Evidence of low impact of hemp bio-aggregates on the thermal conductivity of hemp concrete

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«Evidence of low impact of hemp bio-aggregates on the thermal conductivity of hemp concrete».

hemp plant

Hemp Bio-Aggregates, (HBA)?

hemp stem

- Hemp Bio-Aggregates (HBA)
- fiber
- dust

«Evidence of low impact of hemp bio-aggregates on the thermal conductivity of hemp concrete ».

Hemp Concrete, (HC) ?

aggregates

HBA

binder (ex: lime)+admixtures

water

Mixer

Hemp Concrete, (HC)

flooring

wall

daubing

roof

«Evidence of low impact of hemp bio-aggregates on the thermal conductivity of hemp concrete».

Fabrication process

shuttering

prefabricated

projection

Testing methods & equipments

cubic specimen

cylindric specimen

Formulation & nature of constituants

wall 250kg/m^3

roof 450kg/m^3

flooring 500kg/m^3

binder

HBA

etc.

1. HBA characterizations

2. Study parameters

3. Results and discussions

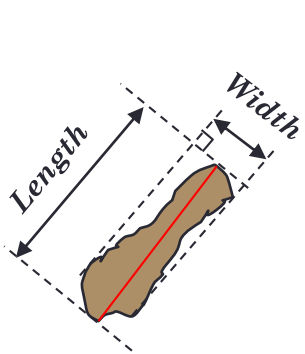
4. Conclusion and perspectives

HBA characterized

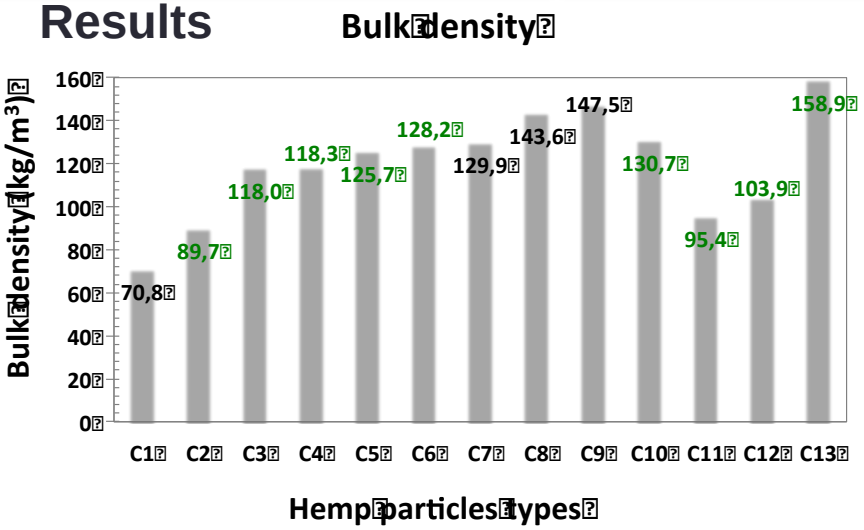
C1	Chanvre Auvergne Fibré
C2	Chanvre brut (TREMARGAT)
C3	Chanvre Anglais
C4	Chanvre Auvergne Brut(Standard)
C5	Chanvre LCDA
C6	Chanvre ISOcanna (CESA)
C7	Chanvre Suedois
C8	Chanvre Vicat (KANABAT)
C9	Chanvre ENTPE (KANABAT)
C10	Chanvre Standard Combraille
C11	Chanvre Standard Lézoux
C12	Chanvre Standard Brioude
C13	Chanvre CVF

Analysed properties

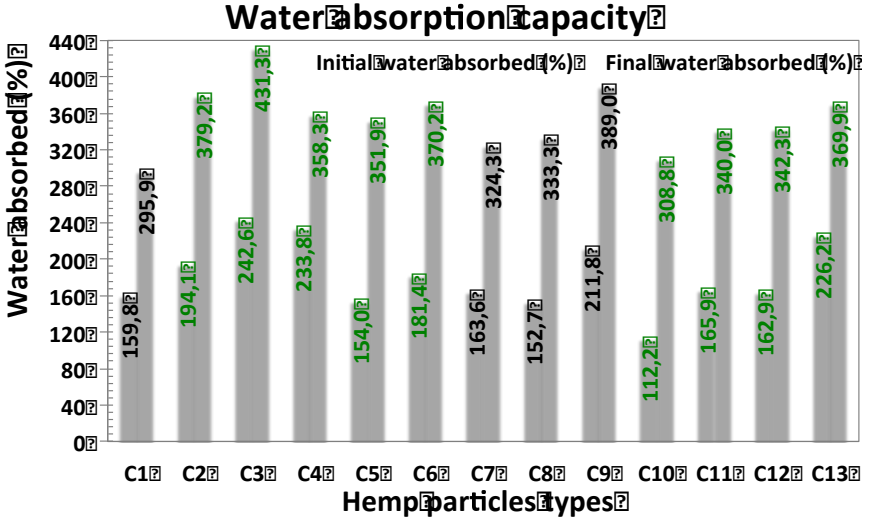
- Bulk density
- Water absorption capacity
- Particle size (image analysis)



