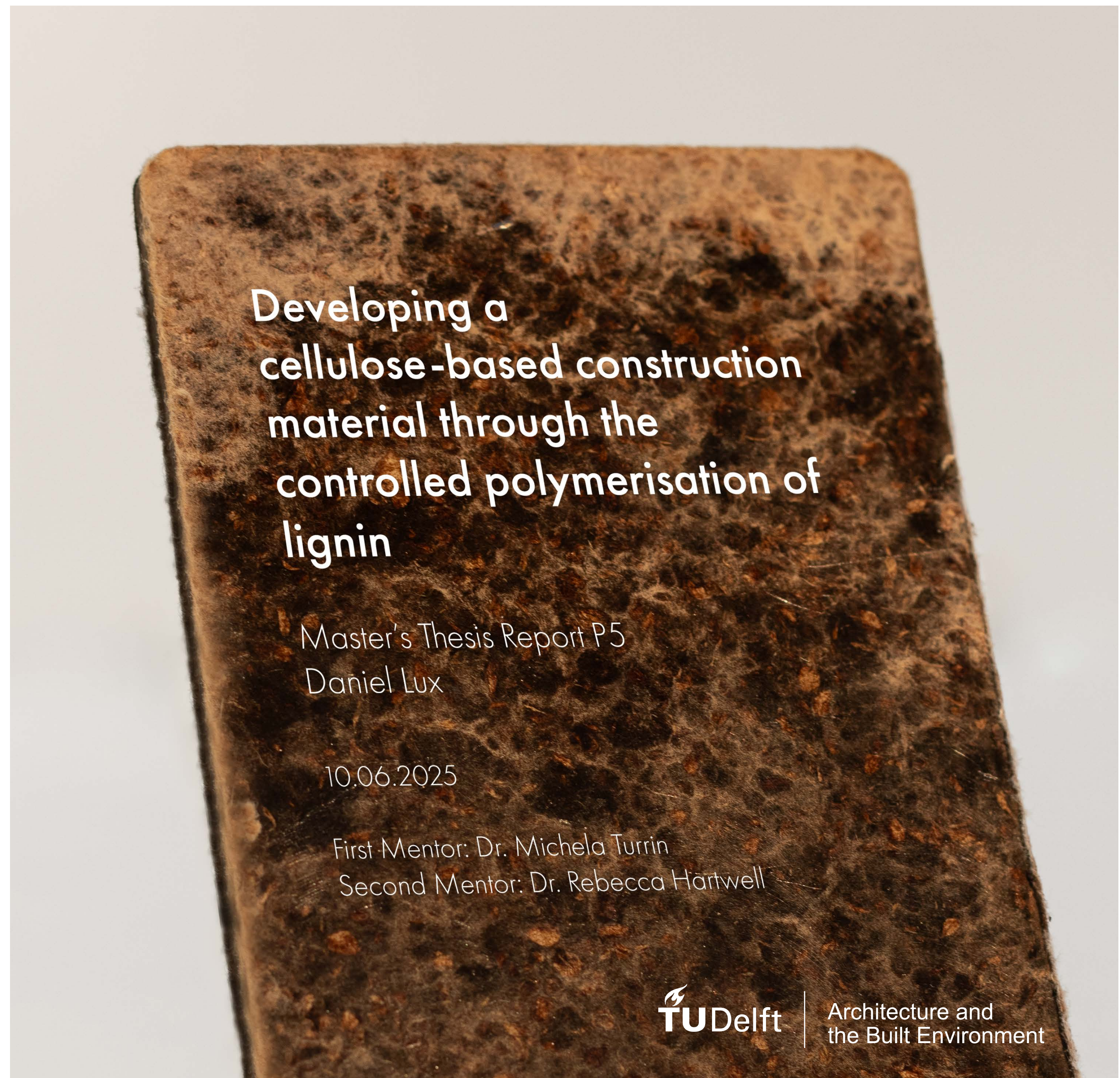


Daniel Lux

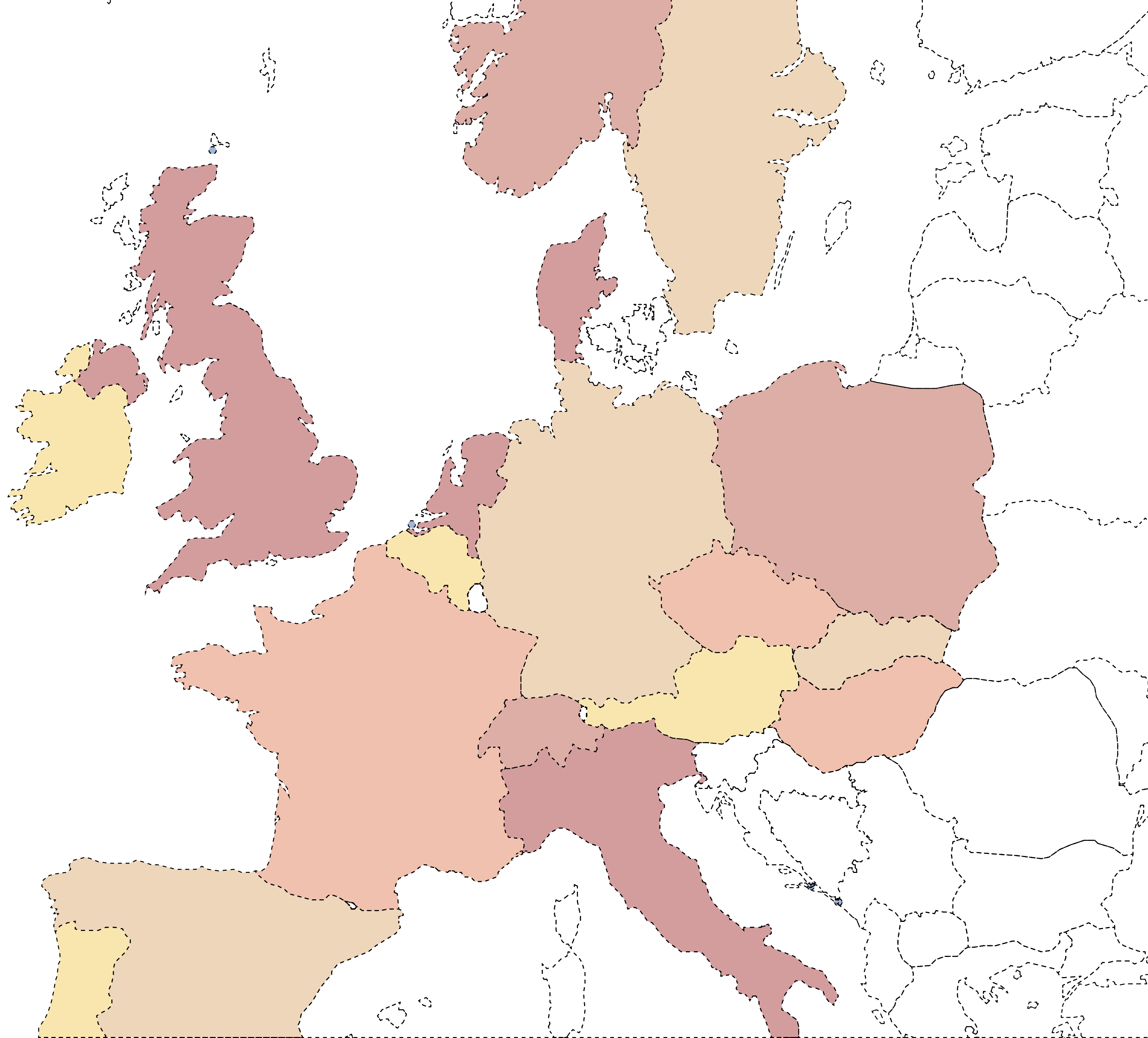
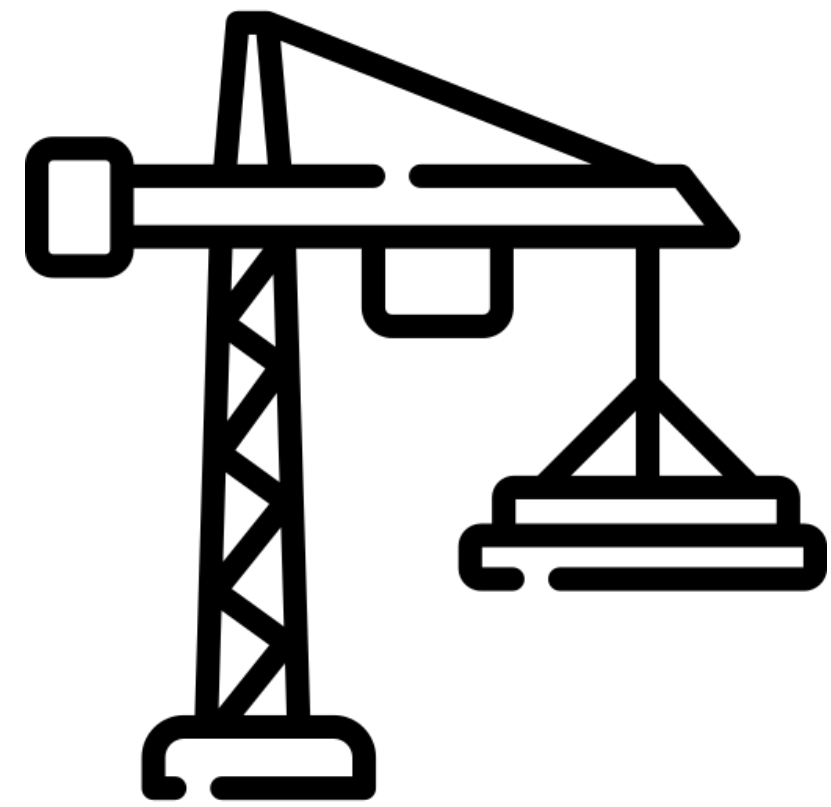
Wood without Trees

P5 Presentation

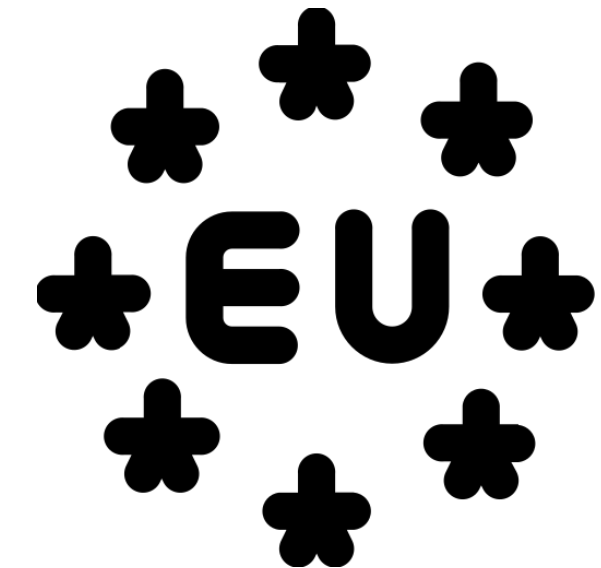
17.06.2025



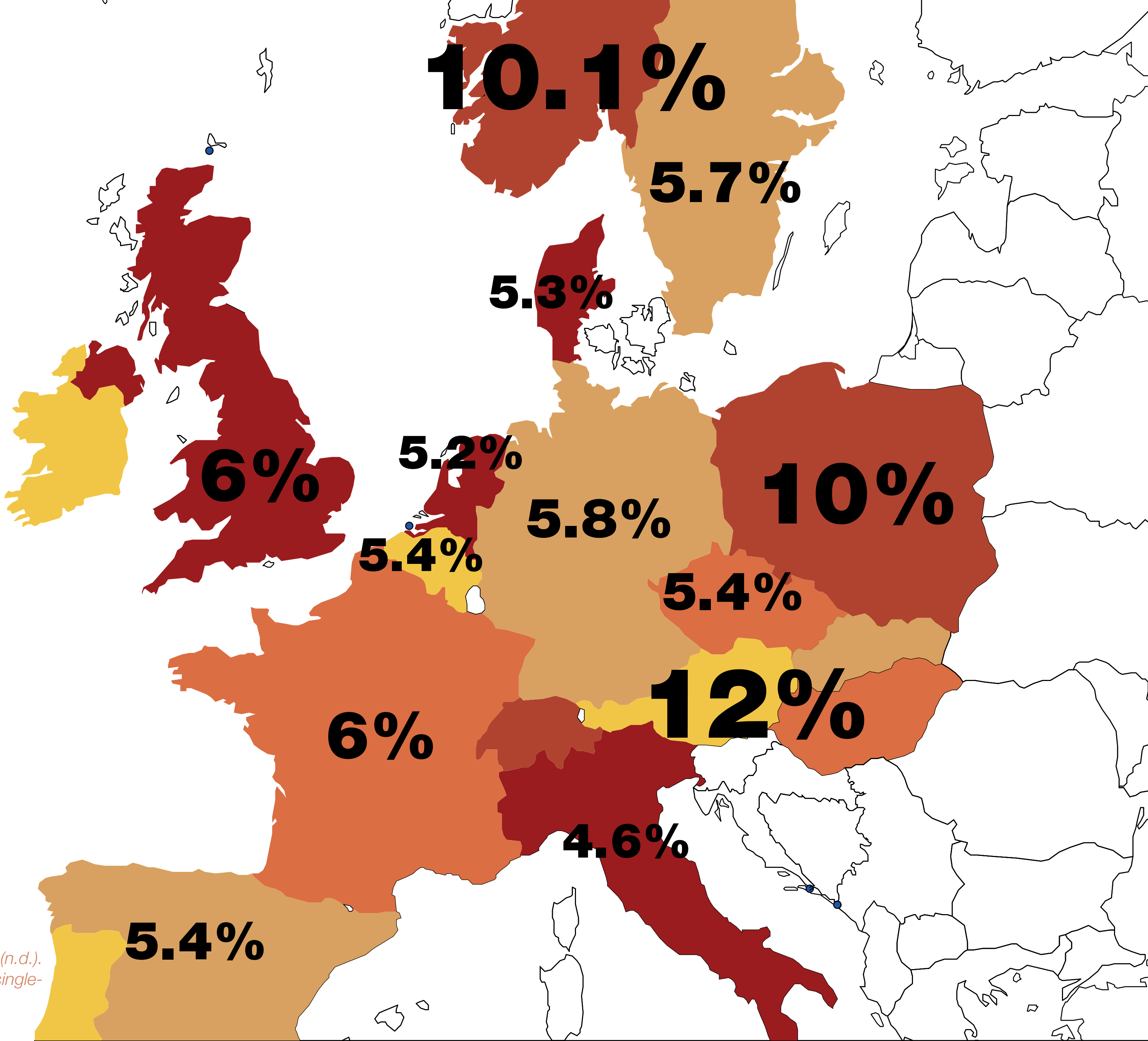
Construction Demand



Construction Sector Size Per Nation in % of GDP



~9%*



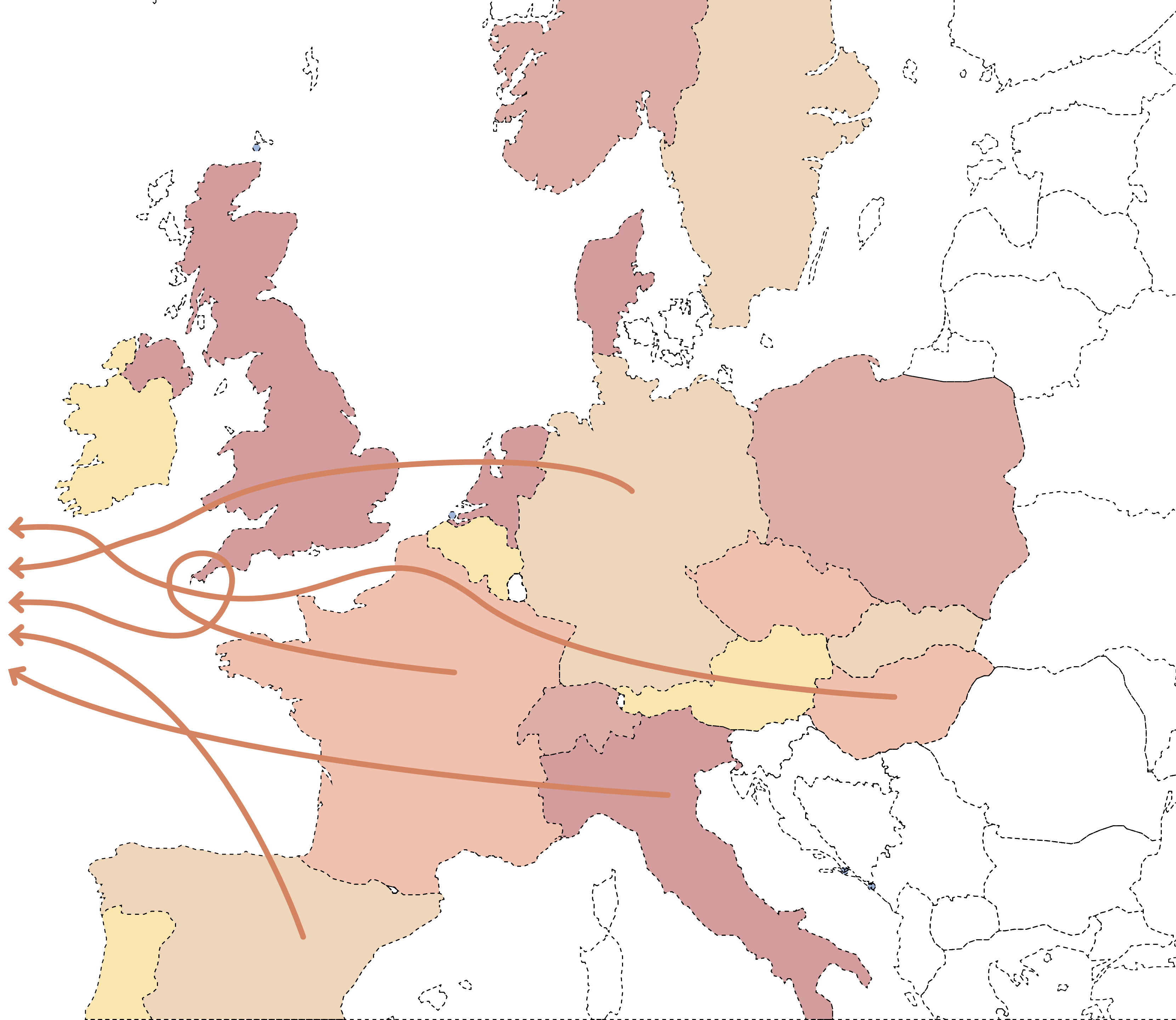
3 *Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. (n.d.). Construction sector. European Commission. Retrieved June 12, 2025, from https://single-market-economy.ec.europa.eu/sectors/construction_en

Waste Production

Construction and Demolition Waste



Largest Waste-Stream of EU



50%

**Consumption
of Extracted
Virgin
Materials***



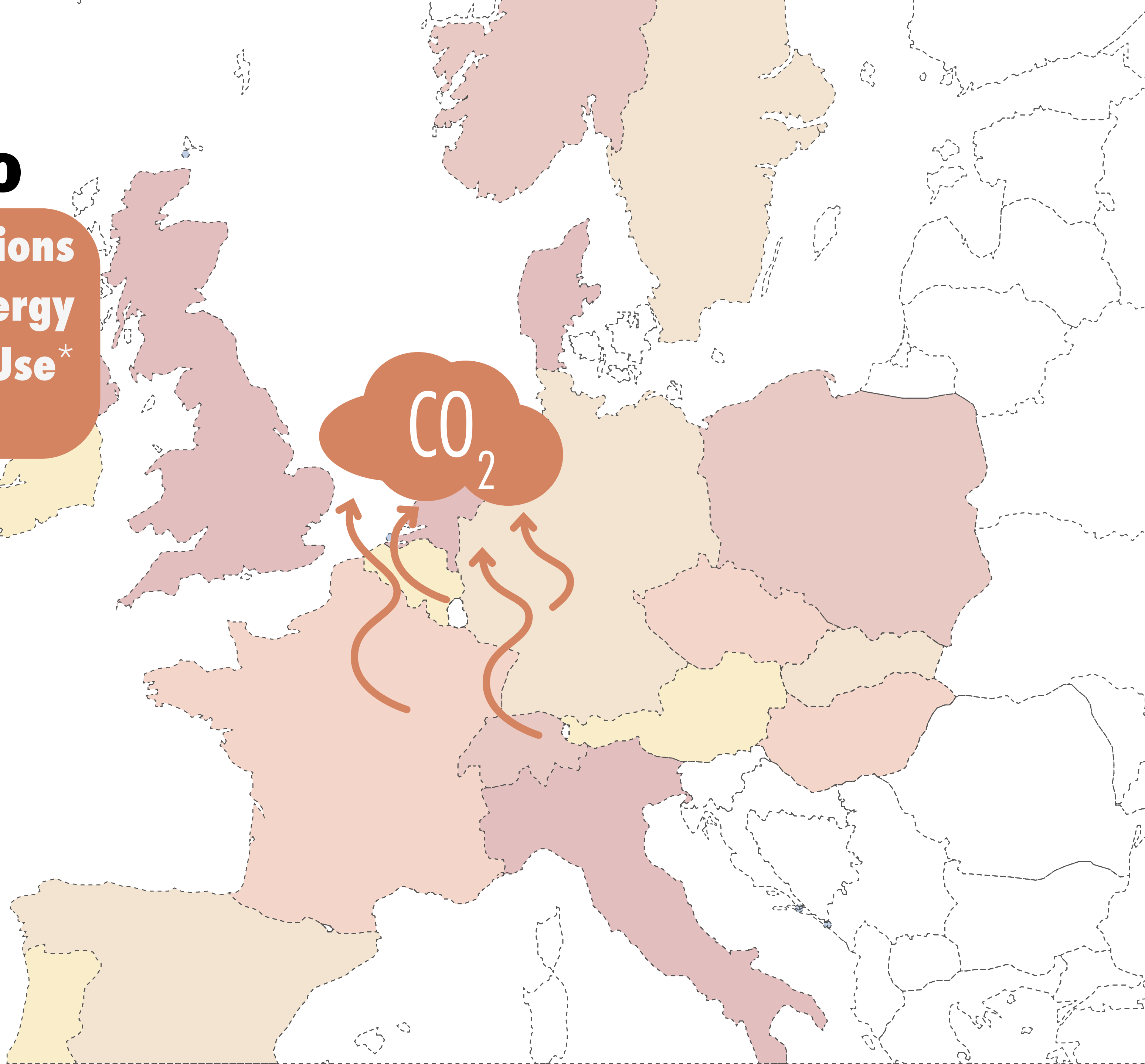
36%

**Emissions
from Energy
Use***



Contributes to Major Challenges

**↑ Material
Scarcity & ↑ Climate
Impact**



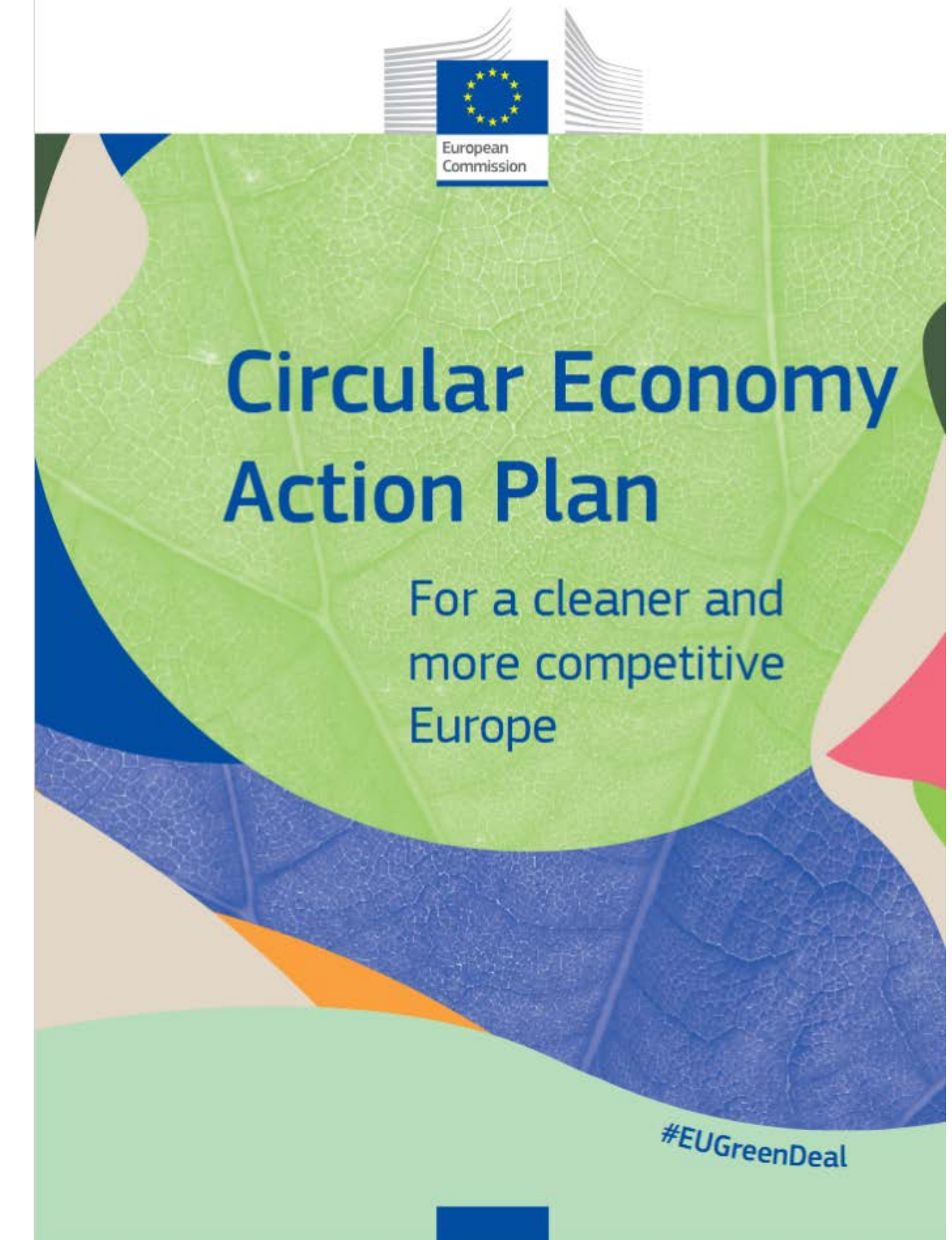


Image from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fop.europa.eu%2Fde%2Fpublication-detail%2F-%2Fpublication%2F45cc30f6-cd57-11ea-adf7-01aa75ed71a1%2Flanguage-en&psig=AOvVaw3waOFdB8oGE2tJ-JwcXkwA&ust=1750327437215000&source=images&opi=89978449>

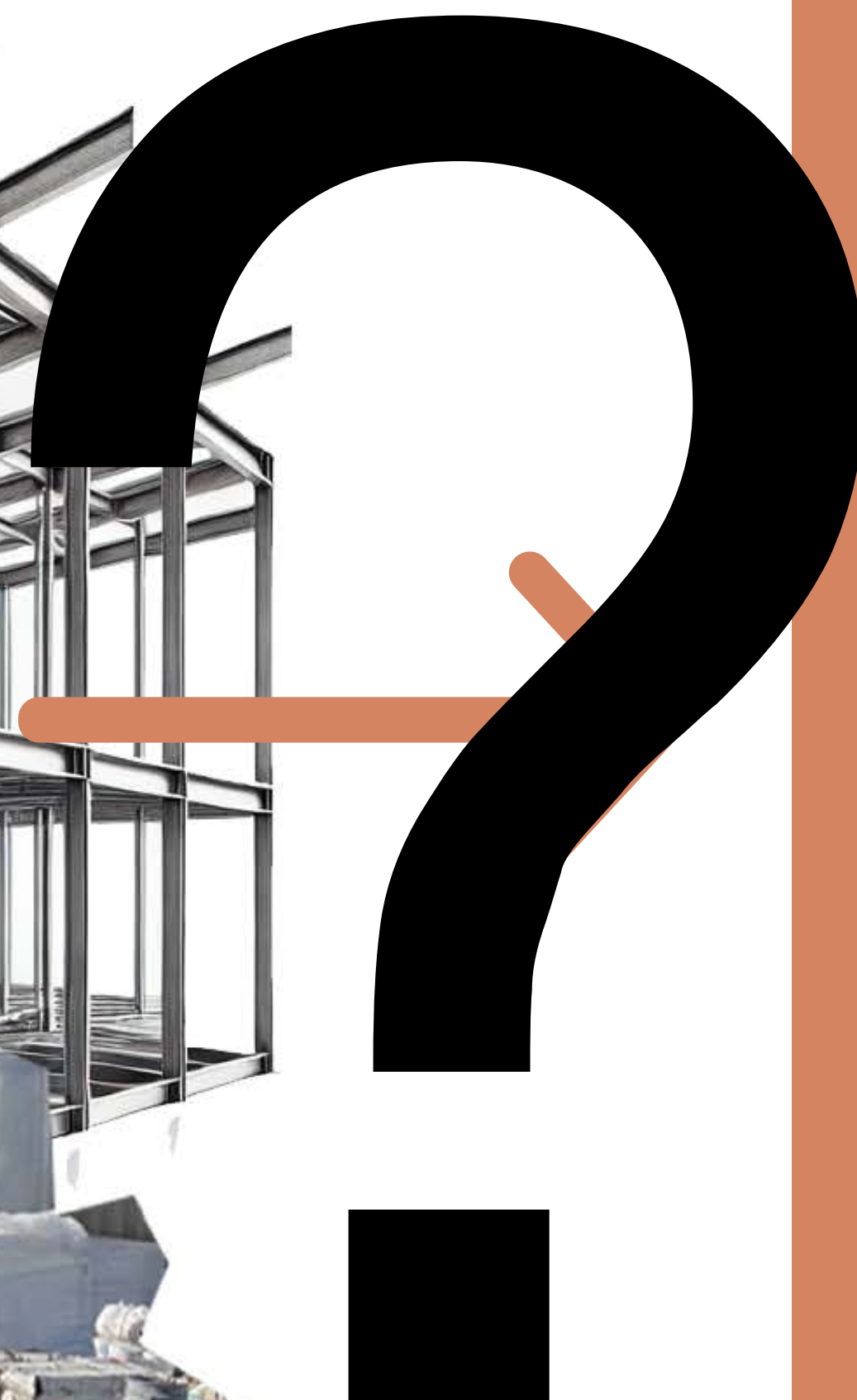
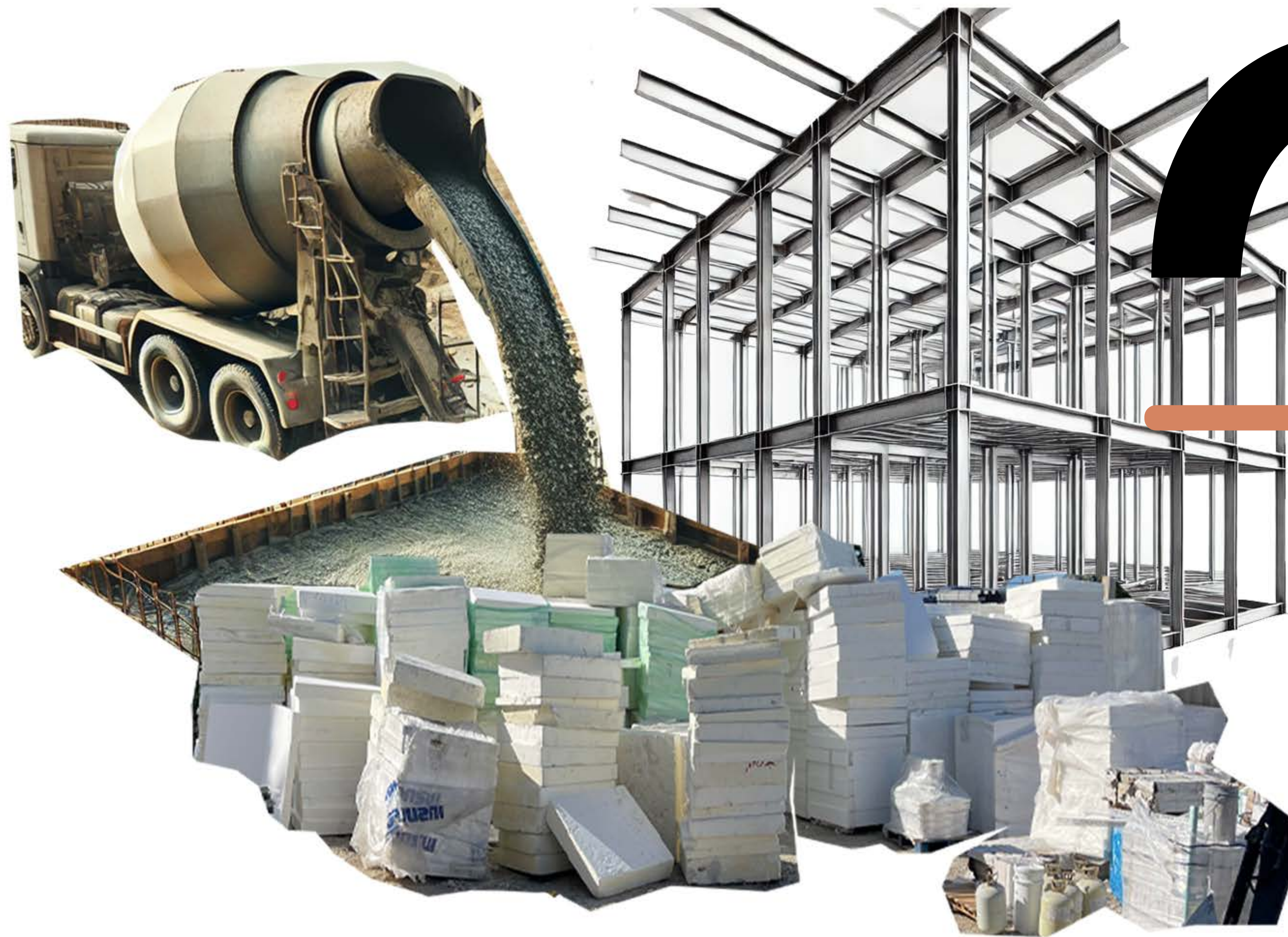


Renewable Resources



Lower embodied
Carbon

Regenerable
within a human
timeframe

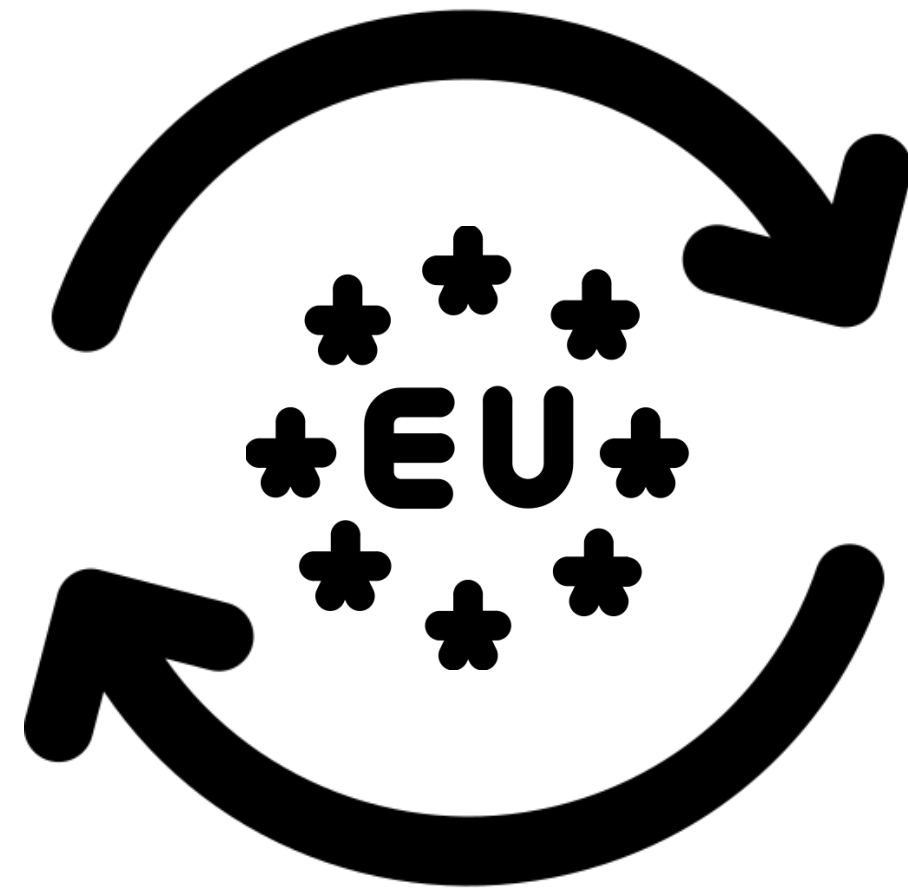


Renewable Resources

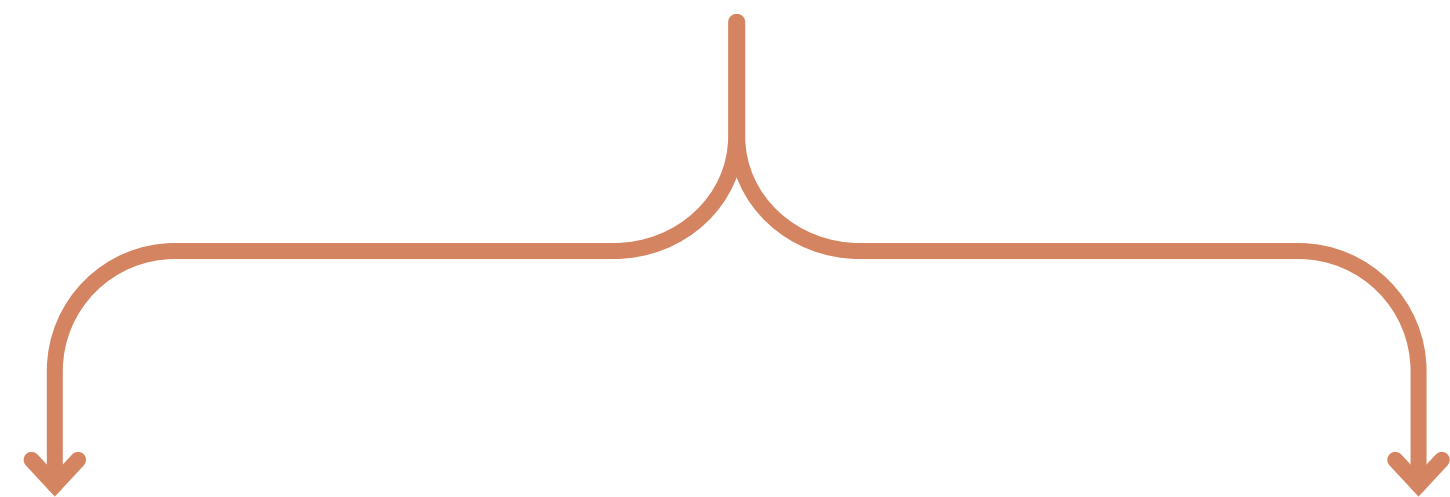


Lower embodied
Carbon

Regenerable
within a human
timeframe



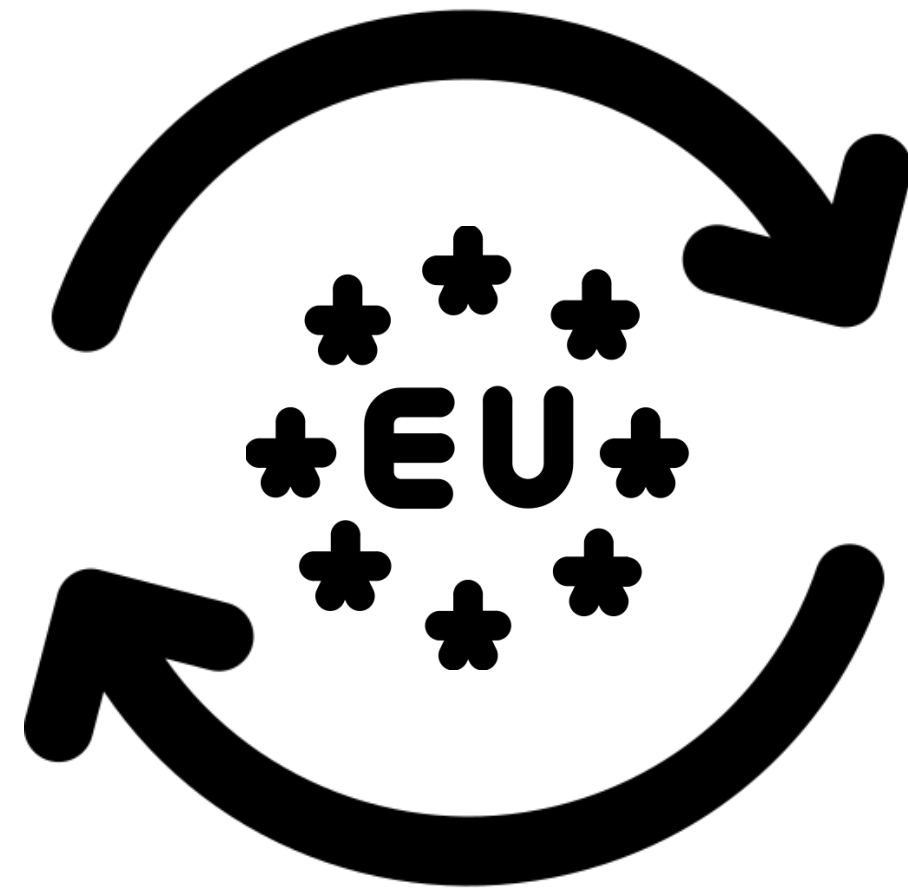
Circular Economy by 2050



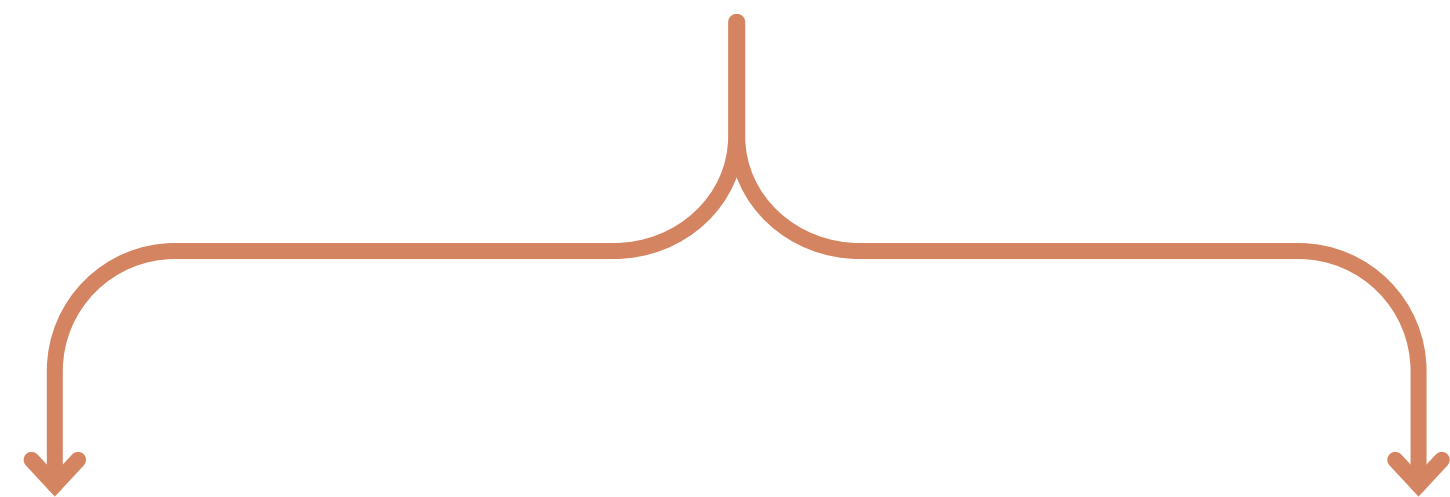
**Reduced Waste
Production**

**Waste
Utilisation**

The global material consumption should be fully circular by 2050. All materials streams are closed circles. No waste! No greenhouse gas emissions!¹



Circular Economy by 2050



**Reduced Waste
Production**

**Waste
Utilisation**

The global material consumption should be fully circular by 2050. All materials streams are closed circles. No waste! No greenhouse gas emissions!¹



Cellulose



Cellulose-containing waste, is almost immeasurable.
5 mill. tons of paper waste annually² in germany alone.

Lignin



50 -70 million tons of Lignin from the Kraft Process³, and largely not utilized 98%⁴ is being used for energy production

² (Waste Management in Germany 2023 — Facts, Data, Figures, 2023), ³(Bajwa et al., 2019), ⁴ (Global Lignin Market Report 2023-2033 with Profiles of 75+ Lignin Producers - ResearchAndMarkets.Com, 2023)

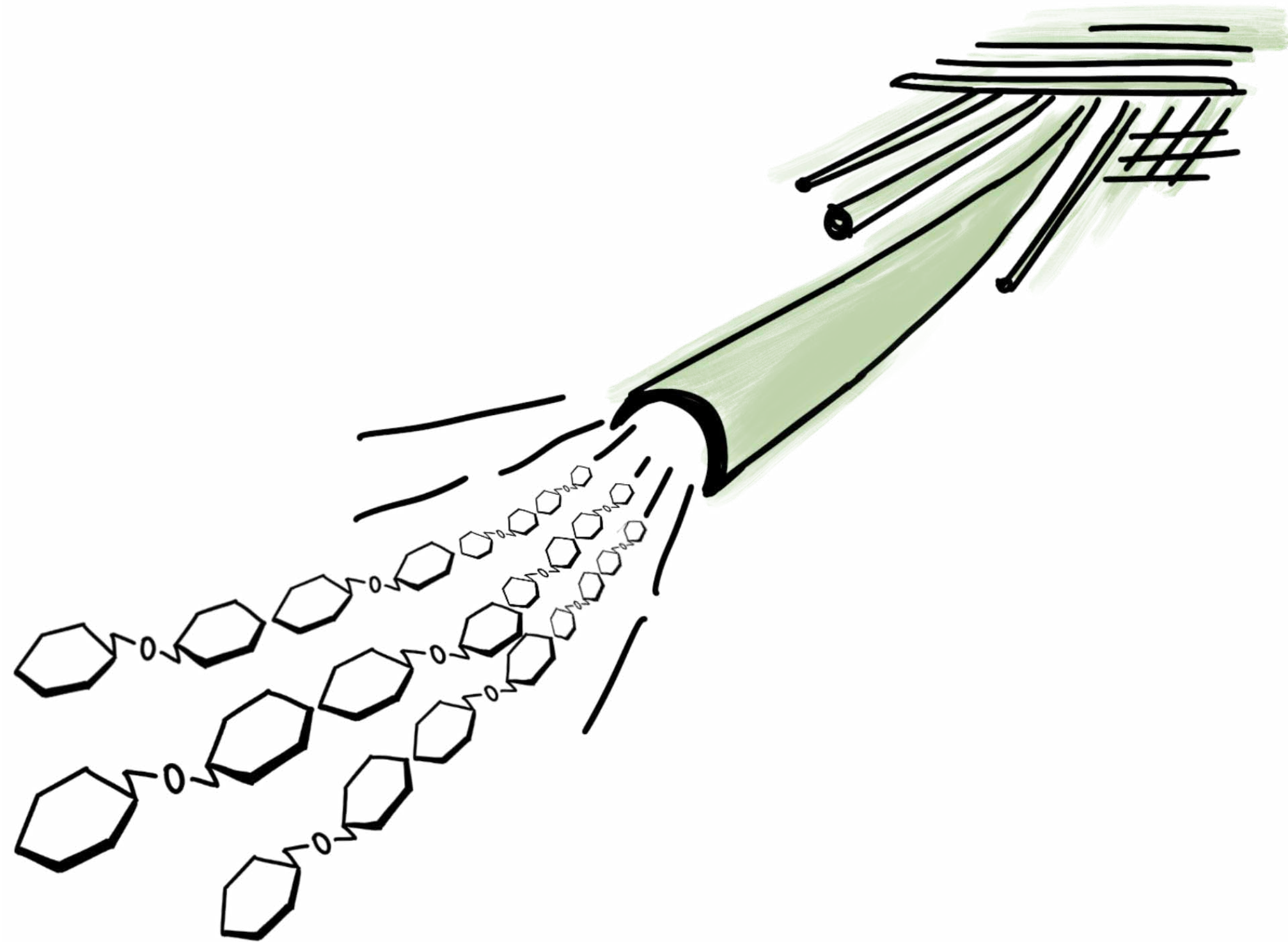


Isocell insulation material, from: <https://www.isocell.com/en/product/zellulose>



Three different lignin types, from: <https://carboncredits.com/what-is-lignin-definition-uses-and-processes/>

Cellulose Fibril

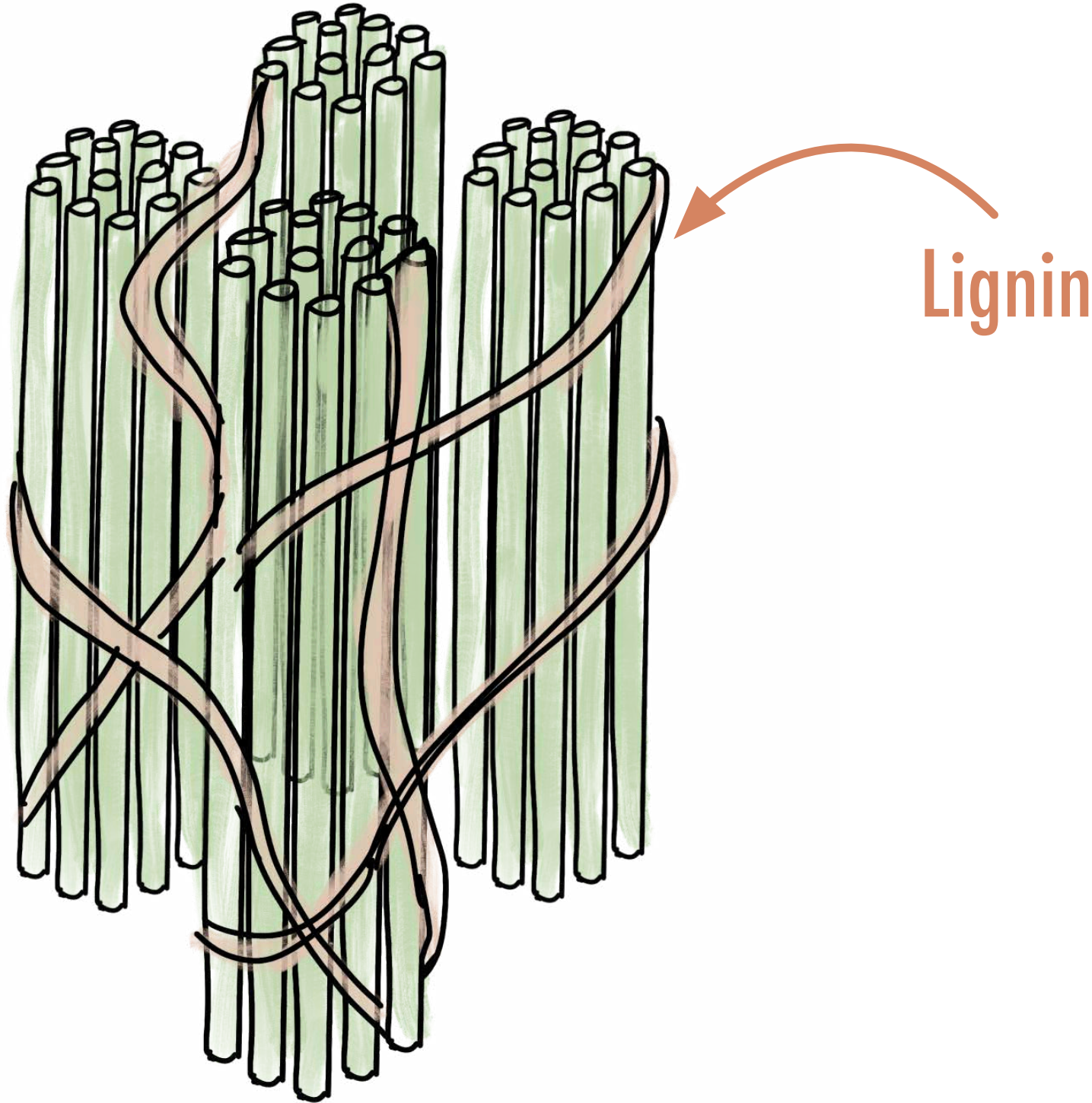


Crystalline cellulose of elementary fibrils:

Tensile strength f_t : 7.5 - 7.7 GPa
E-Modulus E: 140-150 GPa

Glass	Steel S275
7 GPa	430 MPa
50-125 GPa	210 GPa

Cellulose Fibril

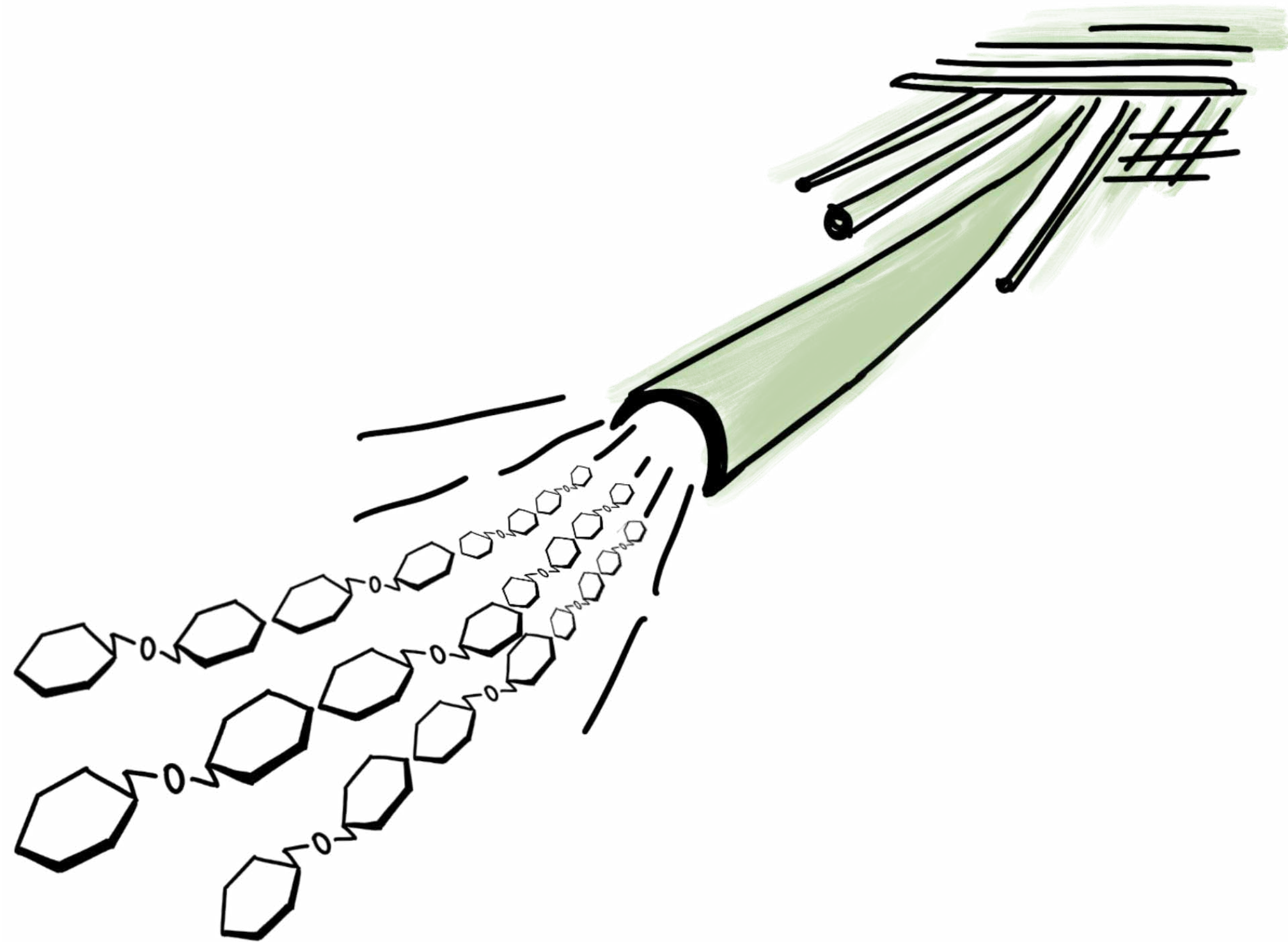


Technical Lignin natural adhesive properties

Cross-linking of polymers exhibits
"exceptional adhesive properties"¹

¹ Yan, L., Liu, H., Wang, R., Dai, L., Yuan, Z., & Si, C. (2025). Hot-pressing-assisted fabrication of high-lignin-content and self-crosslinked strong adhesives. Chemical Engineering Journal, 514, 163215. <https://doi.org/10.1016/j.cej.2025.163215>

Cellulose Fibril

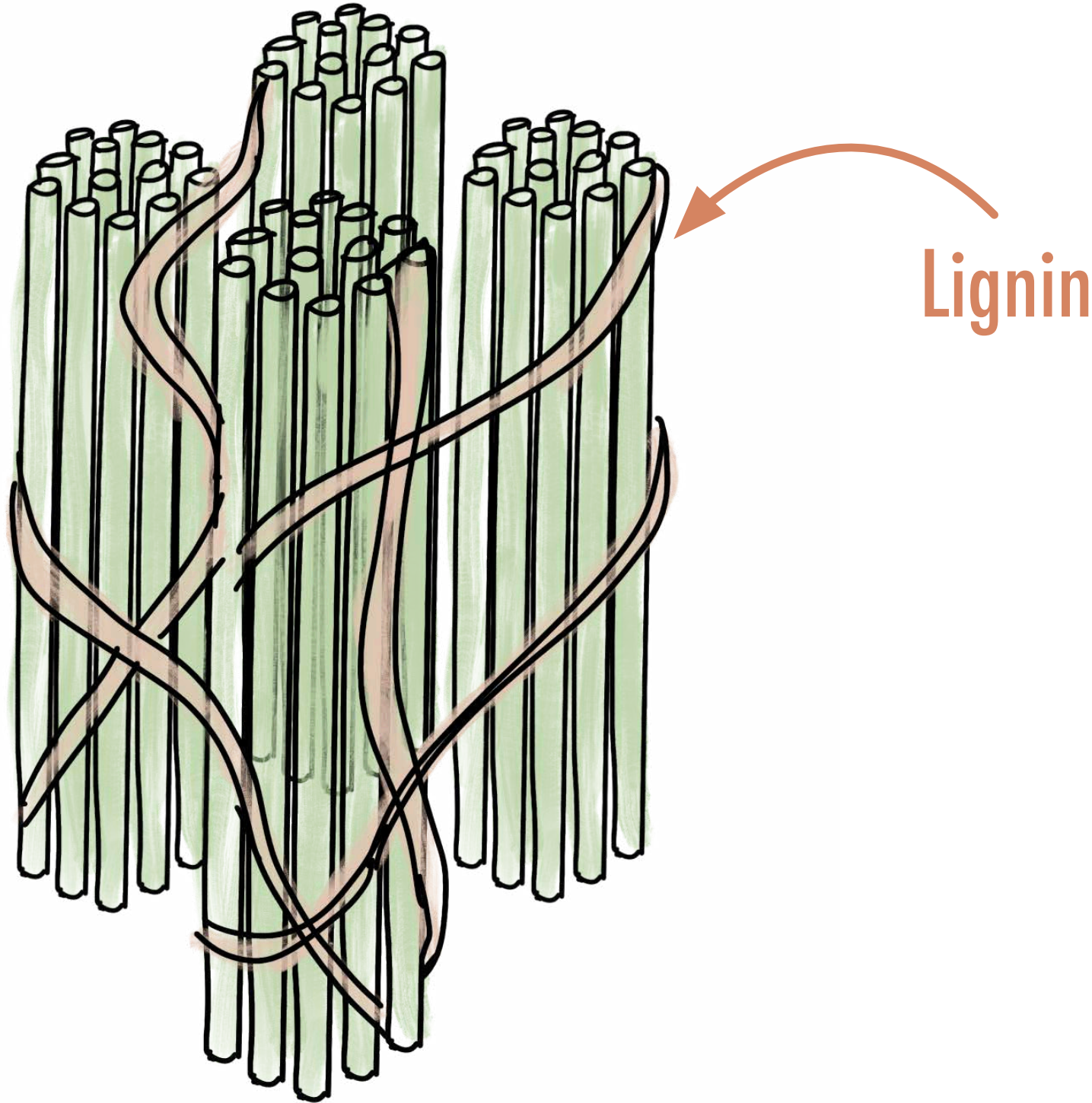


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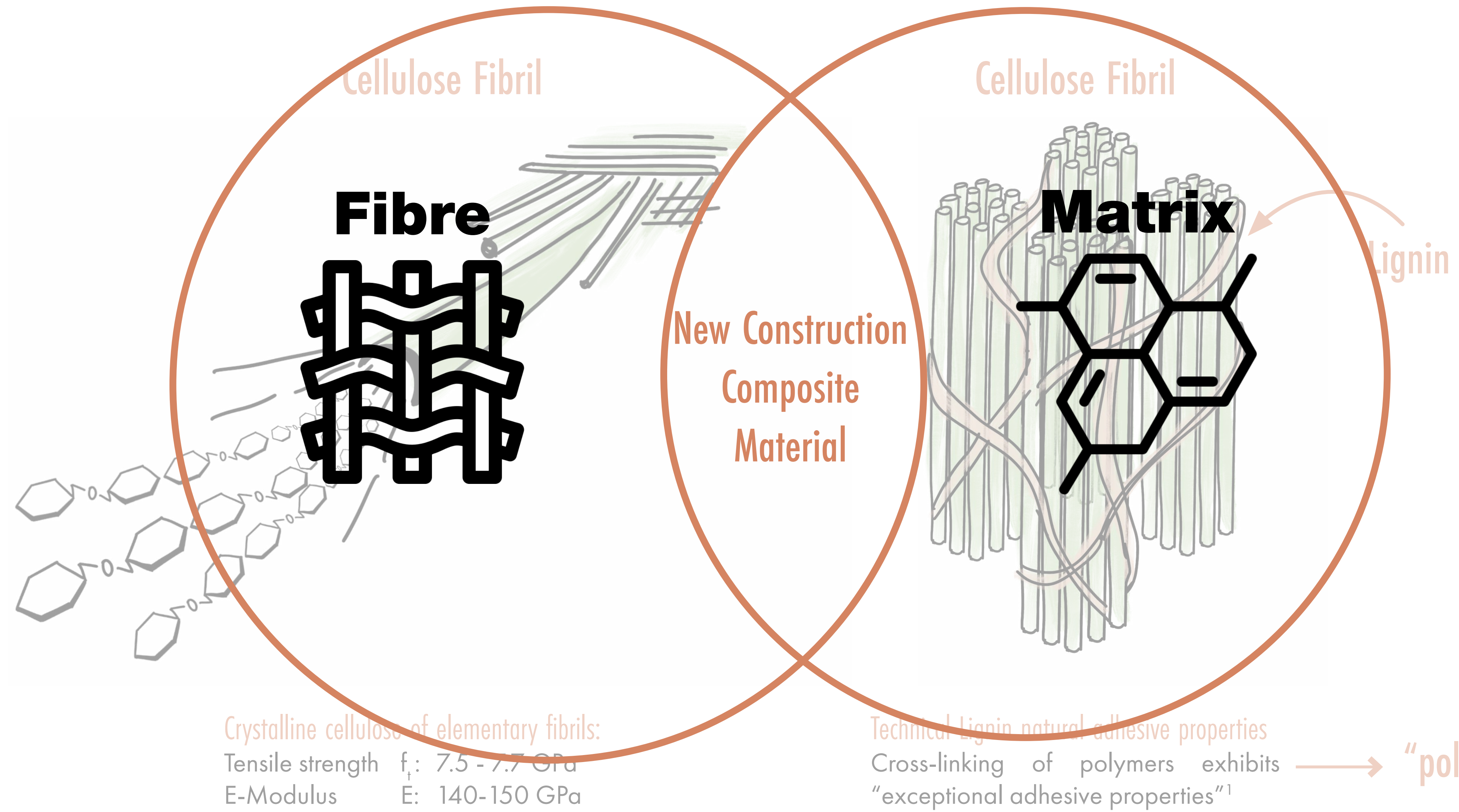
Cellulose Fibril



Technical Lignin natural adhesive properties

Cross-linking of polymers exhibits —————> “polymerisation”¹
 “exceptional adhesive properties”¹

¹ Yan, L., Liu, H., Wang, R., Dai, L., Yuan, Z., & Si, C. (2025). Hot-pressing-assisted fabrication of high-lignin-content and self-crosslinked strong adhesives. Chemical Engineering Journal, 514, 163215. <https://doi.org/10.1016/j.cej.2025.163215>



Research Question:

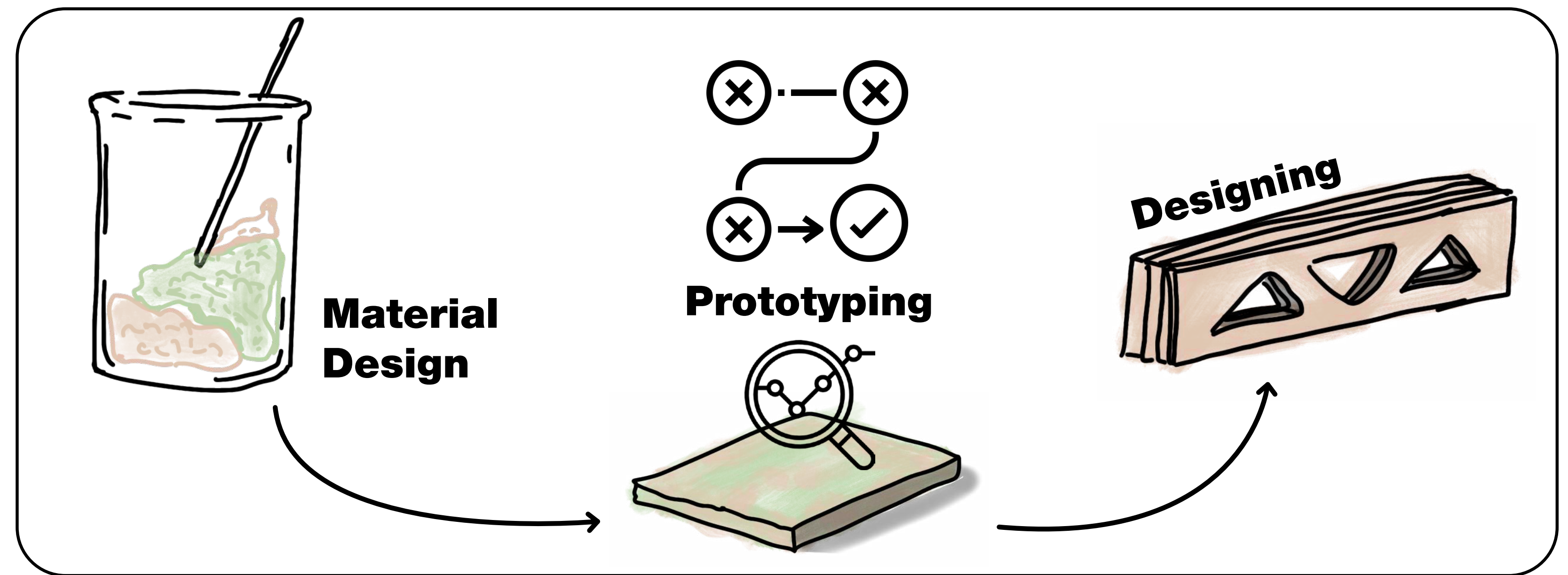
How can an optimised mixture and a suitable hot-press production method be developed that uses by-product-lignin and -cellulose, to utilize lignin's natural binding properties through controlled polymerization?

Research Question:

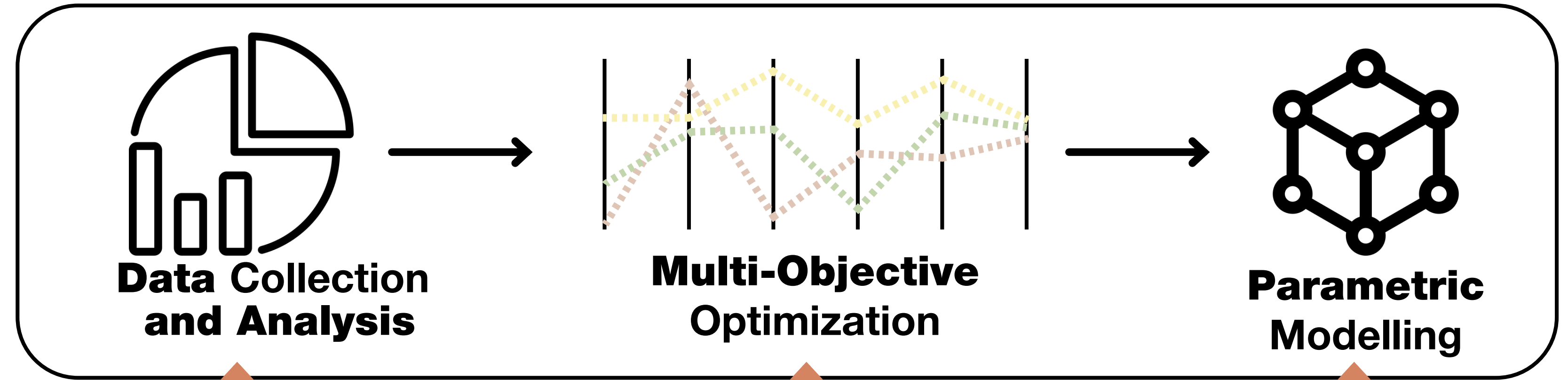
How can an optimised mixture and a suitable hot-press production method be developed that uses by-product-lignin and -cellulose, to utilize lignin's natural binding properties through controlled polymerization?

➡ How to turn lignin into an adhesive?

