WEBS conference: The plastics & composites: Waste or Resources?
May 2016, Paris

Valorization of mixed and emerging plastics into composite building materials

Valorisation des plastiques mixtes et émergents en matériaux composites pour le génie civil

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GAUDREAU LES ENVIRO-MAÎTRES

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INRS UNIVERSITÉ DE RECHERCHE

NSERC CRSNG

Gaudreau Environnement's MRF (Plastics only)

10%
Bulky

30%
Bags and films

6%
Pails

7%
Dark items

WEEE / C&D

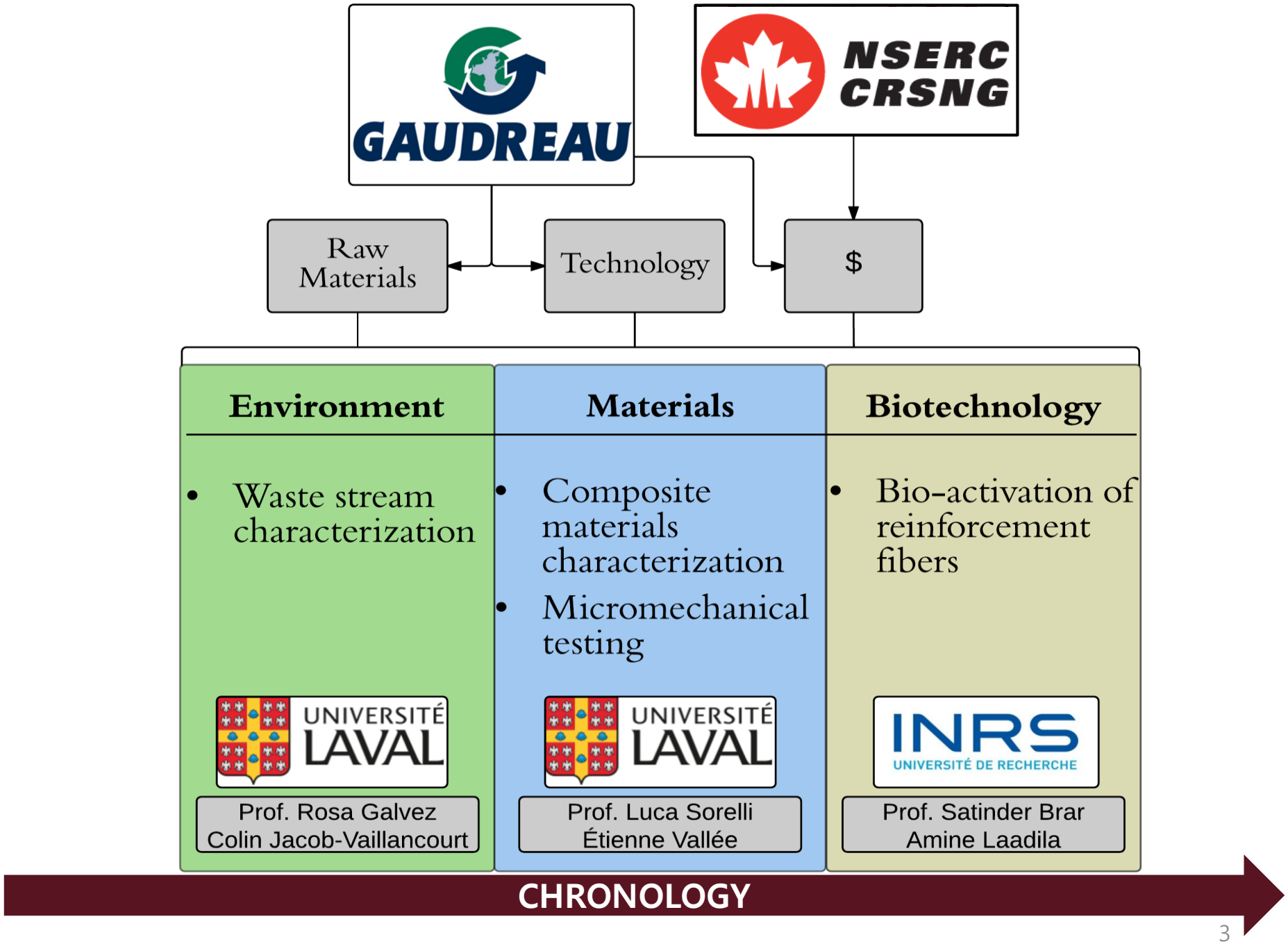
PET
20%

15%
HDPE

Optical sorting

Bioplastics

Mixed rigid 12%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Raw Materials
Technology
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Environment
Materials
Biotechnology
• Waste stream characterization
• Composite materials characterization
• Micromechanical testing
• Bio-activation of reinforcement fibers
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Prof. Rosa Galvez
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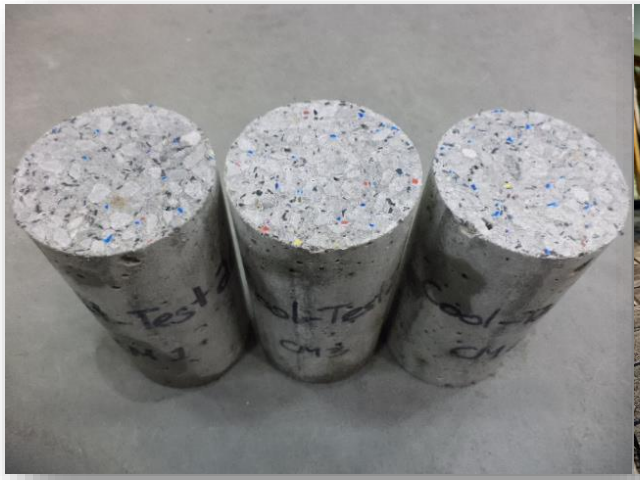
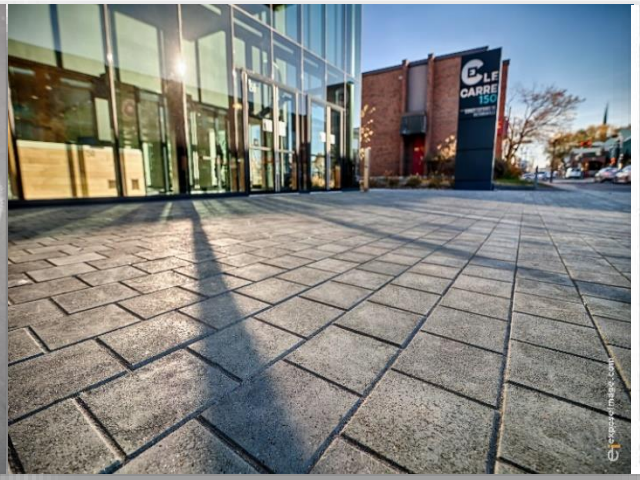
Prof. Luca Sorelli
Étienne Vallée
Prof. Satinder Brar
Amine Laadila
CHRONOLOGY