Results

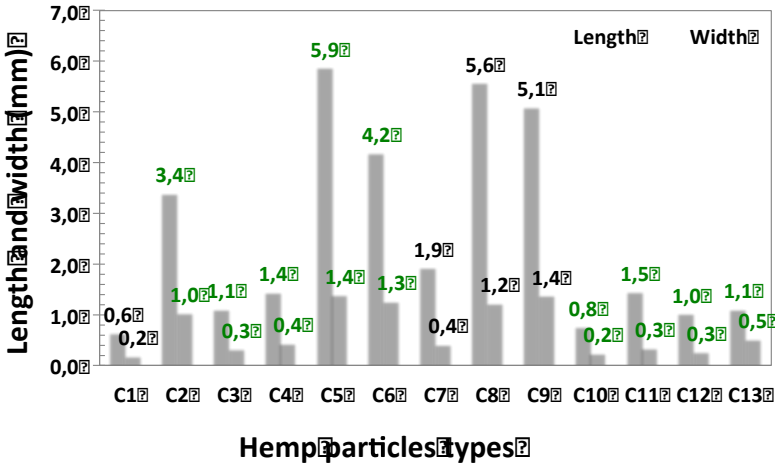


70.8 to 158.9 kg/m^3



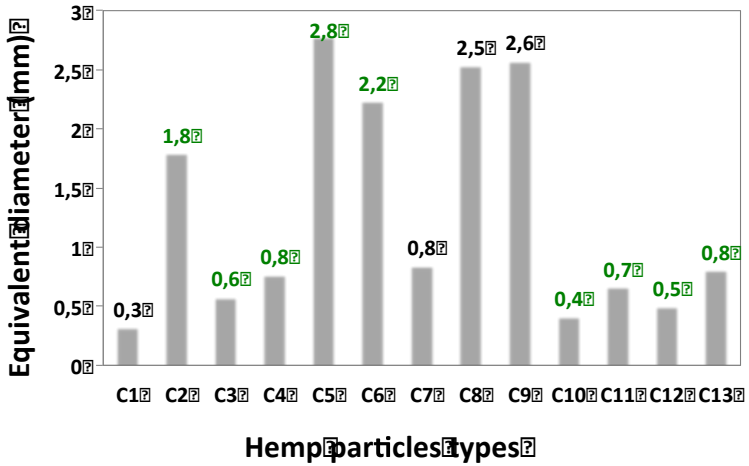
Initial : 112.2 to 242.6%

Final : 295.9 to 431.3%



Width : 0.2 to 1.4mm

Length : 0.6 to 5.9mm



0.3 to 2.8 mm

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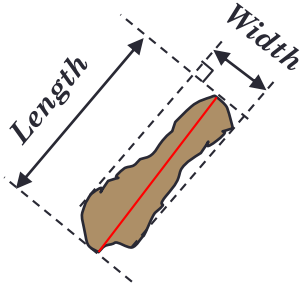
C11	Chanvre Standard Lézoux
C12	Chanvre Standard Brioude
C13	Chanvre CVF

9 : **Selected HBA**

Analysed properties

- Bulk density
- Water absorption
- Particle size (image analysis)



- **9 types of HBA**

- **One formulation : 250 kg/m³**

Batch (l)	HBA	Binder (kg)	Water (l)	Water/binder	HBA/binder
95	11,4	23,75	28,5	1,2	0,48

