Interreg North Sea

Co-funded by the European Union

BBOBB

Webinar : Potential of biobased binders for sustainable construction : Lignin and used vegetable oil waste

IMT Nord Europe
École Mines-Télécom
IMT-Université de Lille

Gecco

Cerema
CLIMAT & TERRITOIRES DE DEMAIN

12 12 2025

Participants of BBoBB project

- Province of Fryslân, The Netherlands
- House of Design, The Netherlands
- Biosintrum, The Netherlands
- Circulair Friesland, The Netherlands
- Kompetenzzentrum 3N, Germany
- Jade Hochschule, Germany
- Heidekreis, Germany
- Guldborgsund Kommune, Denmark
- Business Lolland-Falster, Denmark
- Agrovi, Denmark
- CELF, Denmark
- Design Regio Kortrijk VZW, Belgium
- University Gent, Belgium
- IMT Nord Europe, France
- CEREMA, France
- GECCO, France

IMT Nord Europe
École Mines-Télécom
IMT-Université de Lille

IMT Nord Europe is a French Graduate School of Engineering affiliated to the Institut MinesTélécom and a partner of the University of Lille. IMT Nord Europe is a major research and education player in today's energy, ecological, digital and industrial transitions.

Cerema
CLIMAT & TERRITOIRES DE DEMAIN

Cerema, a public establishment reporting to the Ministry of Ecological Transition and Territorial Cohesion, supports the State and local authorities in the development, deployment and evaluation of public planning and transport policies.

GECCO

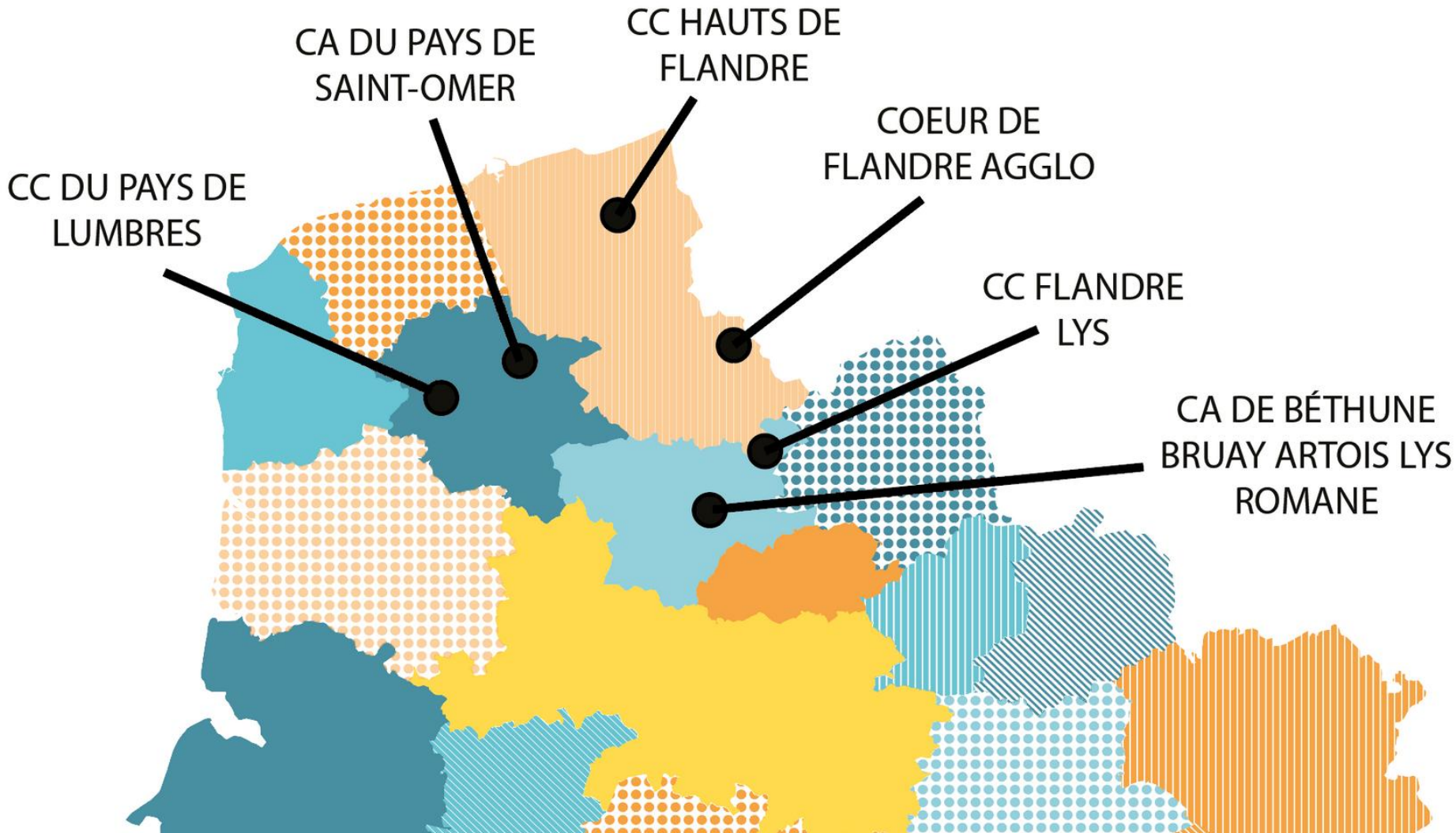
GECCO Social and Solidarity company created in 2007, expert in the collection and recovery of used food oils and bio-waste.We collect used cooking oils and bio-waste from catering professionals.We It collects cooking oils generated by individuals, via voluntary drop-off points set up in recycling centers and partner stores.