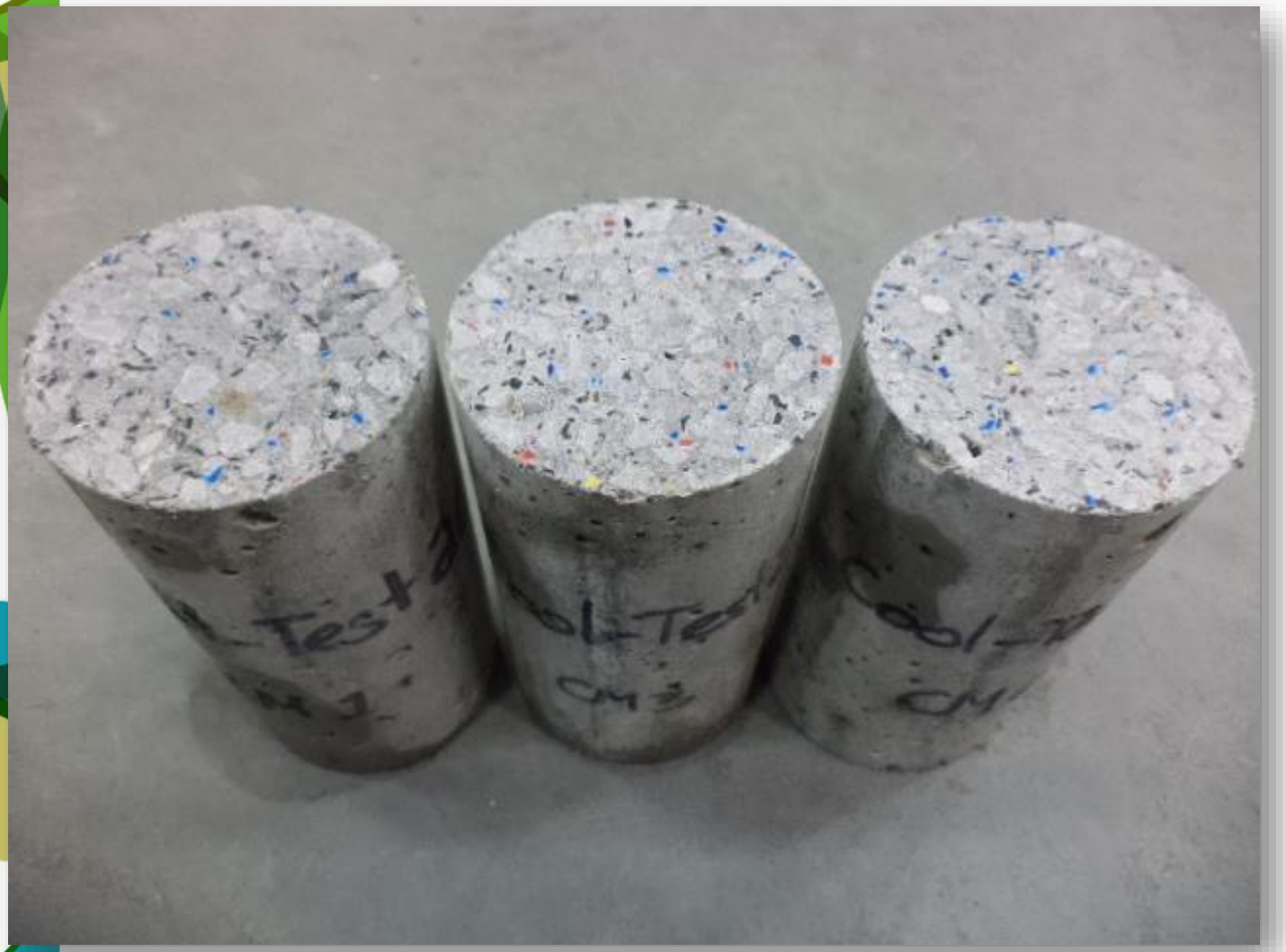
Our composites:





Concrete with plastic aggregates	Plastic and glass pavers	Natural fibre / PLA structural panels
• Rigid mixed plastics	• Mixed films/bags • Glass	• Bioplastics (PLA) • Cellulosic fibres