- **The same drying conditions**

Non controlled room

Temperature
21°C

48% HR

In an oven

60°C

- **The same thermal conductivity test protocol**

- **Age: (30 days; 60 days; 90 days and 180 days**

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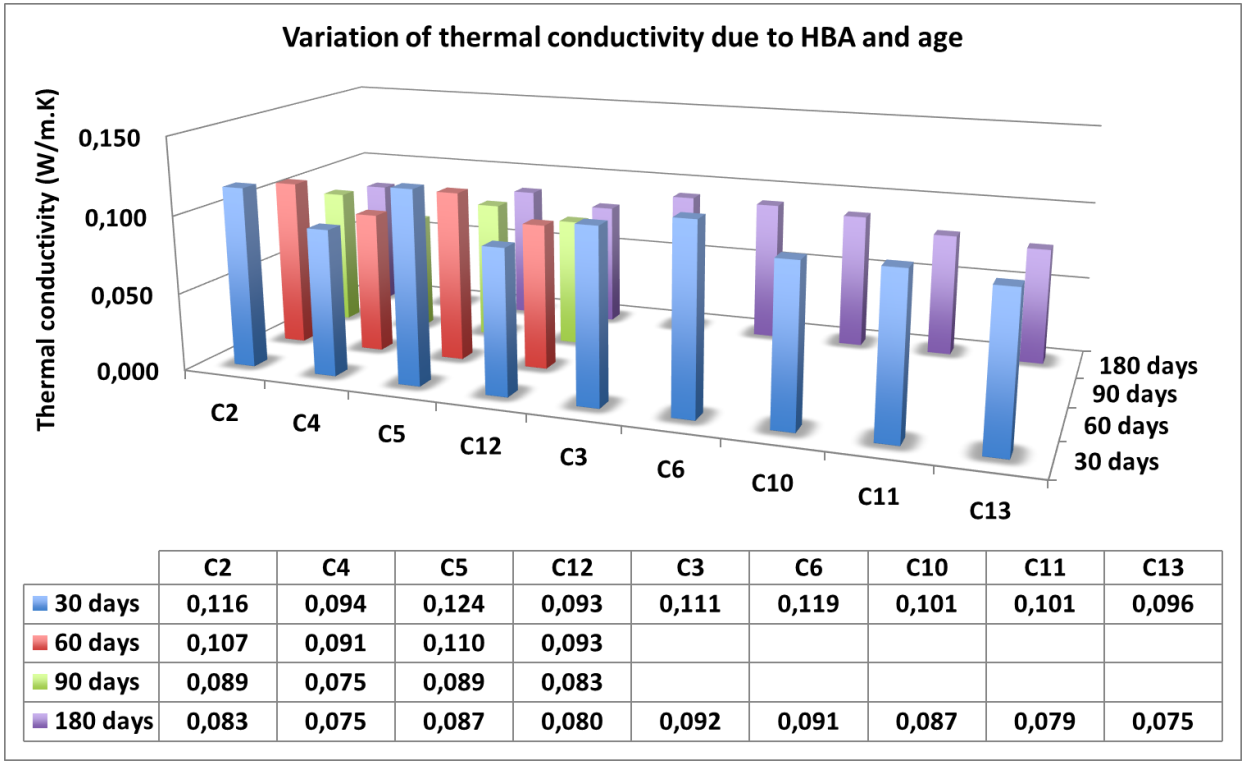
Change in thermal conductivity with HBA and age

The "hot wire" method



	C2	C4	C5	C12	C3	C6	C10	C11	C13
30 days	0,116	0,094	0,124	0,093	0,111	0,119	0,101	0,101	0,096
60 days	0,107	0,091	0,110	0,093					
90 days	0,089	0,075	0,089	0,083					
180 days	0,083	0,075	0,087	0,080	0,092	0,091	0,087	0,079	0,075

- Small variation for HBA with a SD less than 0,011 W/m.K for all ages
- Decrease with age

	At 30 days	At 180 days
Minimum	0.093 W/m.K (C12)	0.075 W/m.K (C4,C13)
Maximum	0.124 W/m.K (C5)	0.092 W/m.K (C3)