- Regional stakeholders Eura Industry Innov : S. Dubar
- New materials uses: Eco-friendly materials (IMT NE): L. Khouchaf, F. Belayali
- Design aspects (Designers): S. Nader, T. Neuville
- Hydraulic Bio-binders in construction (Cerema): H. Beddaa, A. Ben Fraj
- Bio-binders for roads (Cerema): C. Some, V. Mouillet

eura industry innov'

BIOECONOMY DEVELOPMENT

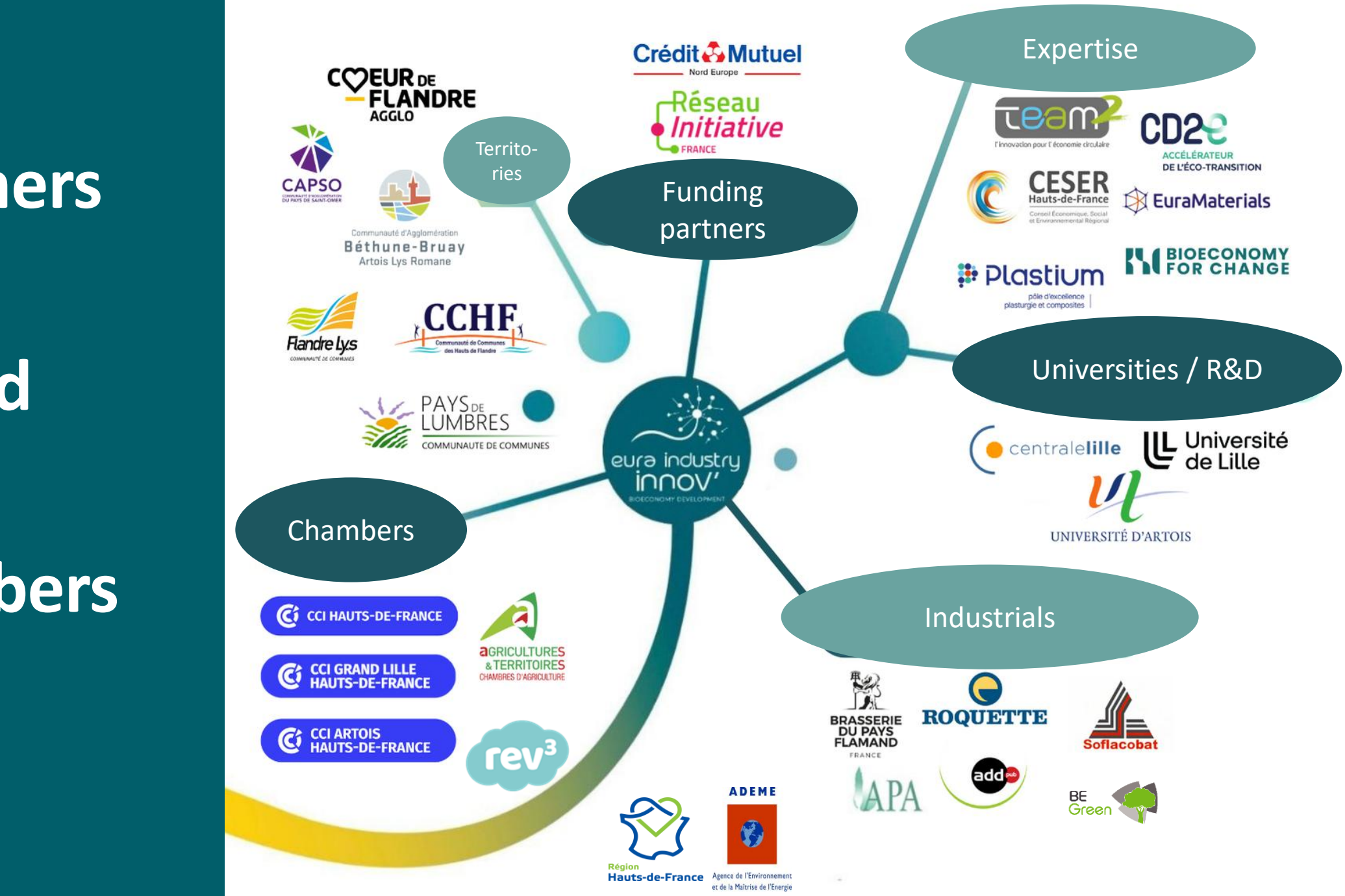
Hauts de France Territories of Eura Industry Innov’