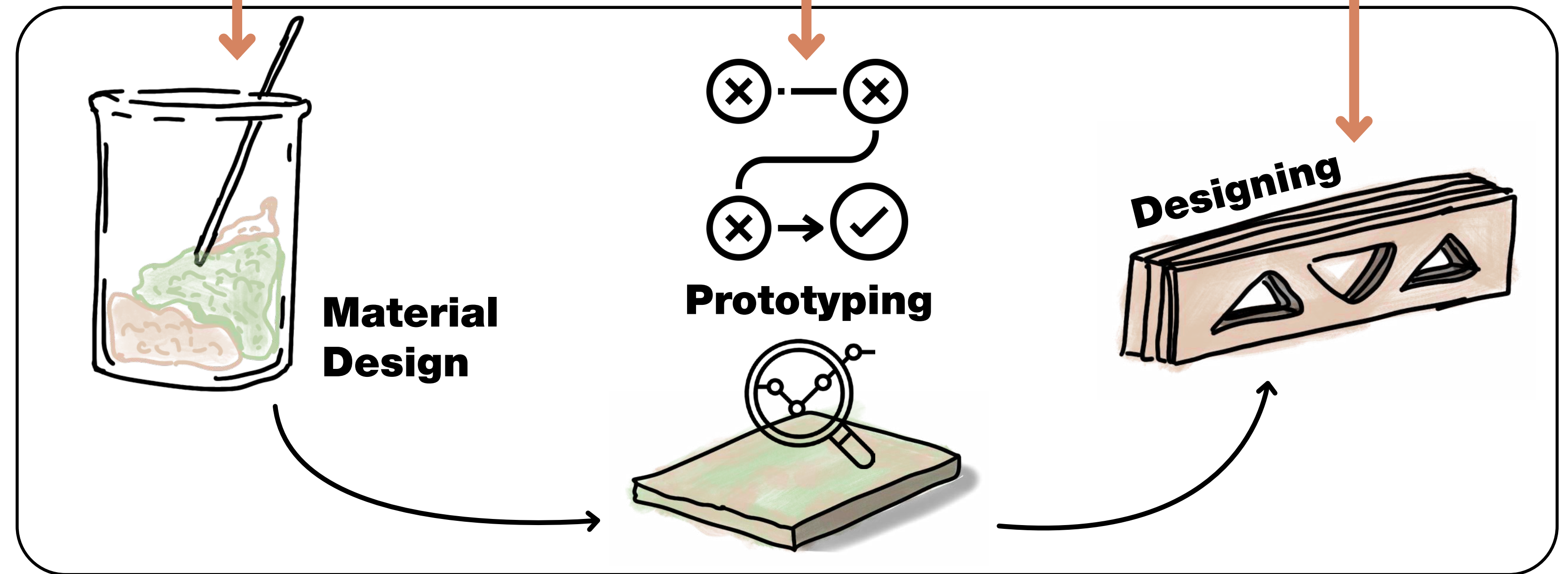
MATERIAL DEVELOPMENT



COMPUTATIONAL INTEGRATION

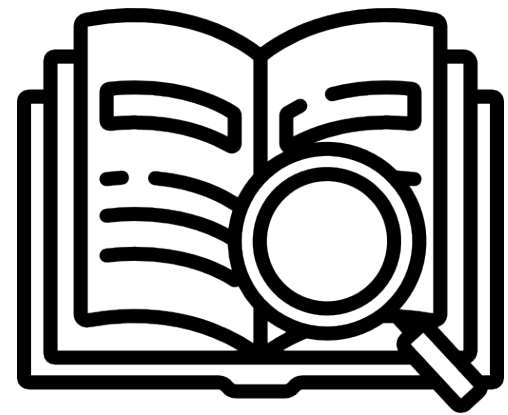


MATERIAL DEVELOPMENT

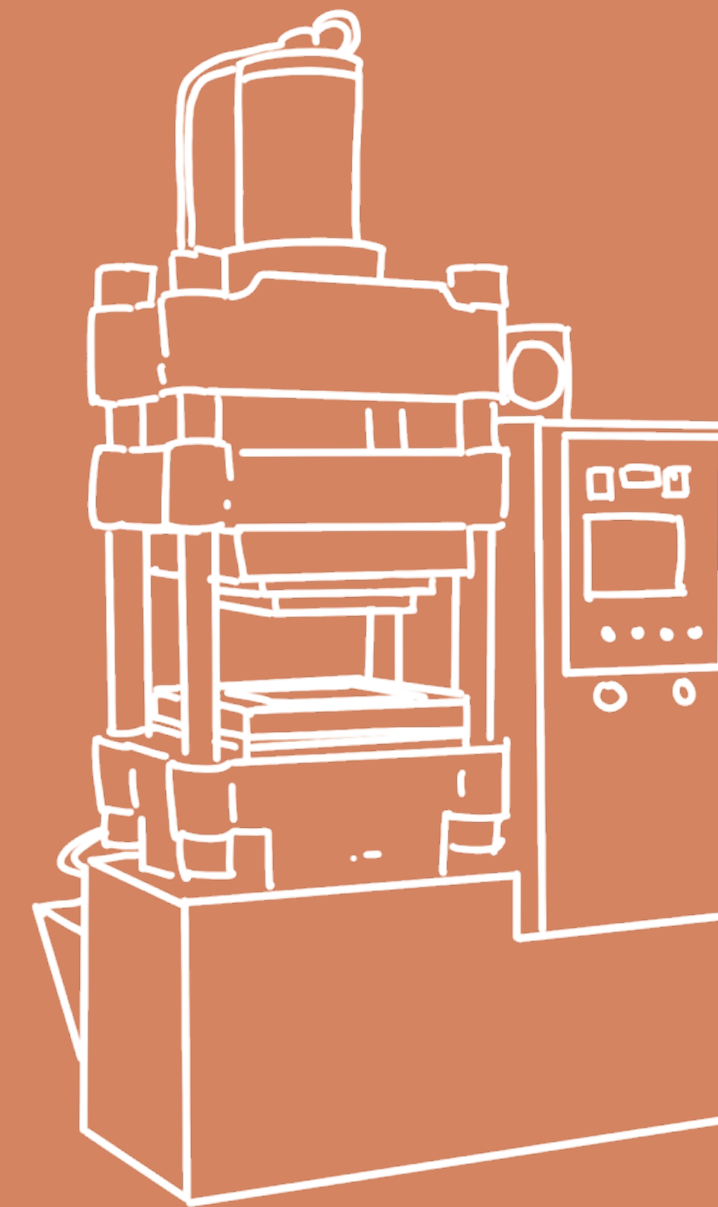


Project Process

Literature Review



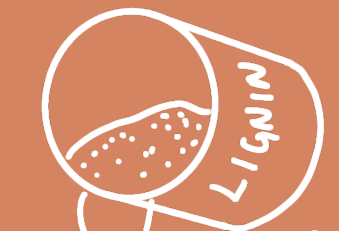
HOT-PRESSING PROCEDURE



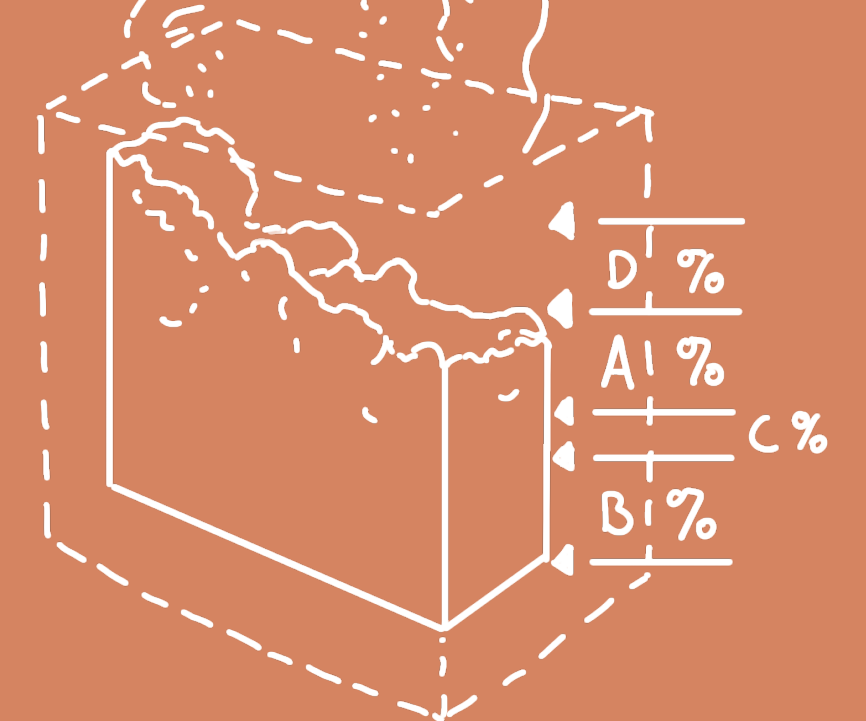
PROCESSING CONDITIONS

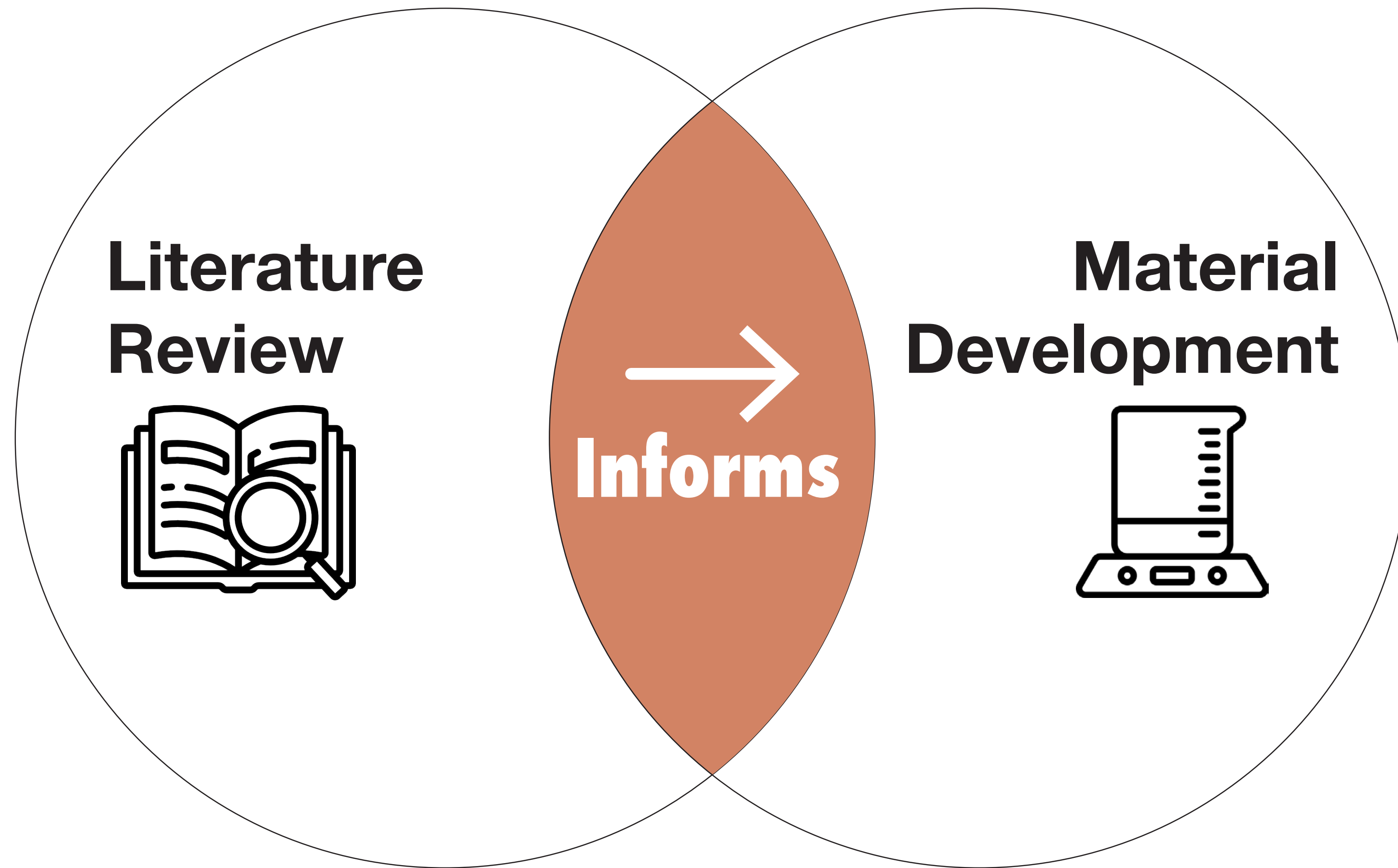


MATERIAL SOURCES



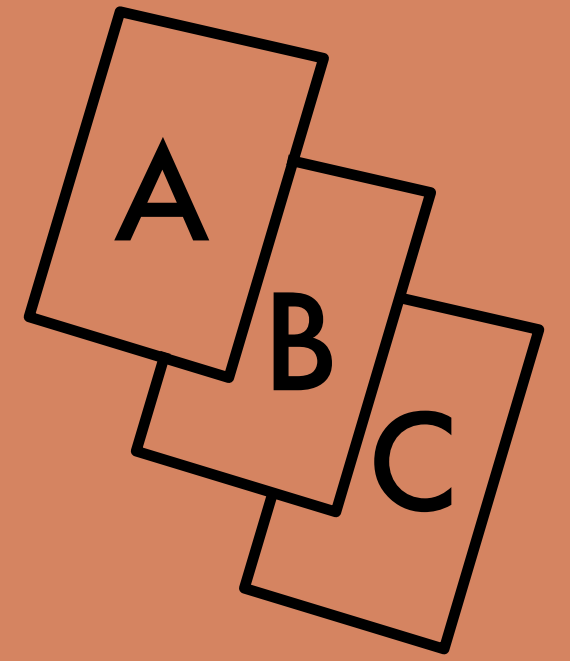
ADDITIVES



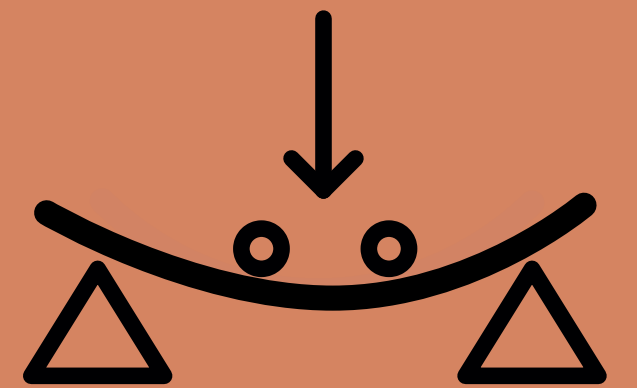


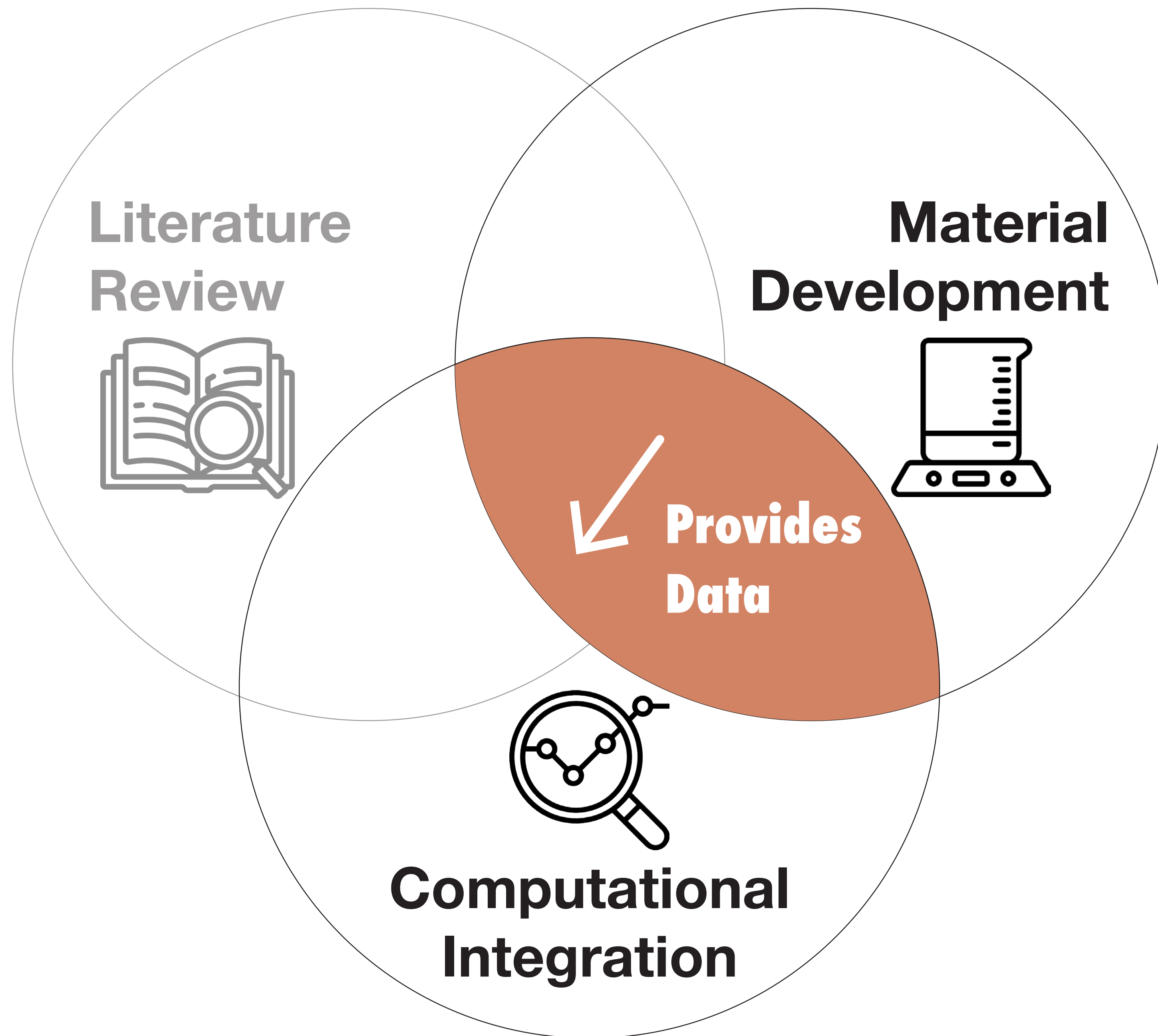
TRIALS

Production of
Variations of Mixture
and Pressing
Conditions

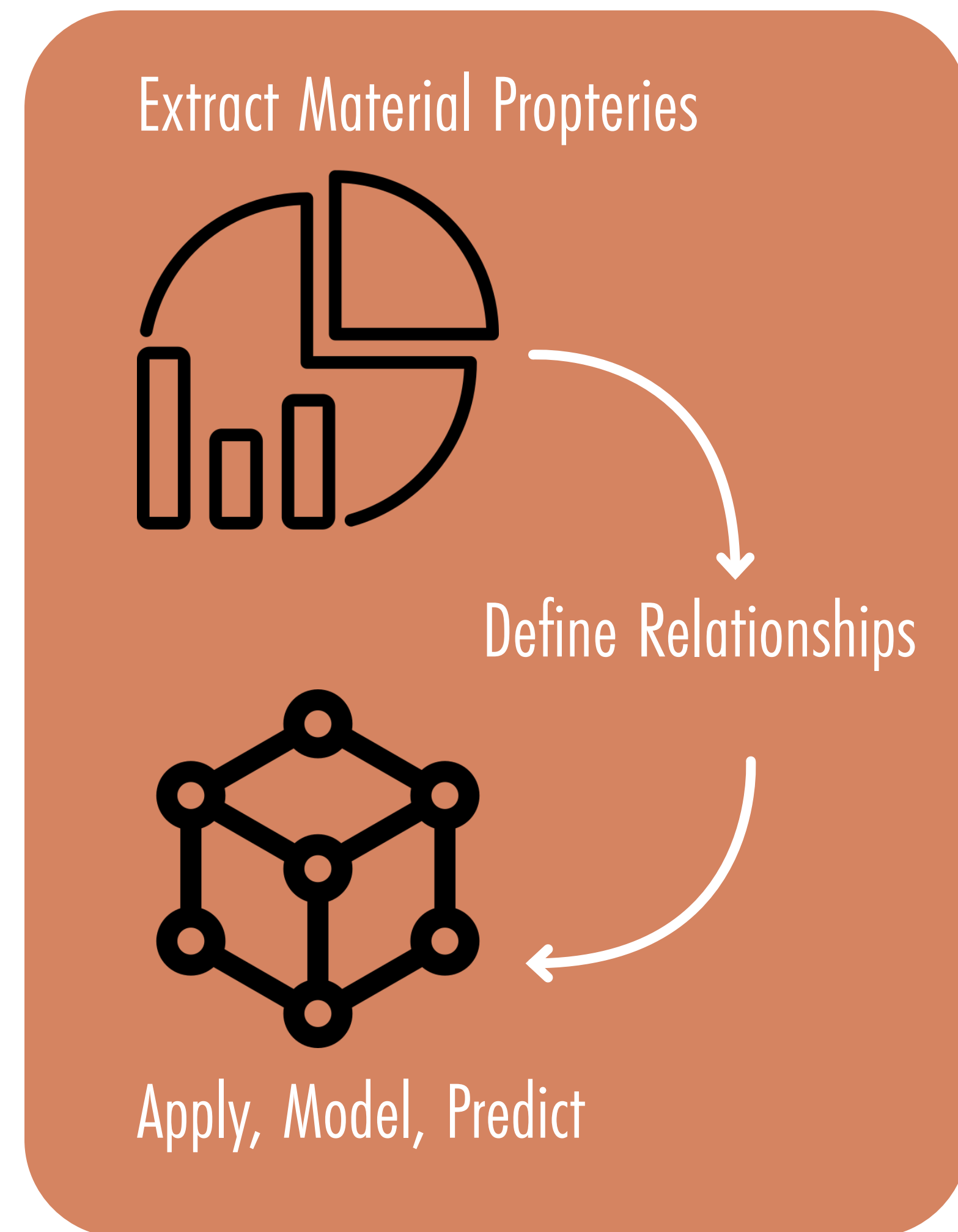


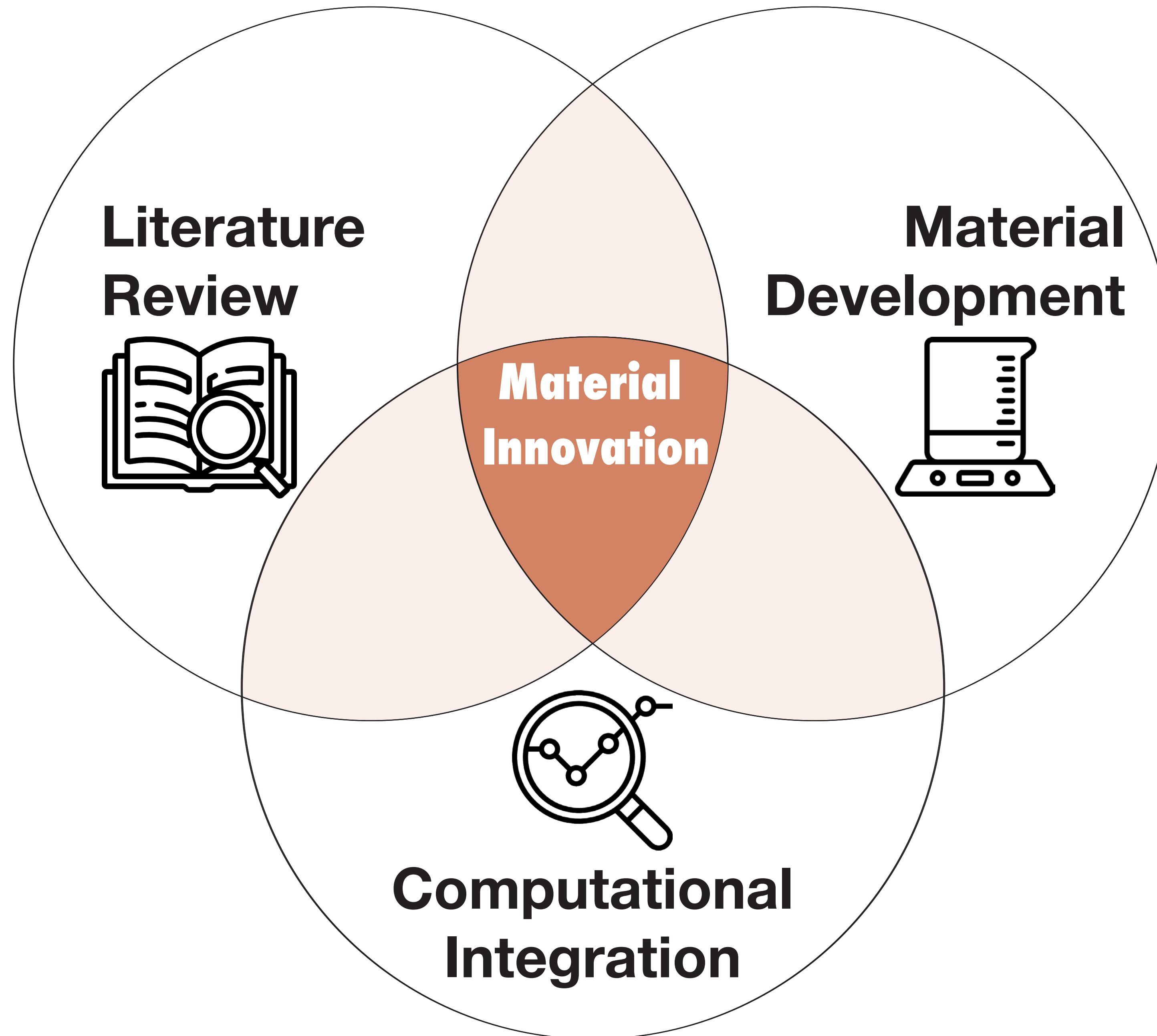
Mechanical Testing
to Determine the
Impact of the
Variations

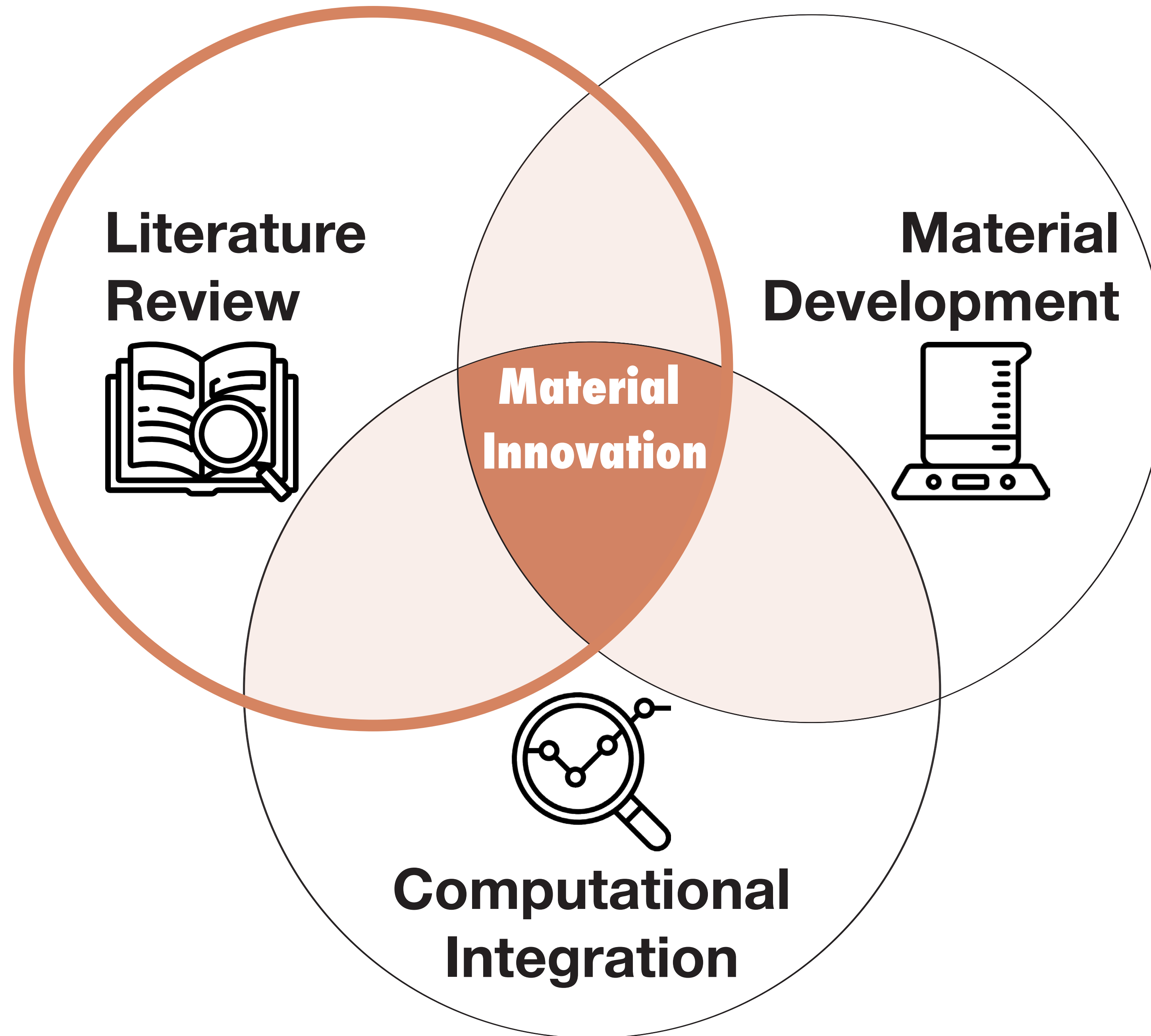


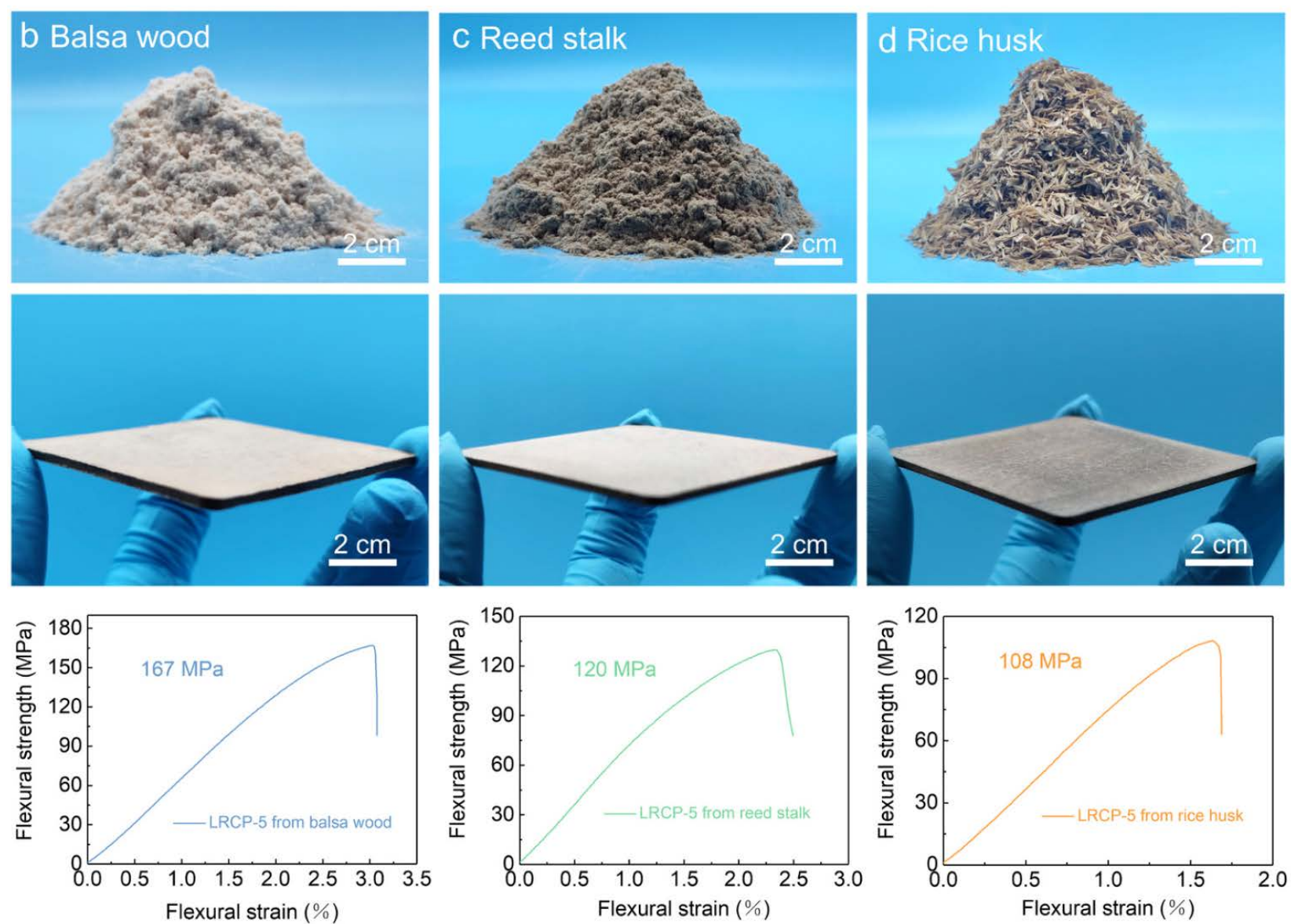


DATA ANALYSIS



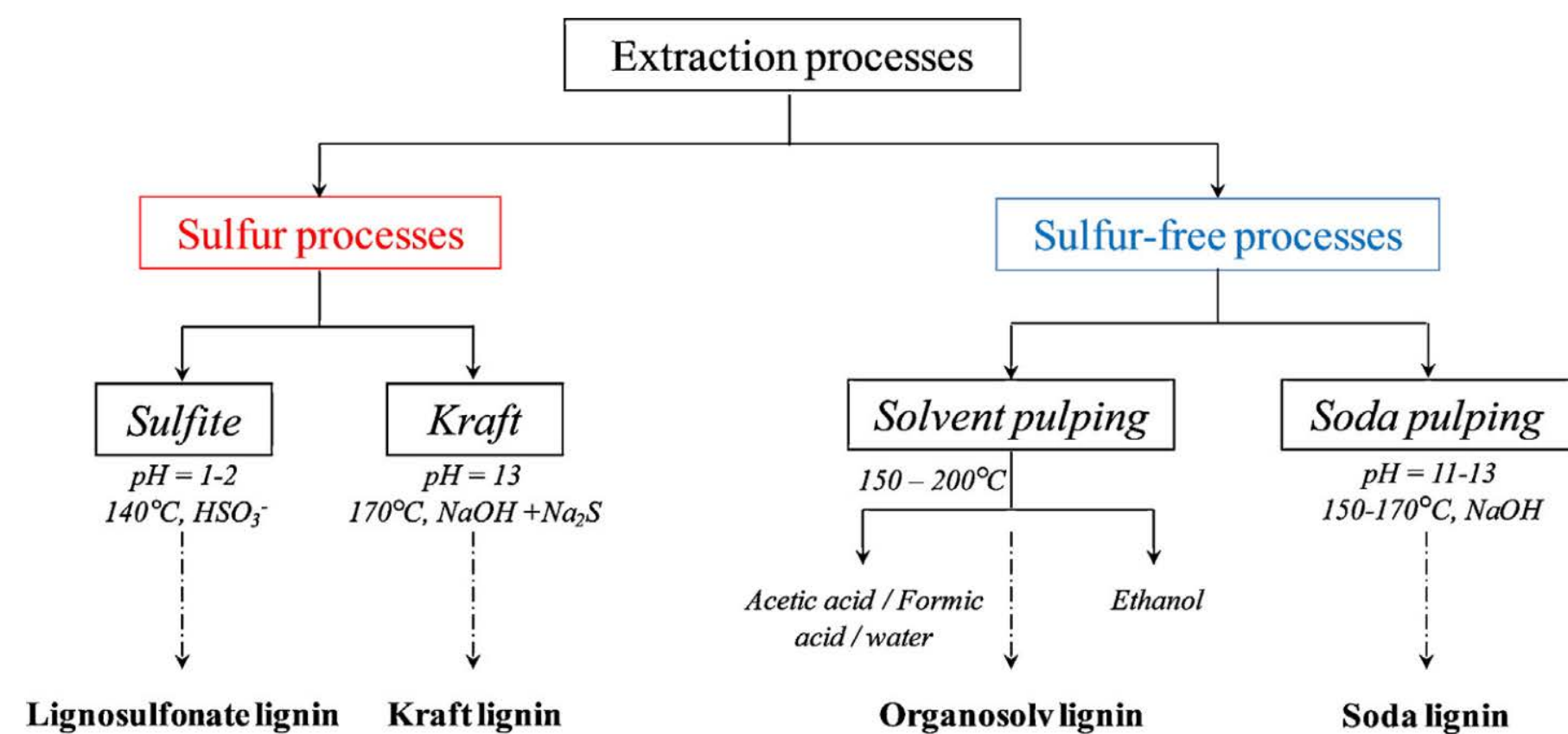




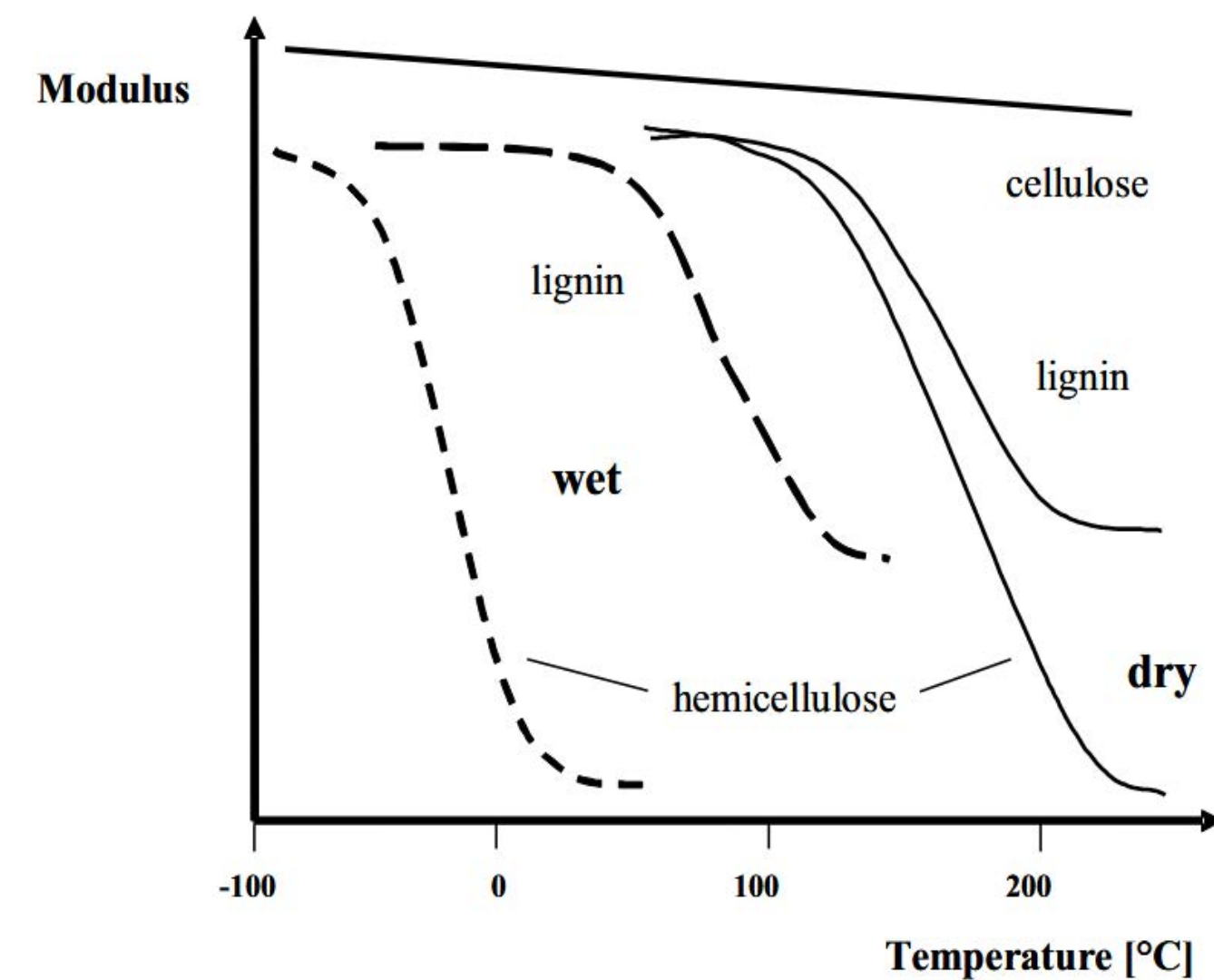


ced cellulose strategy. (a-d) LRPCs obtained from natural bamboo (a), balsa wood (b), reed stalk (c) and rice husk (d). Each al photo of the raw material, a digital photo of LRPC-5, and the flexural stress-strain curve of LRPC-5, respectively.

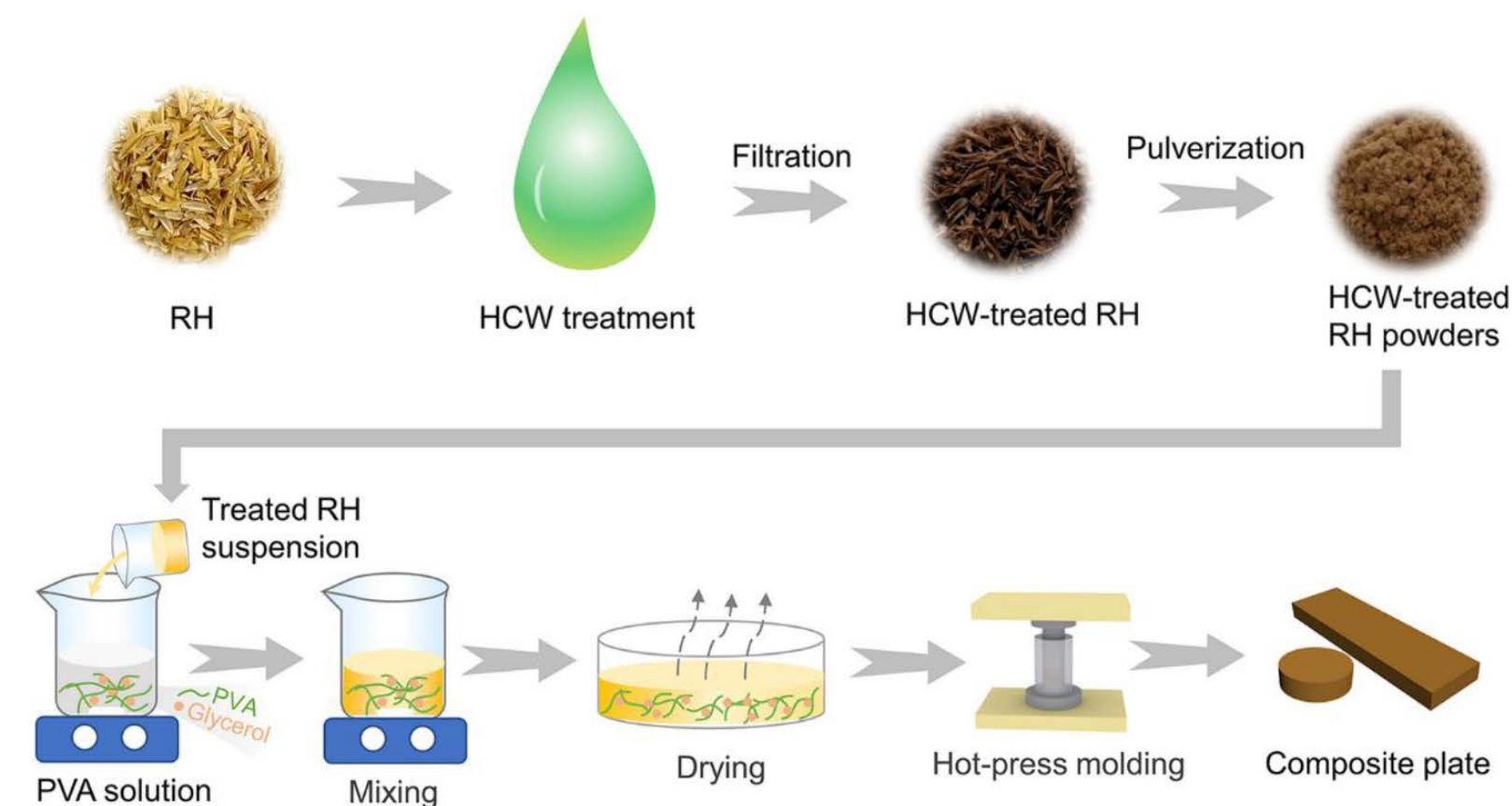
Mechanical Testing Results of LRPCs. From Qin et al. 2023



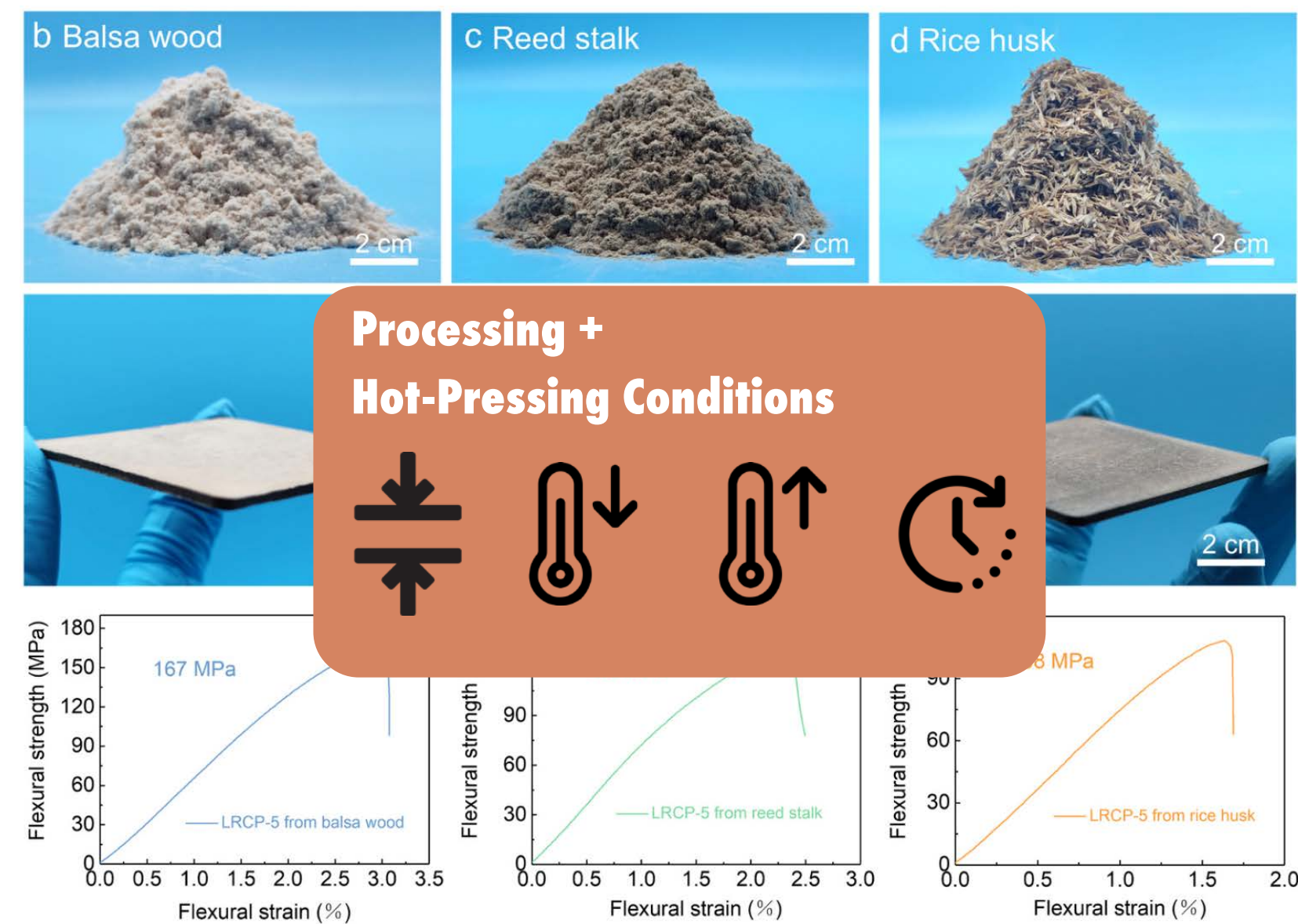
Lignin Extraction Process, from Laurichesse & Avérous, 2014



The glass-transition temperature of lignin as a function of moisture content, from Kuntar & Sernek, 2007

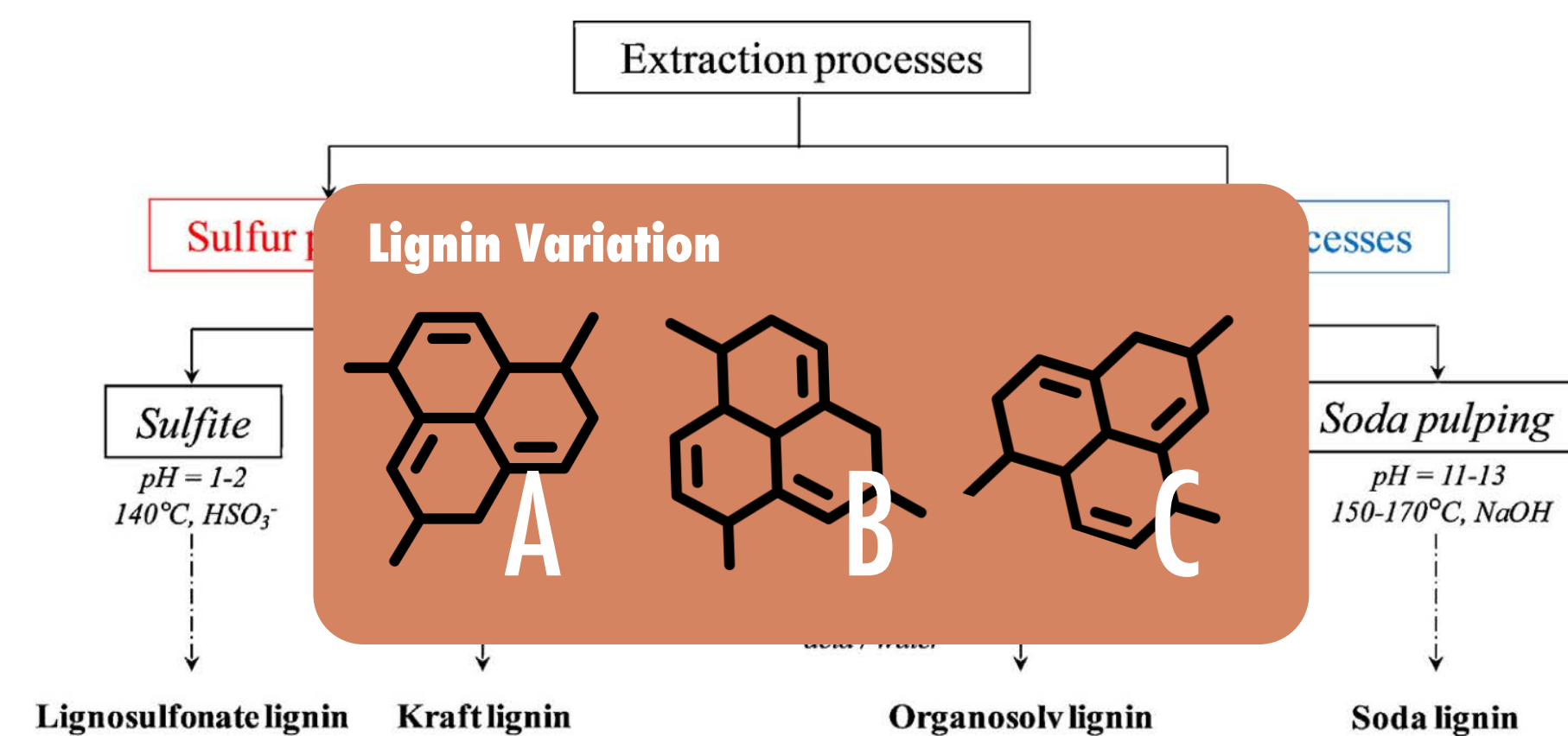


Rice Husk Composite Plate Production Process. From Qianli, 2022

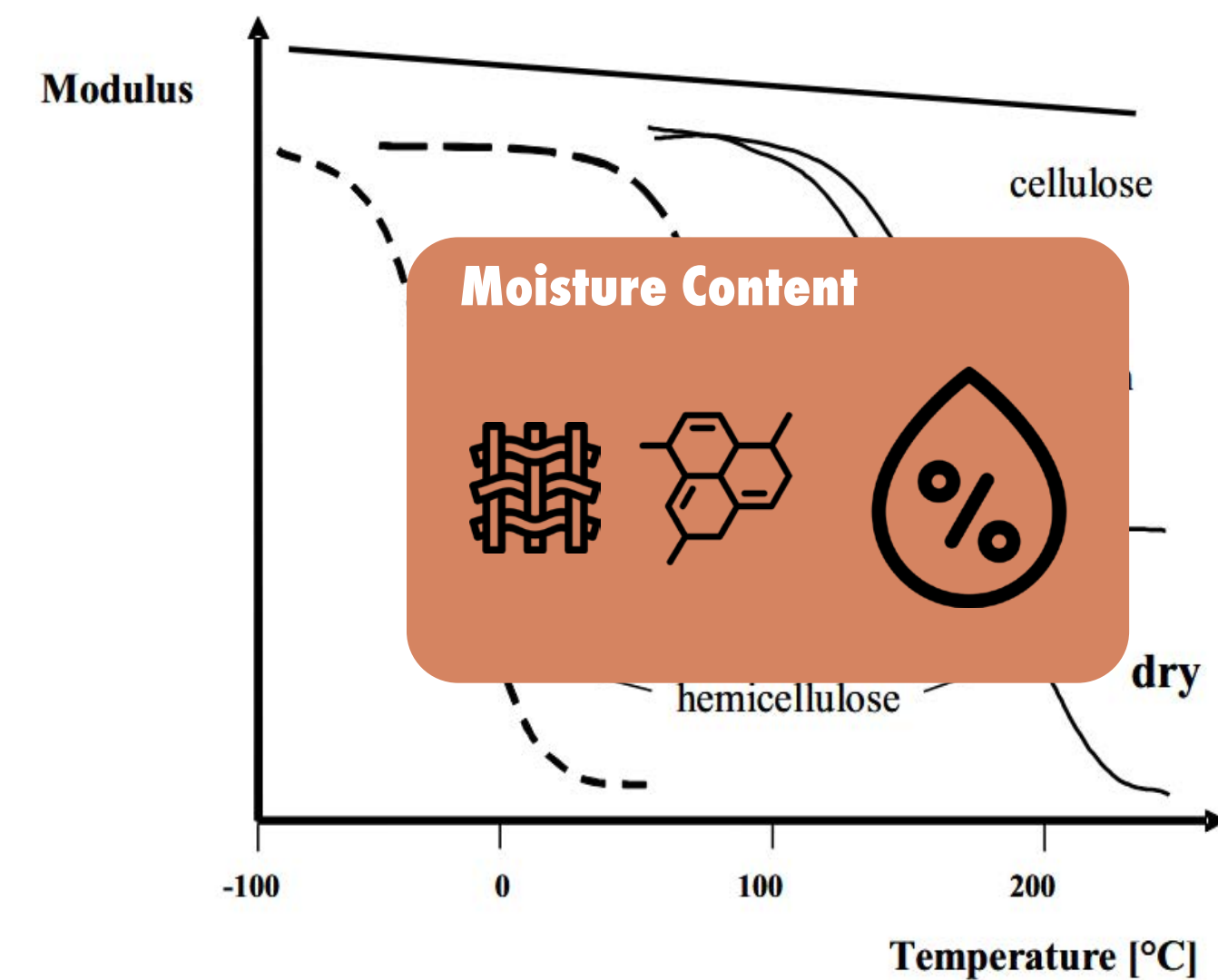


ced cellulose strategy. (a-d) LRCPs obtained from natural bamboo (a), balsa wood (b), reed stalk (c) and rice husk (d). Each al photo of the raw material, a digital photo of LRCP-5, and the flexural stress-strain curve of LRCP-5, respectively.

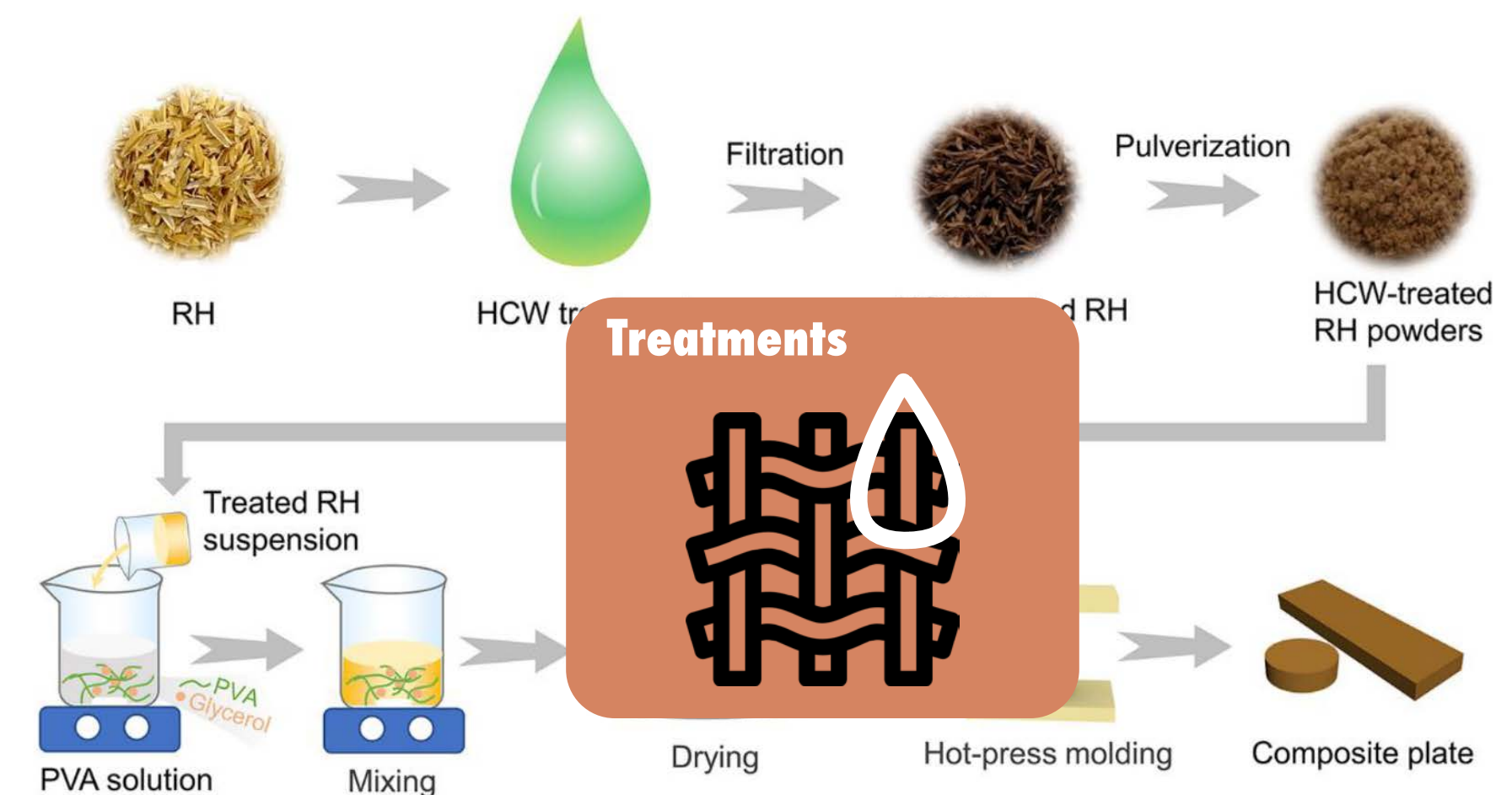
Mechanical Testing Results of LRCPs. From Qin et al. 2023



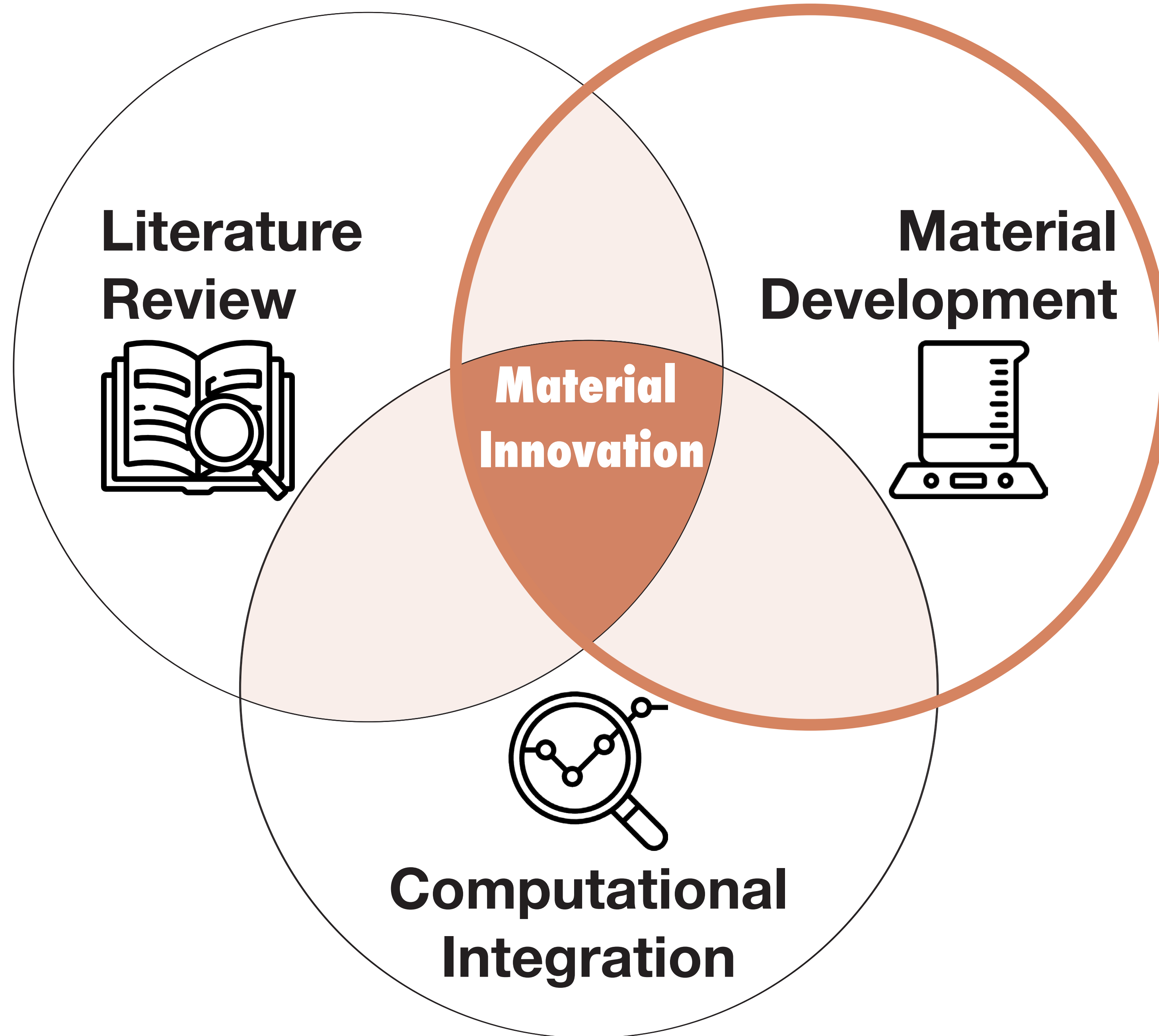
Lignin Extraction Process, from Laurichesse & Avérous, 2014



The glass-transition temperature of lignin as a function of moisture content, from Kuntar & Sernek, 2007



Rice Husk Composite Plate Production Process. From Qianli, 2022



Material Constituents

Cellulose



Shredded and untreated newspaper fibres
x150 magnification

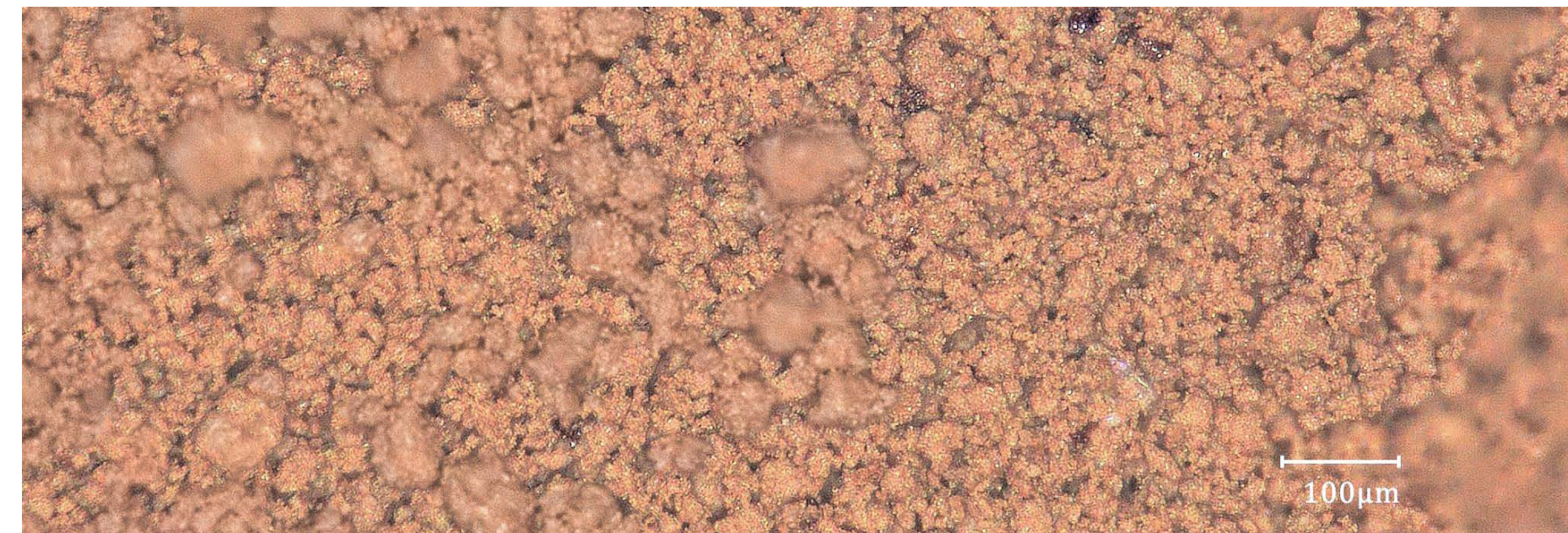
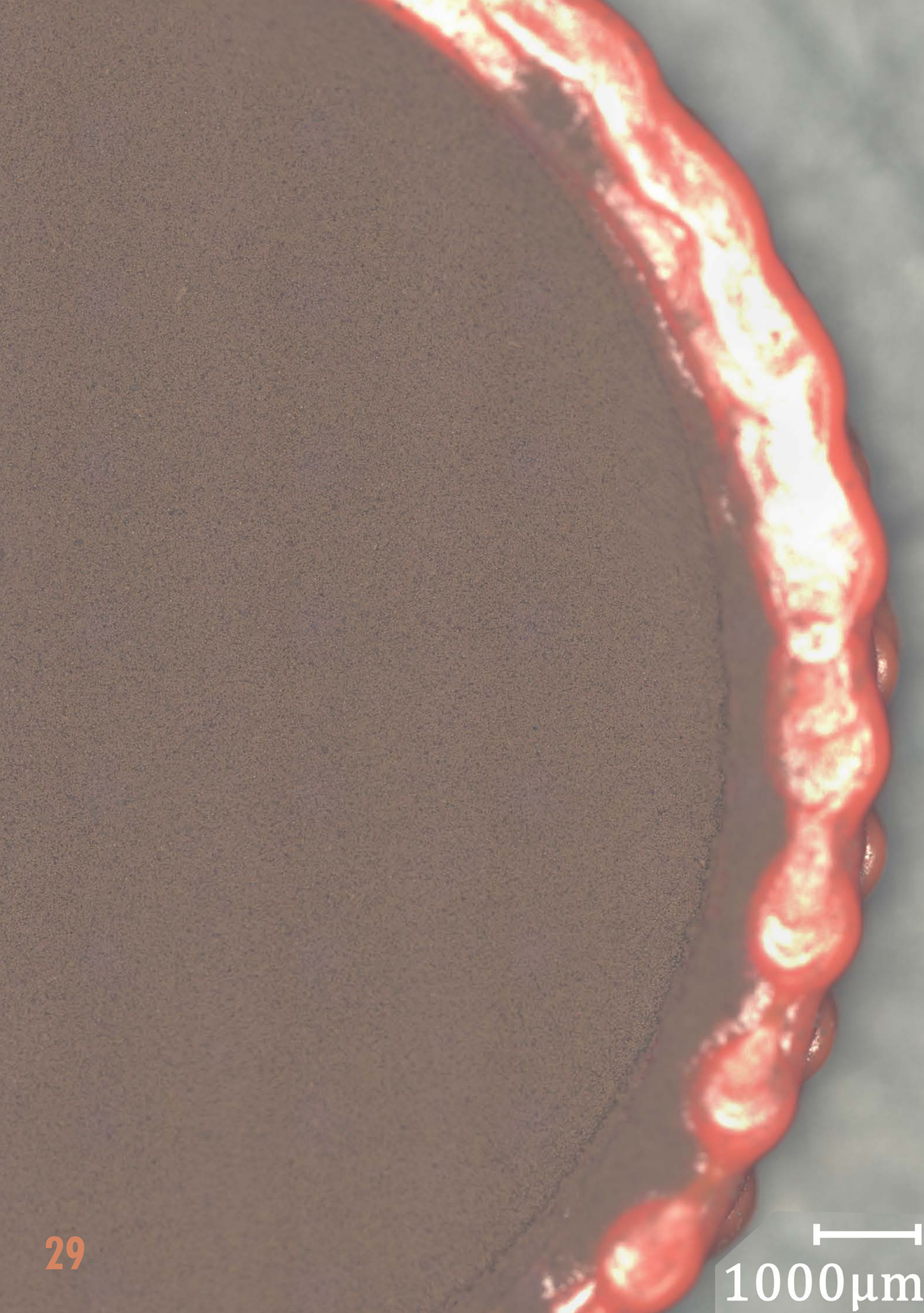
cellulose 40 – 70%, hemicellulose 10 – 40% and lignin 5 – 30%,



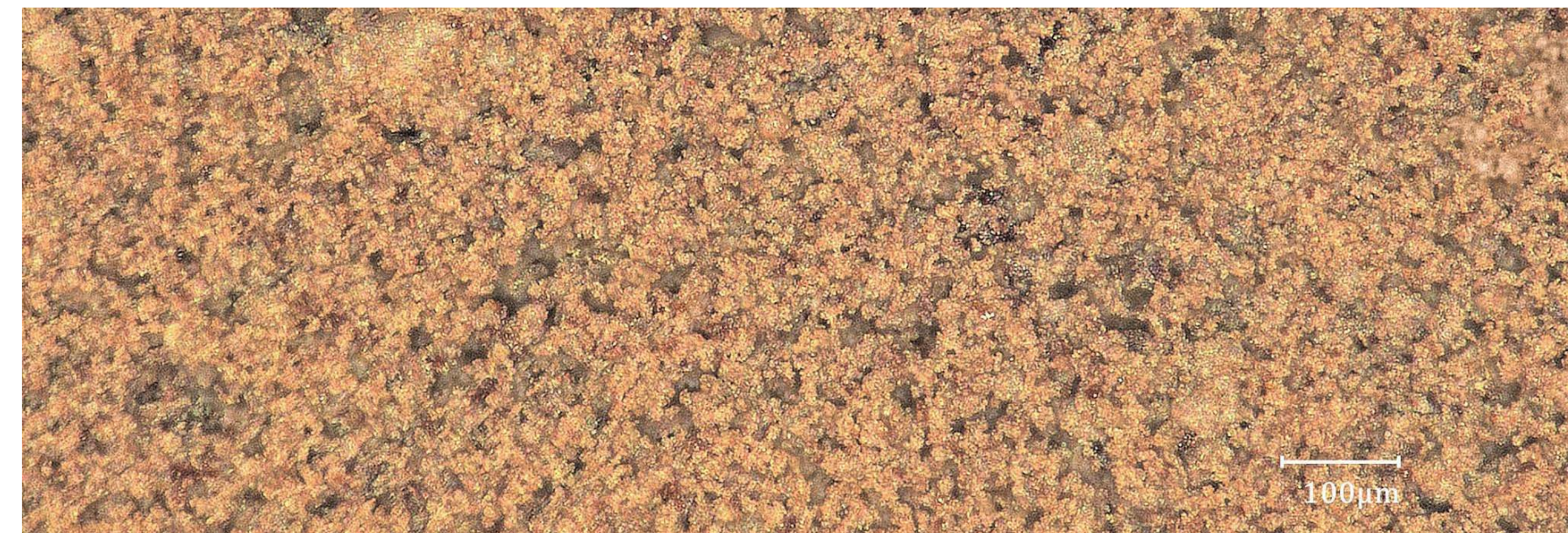
image source [https://www.google.com/](https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.isocell.com)
[url?sa=i&url=https%3A%2F%2Fwww.isocell.com](https://www.isocell.com)