Change in thermal conductivity with HBA and direction of heat flux

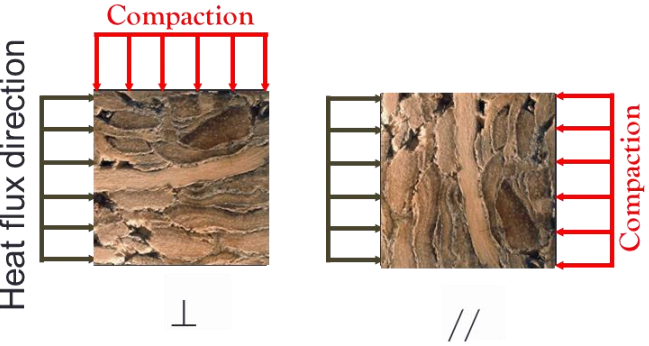
Compaction direction

Perpendicular

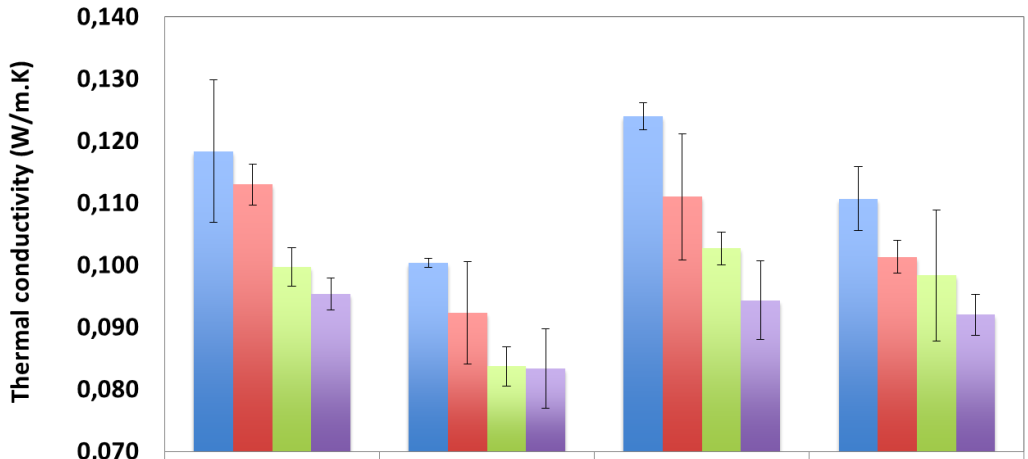
Shuttered HC wall

Parallel

Projected HC wall



Variation of thermal conductivity due to HBA and direction of compaction energy

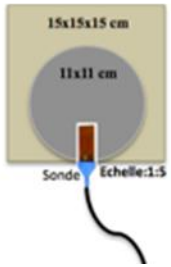


	C2	C4	C5	C12
Perpendicular at 30 days	0,118	0,100	0,124	0,111
Parallel at 30 days	0,113	0,092	0,111	0,101
Perpendicular at 180 days	0,100	0,084	0,103	0,098
Parallel at 180 days	0,095	0,083	0,094	0,092

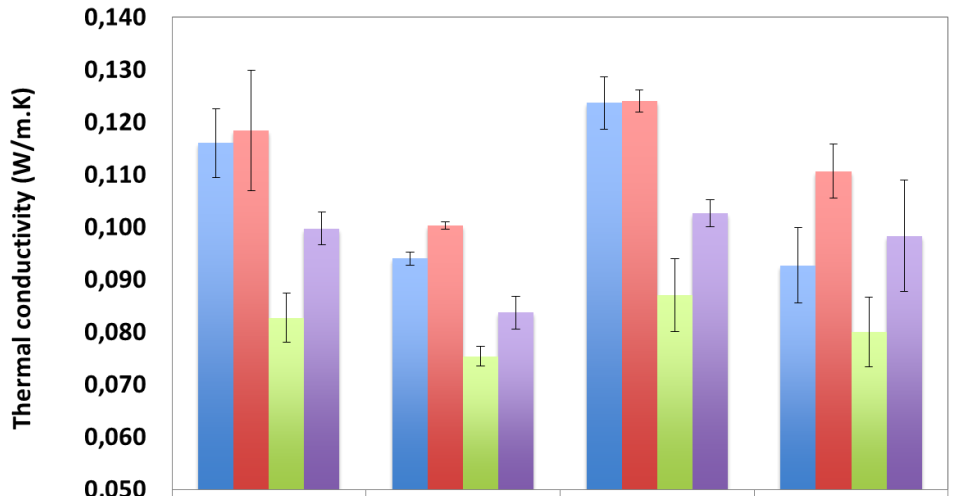
Thermal conductivity is greater in perpendicular direction regardless the age