THEMATIQUES

- **Bio-based materials and products** (for construction, packaging, transportation, plastics/composites, etc.)
- **Plant-based chemistry** (for cosmetics, food processing, pharmaceuticals, etc.)
- **Circular economy** (valorization of agricultural by-products and waste)
- **Natural products and well-being**
- **Sustainable food**
- **Bioenergy**

Partners and members



Our Missions

FACILITATOR

Project Support

One-stop shop
Project identification
Needs identification
Guidance portal to partners

FÉDÉRATOR

Territorial ecosystem facilitation

Collective intelligence to support the emergence of projects
Connecting actors along the value chain
Mobilizing stakeholders
Skills development

Accelerator

Communication

Territorial marketing contributor
Organization of events
Territorial observatory

Business creation - Job creation - Wealth creation - Creation of added value

Annual events

More than 20 projects

PROCOLBIO (UTA-Université d'Artois)

ADD PUB

TIMOBAT (LGCGE-Université d'Artois)

TERENVI

BIOTEOS

HAUTS-DE-CHANVRE

VEGSKIN

NOGASHI

Valorisation du Miscanthus

PROTIBOX

More than 20 projects

Agribiomix

EcoXtract

Protibox

NORD CHALEUR

Boulonn'Haies Durables

DECIDUOUS

BKB Chemicals

UNIVERSITÉ D'ARTOIS

eura industry innov'
BIOECONOMY DEVELOPMENT

CCI HAUTS-DE-FRANCE

AGRICULTURES & TERRITOIRES
CHAMBRES D'AGRICULTURE

BIOECONOMY STUDIES

Conduct 2 studies in 2021-2022 and 2024-2025

- **Qualify and quantify biomass resources** within the pilot territory and industrial opportunities
- **Better understand current challenges:** comprehend and address needs, expectations, and issues
- **Identify obstacles/limitations to the economic development of the bioeconomy**
- **Focus on the Hops and Hemp sectors**

More than 12 million tons of fossil-based products and about 2 billion tons of natural aggregates are consumed every year in the EU.

For the construction of new, so-called smart cities, we need raw materials and building materials that respect the environment.

Pilars of Circular Bio economy

Green Bitumen and Green concrete.

This also involves using biobased and recycling methods (circular bioeconomy) through the recovery of organic waste : Lignin, Vegetable cooking oils,

EUROPEAN ASPHALT PAVEMENT ASSOCIATION. EAPA—Asphalt in Figures 2020. Available online: 〈https://096.wpcdnnode.com/eapa.org/wp-cont ent/uploads/2021/12/asphalt_in_figures_2020.pdf〉.

Who doesn't like living in a green building?
Who doesn't like parking or driving on a green road?

Concrete is the most widely used building material in the world. Cement is a key component of concrete—and its production process, in particular, contributes significantly to climate change. Each year, more than 4 billion tons of cement are produced, and this activity is responsible for approximately 8% of global CO2 emissions.

civil engineering construction

Roadways, pavement

Fossil Asphalt ⟹ Emissions of particulate matters, volatile organic compounds and polycyclic aromatic hydrocarbons from warm and hot asphalt mixes

WHY LIGNIN?

- it is the second most abundant renewable biopolymer on Earth, after cellulose. Together, they account for more than 70% of total biomass.