Plastic aggregates for concrete



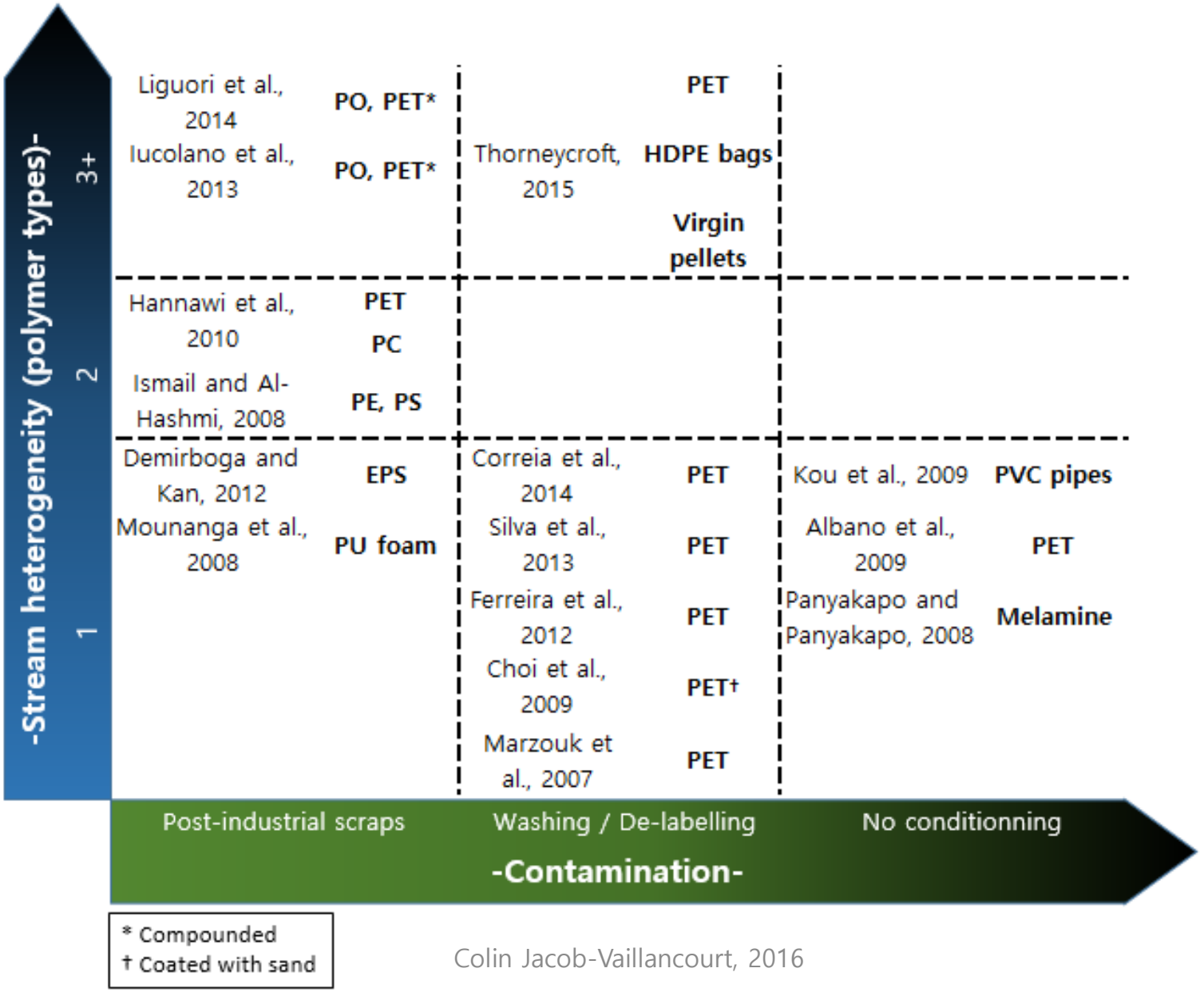
Plastic aggregates for concrete

- This approach is interesting because it would allow for complex plastic streams to be valorised within a single process

- Research has been done previously on waste plastic particles used as sand/aggregate replacement in concrete mixes

- Not enough attention directed towards complex waste streams (high contamination and heterogeneity)

Plastic aggregates for concrete



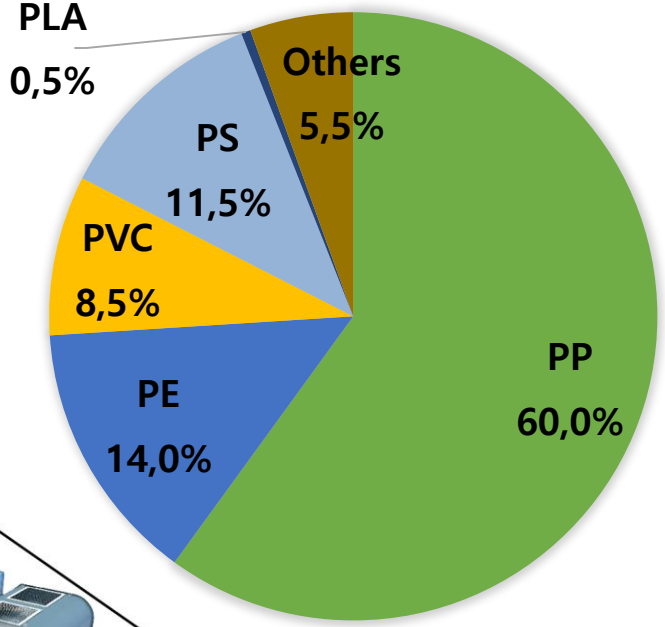
Plastic aggregates for concrete

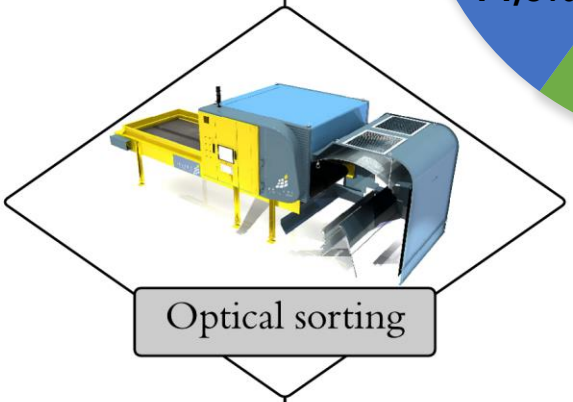
- The first objective was to generate various plastic streams using the mixed rigid plastics as raw material and NIR optical sorters

- Then, each material stream was characterised by composition and packaging types and physical quality profiles were established

Plastic aggregates for concrete

MIX





PP

PE

PVC

PS

PLA

Others

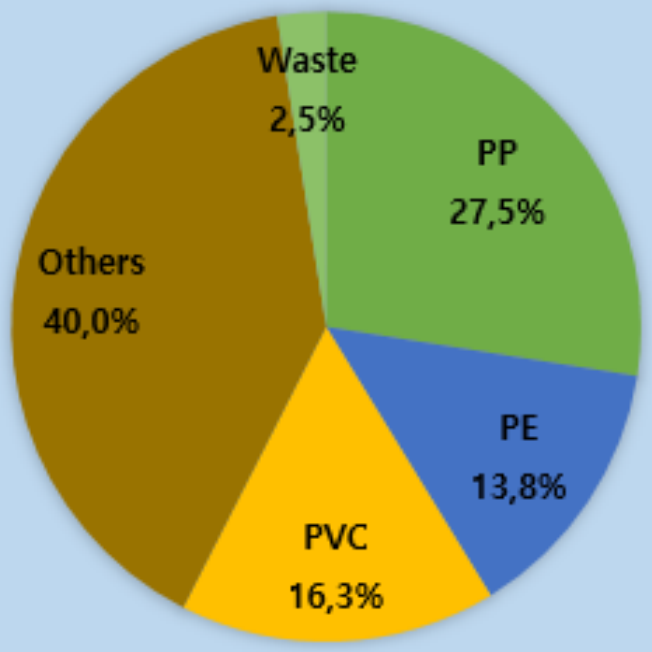
Plastic aggregates for concrete

POLYSTYRENE

Sampling date:	2015-04-20
Sample mass:	7,39 Kg

Purity	**94,60** %
Contamination	**5,40** %

Contaminant composition:



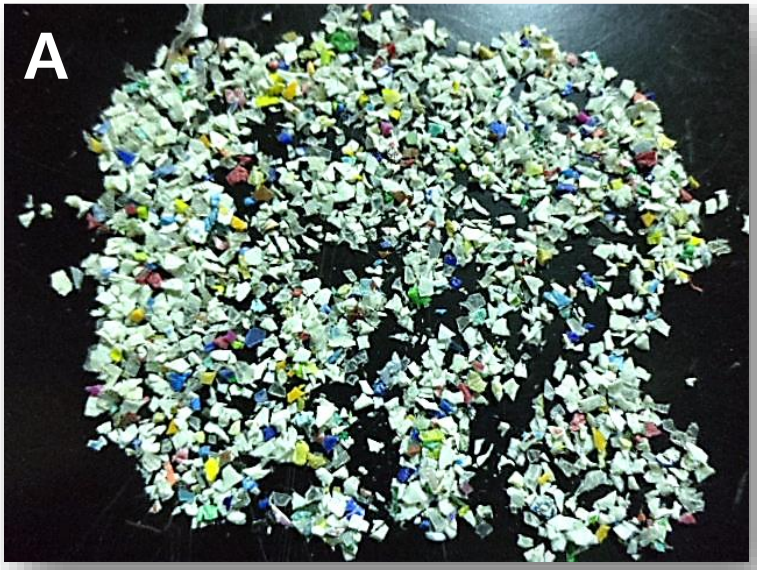
Quality profile:

Specific gravity	**1,0777** g/cm^3
ASTM D5550	
Ash content	**5,73** %
Volatiles	**6,29** %
Thermal degradation onset	**417,27** °C
ASTM E1131	

Plastic aggregates for concrete

- The plastic streams were granulated to different sizes to be used as aggregates
- A reference concrete design was used (CTRL), and its sand fraction was partially replaced by plastic aggregates at set volumes (5, 10, 20%)
- Concrete mixes were cast into cylinders and compression tested at a controlled displacement rate

Plastic aggregates for concrete



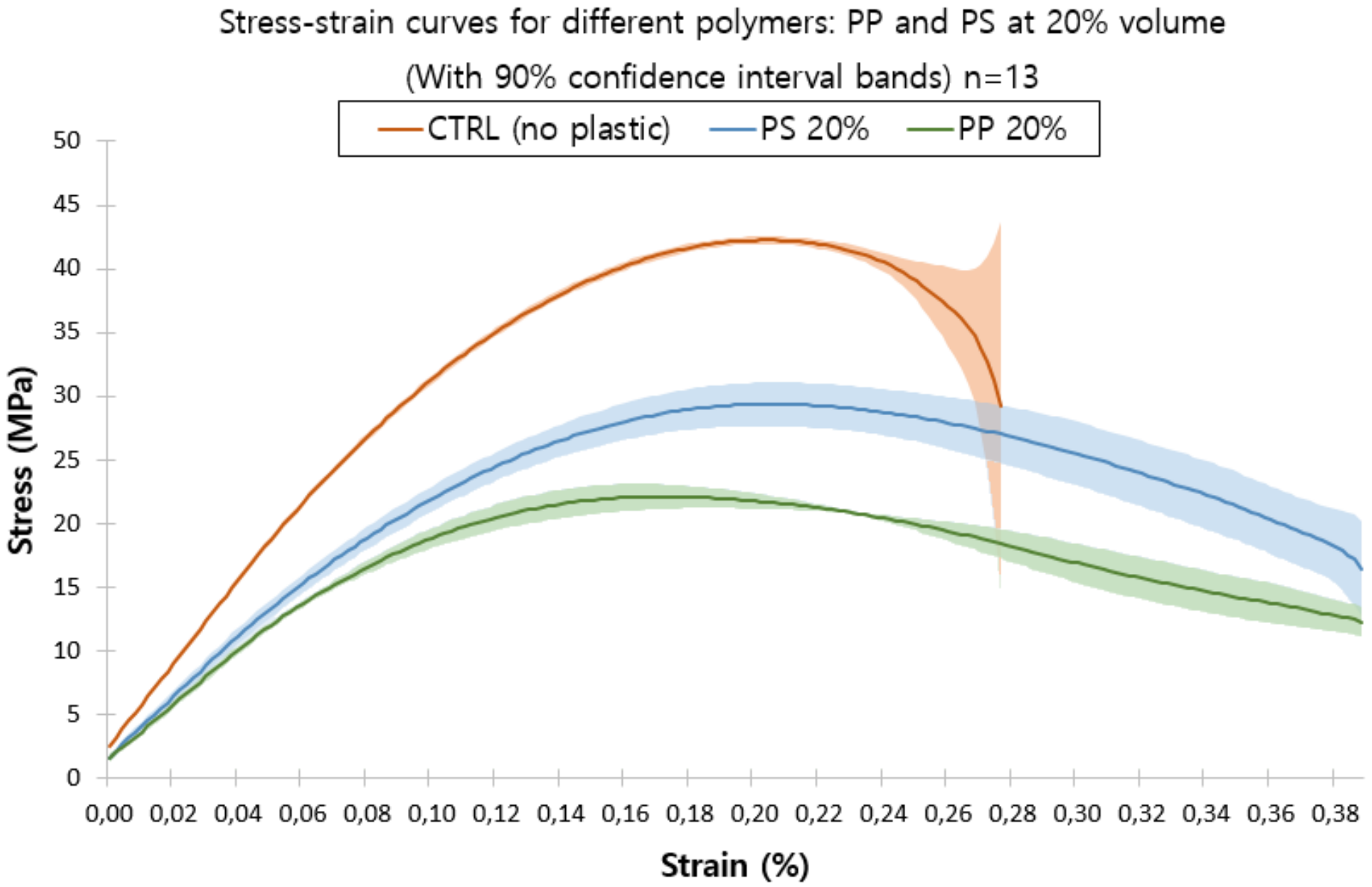
LVDT (x3)

