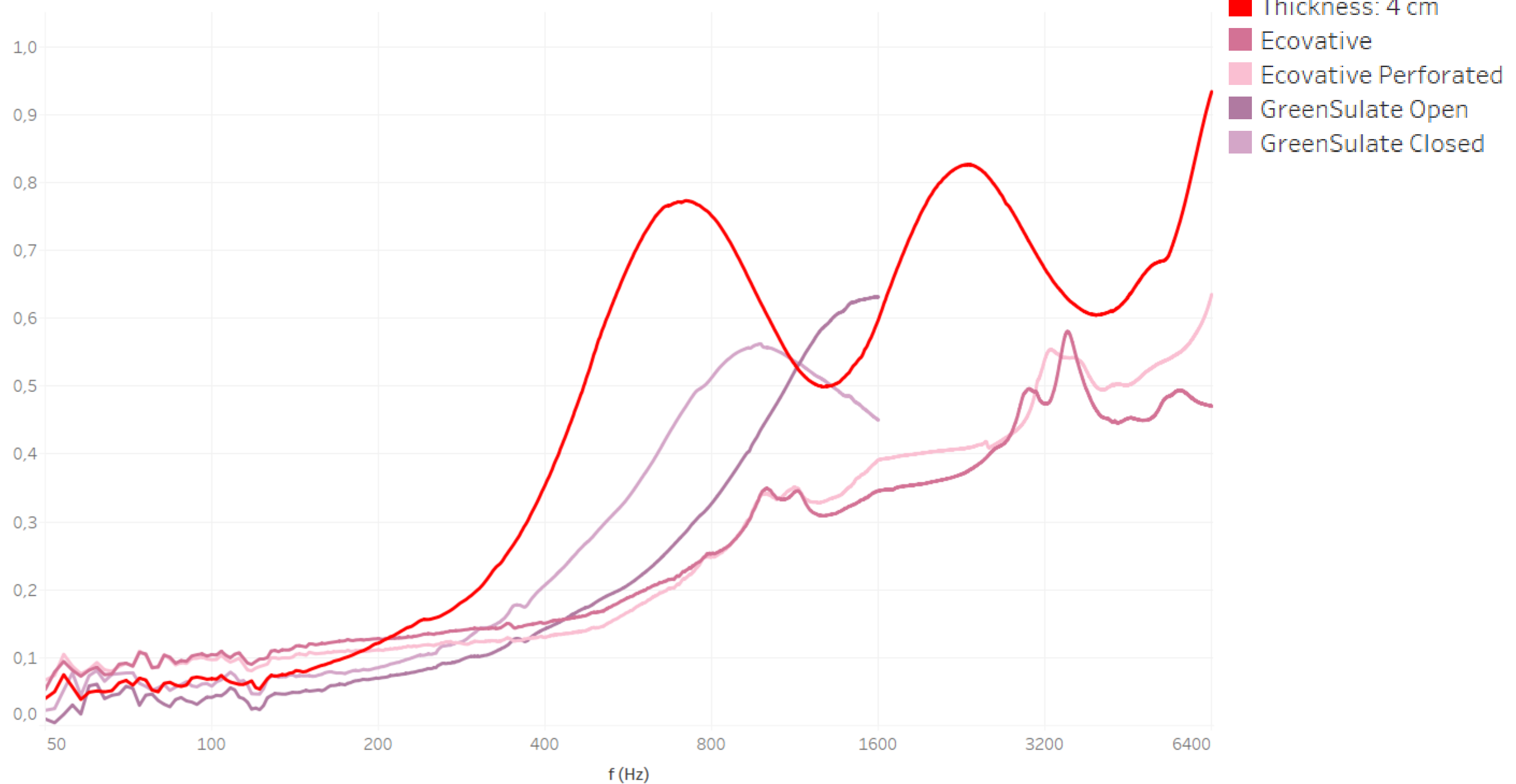
Products: GreenSulate open



Impedance tube tests

Products: Mycelium

Acoustic Absorption



Impedance tube tests

Products: Knauf Ecosse



Impedance tube tests

Products: Isovlas



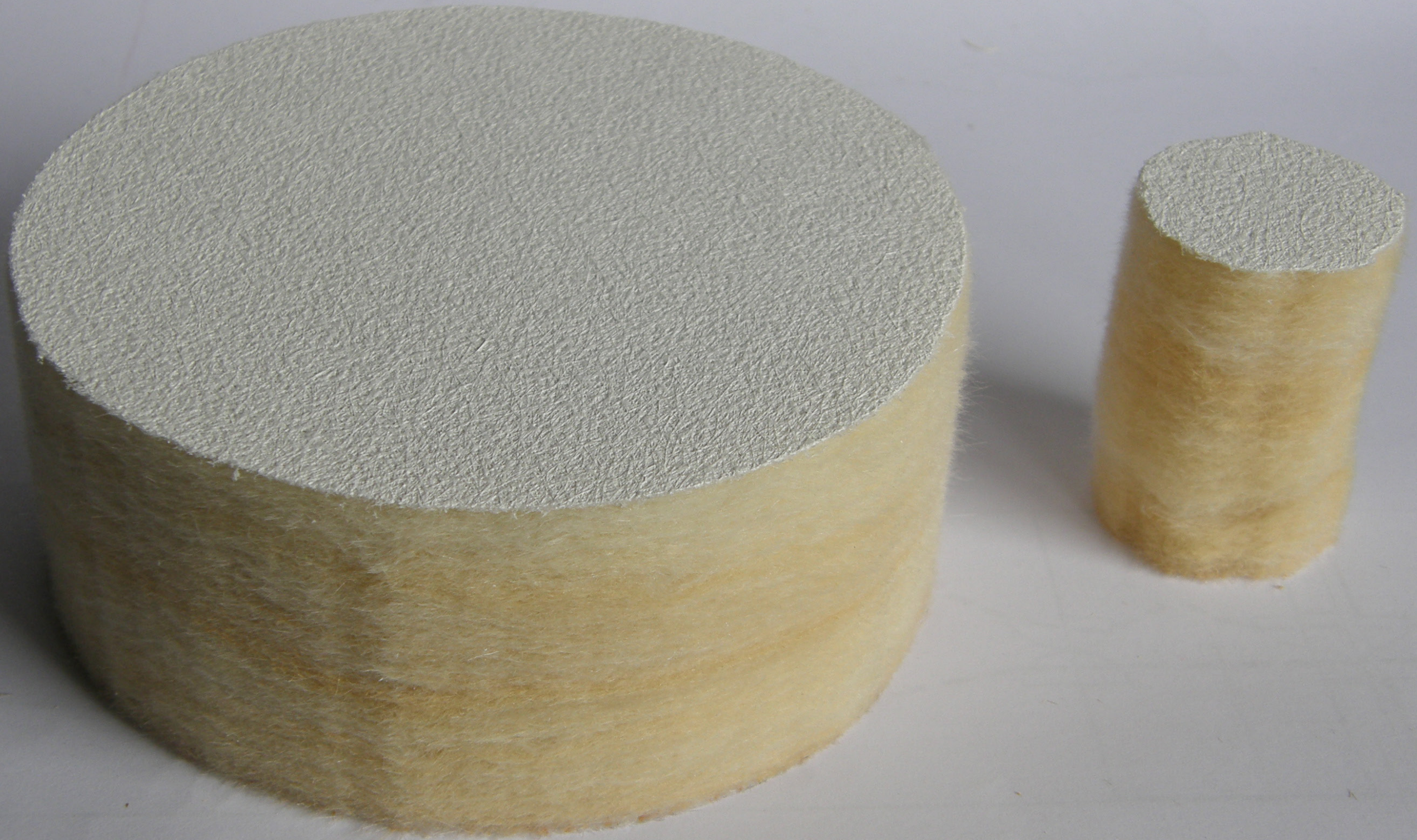
Impedance tube tests

Products: Troldekt



Impedance tube tests

Products: Ecophon Akusto



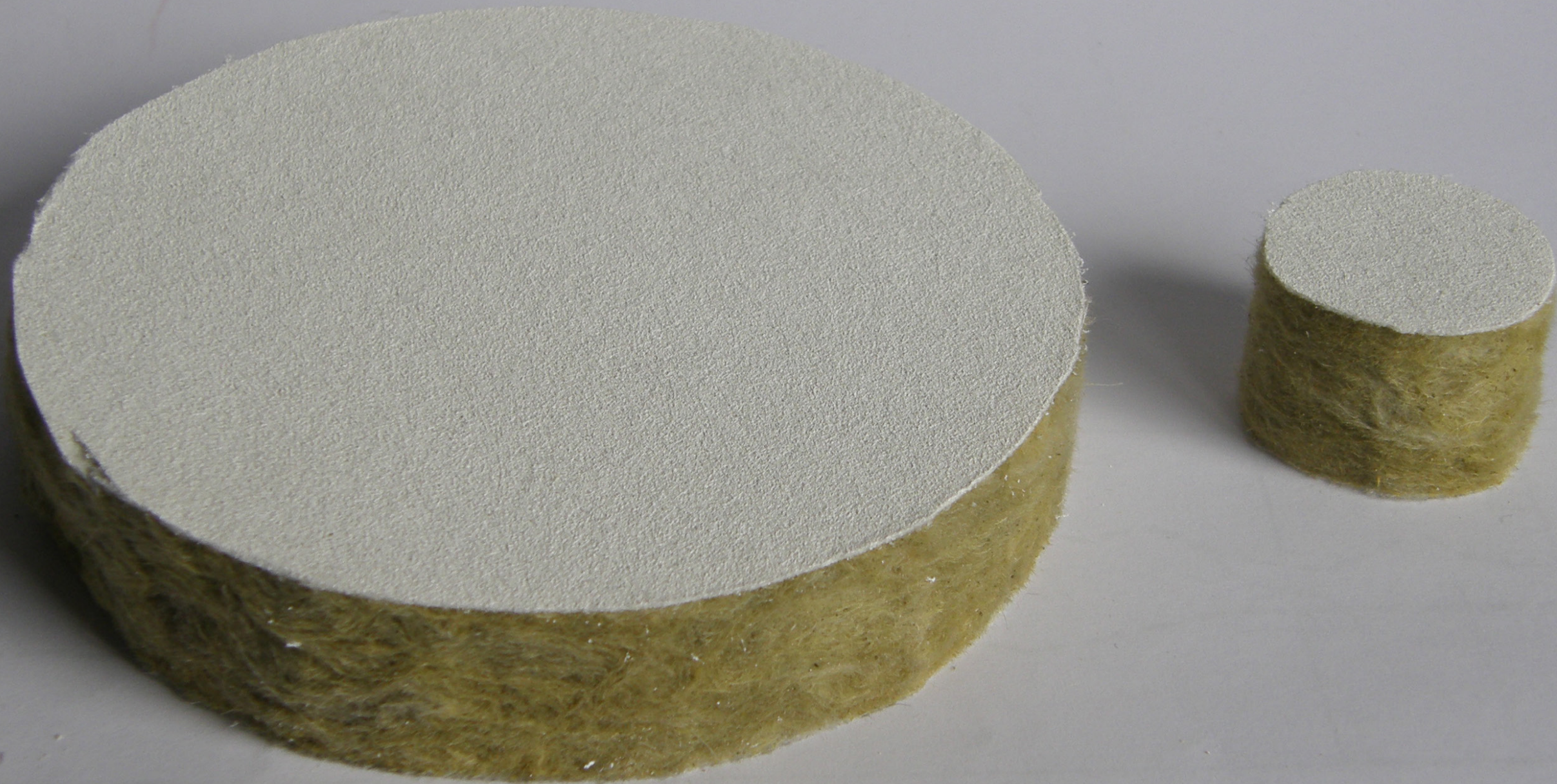
Impedance tube tests

Products: Heraklith



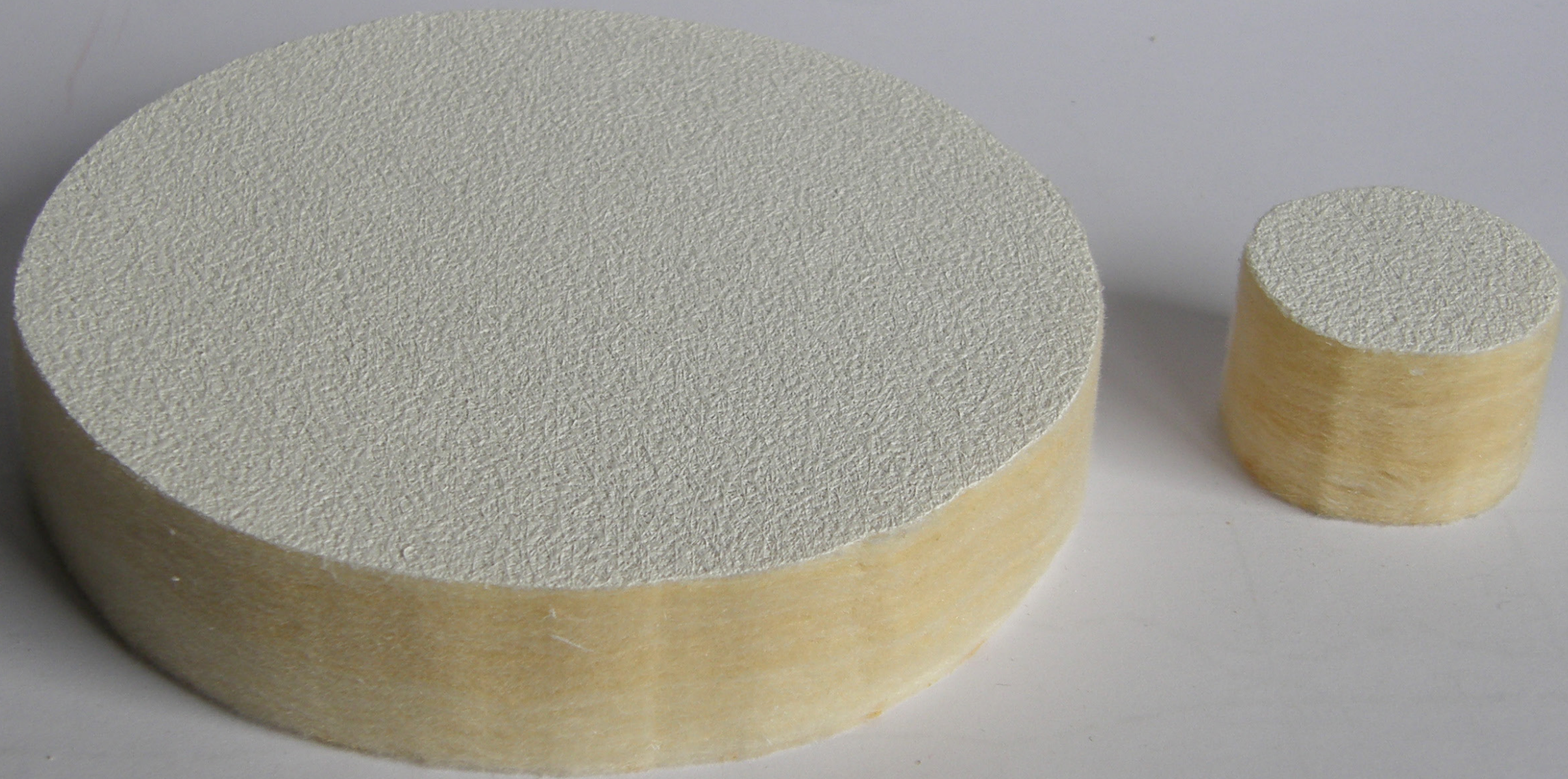