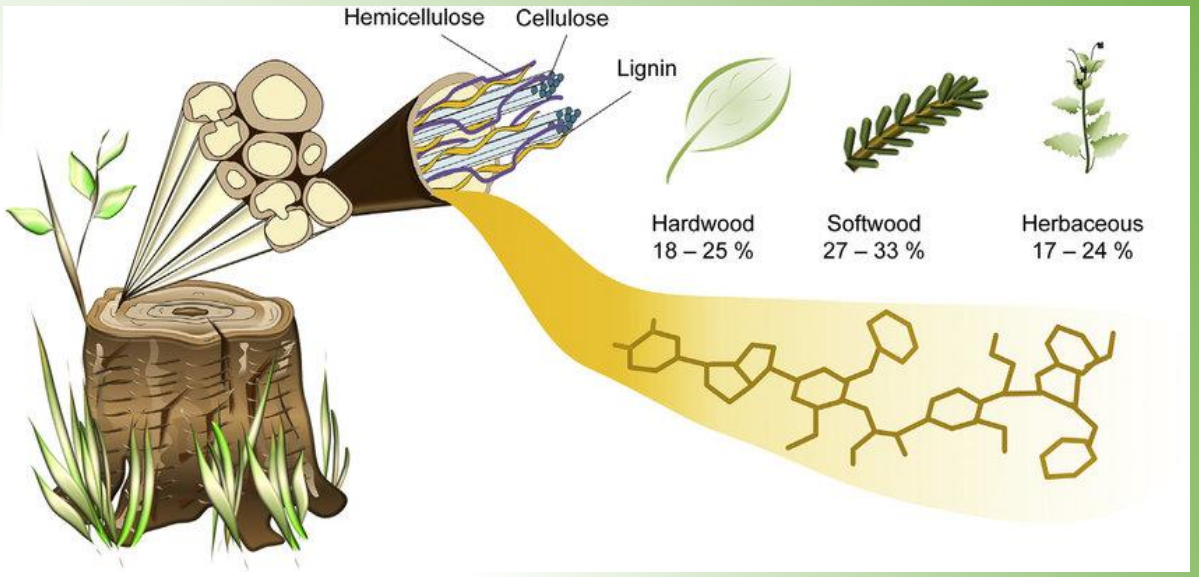
Lignin makes up approximately **20–35% of the plant biomass**

- The most abundant **natural resource of bioaromatics**

- The total lignin amount present in the biosphere exceeds **300 billion tons and increases by approximately 7% every year**

- The main source of lignin is the pulp and paper industry, the material usually being discarded by sawmills.

Lignin: : Lignin is one of the main components of wood, along with cellulose and hemicellulose:
it is the second most abundant renewable biopolymer on Earth, after cellulose.



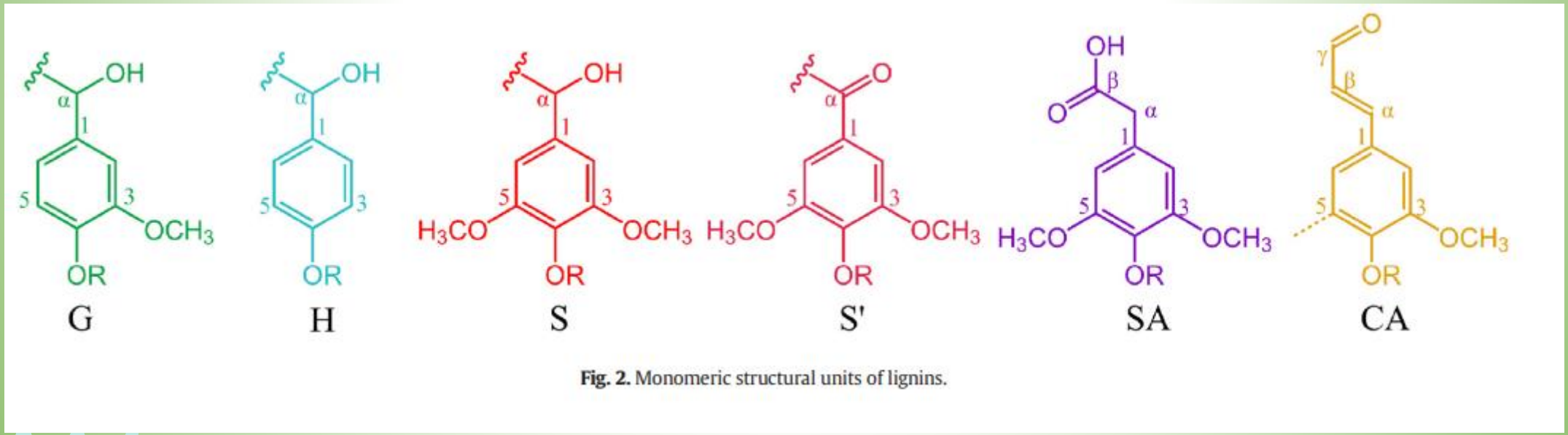


Fig. 2. Monomeric structural units of lignins.

V.A. Belyy et al. / International Journal of Biological Macromolecules 128 (2019) 40–48

Where Waste Vegetable Oil Is used after Cleanup?