Material Constituents

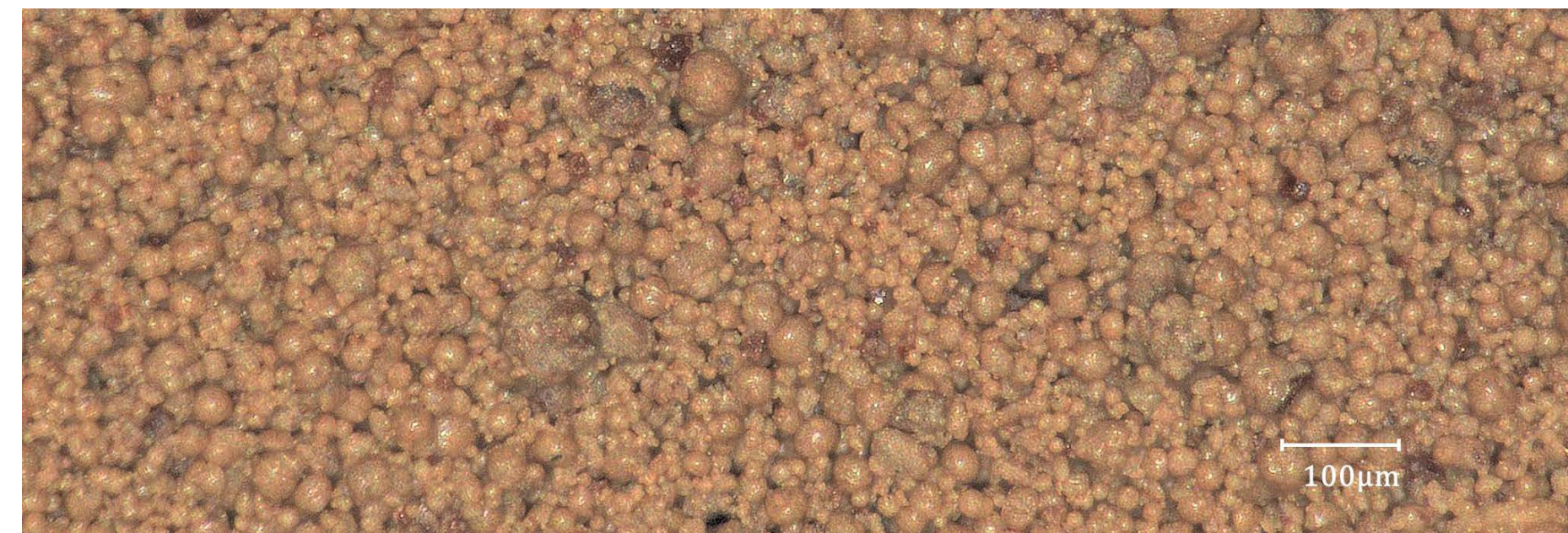
Lignin



Kraft Lignin
x250 magnification



Organosolv Lignin
x250 magnification



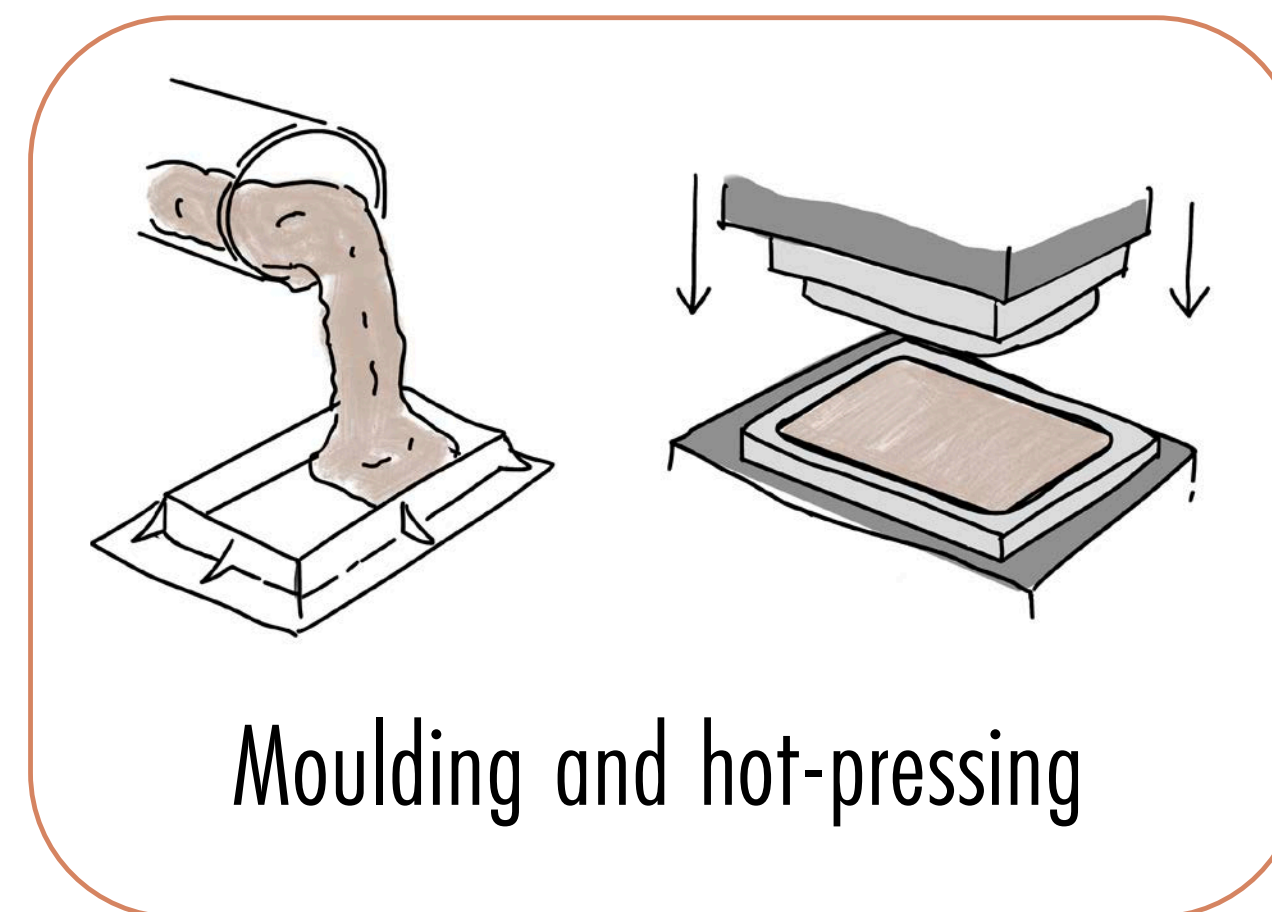
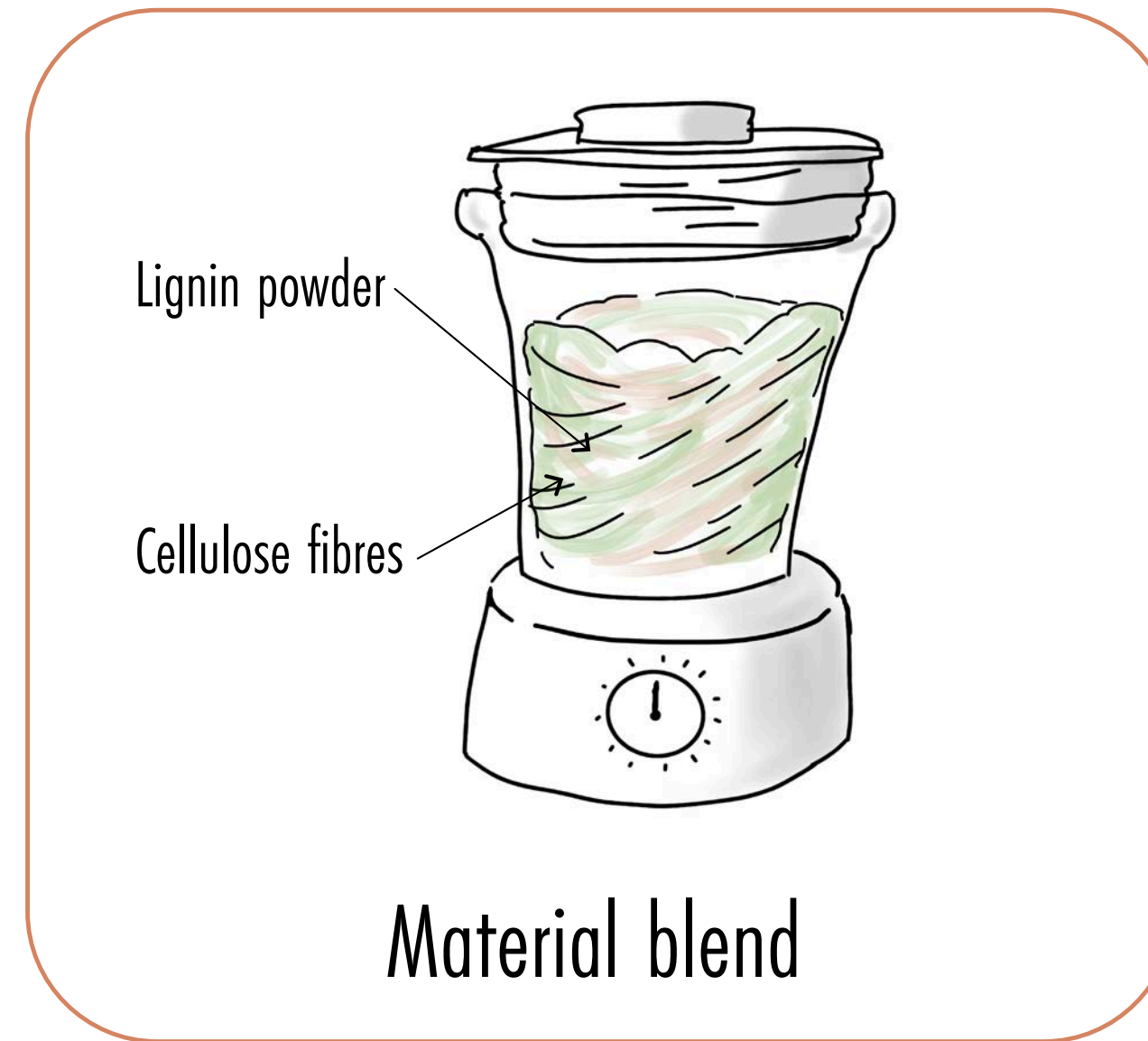
Soda Lignin
x250 magnification

Trial and Error phase





Chosen production methods for experimental part

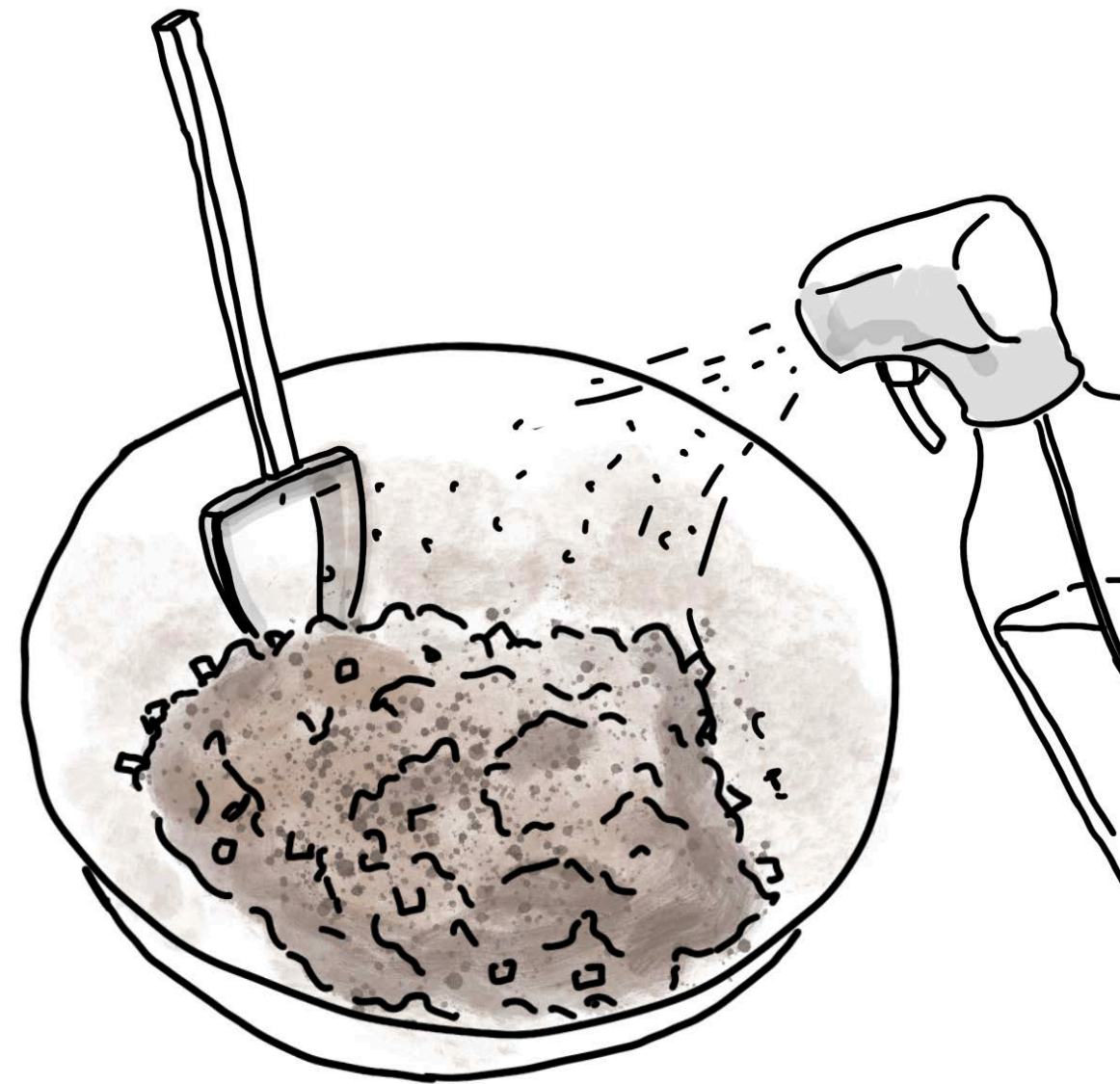


1. Mixing
2. Hot-Pressing
3. Post-Processing

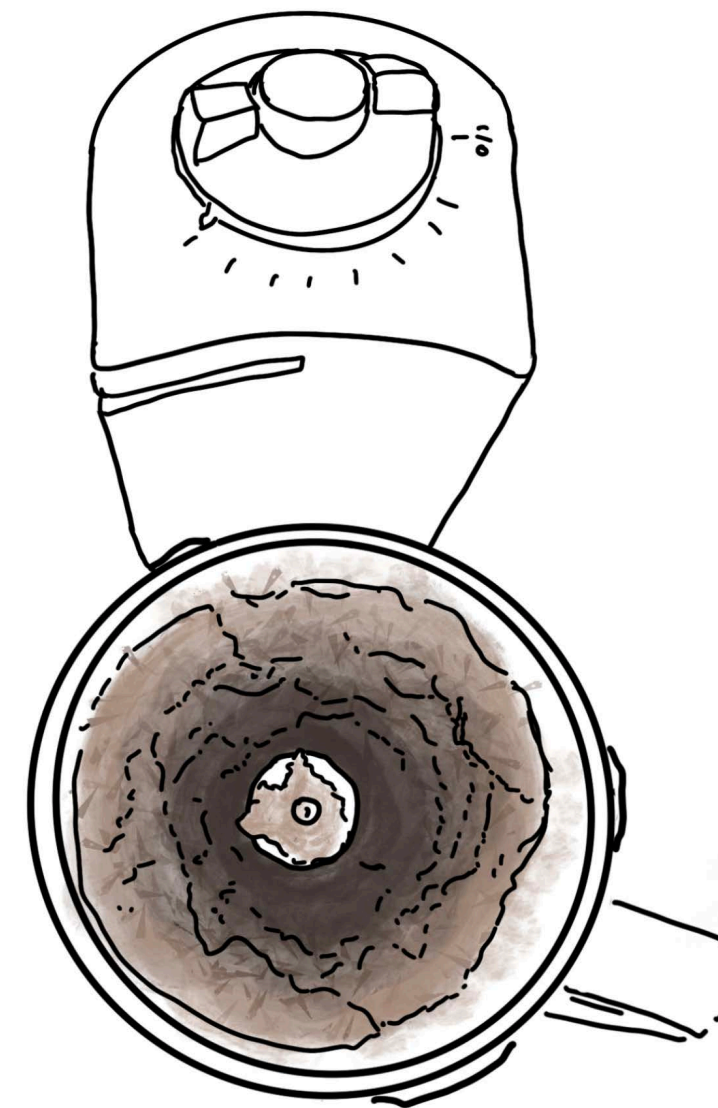
1. Material Mixture

- Precision balance (± 0.01 g)
- Kitchen Blender or Food processor
- Spray Bottle for distilled water
- Metal bowls for mixing
- Metal mortar for bowl
- Glass beaker 800ml
- Scraper or Spatula
- Drying oven
- Zip-lock bags
- Vacuum pump/ cleaner.





Combining constituents dry (total of 50g) and adding water to achieve moisture content X%.



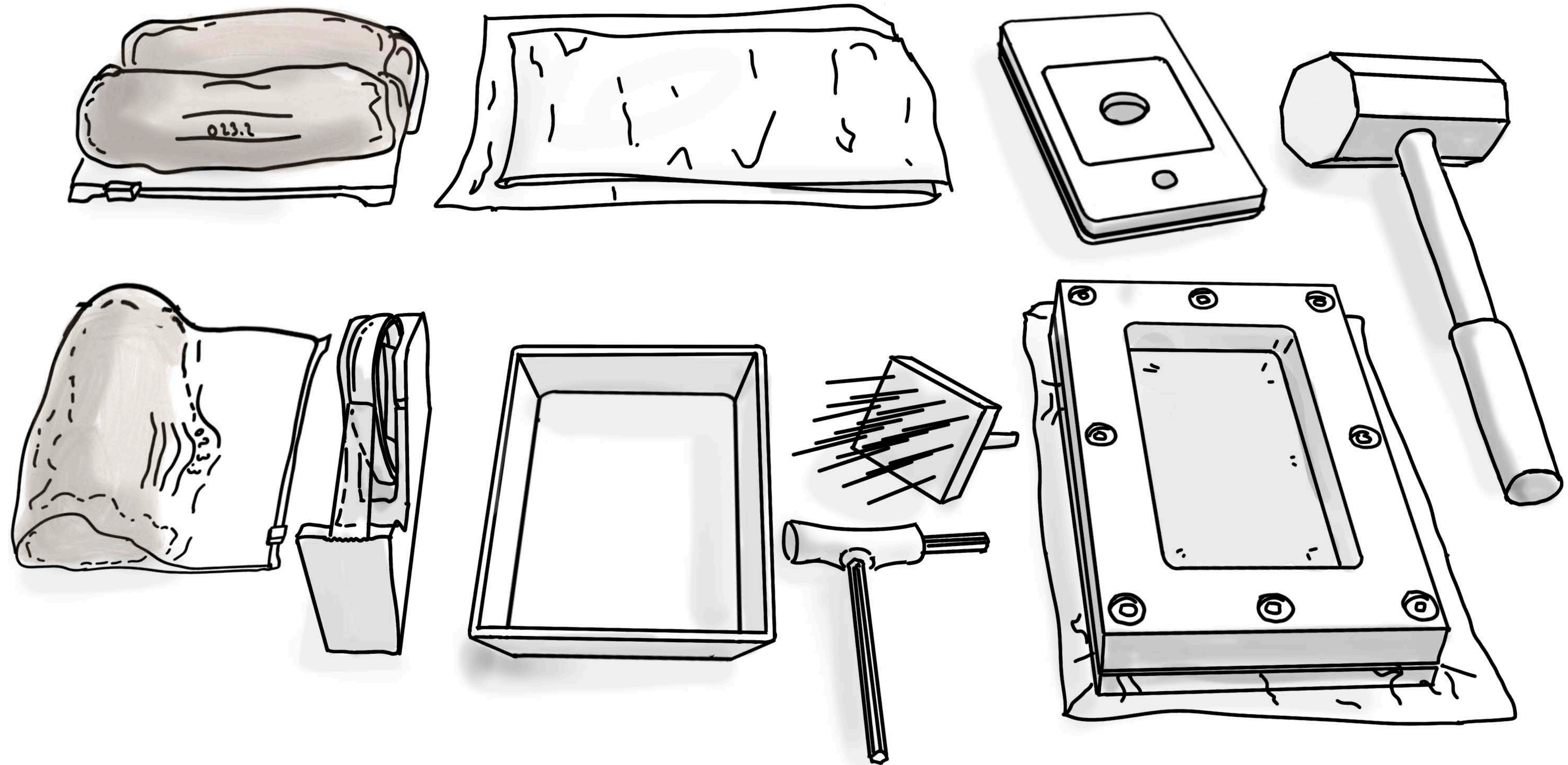
Blending materials until even distribution and even colour.



Weighing and packaging to maintain exact moisture content.

2. Hot-pressing

- Aluminium/ Steel mould (specimen: 150mm by 90mm)
- Unperforated releasefilm, FEP, Max. Temp. 240 °C
- M8 Screwdriver
- "Coffee Mixer"; Spiked tool to loosen and even out fibres in mould
- Heat Resistant Kapton Tape
- 3D printed funnel in size of the mould opening
- Cellulose/Lignin Mixture
- Rubber hammer

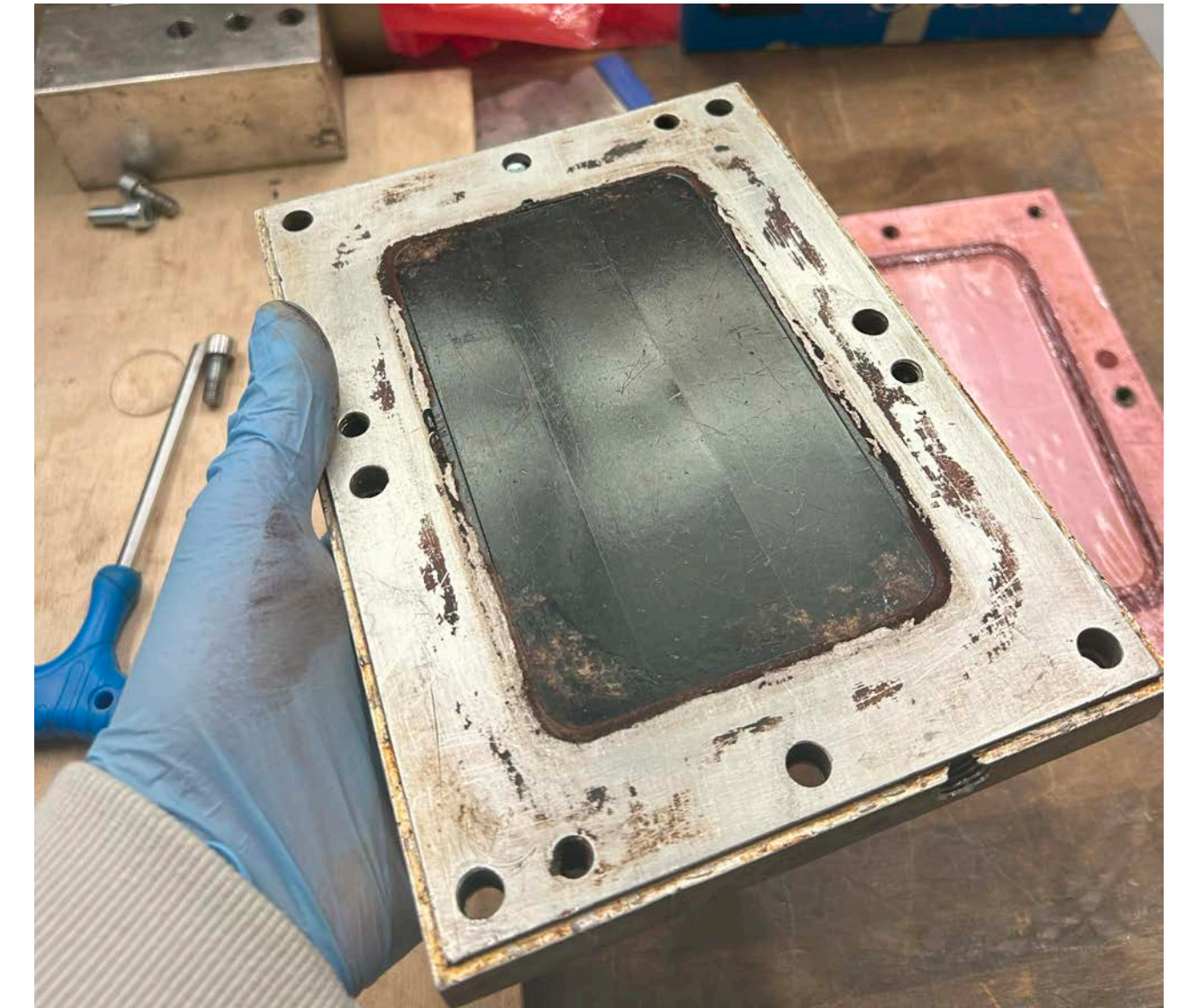




Preparing mixture in mould using the funnel and mixing tool.



Hot-pressing at specific conditions (time, pressure, temperature).



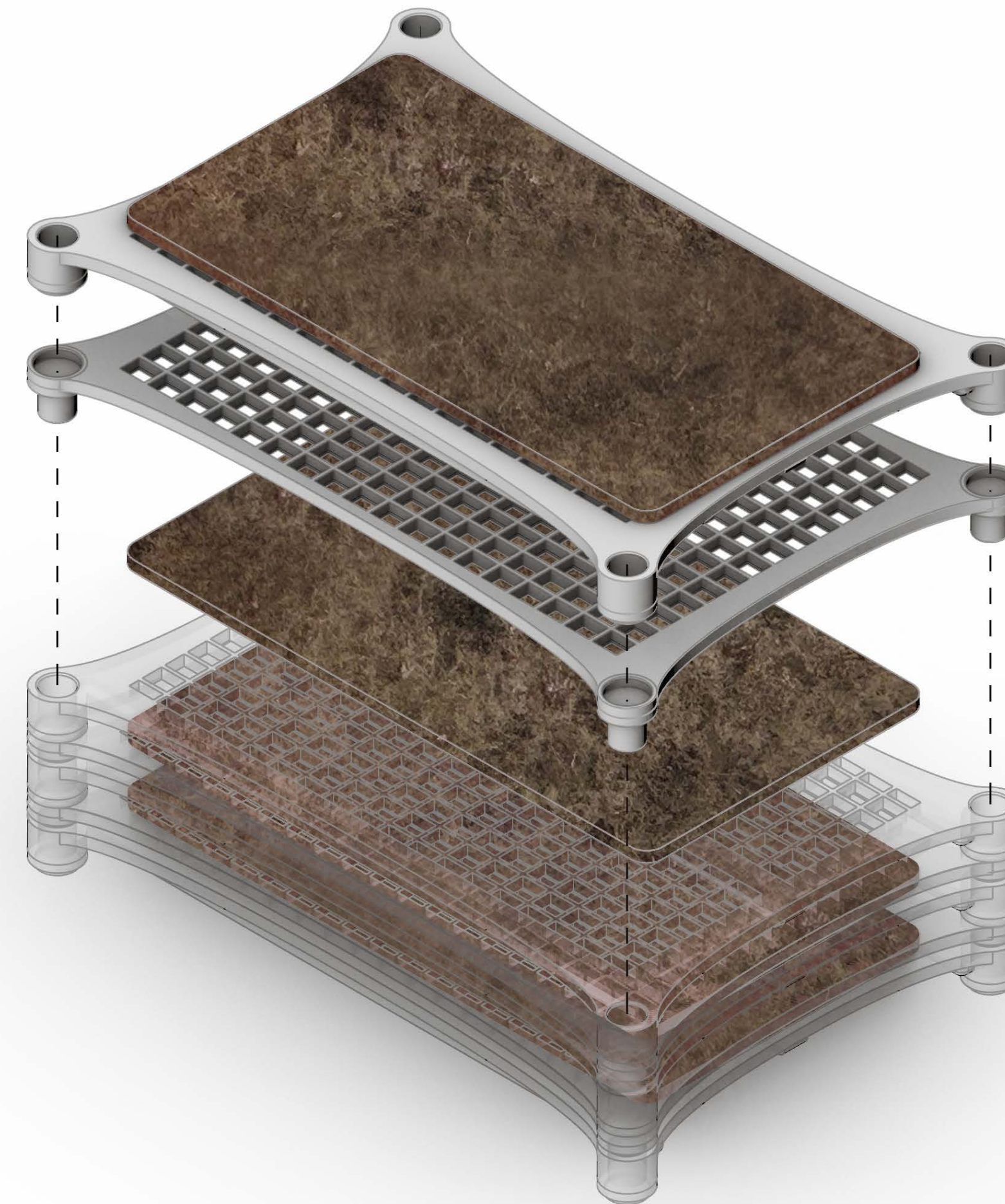
Removing plate from mould using rubber hammer.

3. Post-processing

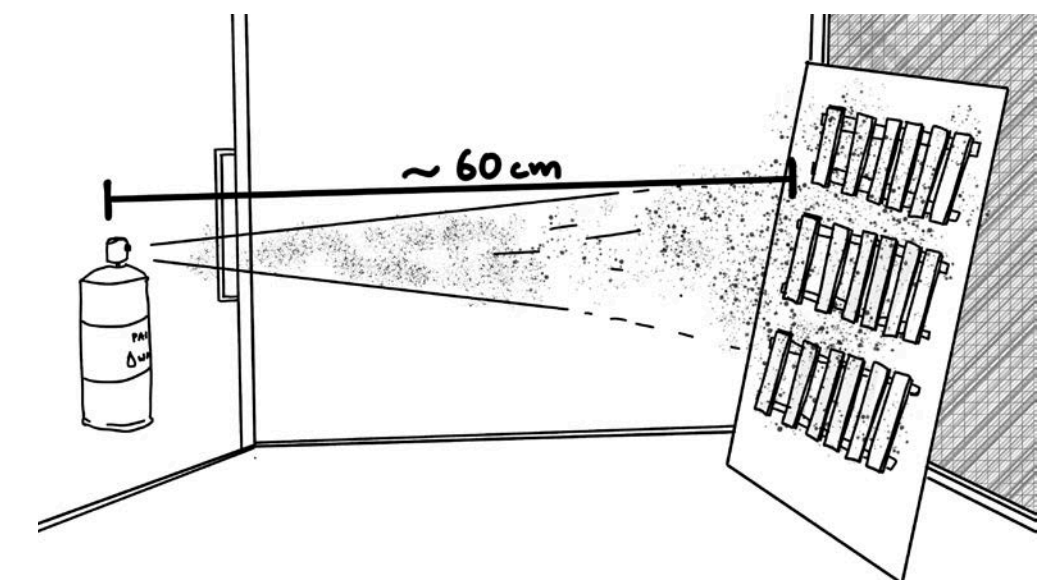
- Drying to prevent warping
- Cutting for mechanical tests
- Applying speckle pattern for DIC

Required Equipment:

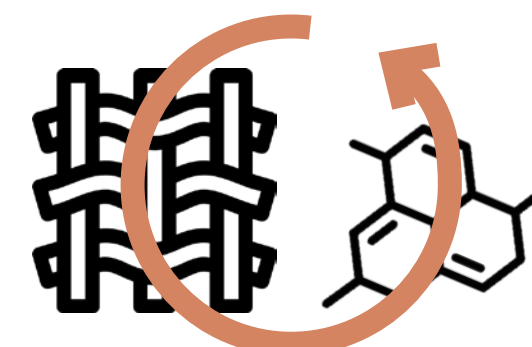
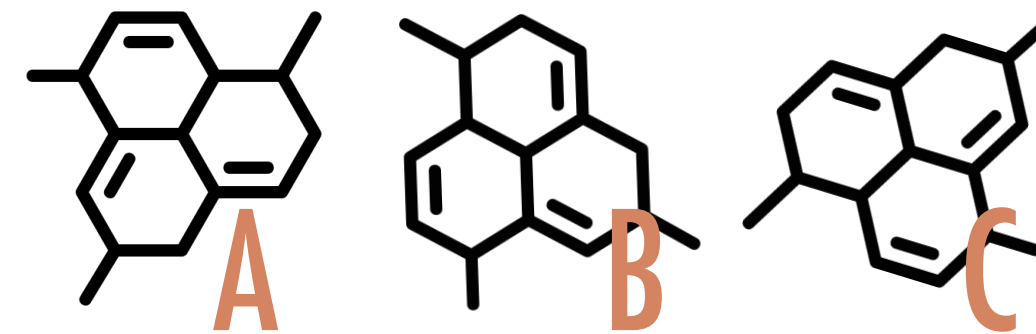
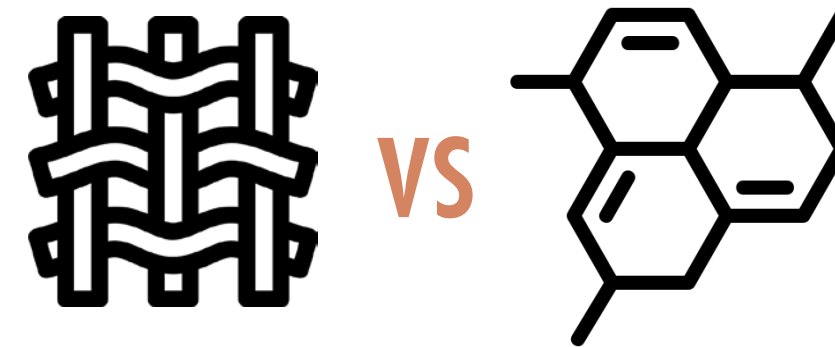
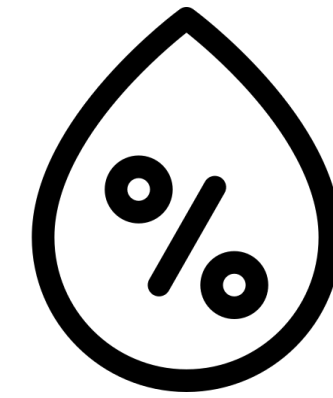
- Drying rack for samples
- Drying oven
- White and Black Spray-paint
- Band-saw



3d-printed drying rack



Mixture Variation Trials



Moisture content variation,
at constant mixture ratio

Cellulose/Lignin ratio variation,
at constant moisture

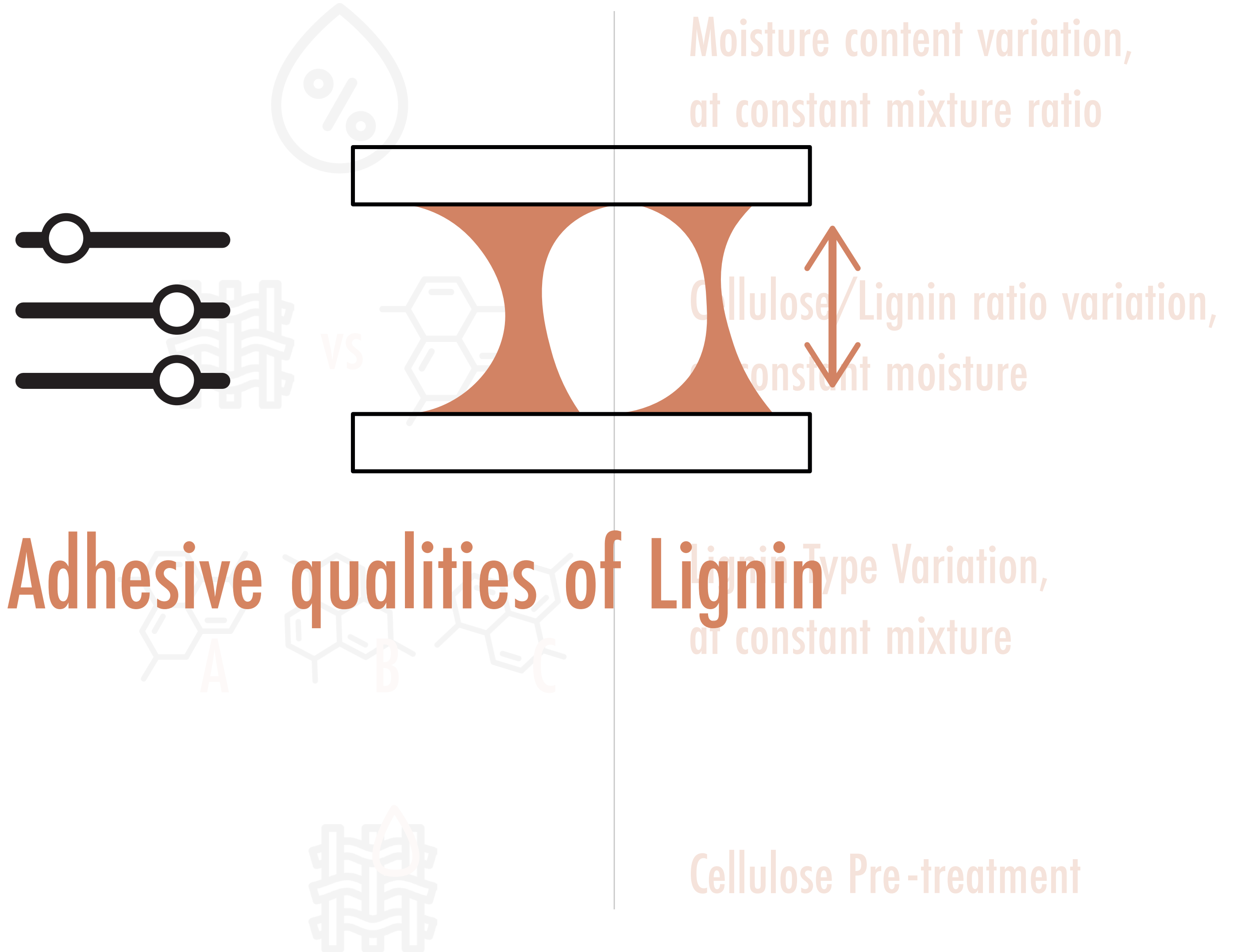
Lignin Type Variation,
at constant mixture

Cellulose Pre-treatment

Recyclability of hot-pressed plates

Aim:

Mixture Variation Trials



Moisture Trial

Mixture Profile

 C - 20g

30g - L Soda



Hot-Pressing Profile

 2 MPa

 85 °C

 60 °C

 15 min

Mositure

 0 - 25 wt%

The image shows five rectangular samples of a material, likely a polymer or composite, arranged in a row. Each sample is labeled with its moisture content: 0 wt%, 5 wt%, 10 wt%, 15 wt%, and 25 wt%. The samples are dark brown and appear to be made of a layered or fibrous material. The 0 wt% sample is the lightest and most uniform in color, while the 25 wt% sample is the darkest and shows significant discoloration and texture changes. The samples are arranged in a way that shows the progression of moisture content from left to right.

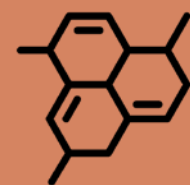
- 25 wt%
- 20 wt%
- 15 wt%
- 10 wt%
- 5 wt%
- 0 wt%

39

Qualifier: glossiness and colour

Moisture Trial

Mixture Profile

 C - 20g | 30g - L Soda 

Hot-Pressing Profile

 2 MPa |  85 °C
 60 °C |  15 min

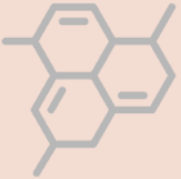
Mositure

 0 - 25 wt%

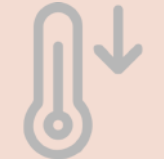


Moisture Trial

Mixture Profile

 C - 20g | 30g - L Soda 

Hot-Pressing Profile

 2 MPa |  85 °C
 60 °C |  15 min

Mositure

 0 - 25 wt%

Confirmation of theroy in literature



**Lignin
Flow** ↑

high moisture → lower Tg → earlier lignin flow

25 wt%
20 wt%
15 wt%
10 wt%
5 wt%
0 wt%

Moisture Trial

Mixture Profile

 C - 30g

|

20g - L
Soda



Additional trial to test backwards-compatibility of moisture theory



Hot-Pressing Profile*

	19 Mpa			140 °C
	2.2 Mpa			
	45 °C			15 min
				

Hot-Pressing Profile

	19 Mpa			90 °C
	2.2 MPa			
	45 °C			15 min
				

Hot-Pressing Profile

	19 MPa			70 °C
	2.2 MPa			
	45 °C			15 min
				

Moisture Trial

Mixture Profile

 C - 30g | 20g - L Soda 

Additional trial to test backwards-compatibility of moisture theory

5 wt%



10 wt%



25 wt%



Theory is reproducible

Hot-Pressing Profile*



19 Mpa
2.2 Mpa



140 °C



45 °C



15 min

Hot-Pressing Profile



19 Mpa
2.2 MPa



90 °C



45 °C



15 min

Hot-Pressing Profile



19 MPa
2.2 MPa



70 °C



45 °C



15 min

C/L ratio Trial

Hot-Pressing Profile

↓ 19 Mpa
↑ 2.2 Mpa
↑ 85 °C
↓ 40 °C
15 min

Mixture Profile

20 - 40g ISO C.
20 - 40g Soda L.
25 wt%

40g C. | L. 10g

30g C. | L. 20g

20g C. | L. 30g



35g C. | L. 15g

25g C. | L. 25g

C/L ratio Trial

Hot-Pressing Profile

↓ 19 Mpa
↑ 2.2 Mpa
↓ 40 °C
↑ 85 °C
15 min

Mixture Profile

20 - 40g ISO C.
20 - 40g Soda L.
25 wt%

40g C. | L. 10g

30g C. | L. 20g

20g C. | L. 30g

Aim:

Determine relative strength and stiffness to C/L ratio

35g C. | L. 15g

25g C. | L. 25g

Lignin Variation Trial

Hot-Pressing Profile

**19 Mpa**
3.7 Mpa

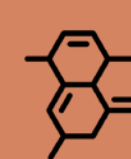
**140 °C**

**35 °C**

**15 min**

Mixture Profile

**25g ISO C.**

**25g Lignin**

**10 wt%**



(Material source: Softwoods)



(Material source: Straw, Baggase)



(Material source: Soft- or Hardwoods)

Lignin Variation Trial

Hot-Pressing Profile

↓ 19 Mpa
↑ 3.7 Mpa
↑ 140 °C
↓ 35 °C
15 min

Mixture Profile

25g ISO C.
25g Lignin
10 wt%

Aim:

Determine relative strength and
stiffness to Lignin type

Kraft

Soda (new)

Organosolv



Cellulose Pre-treatment Trial

Hot-Pressing Profile

↓ 19 Mpa		↑ 140 °C
↑ 3.7 Mpa		
↓ 35 °C		⌚ 15 min

Mixture Profile

25g ISO C.	10 wt%
25g Soda Lignin (new)	



Cellulose Pre-treatment Trial

Hot-Pressing Profile

↓ 19 Mpa
↑ 3.7 Mpa

↑ 140 °C

↓ 35 °C

⌚ 15 min

Mixture Profile

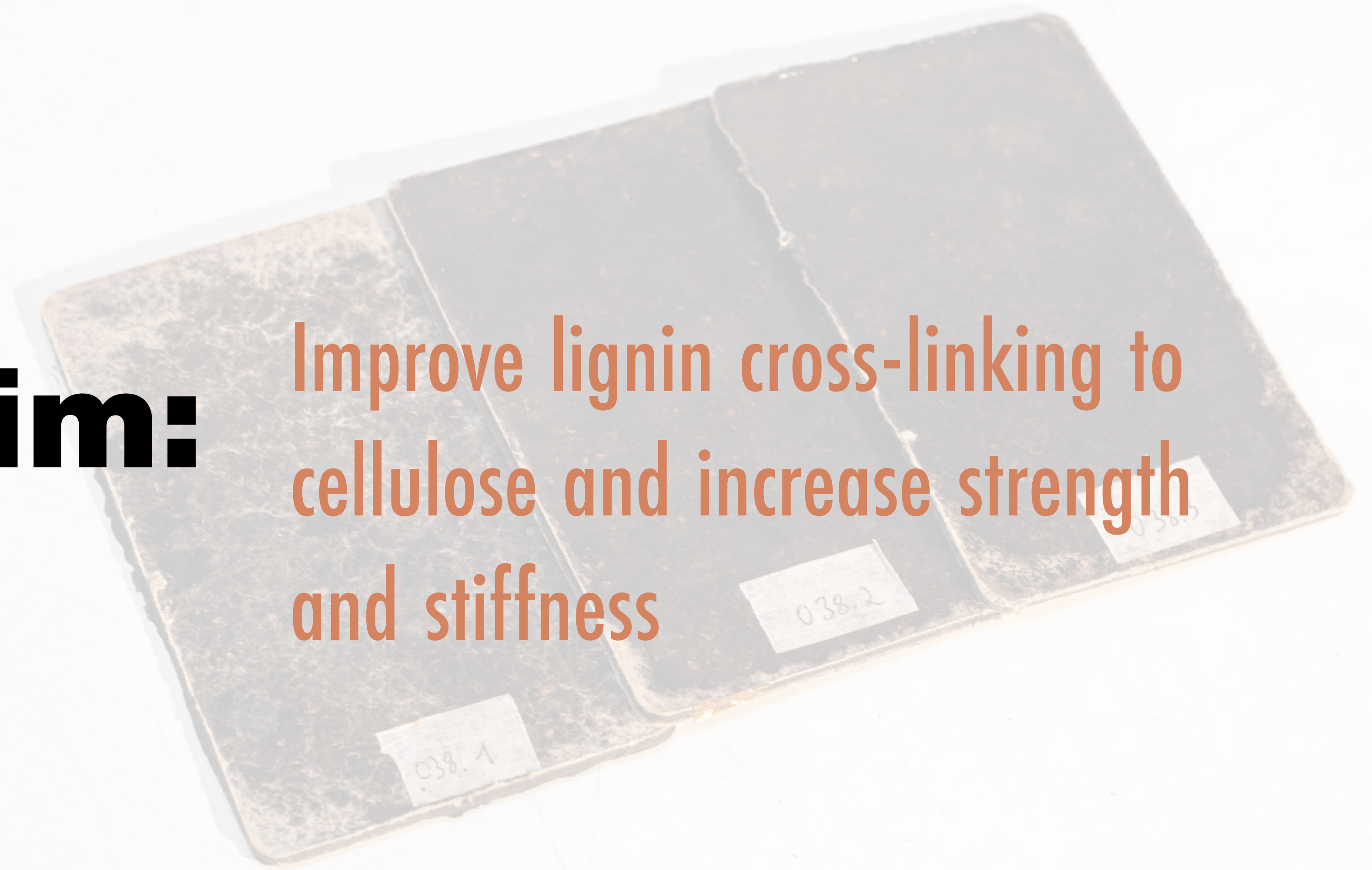
🧱 25g ISO C.

🧴 10 wt%

🌿 25g Soda Lignin (new)

Aim:

Improve lignin cross-linking to cellulose and increase strength and stiffness



Cellulose Pre-treatment Trial

- Preparation of 5% NaOH Solution
- Soaking of Shredded newspaper for 6 to 9 hours
- Straining of Pulp
- Declumping and drying

Required Equipment:

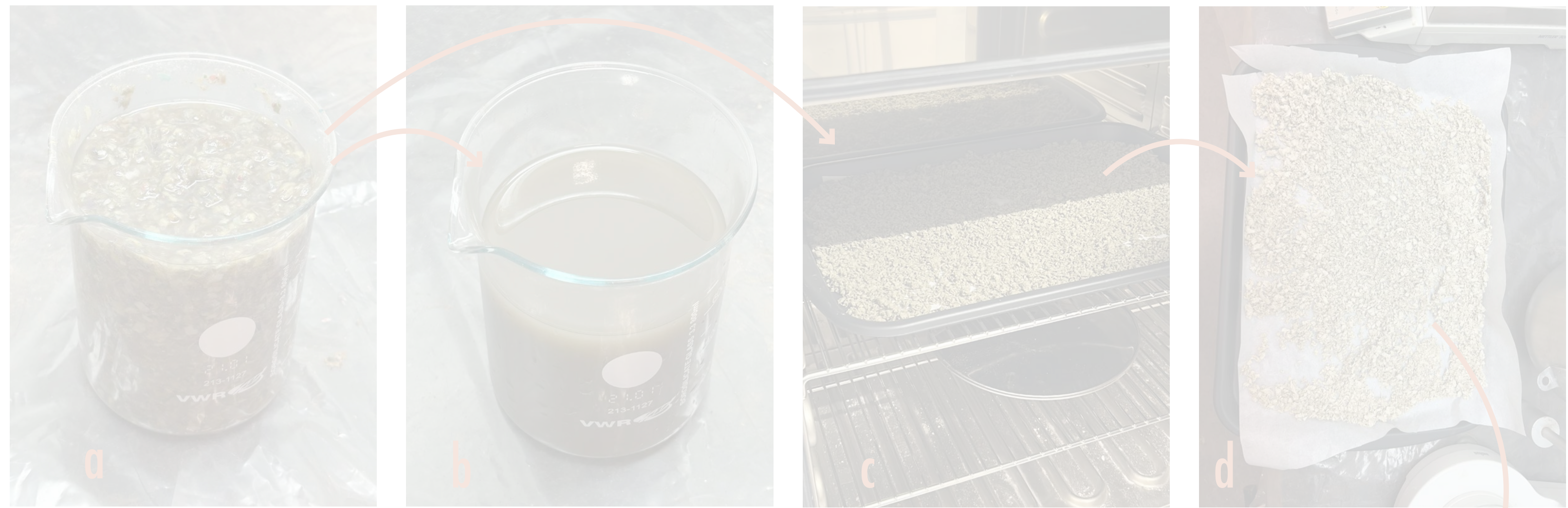
- Large glass beakers ~ 1 litre
- Straining Cloth
- Drying Oven + Rack
- NaOH - Sodium Hydroxide

Result:

140g of newspaper -> 75g of dried, treated fibres.



Cellulose Pre-treatment Trial



- Preparation of 5% NaOH solution
 - Soaking of Shredded newspaper for 6 to 9 hours
 - Straining of mixture
 - Declumping and drying
- Literature background:**

Required Equipment:

- Large glass beakers ~ 1 litre
- Straining Cloth
- Drying Oven + Rack
- NaOH - Sodium Hydroxide

stripping of hemicellulose and lignin from the newspaper for better cross-linking of new lignin

much less contamination

Microscopy image of pre-treated cellulose x 100

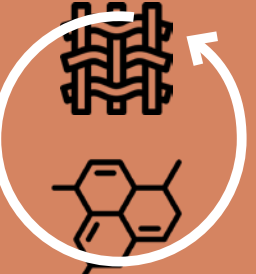
100µm

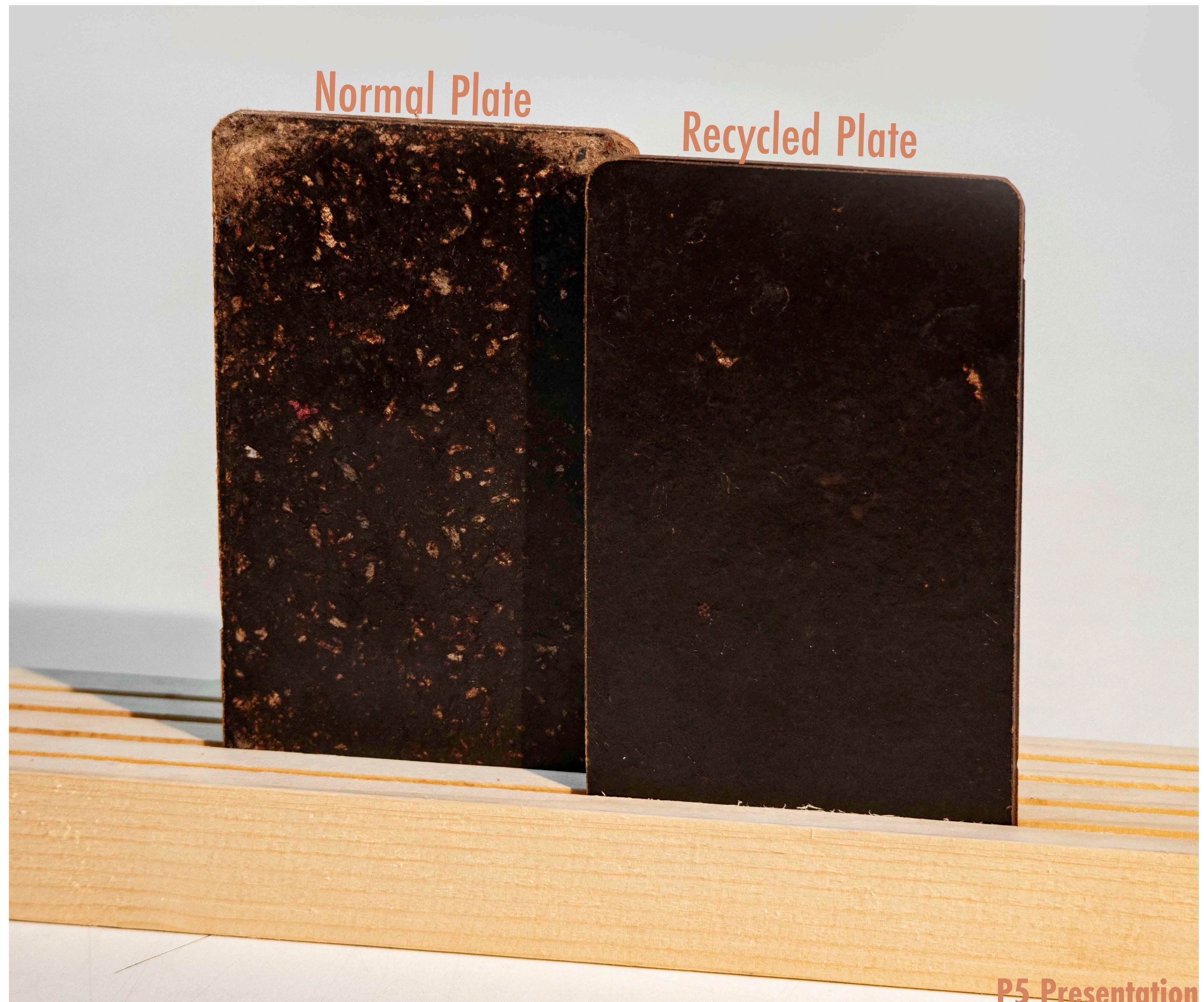
Material Recycling Trial

Hot-Pressing Profile

 19 Mpa	 115 °C
 3.7 Mpa	
 60 °C	 15 min

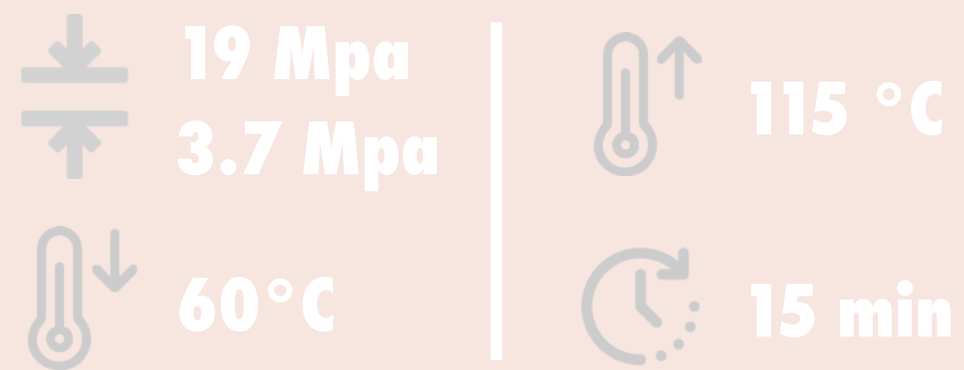
Mixture Profile

	50g (3:2)	 10 wt%
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Material Recycling Trial

Hot-Pressing Profile

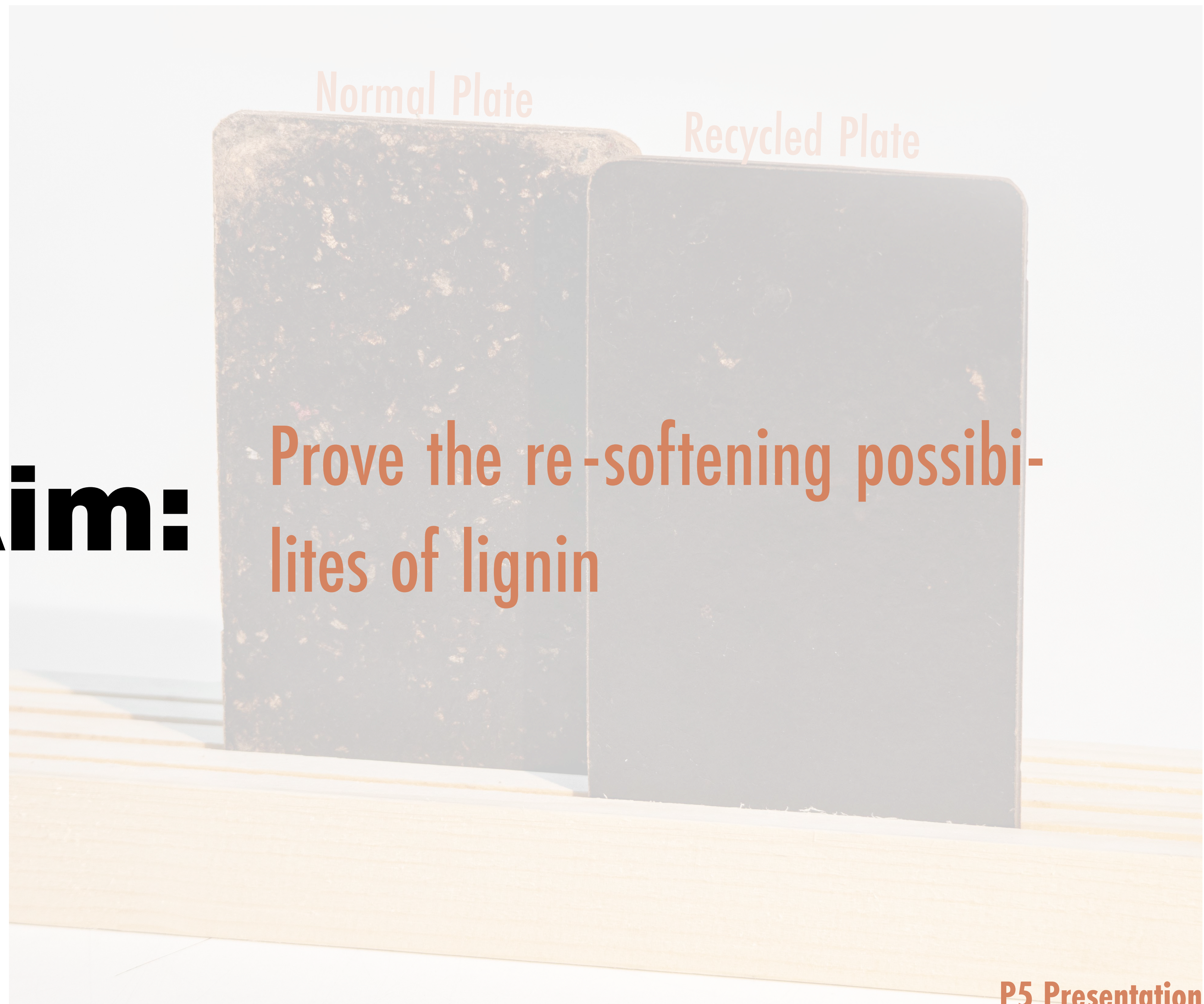


Mixture Profile



Aim:

Prove the re-softening possibilities of lignin





Scraps



Soaking



Wetted Scraps



Pulp



Straining



Dried pulp



Blending



Pressing

1. Lower σ 1700 kg/cm²
 2. Product surface temp. = 100°C for mechanical testing
 4.9 Percent Slab.
 2.8% time 45 min.

Master Thesis: Wood without Trees

Daniel Lee, 6037097

Mechanical Testing Documentation Table

Parameter	Exp- 022	Exp- 023	Exp- 024	Exp- 025
Date	2.1.03	2.1.03	2.1.03	2.1.03
Sample Type	024.1.1	024.1.2	024.1.3	024.1.4
Test Type	200N	-10	-10	-10
Machine Type	200N	-10	-10	-10
Fixture/ Grip	4.601-001	-10	-10	-10
Length	450.8	450.5		50.0
Width	43.4	43.9		43.3
Thickness	3.3	3.2	7.2	3.2
Gross Section				
Percent of Inertia				
Density				
Surface Condition/ Defects				
Loading Speed	5 mm/min	-10	-10	-10
Peak Load	28.3	30.7	29.4	27.5
Peak Deflection	4.7	2.8	4.7	8.5
Observations, Failure Positioning				

Parameter	Exp. 0.1	Exp. 0.2	Exp. 0.3	Exp. 0.4
Date	2.1.03	2.1.03	2.1.03	2.1.03
Sample type	0.2.1.5	0.2.1.1	0.2.1.5	0.2.1.1
Test type	Bend	-10°	-20°	-10°
Machine type	Knock 40 LK	-10°	-20°	-10°
Failure/Stop	Resin Band	yes	yes	yes
Length	150,4	150,4	150,4	150,4
Width	13,0	13,0	13,0	13,0
Thickness	3,9	3,9	3,6	3,1

Speed	5 mm/min	-10°	-20°	-10°
Pull Load	29,3	34,5	53,6	35,4
Peak Deflection	5,6	8,5	6,2	5,7

VGNormations:
 Failure
 Positioning





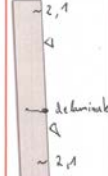

[illegible]

Parameter	Exp- 012	Exp- 011	Exp- 013	Exp- 016
Date	21.03	21.03	21.03	21.03
Testing type	025.1.1	025.1.2	025.1.5	025.1.4
Test type	Speed	-11	-16	-16
Machine type	20000 400N	-11	-16	-16
Fixture/ Grip	1.2001 Bench	-11	-16	-16
Length	150	150,8	150,6	150,3
Width	13,5	13,4	13,5	13,5
Thickness	3,6	3,6	3,6	3,6
Observations, Failure Description				

[illegible]

Parameter	Exp- 005	Exp- 006	Exp- 007	Exp- 008
Length	102.5	102.6	102.8	102.9
Width	12.5	12.6	12.7	12.8
Thickness	1.2	1.3	1.4	1.5
Grain Direction	0°	0°	0°	0°
Moisture Content	12.5	12.6	12.7	12.8
Density	0.75	0.76	0.77	0.78
Modulus of Elasticity	10.5	10.6	10.7	10.8
Compressive Strength	10.5	10.6	10.7	10.8
Flexure Strength	10.5	10.6	10.7	10.8
Impact Strength	10.5	10.6	10.7	10.8
Fire Retardancy	10.5	10.6	10.7	10.8
Weathering	10.5	10.6	10.7	10.8
Paint Adhesion	10.5	10.6	10.7	10.8
Biodegradability	10.5	10.6	10.7	10.8
Acoustic Properties	10.5	10.6	10.7	10.8
Thermal Stability	10.5	10.6	10.7	10.8
Electrical Properties	10.5	10.6	10.7	10.8
Mechanical Properties	10.5	10.6	10.7	10.8
Chemical Properties	10.5	10.6	10.7	10.8
Physical Properties	10.5	10.6	10.7	10.8
Biological Properties	10.5	10.6	10.7	10.8
Environmental Properties	10.5	10.6	10.7	10.8
Health and Safety	10.5	10.6	10.7	10.8
Economic Properties	10.5	10.6	10.7	10.8
Social Properties	10.5	10.6	10.7	10.8
Cultural Properties	10.5	10.6	10.7	10.8
Historical Properties	10.5	10.6	10.7	10.8
Archaeological Properties	10.5	10.6	10.7	10.8
Anthropological Properties	10.5	10.6	10.7	10.8
Linguistic Properties	10.5	10.6	10.7	10.8
Historical Linguistics	10.5	10.6	10.7	10.8
Archaeological Linguistics	10.5	10.6	10.7	10.8
Anthropological Linguistics	10.5	10.6	10.7	10.8
Linguistic Anthropology	10.5	10.6	10.7	10.8
Historical Linguistics	10.5	10.6	10.7	10.8
Archaeological Linguistics	10.5	10.6	10.7	10.8
Anthropological Linguistics	10.5	10.6	10.7	10.8
Linguistic Anthropology	10.5	10.6	10.7	10.8
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Linguistic Anthropology	10.5	10.6	10.7	10.8
Historical Linguistics	10.5	10.6	10.7	10.8
Archaeological Linguistics	10.5	10.6	10.7	10.8
Anthropological Linguistics	10.5	10.6	10.7	10.8
Linguistic Anthropology	10.5	10.6	10.7	10.8
Historical Linguistics	10.5	10.6	10.7	10.8

Parameter	Exp. 001	Exp. 002	Exp. 003	Exp. 004
Date:	21.03	21.03	21.03	21.03
Sample type:	022.5	022.2	022.5	022.4
Test type:	Beam	Beam	-11-	-11-
Machine type:	Test 1010	-11-	-11-	-11-
Finisher grip:	4 fixed band	-11-	-11-	-11-
Lengths:	147,2 mm	147,8	147,3	147,5
Widths:	43,7 mm	43,2	43,2	43,8
Thickness:	3,4 mm	3,7	3,7	3,2
Amount of fibres:				
Density:				
Surface Composites / Defects:				
Leaking liquid:	5 mm/min	5 mm/min	5 mm/min	-3-
Peak Load:	~ 22,1	~ 24	~ 22,2	43,2
Peak Deflection:		3,8 mm	7 mm	
Vibrations, Failure Positioning:				






[illegible]

Experimental Results

Master Thesis: Wood without Trees					Daniel Wolf, 6037309				
Heat-pressing Documentation Table									
Parameter	Exp-001	Exp-002	Exp-003	Exp-004	Exp-005				
Date	18.02	08.02	26.02	28.02	28.02				
Sample type	80/8	0.66	0.06	0.06	0.06				
Time (min)	05 + 12 s/s 08 steps only	5 min	5 min	5 min	30 min				
Pressure	1 MPa	1 MPa	1 MPa	5 MPa	5 MPa				
Temperature (°C)	160	140	160	180	200				
Post-heat-pressing weight	1163	100	PER	PER	PER	PER	PER	PER	PER
	53,8	330	44,2	41,2	41,2				40
Observations (Parting, Heterogeneity, etc.)	1. 0.66+3% 2. 140+15% 3. 140+3% 4. 5 min hold 5. 0.66+3% 6. 0.66+3% 7. 0.66+3% 8. 0.66+3% 9. 0.66+3% 10. 0.66+3% 11. 0.66+3% 12. 0.66+3% 13. 0.66+3% 14. 0.66+3% 15. 0.66+3% 16. 0.66+3% 17. 0.66+3% 18. 0.66+3% 19. 0.66+3% 20. 0.66+3% 21. 0.66+3% 22. 0.66+3% 23. 0.66+3% 24. 0.66+3% 25. 0.66+3% 26. 0.66+3% 27. 0.66+3% 28. 0.66+3% 29. 0.66+3% 30. 0.66+3% 31. 0.66+3% 32. 0.66+3% 33. 0.66+3% 34. 0.66+3% 35. 0.66+3% 36. 0.66+3% 37. 0.66+3% 38. 0.66+3% 39. 0.66+3% 40. 0.66+3% 41. 0.66+3% 42. 0.66+3% 43. 0.66+3% 44. 0.66+3% 45. 0.66+3% 46. 0.66+3% 47. 0.66+3% 48. 0.66+3% 49. 0.66+3% 50. 0.66+3% 51. 0.66+3% 52. 0.66+3% 53. 0.66+3% 54. 0.66+3% 55. 0.66+3% 56. 0.66+3% 57. 0.66+3% 58. 0.66+3% 59. 0.66+3% 60. 0.66+3% 61. 0.66+3% 62. 0.66+3% 63. 0.66+3% 64. 0.66+3% 65. 0.66+3% 66. 0.66+3% 67. 0.66+3% 68. 0.66+3% 69. 0.66+3% 70. 0.66+3% 71. 0.66+3% 72. 0.66+3% 73. 0.66+3% 74. 0.66+3% 75. 0.66+3% 76. 0.66+3% 77. 0.66+3% 78. 0.66+3% 79. 0.66+3% 80. 0.66+3% 81. 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[illegible][illegible]

Master Thesis: Wood without Trees						Daniel Lutz, 6037097					
Hot-spreading Documentation Table											
Parameter	Exp. 016	Exp. 017	Exp. 018	Exp. 019	Exp. 019	Exp. 020	Exp. 021	Exp. 022	Exp. 023	Exp. 024	Exp. 025
Date	11.03	14.03	17.03	21.03	24.03	27.03	30.03	31.03	01.04	04.04	06.04
Sample type	022	023	020	022	019	024	025	026	027	028	029
Time	cell	15	120	121 (21.04)	15	15	15	15	15	15	15
Pressure	3 MPa	2 MPa	2-10-2	10-2	2	10-2	10-2	10-2	10-2	10-2	10-2
Temperature (°C)	85	85	85	85	85	85	85	85	85	85	85
Weight	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	59.1	51.6	61.4	58.2	61.4	59.1	57.2	58.1	64.5	57.8	57.8
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6	1.9, 5.6
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4	35.6, 28.4
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4	31.1, 28.4
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8	End: 35.8
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Post
	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1	10.5, 12.1
Displacement	Pre	Post	Pre	Post	Pre	Post	Pre	Post			

Master Thesis: Wood without Trees					Daniel Lux, 0037097	
Hot-pressing Documentation Table						
Parameter	Exp. 014	Exp. 022	Exp. 013	Exp. 016	Exp. 15	
Date	14.03	14.03	19.03	18.07	18.07	
Sample type	0.25 x 1	0.26 x 1	0.29 x 1	0.25 x 2	0.28 x 2	
Time point	45	190 s	45	45	45	
Pressure	160 x 4.14	200 x 2.7	200 x 2.7	200 x 2.7	200 x 2.7	
Temperature (°C)	80	85	85	85	85	
Weight	Pre-Post	Pre-Post	Pre-Post	Pre-Post	Pre-Post	
	61.61	58.94	60.3	59.73	57.9	60.8 58.9 60.0 58.3
Displacement Protocol	Start: 33.4	Start: 33.5	Start: 33.5	Start: 33.4	Start: 33.4	
	2.160 x 3.34	2.160 x 3.35	2.160 x 3.35	2.160 x 3.35	2.160 x 3.35	
	End: 33.4	End: 33.4	End: 33.9	End: 33.4	End: 33.4	
Displacement from Plan	Filled out grist and saw the shavings into those again	Wickman 3.2 x 1.5	11.02 11.06 11.06 3.2 x 3.36	12.17 13.30 13.30 3.2 x 3.36	13.40 15.40 15.40 3.2 x 3.36	
Losses	4.7%	2.7%	2.4%	3.4%	2.4%	
Moisture Content	11.64%	17.3%	15.83%	17.64%	16.6%	
Comments / Improvements	Thick: 3.08 x 3.6 x 1.5 medium medium	not enough liquor in the vessels to keep the surface, but they remained				

[illegible][illegible][illegible]

Master Thesis: Wood under Treatments										Daniel Luek, 6073097	
Hot-pressing Documentation Table											
Parameter	Exp. 04.1	Exp. 04.2	Exp. 04.3	Exp. 04.4	Exp. 04.5	Exp. 04.6	Exp. 04.7				
Date	02.04.	02.04.	21.04.	22.04.	22.04.						
Sample type	03.1	039.1	038.2	038.3	039.1						
Type (mm)	45 - E	45 - 10	45 - 10	45 - 10	45 - 10	45 - 6					
Pressure	250 - 50	250 - 50	250 - 50	250 - 50	250 - 50	250 - 50					
Temperature (°C)	80	120°C	120°C	120 °C	120 °C	85					
Weight	Pre Post	Pre Post	Pre Post	Pre Post	Pre Post	Pre Post	Pre Post				
Displacement Protocol	Start: 54.1	Start: 54.5	Start: 54.9	Start: 55.0	Start: 56.4	Start: 55.85	Start: 56.1				
Deviation from Plan	End: 14.04	End: 12.33	End: 14.17	End: 14.03	End: 14.05	End: 14.05	End: 14.05				
Losses	14.00	14.08	14.10	14.10	14.15	14.15	14.15				
Miscellaneous Comments / Improvements											