Impedance tube tests

Products: Rockfon



Impedance tube tests

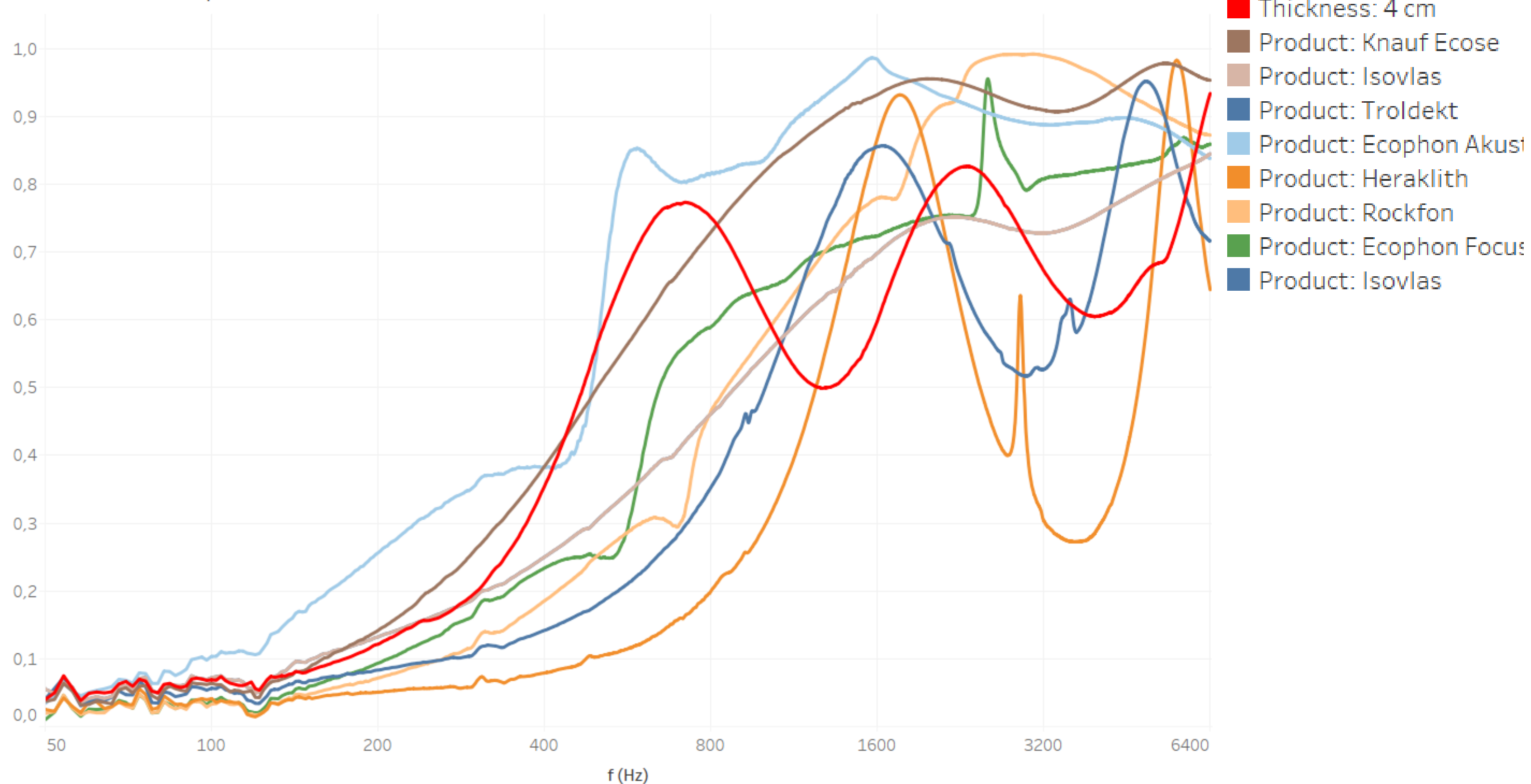
Products: Ecophon Focus



Impedance tube tests

Products: Conventional

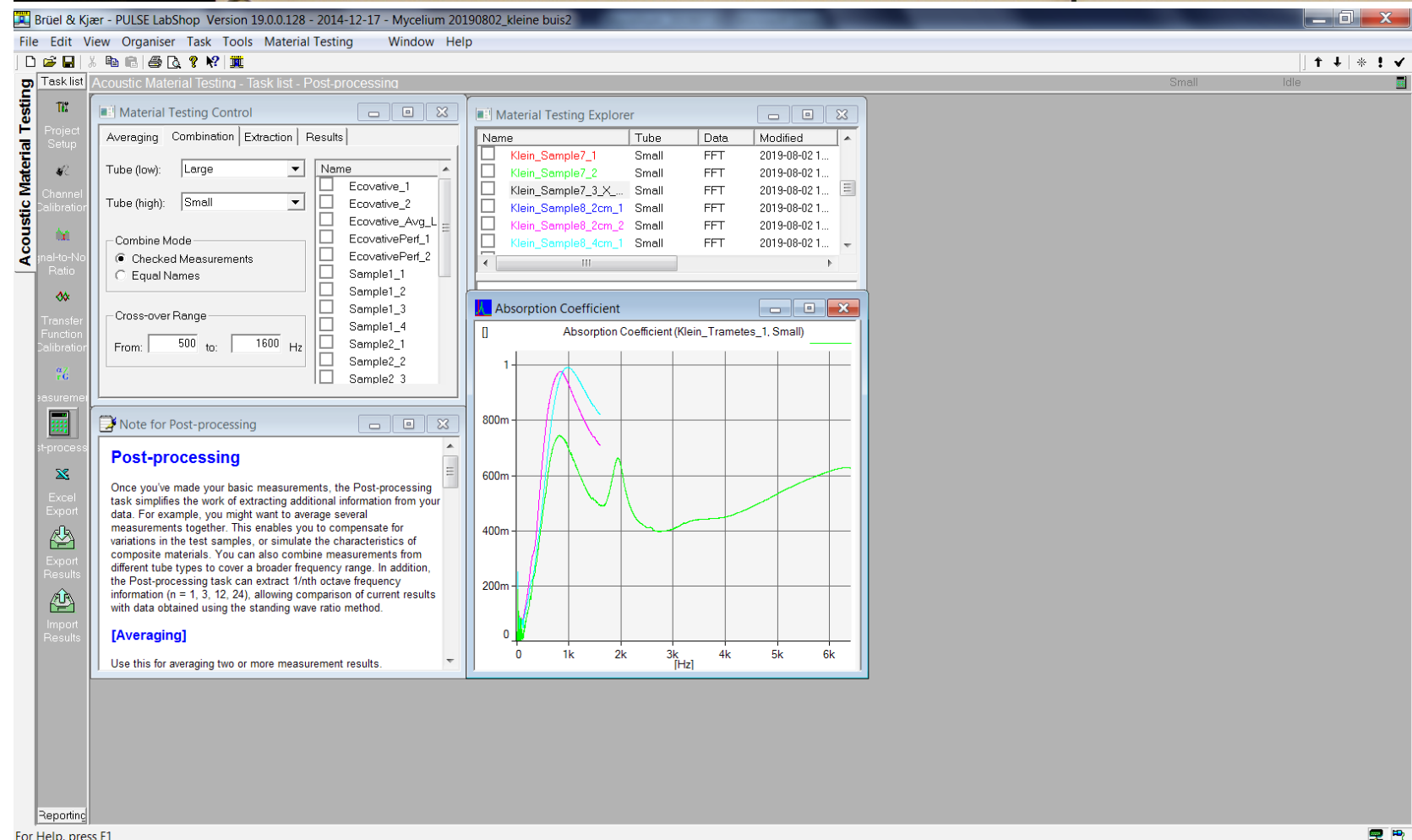
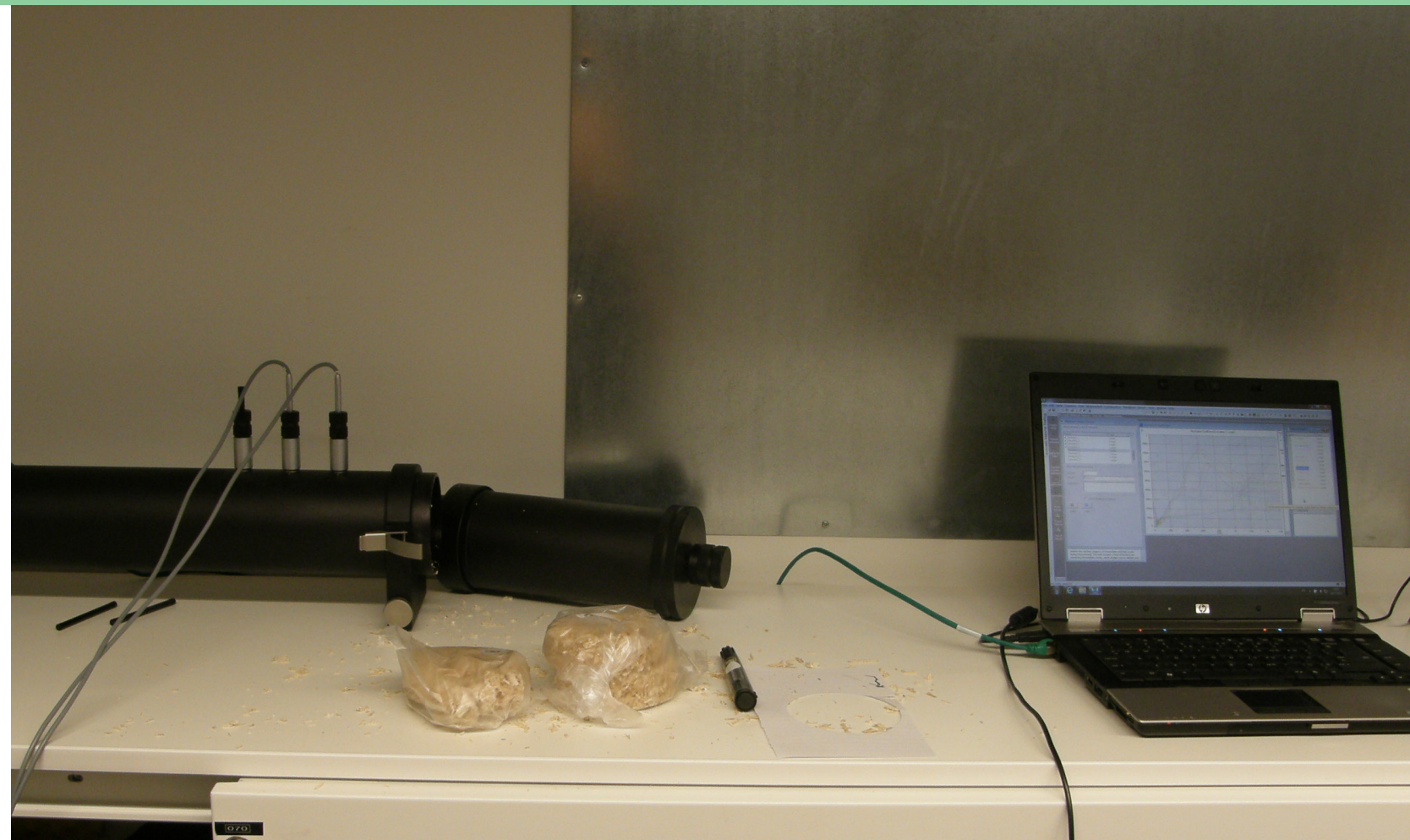
Acoustic Absorption



Impedance tube tests

Conclusion

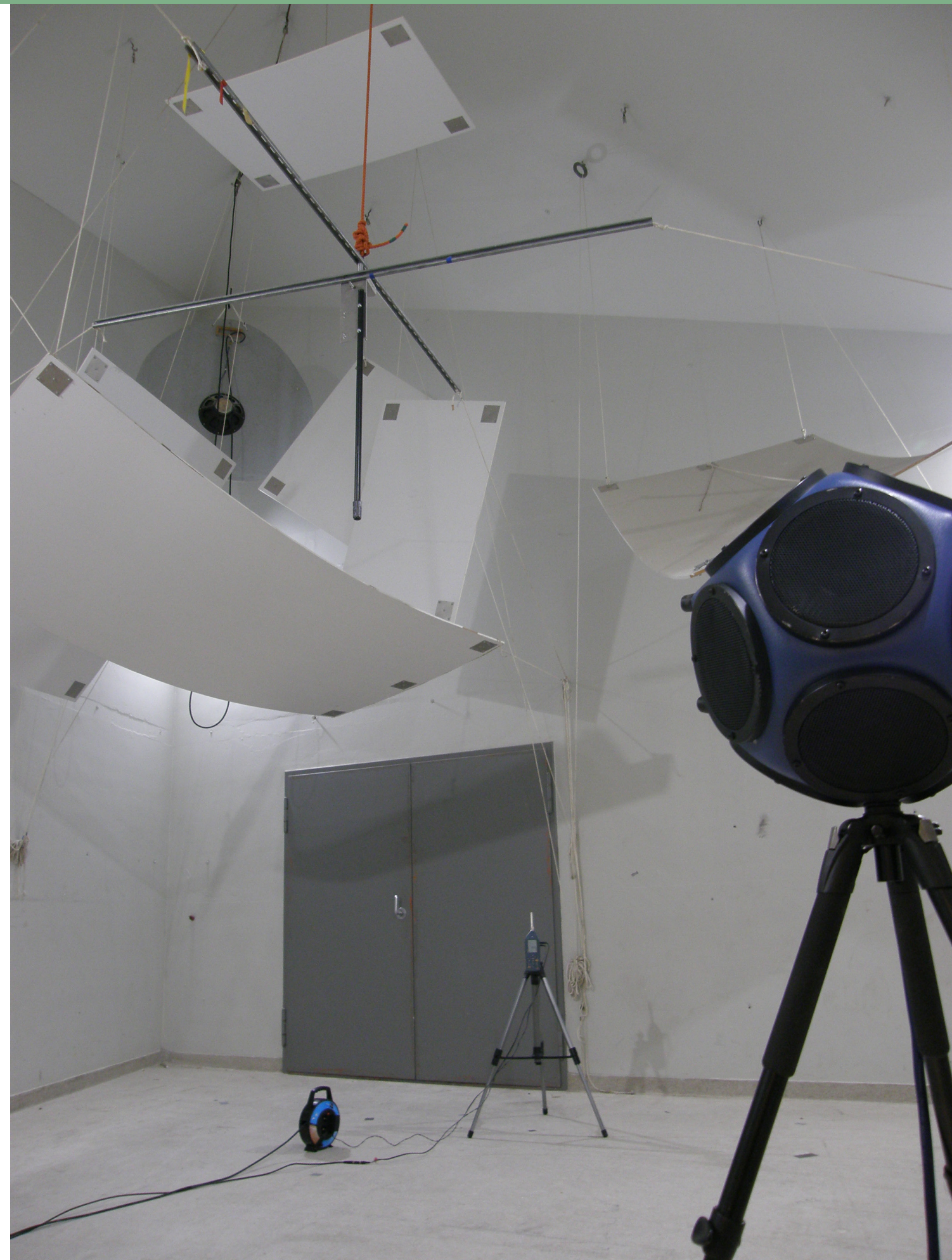
- Density most important parameter
- Open/closed effect
- Surface shapes no effect
- Sine-wave like curve