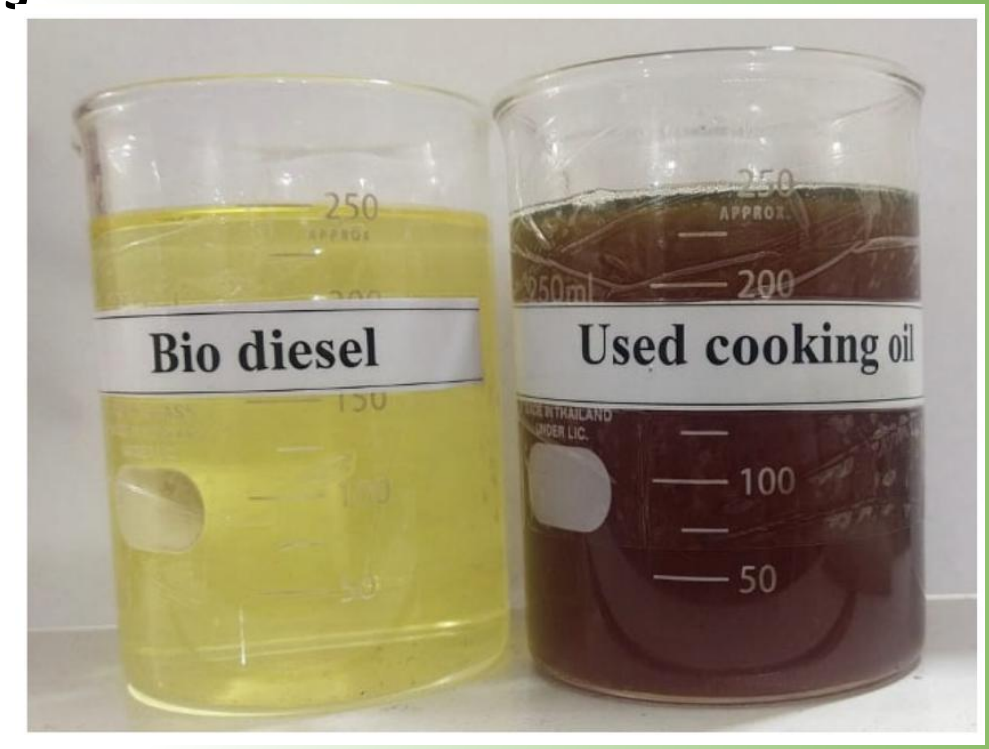
Converted into biodiesel for use in cars, trucks, and buses

Transportation

Chemical Industry

Agriculture

Cosmetics & Personal Care



Its economic viability is assessed

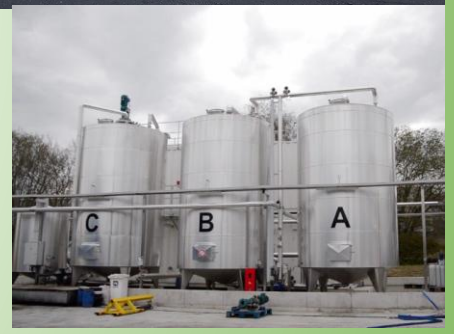
How can we find other ways to valorize Waste Vegetable Oil (WVO)?

Energies DOI:10.3390/en15249534

Bio binders are gaining prominence as sustainable alternatives to traditional petroleum-based asphalt and concrete.

Valorization of used cooking oil

Production of biodiesel



To promote the application of bio-materials and provide development, we need further researches, and new solutions :

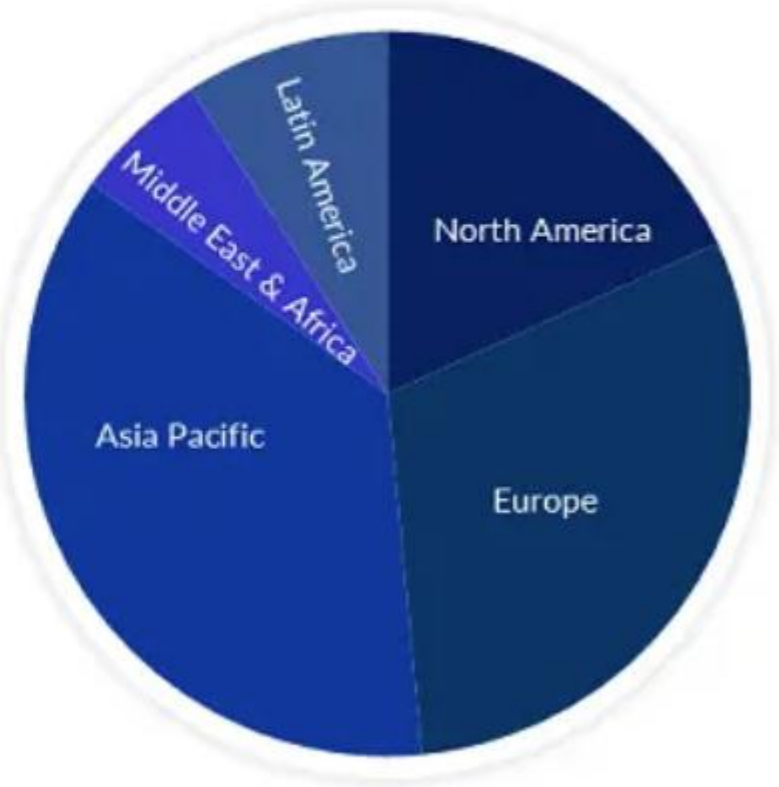
https://www.linkedin.com/pulse/biobinder-bioasphalt-mixtures-overview-our-recent-davide-lo-presti