Master Thesis: Wood without Trees										Daniel Lux, 03/07/07	
Hot-pressing Documentation Table											
Parameter	Exp. 0-6	Exp. 0-12	Exp. 0-18	Exp. 0-24	Exp. 0-30	Exp. 0-36	Exp. 0-42	Exp. 0-48	Exp. 0-54	Exp. 0-60	
Date	29.04.07	28.04.07	28.04.07	28.04.07	28.04.07	28.04.07	28.04.07	28.04.07	28.04.07	28.04.07	
Sample type	0.30.2	0.30.5	0.31.1	0.31.4	0.31.7	0.32.0	0.32.3	0.32.6	0.32.9	0.33.2	
Time (min)	48-5	19-5	19-5	19-5	19-5	19-5	19-5	19-5	19-5	19-5	
Pressure	64	250-50	250-50	250-50	250-50	250-50	250-50	250-50	250-50	250-50	
Temperature (°C)	120	40-40	120-15	120-15	120-15	120-15	120-15	120-15	120-15	120-15	
Weight	200g	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	Pre: 59.9 Post: 57.0	
Displacement	200g	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	
Protocol	1-12 19-42	19-00 12-12	19-11 12-11	19-11 12-11	19-11 12-11	19-11 12-11	19-11 12-11	19-11 12-11	19-11 12-11	19-11 12-11	
Destinations from Plan	2. 1st floor 3. 2nd floor 4. 3rd floor 5. 4th floor 6. 5th floor 7. 6th floor 8. 7th floor 9. 8th floor 10. 9th floor 11. 10th floor 12. 11th floor 13. 12th floor 14. 13th floor 15. 14th floor 16. 15th floor 17. 16th floor 18. 17th floor 19. 18th floor 20. 19th floor 21. 20th floor 22. 21st floor 23. 22nd floor 24. 23rd floor 25. 24th floor 26. 25th floor 27. 26th floor 28. 27th floor 29. 28th floor 30. 29th floor 31. 30th floor 32. 31st floor 33. 32nd floor 34. 33rd floor 35. 34th floor 36. 35th floor 37. 36th floor 38. 37th floor 39. 38th floor 40. 39th floor 41. 40th floor 42. 41st floor 43. 42nd floor 44. 43rd floor 45. 44th floor 46. 45th floor 47. 46th floor 48. 47th floor 49. 48th floor 50. 49th floor 51. 50th floor 52. 51st floor 53. 52nd floor 54. 53rd floor 55. 54th floor 56. 55th floor 57. 56th floor 58. 57th floor 59. 58th floor 60. 59th floor 61. 60th floor 62. 61st floor 63. 62nd floor 64. 63rd floor 65. 64th floor 66. 65th floor 67. 66th floor 68. 67th floor 69. 68th floor 70. 69th floor 71. 70th floor 72. 71st floor 73. 72nd floor 74. 73rd floor 75. 74th floor 76. 75th floor 77. 76th floor 78. 77th floor 79. 78th floor 80. 79th floor 81. 80th floor 82. 81st floor 83. 82nd floor 84. 83rd floor 85. 84th floor 86. 85th floor 87. 86th floor 88. 87th floor 89. 88th floor 90. 89th floor 91. 90th floor 92. 91st floor 93. 92nd floor 94. 93rd floor 95. 94th floor 96. 95th floor 97. 96th floor 98. 97th floor 99. 98th floor 100. 99th floor 101. 100th floor 102. 101st floor 103. 102nd floor 104. 103rd floor 105. 104th floor 106. 105th floor 107. 106th floor 108. 107th floor 109. 108th floor 110. 109th floor 111. 110th floor 112. 111st floor 113. 112nd floor 114. 113rd floor 115. 114th floor 116. 115th floor 117. 116th floor 118. 117th floor 119. 118th floor 120. 119th floor 121. 120th floor 122. 121st floor 123. 122nd floor 124. 123rd floor 125. 124th floor 126. 125th floor 127. 126th floor 128. 127th floor 129. 128th floor 130. 129th 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Master Thesis: Wood without Trees				Daniel Wood, 0037097		
Material Experiment Documentation Table						
Parameter	Exp. 036	Exp. 037	Exp. 038	Exp. 039	Exp.	Exp.
Dry Mass weight & G/L Ratio	27.03	27.03	46.83	47.03		
MOISTURE	55% 3/2	64.5% 3/2				
	30	30	25 (model)	25		
Flourished pure cellulose (FPC)			✓	✓		
Extr. Paper			✓	✓		
Clay			✓	✓		
Lignin Type & Amount (g)	20	20	25	25		
Fast Lign.						
Soft Lign.		✓	x (new)	x (new)		
Organic/L						
Water Content	5%	12.5%	10.5%	12.5%		
Moisture Content at 100°C	100%	45-54%	100%	25-35%		
Pressing Process (Time, Speed, Method)						
Drying Conditions / Weight	562	699	Press weight	Press weight	Press weight	
Observations (Textures, Heterogeneity, etc.)			140g cellulose in 50% water → 25% model	2 RIEP To 100% after		
Directions from Plan			-Dadd water until better able			
Lines during mixing	141%	98%				
Comments / Improvements	Press at 90°C	Press at 70°C	to be pressed at 110°C + cardboard hold 10 min at 50W			

Master Thesis: Wood without Trees						Daniel Lux, 6037097	
Material Experiment Documentation Table							
Parameter	Exp-026	Exp-027	Exp-028	Exp-024.3	Exp-025.3		
Date	11.03	11.03	11.03	26.03	26.03		
Sample weight & C.R. Rate	62.5 g/2	61.5 g/3	61.5 g/3	62.5 g/3	62.5 g/4	61.5 g/4	
Horizontal panel cellulosin (PPC)		35	20	40	25		
Kraft-Paper	✓	✓	✓	✓	✓		
Uppin Tape & Lignin							
Uppin Tape (g)	2.0	1.5	3.0	1.0	2.5		
Soda Lignin	✓	✓	✓	✓	✓		
Organosolvent							
Water Content	11.5 %	16.5 %	13.5 %	13.5 %	13.5 %		
Moisture Content (wt %)	15 wt %	25 wt %	25 wt %	26 wt %	25 wt %		
Pinning, Speed, Method							
Drying							
Grains / Sheets / Plates	60.3	59.3	61.2	61.9	60.5		
Observations (textures, heterogeneity, etc.)	60.0	60.3	61.1	61.9	60.5	→ no pre-press, directly into bag Some	
Discoloration from Sun							
Lines on during mixing	365 %	5.1 %	0.58 %	0.58 %	2.9 %		
Comments / Improvements	4.1 %	2.8 %	0.59 %				

[illegible][illegible]

Master Thesis: Wood without trees				Daniel Lux, 6037097		
Material Experimentation Database						
Parameter	Exp- 024.5	Exp- 027.5	Exp- 028.5	Exp- 029.5	Exp- 030	Exp- 030.5
Date	20.03					
Specimen length & C/L Ratio	41.5	3/2	42.5	7/3	62.5	4/3
ROCKWELL	30	35	20	25	25	29
Wood Species (cellulose (PC))						
Card-Paper						
Other						
Lignin Type & Amount (g)	20	45	30	25	25	21.5
Soda Ligno	x	x	x	x	x	x
Organic Ligno						
Water Content	11.5	11.5	12.5	11.5	10.5	10.5
Moisture Content (Hum. Speed, Relative)	25 w%	25 w%	25 w%	25.4%	25.4%	25.4%
Finishing Process (Time, Speed, Method)						
Weight Conditions / Weight	64.2	64.75	64.95	64.66	64.94	57.87
Observations (Dens., Homogeneity, etc.)				1.05	1.05	1.05
Deviations from Plan				0.55%	0.55%	0.55%
Finishing Rating	2.11%	1.21%	1.05%	1.05%	1.05%	1.05%
Comments / Improvements				2.9%	2.9%	2.9%

[illegible]

Improvements
55

P5 Presentation

$$V_s = 15. \quad w_c = 30g \cdot 15 = 450 \text{ ml} \quad \text{at } 5\% \text{ NaOH}$$

- bring baling paper

Mixture Development



- Dry-mixing using controlled adding of moisture - optimal 10 wt%



- 3:2 - 1:1 C/L ratio optimal (also economical)



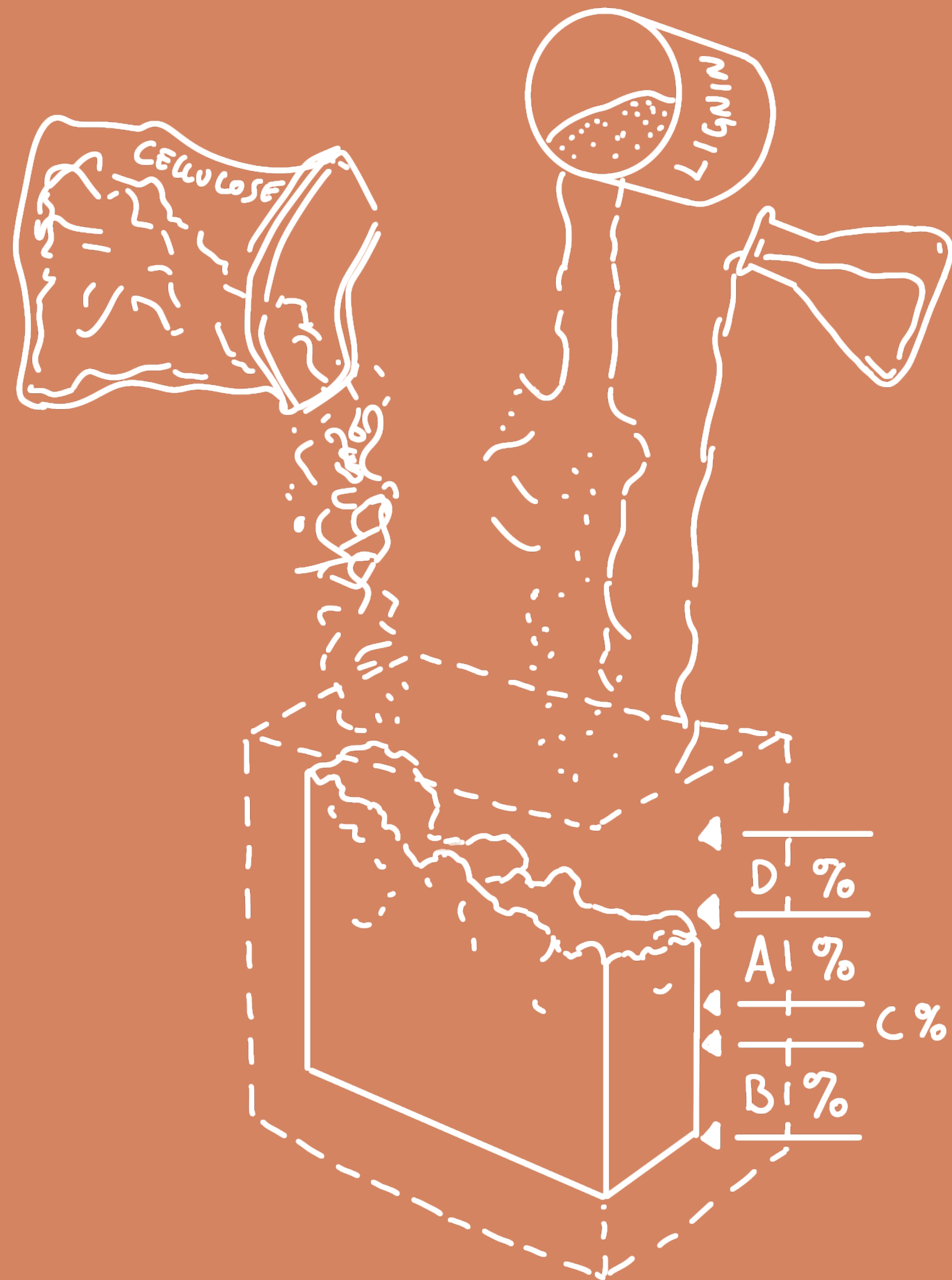
- Organosolv lignin shows poor visual results



- Cellulose pre-treatment Samples show exceptional visual qualities.



- Recycling Trial succesfull, also exceptional visual qualities!

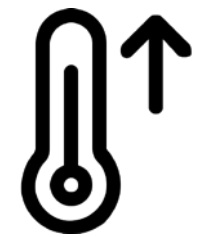




Hot-Pressing Process



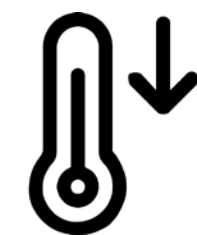
- Pre-compression of 20MPa



- Heat to 120°C at 3MPa



- Hold at 120°C for 15min

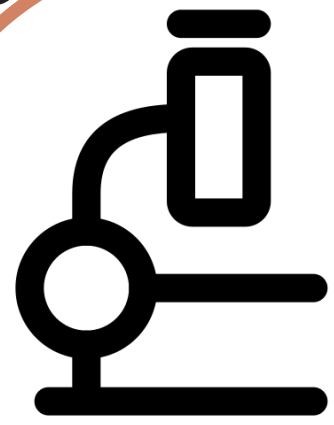


- Cool to 35°C -> no blisters
- Direct bagging and controlled drying can reduce warping

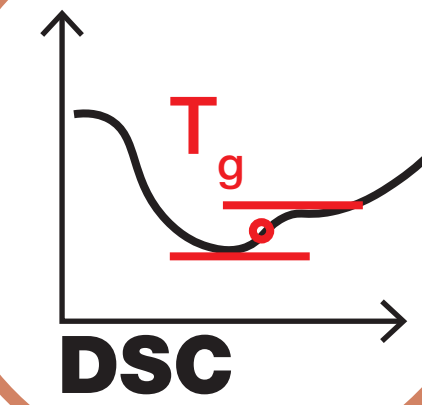


Analysis Tools

Microscopy



Thermal Analysis



Mechanical Testing

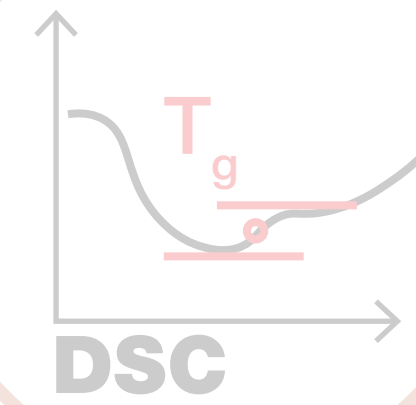


Analysis Tools

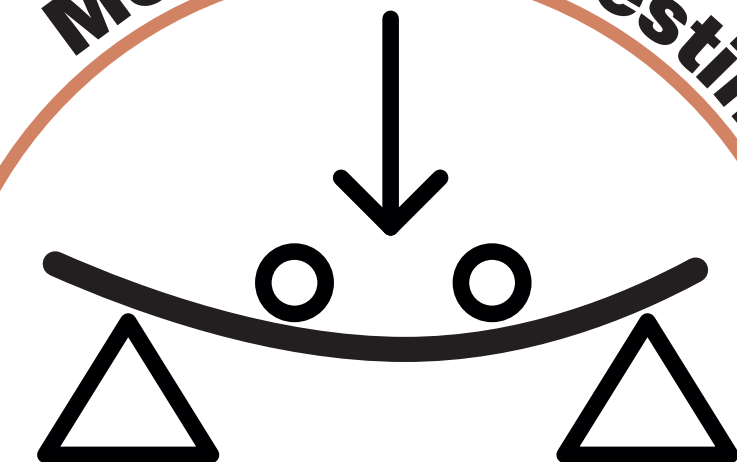
Microscopy



Thermal Analysis

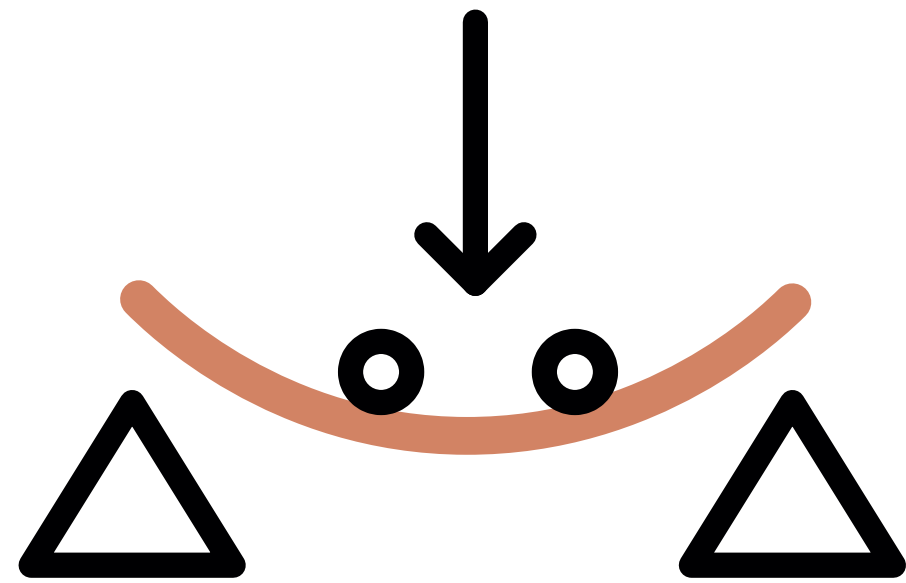


Mechanical Testing



Compression
Bending
Tension

Four-Point Bending

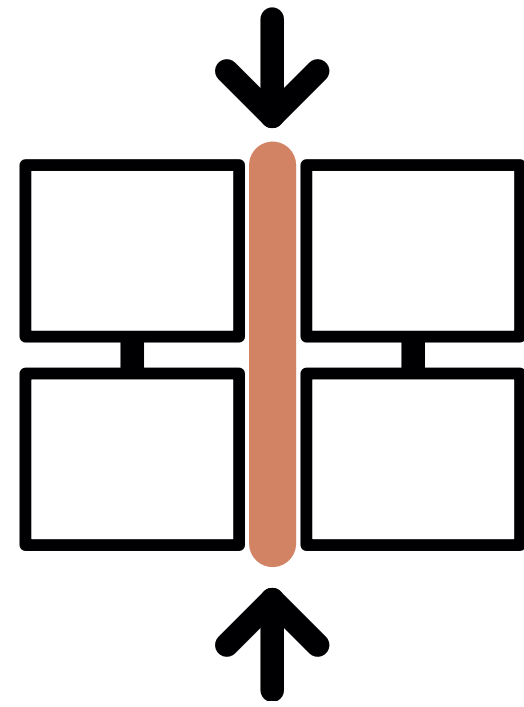


For determining:
Flexural Strength and Stiffness

*@ TU Delft Mechanical Engineering -
Mechanical Behaviour Laboratory*



Compression



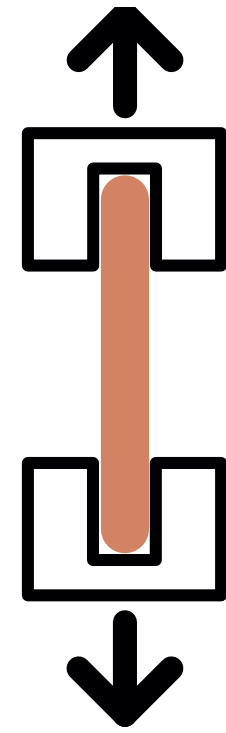
For determining:
Compressive Strength and
Stiffness

@ TU Delft Aerospace Engineering - DASML



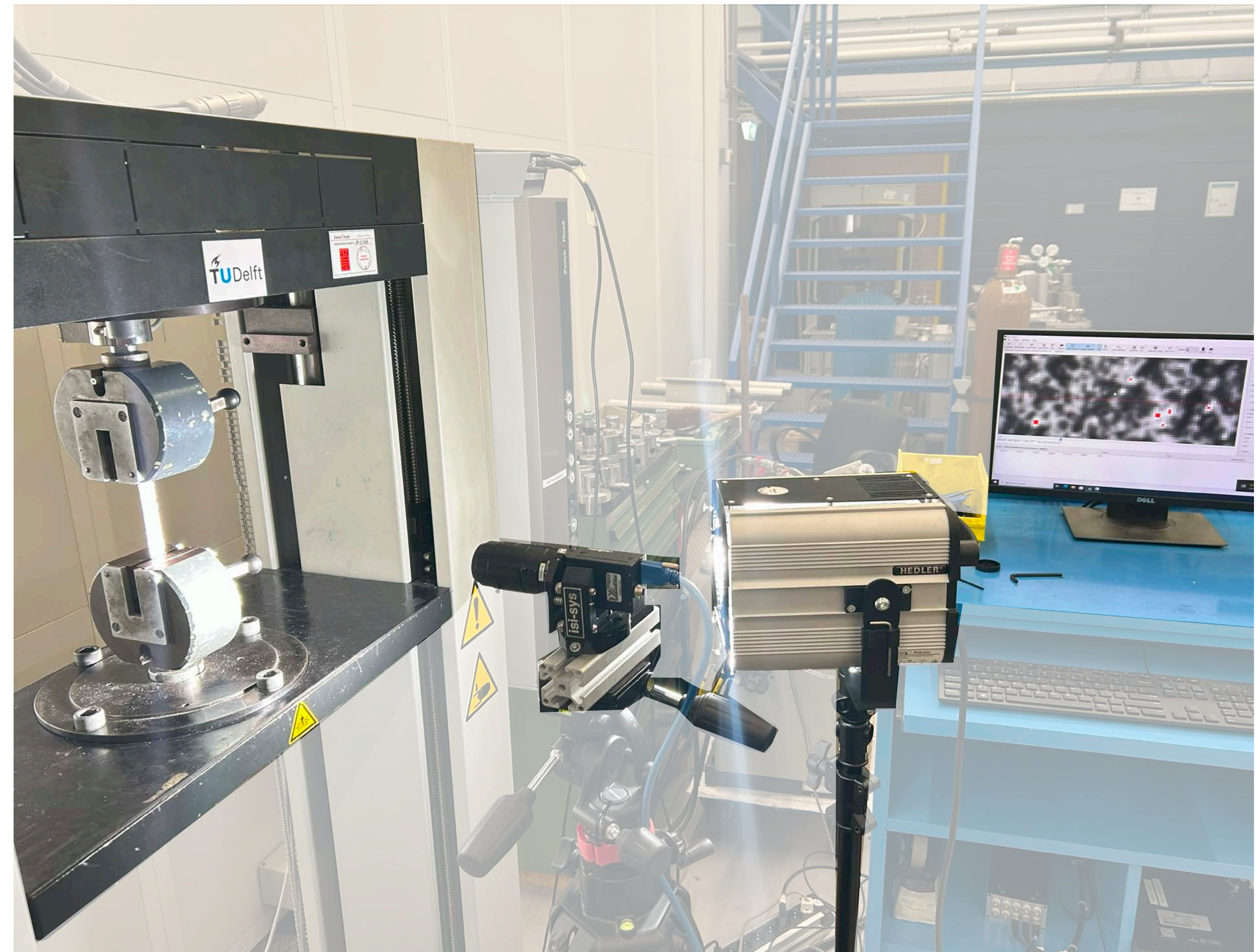
using ASTM D6641 anti-buckling fixture

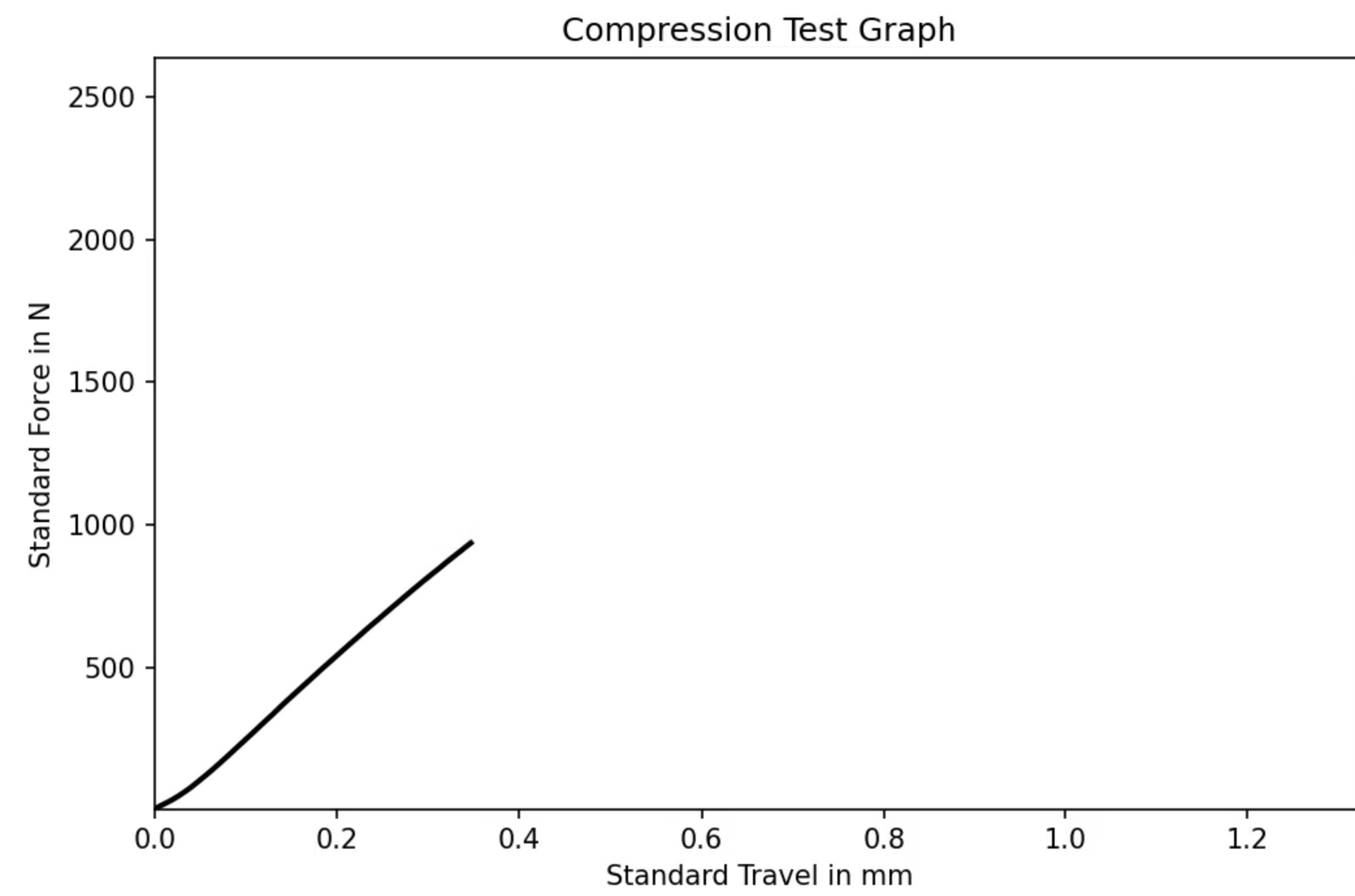
Tension + DIC



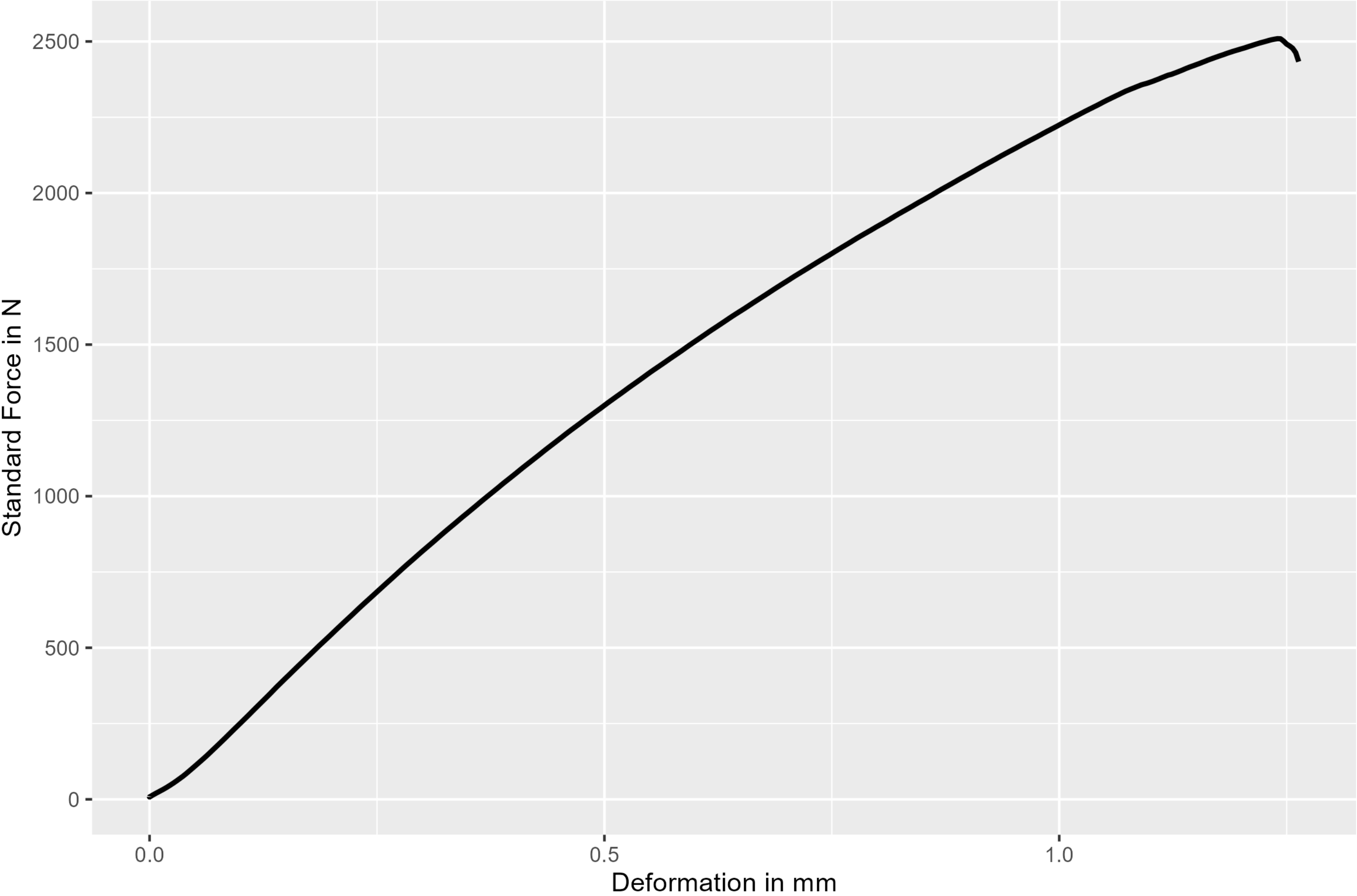
For determining:
Tensile Strength and Stiffness
+ lateral and longitudinal Strain
(for Poisson's ratio to Shear Modulus (G))

@ TU Delft Aerospace Engineering - DASML

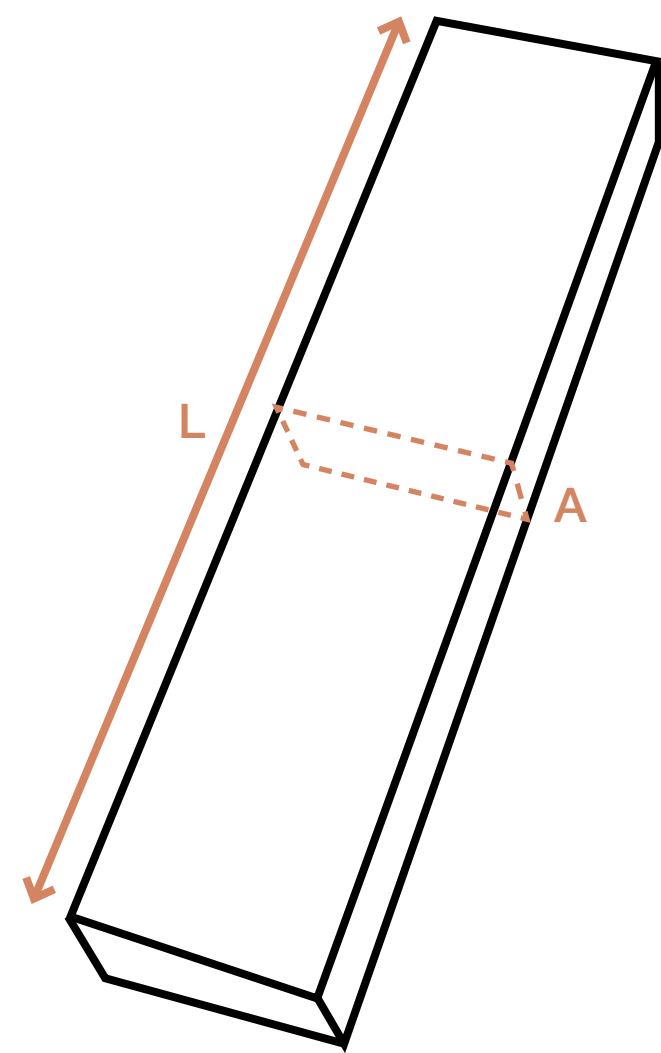




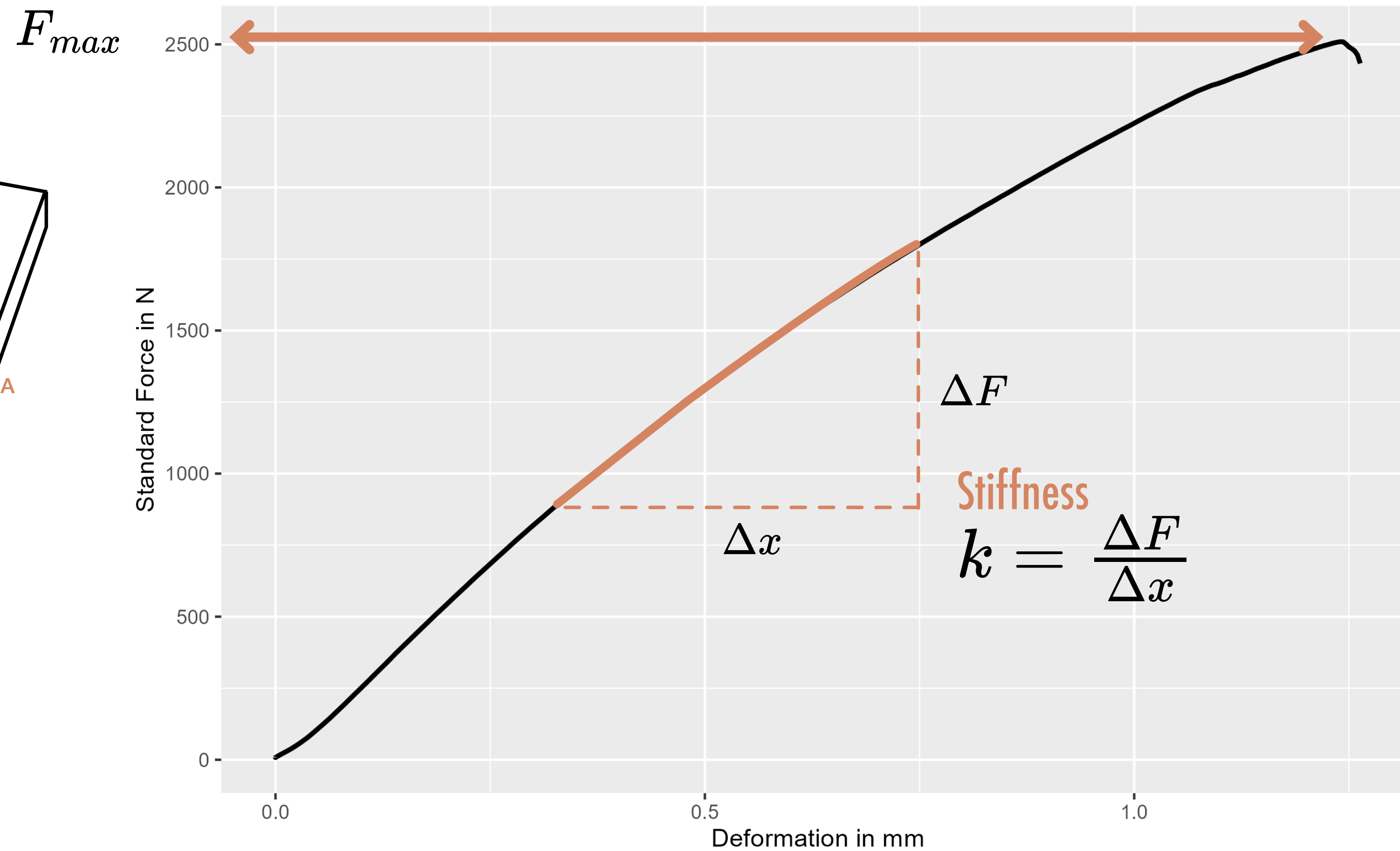
Specimen: C.39.2.6
Compressive Tests 22.05.2025 of Testspecimen



Data comes from the compressive tests at Zwick 10kN machine



Specimen: C.39.2.6
Compressive Tests 22.05.2025 of Testspecimen



Data comes from the compressive tests at Zwick 10kN machine

Compressive Strength

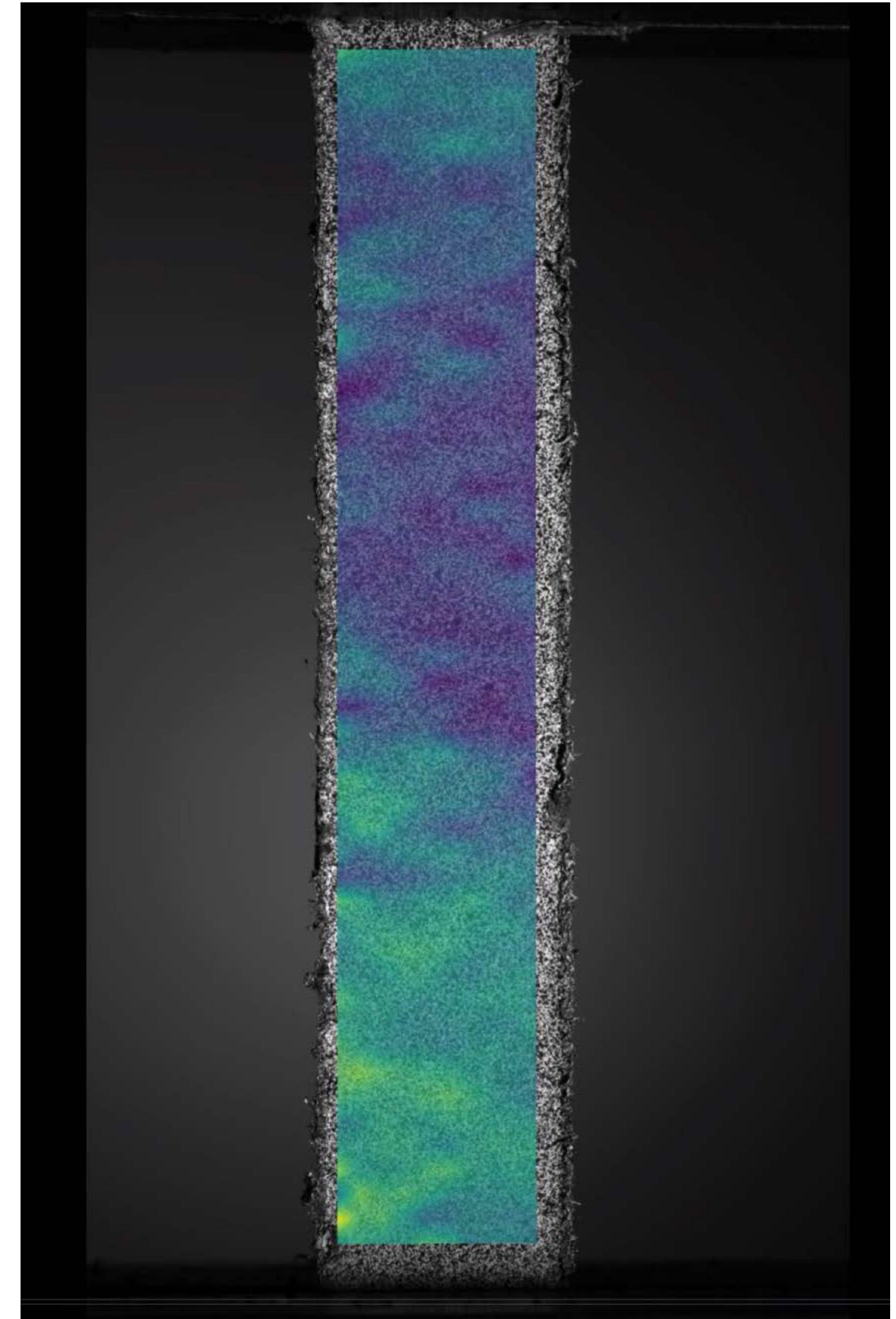
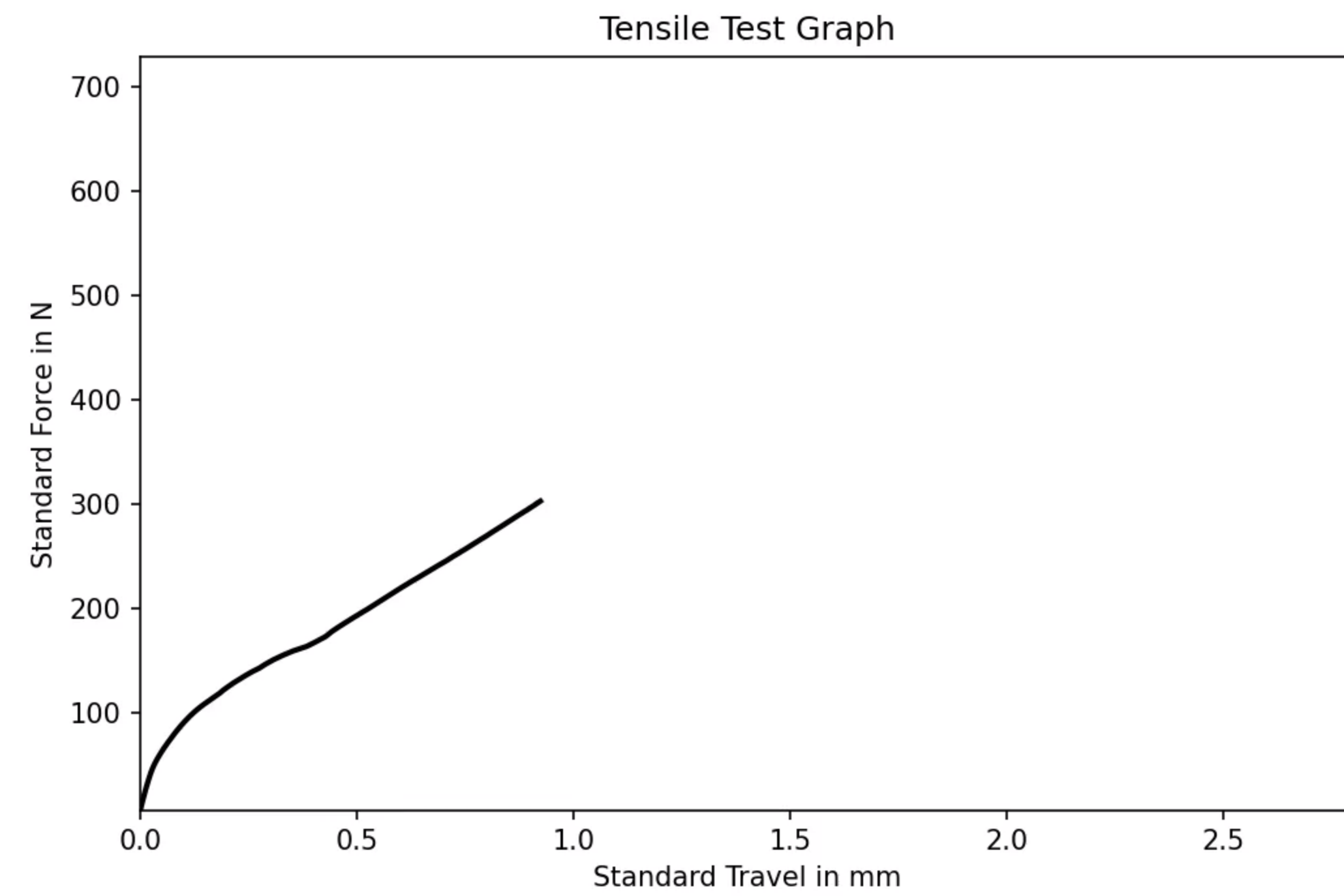
$$f_c = \frac{F_{max}}{A}$$

Compressive Modulus

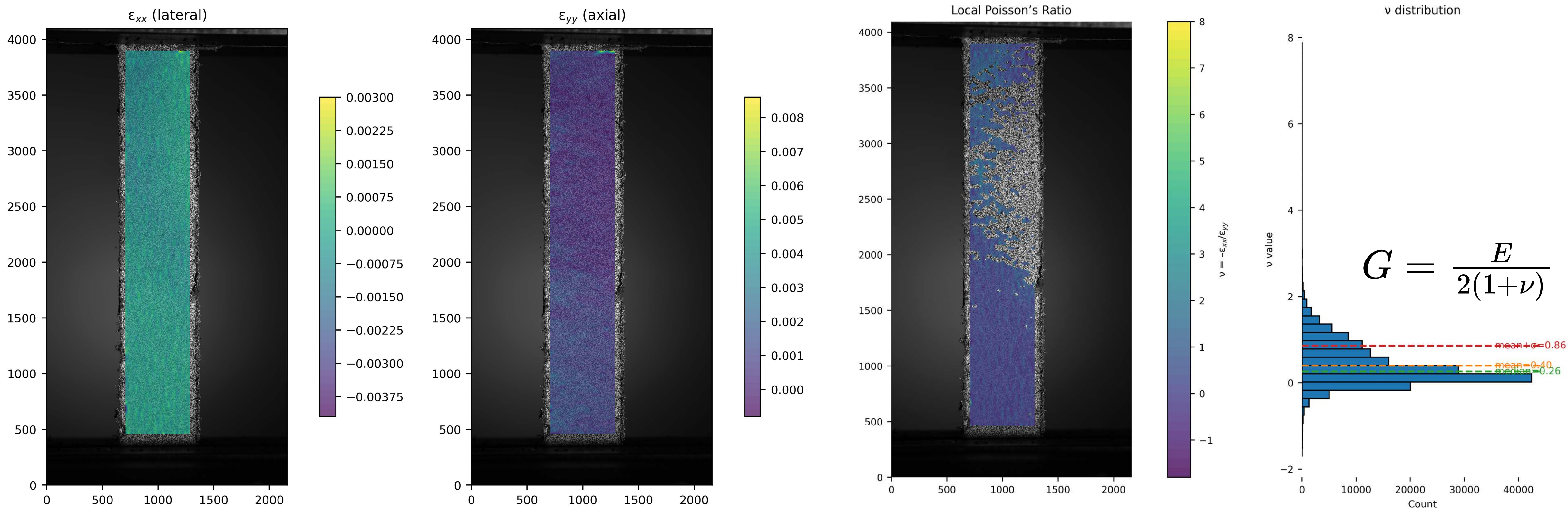
$$E_c = \frac{kL}{A}$$

Stiffness

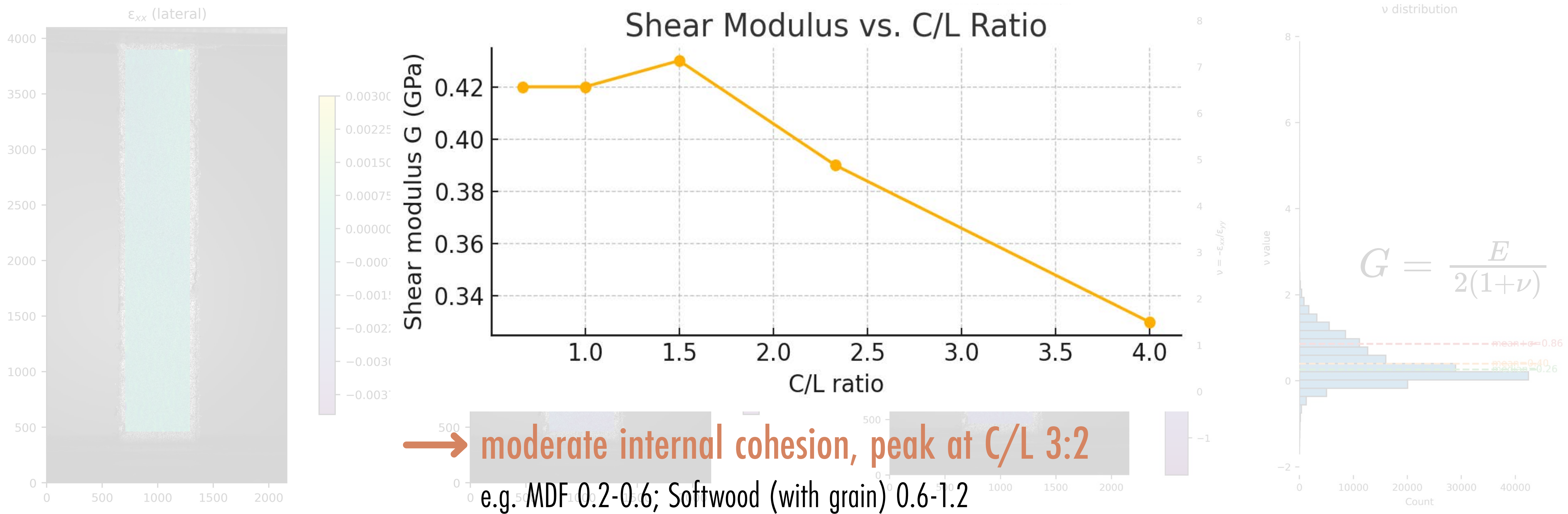
$$k = \frac{\Delta F}{\Delta x}$$



Determination of Poisson's Ratio

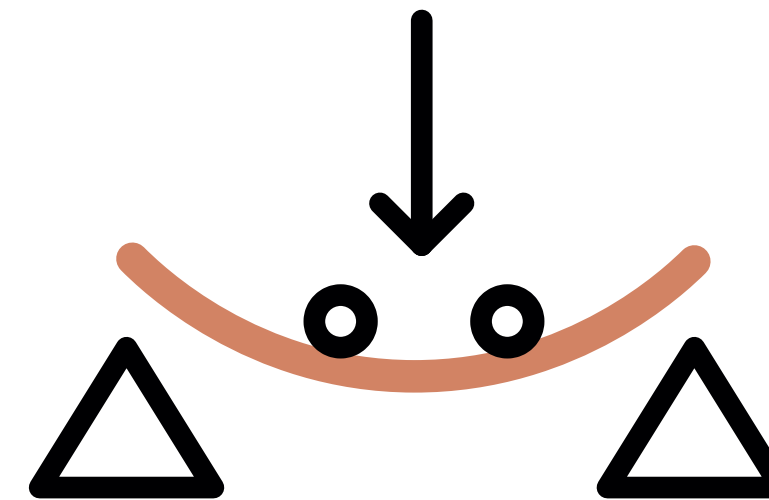
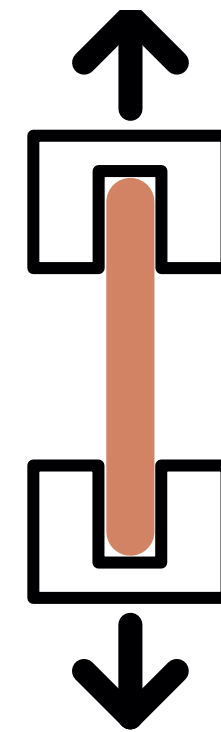
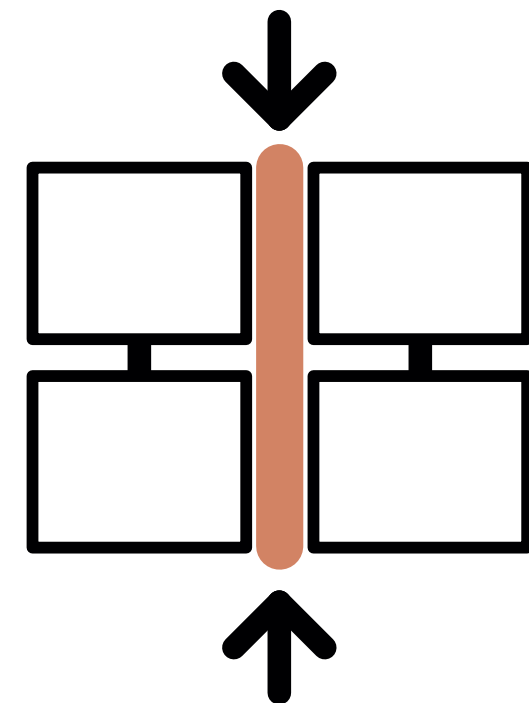


Determination of Poisson's Ratio



Tensile Test + DIC

Mechanical Testing Results



Type	ID	modulus	strength	thickness	width	L	Trial	Moisture- Pressing-		ID_group		
								C/L	Lignin			
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6215,326	11,48825	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.6	5290,872	8,867406	3,2	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	25.1.1	6188,904	15,54374	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.2	5674,324	14,70073	3,6	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.3	6503,451	12,66391	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.4	5607,25	16,33841	3,4	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.5	5666,974	13,49964	3,7	13,6	150	C-L	1	Soda	12,5	85	25
B	25.1.6	7044,832	16,63206	3,2	13,3	150	C-L	1	Soda	12,5	85	25
B	27.1.1	6800,276	14,7554	3,3	13,2	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.2	5152,383	15,89623	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.3	7256,76	14,12752	3,4	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.4	5299,508	16,67117	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.5	8259,459	16,78037	3,4	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.6	9670,392	19,14852	3,3	12,9	150	C-L	2,333333	Soda	12,5	85	27
B	26.1.1	7517,785	14,55511	3,3	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.2	6522,592	16,8058	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.3	8244,057	16,01036	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.4	5128,713	15,05476	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.5	8611,443	22,78519	3,3	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.6	7927,4	22,23617	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	24.1.1	4767,761	9,510516	3,6	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.2	5229,5	9,207148	3,6	13,25	150	C-L	4	Soda	12,5	85	24
B	24.1.3	4236,728	7,758672	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.4	4623,934	10,29196	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.5	4769,64	11,98886	3,8	13,3	150	C-L	4	Soda	12,5	85	24
B	24.1.6	3989,662	8,649974	3,5	12,9	150	C-L	4	Soda	12,5	85	24
C	23.1	6311,049	19,1977	3,2	11,9	150	C-L	0,666667	Soda	12,5	85	23
C	23.2	7129,824	20,3512	3,3	12,1	150	C-L	0,666667	Soda	12,5	85	23
C	24.2.1	6873,97	10,17598	3,4	12,4	150	C-L	4	Soda	12,5	85	24
C	24.2.2	9212,007	20,47299	3,3	12,4	150	C-L	4	Soda	12,5	85	24
C	24.3.1	5572,161	14,66721	3,3	12,41	150	C-L	4	Soda	12,5	70	24
C	24.2.3	7852,884	28,76704	3,3	12,41	150	C-L	4	Soda	12,5	85	24
C	24.3.2	7019,717	14,55646	3,44	12,17	150	C-L	4	Soda	12,5	70	24
C	24.3.3	6022,323	15,70994	3,41	12,26	150	C-L	4	Soda	12,5	70	24
C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

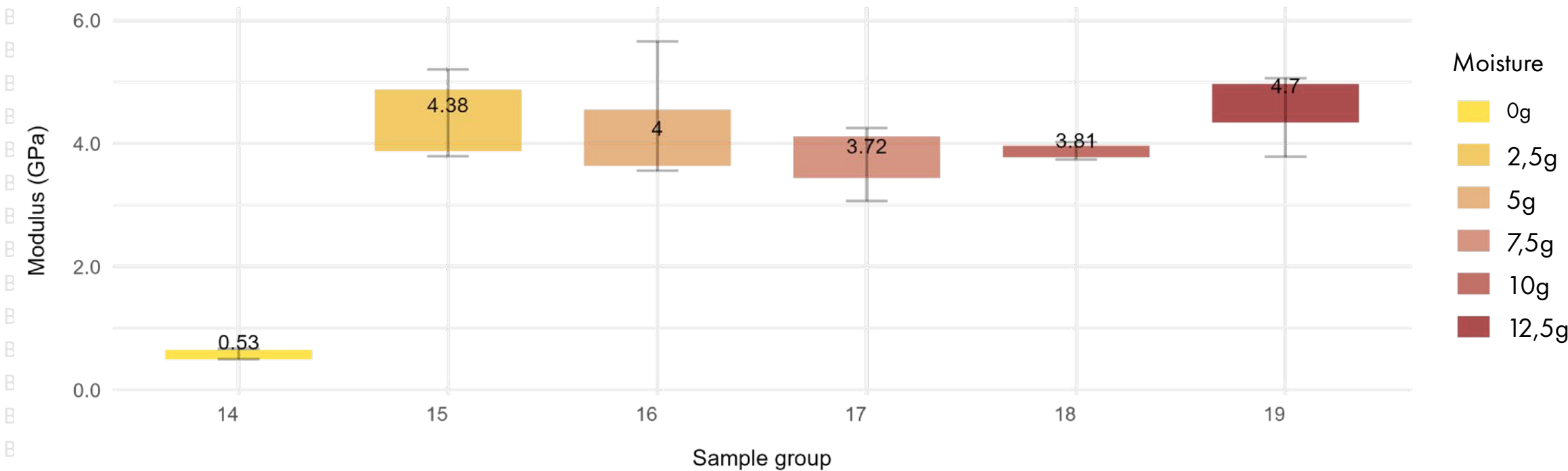
Mechanical Testing Results

- Material has asymmetric strain response due to:

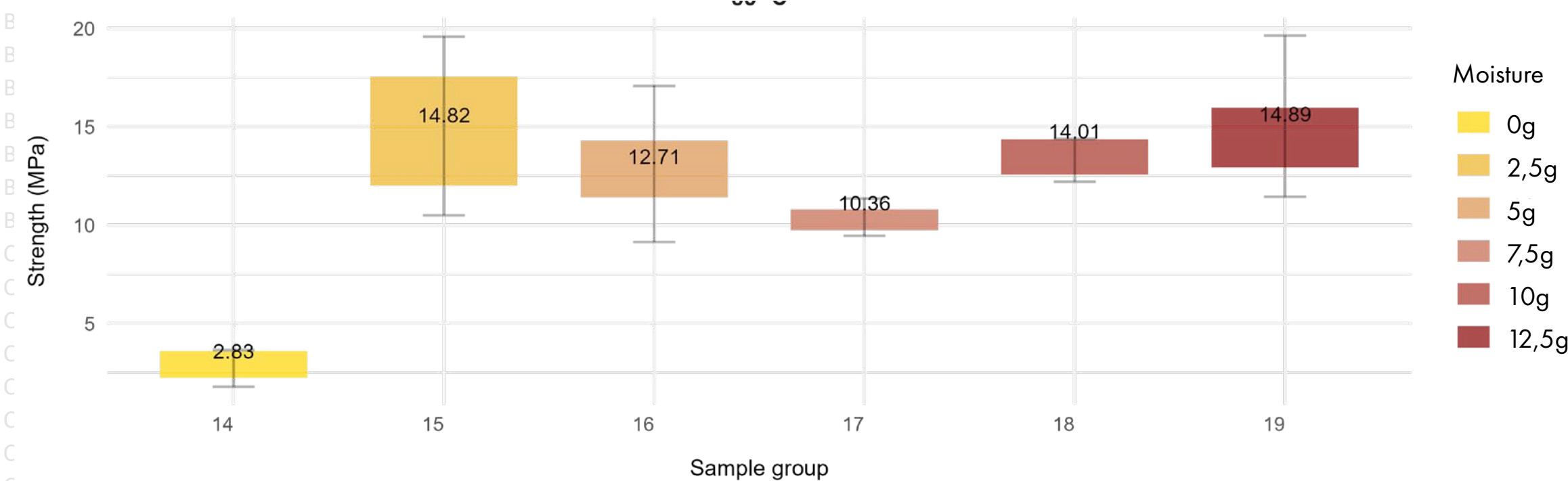
$$E_c \neq E_t$$

Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture- Content	Pressing- temp.	ID_group
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6244,037	10,01030	3,2	13,5	150	C-L	1,5	Soda	12,5	85	28

Bending Stiffness Results Moisture Variation Trial



Bending Strength Results Moisture Variation Trial



C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

Mechanical Testing Results

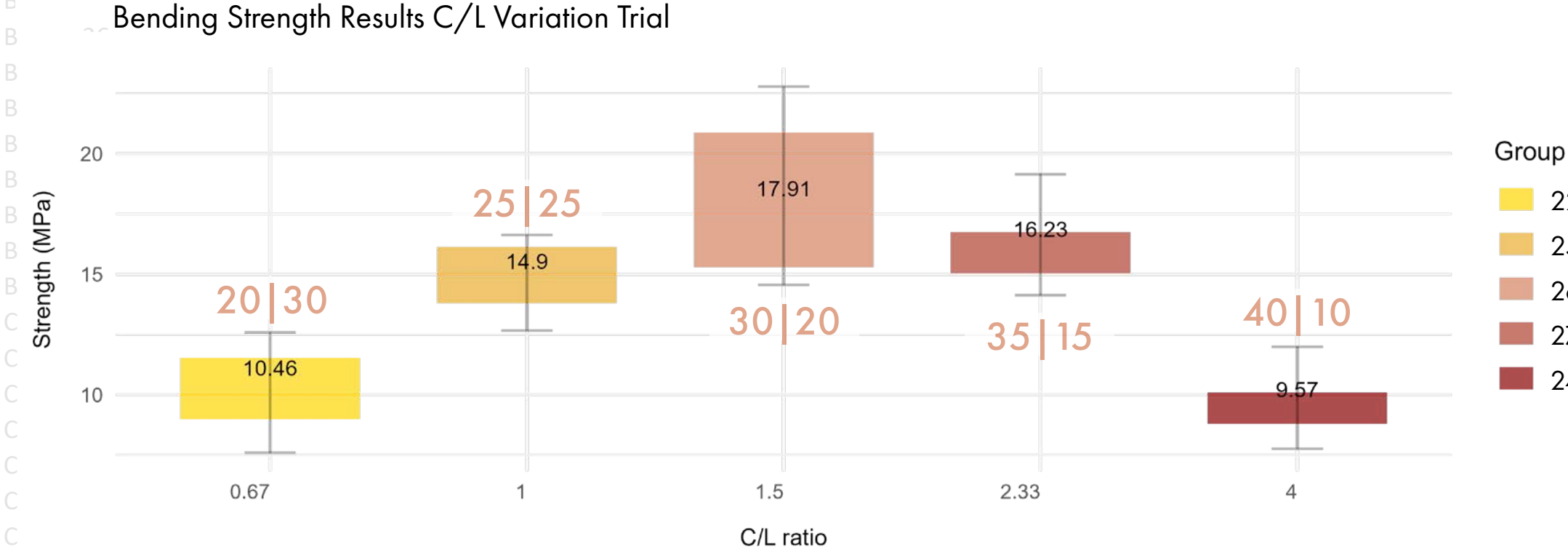
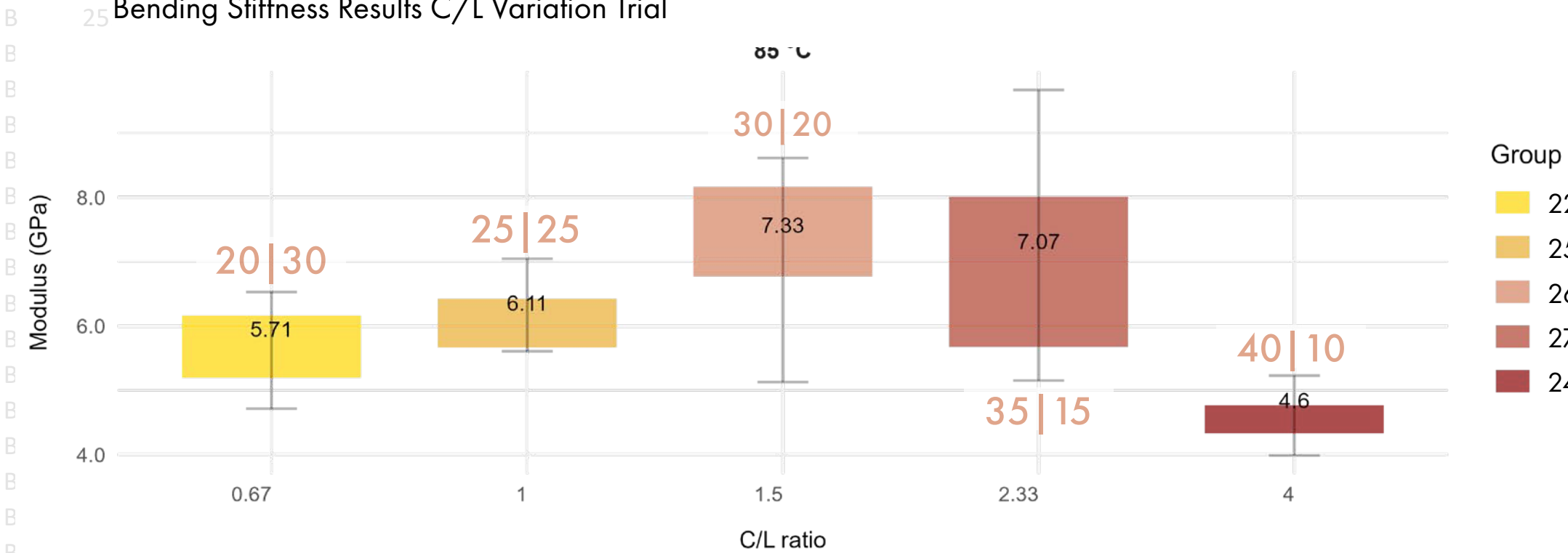
- Material has asymmetric strain response due to:

$$E_c \neq E_t$$



- Moisture of 0wt% behaves the weakest, beyond “dip-and-recover”

Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture-Content	Pressing-temp.	ID_group
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6215,326	11,48825	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.6	5290,872	8,867406	3,2	13,5	150	C-L	0,666667	Soda	12,5	85	28



C	24.3.3	6022,323	15,70994	3,41	12,26	150	C-L	4	Soda	12,5	70	24
C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

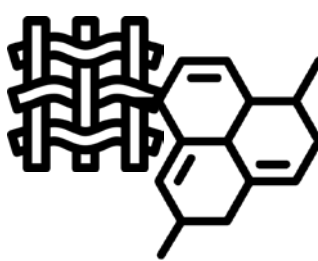
Mechanical Testing Results

- Material has asymmetric strain response due to:

$$E_c \neq E_t$$



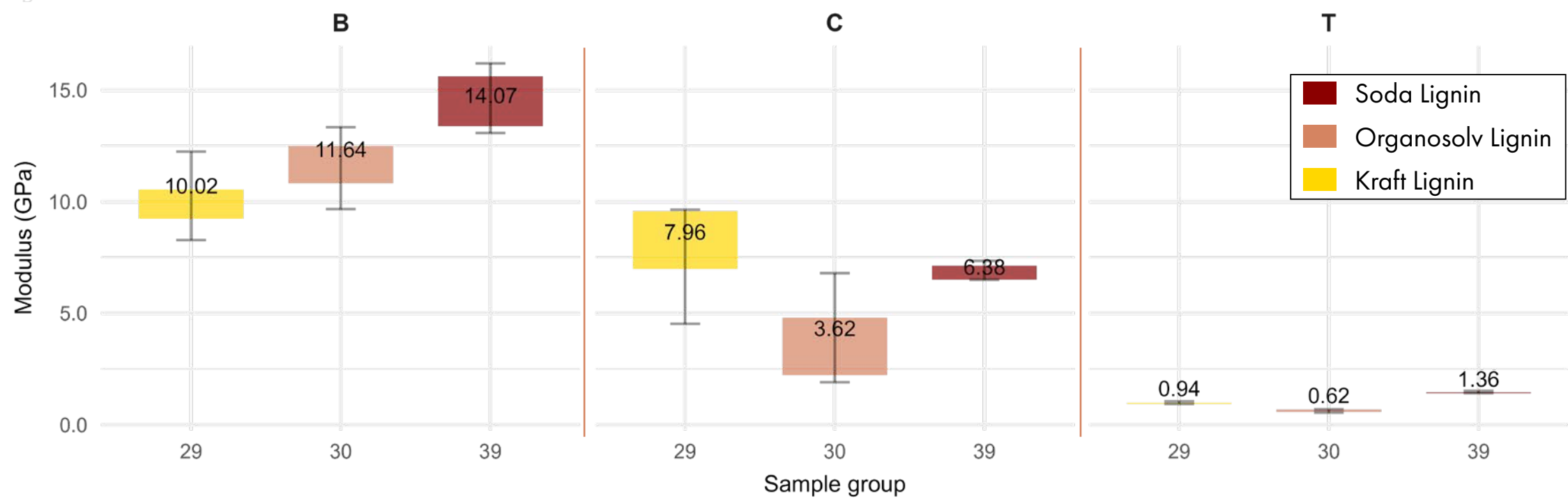
- Moisture of 0wt% behaves the weakest, beyond “dip-and-recover”



- C/L mixtures 3:2 and 2:3 are the most promising

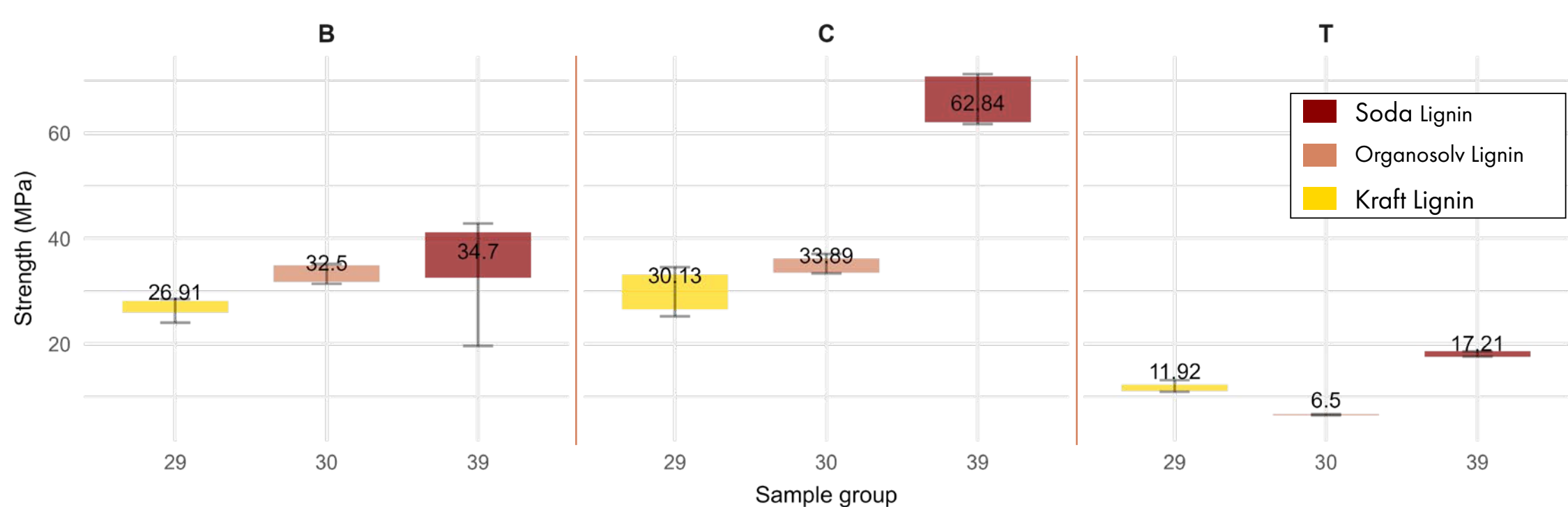
Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture- Content	Pressing- temp.	ID_group
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28