Reverberation chamber tests

Reverberation chamber

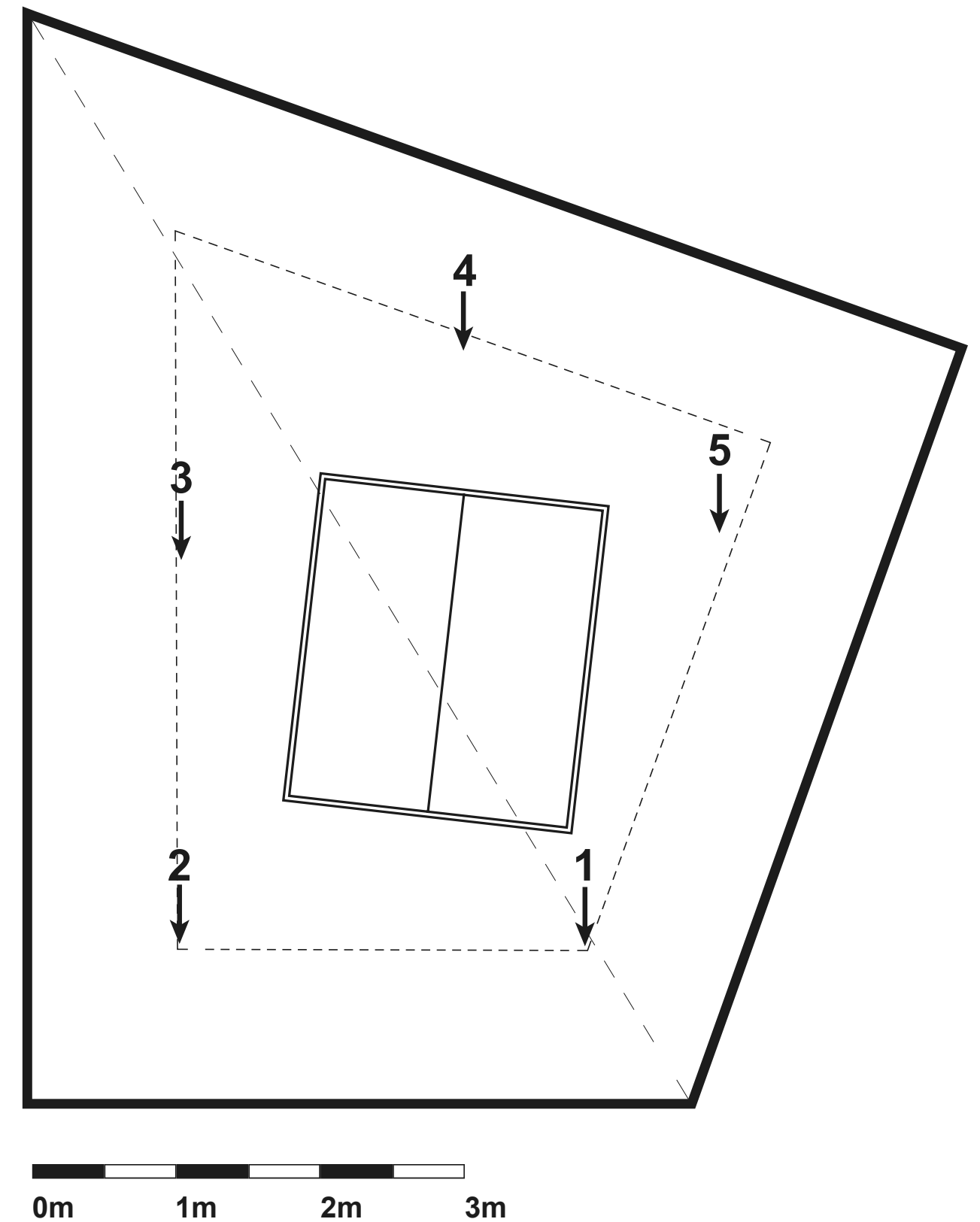
- Diffuse field
- Realistic measurements
- Norms are important
- Compare with impedance tube



Reverberation chamber tests

Set-up

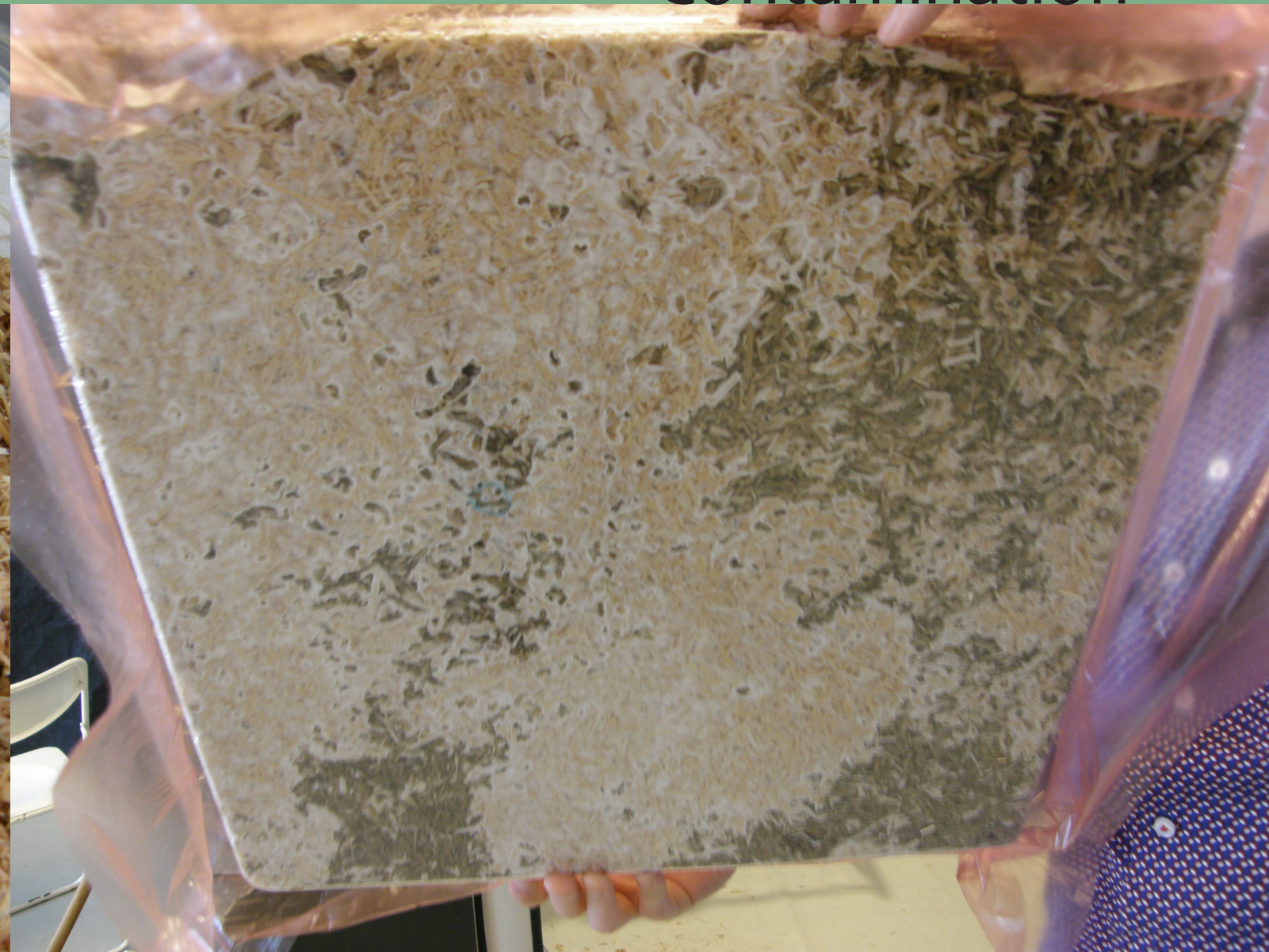
- 5 microphone/loudspeaker positions
- No parallel walls
- Relative humidity, temperature, air pressure