Lignin and vegetable oils in concrete : towards the vegetable concrete (low CO2 emission)

Waste lignin

Waste vegetable oils

Global Lignin Market Share (in %), Segmented by Region, 2036



- Choice of materials and bio based materials
- Production process
- Choice of analysis and characterization techniques
- Carrying out the tests on Bio Asphalt, and Bio Concrete
- Design aspects
- Environmental Impact Assessment Protocol
- Search for companies and partners in the region.

News / 08/12/2020

Lignin replaces bitumen in all layers

Bio-asphalt road in Vlissingen put into use

No Comments

Commissioned by North Sea Port, contractor H4A has constructed a sustainable road in Vlissingen of which the bottom layer, the intermediate layer and the top layer all consist of biobased asphalt.

Editorial office / Vlissingen

road section made of a bio-asphalt with a plant-based lignin binding agent, which offer a CO_2 reduction in road building.

RVO awards Avantium substantial subsidy

Half a million euros for lignin production for biobased asphalt

Delfzijl

Chemical company Avantium announced that it has received a € 0.5 million grant for its participation in the CHAPLIN XL project

→ **Production of biobased asphalt, in which fossil bitumen is replaced with lignin.**

→ **Allowing for a significant reduction in the carbon footprint of road construction."**

Lignin is a main component of woody biomass and is very suitable for energy generation. It has been produced since 2018 in the pilot biorefinery of Avantium in **Delfzijl.**

Design aspects

Démonstrateur - Nouveau bitume et bitume réemployé
Modélisation - Maquette échelle 1/20e

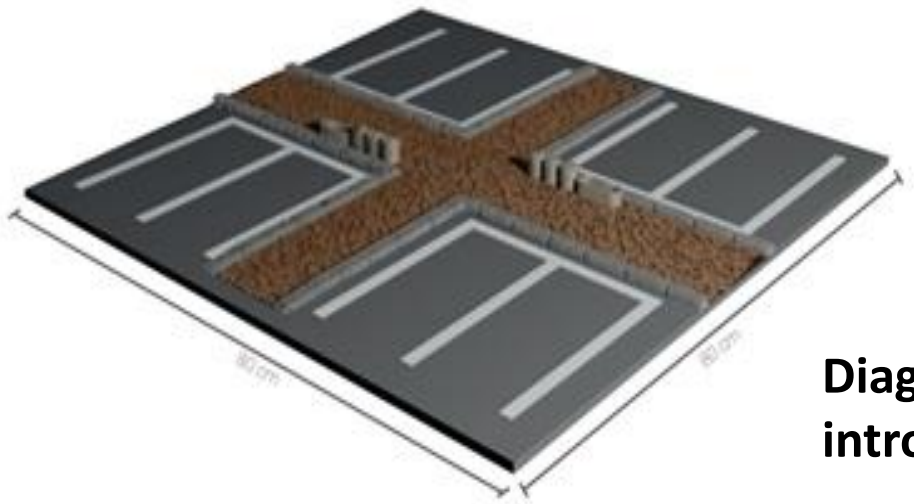


Diagram for creating 8 parking spaces by introducing lignin and vegetable oil waste.

Cette maquette présente l'aménagement de huit places de stationnement, réalisées avec une dalle coulée dans le matériau innovant développé par l'équipe de l'IMT Nord-Europe dans le cadre du projet B.B.O.B.B. Au centre, un cheminement est recouvert de copeaux de lignine. Le long de ce parcours, des éléments de mobilier suggèrent des formes d'assises ou de jardinières.

Dans un scénario prospectif, le nouveau revêtement mis au point par l'IMT pourrait remplacer le bitume conventionnel. Se pose alors la question du devenir des déchets de bitume issus des chantiers. Nous proposons d'envisager leur transformation en mobilier urbain, conçu pour résister aux conditions extérieures, en utilisant un béton de chanvre dans lequel seraient incorporés des fragments de bitume, créant ainsi un nouveau type de terrazzo. Une deuxième option proposant d'intégrer directement de la paille de chanvre dans un mélange de bitume de réemploi servant de liant est également une piste qui sera testée les 6 et 7 octobre par maquette.