Stiffness Results Lignin Variation Trial



B	26.1.3	8244,057	16,01036	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.4	5128,713	15,05476	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26

Strength Results Lignin Variation Trial



C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

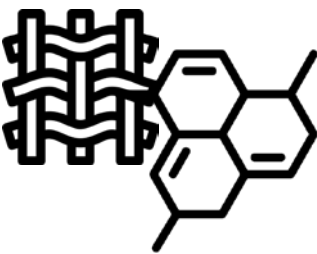
Mechanical Testing Results

- Material has asymmetric strain response due to:

$$E_c \neq E_t$$



- Moisture of 0wt% behaves the weakest, beyond “dip-and-recover”



- C/L mixtures 3:2 and 2:3 are the most promising



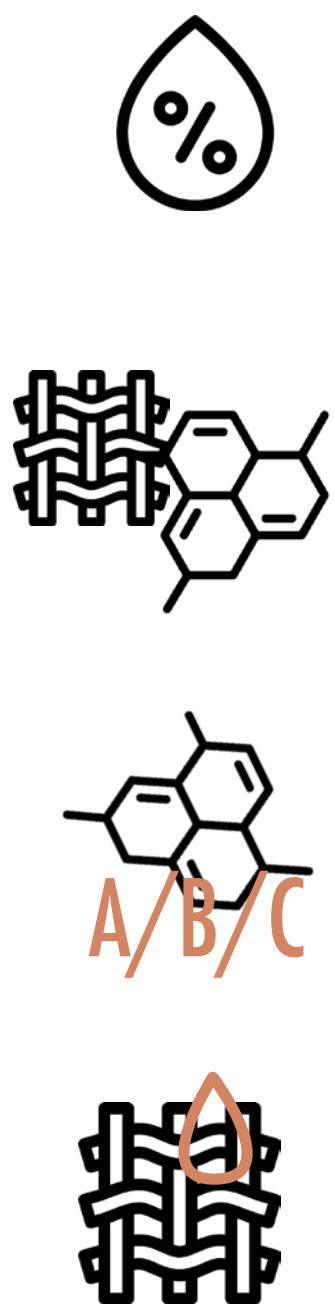
- Soda Lignin shows the best performance

Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture- Content	Pressing- temp.	ID_group
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6215,326	11,48825	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.6	5290,872	8,867406	3,2	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	25.1.1	6188,904	15,54374	3,7	13,4	150	C-L		1 Soda	12,5	85	25
B	25.1.2	5674,324	14,70073	3,6	13,4	150	C-L		1 Soda	12,5	85	25
B	25.1.3	6503,451	12,66391	3,7	13,4	150	C-L		1 Soda	12,5	85	25
B	25.1.4	5607,25	16,33841	3,4	13,4	150	C-L		1 Soda	12,5	85	25
B	25.1.5	5666,974	13,49964	3,7	13,6	150	C-L		1 Soda	12,5	85	25
B	25.1.6	7044,832	16,63206	3,2	13,3	150	C-L		1 Soda	12,5	85	25
B	27.1.1	6800,276	14,7554	3,3	13,2	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.2	7256,76	14,12757	3,4	13,2	150	C-L	2,333333	Soda	12,5	85	27
Stiffness Results Cellulose Pre-treatment Trial												
Strength Results Cellulose Pre-treatment Trial												
C	23.1	6511,049	19,1977	3,4	11,9	150	C-L	0,666667	Soda	12,5	85	23
C	23.2	7129,824	20,3512	3,3	12,1	150	C-L	0,666667	Soda	12,5	85	23
C	24.2.1	6873,97	10,17598	3,4	12,4	150	C-L		4 Soda	12,5	85	24
C	24.2.2	9212,007	20,47299	3,3	12,4	150	C-L		4 Soda	12,5	85	24
C	24.3.1	5572,161	14,66721	3,3	12,41	150	C-L		4 Soda	12,5	70	24
C	24.2.3	7852,884	28,76704	3,3	12,41	150	C-L		4 Soda	12,5	85	24
C	24.3.2	7019,717	14,55646	3,44	12,17	150	C-L		4 Soda	12,5	70	24
C	24.3.3	6022,323	15,70994	3,41	12,26	150	C-L		4 Soda	12,5	70	24
C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L		1 Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L		1 Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L		1 Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L		1 Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L		1 Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L		1 Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L		1,5 Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L		1,5 Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L		1,5 Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L		1,5 Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L		1,5 Soda	12,5	70	26

Mechanical Testing Results

- Material has asymmetric strain response due to:

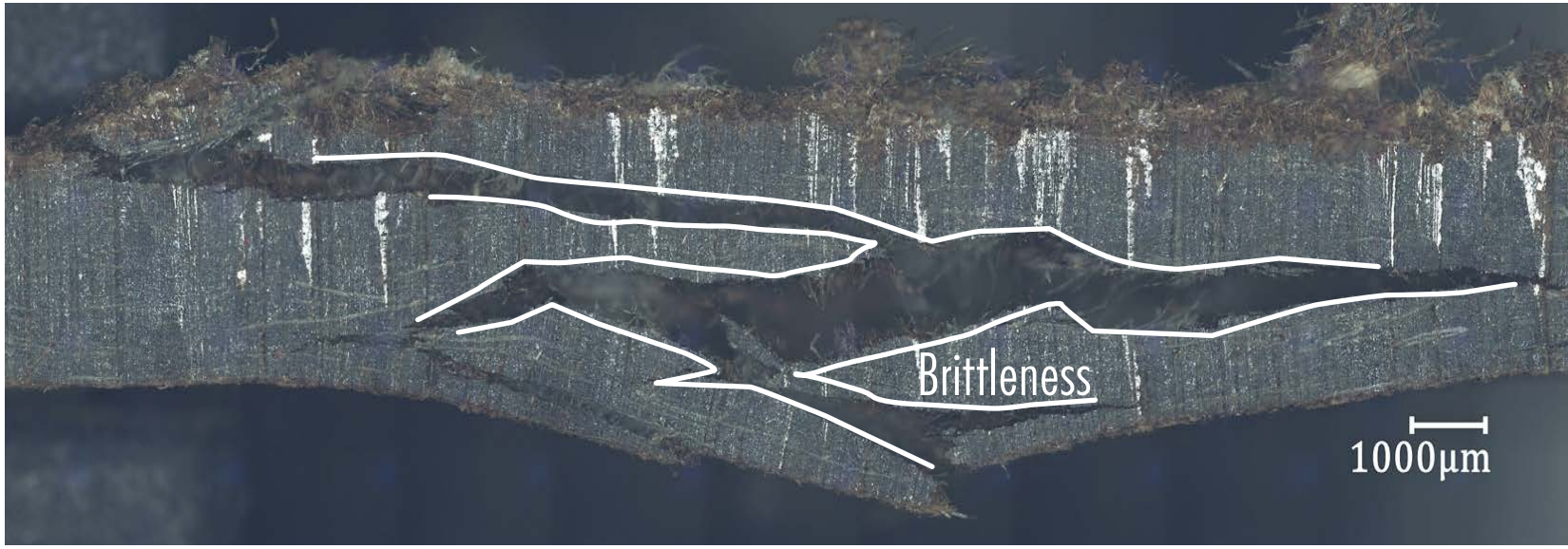
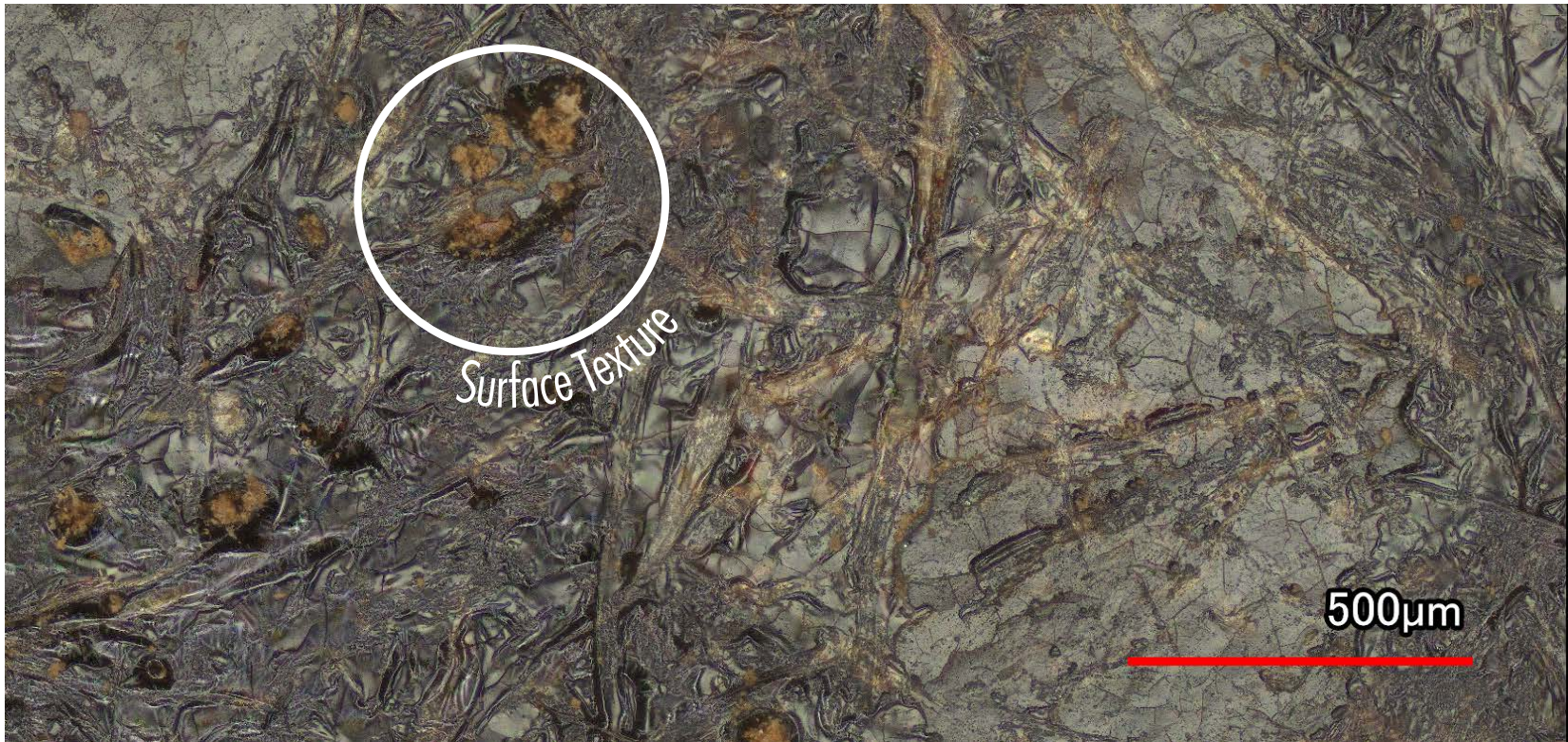
$$E_c \neq E_t$$

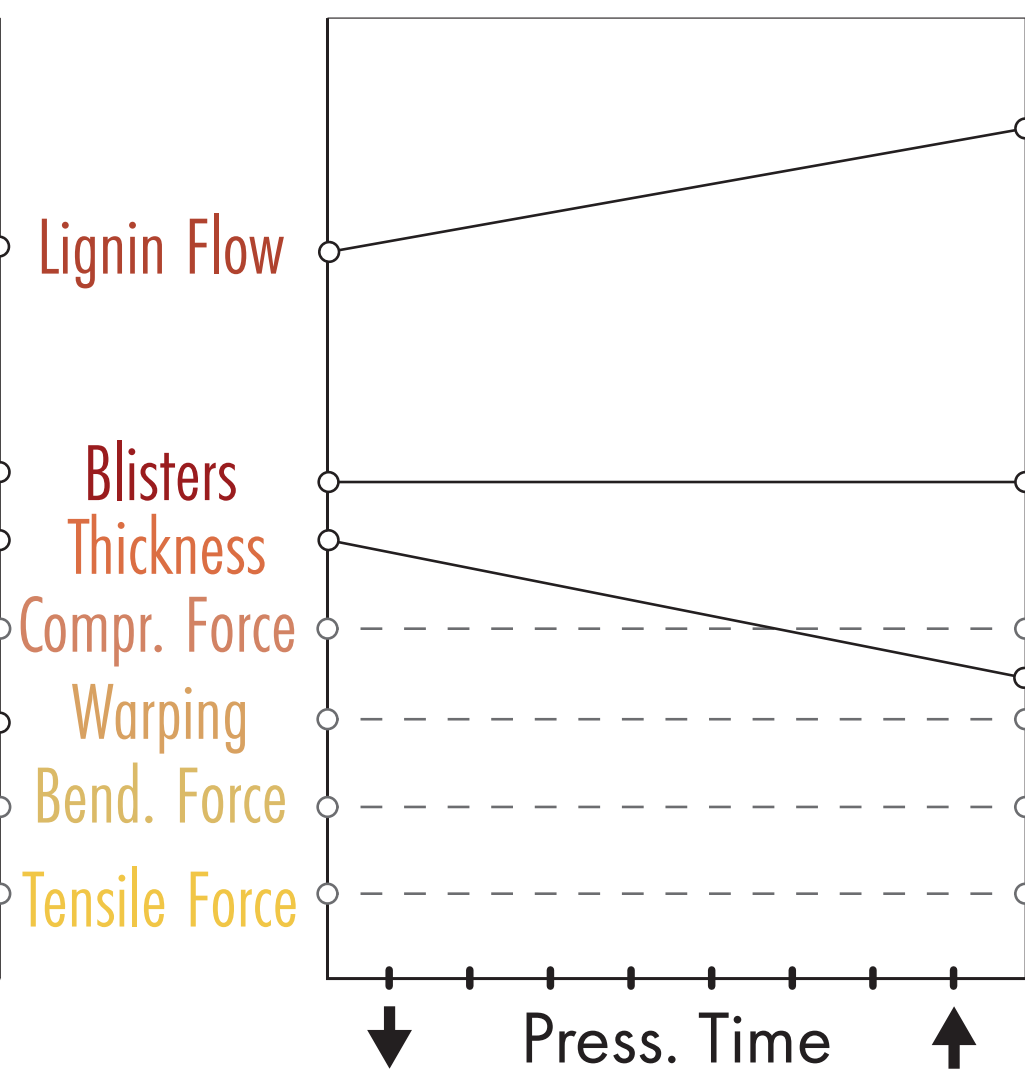
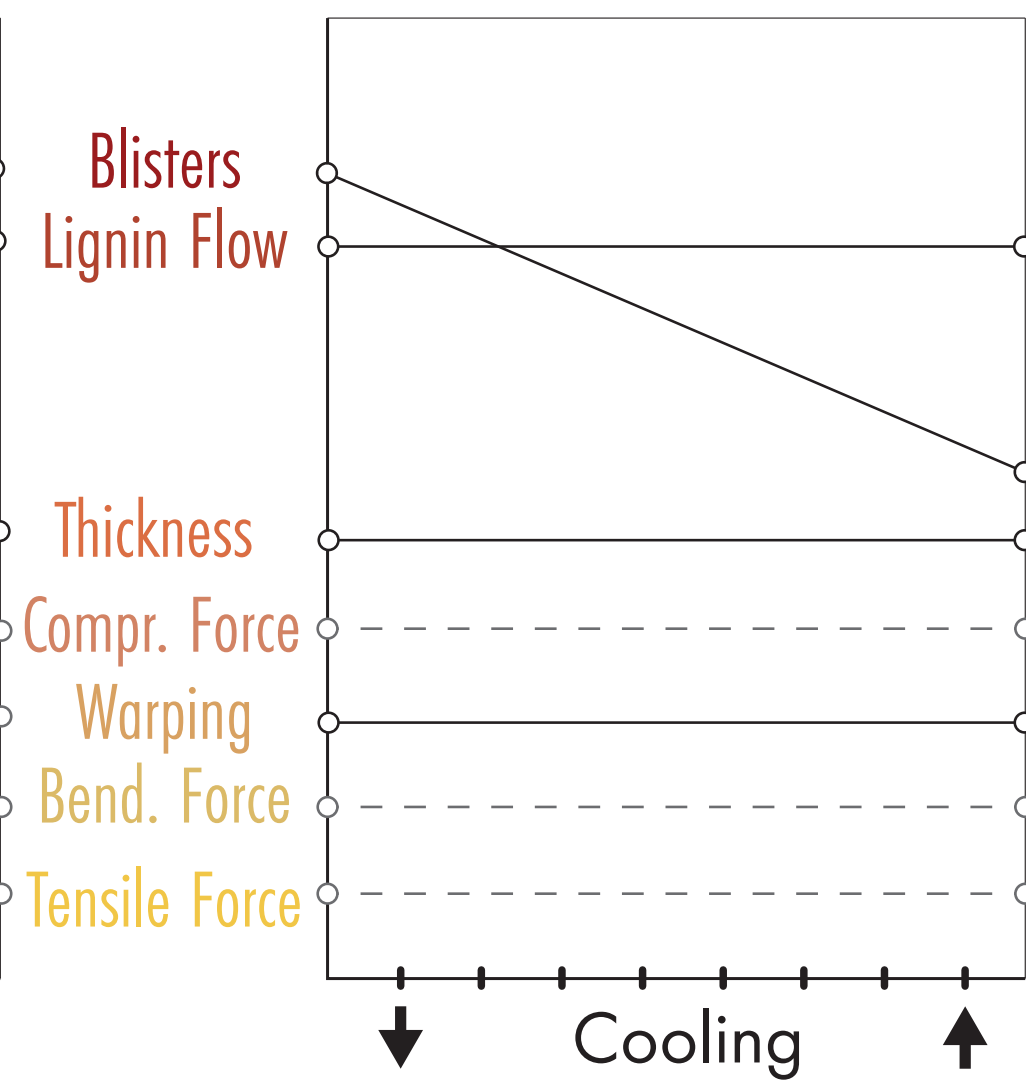
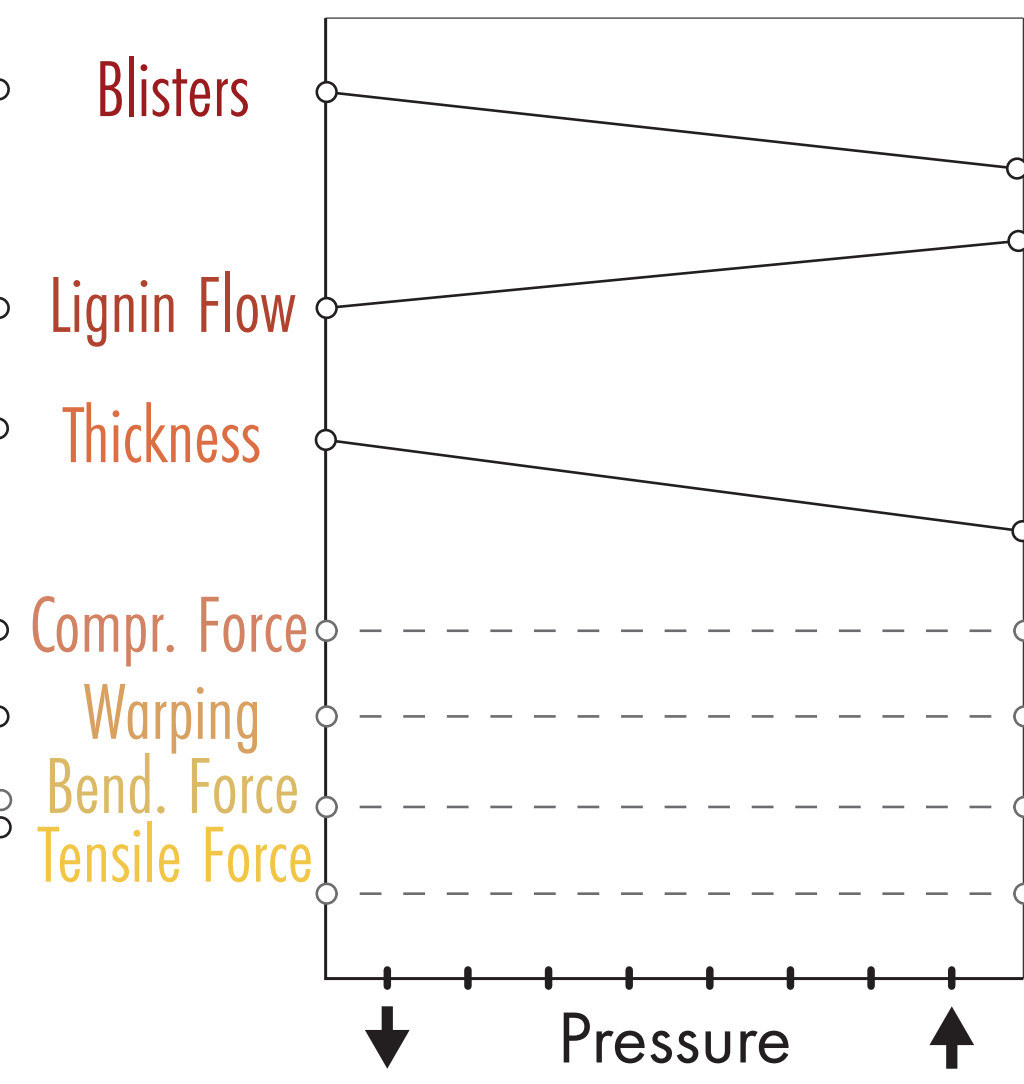
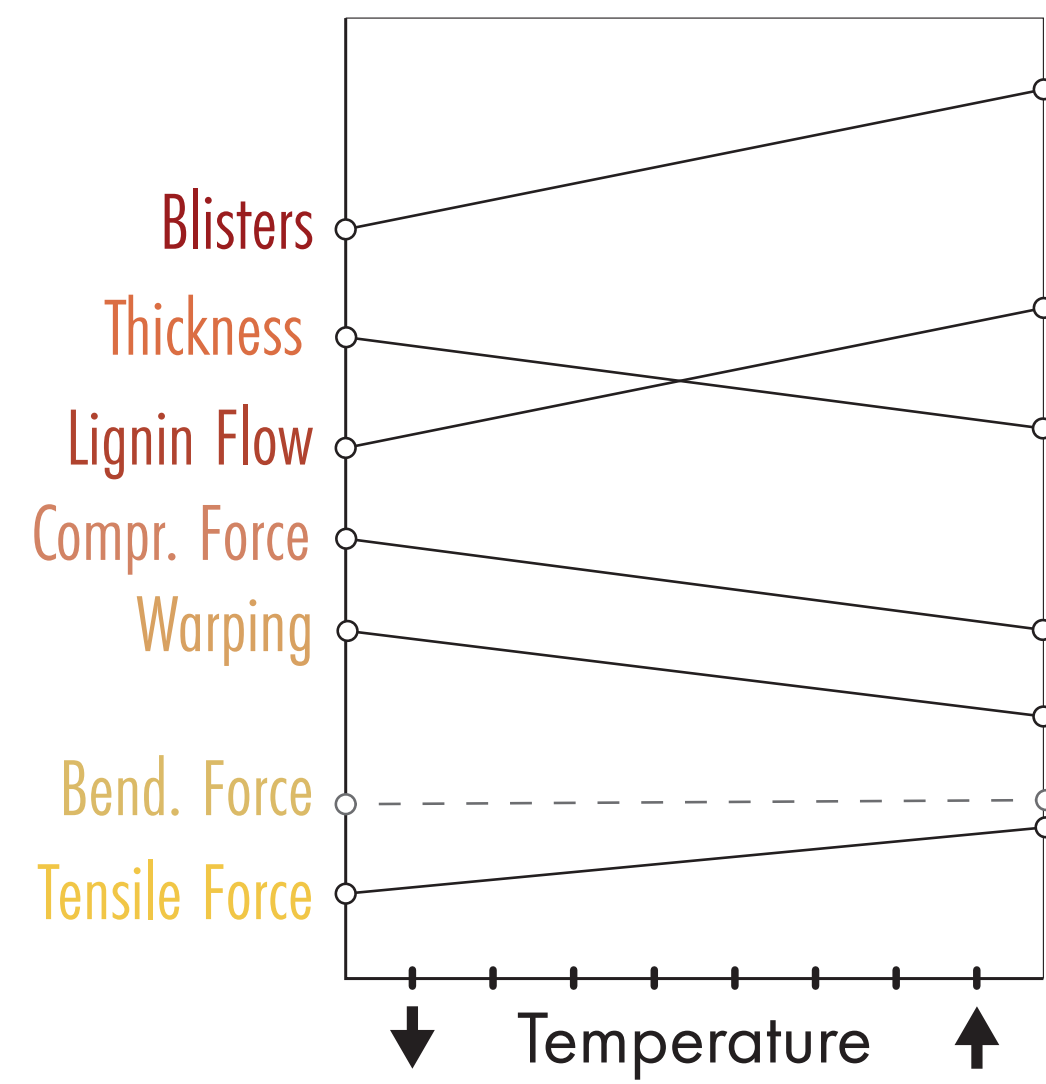
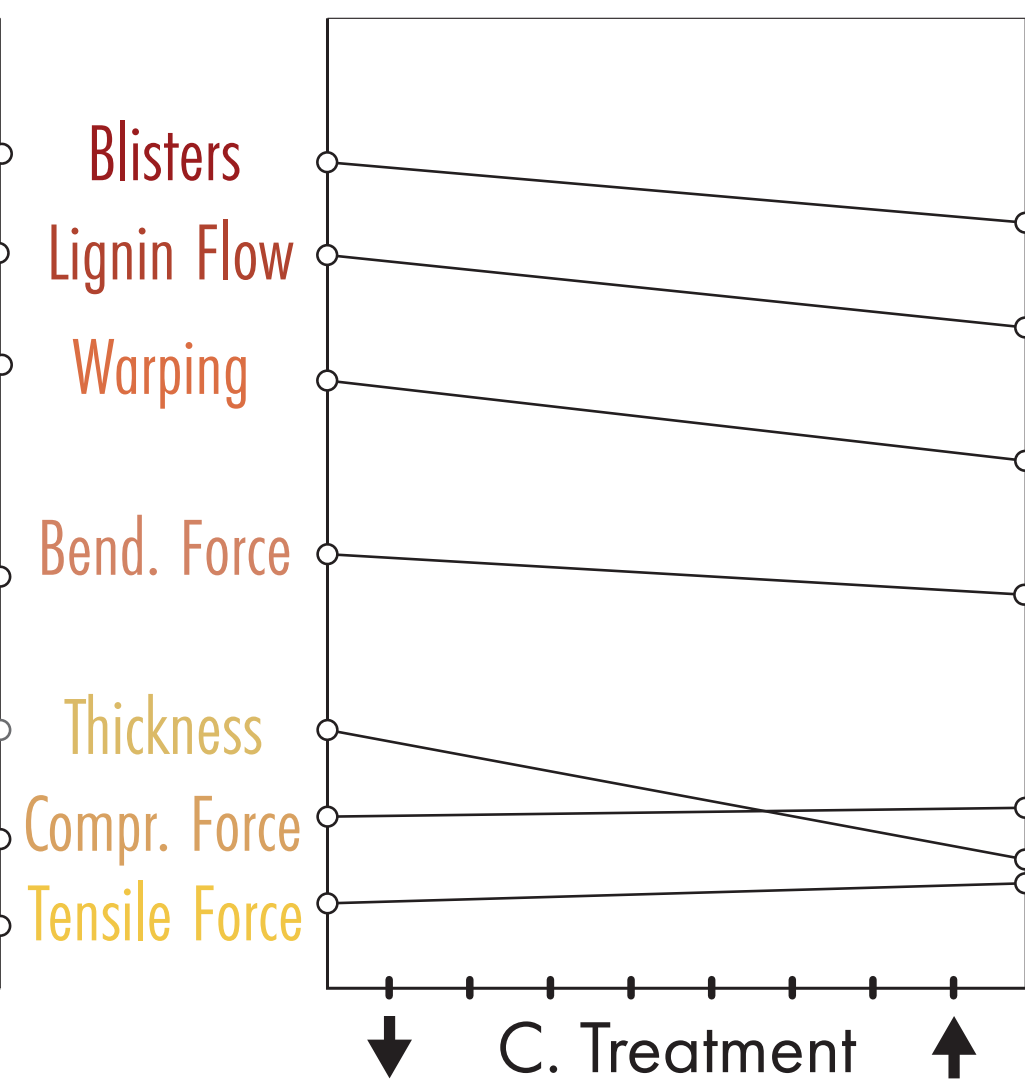
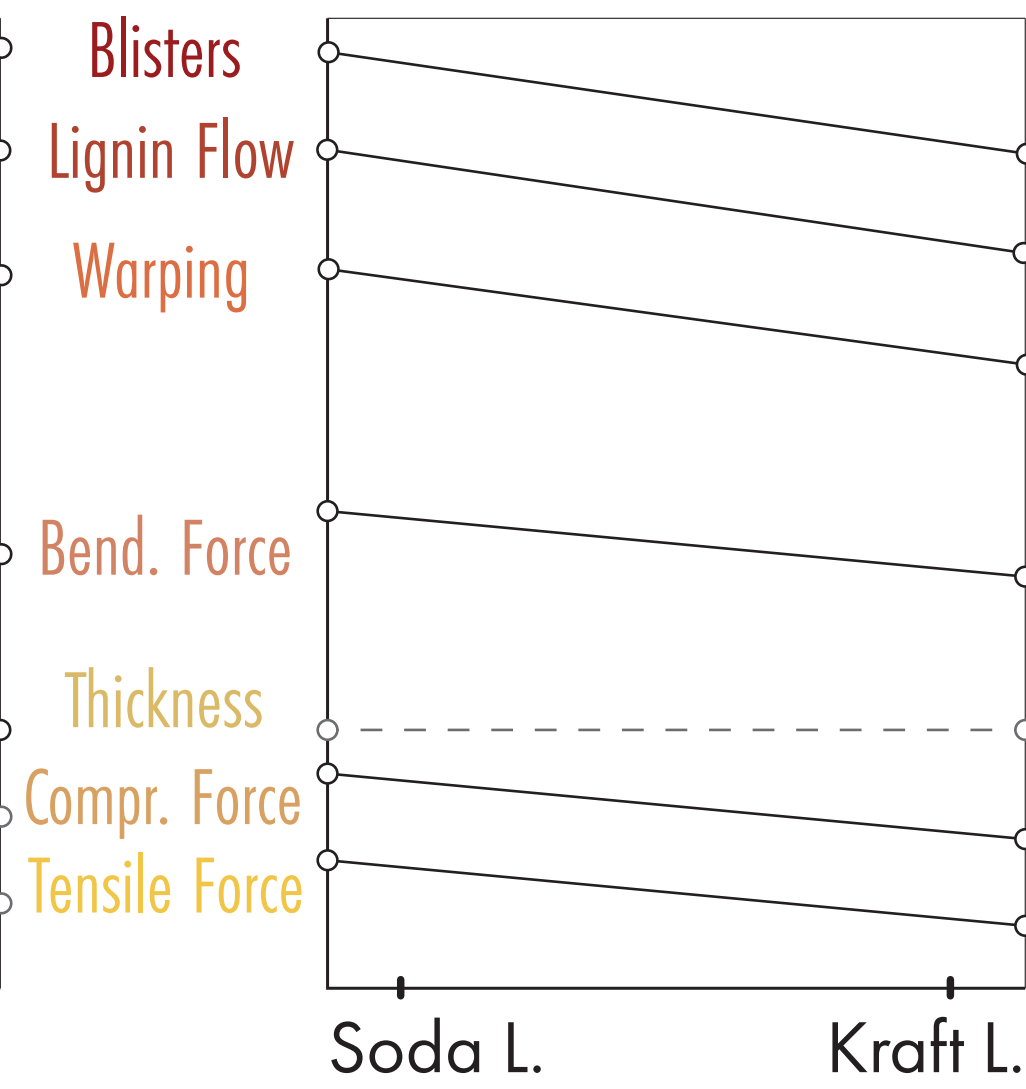
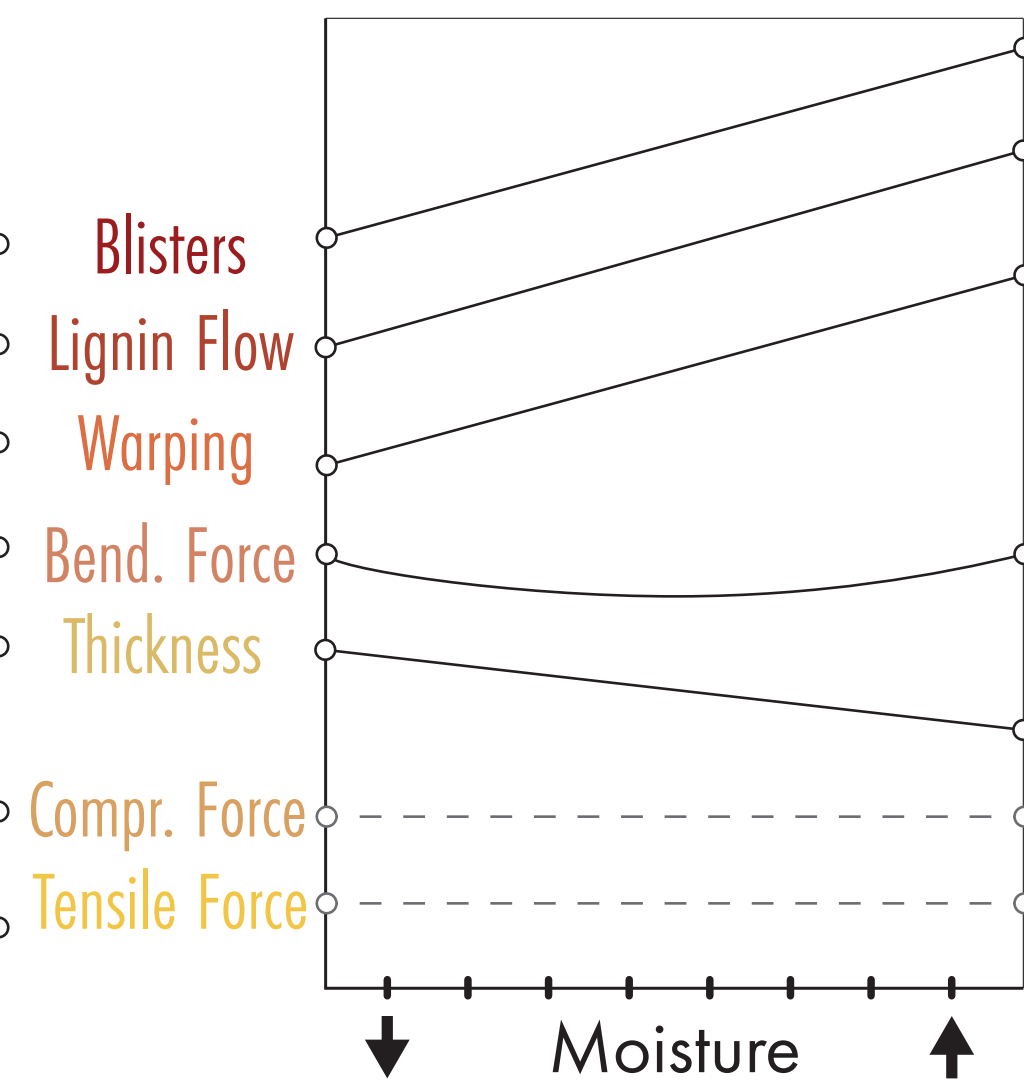
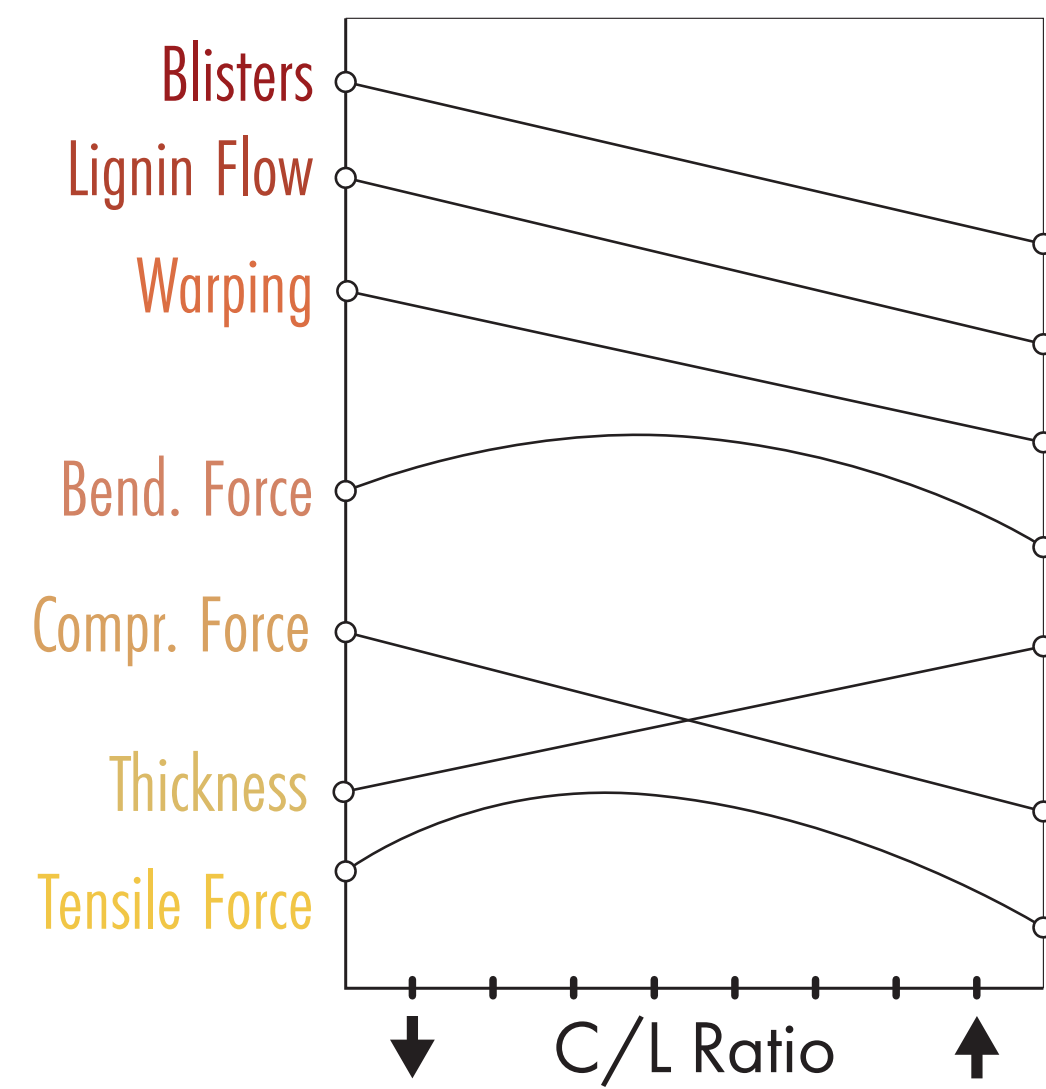


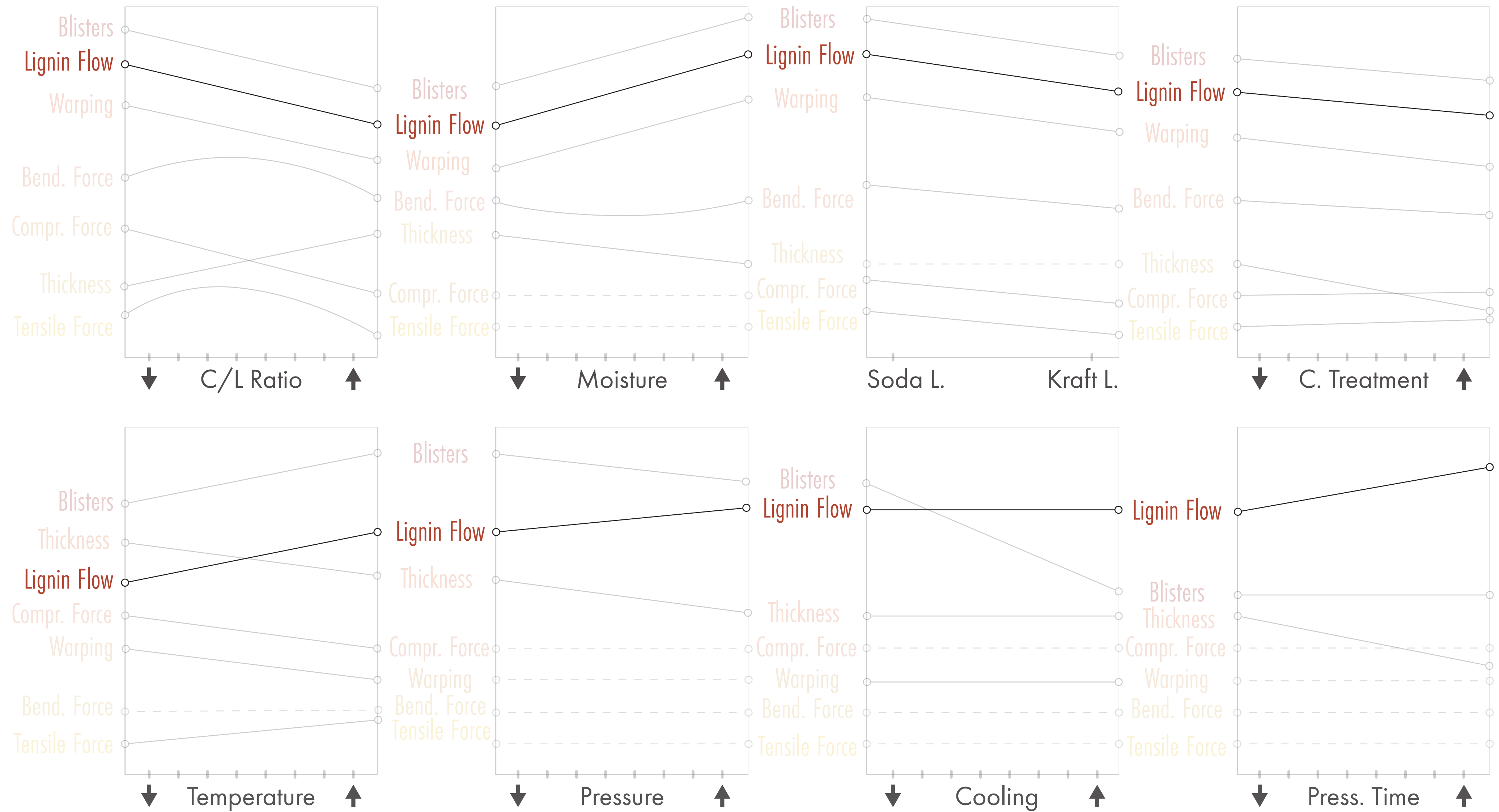
- Moisture of 0wt% behaves the weakest, beyond “dip-and-recover”
- C/L mixtures 3:2 and 2:3 are the most promising
- Soda Lignin shows the best performance
- C-Pre-Treatment shows no significant performance improvements

Qualitative Material Properties

- Thickness
- Lignin Flow
- Compr. Force
- Warping
- Bend. Force
- Tensile Force
- Brittleness
- Blisters

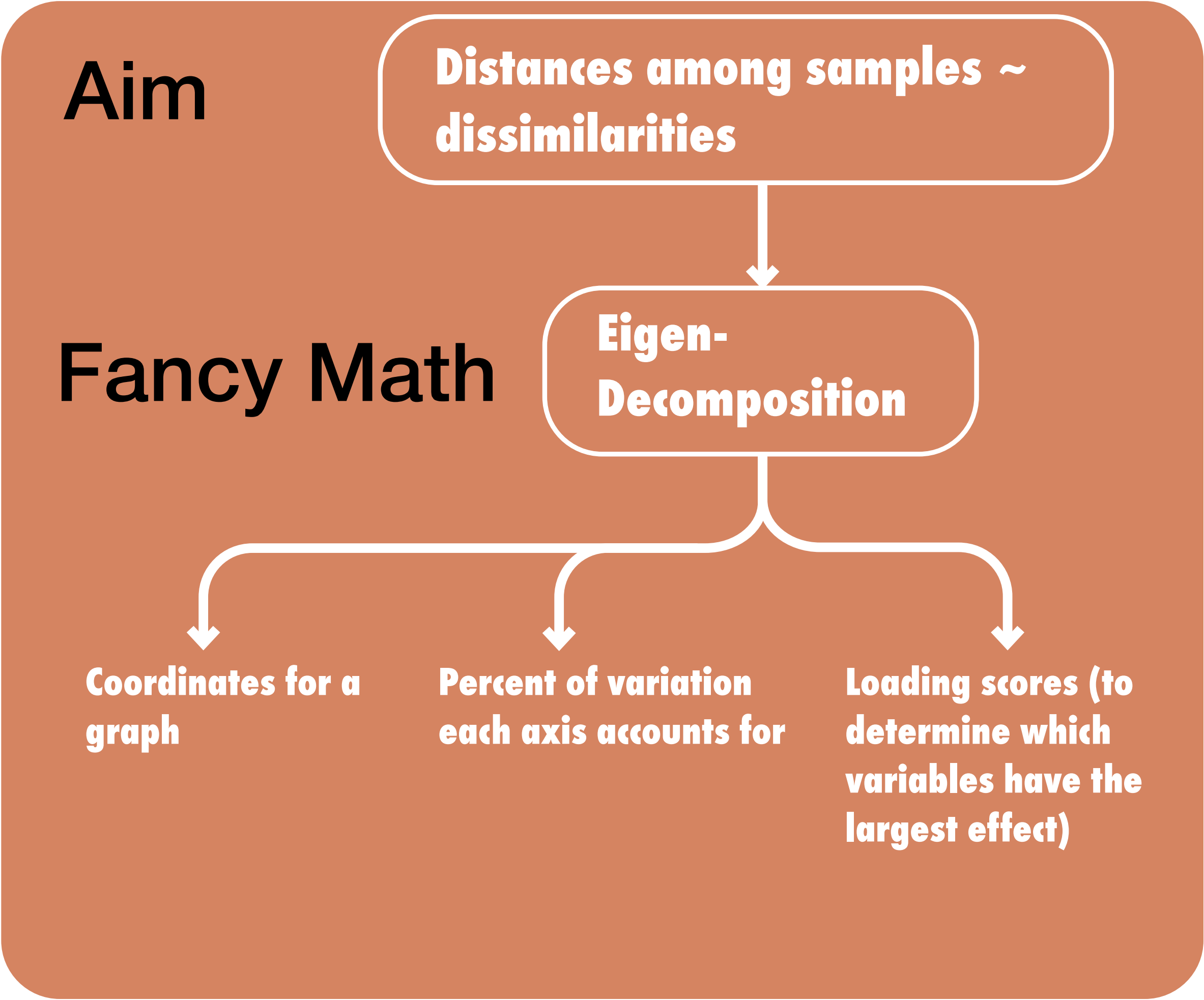






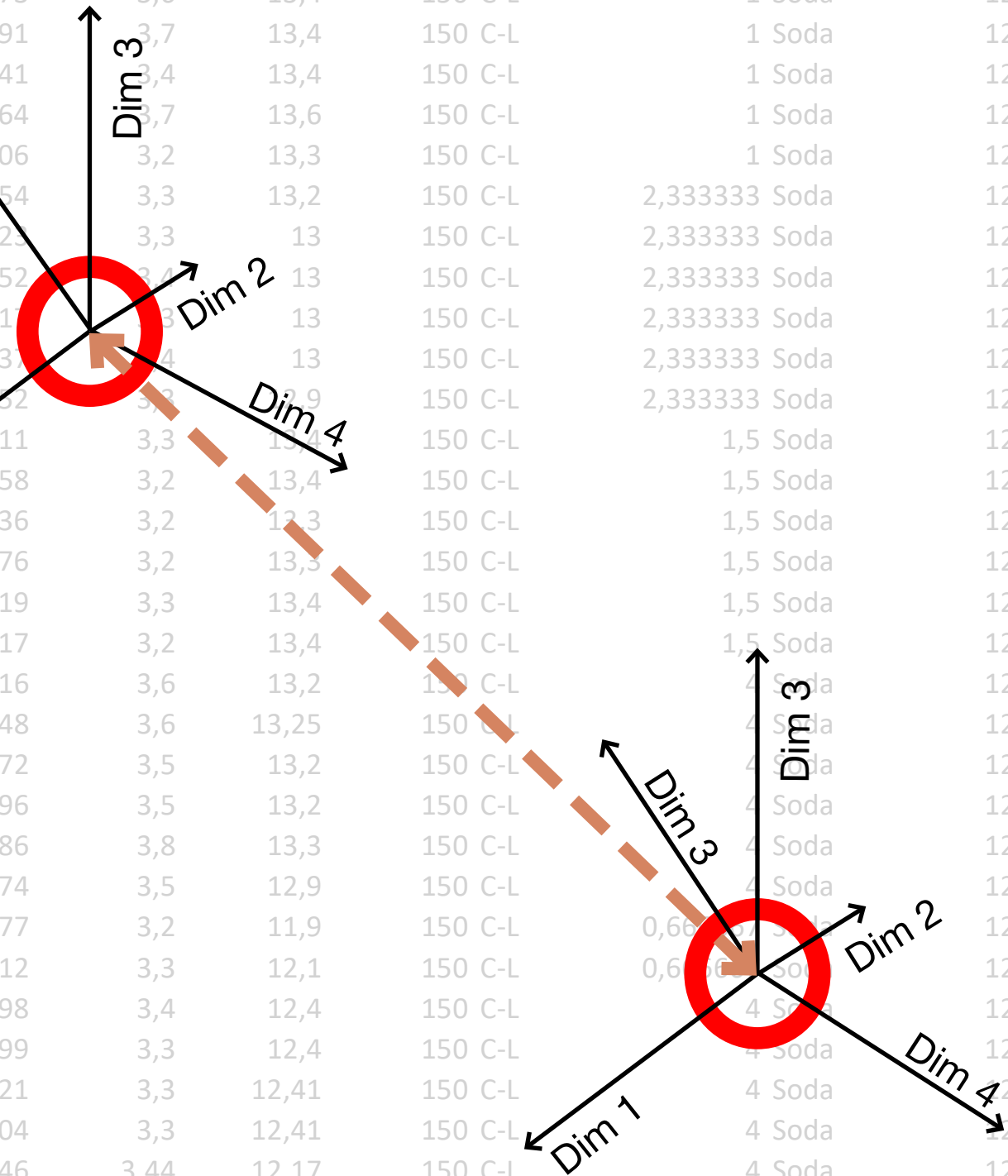
Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture-	Pressing-	ID_group
										Content	temp.	
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,1	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6215,326	11,48825	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.6	5290,872	8,867406	3,2	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	25.1.1	6188,904	15,54374	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.2	5674,324	14,70073	3,6	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.3	6503,451	12,66391	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.4	5607,25	16,33841	3,4	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.5	5666,974	13,49964	3,7	13,6	150	C-L	1	Soda	12,5	85	25
B	25.1.6	7044,832	16,63206	3,2	13,3	150	C-L	1	Soda	12,5	85	25
B	27.1.1	6800,276	14,7554	3,3	13,2	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.2	5152,383	15,89623	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.3	7256,76	14,12752	3,4	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.4	5299,508	16,67117	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.5	8259,459	16,78037	3,4	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.6	9670,392	19,14852	3,3	12,9	150	C-L	2,333333	Soda	12,5	85	27
B	26.1.1	7517,785	14,55511	3,3	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.2	6522,592	16,8058	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.3	8244,057	16,01036	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.4	5128,713	15,05476	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.5	8611,443	22,78519	3,3	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.6	7927,4	22,23617	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	24.1.1	4767,761	9,510516	3,6	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.2	5229,5	9,207148	3,6	13,25	150	C-L	4	Soda	12,5	85	24
B	24.1.3	4236,728	7,758672	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.4	4623,934	10,29196	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.5	4769,64	11,98886	3,8	13,3	150	C-L	4	Soda	12,5	85	24
B	24.1.6	3989,662	8,649974	3,5	12,9	150	C-L	4	Soda	12,5	85	24
C	23.1	6311,049	19,1977	3,2	11,9	150	C-L	0,666667	Soda	12,5	85	23
C	23.2	7129,824	20,3512	3,3	12,1	150	C-L	0,666667	Soda	12,5	85	23
C	24.2.1	6873,97	10,17598	3,4	12,4	150	C-L	4	Soda	12,5	85	24
C	24.2.2	9212,007	20,47299	3,3	12,4	150	C-L	4	Soda	12,5	85	24
C	24.3.1	5572,161	14,66721	3,3	12,41	150	C-L	4	Soda	12,5	70	24
C	24.2.3	7852,884	28,76704	3,3	12,41	150	C-L	4	Soda	12,5	85	24
C	24.3.2	7019,717	14,55646	3,44	12,17	150	C-L	4	Soda	12,5	70	24
C	24.3.3	6022,323	15,70994	3,41	12,26	150	C-L	4	Soda	12,5	70	24
C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

Data Interpretation- Multidimensional Sacling(MDS)



Type	ID	modulus	strength	thickness	width	L	Trial	C/L	Lignin	Moisture- Content	Pressing- temp.	ID_group
B	22.2	6265,322	11,55944	3,4	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.3	5013,124	11,10884	3,7	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	22.4	5997,309	12,59063	3,2	13,8	150	C-L	0,666667	Soda	12,5	85	22
B	22.5	5982,93	11,23988	3,3	13,9	150	C-L	0,666667	Soda	12,5	85	22
B	22.6	4714,929	12,5374	3,1	13,7	150	C-L	0,666667	Soda	12,5	85	22
B	28.1.1	5101,026	8,70677	3,2	13,7	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.2	6110,462	10,29947	3,1	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.3	5589,53	9,100465	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.4	6527,995	7,59552	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.5	6215,326	11,48825	3,1	13,4	150	C-L	0,666667	Soda	12,5	85	28
B	28.1.6	5290,872	8,867406	3,2	13,5	150	C-L	0,666667	Soda	12,5	85	28
B	25.1.1	6188,904	15,54374	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.2	5674,324	14,70073	3,6	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.3	6503,451	12,66391	3,7	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.4	5607,25	16,33841	3,4	13,4	150	C-L	1	Soda	12,5	85	25
B	25.1.5	5666,974	17,49964	3,7	13,6	150	C-L	1	Soda	12,5	85	25
B	25.1.6	7044,832	15,33206	3,2	13,3	150	C-L	1	Soda	12,5	85	25
B	27.1.1	6800,276	15,85554	3,3	13,2	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.2	5152,383	15,85523	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.3	7256,76	14,12752	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.4	5299,508	16,67113	3,3	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.5	8259,459	16,78031	3,4	13	150	C-L	2,333333	Soda	12,5	85	27
B	27.1.6	9670,392	19,14832	3,3	13,9	150	C-L	2,333333	Soda	12,5	85	27
B	26.1.1	7517,785	14,55511	3,3	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.2	6522,592	16,8058	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.3	8244,057	16,01036	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.4	5128,713	15,05476	3,2	13,3	150	C-L	1,5	Soda	12,5	85	26
B	26.1.5	8611,443	22,78519	3,3	13,4	150	C-L	1,5	Soda	12,5	85	26
B	26.1.6	7927,4	22,23617	3,2	13,4	150	C-L	1,5	Soda	12,5	85	26
B	24.1.1	4767,761	9,510516	3,6	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.2	5229,5	9,207148	3,6	13,25	150	C-L	4	Soda	12,5	85	24
B	24.1.3	4236,728	7,758672	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.4	4623,934	10,29196	3,5	13,2	150	C-L	4	Soda	12,5	85	24
B	24.1.5	4769,64	11,98886	3,8	13,3	150	C-L	4	Soda	12,5	85	24
B	24.1.6	3989,662	8,649974	3,5	12,9	150	C-L	4	Soda	12,5	85	24
C	23.1	6311,049	19,1977	3,2	11,9	150	C-L	0,666667	Soda	12,5	85	23
C	23.2	7129,824	20,3512	3,3	12,1	150	C-L	0,666667	Soda	12,5	85	23
C	24.2.1	6873,97	10,17598	3,4	12,4	150	C-L	4	Soda	12,5	85	24
C	24.2.2	9212,007	20,47299	3,3	12,4	150	C-L	4	Soda	12,5	85	24
C	24.3.1	5572,161	14,66721	3,3	12,41	150	C-L	4	Soda	12,5	70	24
C	24.2.3	7852,884	28,76704	3,3	12,41	150	C-L	4	Soda	12,5	85	24
C	24.3.2	7019,717	14,55646	3,44	12,17	150	C-L	4	Soda	12,5	70	24
C	24.3.3	6022,323	15,70994	3,41	12,26	150	C-L	4	Soda	12,5	70	24
C	25.2.1	6951,605	41,44166	3,18	12,35	150	C-L	1	Soda	12,5	85	25
C	25.2.2	9935,626	32,52177	3,12	12,33	150	C-L	1	Soda	12,5	85	25
C	25.2.3	7923,521	24,6303	3,23	12,34	150	C-L	1	Soda	12,5	85	25
C	25.3.1	6536,127	25,18671	3,35	12,32	150	C-L	1	Soda	12,5	70	25
C	25.3.2	6660,878	15,12491	3,51	12,25	150	C-L	1	Soda	12,5	70	25
C	25.3.3	7076,884	17,14666	3,6	12,31	150	C-L	1	Soda	12,5	70	25
C	26.2.1	10559,65	34,29877	3	12,44	150	C-L	1,5	Soda	12,5	85	26
C	26.2.2	9922,856	40,11911	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.2.3	7589,371	41,15995	3,01	12,38	150	C-L	1,5	Soda	12,5	85	26
C	26.3.1	7438,504	18,114	3,06	12,31	150	C-L	1,5	Soda	12,5	70	26
C	26.3.2	8143,955	18,68327	3,13	12,16	150	C-L	1,5	Soda	12,5	70	26

Data Interpretation- Multidimensional Scaling(MDS)



Aim

Distances among samples ~
dissimilarities

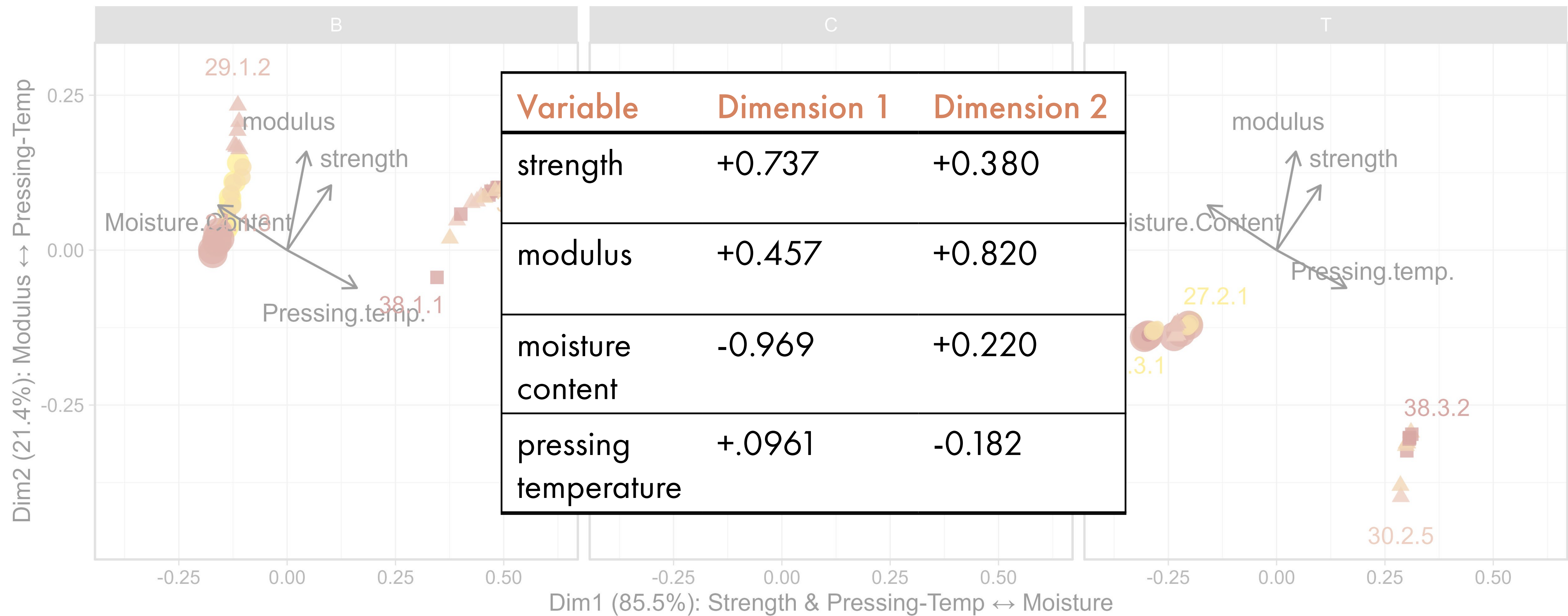
Fancy Math

Eigen-
Decomposition

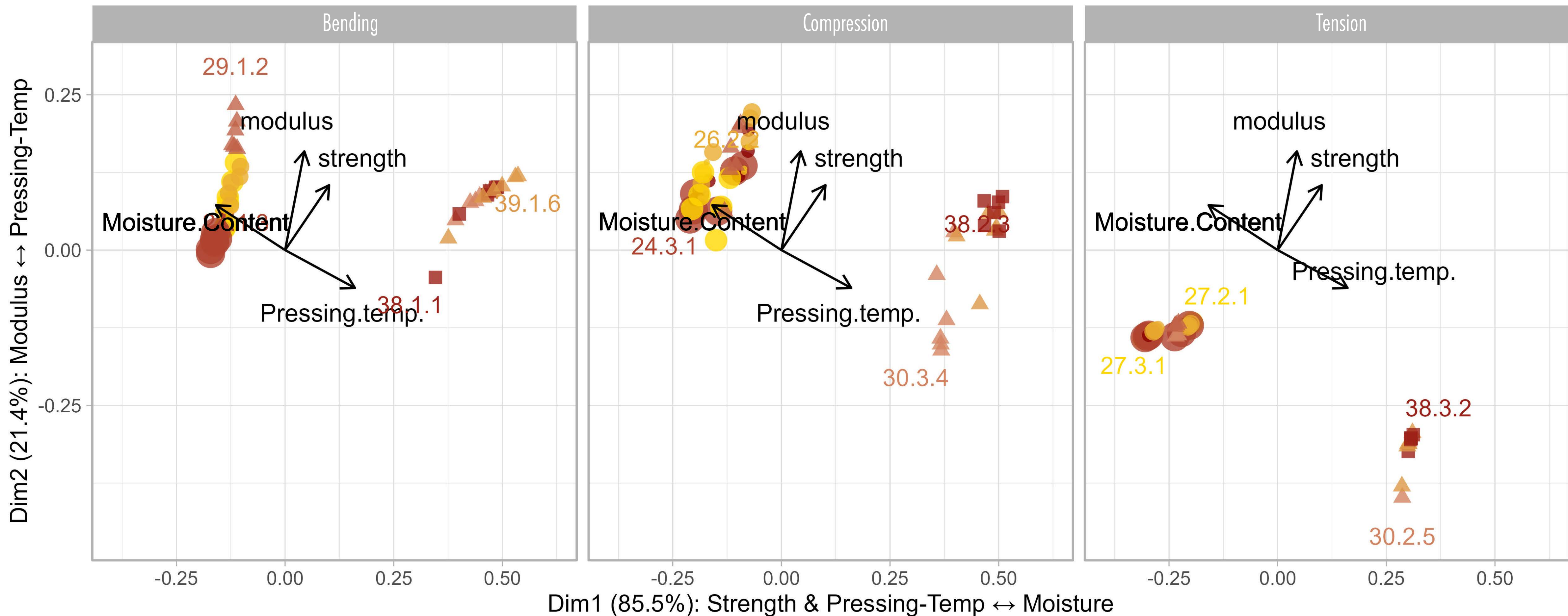
Coordinates for a
graph

Percent of variation
each axis accounts for

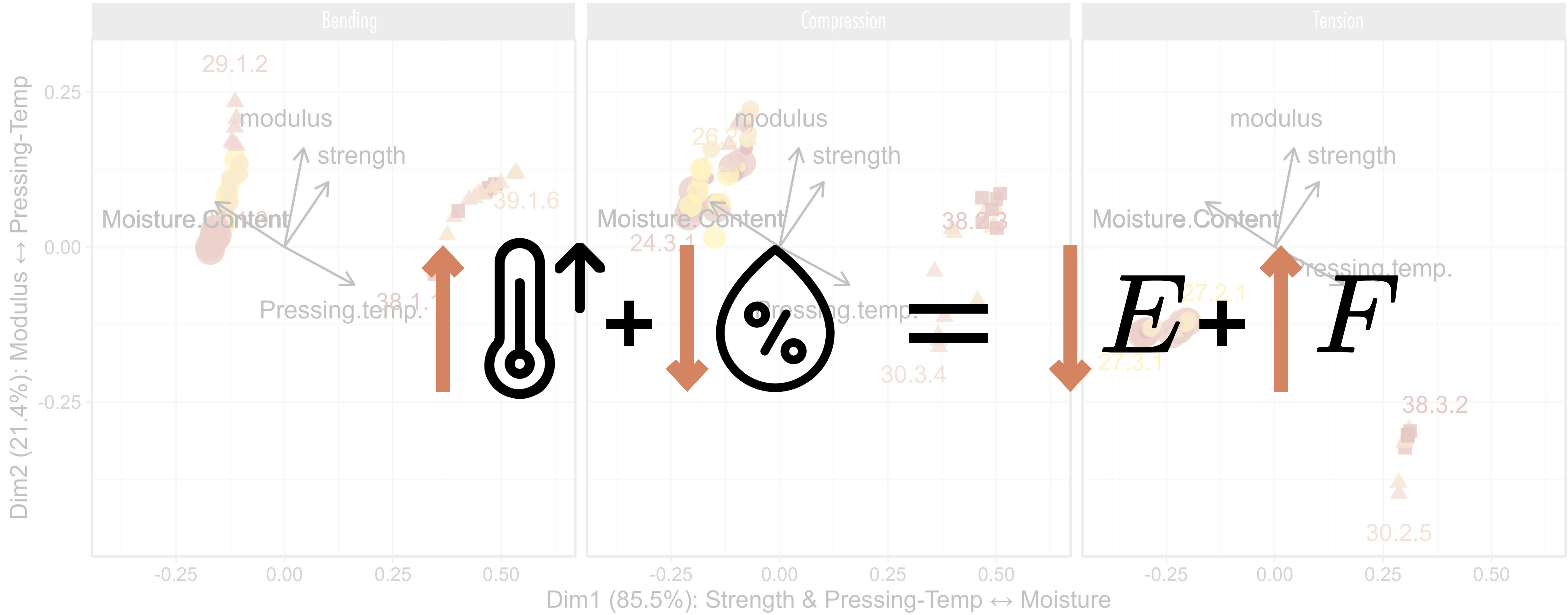
Loading scores (to
determine which
variables have the
largest effect)