Growing the panels



Contamination



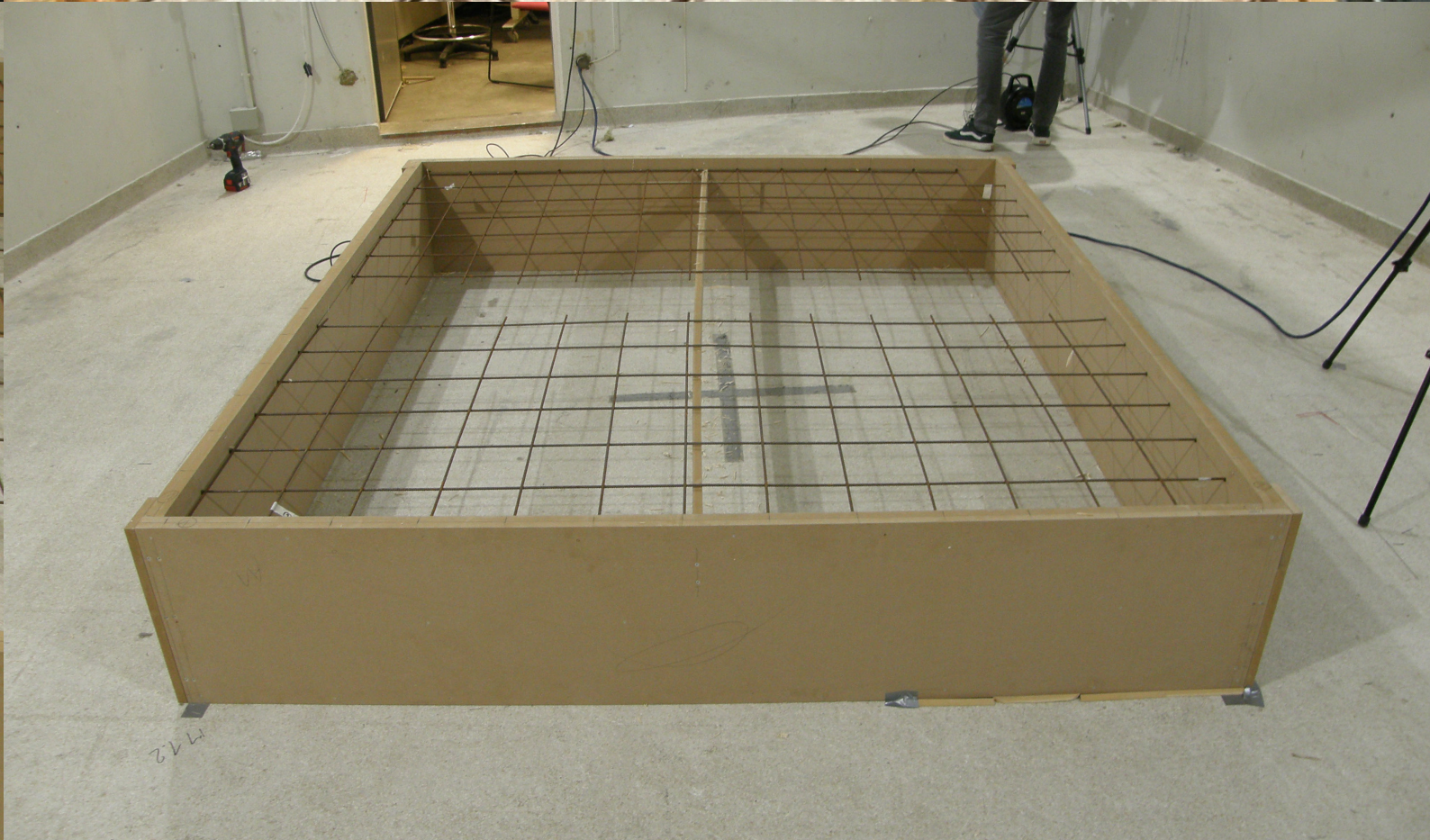
Growing the panels



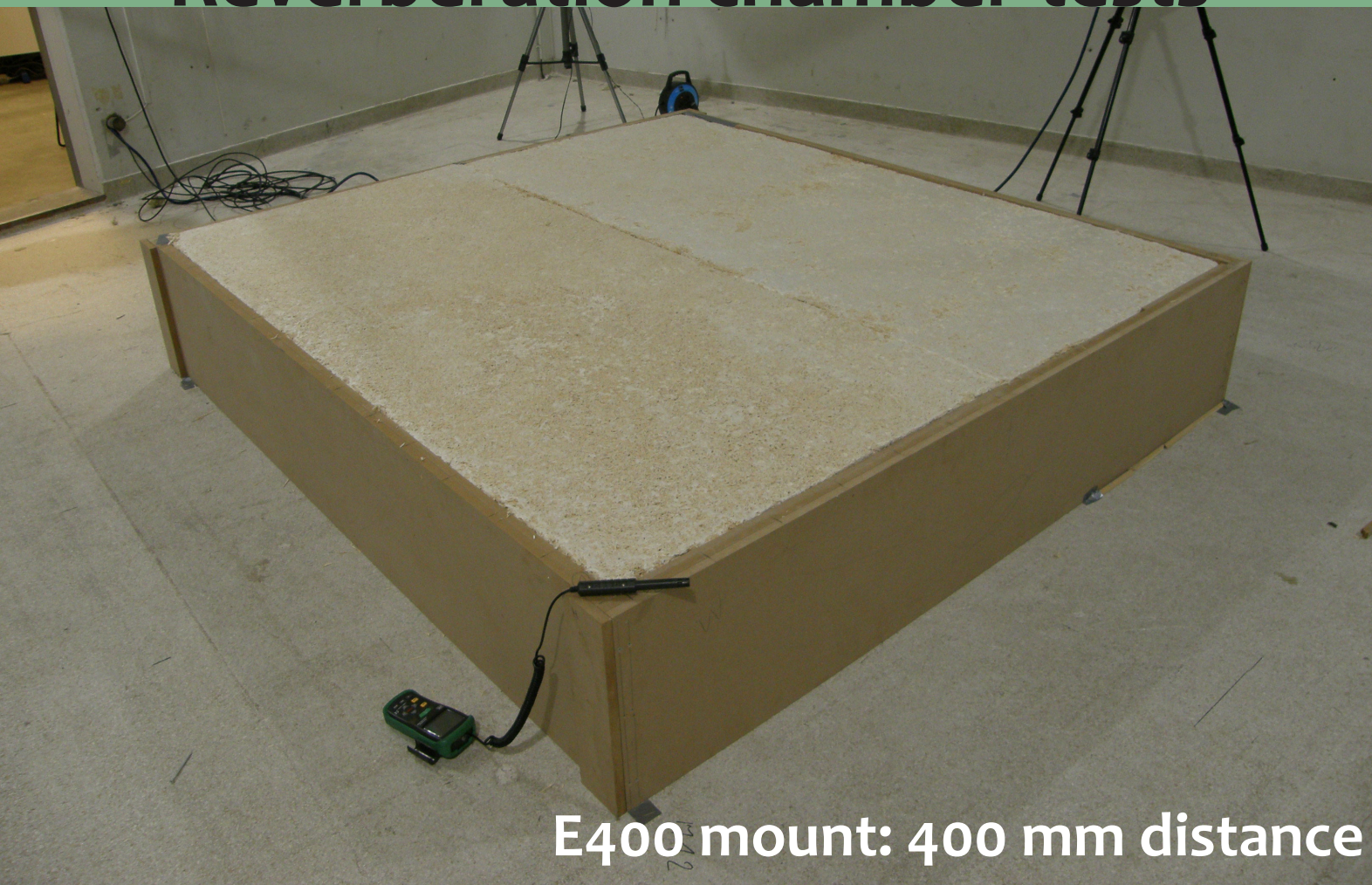
Second try



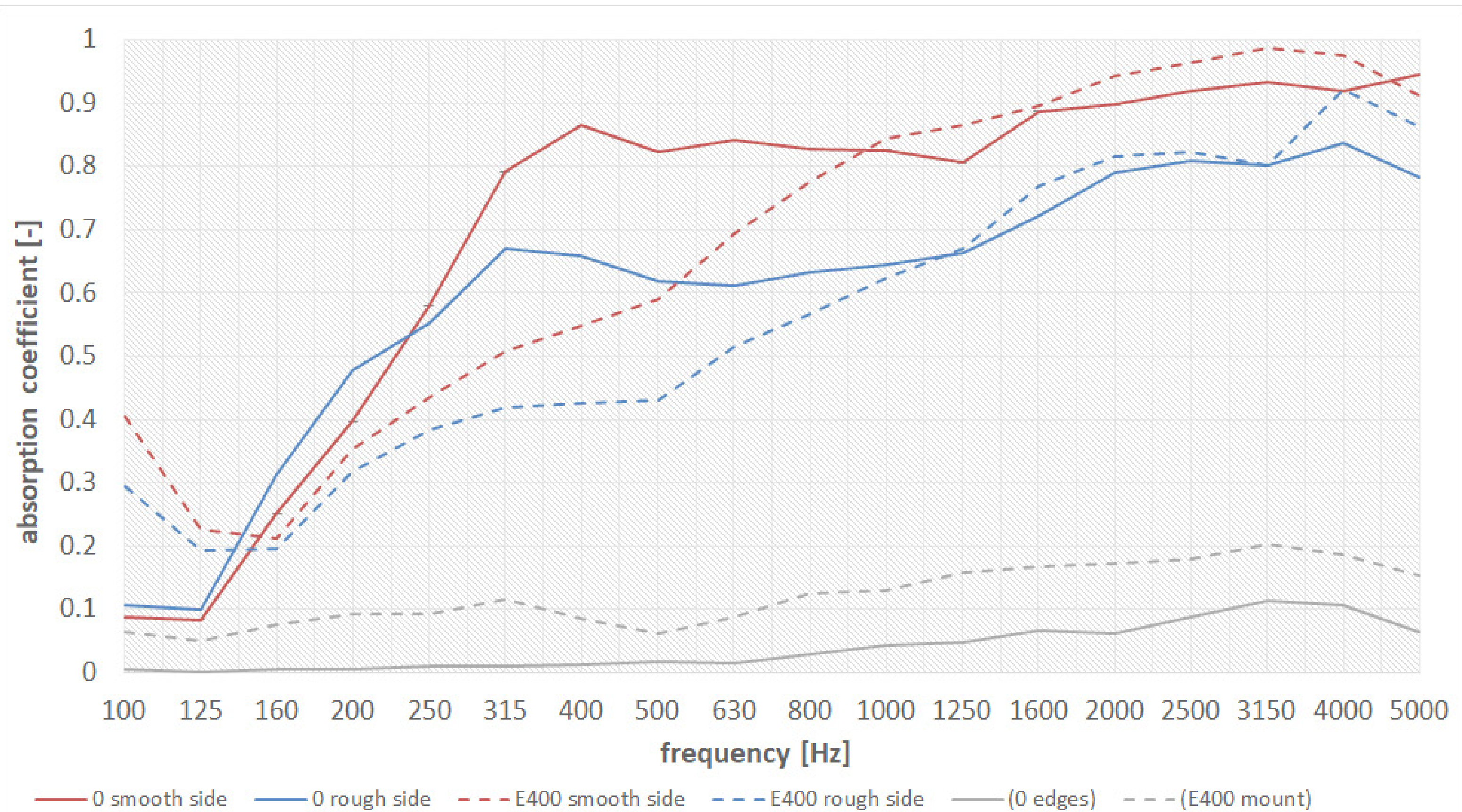
Building the mounting



Reverberation chamber tests

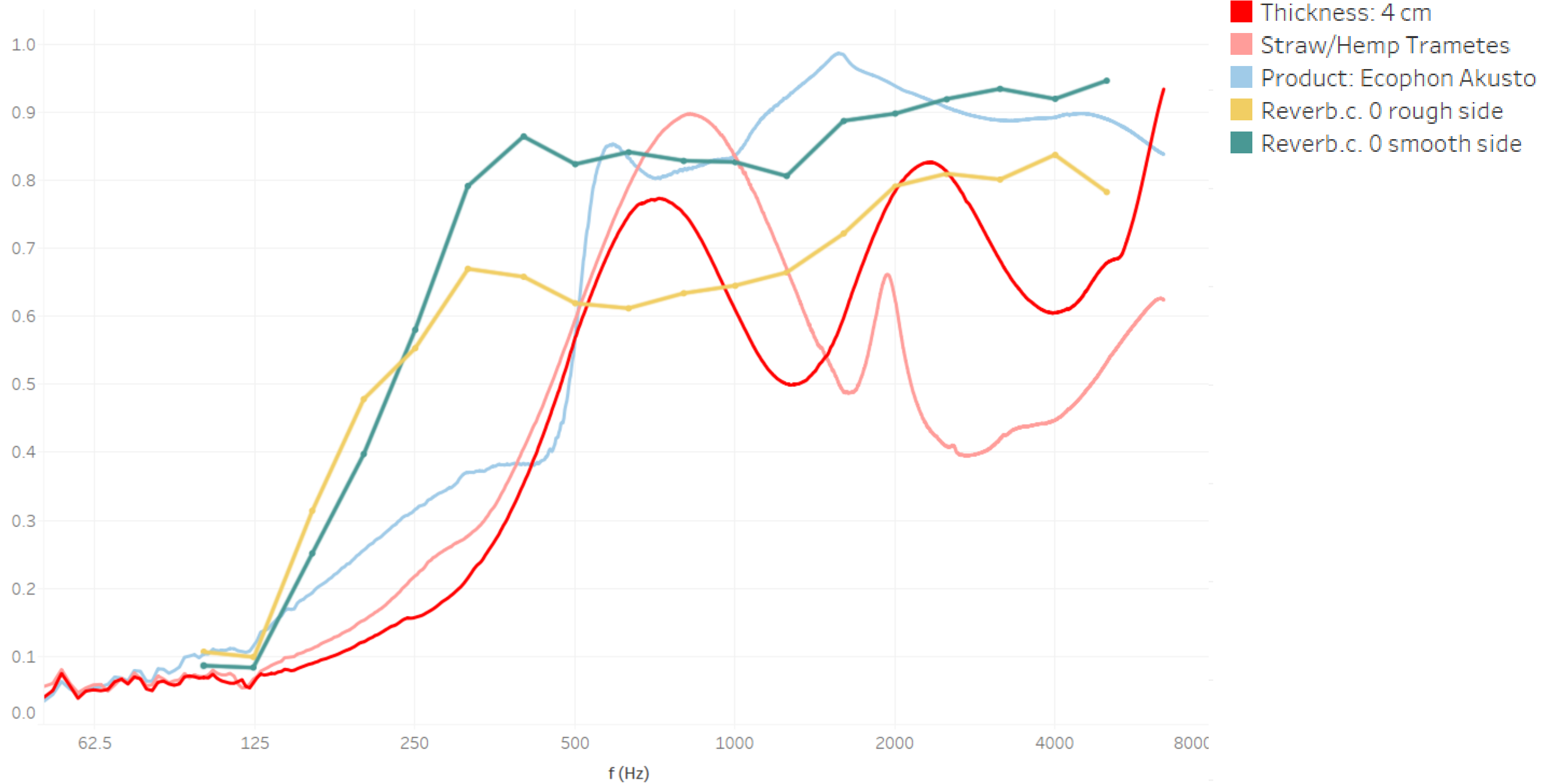


Reverberation chamber tests



Reverberation chamber tests

Acoustic Absorption



Reverberation chamber tests

Conclusion

- Good absorption
- Smooth/rough side
- E400 mount?
- No sine-wave like curve



Microscopic imaging

Samples

- Hemp/straw
- Hemp/straw + extra growth
- Ecovative GIY kit

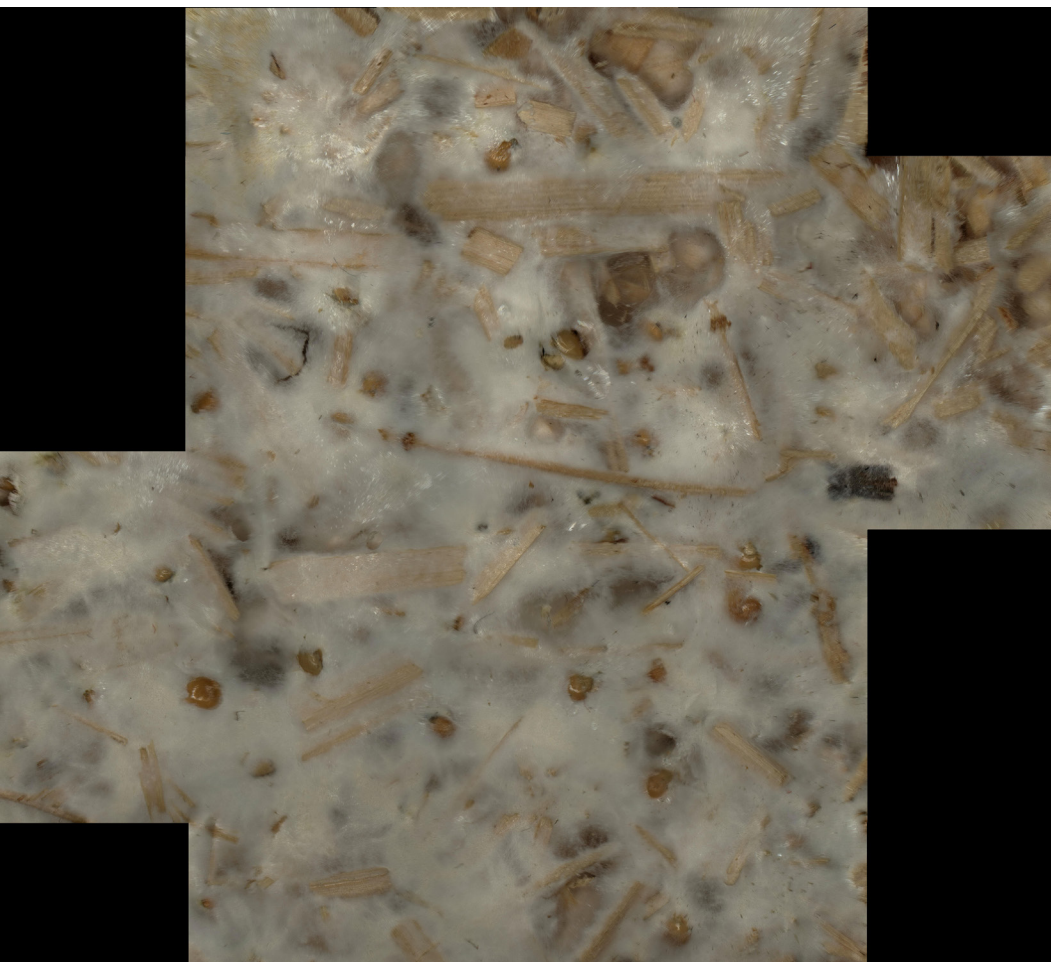
Sections



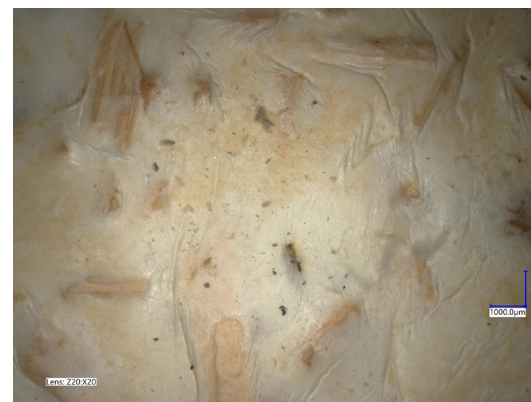
Microscopic imaging

Surface

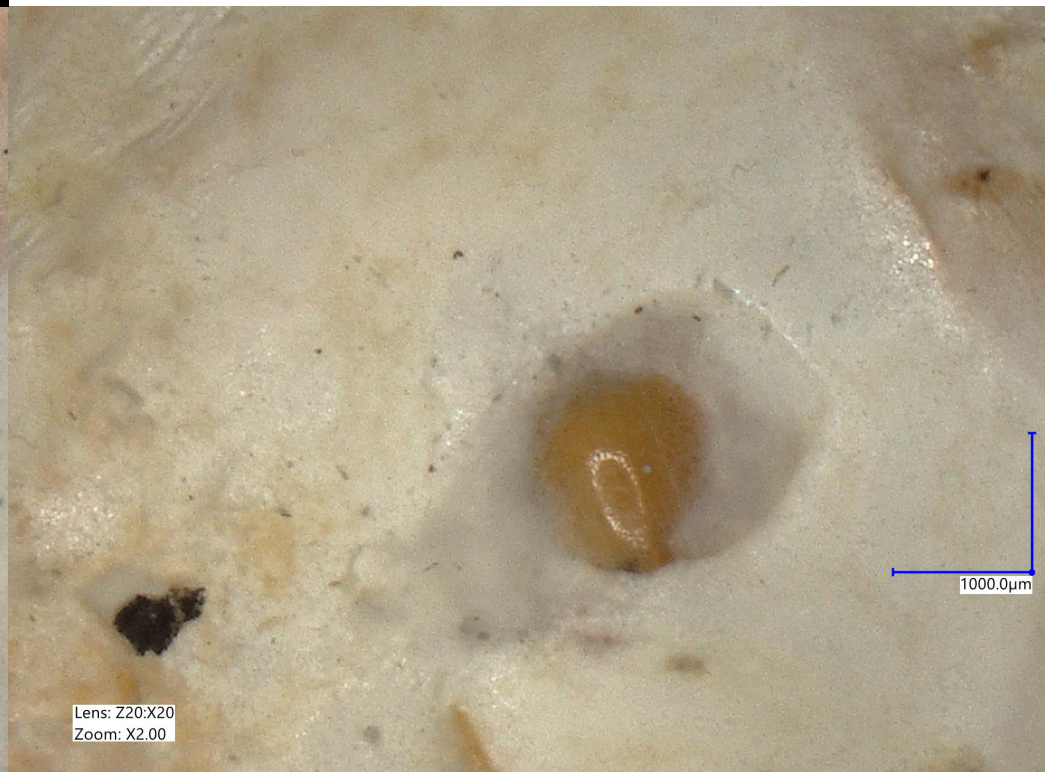
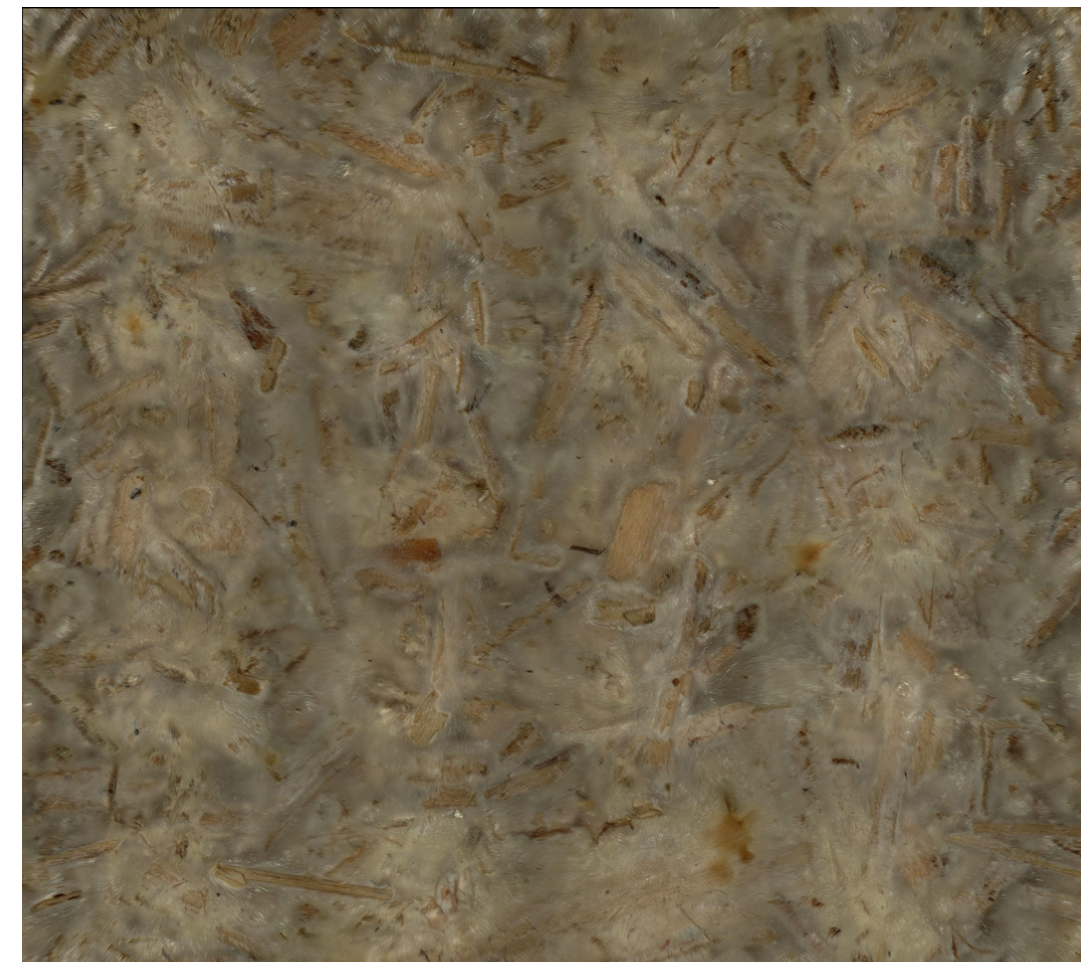
Regular hemp/straw