A) Polypropylene d=5mm

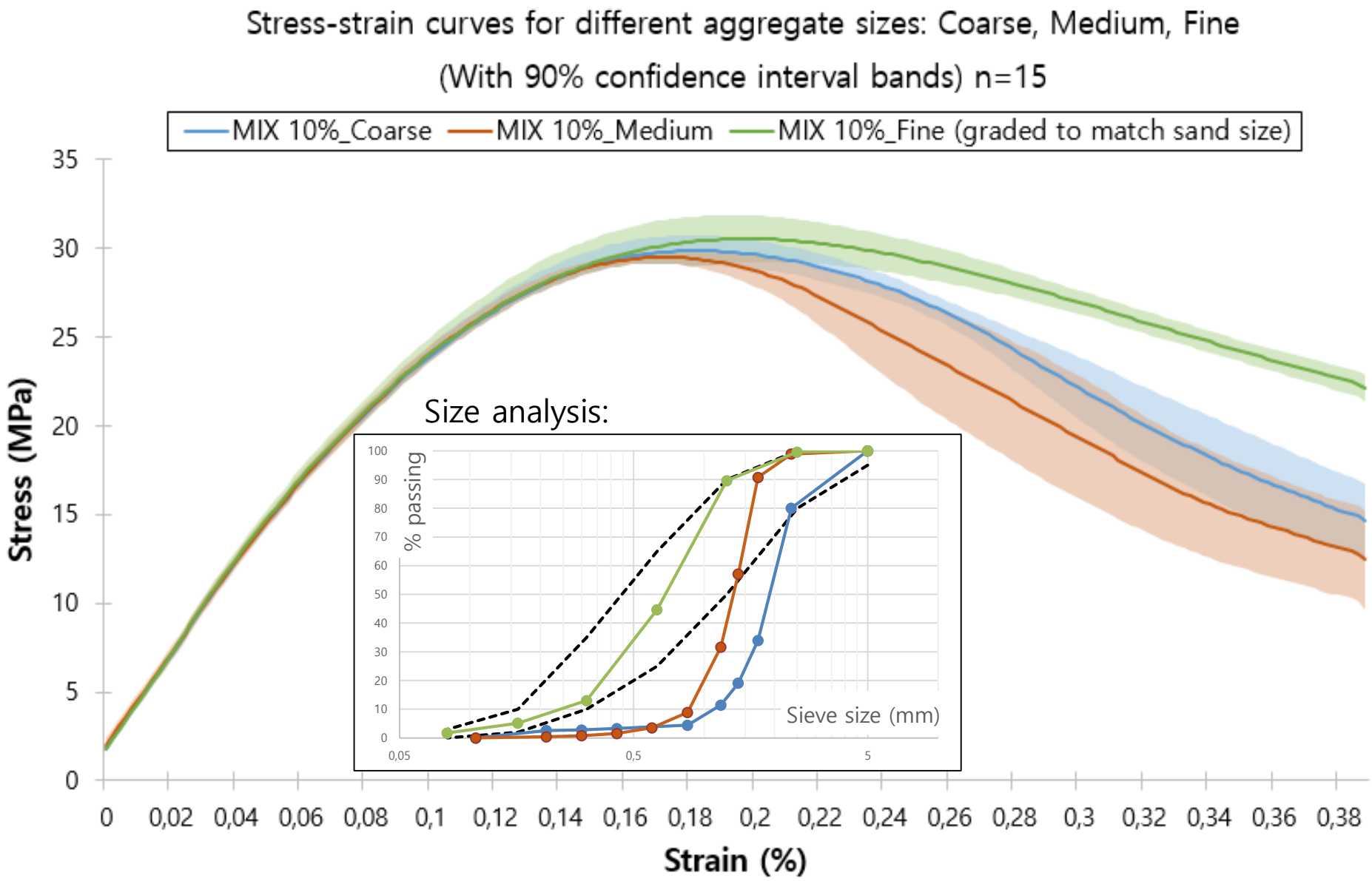
B) Experimental setup

C) Polystyrene d=5mm

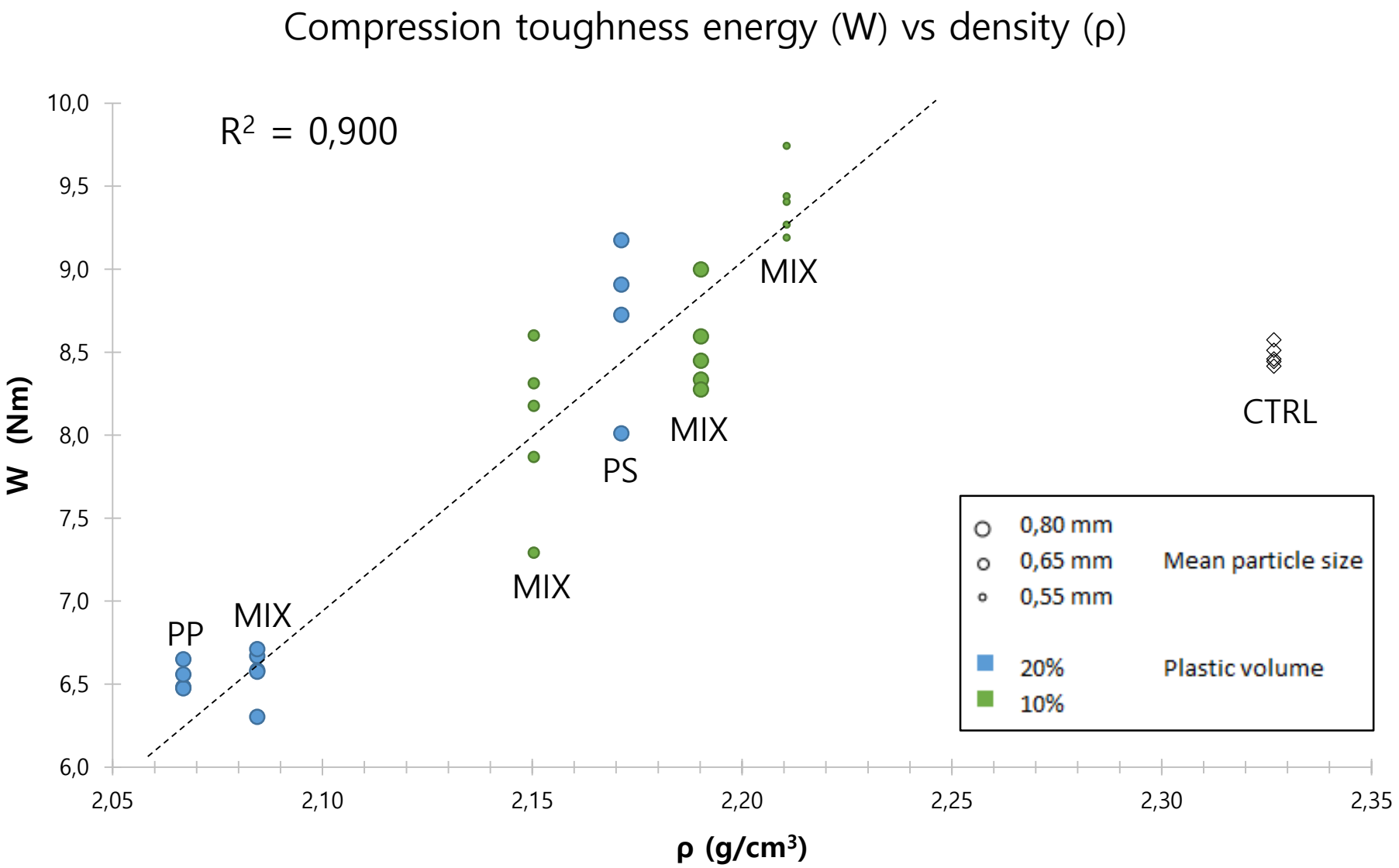
Plastic aggregates for concrete



Plastic aggregates for concrete



Plastic aggregates for concrete



Plastic aggregates for concrete

What we`ve learned / Next steps…

Plastic aggregate	% contamination (TGA analysis)	Dominant packaging type	% entrained air in concrete (at 20% volume)	Concrete compr-essive strenght (20% volume)
-	-		3,7	42,33 ± 0,43
PP	2,95	Injection molded	12,0	21,91 ± 1,28
PS	10,93	Thermoformed	7,0	29,60 ± 1,64

Mix design	Compressive strenght* (MPa)	Compressive toughness energy* (Nm)	Density* (g/cm^3)	Thermal conductivity* (W/mK)
MIX 10% Fine	-28%	+11%	-5%	N/A
MIX 10% Coarse	-29%	equivalent	-6%	-18%