Change in thermal conductivity with HBA and specimen type

Specimen type



Variation of thermal conductivity due to HBA and specimen type

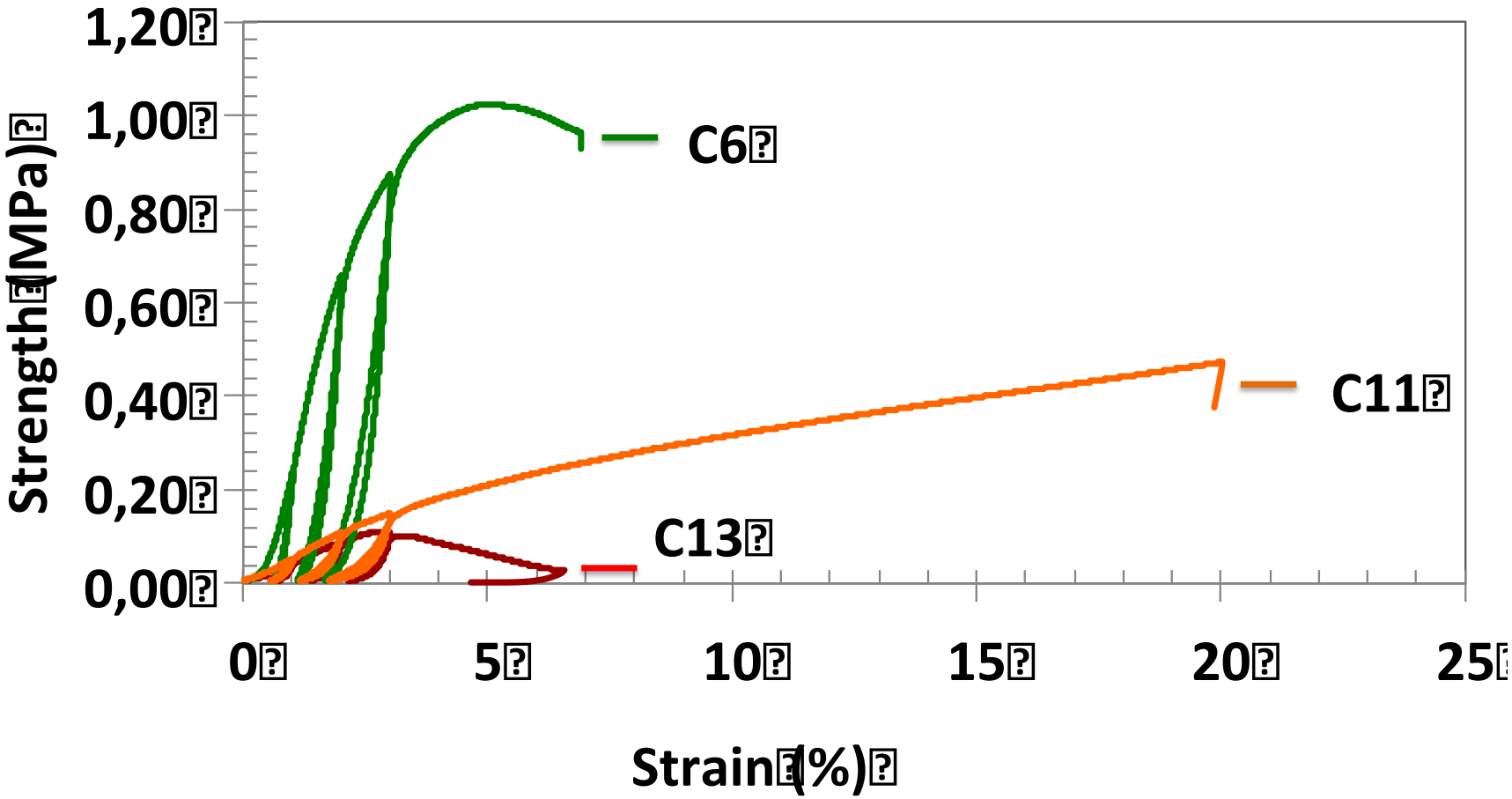


	C2	C4	C5	C12
Cylindrical specimens at 30 days	0,116	0,094	0,124	0,093
Cubic specimens at 30 days	0,118	0,100	0,124	0,111
Cylindrical specimens at 180 days	0,083	0,075	0,087	0,080
Cubic specimens at 180 days	0,100	0,084	0,103	0,098