Extra growth



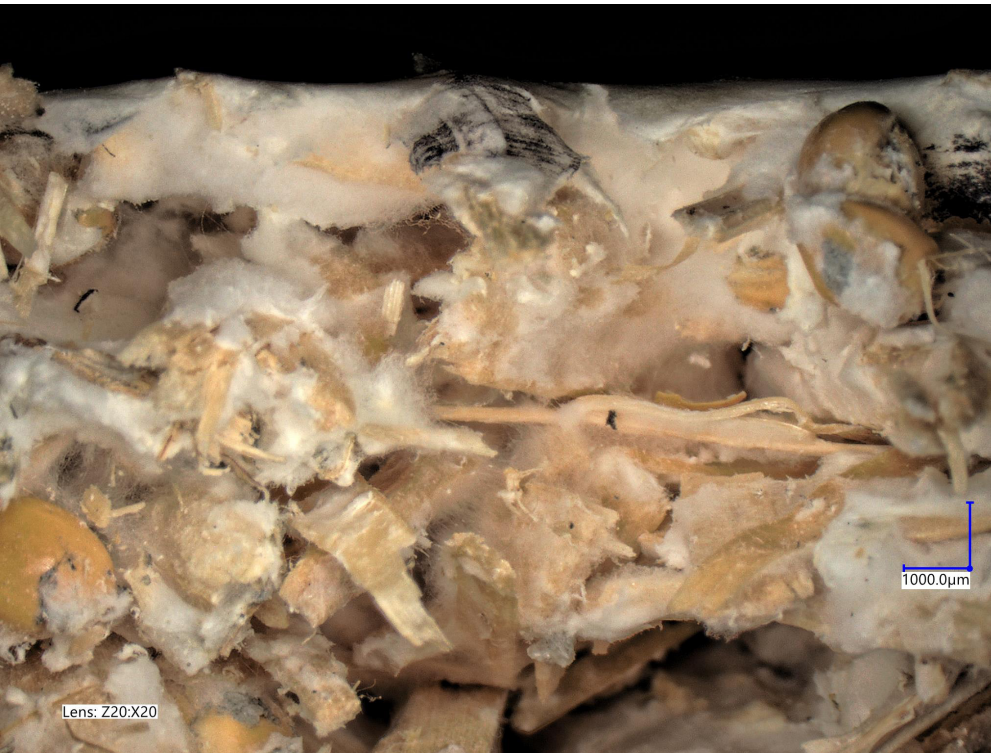
Ecovative



Microscopic imaging

Sections

Regular hemp/straw



Extra growth



Ecovative



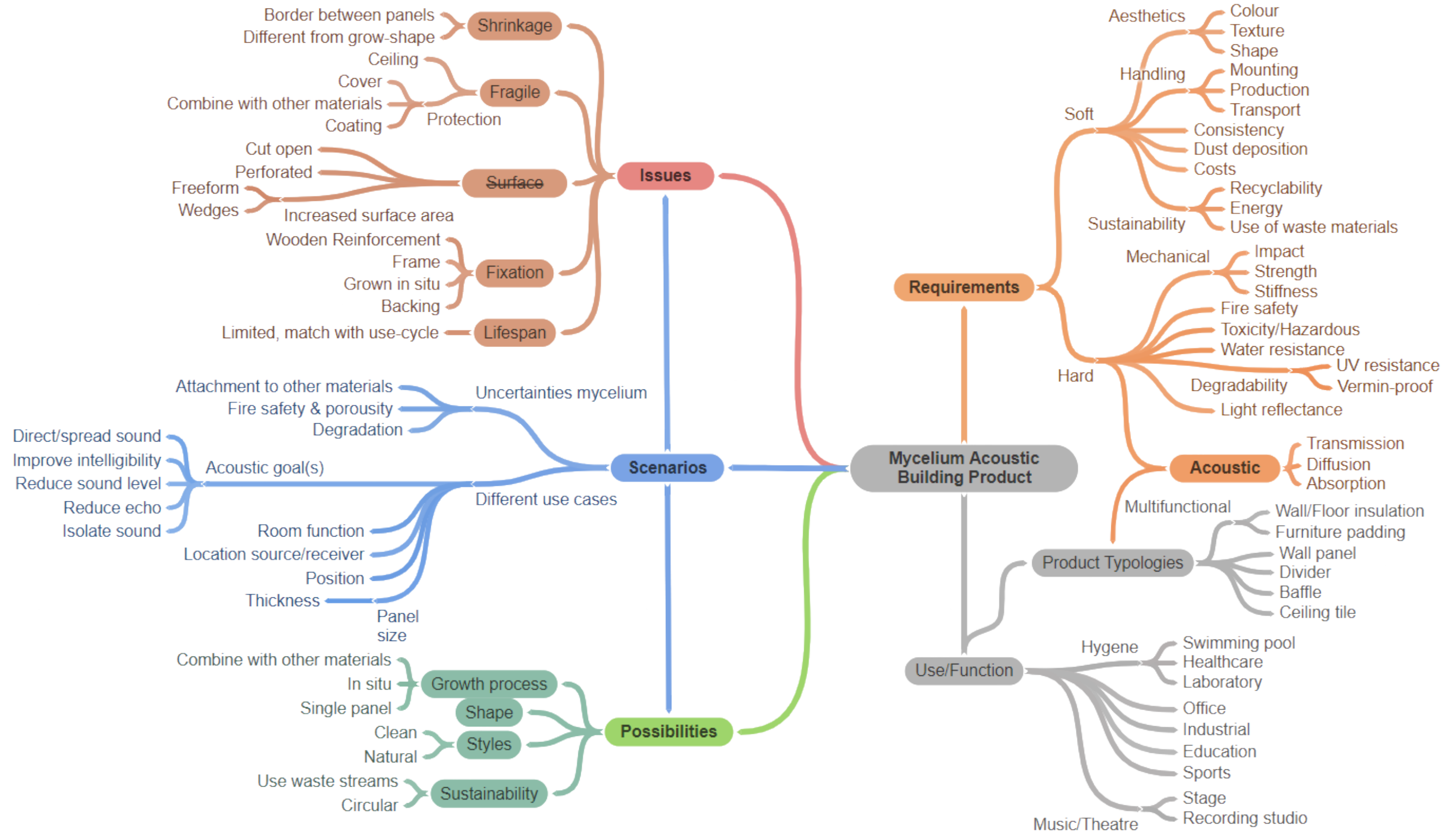
Acoustics

Conclusion

- Good absorption!
- Impedance tube $\leftrightarrow$ reverberation chamber
- E400 mount?



Mycelium design



Mycelium design

Topics:

Openness of the surface

Fragility

Connections

Narrative

Lifecycle and sustainability

Other acoustic types

Shape

Mycelium design

Topics:

Openness of the surface

Fragility

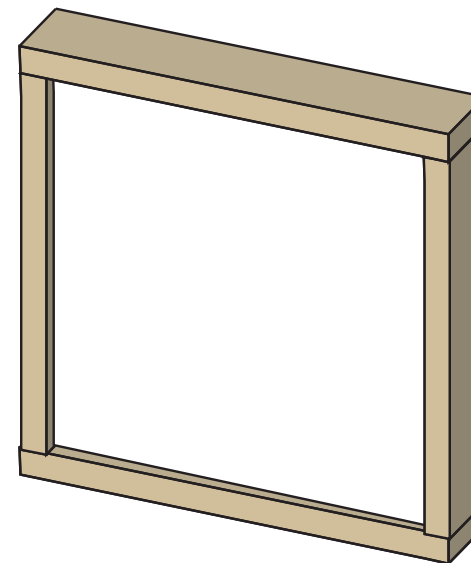
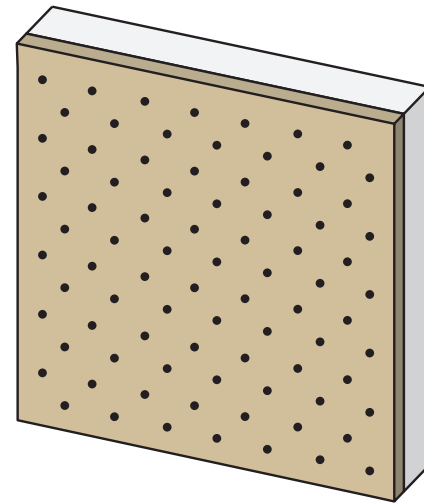
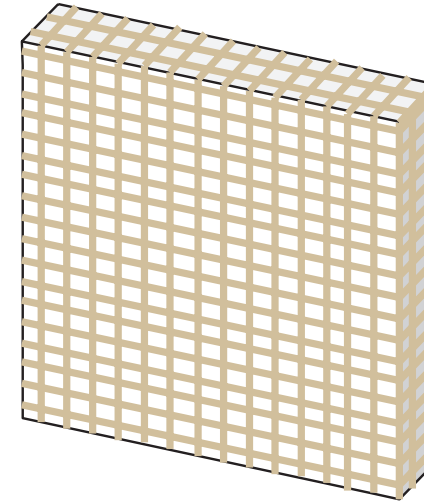
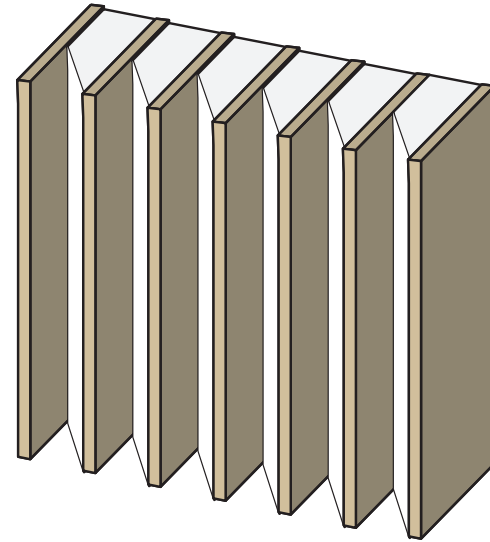
Connections

Narrative

Lifecycle and sustainability

Other acoustic types

Shape



Mycelium design

Topics:

Openness of the surface

Fragility

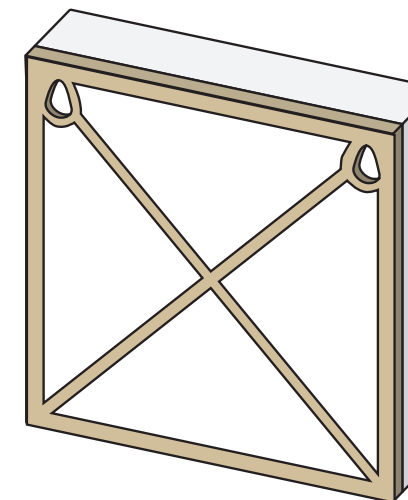
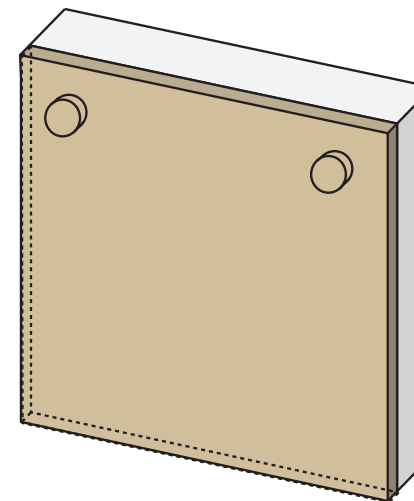
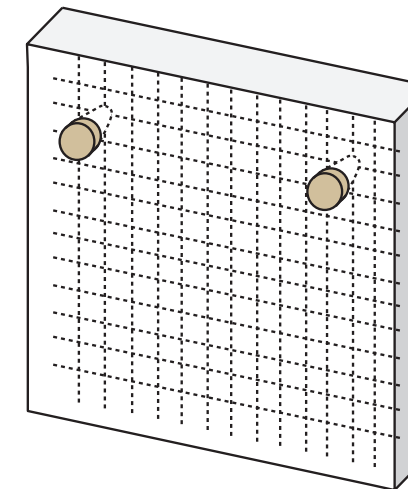
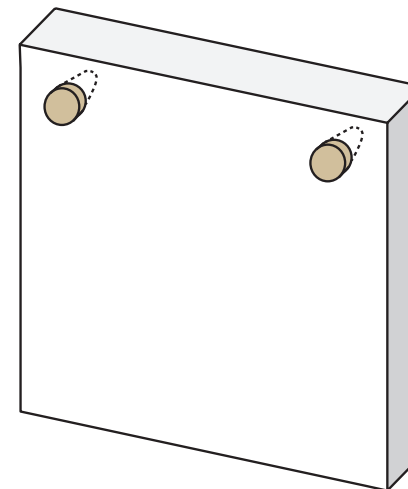
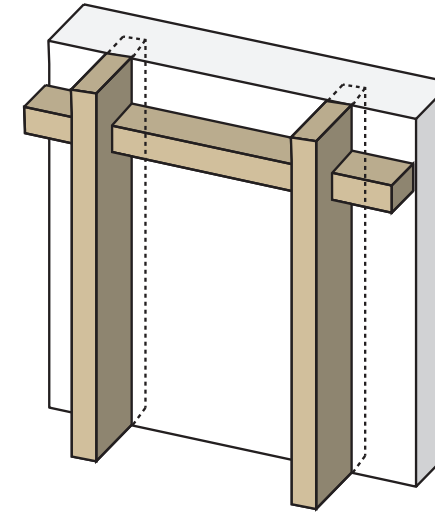
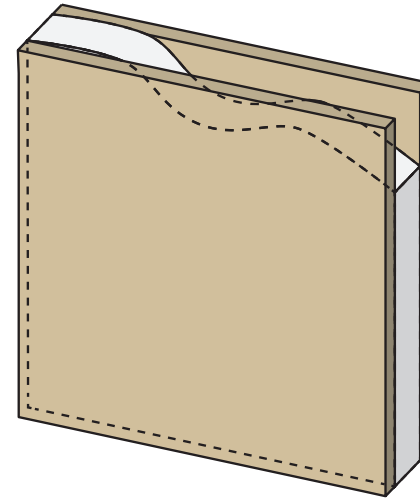
Connections