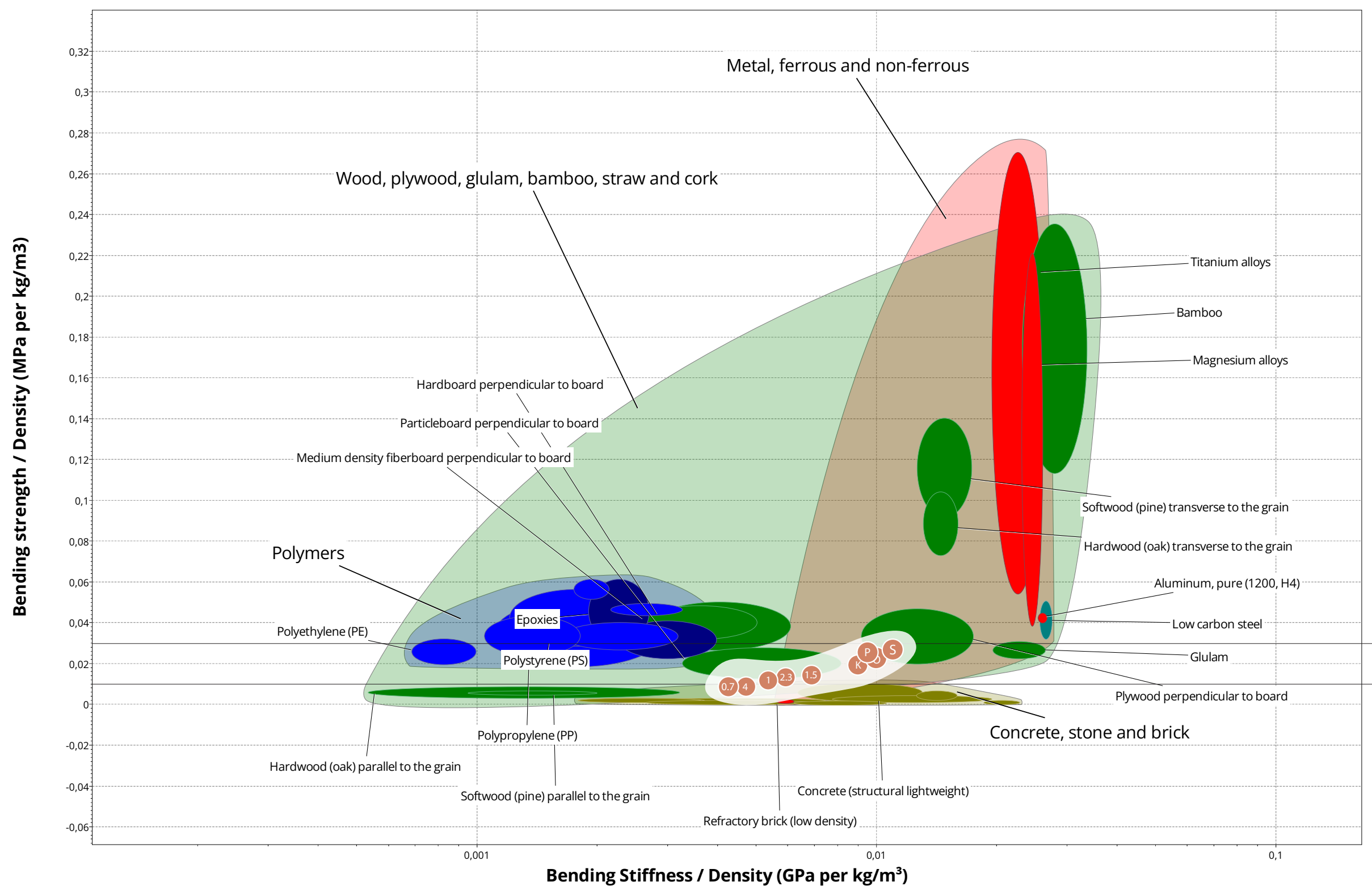
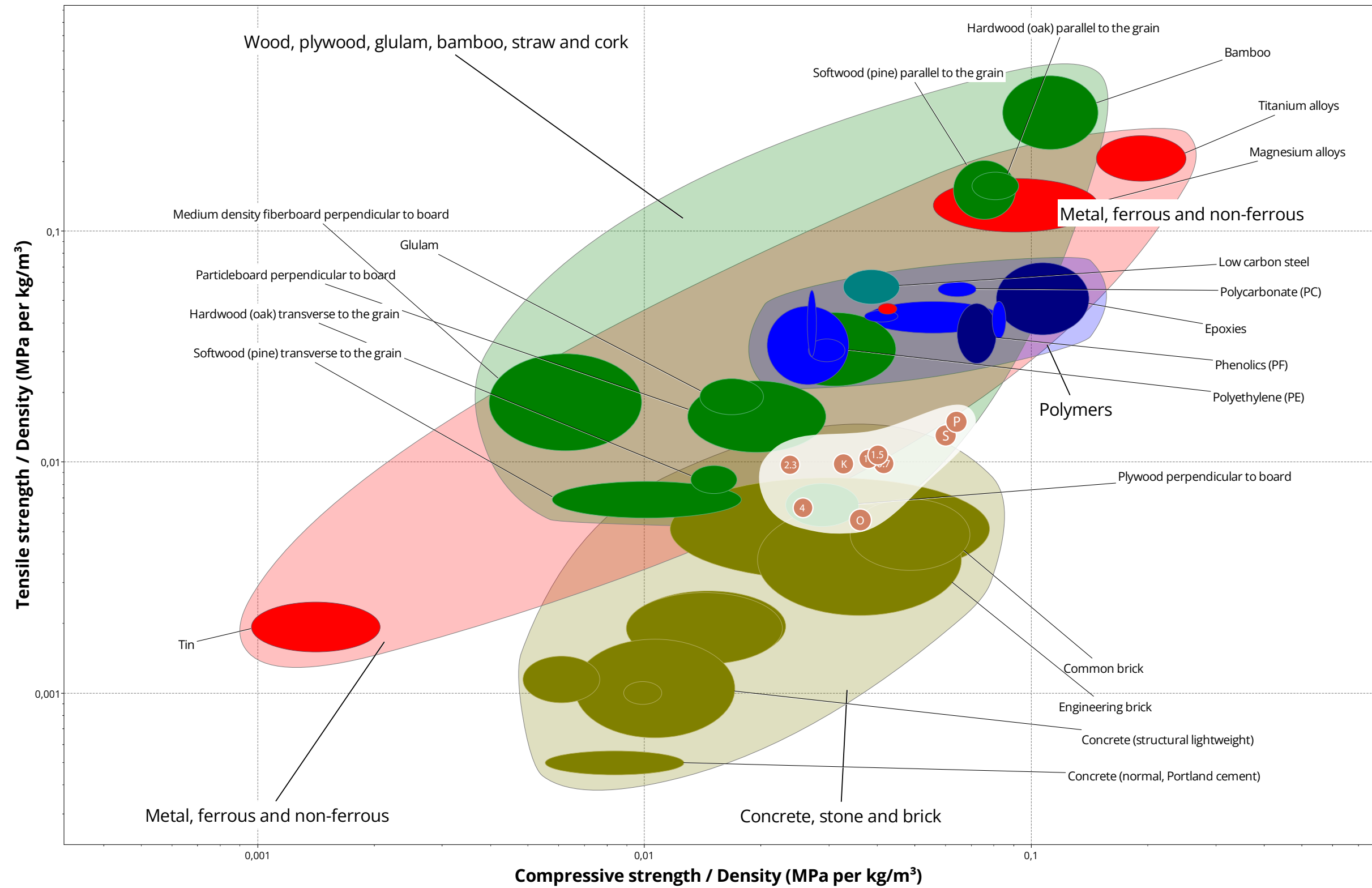
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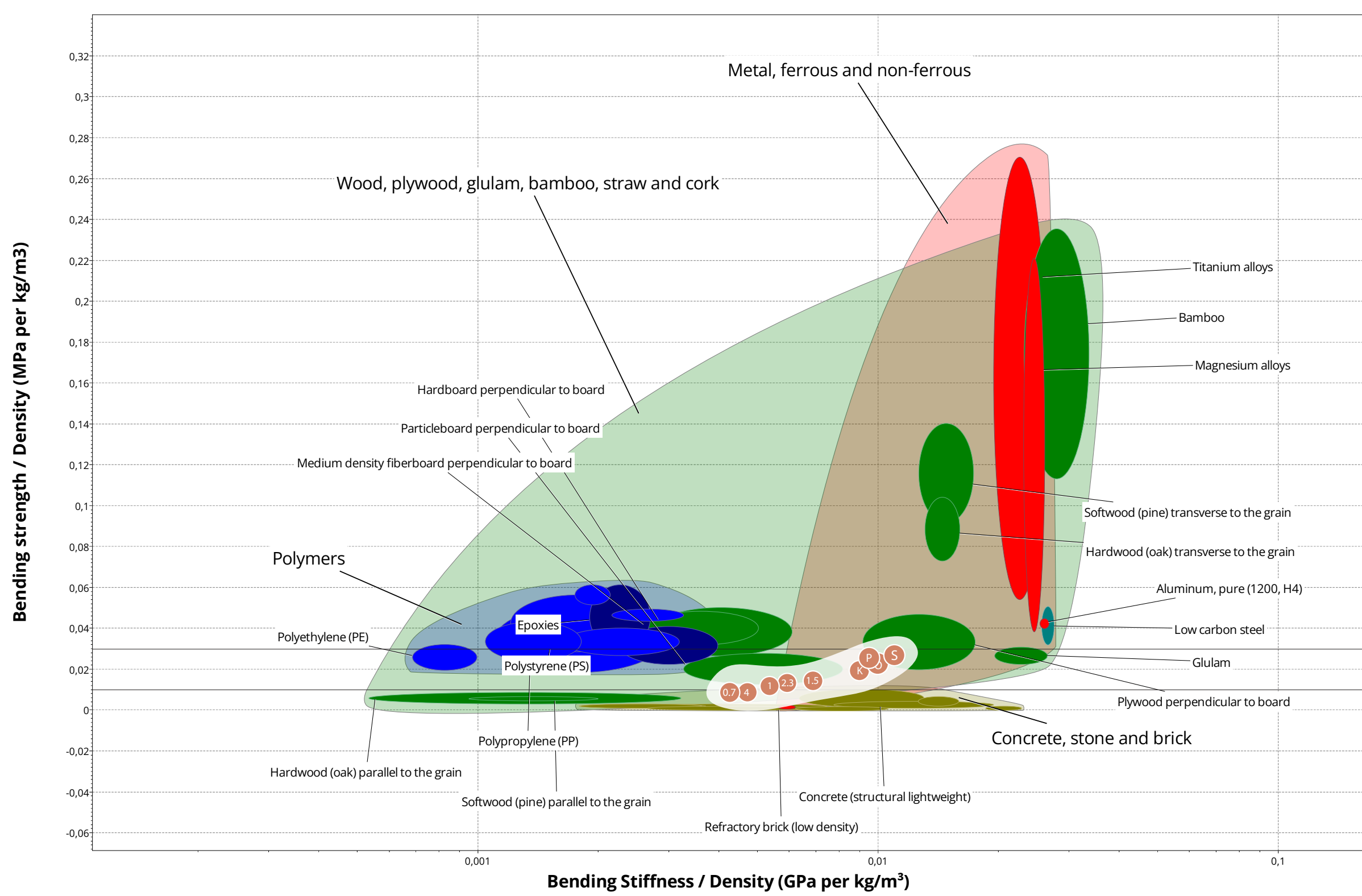
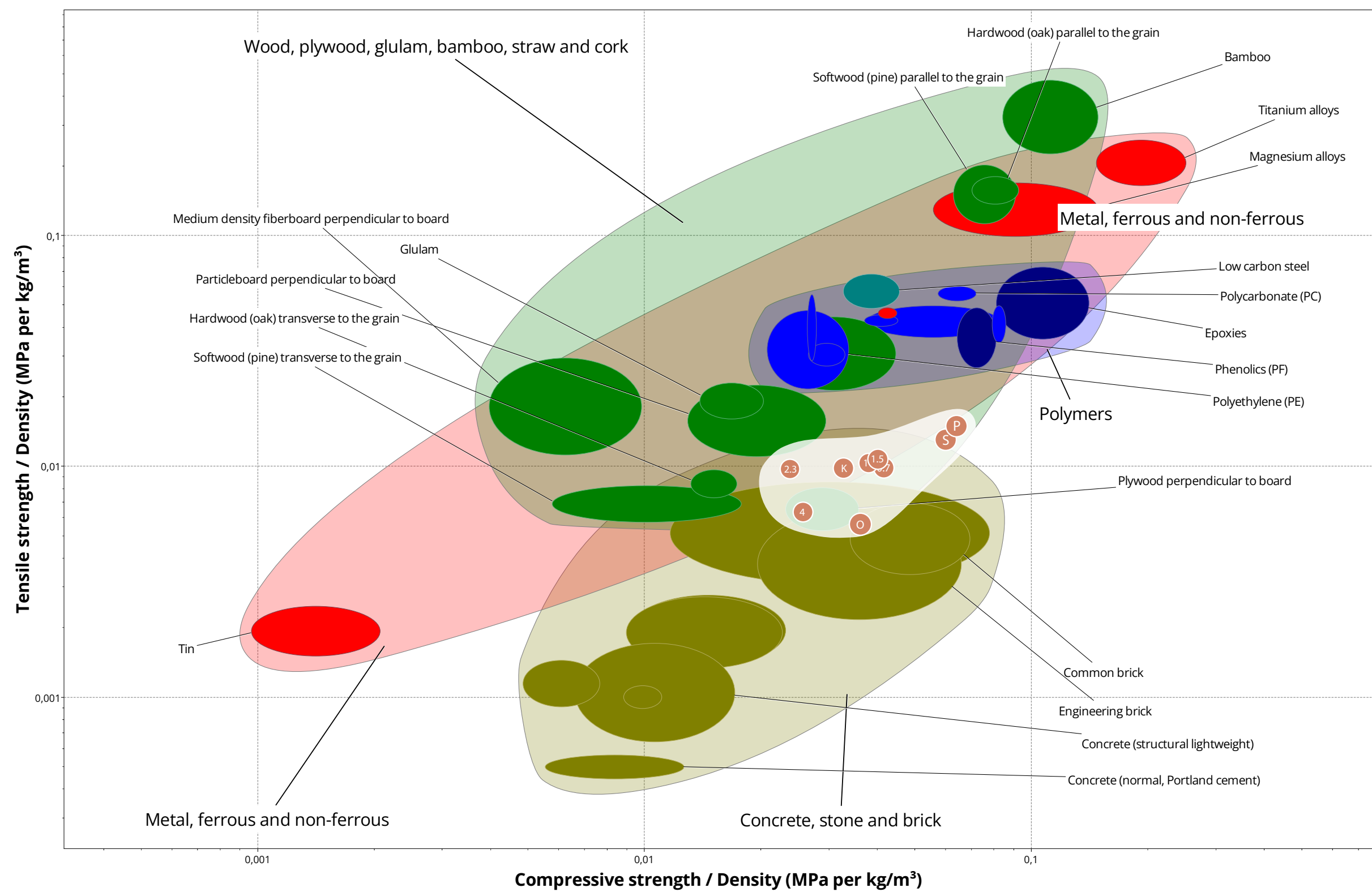
Envfit p: strength=0.001, modulus=0.001, Moisture.Content=0.001, Pressing.temp.=0.001



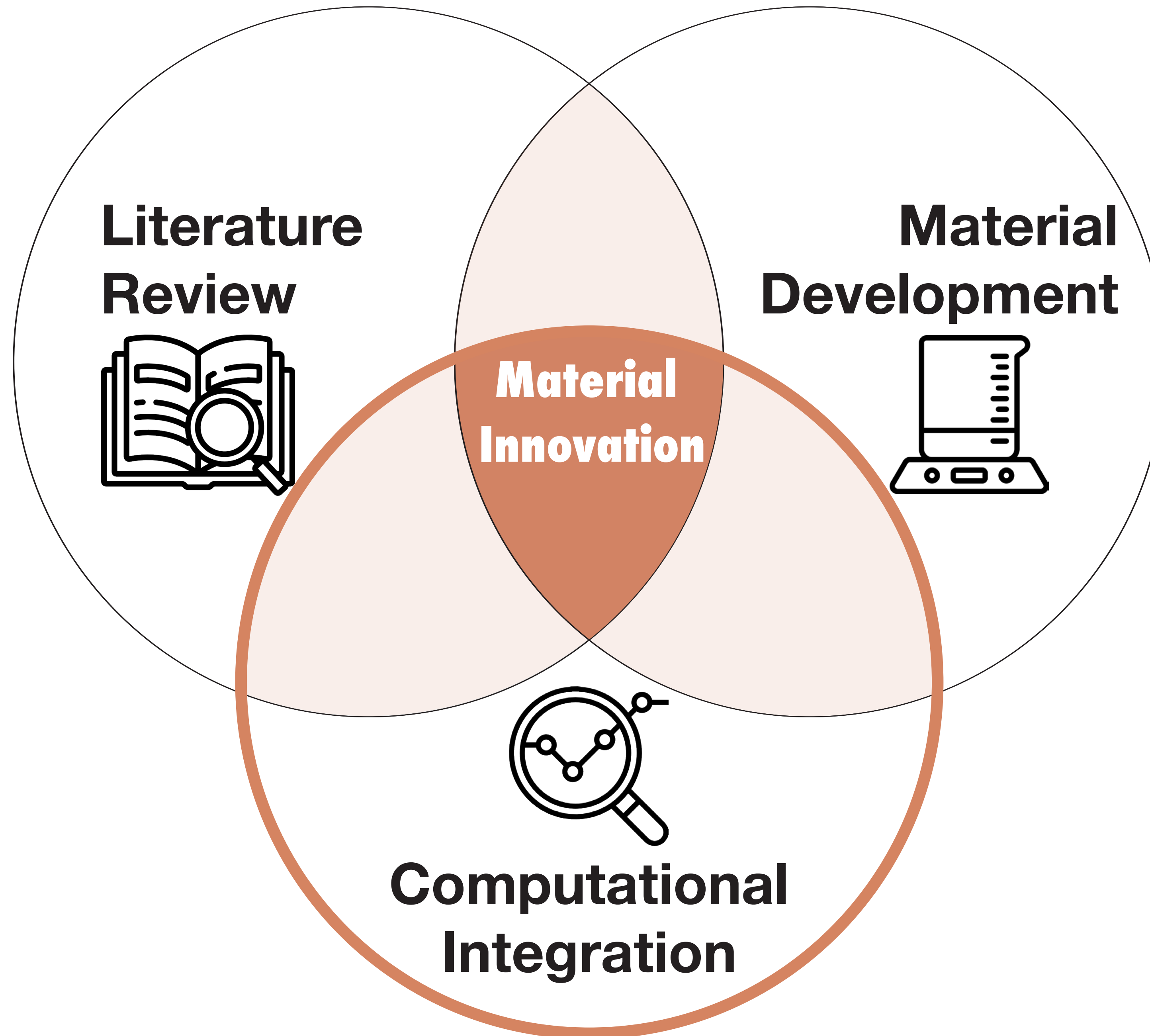
Result Comparison



Result Comparison

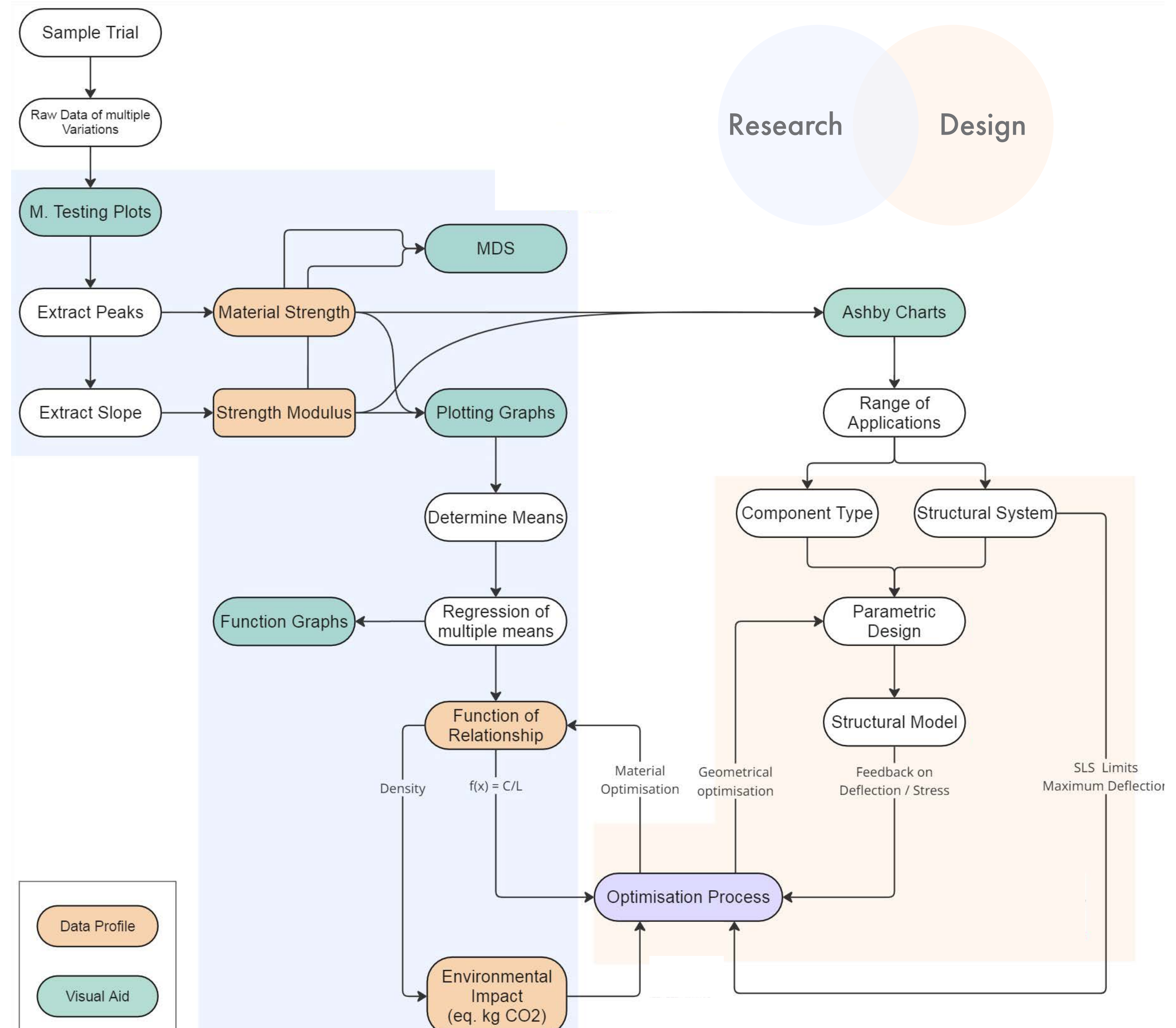


Density: 1230 kg/m³ -> could use some improvements



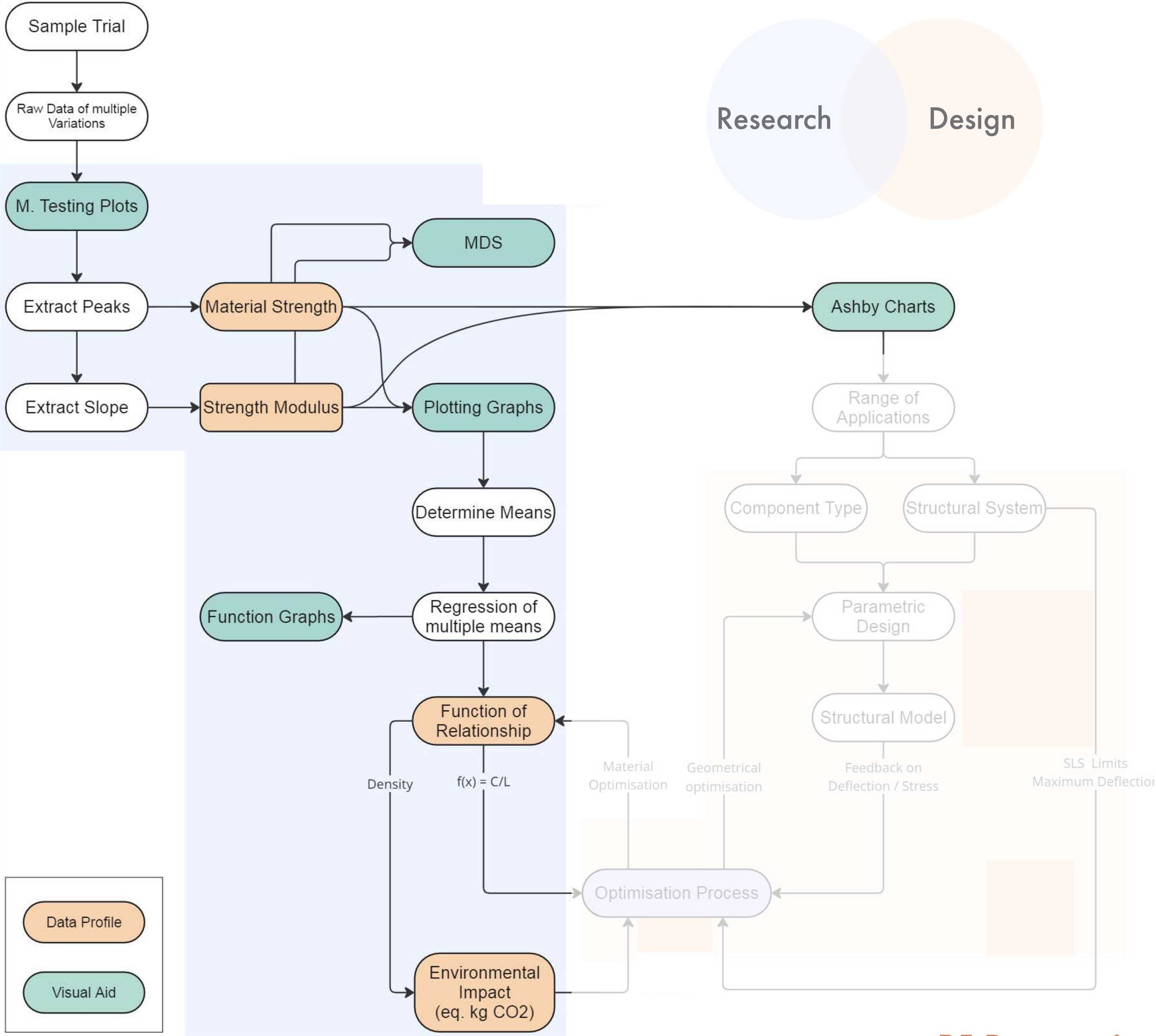
Computational Integration

Integration of Data Analysis
with
Component Design



Computational Integration

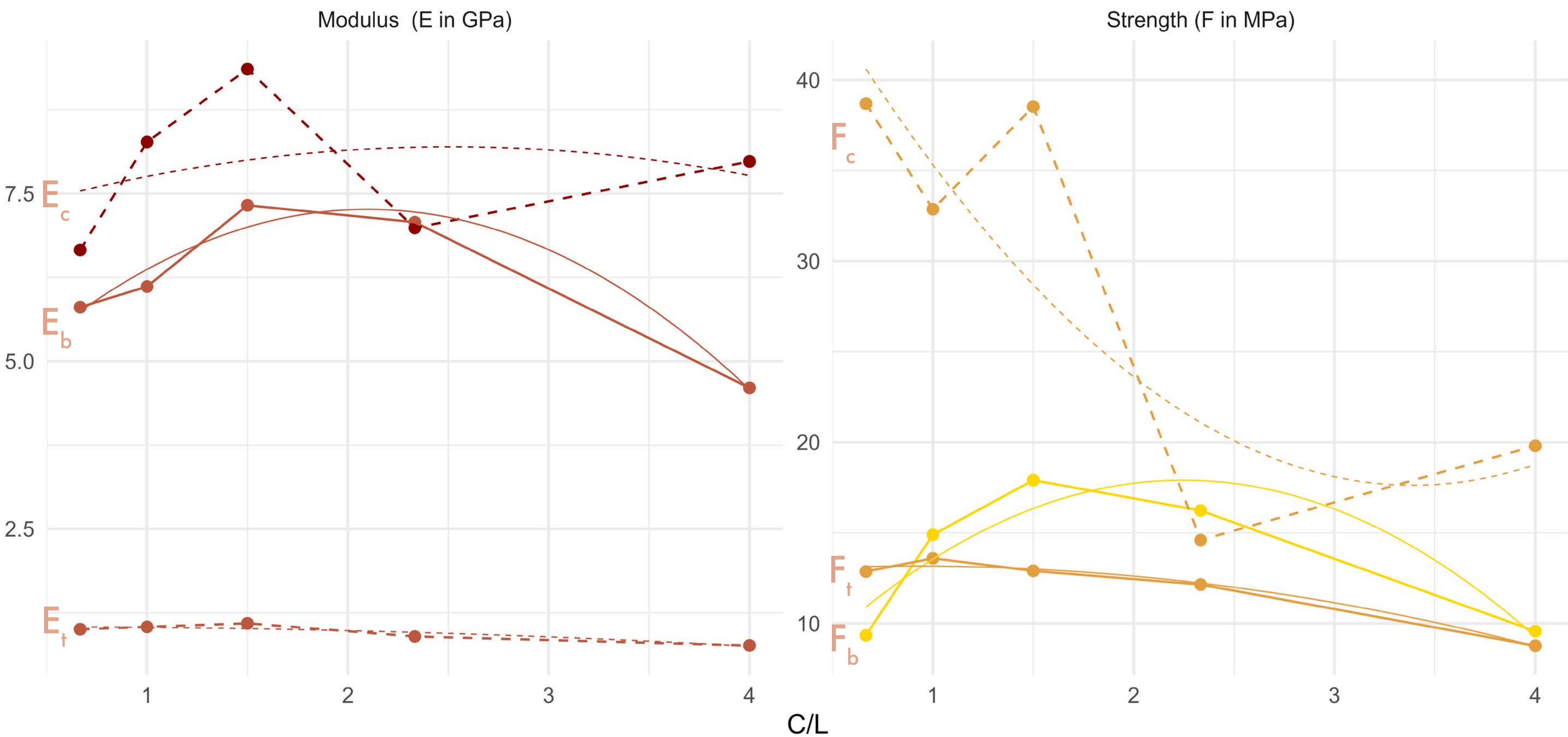
Integration of Data Analysis
with
Component Design





Regression C/L Trial

Results depict a quadratic relationship:
Polynomial 2nd Degree

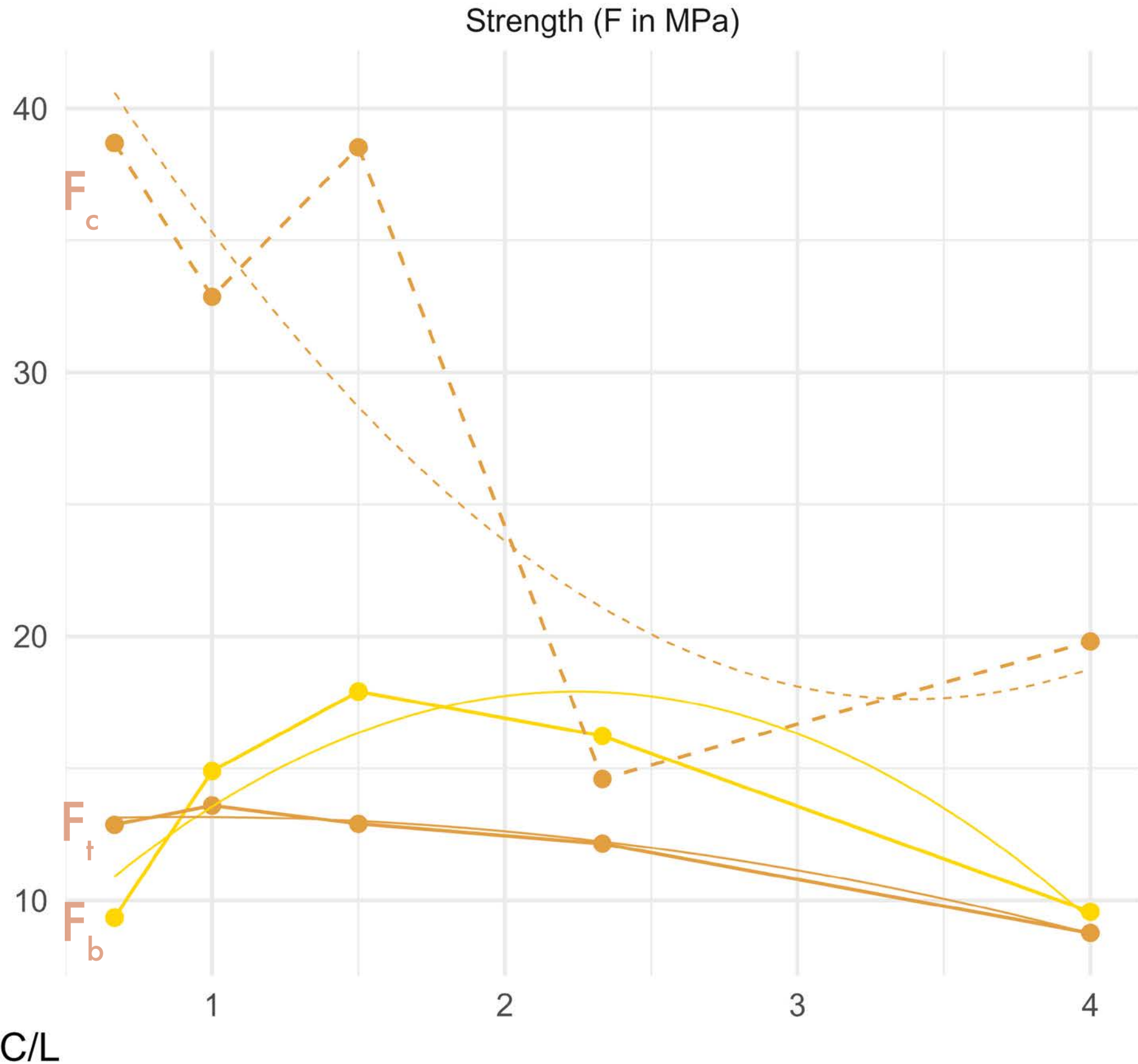
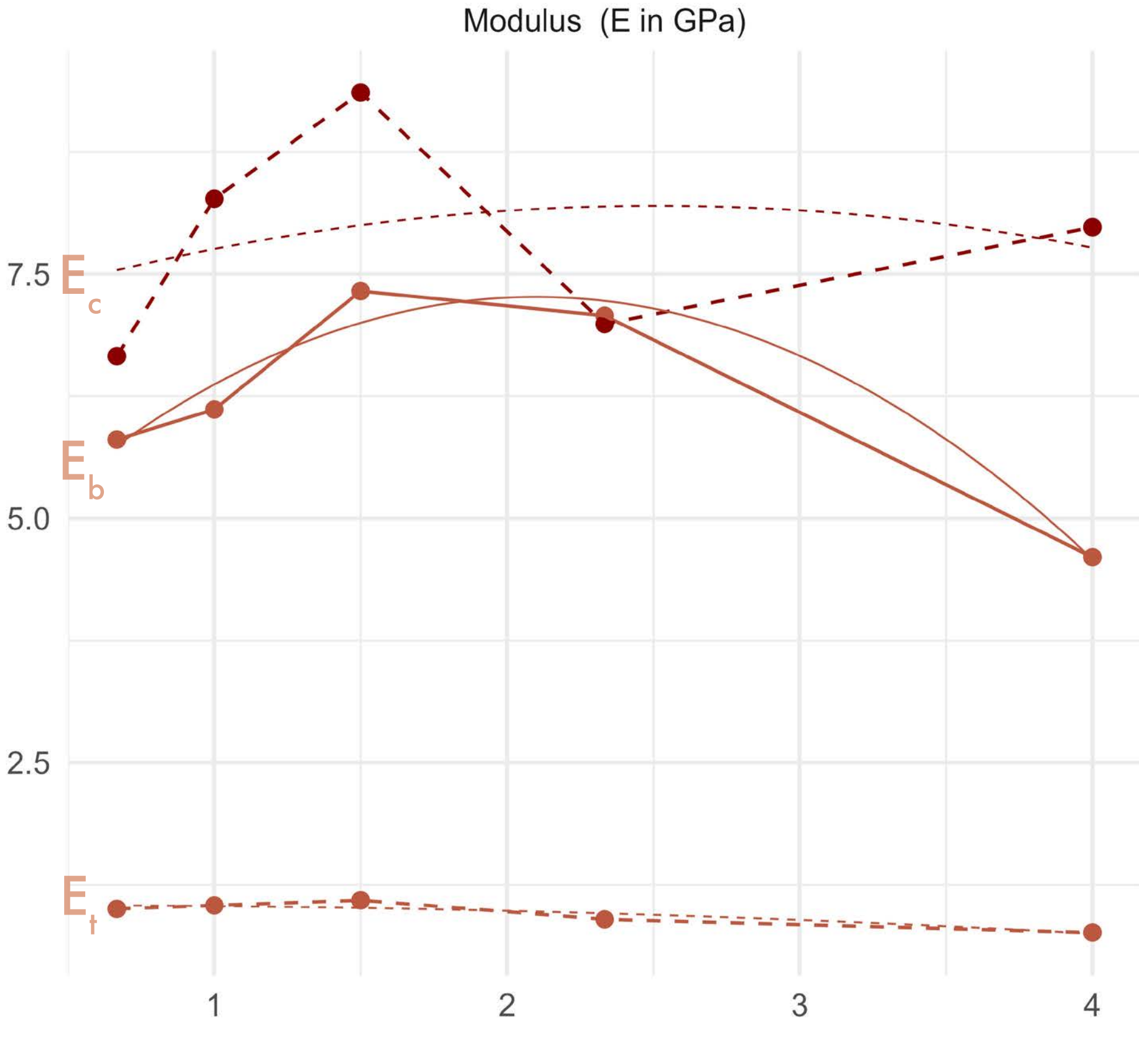


Regression

Results depict a quadratic relationship:

Polynomial 2nd Degree

statistical significance
 $p \leq 0.05$ and high r^2
“Reliable effect and it explains a large share of variability”



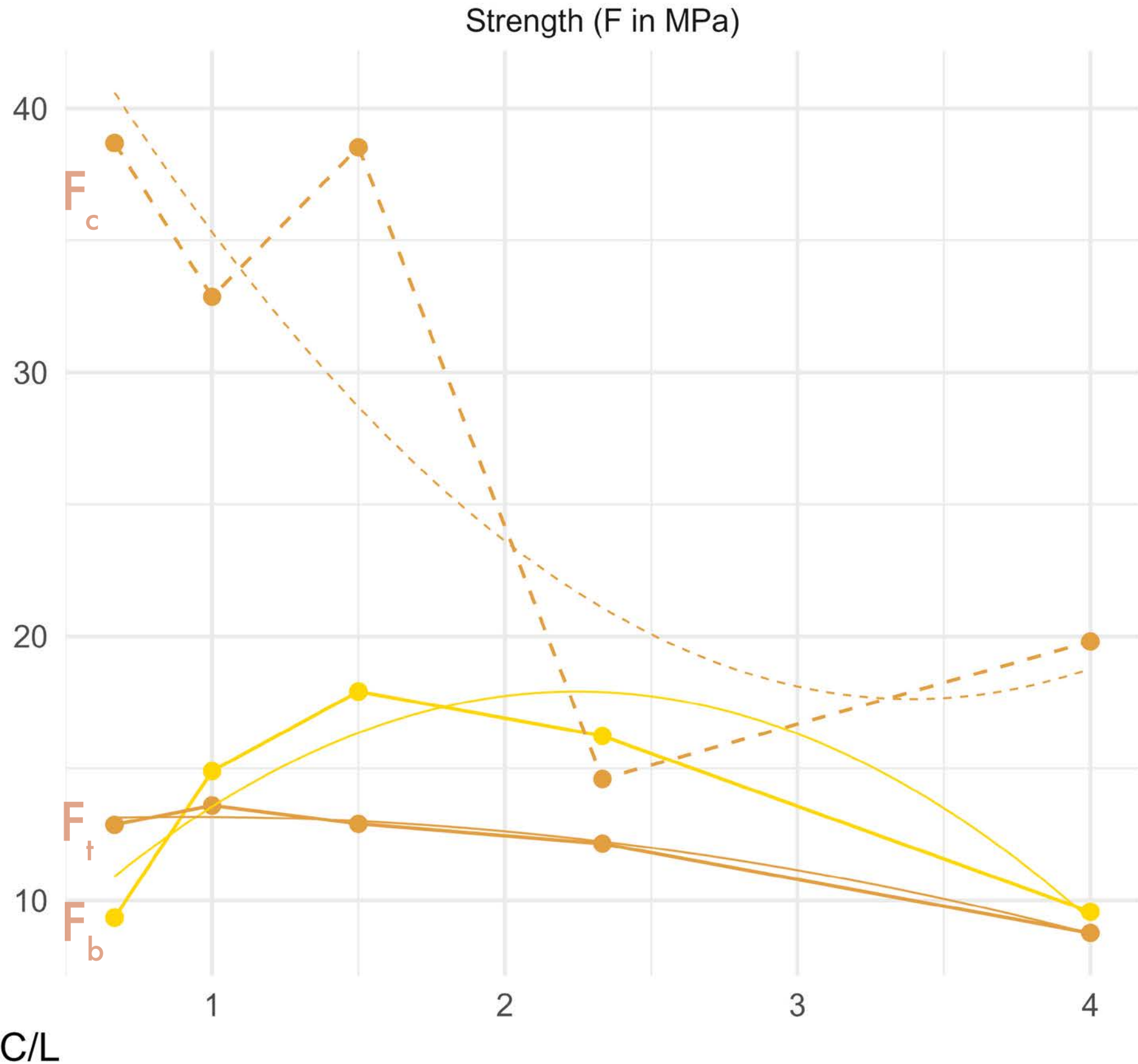
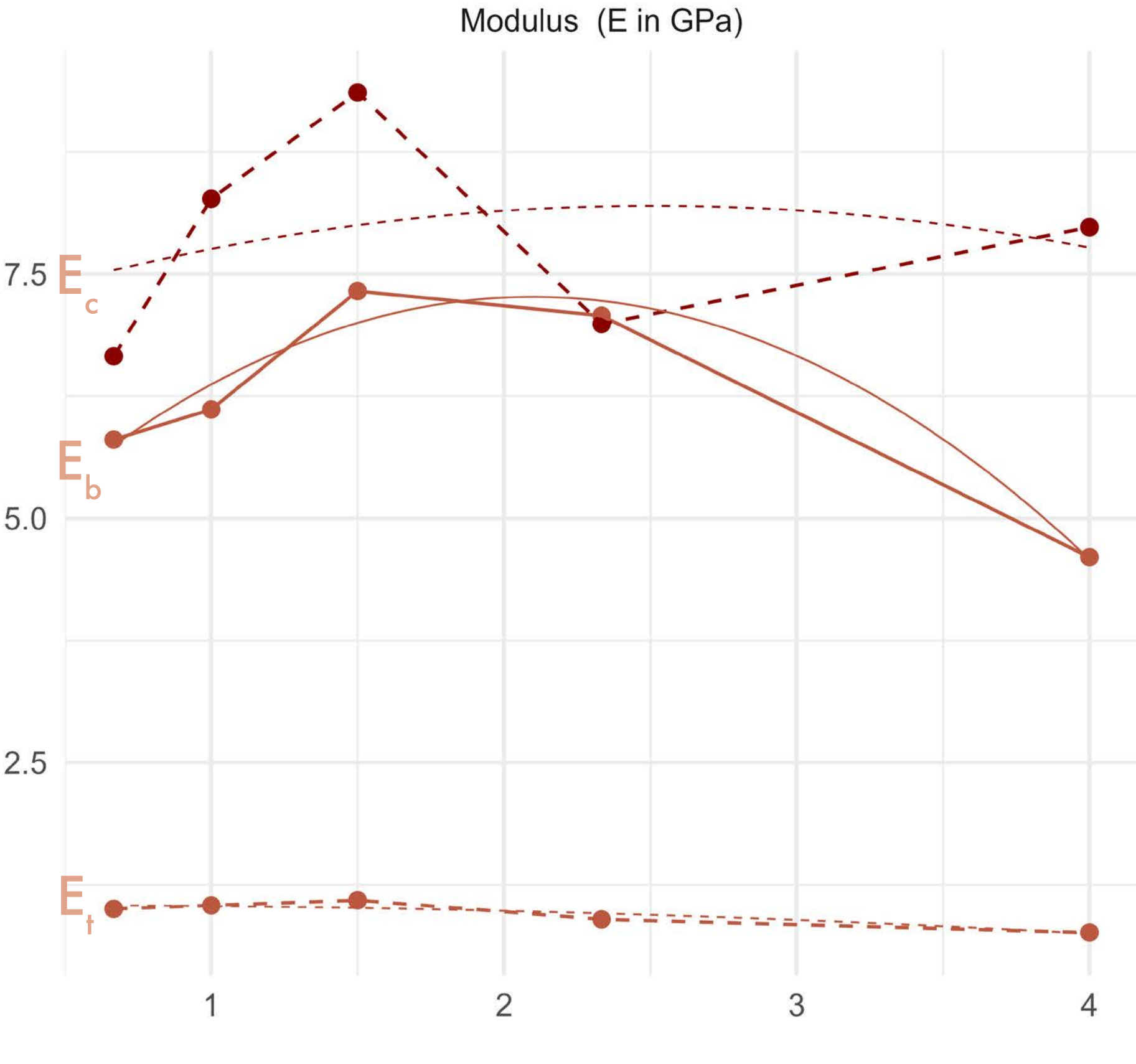
Function	r ² value	p value	Function of E/F to C-L
E_b	0.958	0.0419	$E_b(C/L) = 3.997 + 3.116 \times x + -0.742 \times x^2$
E_c	0.0544	0.946	$E_c(C/L) = 6.976 + 0.973 \times x + -0.194 \times x^2$
E_t	0.837	0.163	$E_t(C/L) = 1.035 + 0.02 \times x + -0.023 \times x^2$
F_b	0.845	0.155	$F_b(C/L) = 3.735 + 12.622 \times x + -2.81 \times x^2$
F_c	0.696	0.304	$F_c(C/L) = 53.228 + -20.999 \times x + 3.096 \times x^2$
F_t	0.981	0.0192	$F_t(C/L) = 12.783 + 0.839 \times x + -0.462 \times x^2$

Regression

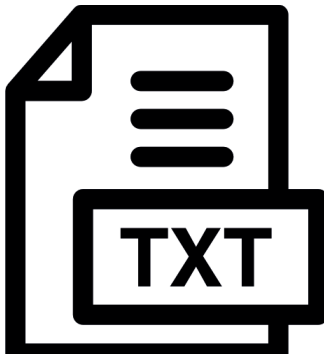
Results depict a quadratic relationship:

Polynomial 2nd Degree

statistical significance
 $p \leq 0.05$ and high r^2
“Reliable effect and it explains a large share of variability”

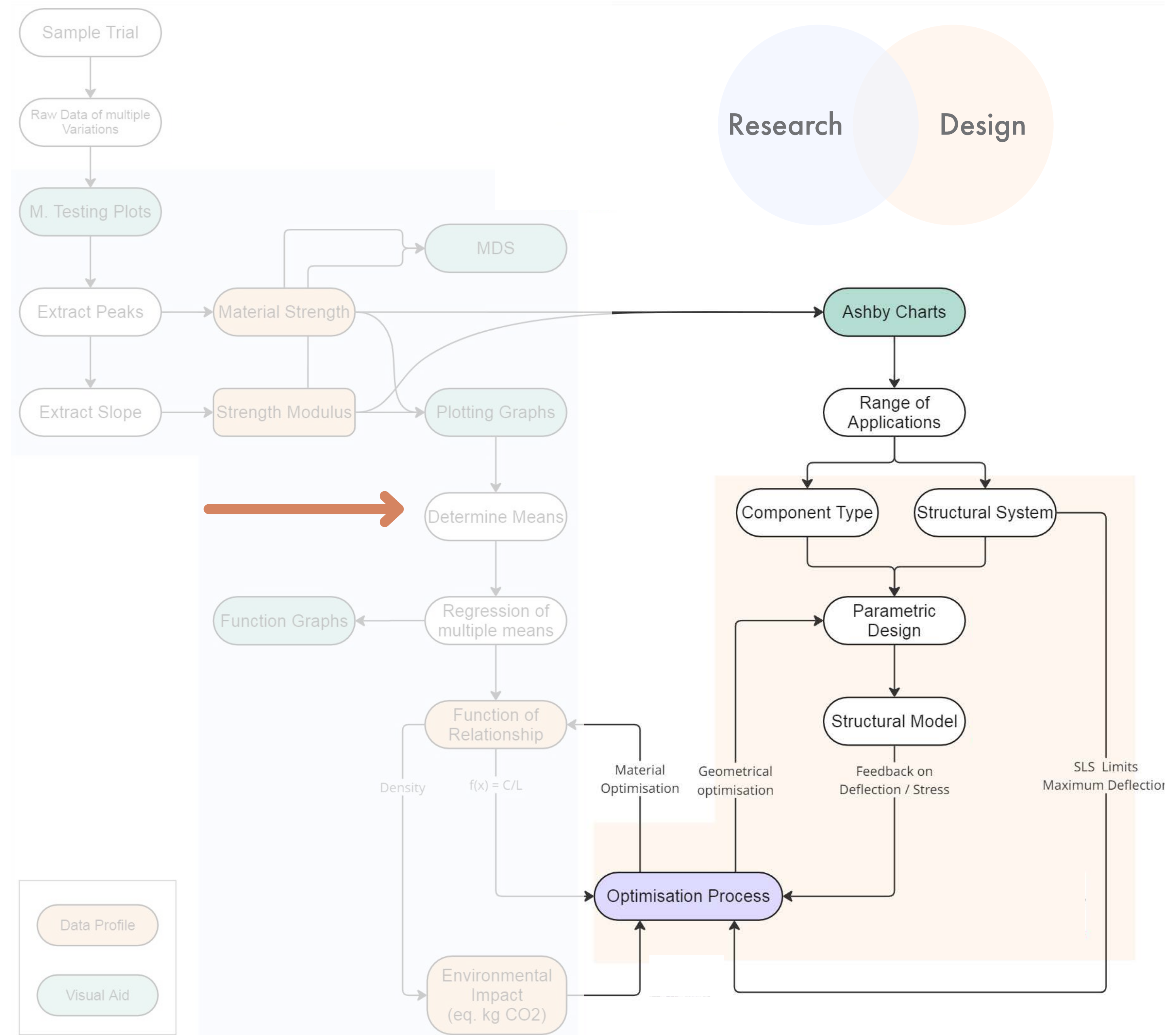


Function	r^2 value	p value	Function of E/F to C-L
E_b	0.958	0.0419	$E_b(C/L) = 3.997 + 3.116 \times x + -0.742 \times x^2$
E_c	0.0544	0.946	$E_c(C/L) = 6.976 + 0.973 \times x + -0.194 \times x^2$
E_t	0.837	0.163	$E_t(C/L) = 1.035 + 0.02 \times x + -0.023 \times x^2$
F_b	0.845	0.155	$F_b(C/L) = 3.735 + 12.622 \times x + -2.81 \times x^2$
F_c	0.696	0.304	$F_c(C/L) = 53.228 + -20.999 \times x + 3.096 \times x^2$
F_t	0.981	0.0192	$F_t(C/L) = 12.783 + 0.839 \times x + -0.462 \times x^2$

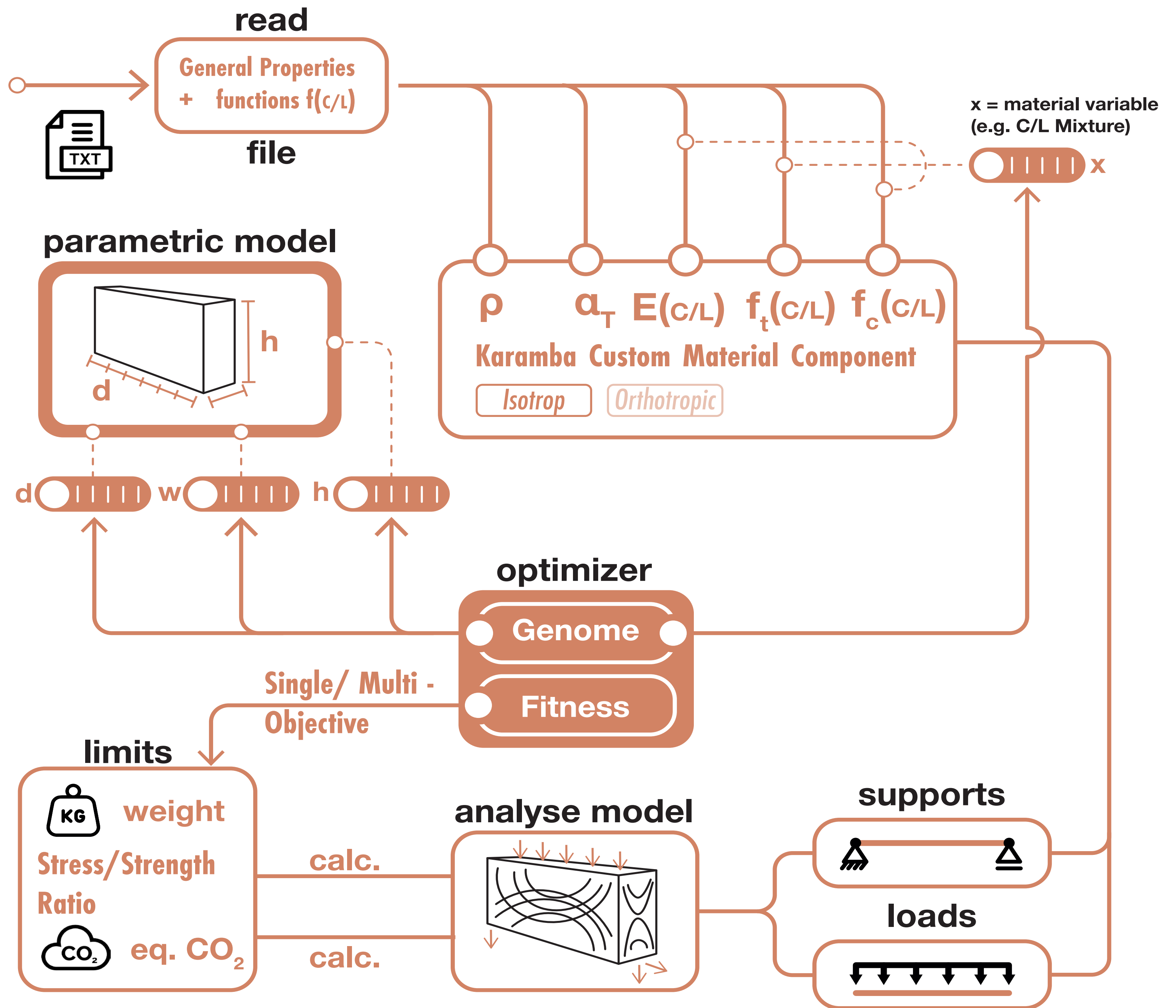


Computational Integration

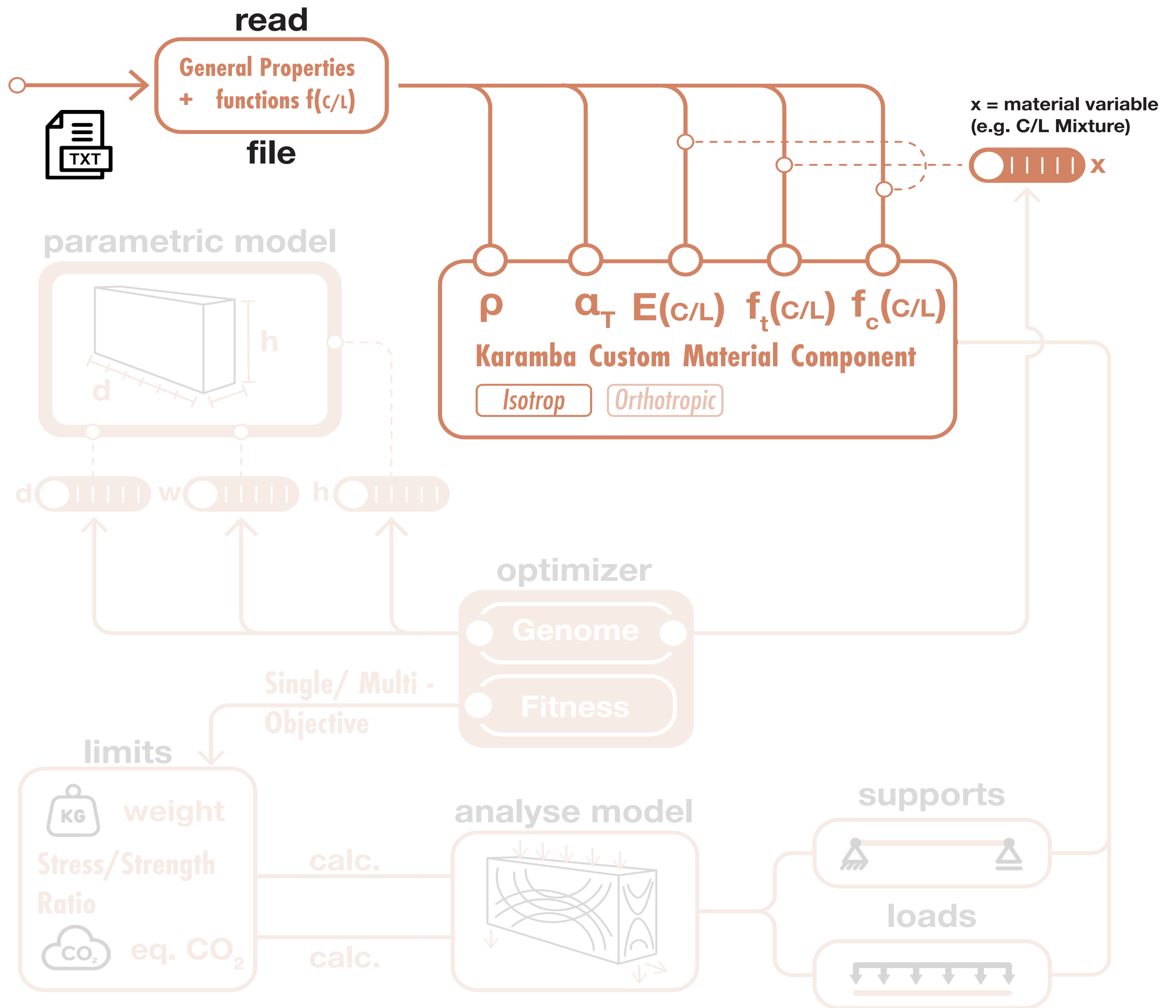
Integration of Data Analysis
with
Component Design



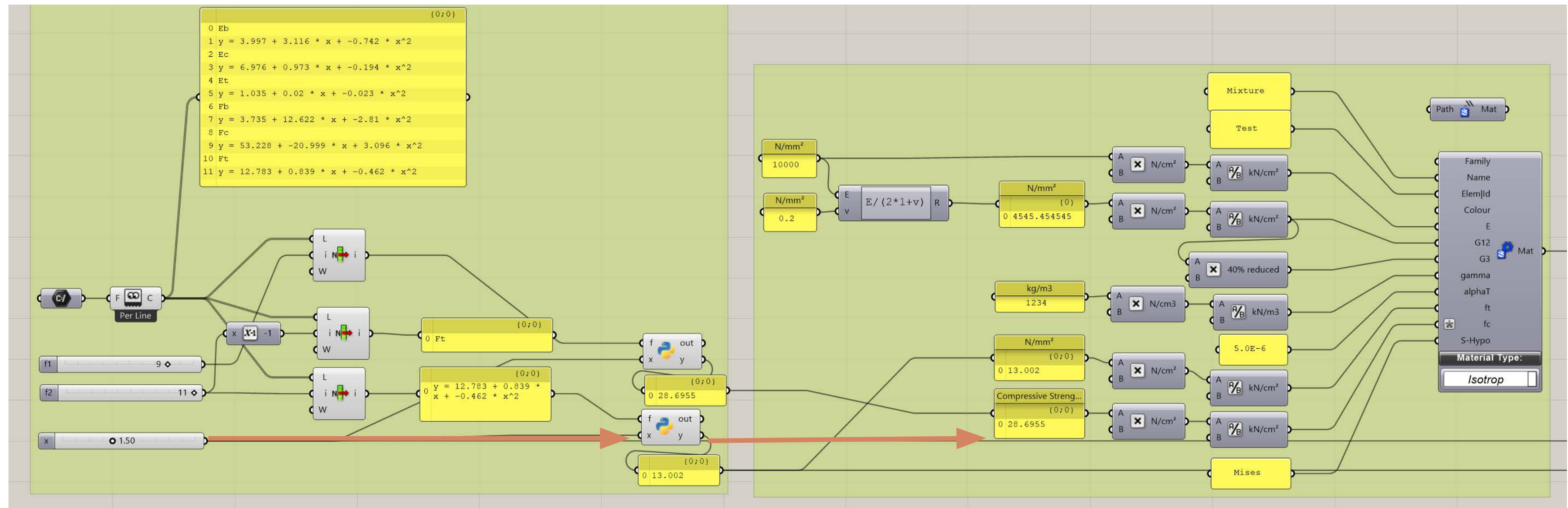
Continuation Grashopper Workflow



Grashopper Workflow



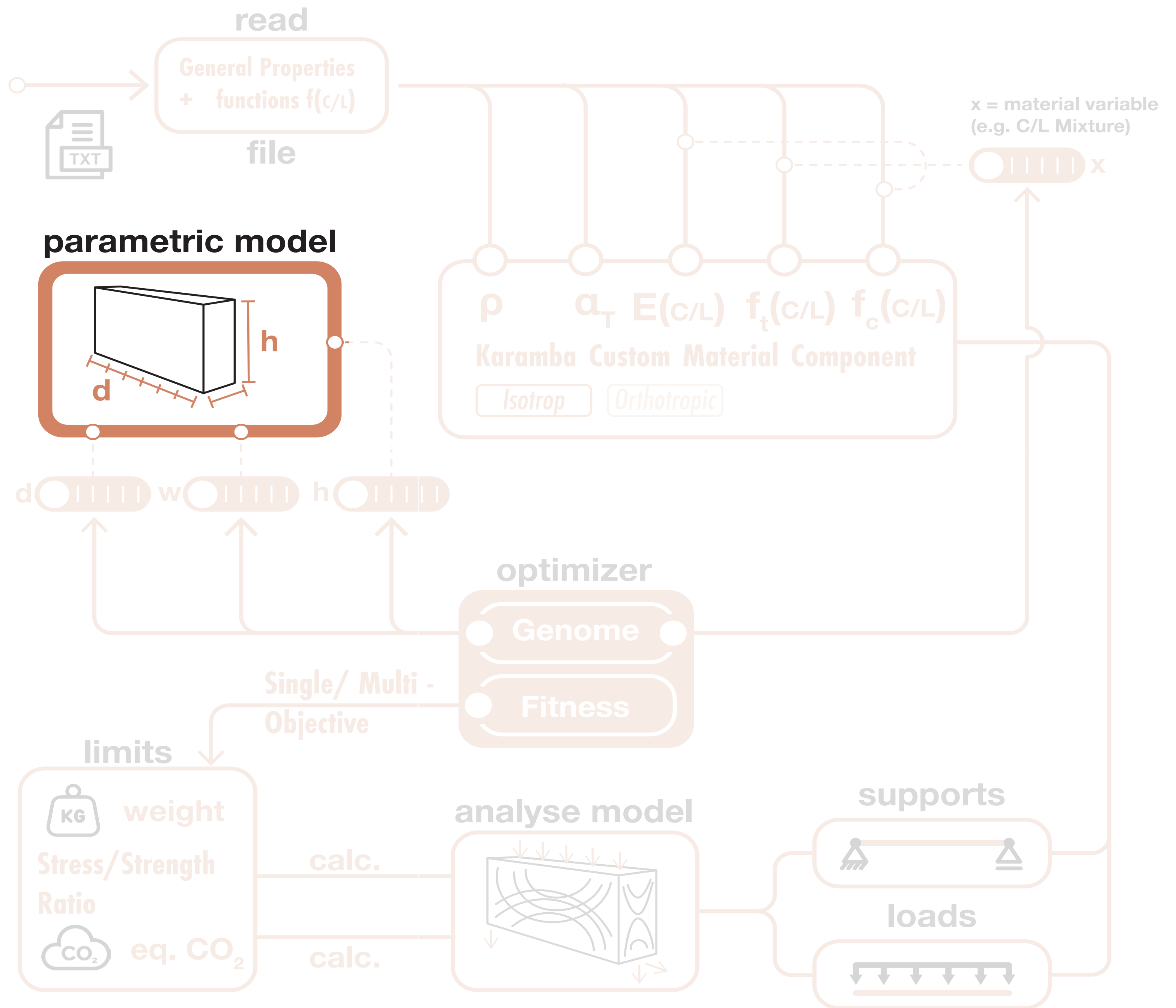
Import and reading of function file



Set variable X with Slider

Feed (F_C and F_I) into Karamba

Grashopper Workflow



Case Study: Finnjoist

- Replacement of the central web made of OSB(3).
- Matching of mechanical performance
- Structural adjustments based on material and process details



image and logo from: https://www.metsagroup.com/contentassets/bdd9a4385ba74645a0815d64c727455d/environmental_product_declaration_for_finnjoist.pdf

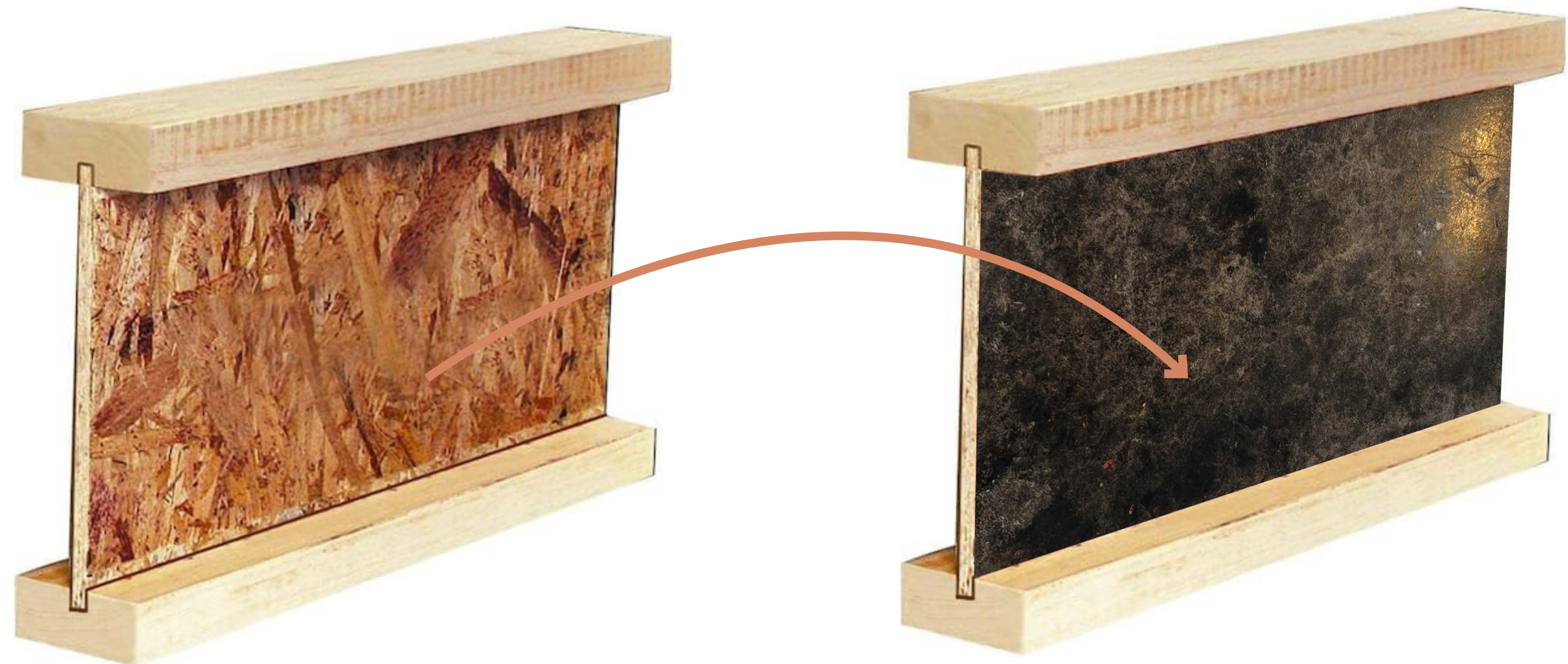
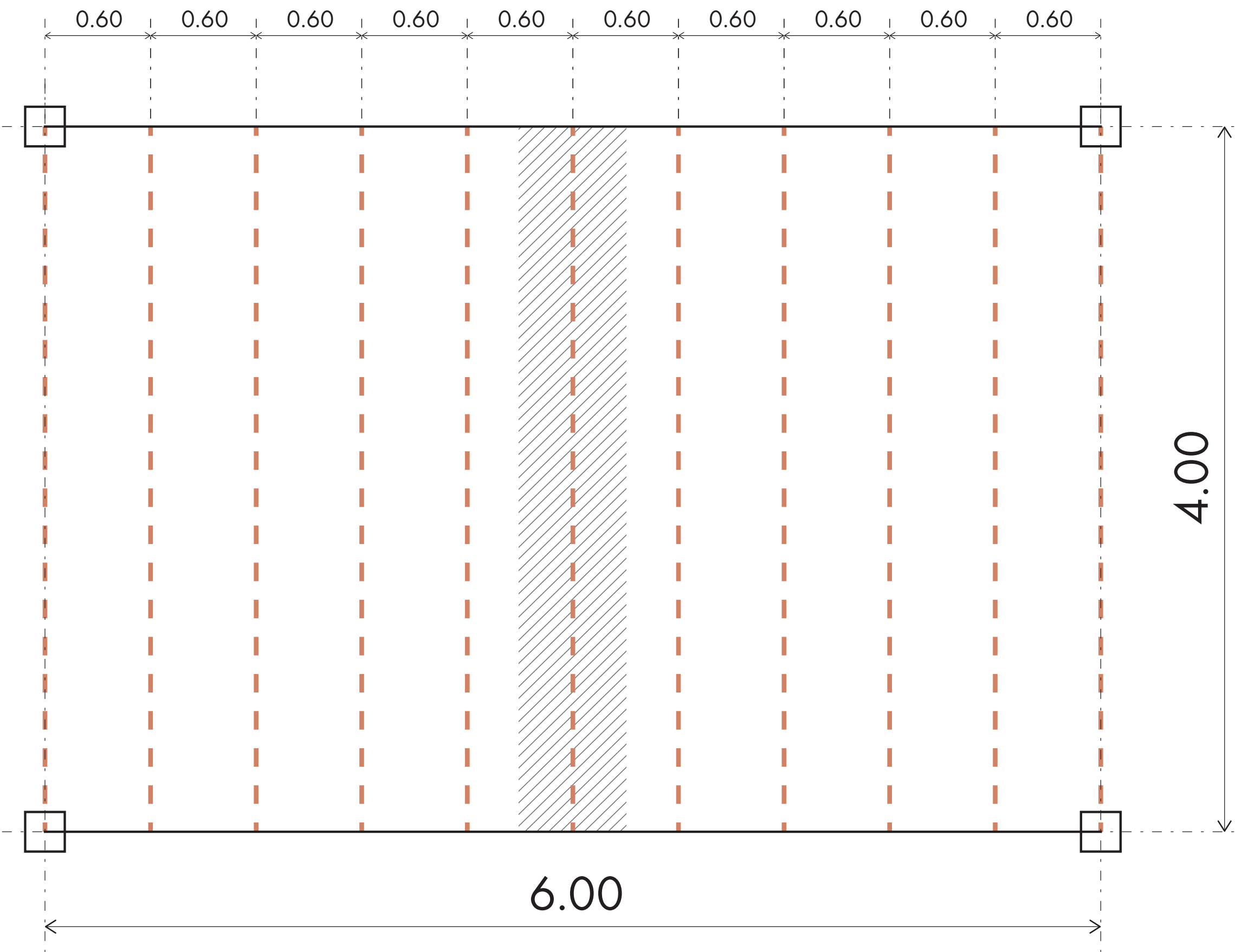


image from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.homedepot.ca%2Fproduct%2F1001854928&psig=AOvVaw08vtlpbDeXu-NnMm-iYQuM&ust=1750326331826000&source=images&opi=89978449>

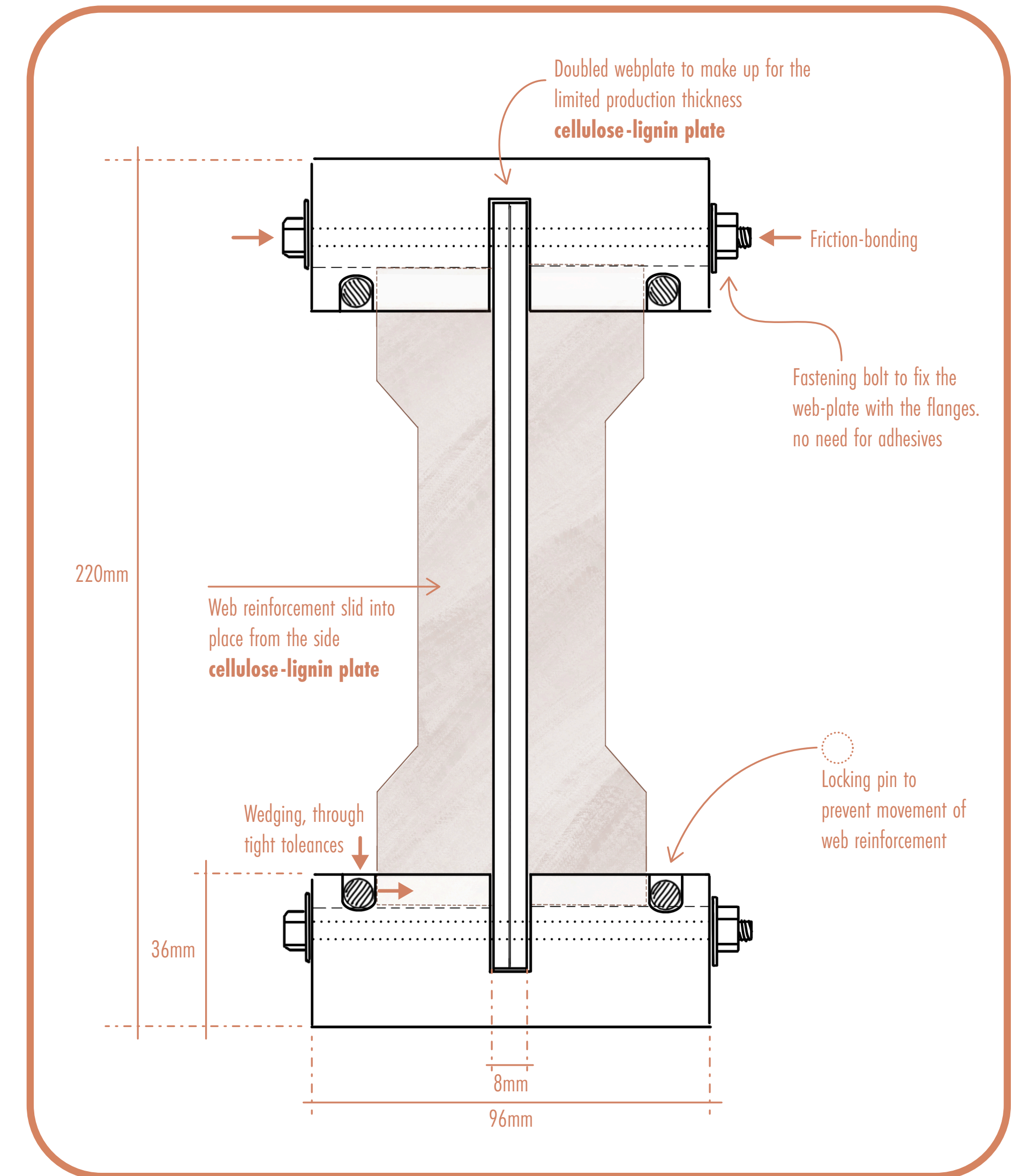
Structural System Requirements

Type	Specification	Standard
Maximum deflection	$\leq L/300$; under characteristic (dead + live) loads	EN 1990:2002
Live load	2 kN/m ² (residential area)	EN 1990-1-1:2002
Dead load	1.5 kN/m ² (floor finishes, services, self-weight of joist and decking)	EN 1990-1-1:2002
Partial safety factors	$\gamma_G = 1.35$ (permanent), $\gamma_Q = 1.50$ (variable)	EN 1991-1-1:2002
Minimum floor surface mass	200 kg/m ² (to achieve $R_{n,w} \approx 50$ dB airborne sound insulation in a timber-framed floor)	EN ISO 12354-2:2017