Thermal conductivity is greater for cubic specimen regardless the age

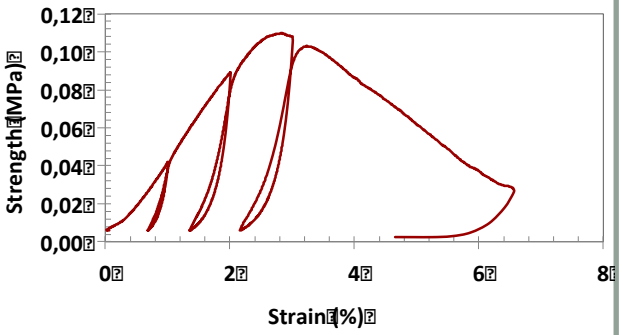
Thermal conductvity is not significantly impacted by HBA type, this is not the case for mechanical properties

Mechanical response



Mechanical response

C13

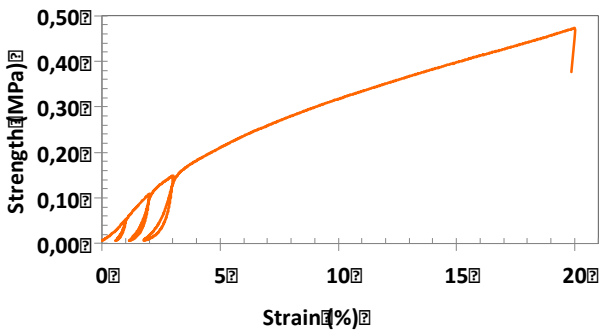


- Small particule size
- High mean specific area
- Total squashing

Test on HBA

Before test After test

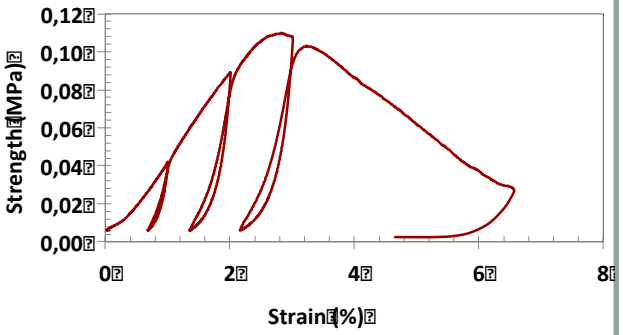
C11



- Rearrangement of hemp particles as a stack of layers
- High water absorption capacity
- High strain

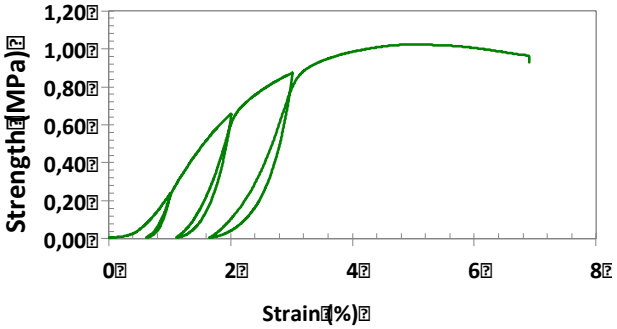
Mechanical response

C13



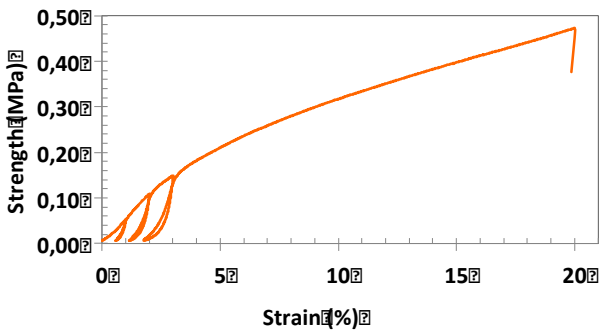
- Small particule size
- High mean specific area
- Total squashing

C6



Medium strain

C11



- Rearrangement of hemp particles as a stack of layers
- High water absorption capacity
- High strain

Conclusion

Results for thermal conductivity show:

- small variation for HBA with a SD less than 0,011 W/m.K for all ages;
- decrease with age;

Specimen type and direction of heat flux are likely to contribute to observed variability:

- thermal conductivity is greater for cubic specimen regardless the age;
- thermal conductivity is greater in perpendicular direction regardless the age.

HBA impact considerably the hemp concrete mechanical properties:

- three main mechanical response behaviors for HC material;
- factor equal to 10.

Perspectives

More investigation taking into account the specimen type and the protcol may allow to better understand observed dispersion and help to fix the standards to be used for characterization of HC.

THANK YOU FOR YOUR ATTENTION!

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QUESTIONS?

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