Tests carried out by designers on the behavior of bio-based asphalt in furniture

LINGNIN AND WASTE VEGETABLE OIL (WVO) IN CONCRETE

STUDY OBJECTIVES

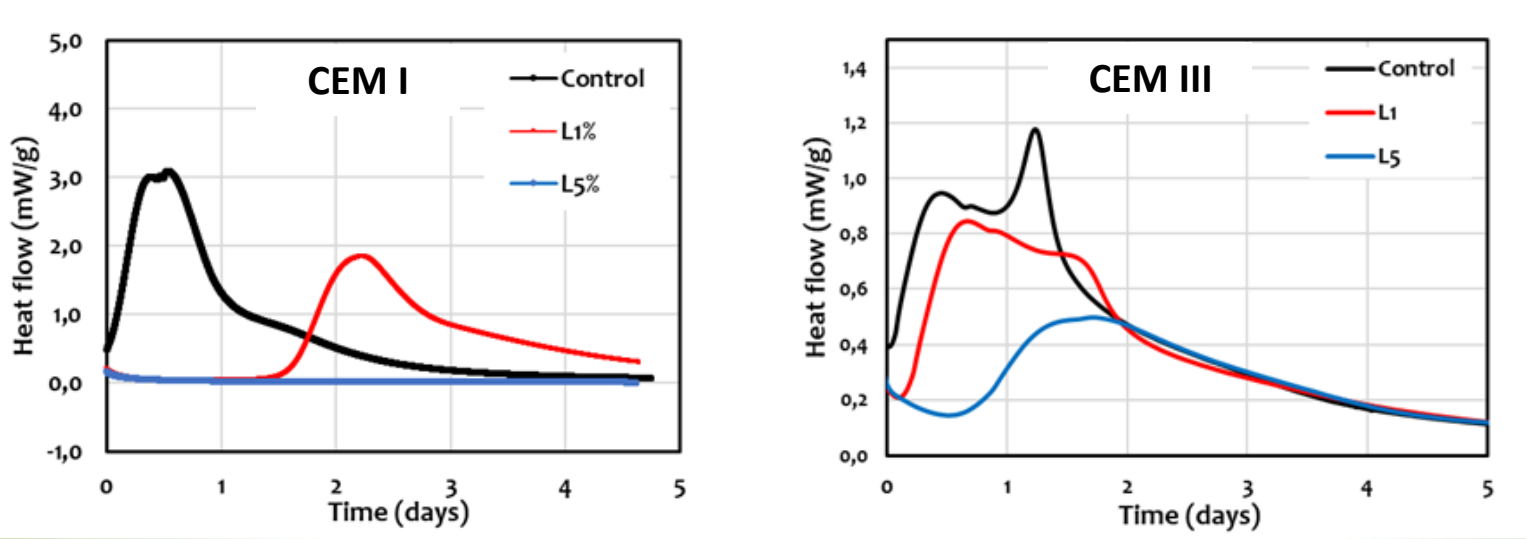
Evaluate the effect of incorporating **lignin** and **oils waste** on the properties of **cementitious materials**

- **Pastes:** hydration, workability, strength
- **Microstructure:** XRD, ,ESEM, TEM, Micro and Nano Analysis TGA, porosity
- **Concrete:** mechanical, durability, thermal behavior

⇨ Multi-scale evaluation to define valorization limits

PRELIMINARY STUDY

➢ Lignin

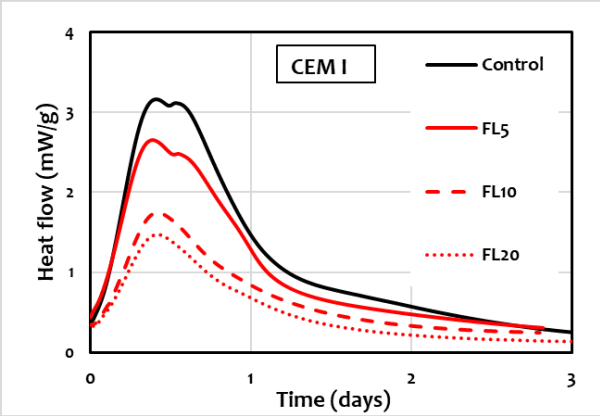


- CEM I : Lignin ≥1% strong hydration delay; nearly complete inhibition.
- CEM III : Hydration peak persists even at 5% lignin thanks to slag activity.