*Relative to control mix

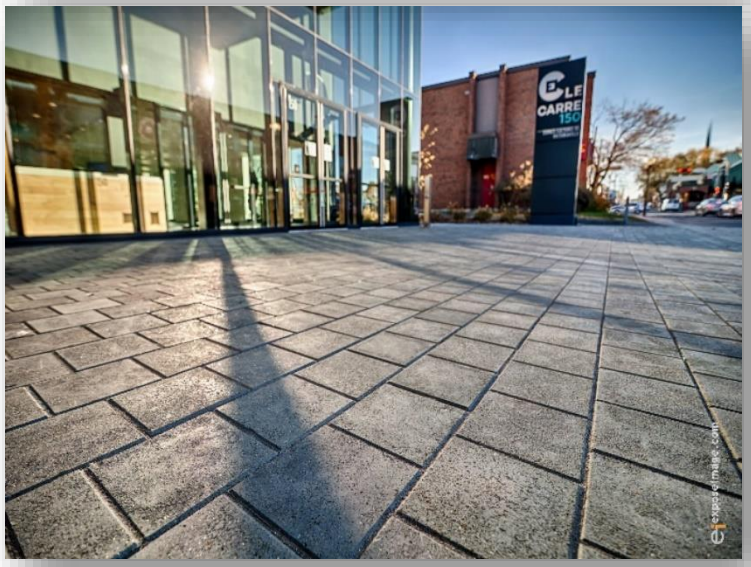
Plastic aggregates for concrete

- Polymer type and particle size of plastic aggregates significantly alter the performances of the concrete. Differences between polymers are partly due to varying amounts of entrained air. Quality profiles may help us understand this phenomenon

- Substituting sand with plastic lowers the peak resistance and E modulus of concrete, but gains are registered in terms of compressive toughness, density and thermal conductivity (along with environmental benefits)

- Further work is underway with more polymer types, and a reduction of entrained air for better mechanical performances

Regeneration™ pavers



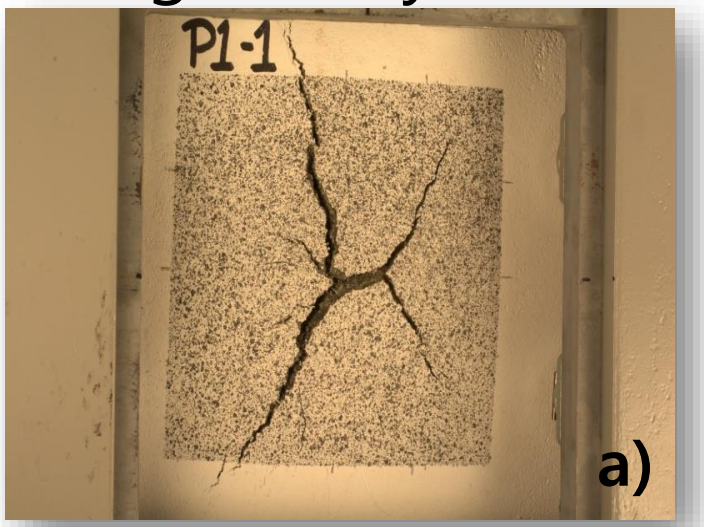
Plastic aggregates for concrete

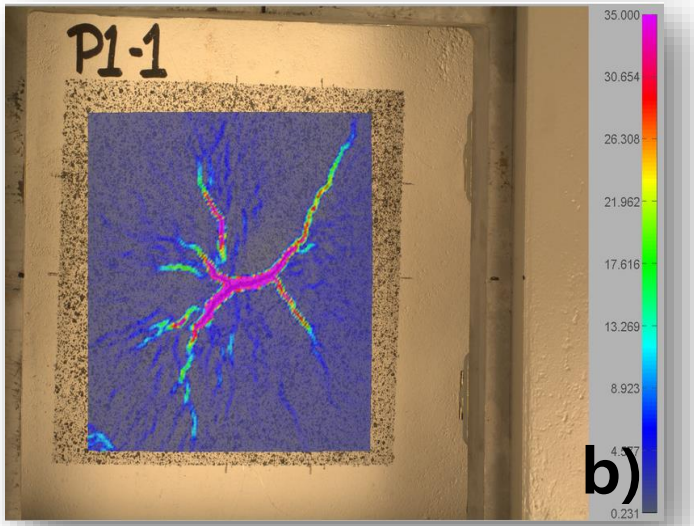
- Gaudreau Environnement is producing recycled pavers made of 25% mixed plastic bags and 75% postconsumer glass

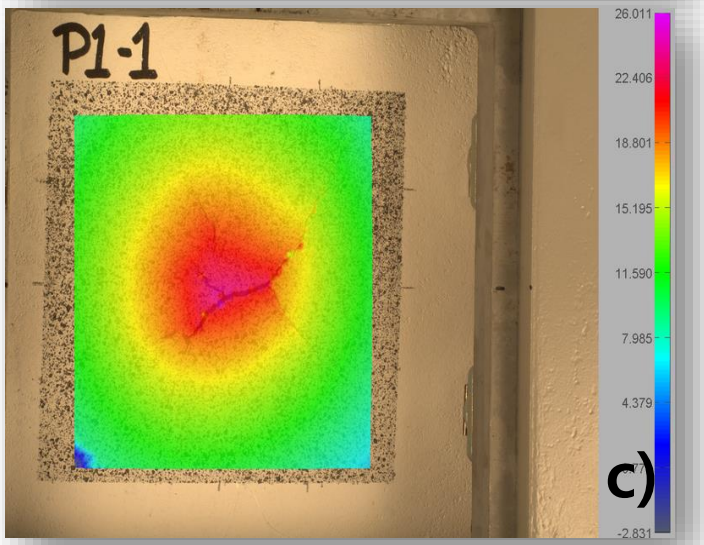
- In order to optimise the mechanical properties of this composite, a homogenisation model is being developed, using microindentation and image analysis techniques