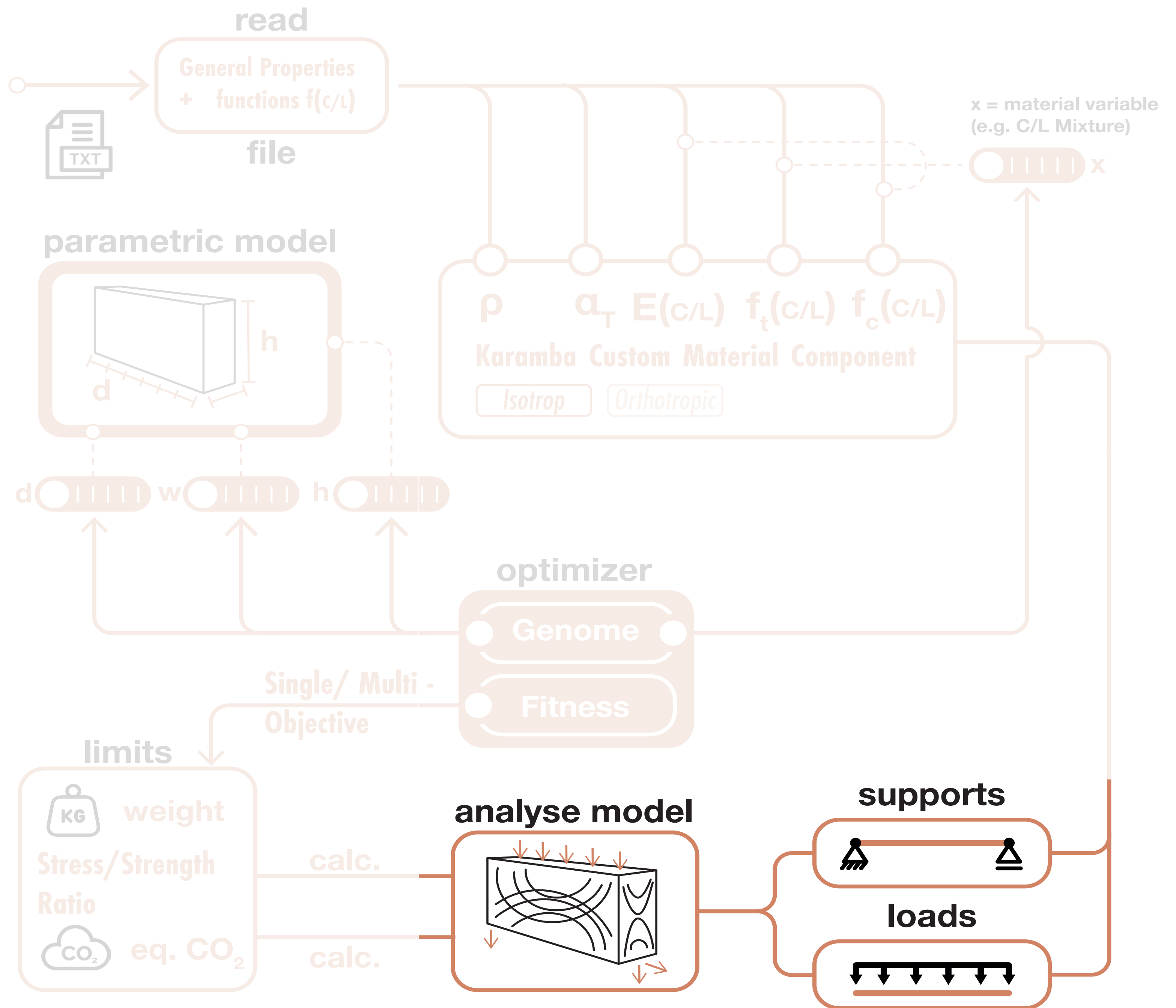


Cross-Section Adjustments

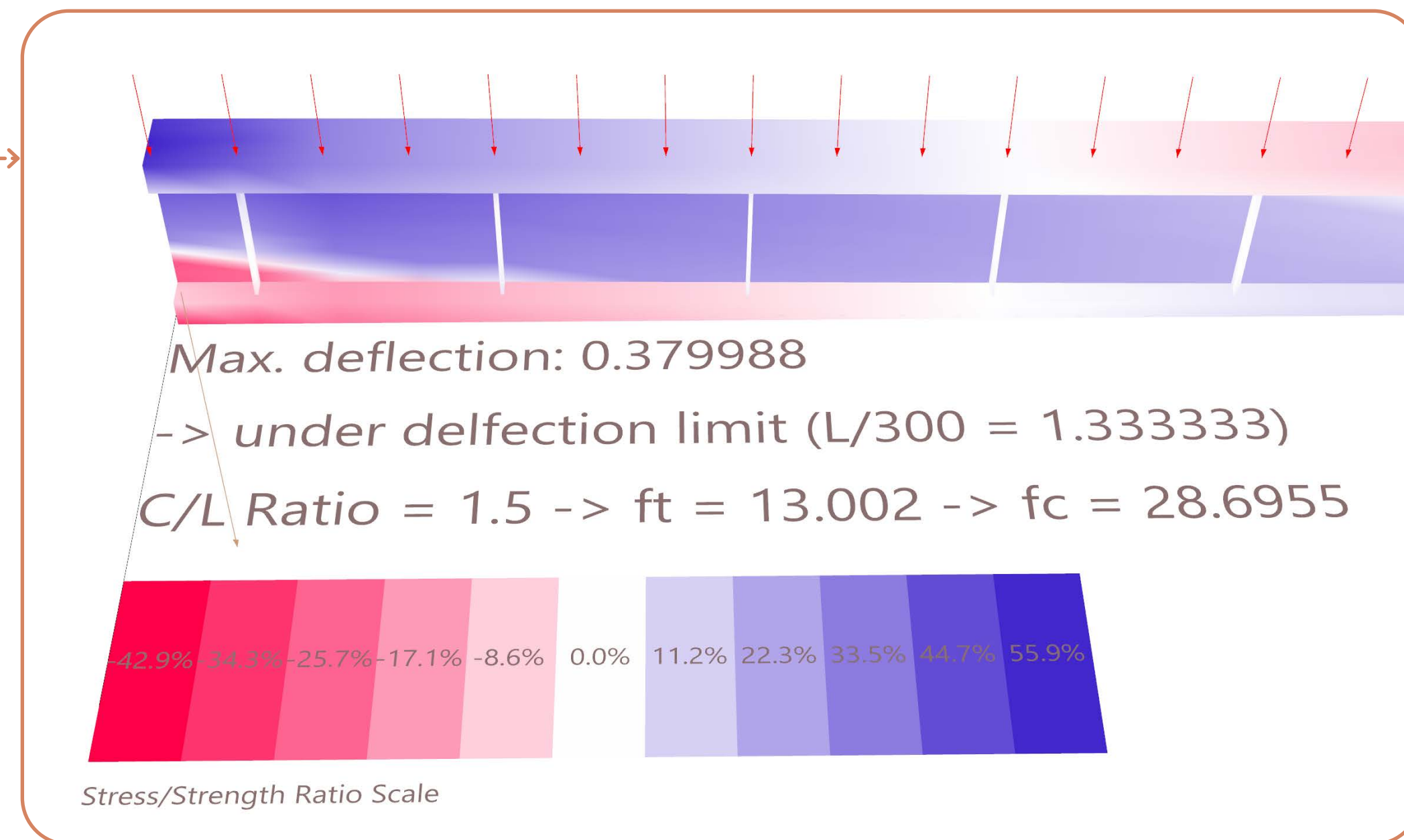
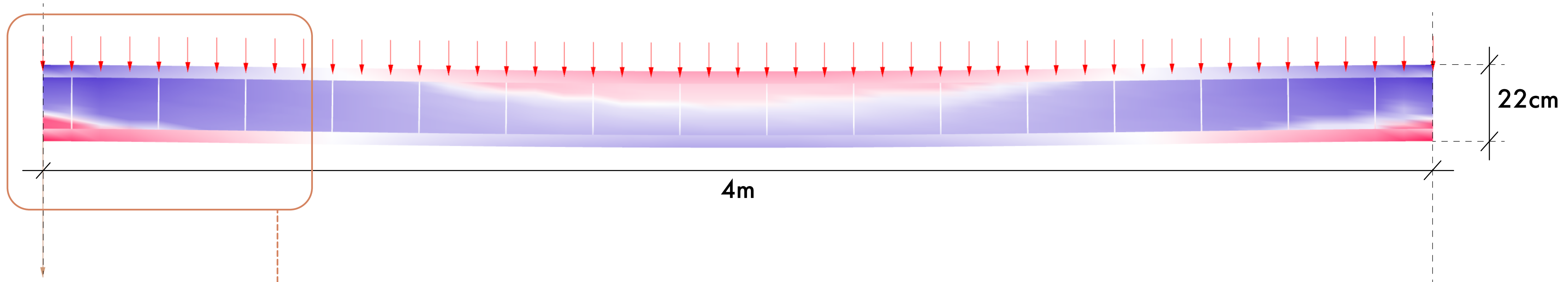
- No adhesives, glues irreversible connection
- Preserve standard joist connections
- Accommodate the limited production thickness of hot-press ($\sim 4\text{mm}$)
- Accommodate low flexural modulus - Introduce buckling reinforcements



Grashopper Workflow

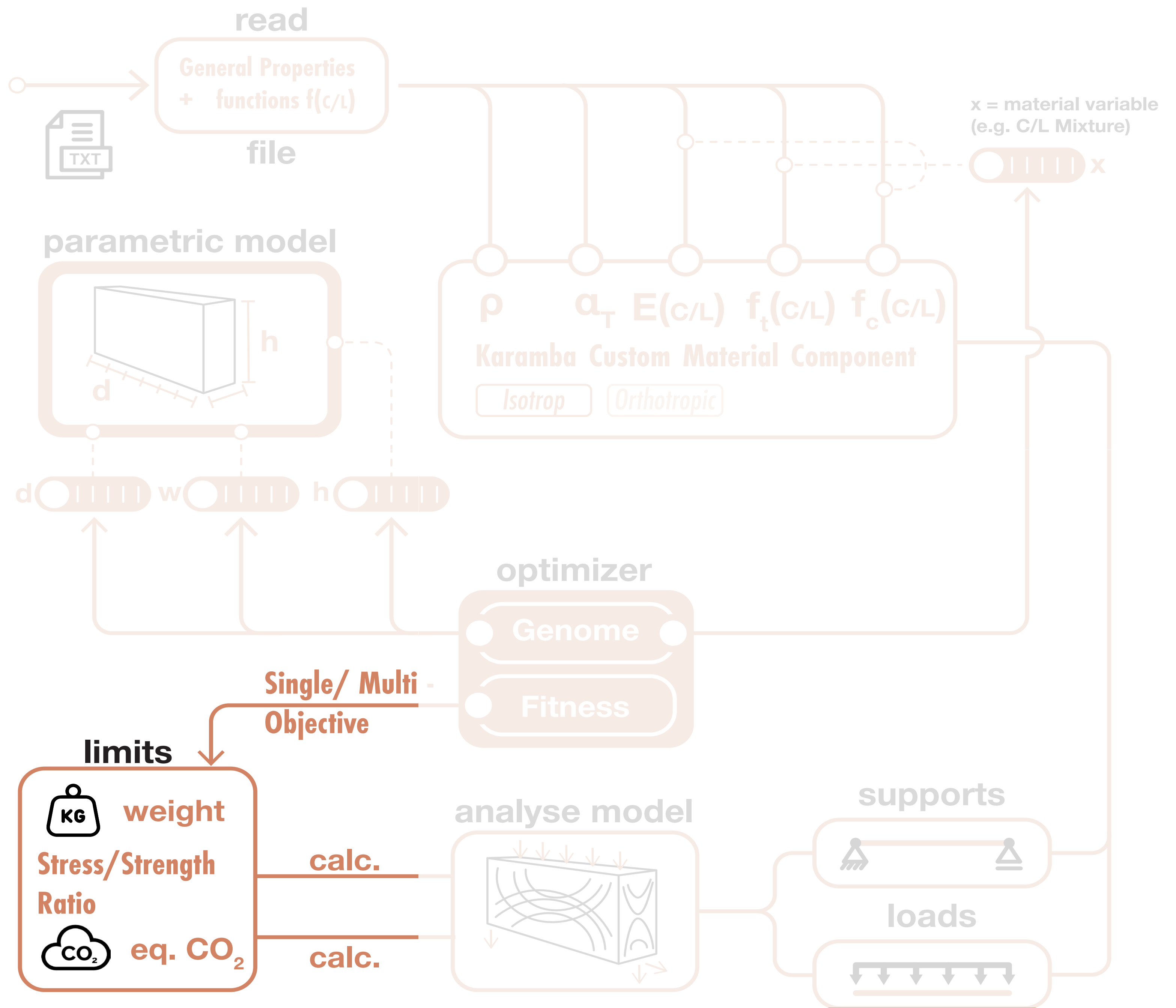


Modelling results

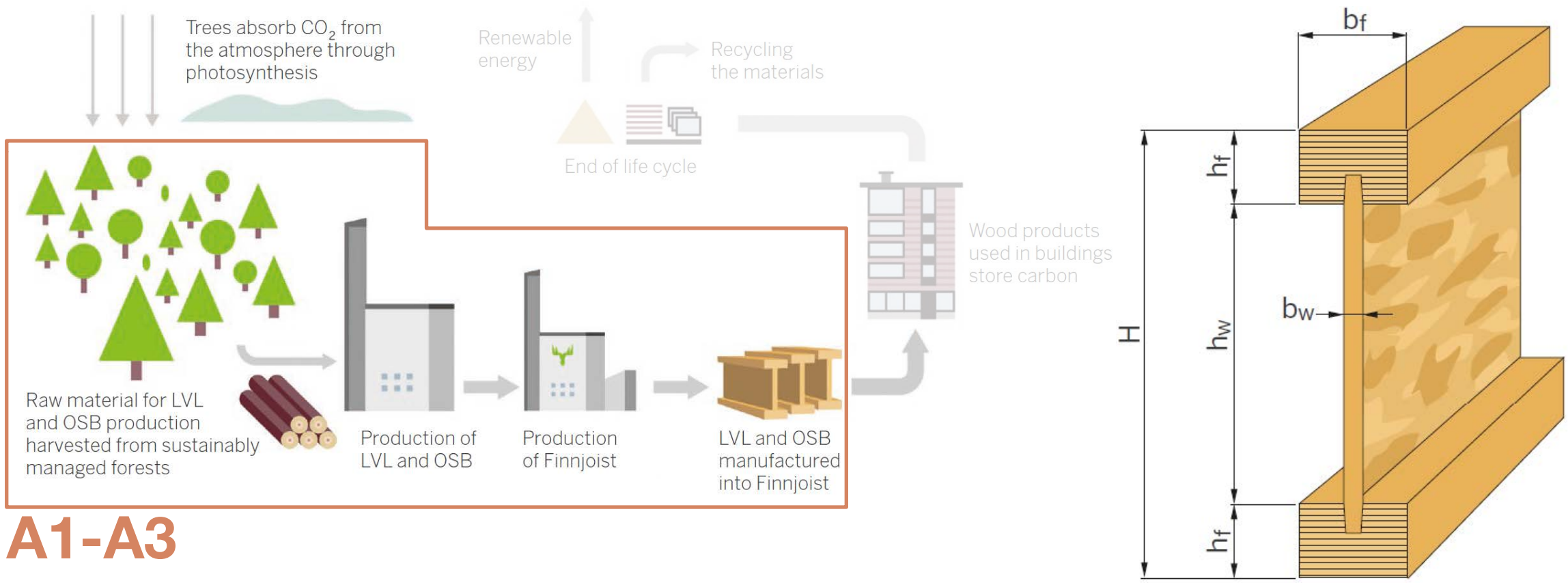


- Exemplary C/L ratio of 1.5 or 3 to 2.
- $f_t = 13.0 \text{ MPa}$ & $f_c = 28.7 \text{ MPa}$
- Deflection limit satisfied
- 43% to 56% strength utilisation

Grashopper Workflow



Environmental Impact

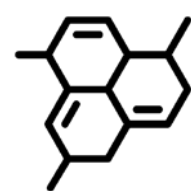


Environmental Information

1 CORE ENVIRONMENTAL IMPACT INDICATORS - 1 KG OF FINNJOIST

Indicator	Unit	A1-A3
Global Warming Potential - total (GWP-total)*	kg CO ₂ eq.	-1.04
Global Warming Potential - fossil fuels (GWP-fossil)	kg CO ₂ eq.	0.581
Global Warming Potential - biogenic (GWP-biogenic)*	kg CO ₂ eq.	-1.63
Global Warming Potential - land use and land use change	kg CO ₂ eq.	9.37 · 10 ⁻⁴

images from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.homedepot.ca%2Fproduct%2F1001854928&psig=AOvVaw08vtlpbDeXu-NhMm-iYQuM&ust=1750326331826000&source=images&opi=89978449>



Kraft Lignin

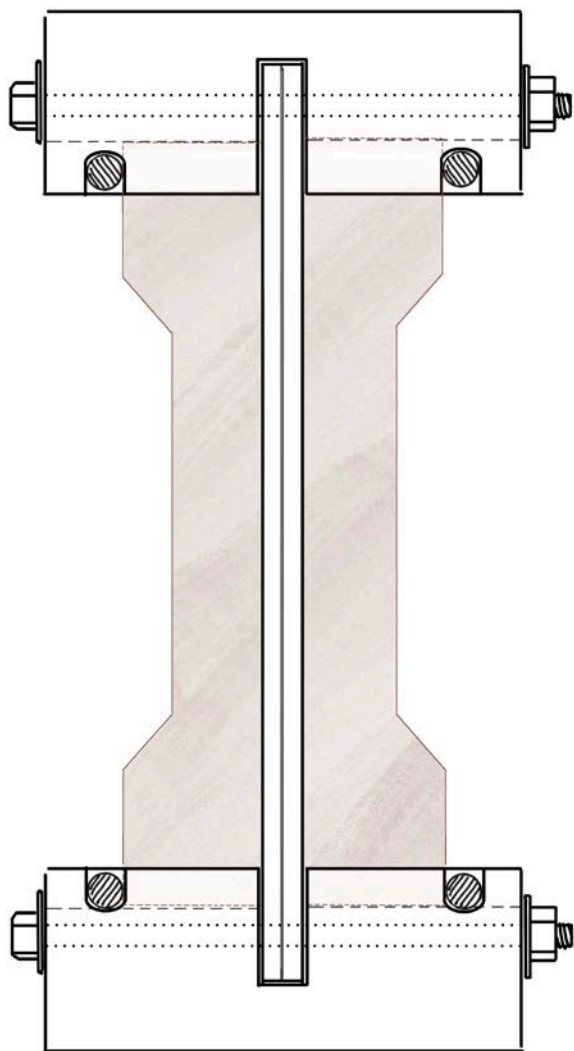


LVL

Fasteners



+ Hot-Pressing Energy (Dutch Energy Mix)



4m of cellulose-lignin Finnjoist

Type	Equivalent kg CO ₂	Amount	Source
Lignin	0.6 kg CO ₂ /kg	4.97 kg	Bernier et al., 2013
Cellulose	-81.1 kg CO ₂ (65kg/kg)	7.46 kg	ISOCELL GmbH. (2014).
LVL	-693 kg CO ₂ /m ³	10.13 kg	Stora Enso. (2023)
Metal Fasteners	6.88 kg CO ₂ /1000kg	0.23 kg	Adolf Würth GmbH & Co. KG, 2024
Type	Specification	Source	
Hot-pressing	6.1 kWh per m ²	Silva et al., 2020	
Dutch Energy Mix	0.2685 kg CO ₂ /kWh	Statista, 2025	
Total kg CO ₂		Total weight:	
-19.02 (-0.9/kg)		22.80 kg	

LVL image from: <https://www.vanhoorebeke.com/en/houtproducten/construction/lvl>
IsoCELL Logo from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.enning-daemmtechnik.de%2Fpartner.html&psig=AOvVaw2qxztFlmK9KjIMnwJqM5RP&ust=1750327061547000&source=images&opi=89978449>
Cellulose and Lignin Image see reference on page 11
Metal Fasteners image from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.melfast.com%2Fblog%2F2016%2F05%2F3-things-about-stainless-steel-fasteners-you-probably-dont-know&psig=AOvVaw2jKW-LDg8OqOaoENwTfAs&ust=1750327170290000&source=images&opi=89978449>

Cellulose-lignin ratio:

0.6 = -0.72 kg eq. CO₂



Cellulose-lignin ratio:

4.0 = -1.06 kg eq. CO₂

Environmental Impact



KG **CO₂**

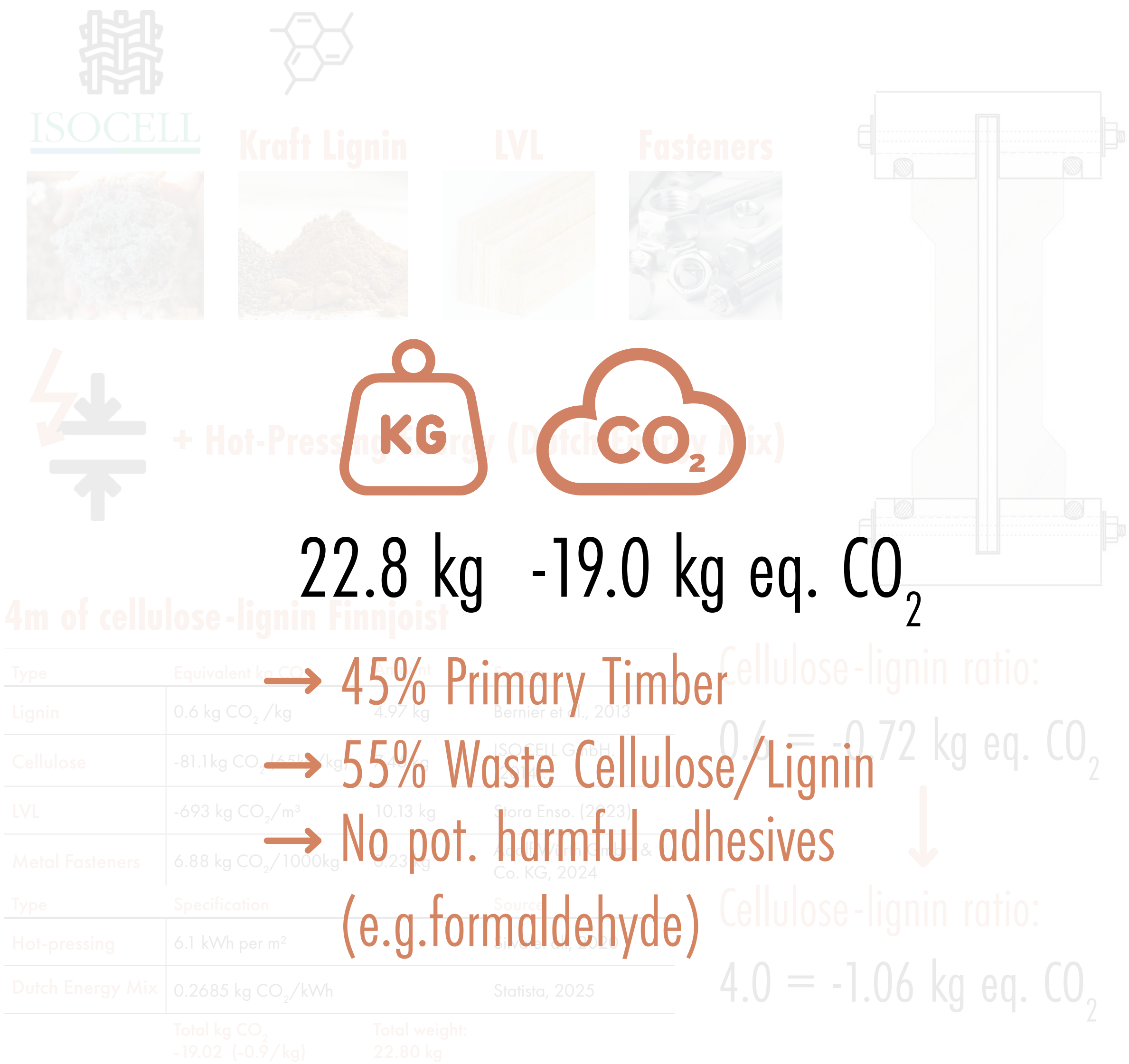
14.0 kg 14.6 kg eq. CO₂

Environmental Information

1 CORE ENVIRONMENTAL IMPACT INDICATORS OF FINNJOIST

Indicator	Unit	A1-A3
Global Warming Potential - total (GWP-total)	kg CO ₂ eq.	1.04
Global Warming Potential - fossil fuels (GWP-fossil)	kg CO ₂ eq.	0.581
Global Warming Potential - biogenic (GWP-biogenic)*	kg CO ₂ eq.	-1.63
Global Warming Potential - land use and land use change	kg CO ₂ eq.	9.37 · 10 ⁻⁴

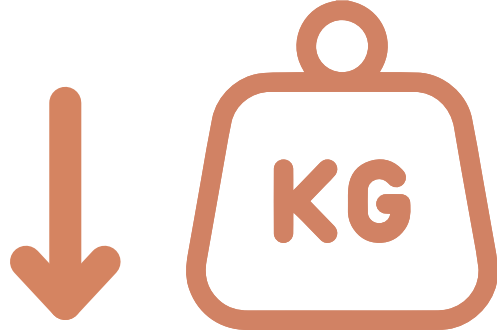
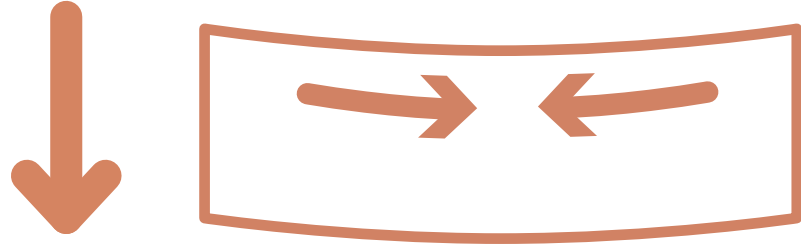
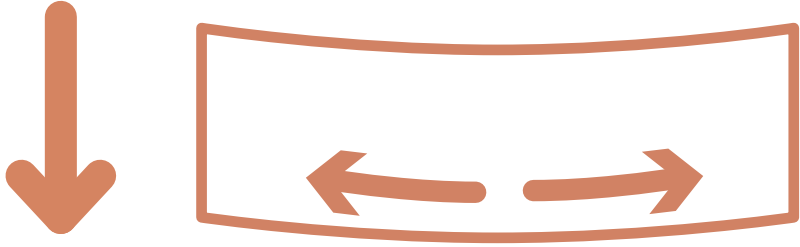
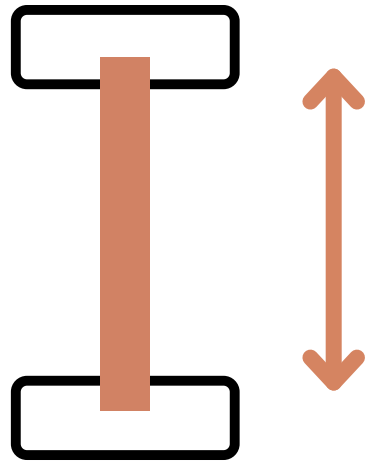
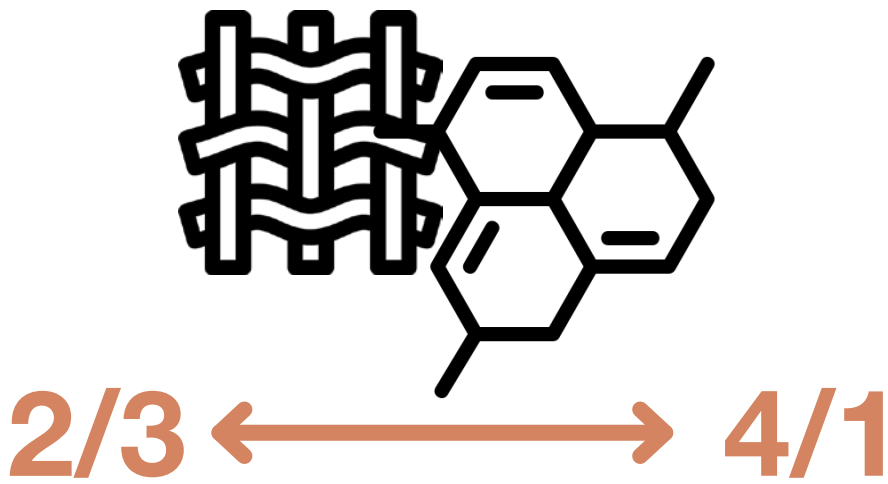
- 100% Primary Timber
- MUF Resins for bonding - non recyclable
- Formaldehyde emissions from OSB plates



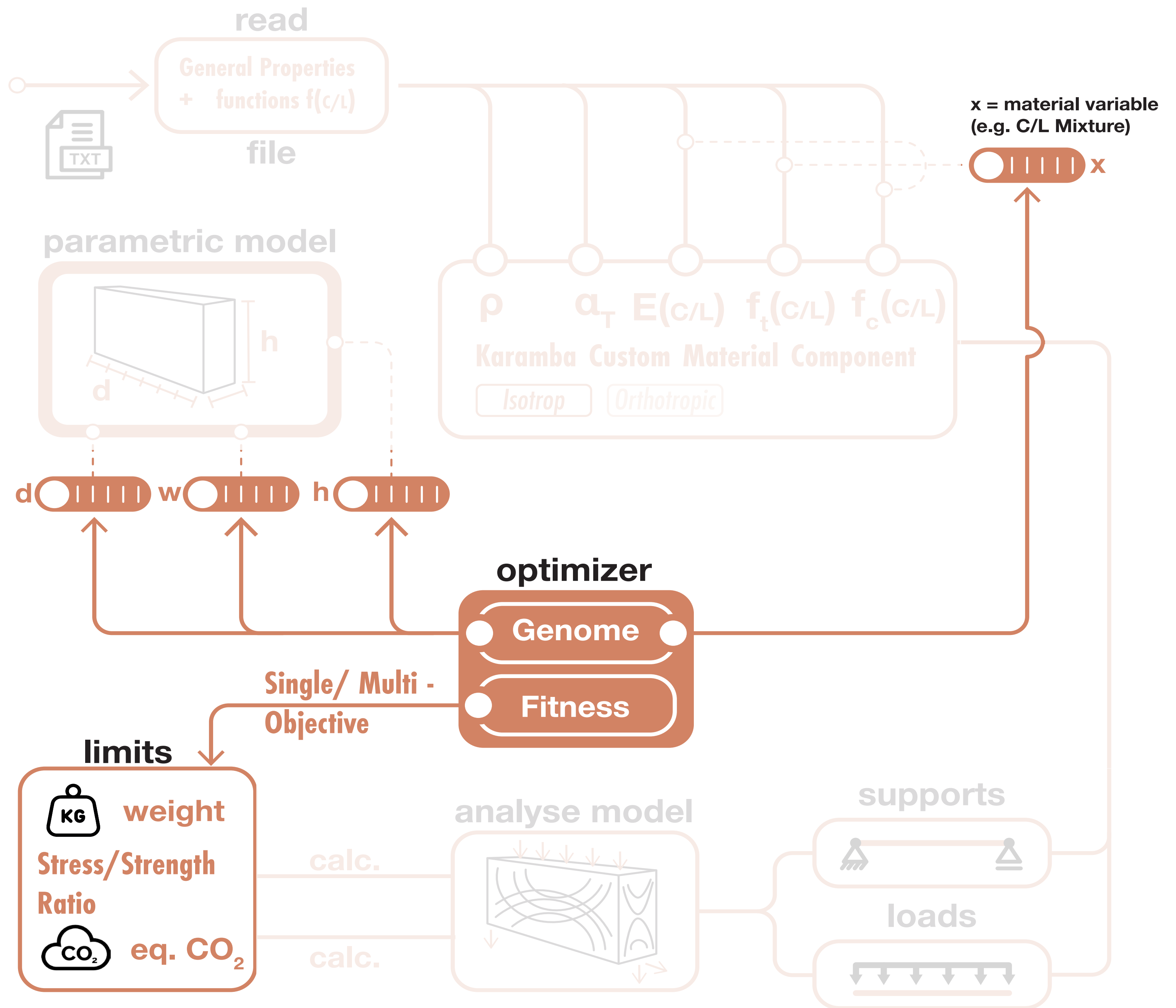
from: <https://www.vanhoorebeke.com/en/houtproducten/construction/lvl>

Optimisation outline

Walleci inputs

Fitness	Minimise equivalent CO2 emissions	Minimise weight	Minimise maximum compressive utilisation (red zone of stress/strength factor)	Minimise maximum tensile utilisation (blue zone of stress/strength factor)
				
Genomes	Web height (Finnjoist catalogue)	C/L ratio -> affecting f_t and f_c (0.66-4.00)		
				

Grashopper Workflow



Optimisation Results

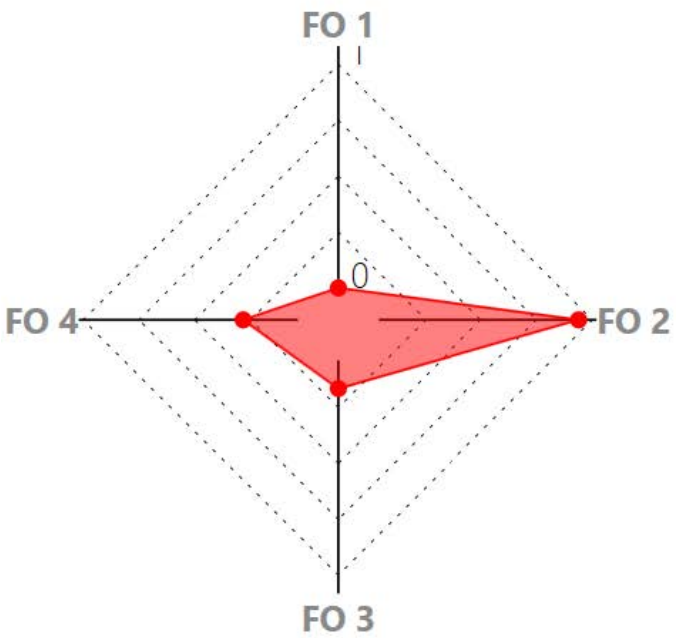
60 generations with 20 individuals

Three solution that show the top ranking results per Fitness Objective

Selected Solution Information

Solution: Gen. 20 | Ind. 2

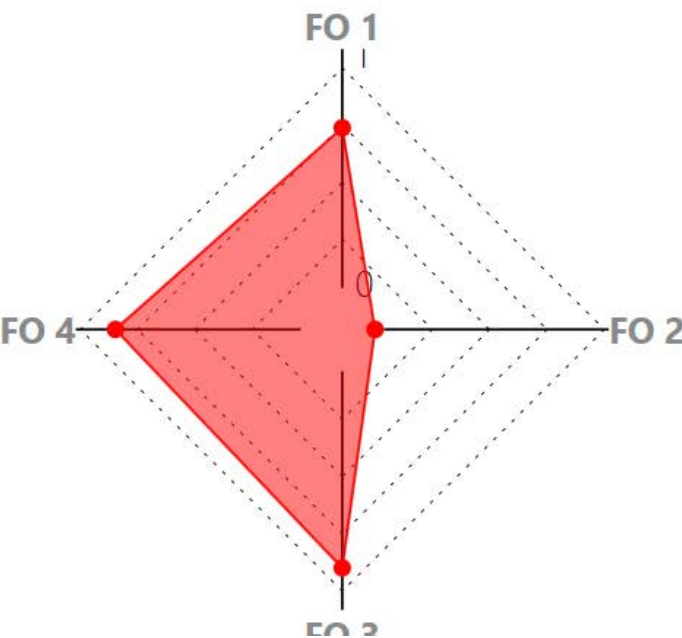
FO1: Minimise CO2	
Fitness Value:	-35.61973
Fitness Rank:	0 / 1199
FO2: Minimise weight	
Fitness Value:	37.964089
Fitness Rank:	1126 / 1199
FO3: Minimise tension zone	
Fitness Value:	23.8
Fitness Rank:	198 / 1199
FO4: Minimise compression zone	
Fitness Value:	41.4
Fitness Rank:	340 / 1199



Selected Solution Information

Solution: Gen. 2 | Ind. 4

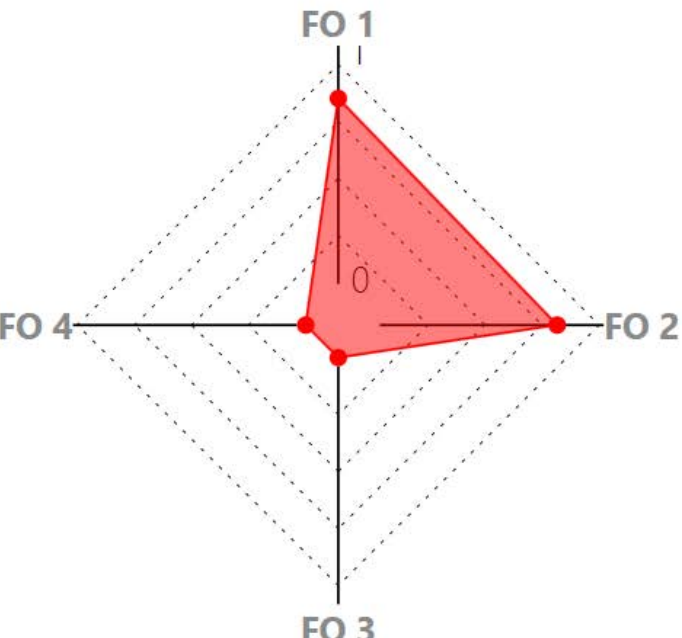
FO1: Minimise CO2	
Fitness Value:	-22.527949
Fitness Rank:	885 / 1199
FO2: Minimise weight	
Fitness Value:	22.421611
Fitness Rank:	0 / 1199
FO3: Minimise tension zone	
Fitness Value:	53
Fitness Rank:	1078 / 1199
FO4: Minimise compression zone	
Fitness Value:	80.5
Fitness Rank:	1015 / 1199



Selected Solution Information

Solution: Gen. 0 | Ind. 10

FO1: Minimise CO2	
Fitness Value:	-19.934033
Fitness Rank:	1021 / 1199
FO2: Minimise weight	
Fitness Value:	37.964088
Fitness Rank:	978 / 1199
FO3: Minimise tension zone	
Fitness Value:	20.8
Fitness Rank:	0 / 1199
FO4: Minimise compression zone	
Fitness Value:	27.8
Fitness Rank:	0 / 1199



Optimisation Results

60 generations with 20 individuals

Three solution that show the top ranking results per Fitness Objective

Selected Solution Information

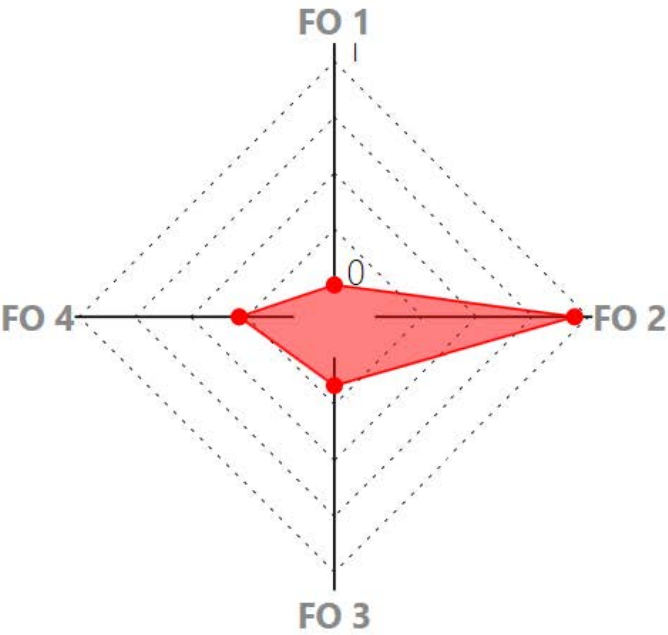
Solution: Gen. 20 | Ind. 2

FO1: Minimise CO2
Fitness Value: -35.61973
Fitness Rank: 0 / 1199

FO2: Minimise weight
Fitness Value: 37.964089
Fitness Rank: 1126 / 1199

FO3: Minimise tension zone
Fitness Value: 23.8
Fitness Rank: 198 / 1199

FO4: Minimise compression zone
Fitness Value: 41.4
Fitness Rank: 340 / 1199



Selected Solution Information

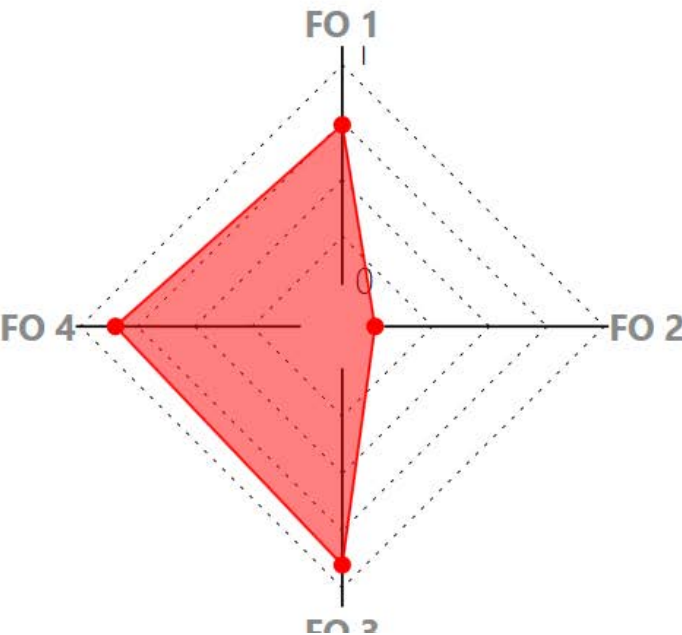
Solution: Gen. 2 | Ind. 4

FO1: Minimise CO2
Fitness Value: -22.527949
Fitness Rank: 885 / 1199

FO2: Minimise weight
Fitness Value: 22.421611
Fitness Rank: 0 / 1199

FO3: Minimise tension zone
Fitness Value: 53
Fitness Rank: 1078 / 1199

FO4: Minimise compression zone
Fitness Value: 80.5
Fitness Rank: 1015 / 1199



Selected Solution Information

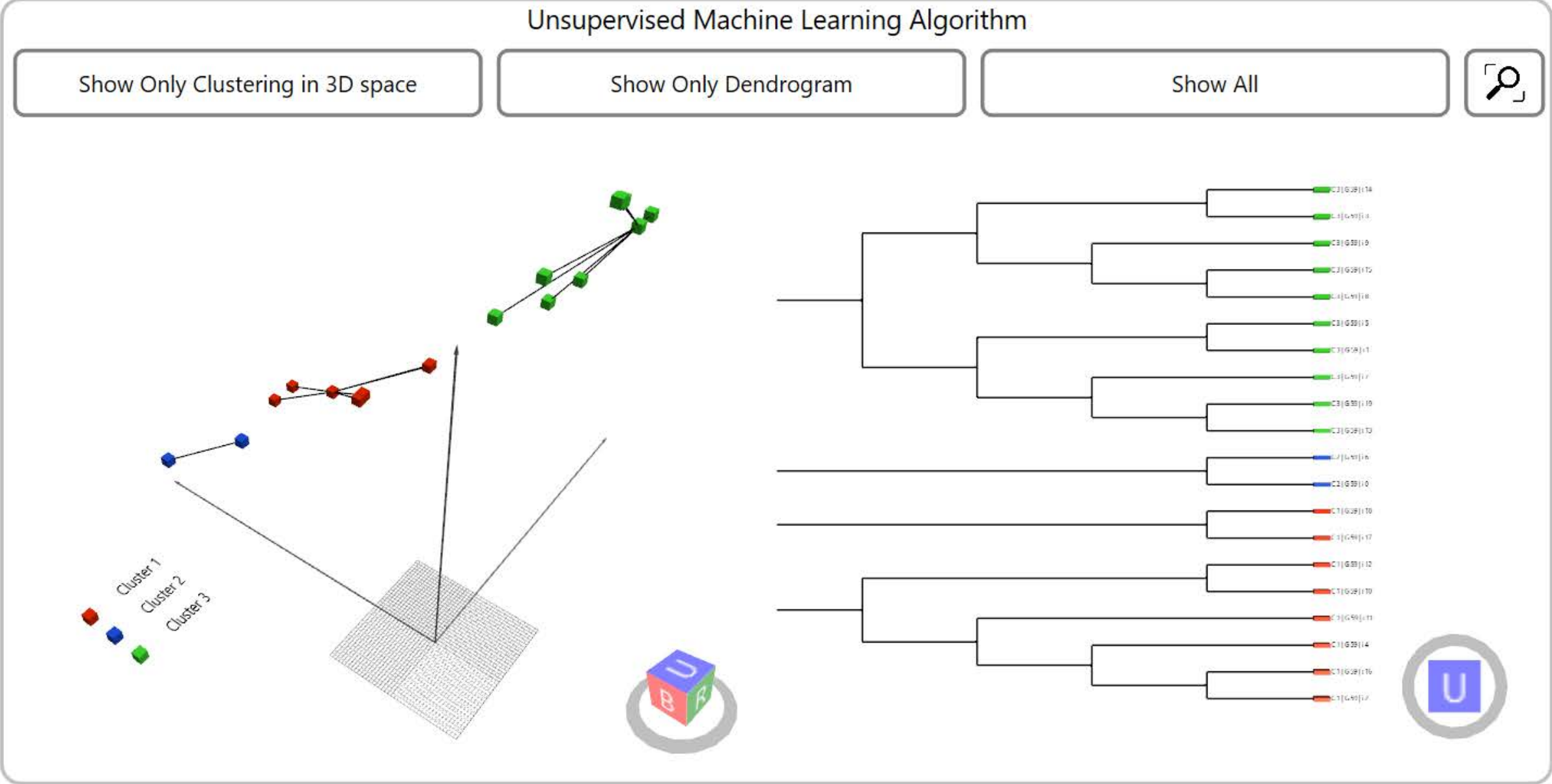
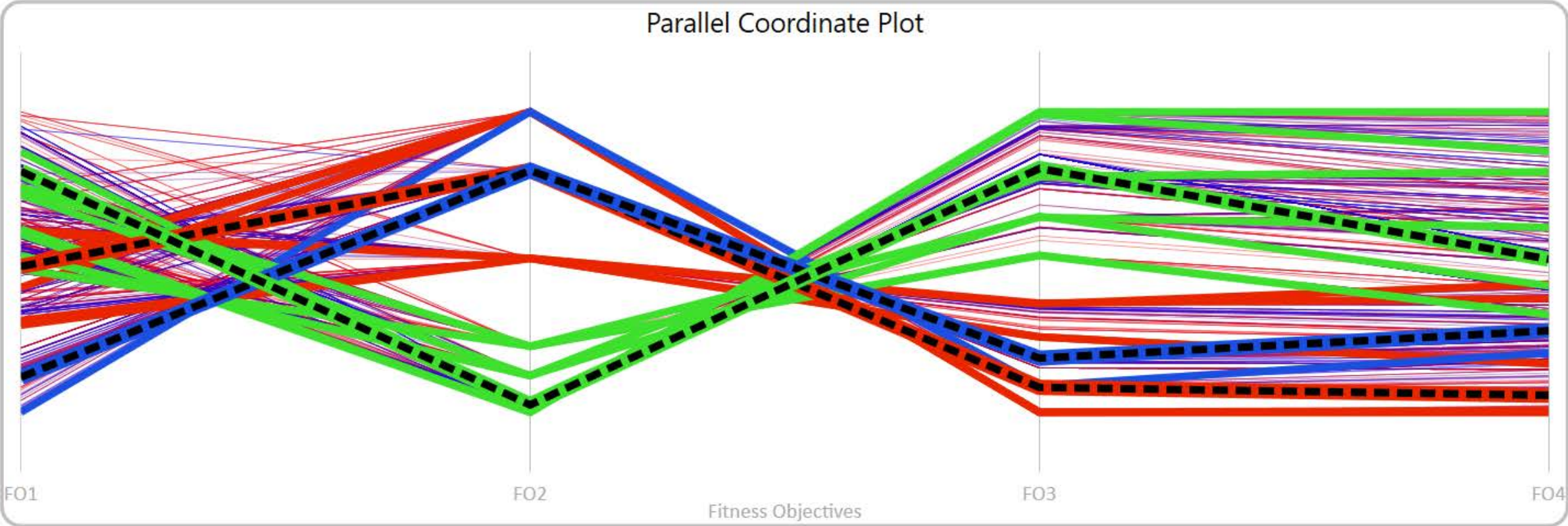
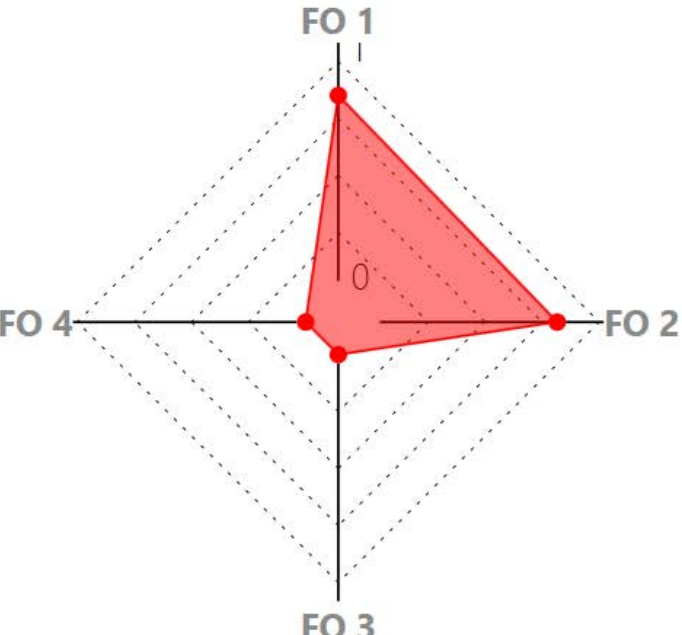
Solution: Gen. 0 | Ind. 10

FO1: Minimise CO2
Fitness Value: -19.934033
Fitness Rank: 1021 / 1199

FO2: Minimise weight
Fitness Value: 37.964088
Fitness Rank: 978 / 1199

FO3: Minimise tension zone
Fitness Value: 20.8
Fitness Rank: 0 / 1199

FO4: Minimise compression zone
Fitness Value: 27.8
Fitness Rank: 0 / 1199





Gen: 59 | Ind: 11

FV. 1 : -25.547889

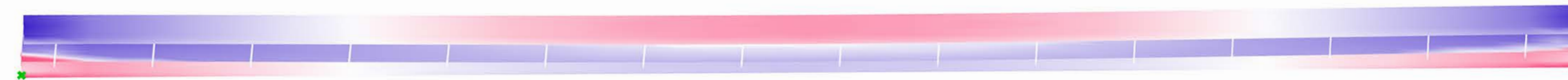
FV. 2 : 34.93141

FV. 3 : 23.6

FV. 4 : 31.7

Data input 1 : -25.547889

Data input 2 : 34.93141



Gen: 59 | Ind: 14

FV. 1 : -18.982479

FV. 2 : 22.800697

FV. 3 : 48.3

FV. 4 : 62.9

Data input 1 : -18.982479

Data input 2 : 22.800697



Gen: 59 | Ind: 6

FV. 1 : -33.200437

FV. 2 : 34.931411

FV. 3 : 26.9

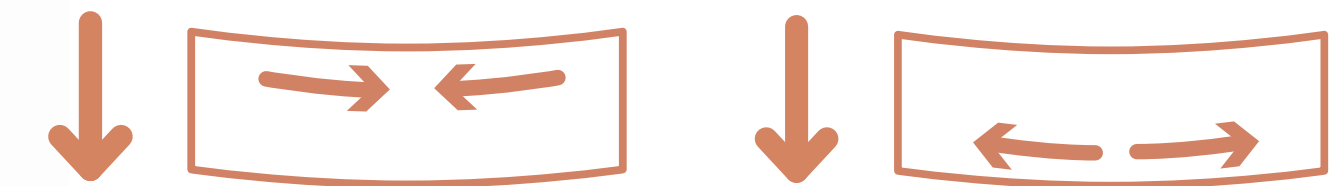
FV. 4 : 46.5

Data input 1 : -33.200437

Data input 2 : 34.931411

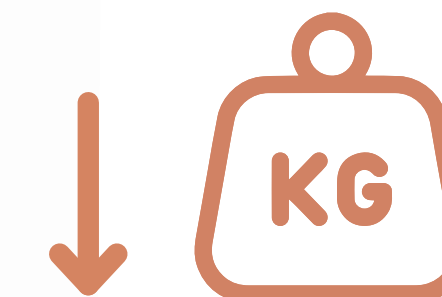
Genome:

Height: 380mm - C/L ratio: 1.71



Genome:

Height: 200mm - C/L ratio: 1.49

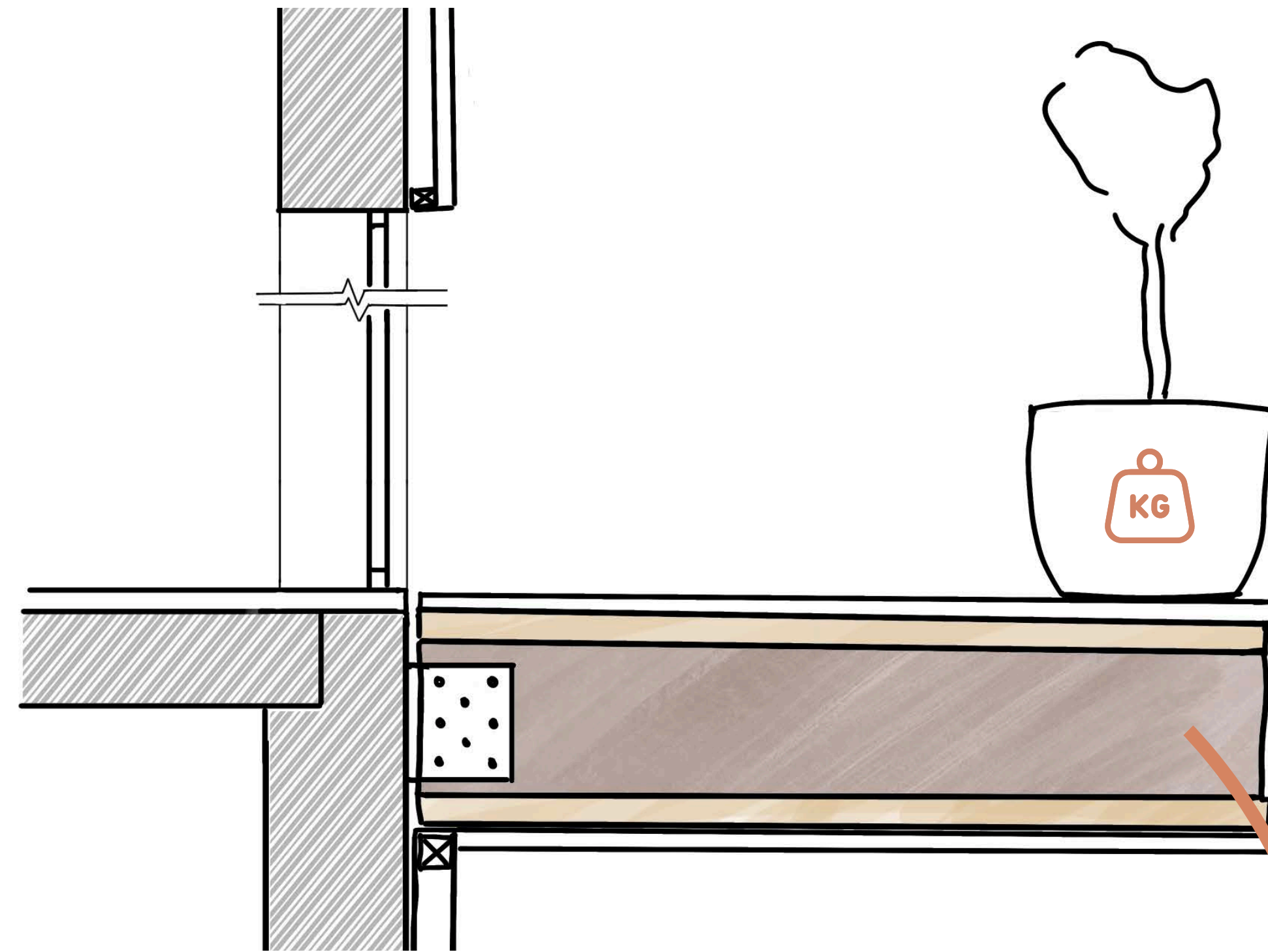


Genome:

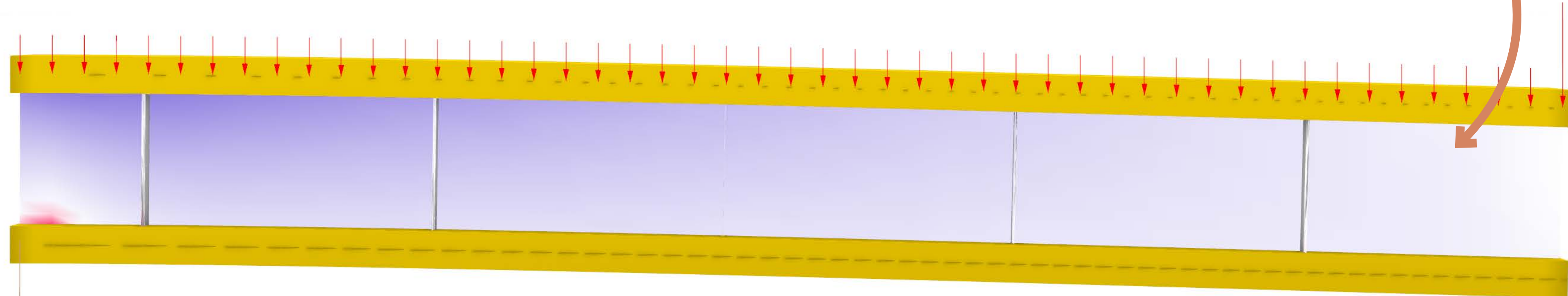
Height: 360mm - C/L ratio: 3.98



Component customisation

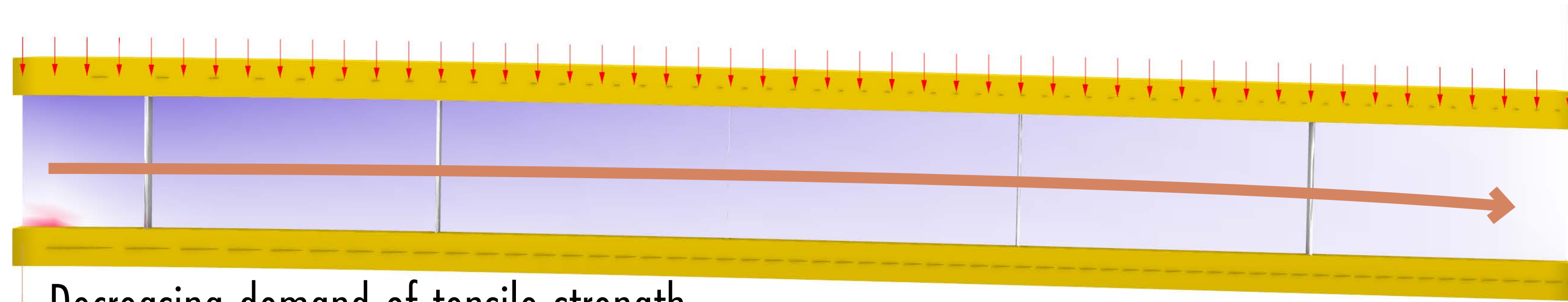


Non-uniform load distribution



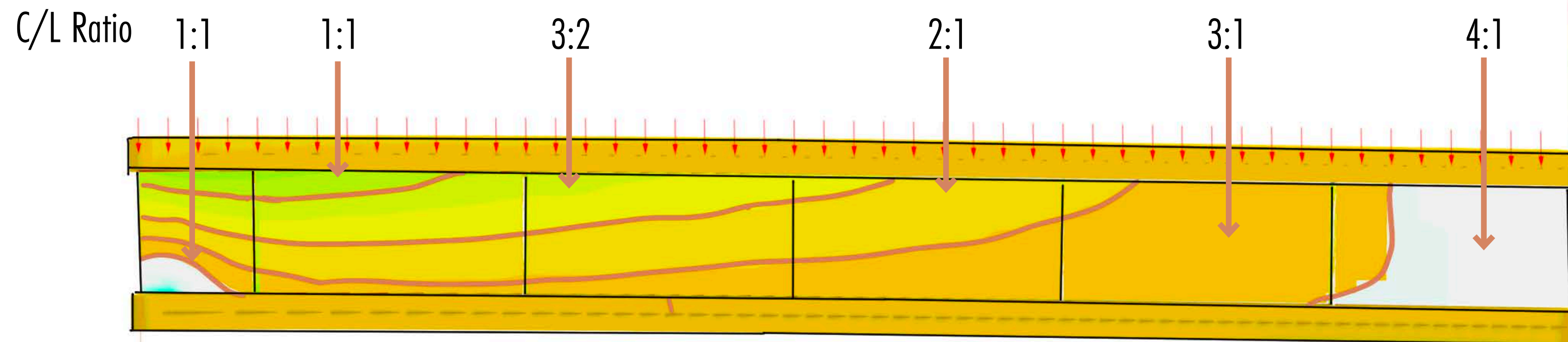
Principal stress 1 is tensile, optimise for tensile performance

Component customisation



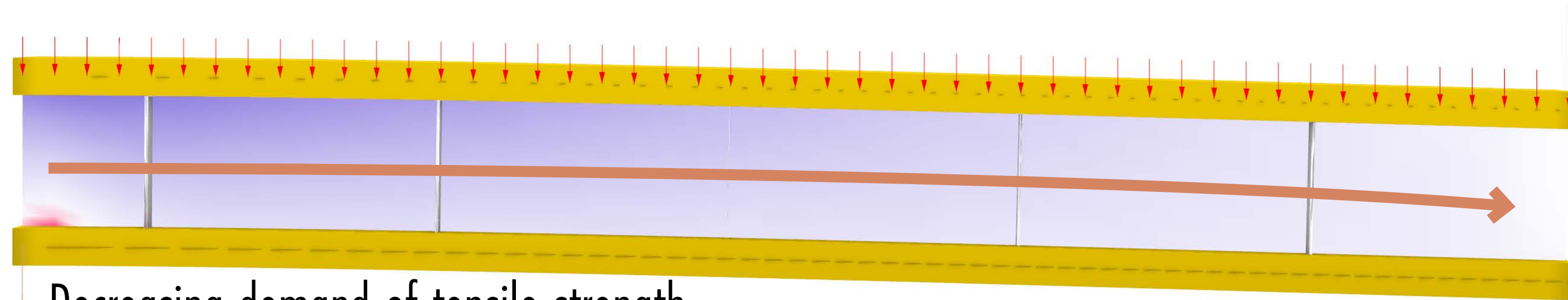
Decreasing demand of tensile strength

Subdivision of component into different mixture zone

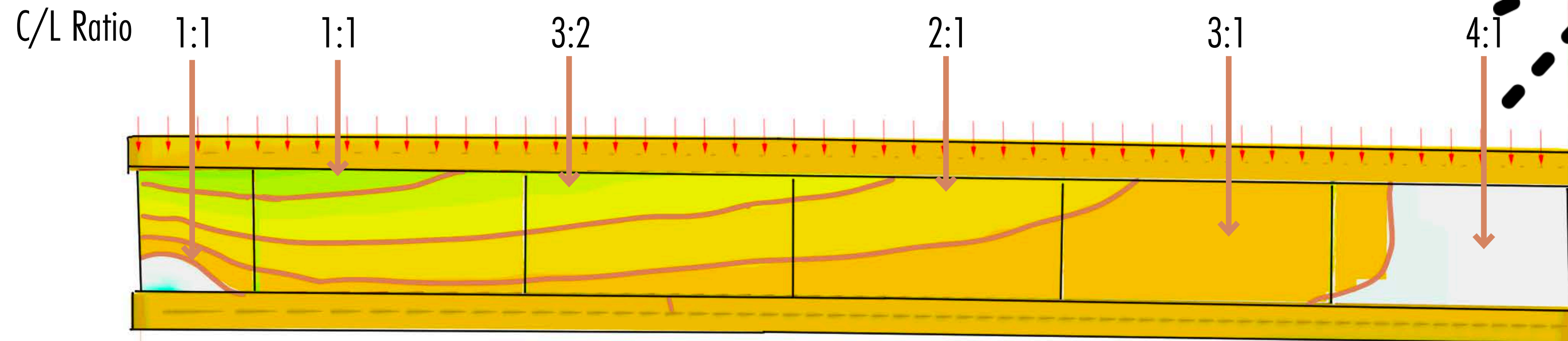


Decreasing lignin content with less demand

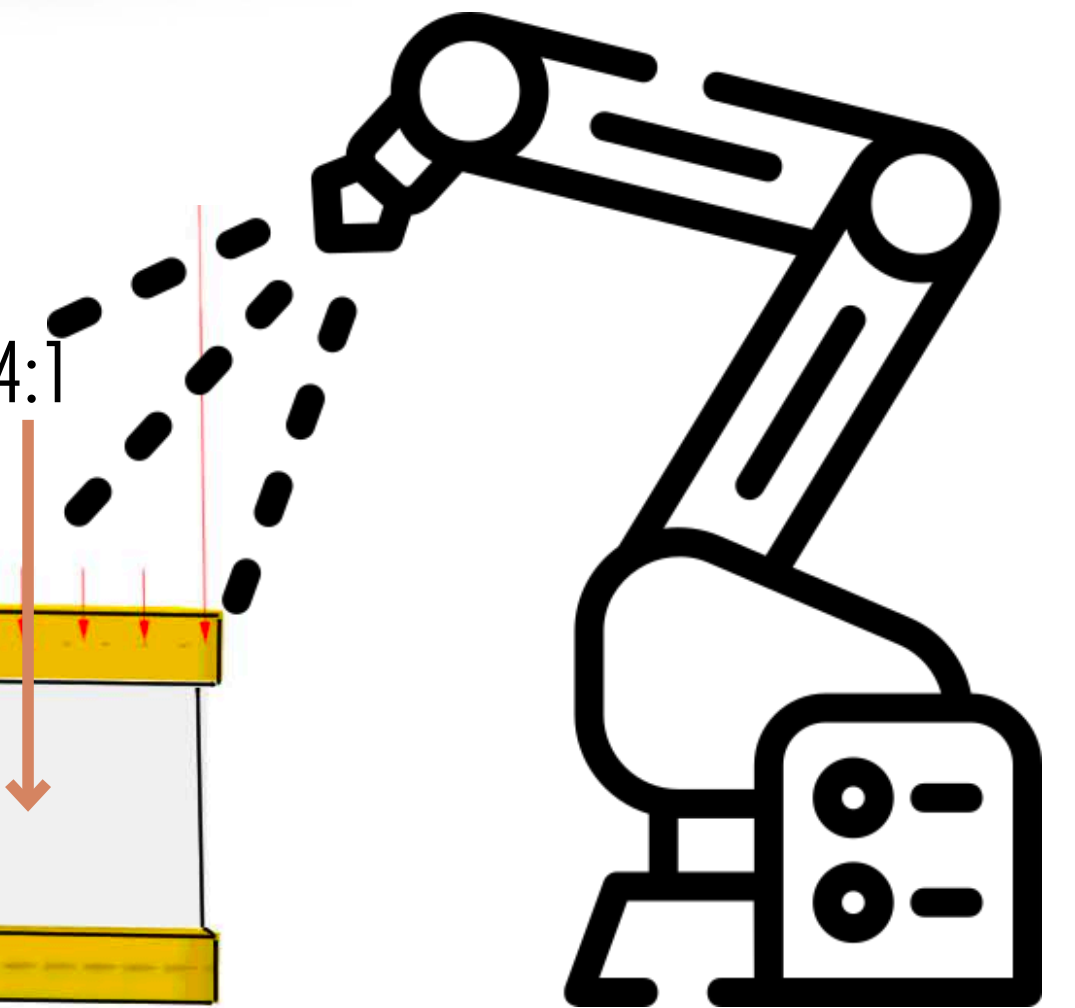
Component customisation



Subdivision of component into different mixture zone



Decreasing lignin content with less demand

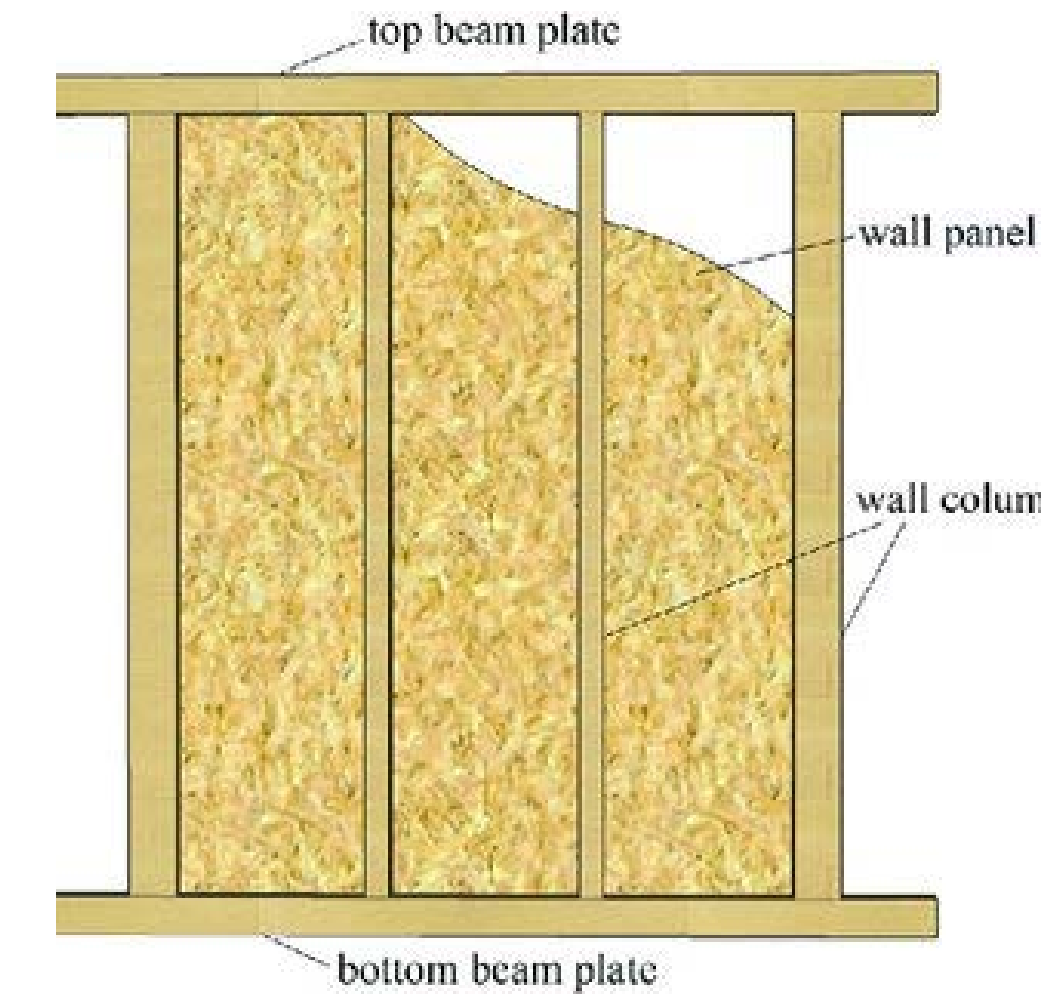


Future Application

Simple Plated Production

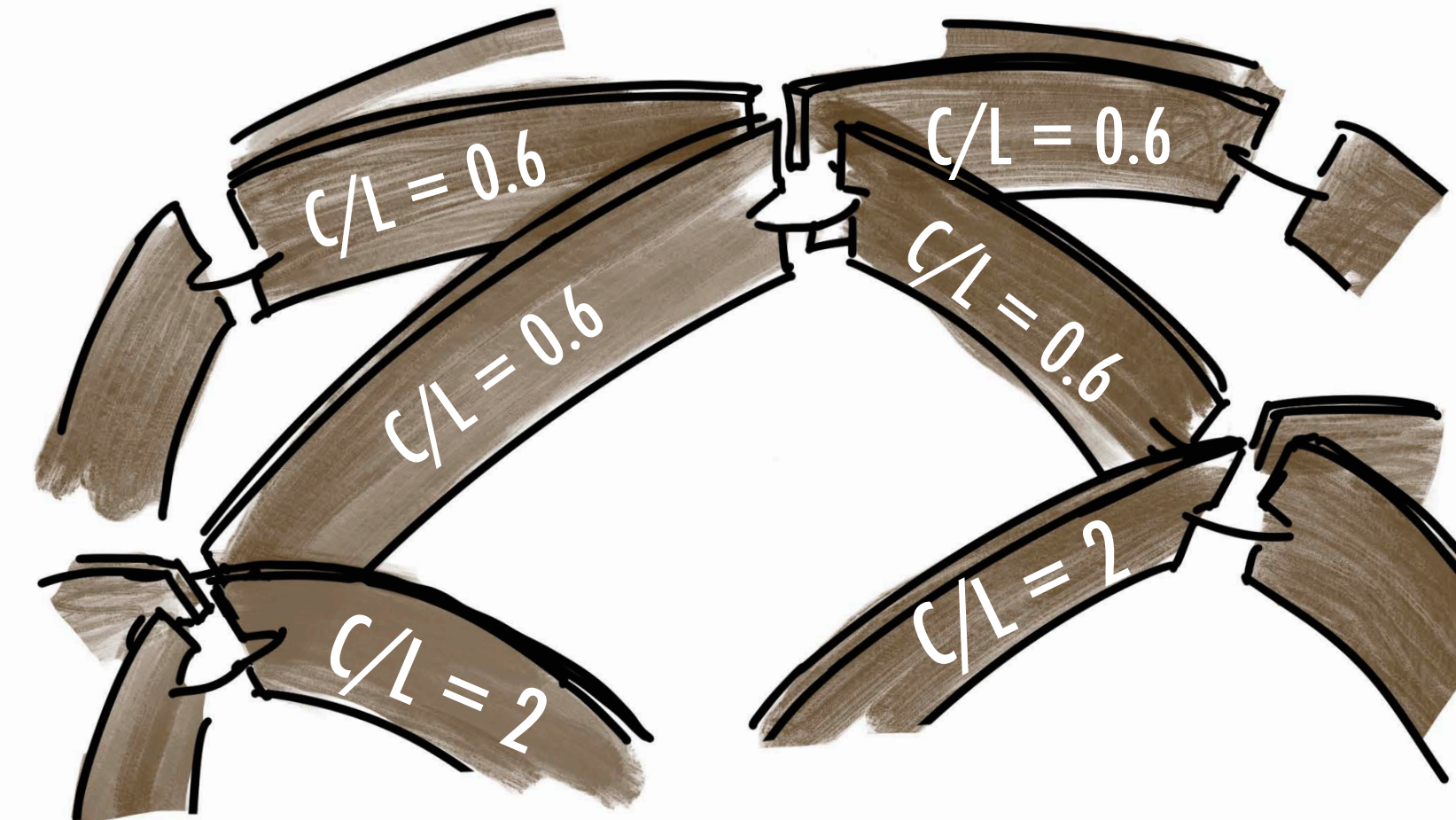
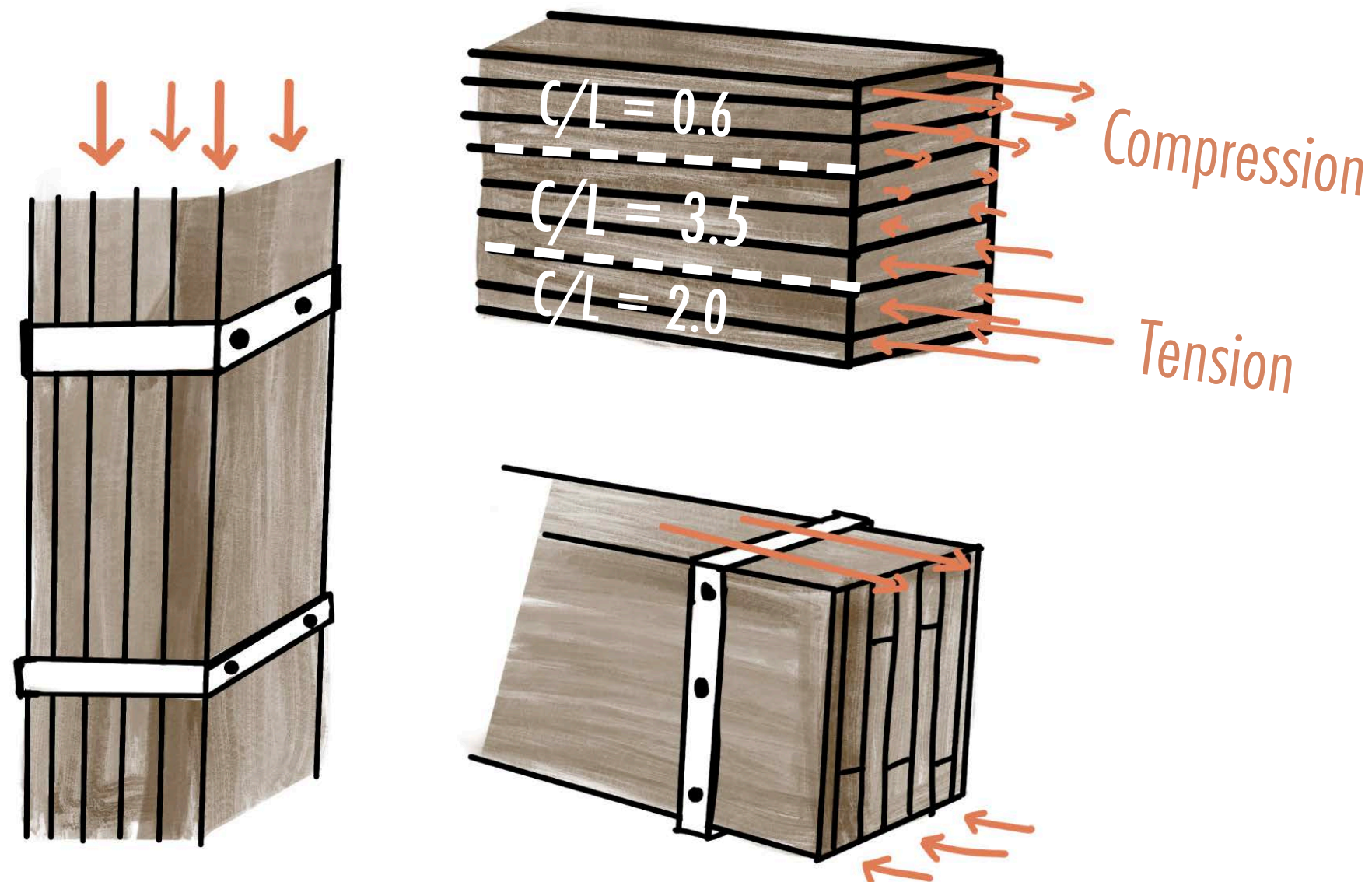
Customised Mould