Narrative

Lifecycle and sustainability

Other acoustic types

Shape



Design outline

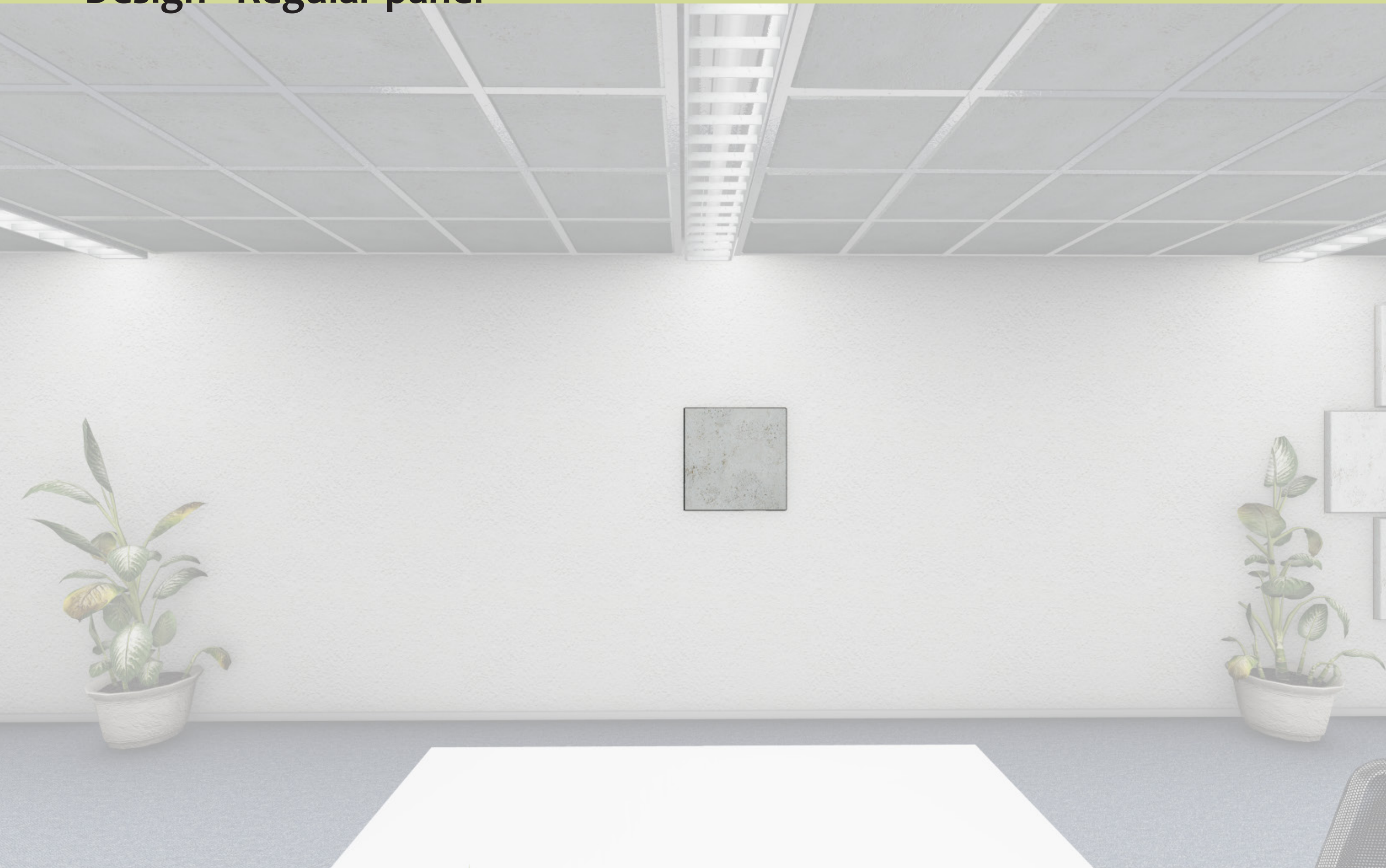
Input for design

- Fragility
- Attachment to other materials

Design

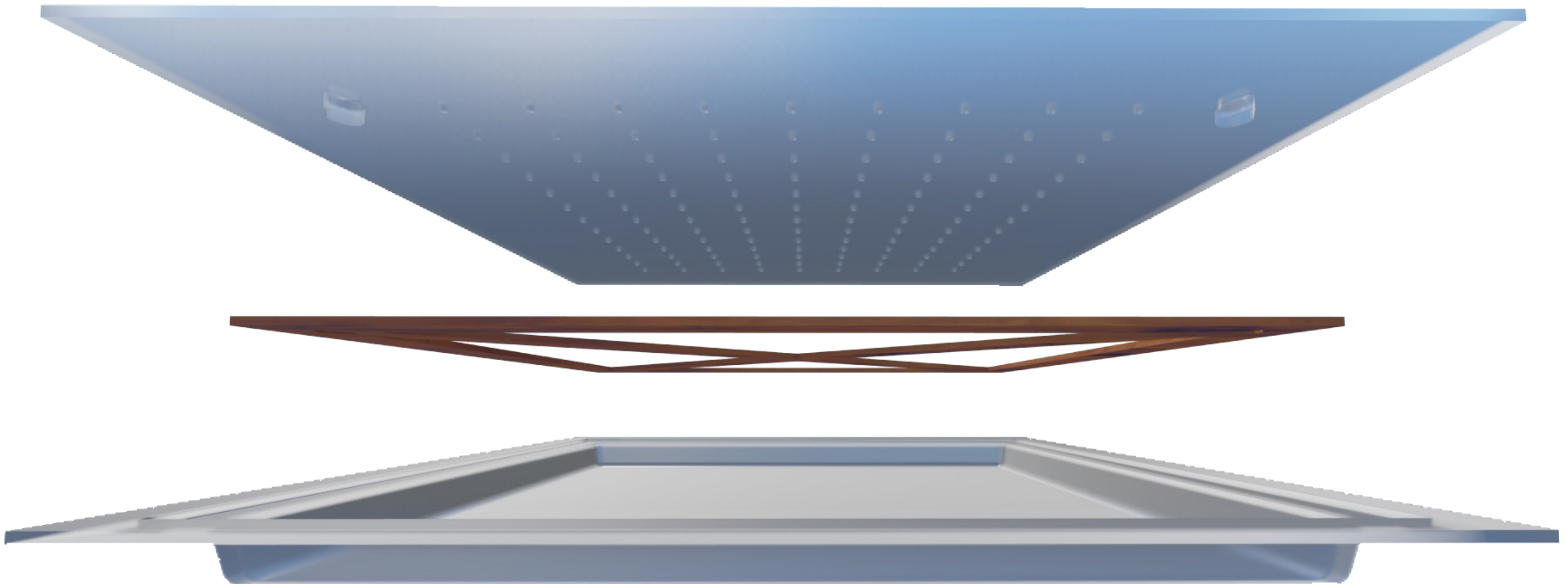
- Simple wall panel
- Backpanel

Design - Regular panel



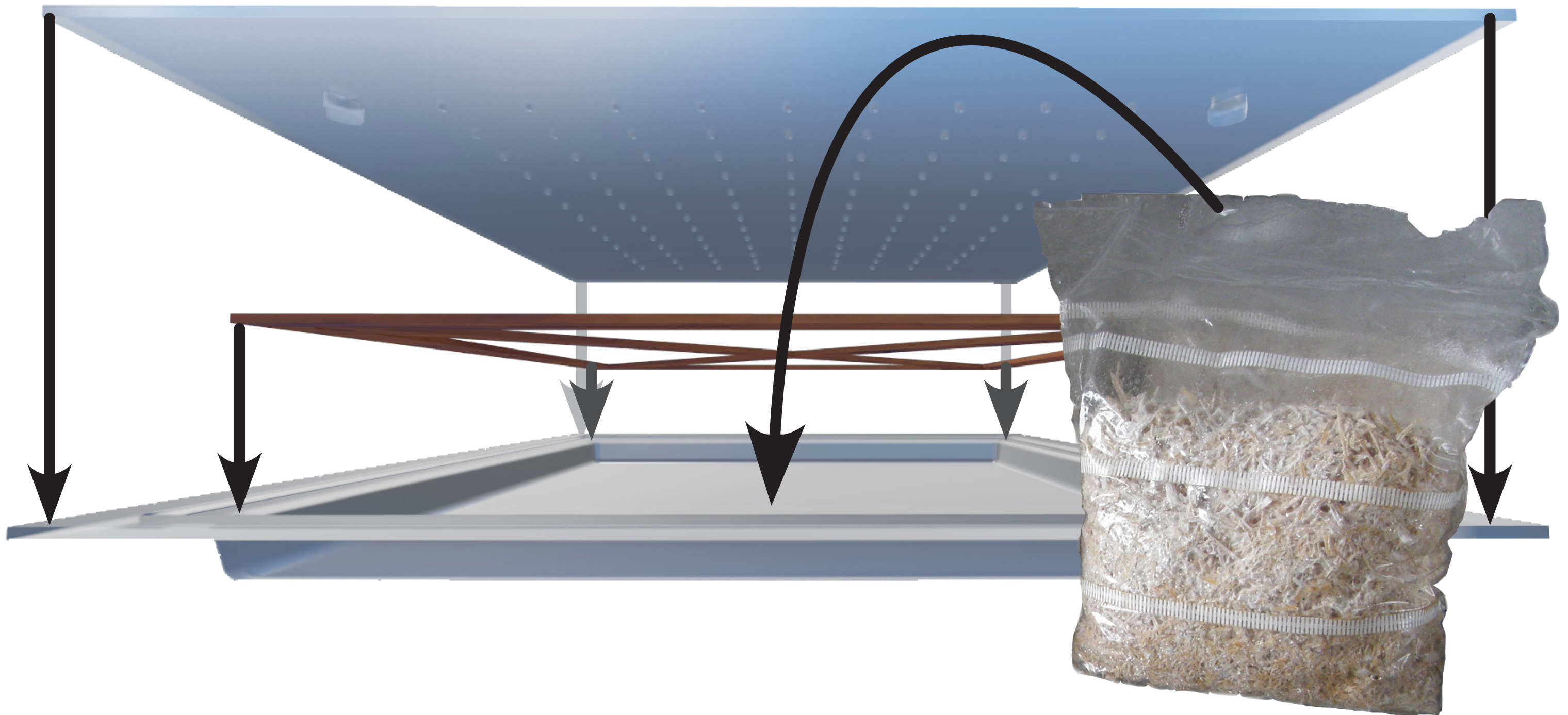
Regular panel

Production



Regular panel

Production



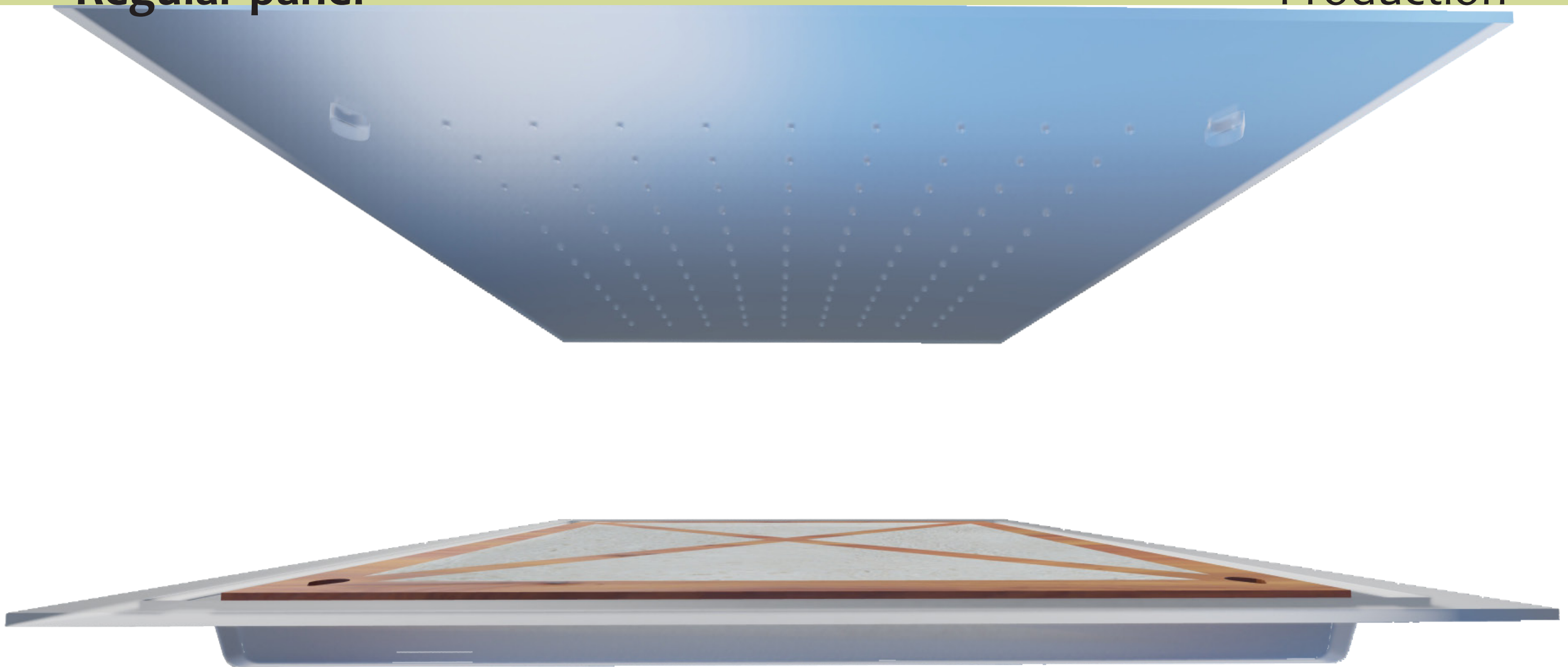
Regular panel

Production



Regular panel

Production



Regular panel

Production



Regular panel



Regular panel