Regeneration™ pavers

Image analysis







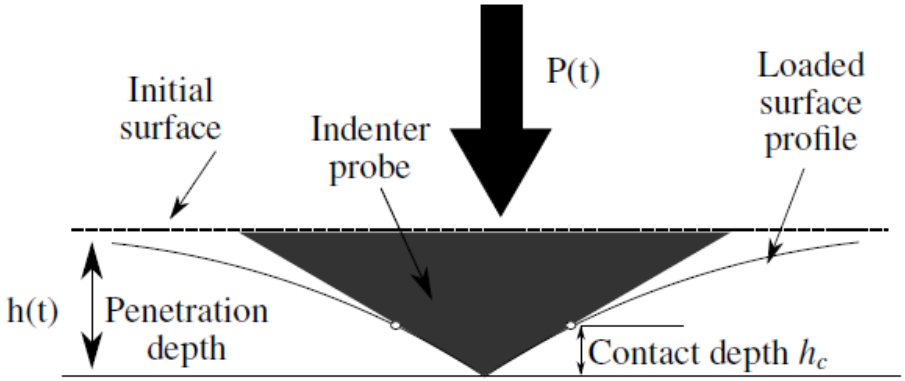
a) 20 x 20 inches slab

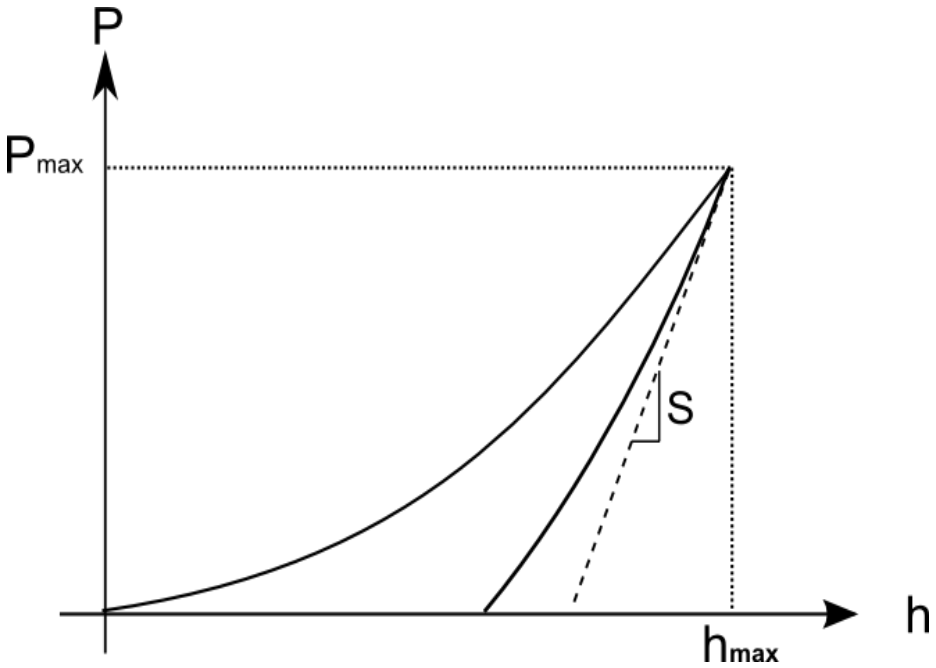
b) Cracking pattern

c) Displacement in z axis

Regeneration™ pavers

Indentation technique:



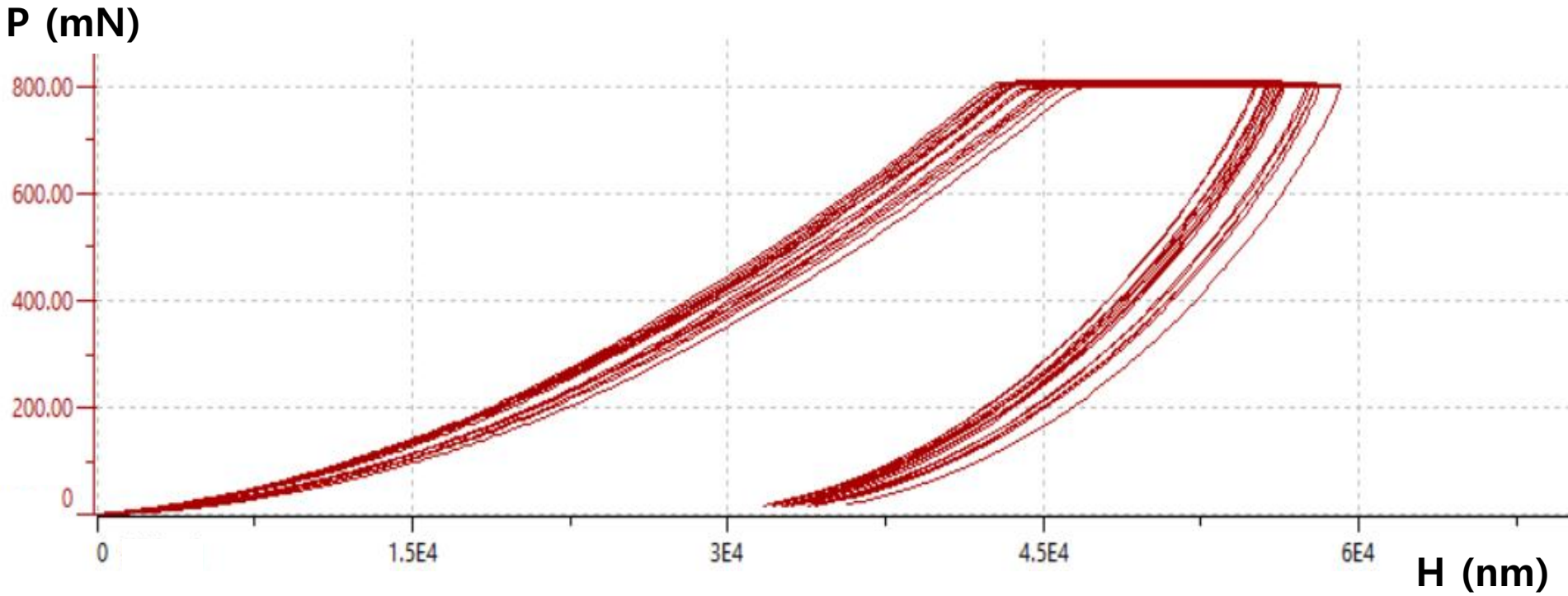


P(t): Load

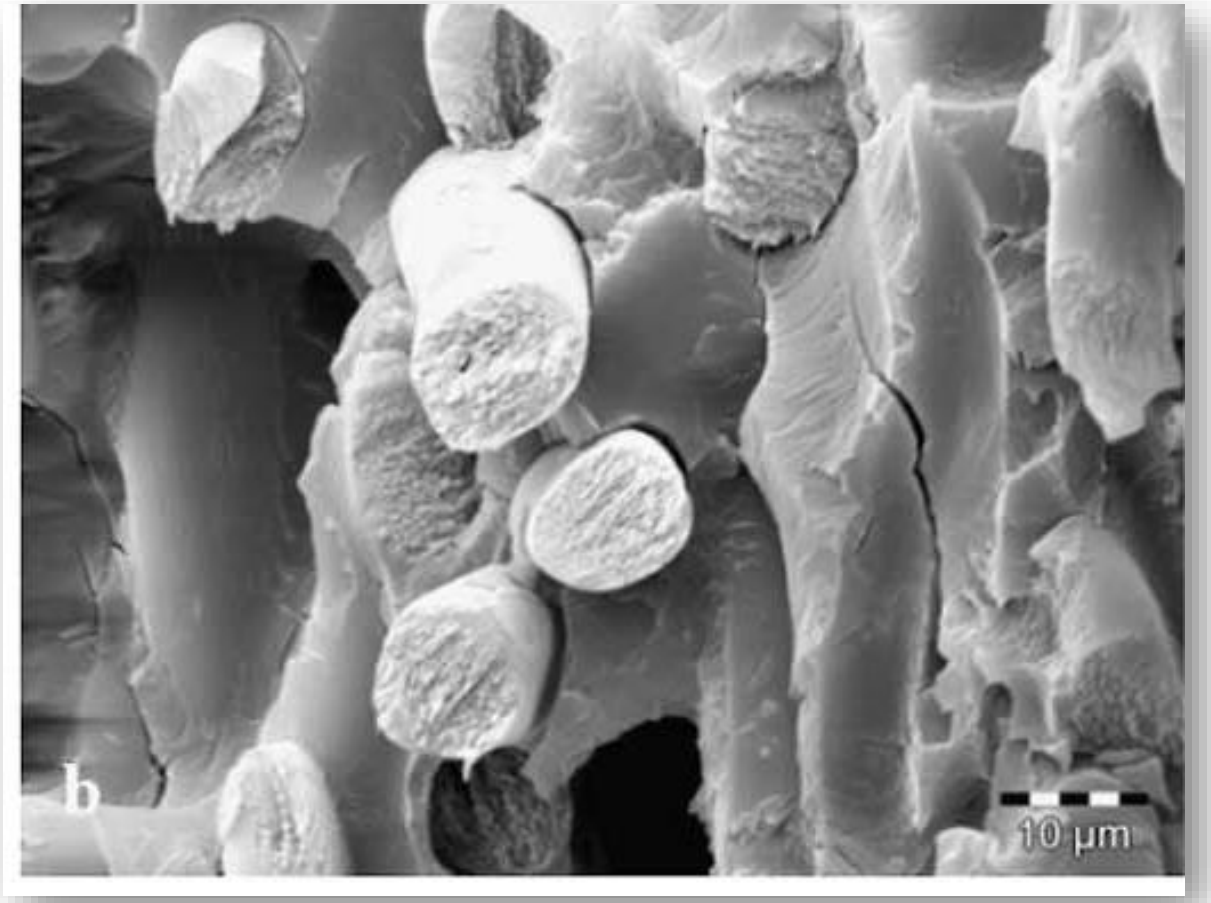
h(t): Displacement

Regeneration™ pavers

Creep analysis by microindentation, Pure LDPE:

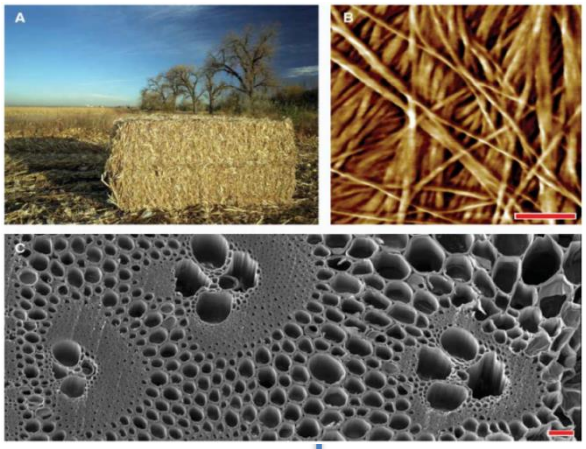


Biocomposite structural panels



Structural biocomposites

Lignocellulosic biomass



Hemp fibres

Pulp and paper waste

Laccase production with T.virsicolor

Cellulase production with T.reesei

Microwave assisted cellulose fibres extraction

Cellulase and laccase

Enzymatic fibre activation

Fibres

+

r-PLA

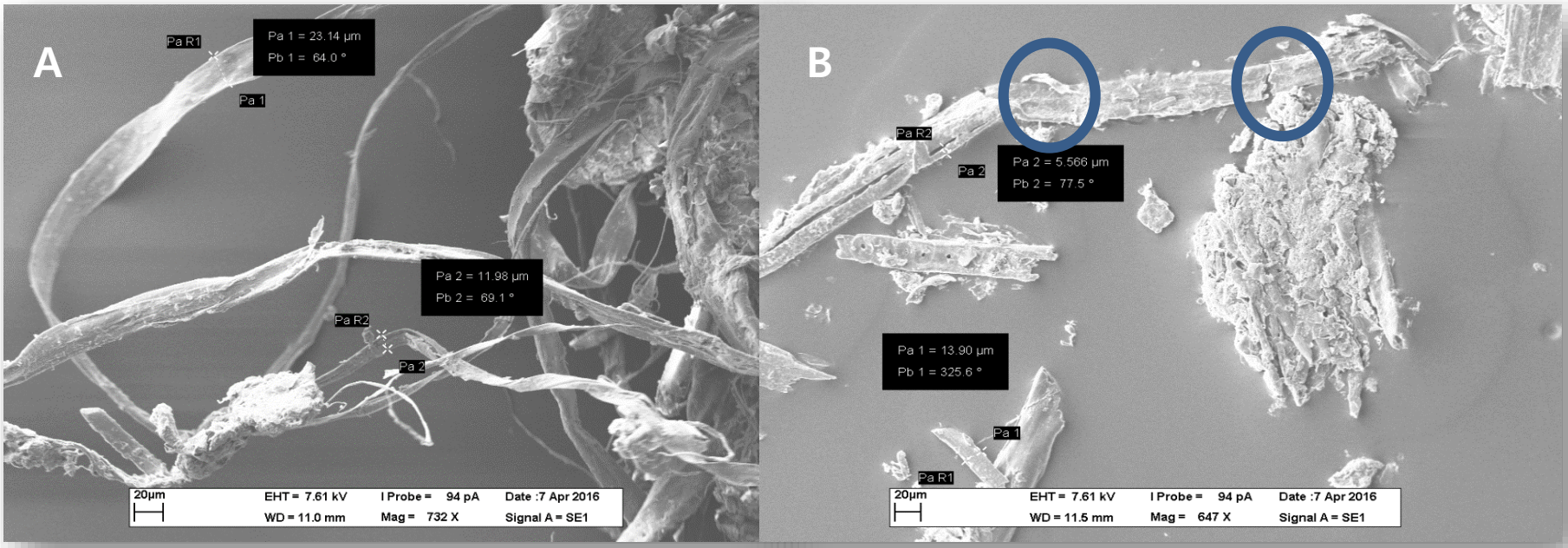
Structural biocomposites

Microwave treatment

Table 1 : Experimentally determined optimal conditions for the microwave treatment of pulp and paper waste fibres.

Materials	Time(min)	Temperature (°C)	(%) H_2SO_4	Fibre size before (µm)	Fibre size after (µm)
Mixed sludge	120	95	2.48	1750	342
Primary sludge	140	150	2.00	895	294

Structural biocomposites



SEM micrograph of treated (B) and untreated (A) mixed biosolids

Future Outlook:
Systems for Continuous Environmental Performance

Concrete and structural panels for thermal mass and insulation

Pavers for albedo control

THANK YOU!

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