Shear Wall Framing



Additive Layering

Mixture adjustment based on load

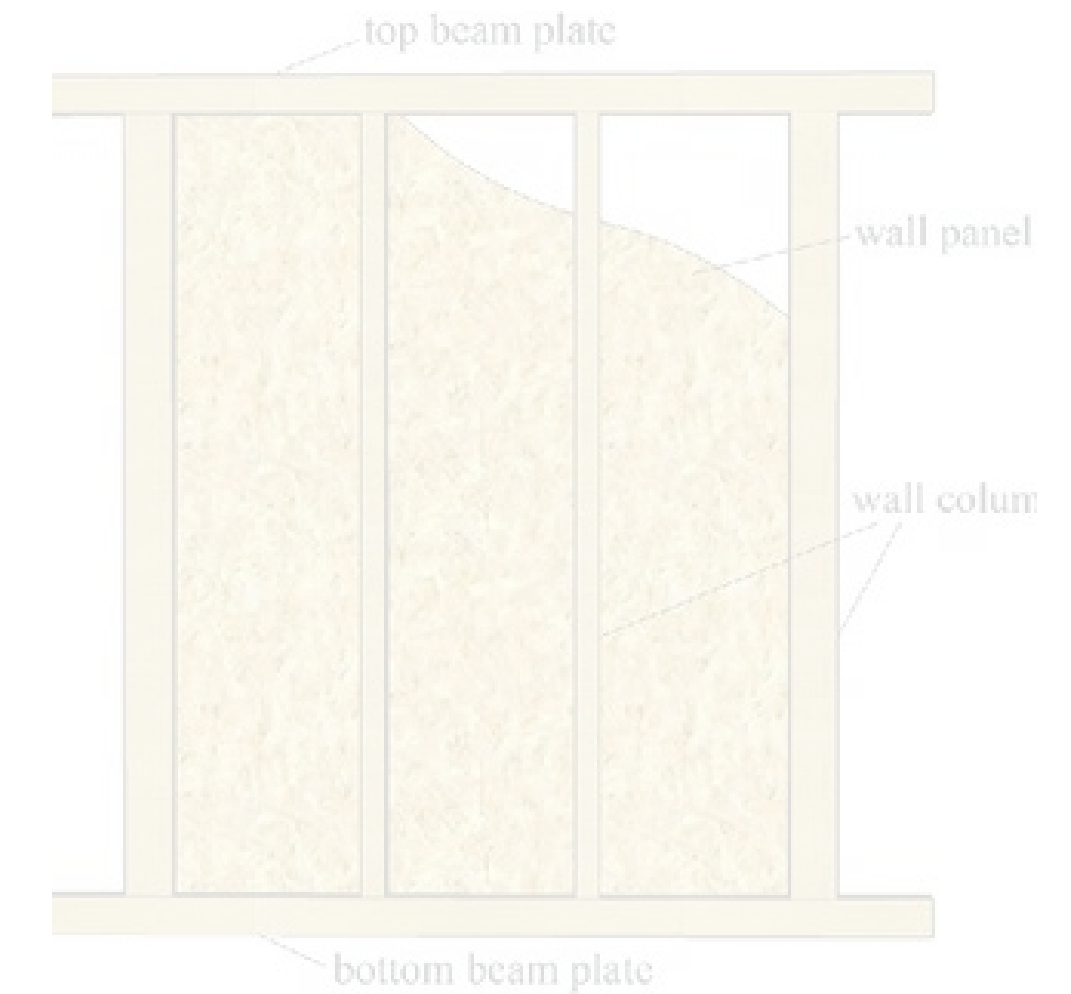


Discrete Elements with customised mixtures

Future Application

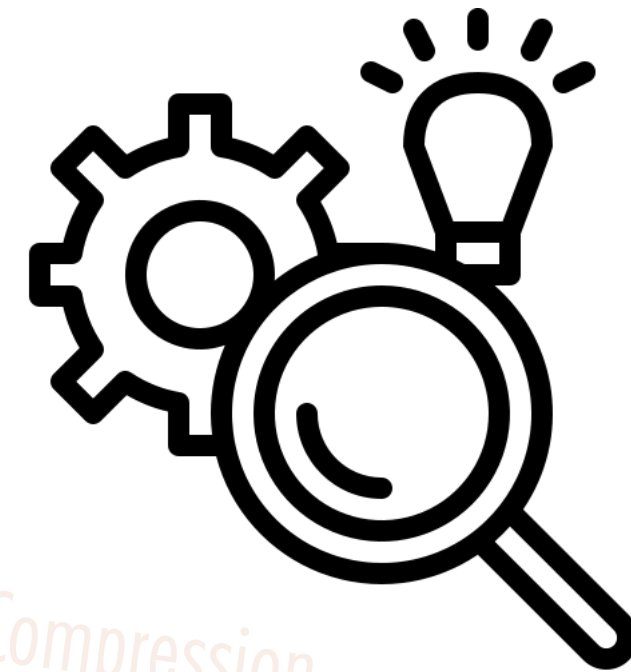
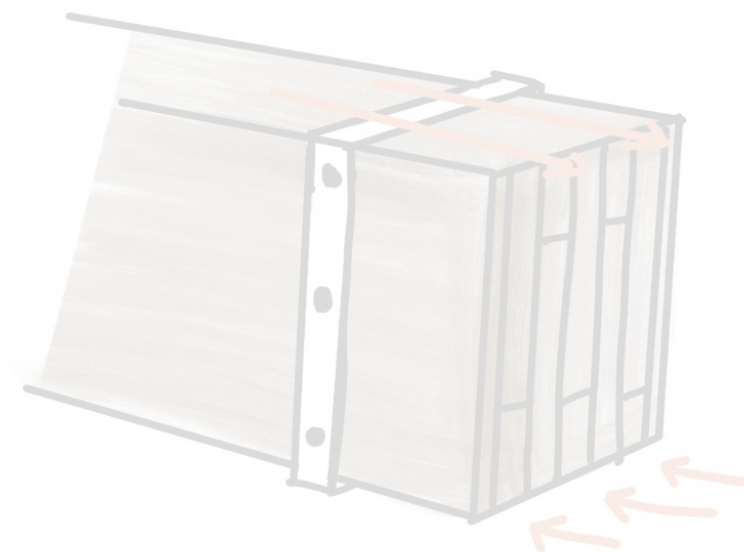
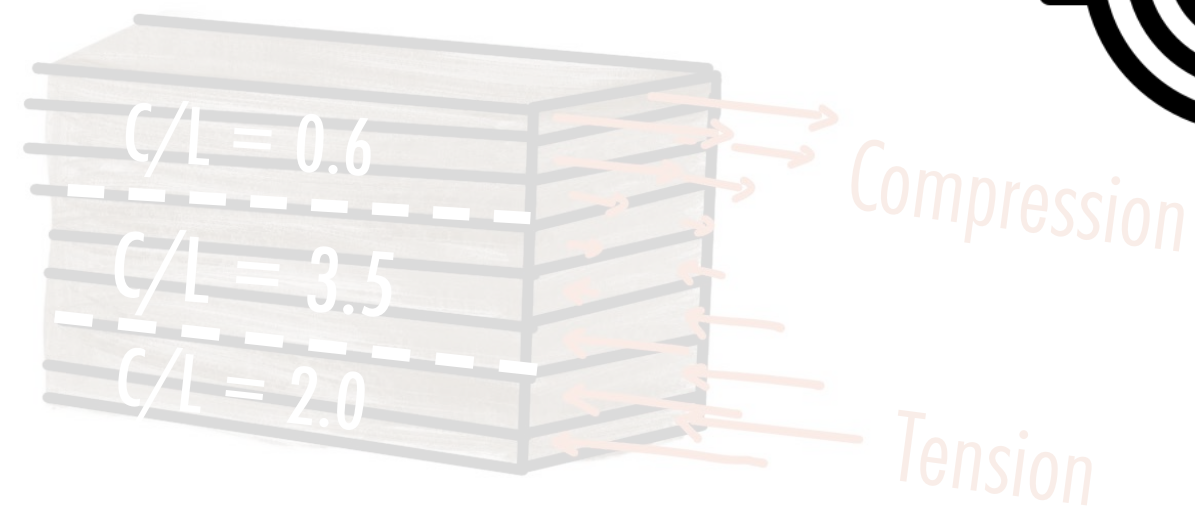
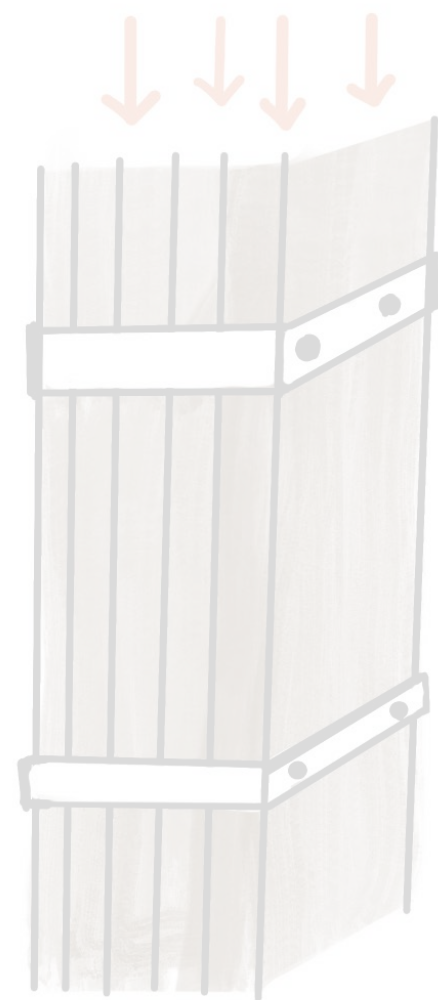
Simple Plated Production

Shear Wall Framing



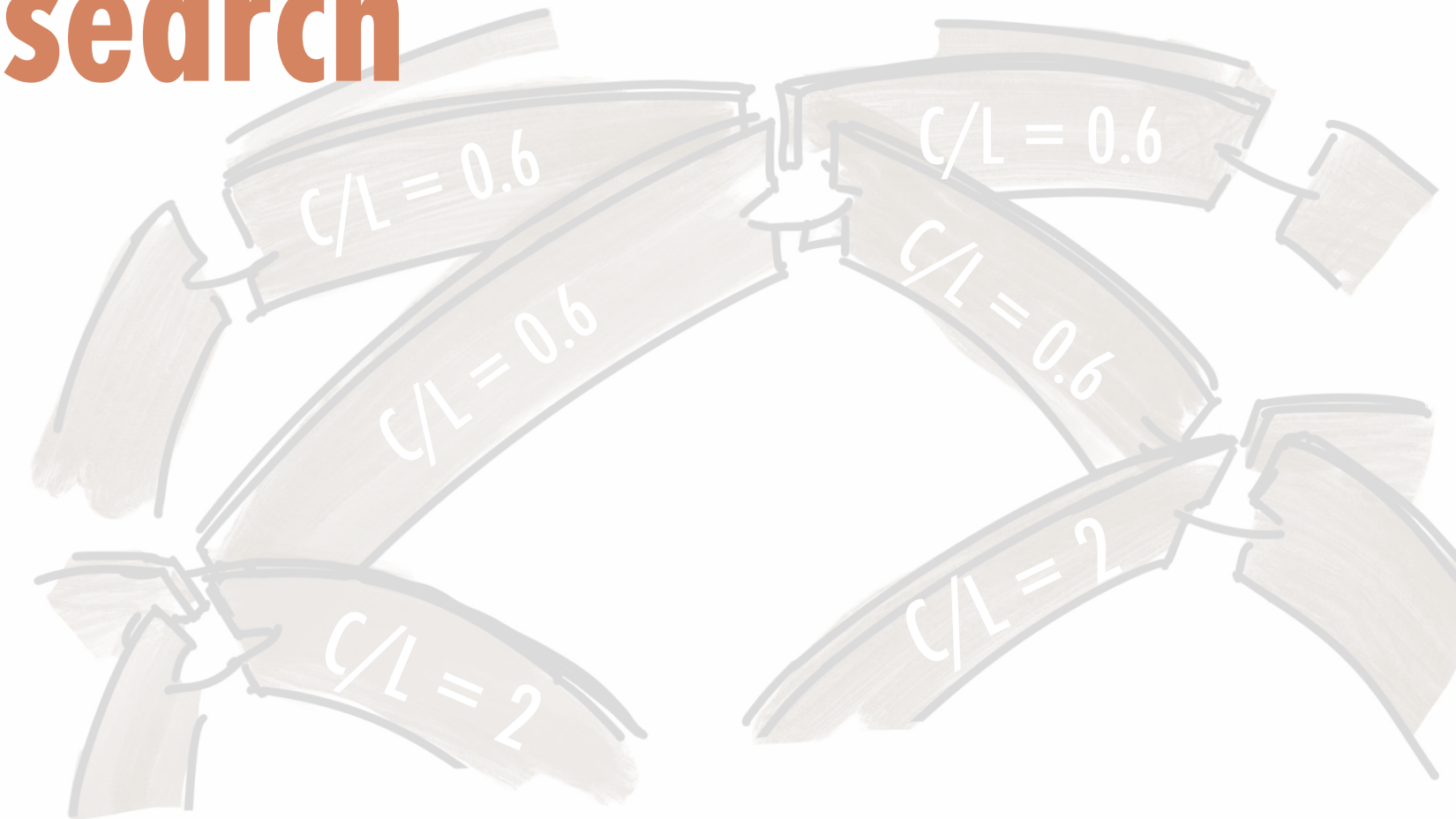
Additive Layering

Mixture adjustment based on load



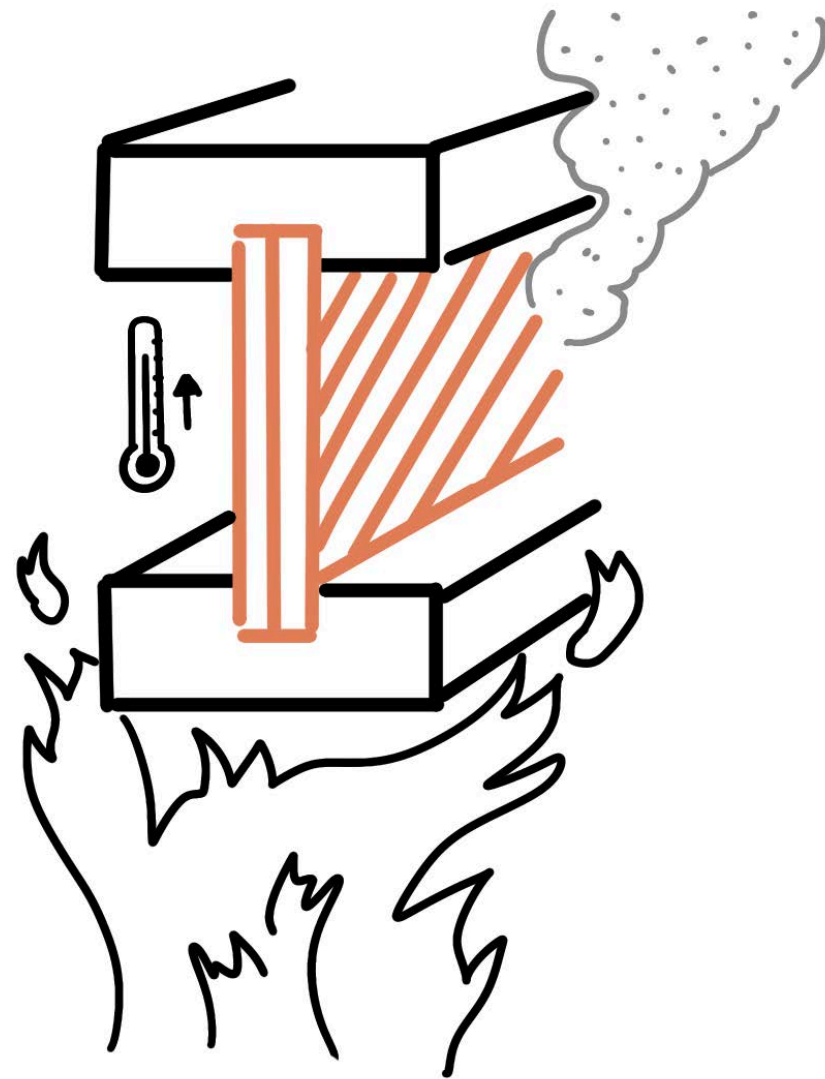
Customised Mould

Future Design Research

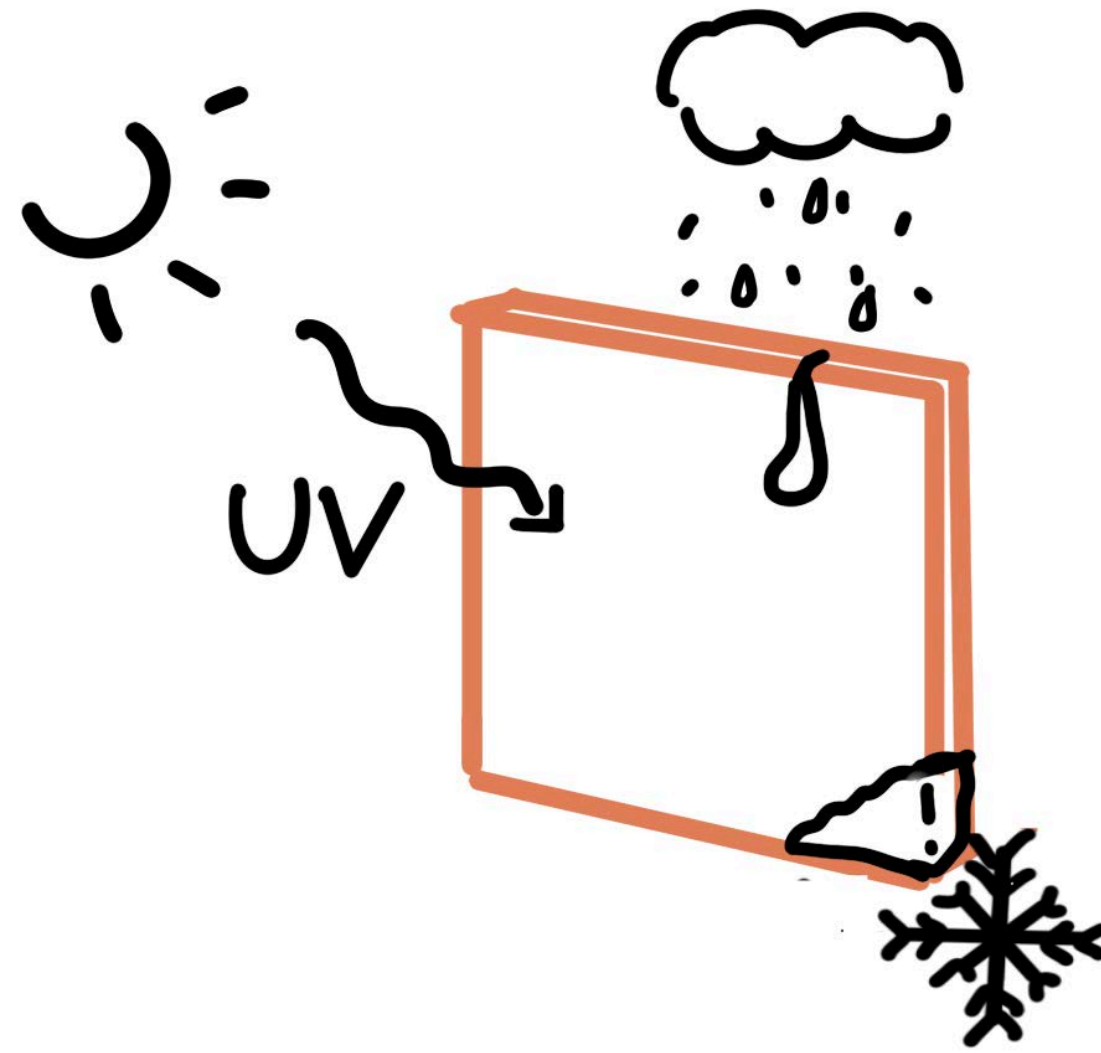


Discrete Elements with customised mixtures

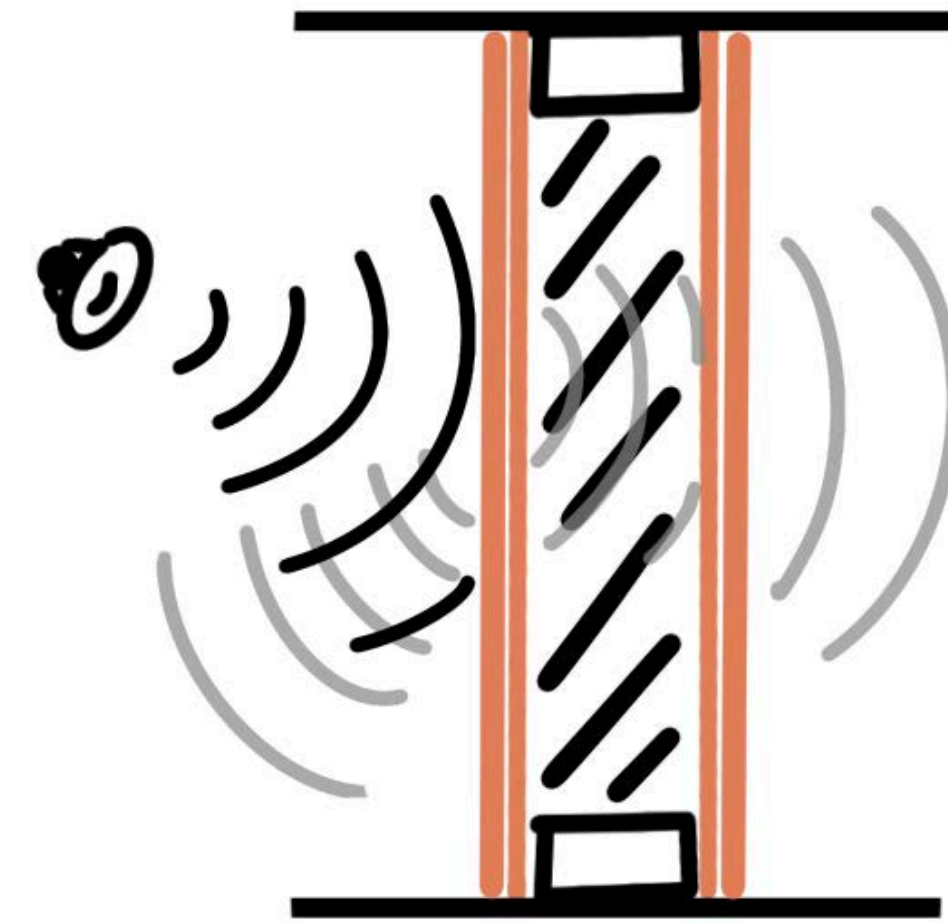
Further Investigation and Improvements



Thermal and Fire Behaviour



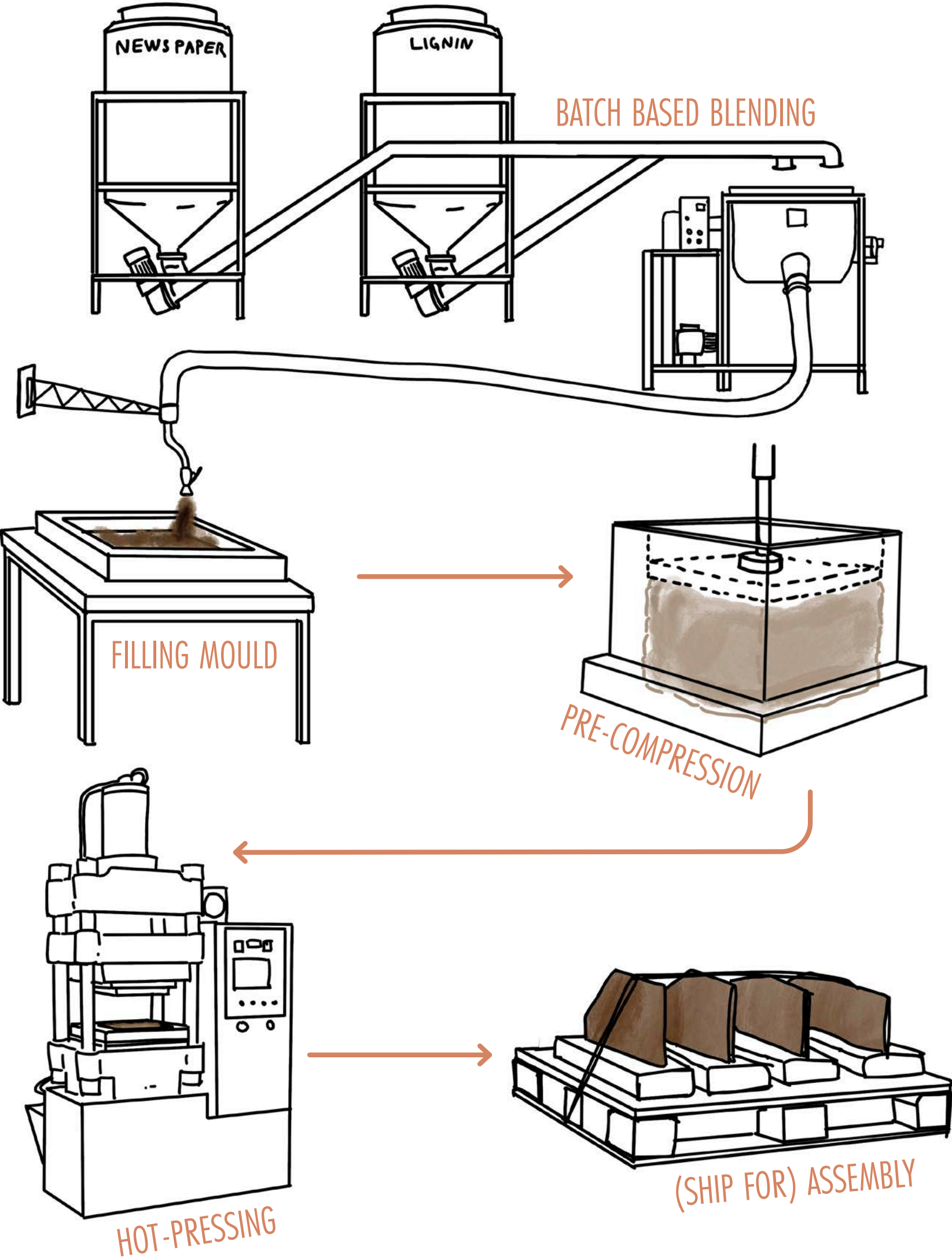
Environmental Response



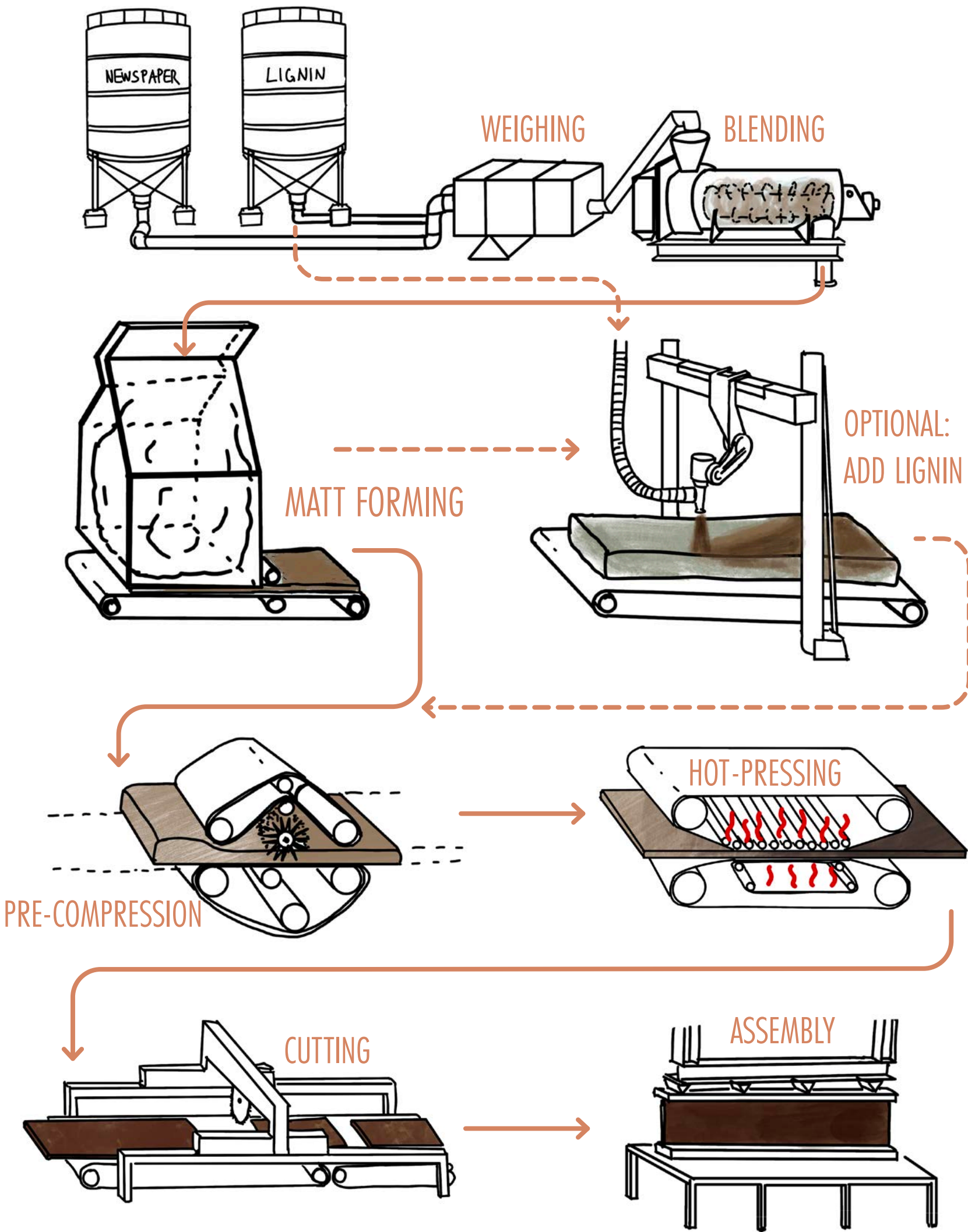
Indoor Performance

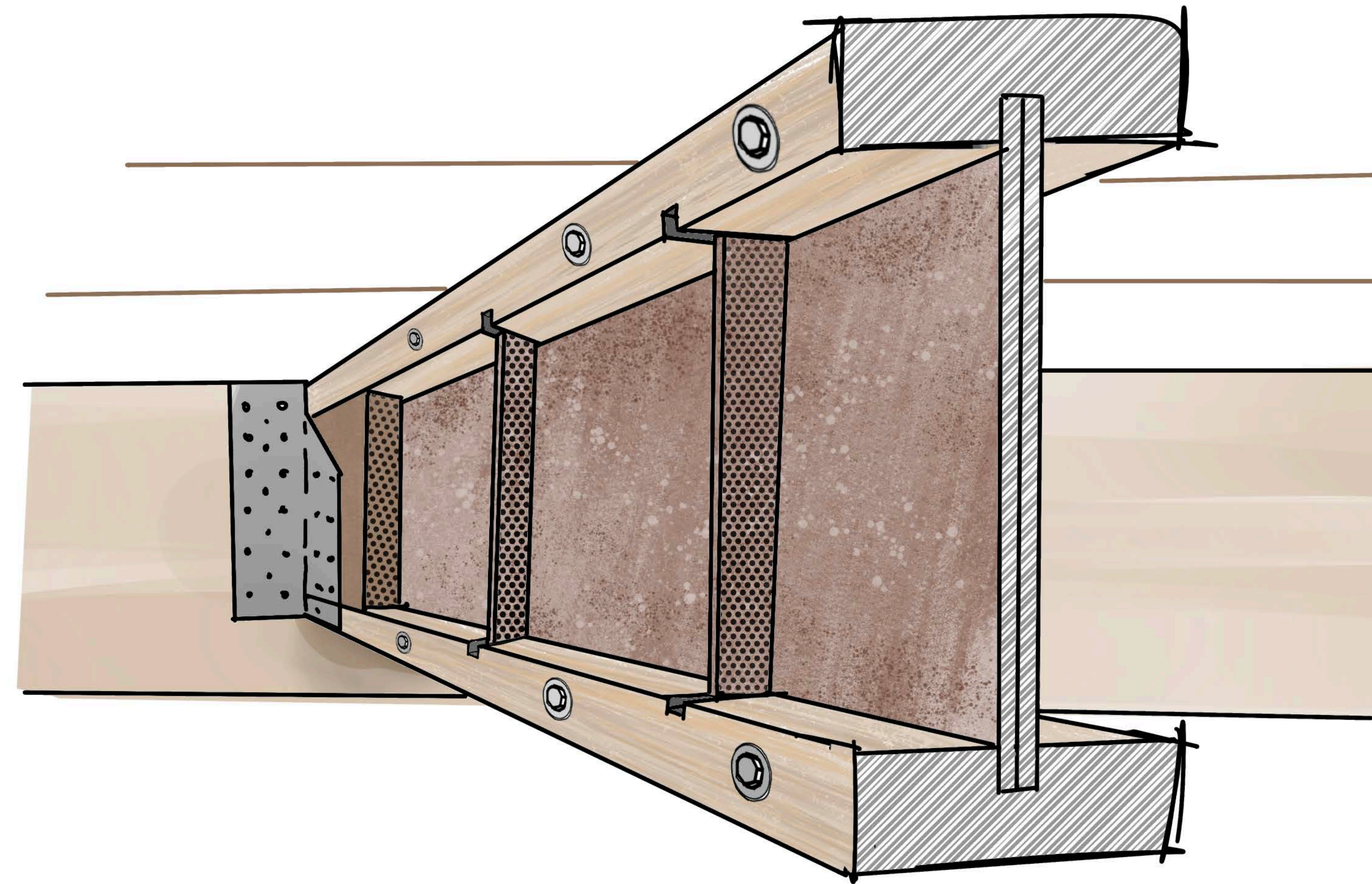
Large Scale Production Process

Individual Hot-pressing



Continuous Plate Production





Conclusion

Research Question:

How can an optimised mixture and a suitable hot-press production method be developed that uses by-product-lignin and -cellulose, to utilize lignin's natural binding properties through controlled polymerization?

➡ **how to turn lignin into an adhesive?**

Research Question:

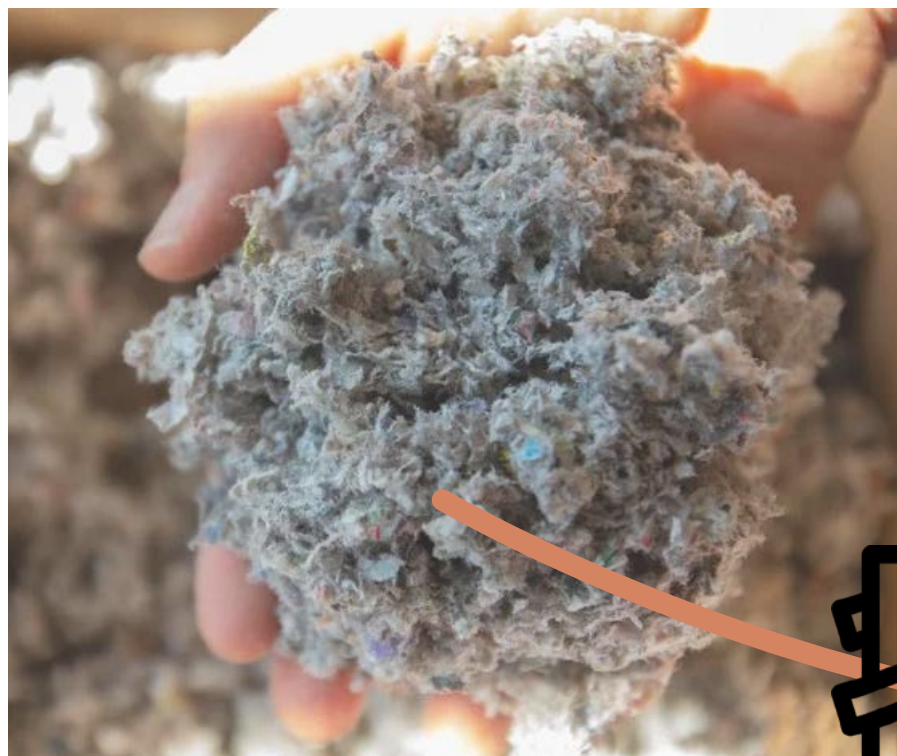
How can an optimised mixture and a suitable hot-press production method be developed that uses by-product lignin and cellulose, to utilize lignin's natural binding properties through controlled polymerization?

→ how to turn lignin into an adhesive?



Mixture Design Production Method

Material Development



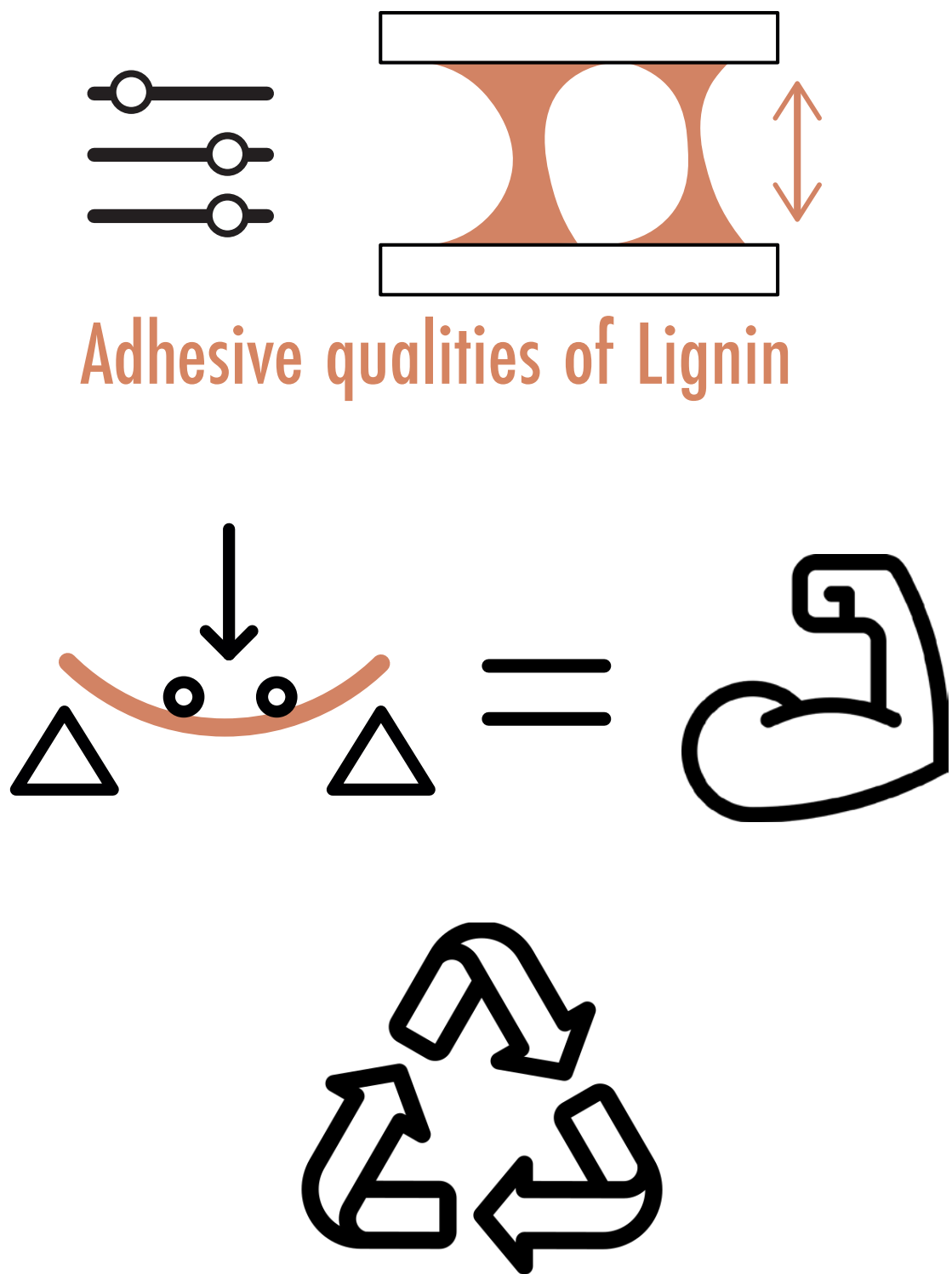
Cellulose and Lignin Image see reference on page 11

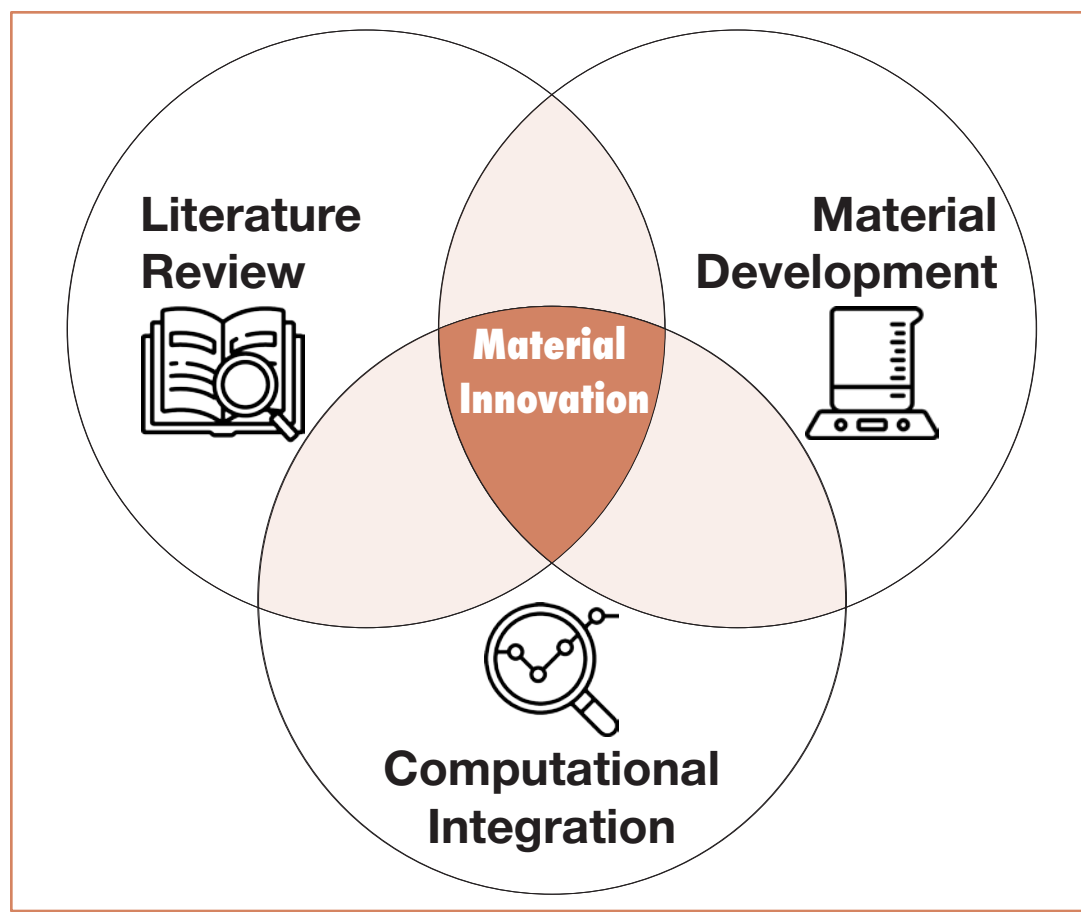


Control mechanisms

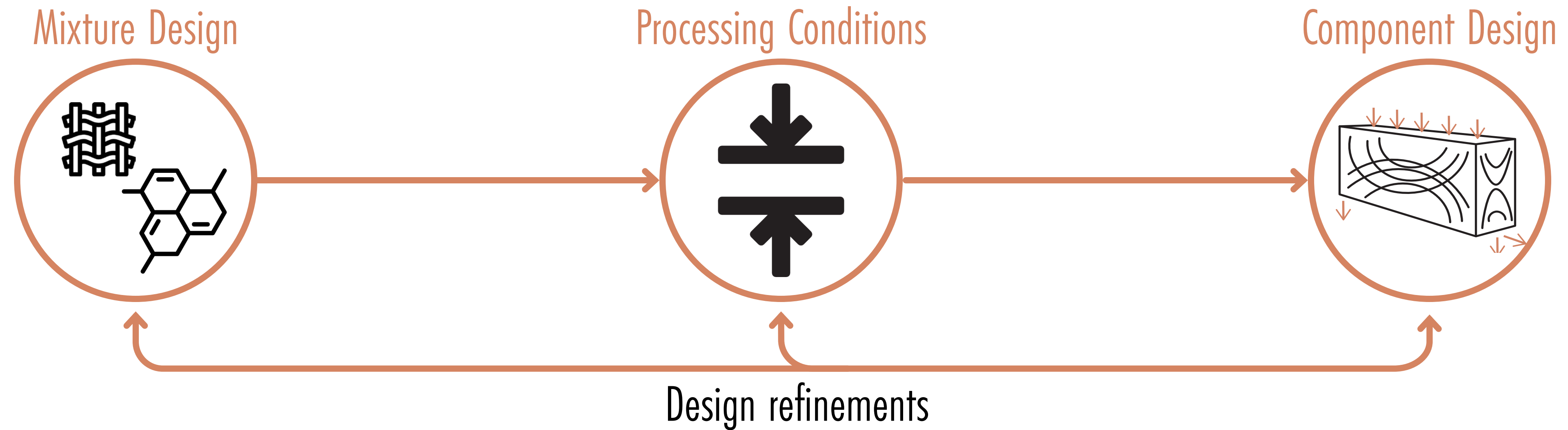


Performance





Level of Control



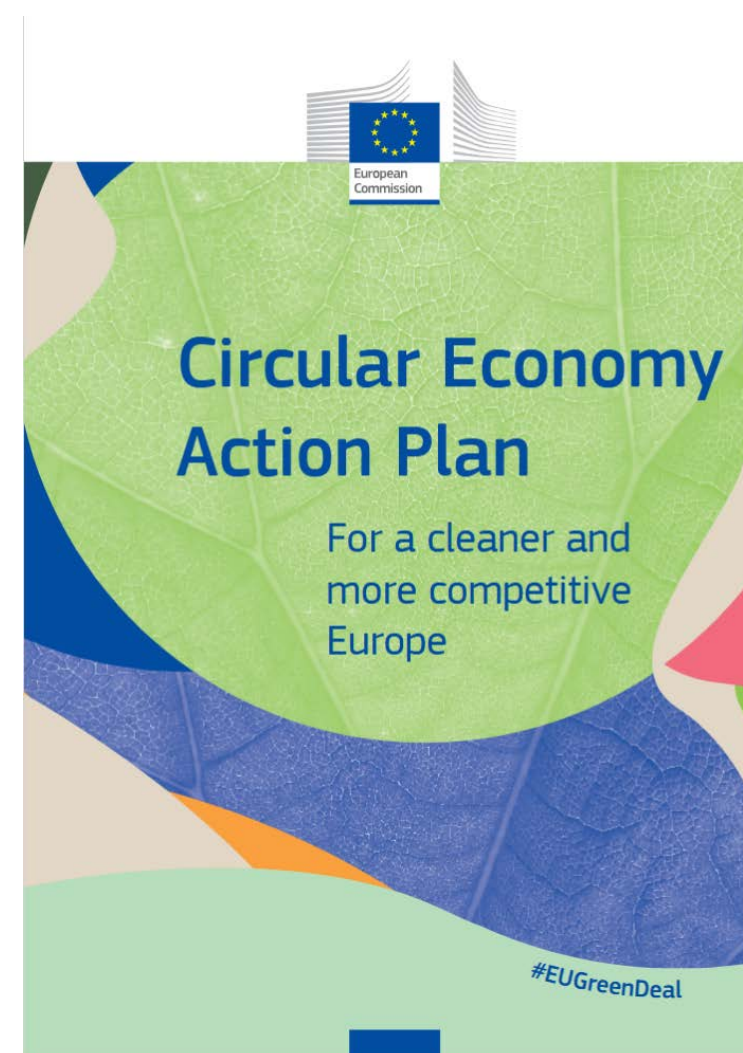
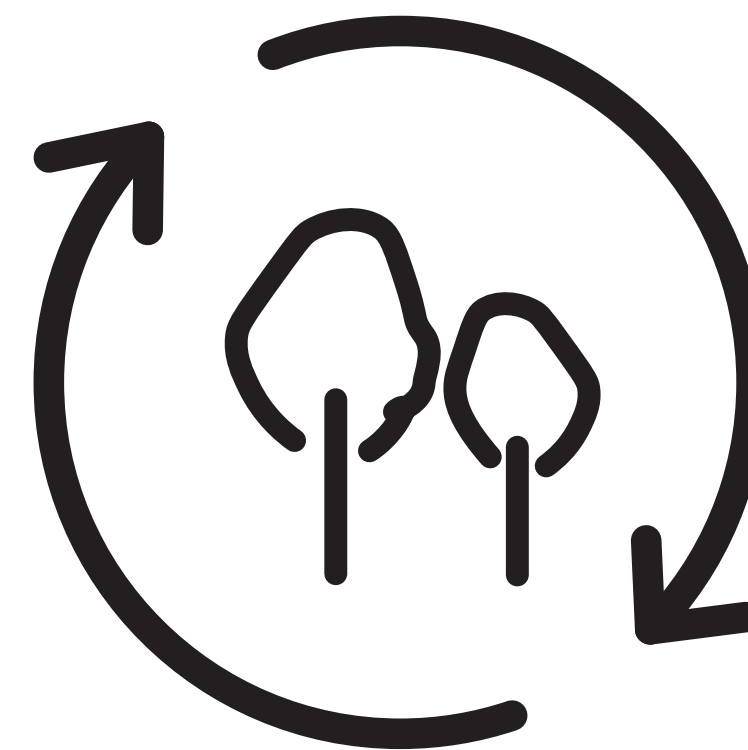


Image from: <https://www.google.com/url?sa=i&url=https%3A%2F%2Fop.europa.eu%2Fde%2Fpublication-detail%2F-%2Fpublication%2F45cc30f6-cd57-11ea-adf7-01aa75ed71a1%2Flanguage-en&psig=AOvVaw3waOfdB8oGE2tJ-JwcXkwA&ust=1750327437215000&source=images&opi=89978449>



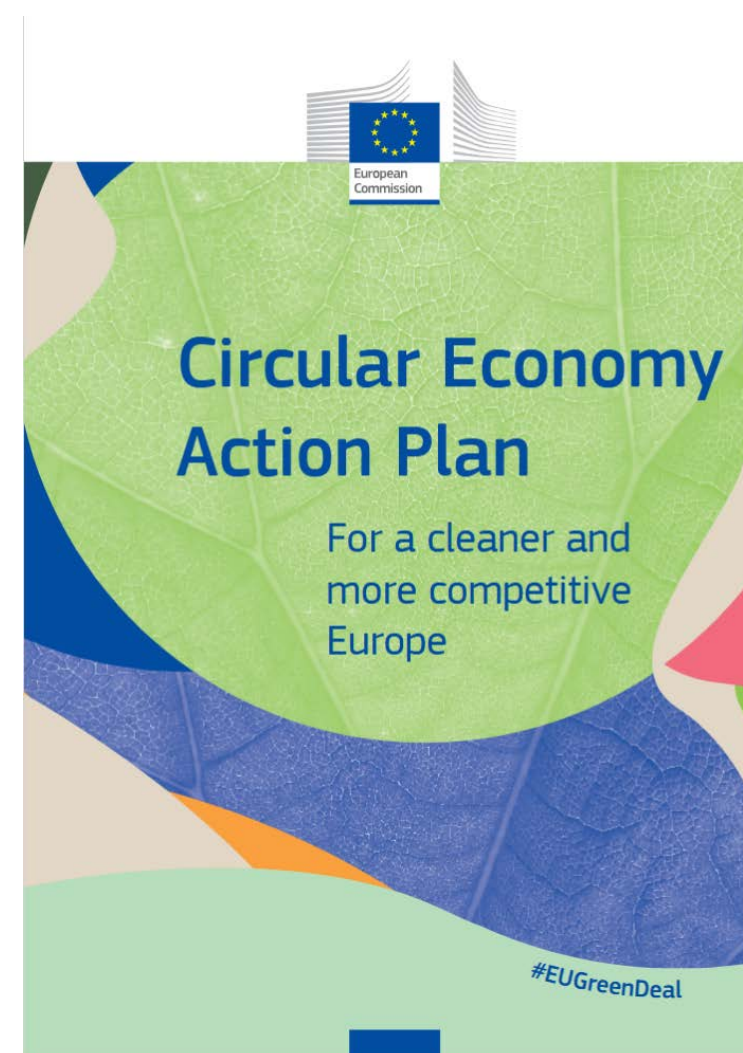
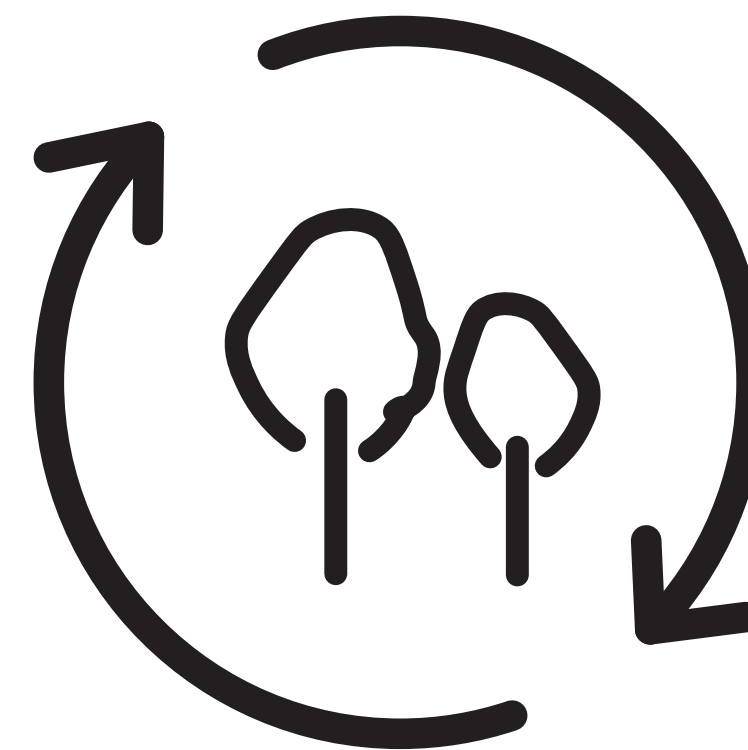
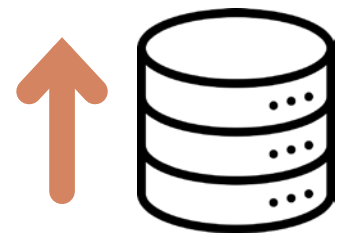


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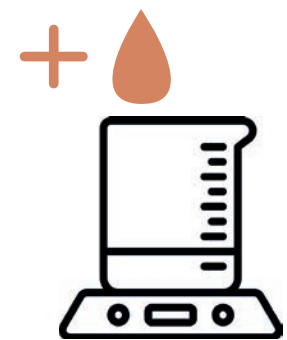


Material Scarcity & Climate Impact

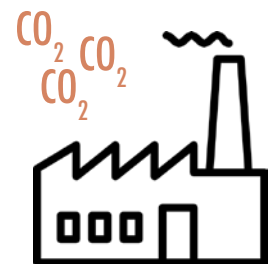
Project Suggestions



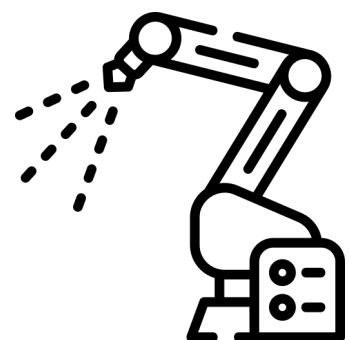
- Perform more material variations and expand the dataset for more accurate models



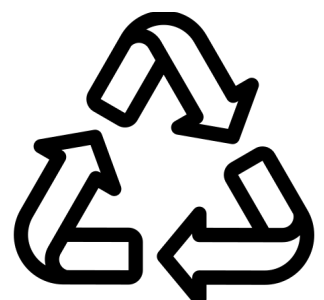
- Exploration of additives for improved performance and processing



- Involvement of industry partners to detail the resource chains and environmental implications

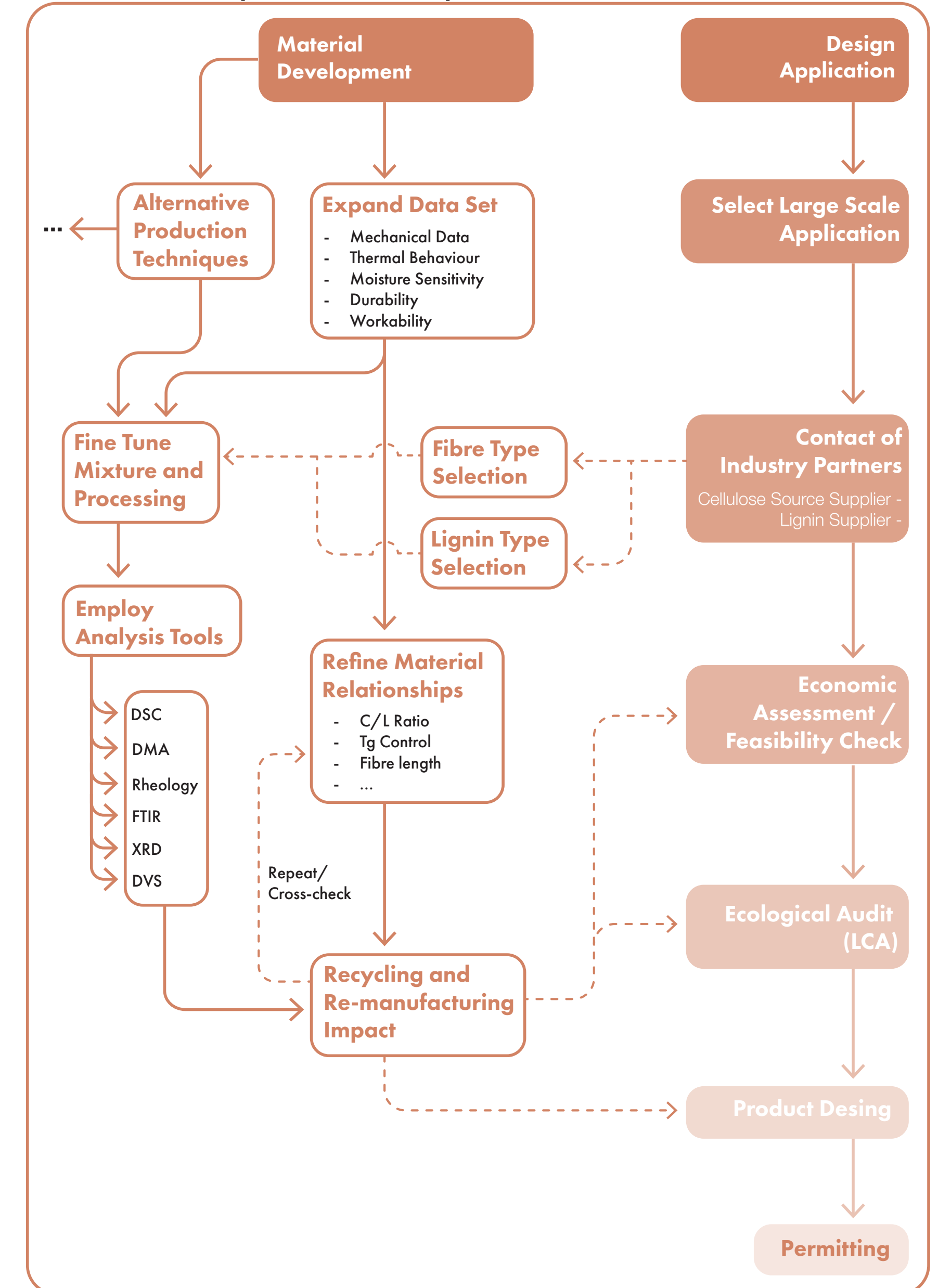


- Develop further production techniques past hot-pressing (e.g. palletisation and 3d-printing)



- Deepen knowledge on the recyclability and performance changes after re-processing

Future Roadmap of Research Topic



**Thank
You!**

Pictogram Reference List

Some Figures have been designed using resources from Flaticon.com see Table below:

Icon Title	Author	Used on Page:	Flaticon URL
Weather	Ivan Abirawa	20,26,39-53,57,83	https://www.flaticon.com/free-icon/weather_13936209
Cell	Nadiinko	14,26,37,39-53,56,73-75, 104, 106,121	https://www.flaticon.com/free-icon/cell_4299855
Horizontal Merge	Freepik	20,26,39-53,57, 104, 122	https://www.flaticon.com/free-icon/horizontal-merge_80716
Textile	Freepik	14,26,37,39-53,56,73-75, 104, 106,121, 122	https://www.flaticon.com/free-icon/textile_5482820
Humidity	Freepik	26,37,39-53,56,72-75,83	https://www.flaticon.com/free-icon/humidity_8678233
Time	Ilham Fitrotul Hayat	20,26,39-56,57,	https://www.flaticon.com/free-icon/time_3395452
Recycle Sign	Hilmy Abiyyu A.	121,125	https://www.flaticon.com/free-icon/recycle-sign_4361302?term=recycle-sign&page=1&position=44&origin=search&related_id=4361302
Time	Ilham Fitrotul Hayat	20,39-53,57	https://www.flaticon.com/free-icon/time_3395452?term=time&page=1&position=35&origin=search&related_id=3395452
Success	Parzival’ 1997	17,18	https://www.flaticon.com/free-icon/success_7508545?term=trial+and+error&page=1&position=3&origin=search&related_id=7508545
Pie Chart	bsd	18,22	https://www.flaticon.com/free-icon/pie-chart_8972636?term=pie+chart+data-&page=1&position=2&origin=search&related_id=8972636
3D-Modeling	Freepik	18,22	https://www.flaticon.com/free-icon/3d-modeling_12008058?term=modeling+cube&page=1&position=31&origin=search&related_id=12008058
TXT-file	Freepik	92,94,95,97, 101,103, 107	https://www.flaticon.com/free-icon/txt-file_104647
Weight	Freepik	94,95,97, 101, 103, 105, 106, 107, 110, 111	https://www.flaticon.com/free-icon/weight_847345?term=weight&page=1&position=1&origin=search&related_id=847345
Carbon Dioxide	Freepik	94,95,97, 101, 103, 105, 106, 107, 110	https://www.flaticon.com/free-icon/carbon-dioxide_550250?term=co2&page=1&position=20&origin=search&related_id=550250

Icon Title	Author	Used on Page:	Flaticon URL
Microscope	Iconir	59	https://www.flaticon.com/free-icon/microscope_18922227
Robotic Arm	Freepik	113,125	https://www.flaticon.com/free-icon/robotic-arm_2823691
Construction	Freepik	2	https://www.flaticon.com/free-icon/construction_2204128
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Circle	Jagat Icon	9	https://www.flaticon.com/free-icon/circle_3839944
EU	Wahyu Adam	3,9	https://www.flaticon.com/free-icon/european-union_3503210?term=eu&page=1&position=53&origin=search&related_id=3503210
Erlenmeyer Flask	Fahrul Oktaviana	10	https://www.flaticon.com/free-icon/erlenmeyer-flask_17184399?term=beaker&page=1&position=55&origin=search&related_id=17184399
Newspaper	Freepik	10	https://www.flaticon.com/free-icon/newspaper_10290333
Research	Freepik	20, 21 , 22, 23, 24, 27, 86, 122	https://www.flaticon.com/free-icon/research_1321070?term=literature&page=1&position=6&origin=search&related_id=1321070
Weighing Scale	juicy_fish	21, 22, 23, 24, 27, 86, 122,125	https://www.flaticon.com/free-icon/weighing-scale_4906768?term=beaker&page=1&position=27&origin=search&related_id=4906768
Analysis	mynamepong	17, 18, 22, 23, 24, 27, 86,122	https://www.flaticon.com/free-icon/analysis_809497
Biceps	Freeepik	121	https://www.flaticon.com/free-icon/biceps_3120798?term=strong&page=1&position=9&origin=search&related_id=3120798
Research & Development	Iconixar	115	https://www.flaticon.com/free-icon/research-and-development_4599811?term=research&page=1&position=1&origin=search&related_id=4599811
Check	Kiranshastry	120	https://www.flaticon.com/free-icon/checked_709510?term=check&page=1&position=7&origin=-search&related_id=709510