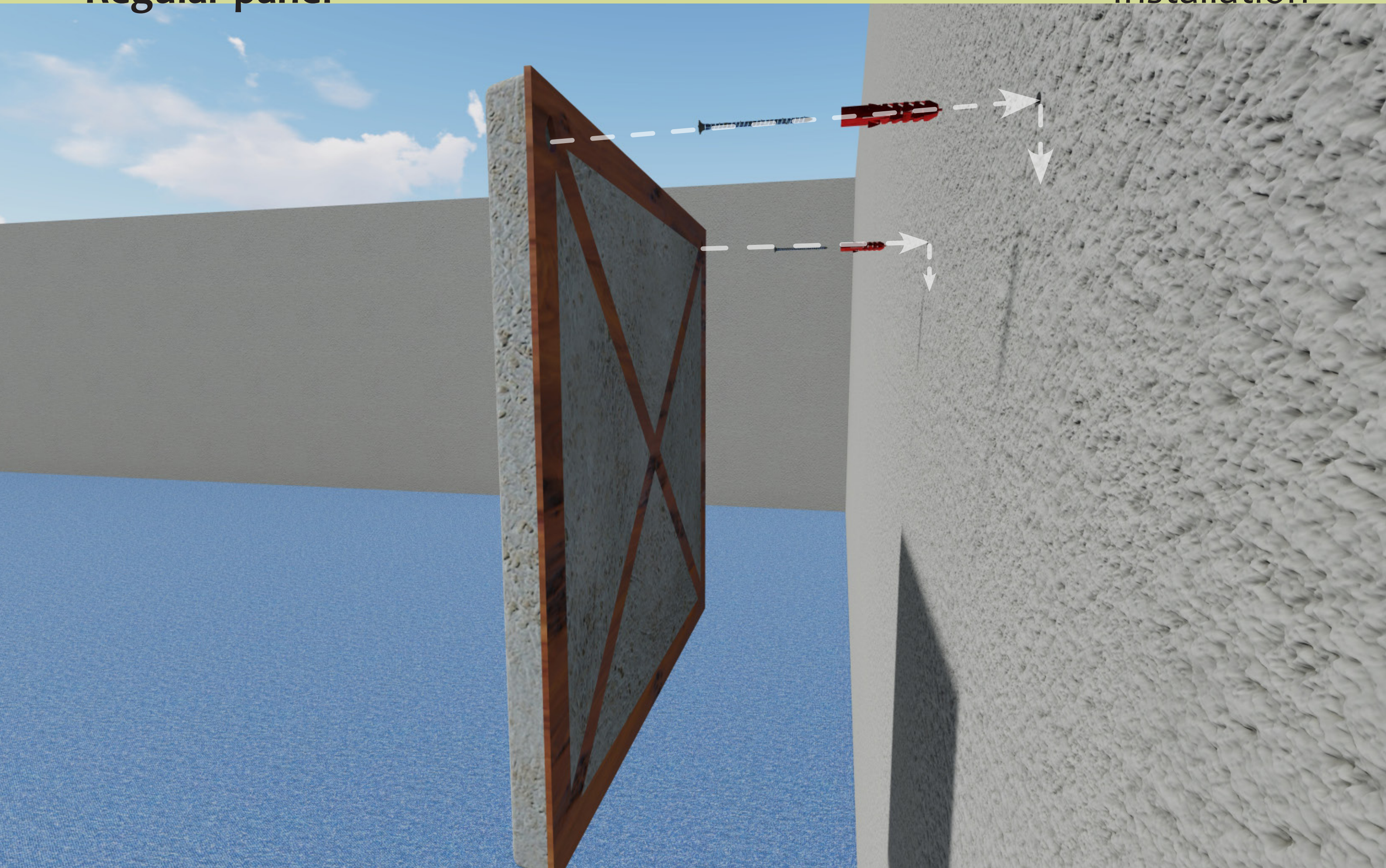


Regular panel



Regular panel

Installation



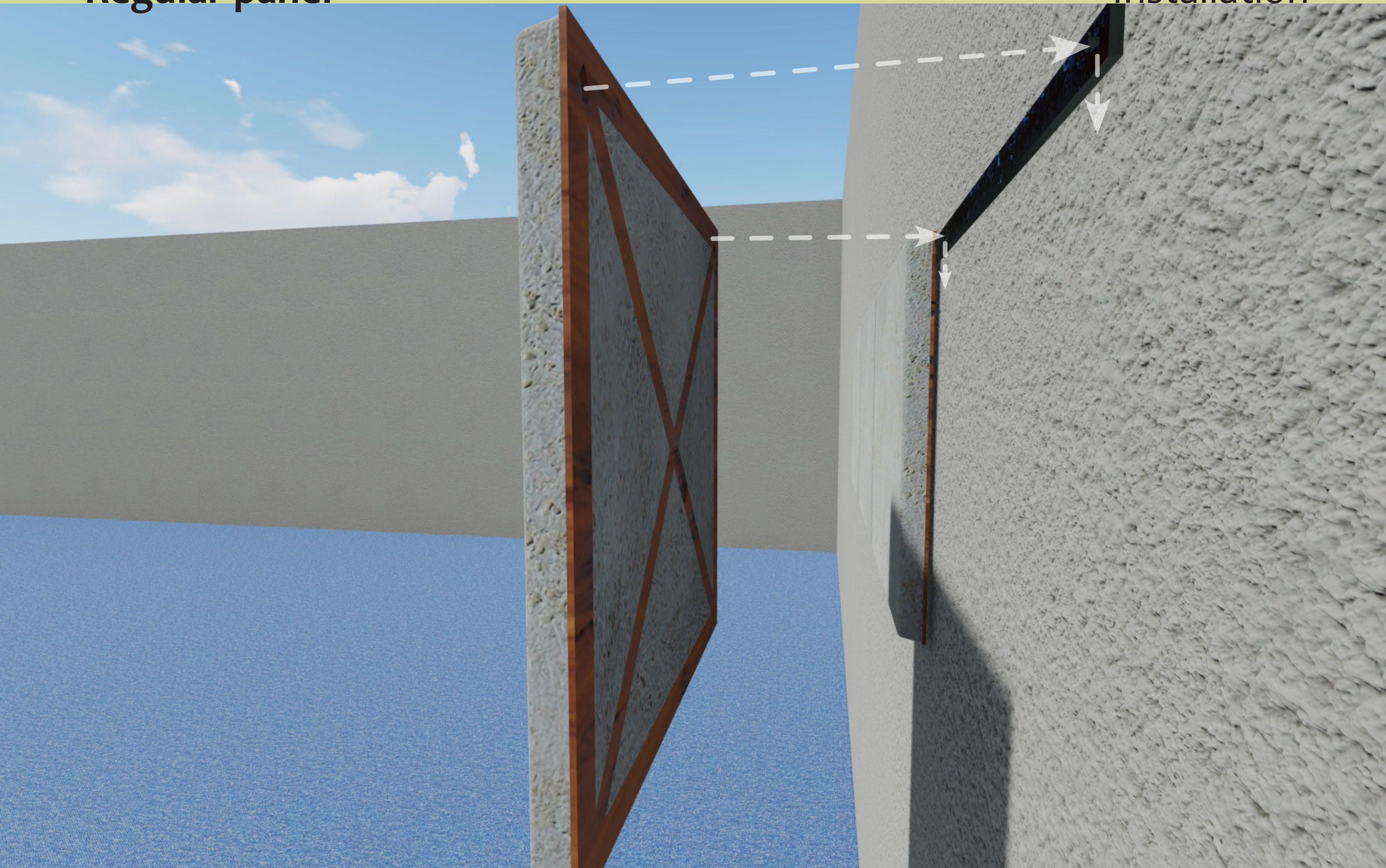
Regular panel

Installation



Regular panel

Installation



Regular panel

Multiple panels



Divder



Divider



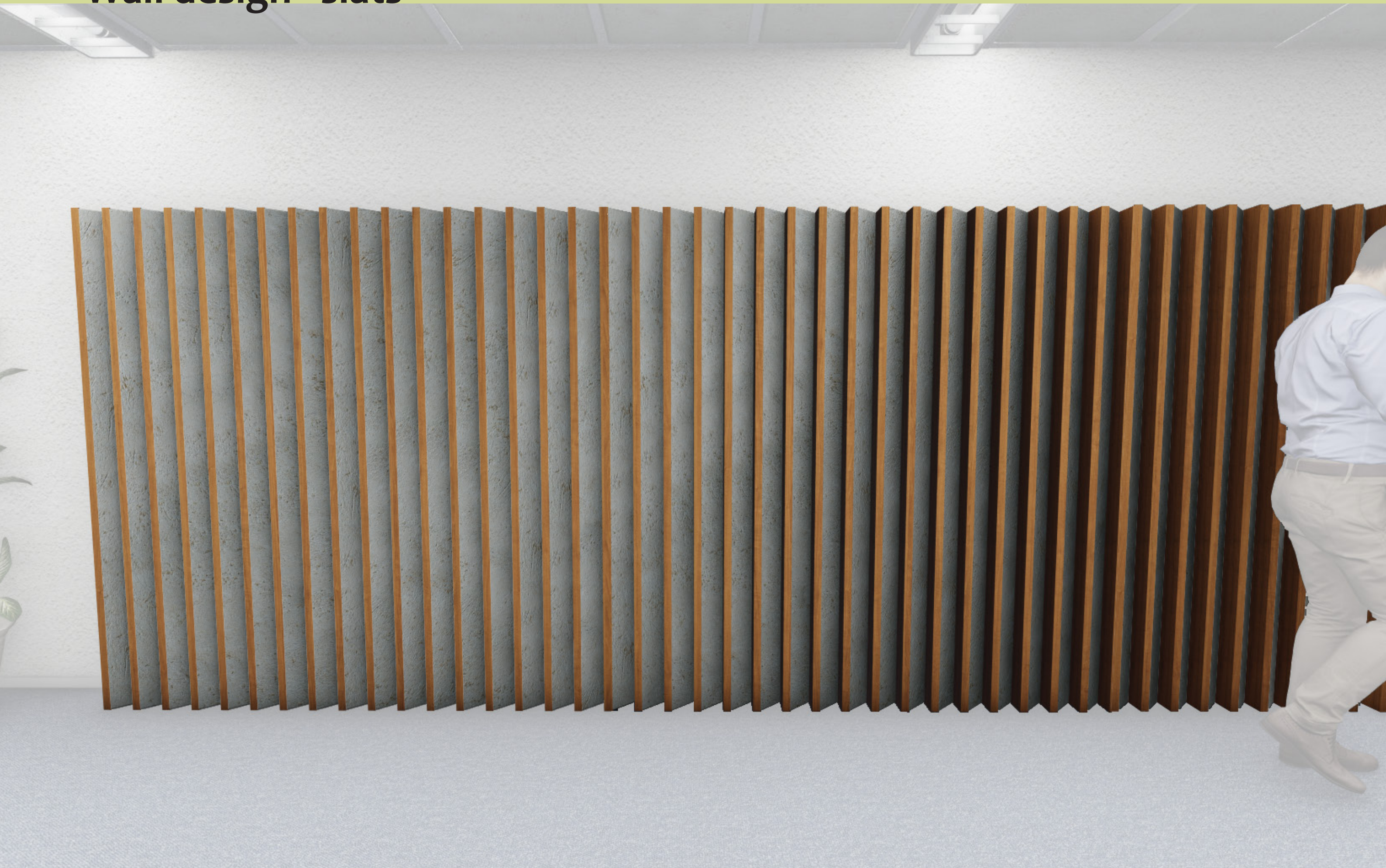
Ceiling tile



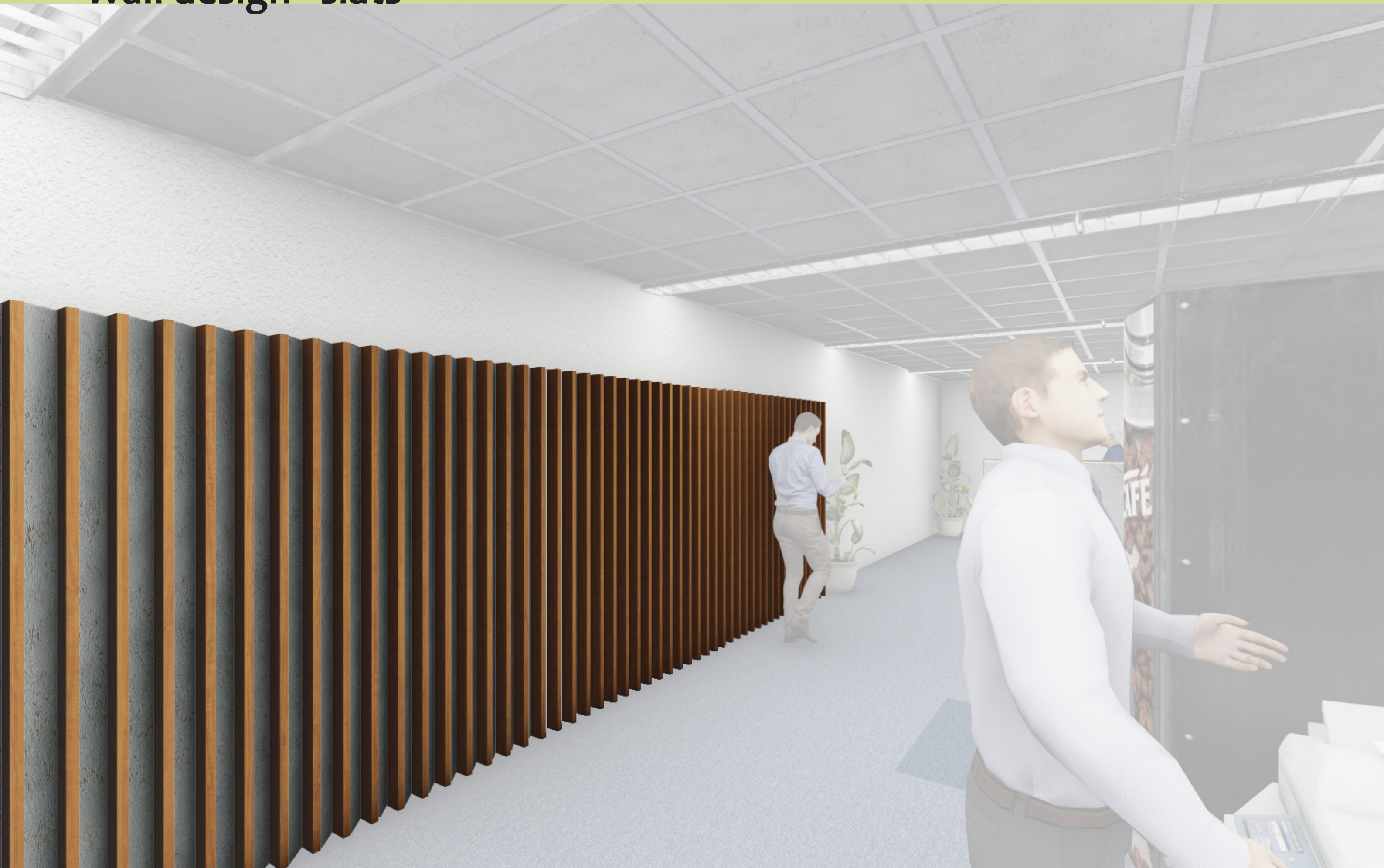
Diffuser



Wall design - slats



Wall design - slats



Compare performance

Compare products

- Conventional
- Bio-based
- Mycelium

Criteria

- Aesthetics
- Acoustics
- Fire safety
- Hygiene/health
- Durability
- Sustainability
- Price

Compare performance

Mycelium



Ecovative Sinewave

Bio-based

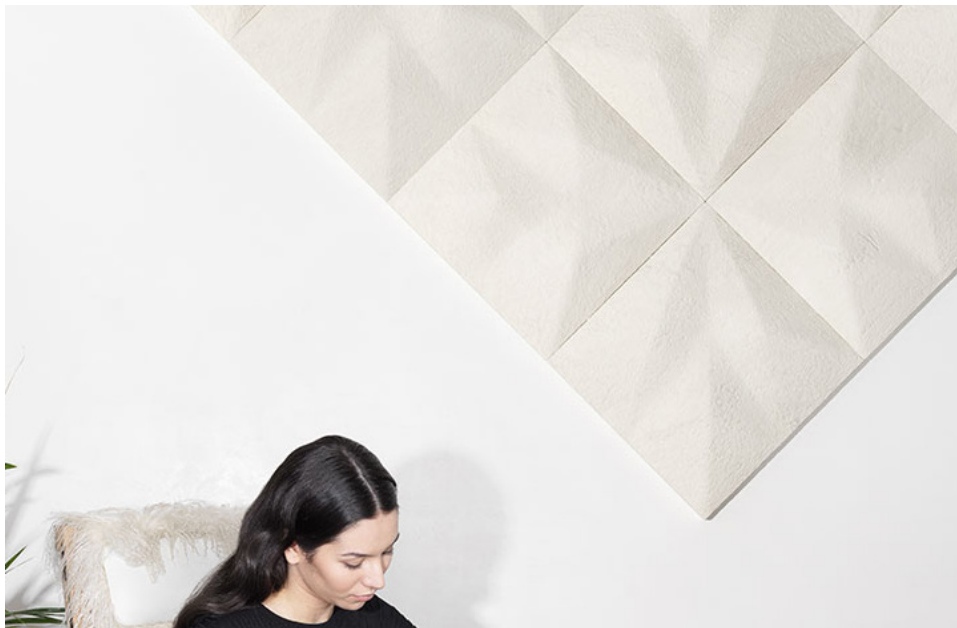


Baux Pulp

Conventional



Kvadrat Clouds



Mogu Kite

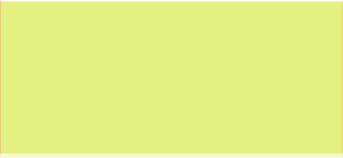
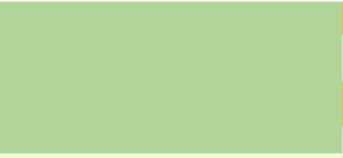
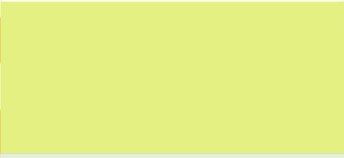


Metisse C Panels

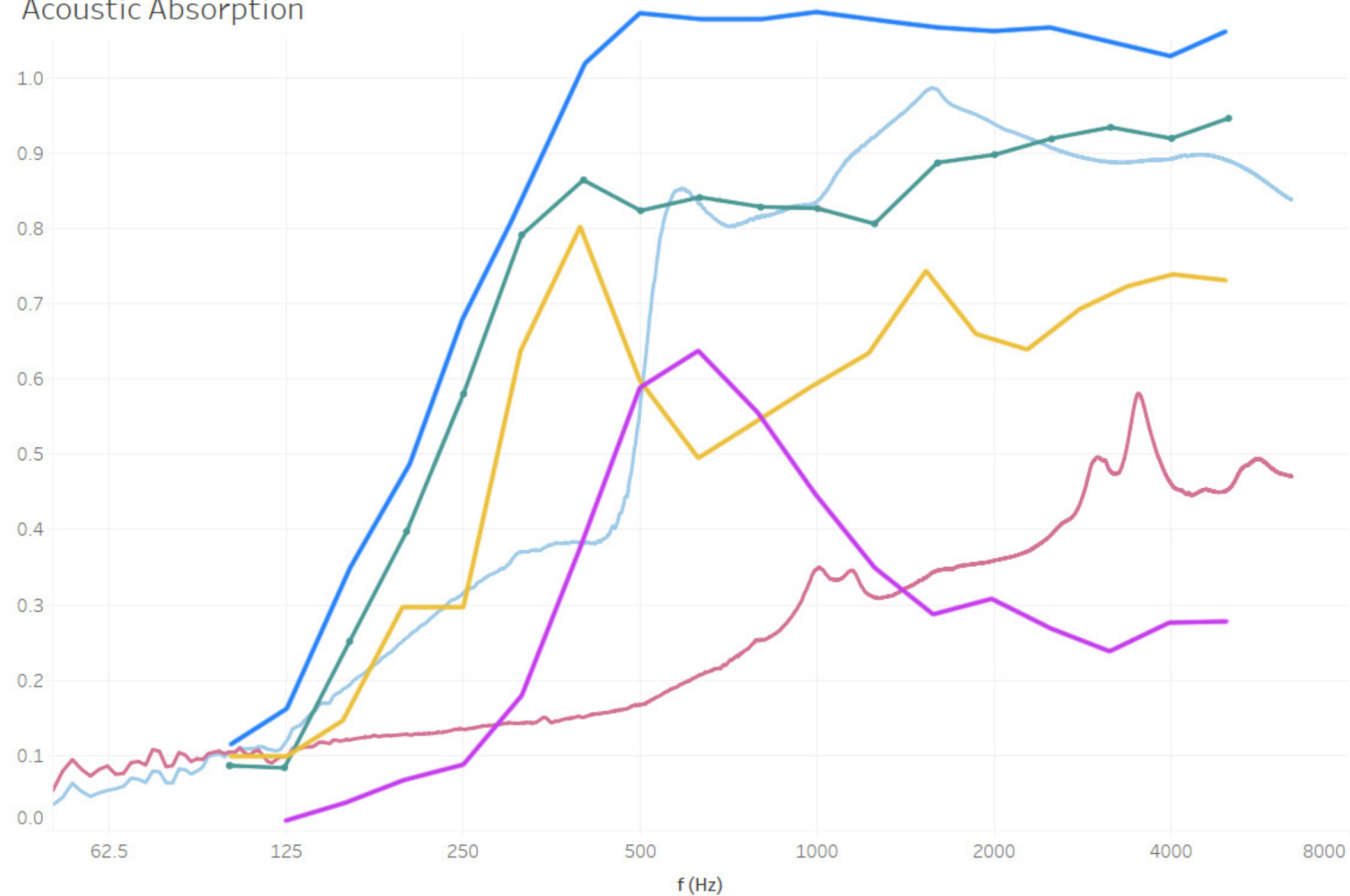


Ecophon Akusto

	Mycelium panel	Ecovative Sinewave	Mogu Kite	Baux Pulp	Métisse C Panel	Kvadrat Clouds	Ecophon Akusto
							
Dimensions (mm ³)	400x400x40	407x407x51	Kite: 500x500x40-75	500x1000x20	600x600x45	8 mm thick, 1 panel= 0.09m2	2700x1200x40
Absorption spectrum (See Figure ..)							
Fire safety (class/smoke/droplets)	D--> B?	US class A - flame spread 20, smoke emmission 50	B-s1-d0	D-s..-d..	B-s1-d0	E-s..-d2	A2-s1-d0
Hygiene (mold/micro organisms)		mold resistant					
Indoor air quality (VOC emmission µg/m2h)	0		10				<1500
Impact resistance							
Water resistance							
Aging					75 year	10 year warranty, regular cleaning	No aging
Recyclability	Compostable	Compostable	Compostable	Compostable	Reuse cotton fibres	PE	Glass wool w. natural binder + metal frame
Source material	Agricultural waste	Agricultural waste	Clothing industry waste	Natural source	Clothing industry waste	Petroleum based	Glass wool + metal
Biodegradability							
Price (€/m2)		211.29			383.33	538.46	221.40

	Mycelium panel	Ecovative Sinewave	Mogu Kite	Baux Pulp	Métisse C Panel	Kvadrat Clouds	Ecophon Akusto
							
Dimensions (mm ³)	400x400x40	407x407x51	Kite: 500x500x40-75	500x1000x20	600x600x45	8 mm thick, 1 panel= 0.09m2	2700x1200x40
Absorption spectrum (See Figure ..)							

Acoustic Absorption



Samples:

-  Mycelium panel
-  Ecovative Sinewave¹
-  Mogu Kite
-  Baux Pulp
-  Métisse C Panel²
-  — Kvadrat Clouds³
-  Ecophon Akusto¹

¹ Impedance tube

² System depth: 600 mm

³ No datam

	Mycelium panel	Ecovative Sinewave	Mogu Kite	Baux Pulp	Métisse C Panel	Kvadrat Clouds	Ecophon Akusto
							
Dimensions (mm ³)	400x400x40	407x407x51	Kite: 500x500x40-75	500x1000x20	600x600x45	8 mm thick, 1 panel= 0.09m2	2700x1200x40
Absorption spectrum (See Figure ..)							
Fire safety (class/smoke/droplets)	D--> B?	US class A - flame spread 20, smoke emmision 50	B-s1-d0	D-s..-d..	B-s1-d0	E-s..-d2	A2-s1-d0
Hygiene (mold/micro organisms)		mold resistant					
Indoor air quality (VOC emmision µg/m2h)	0		10				<1500
Impact resistance							
Water resistance							
Aging					75 year	10 year warranty, regular cleaning	No aging
Recyclability	Compostable	Compostable	Compostable	Compostable	Reuse cotton fibres	PE	Glass wool w. natural binder + metal frame
Source material	Agricultural waste	Agricultural waste	Clothing industry waste	Natural source	Clothing industry waste	Petroleum based	Glass wool + metal
Biodegradability							
Price (€/m2)		211.29			383.33	538.46	221.40

	Mycelium panel	Ecovative Sinewave	Mogu Kite	Baux Pulp	Métisse C Panel	Kvadrat Clouds	Ecophon Akusto
							
Dimensions (mm ³)	400x400x40	407x407x51	Kite: 500x500x40-75	500x1000x20	600x600x45	8 mm thick, 1 panel= 0.09m2	2700x1200x40
Absorption spectrum (See Figure ..)							
Fire safety (class/smoke/droplets)	D--> B?	US class A - flame spread 20, smoke emmision 50	B-s1-d0	D-s..-d..	B-s1-d0	E-s..-d2	A2-s1-d0
Hygiene (mold/micro organisms)		mold resistant					
Indoor air quality (VOC emmision µg/m2h)	0		10				<1500
Impact resistance							
Water resistance							
Aging					75 year	10 year warranty, regular cleaning	No aging
Recyclability	Compostable	Compostable	Compostable	Compostable	Reuse cotton fibres	PE	Glass wool w. natural binder + metal frame
Source material	Agricultural waste	Agricultural waste	Clothing industry waste	Natural source	Clothing industry waste	Petroleum based	Glass wool + metal
Biodegradability							
Price (€/m2)		211.29			383.33	538.46	221.40

	Mycelium panel	Ecovative Sinewave	Mogu Kite	Baux Pulp	Métisse C Panel	Kvadrat Clouds	Ecophon Akusto
							
Dimensions (mm ³)	400x400x40	407x407x51	Kite: 500x500x40-75	500x1000x20	600x600x45	8 mm thick, 1 panel= 0.09m2	2700x1200x40
Absorption spectrum (See Figure ..)							
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Indoor air quality (VOC emmission µg/m2h)	0			10			<1500
Impact resistance							
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Aging					75 year	10 year warranty, regular cleaning	No aging
Recyclability	Compostable	Compostable	Compostable	Compostable	Reuse cotton fibres	PE	Glass wool w. natural binder + metal frame
Source material	Agricultural waste	Agricultural waste	Clothing industry waste	Natural source	Clothing industry waste	Petroleum based	Glass wool + metal
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Price (€/m2)		211.29			383.33	538.46	221.40

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Compare performance

Conclusion

- + Acoustics
- + Sustainability
- Fragile
- Aging?

Research question

*“What are the **specific qualities** of this material and how can it be used in an **acoustic building product**?”*



Conclusion

- Good acoustic performance
- Good indication on how to influence this
- Proven acoustic panels can be grown
- Found issues and possibilities in design



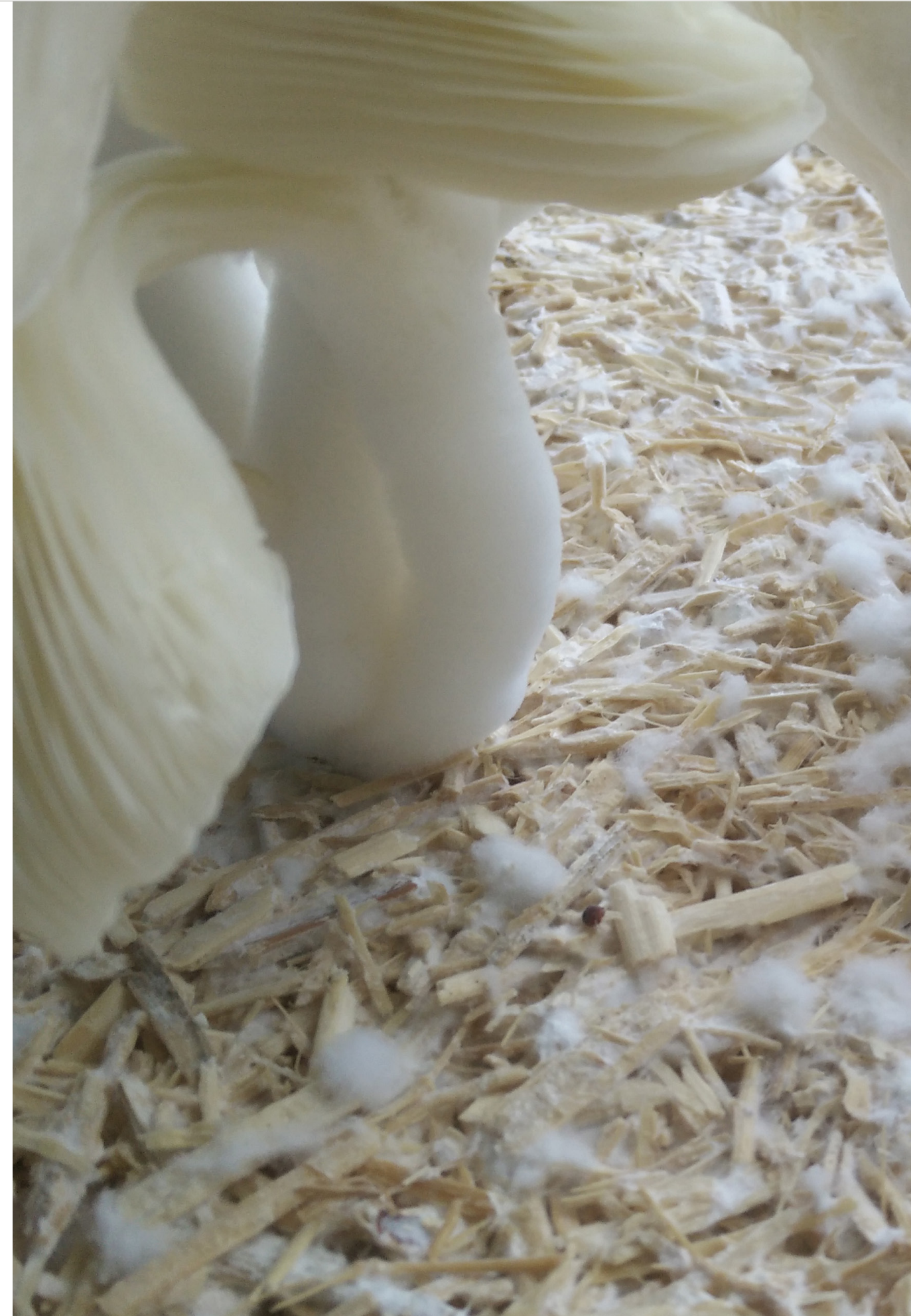
Recommendations

This graduation project:

- Impedance tube test Turkey tail
- Low values E400 mounting?
- Design: practical approach, more prototyping

Further study:

- Further research other properties
- More interdisciplinary research



A photograph of a room with light-colored walls and a concrete floor. In the background, there is a grey door. On the left, a black speaker is mounted on a black tripod. In the foreground, a large, rectangular wooden frame sits on the floor, containing a light-colored, textured material. The text "Thank you for your attention!" is overlaid in the center of the image.

Thank you for your attention!