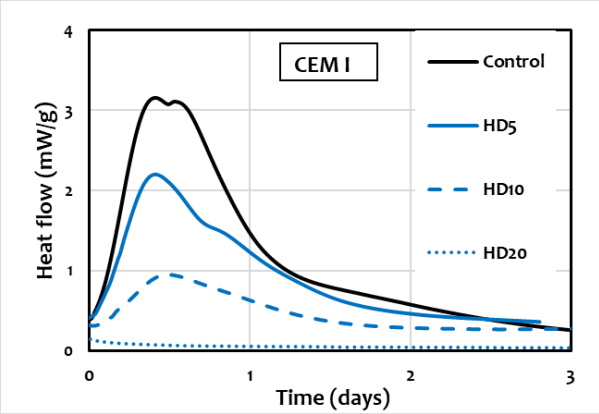
→ Slag makes CEM III more tolerant to lignin than CEM I.

PRELIMINARY STUDY

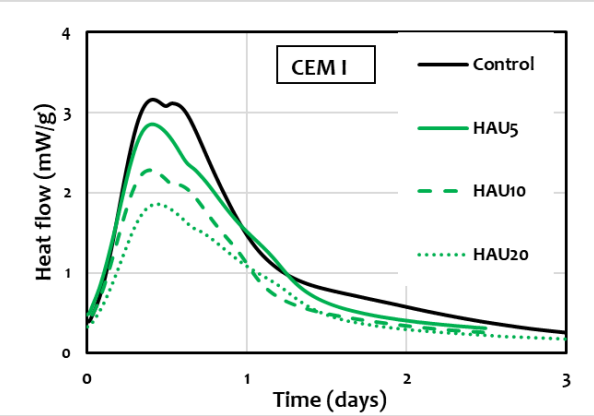
➢ Oils



Fat Lutosa



Degraded Oil



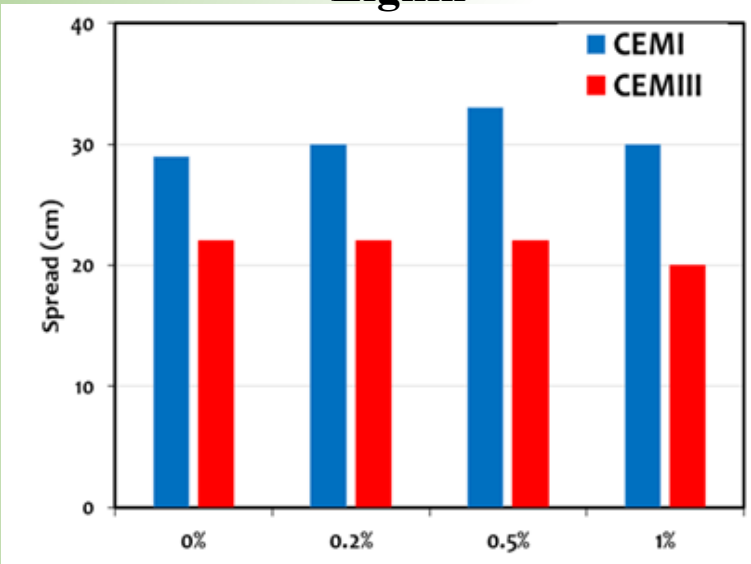
HAU Process

- **All oils reduce hydration**, with stronger inhibition at higher dosages.
- **HAU is the least inhibiting** and remains reactive even at 20%.
- Mechanisms: **hydrophobic barrier** + reduced dissolution/nucleation.

ANALYSIS OF EFFECTS

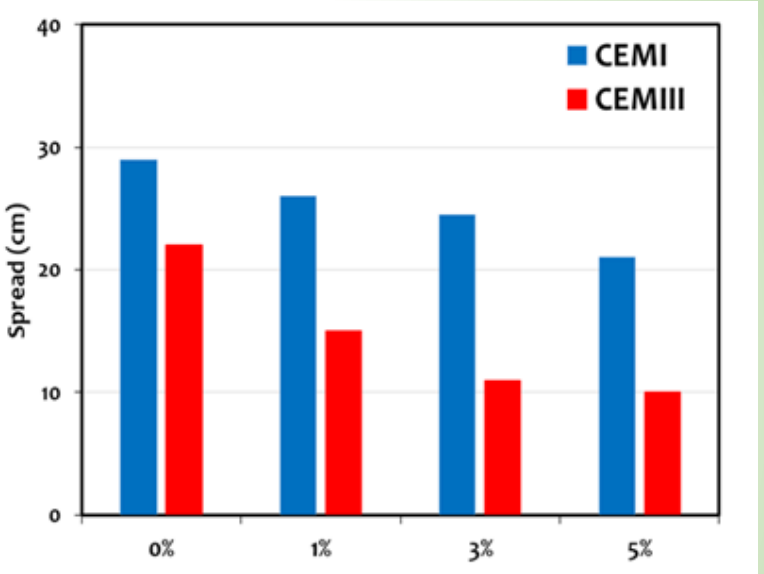
➢ Effect on Workability

Lignin



- Neutral plasticizing effect

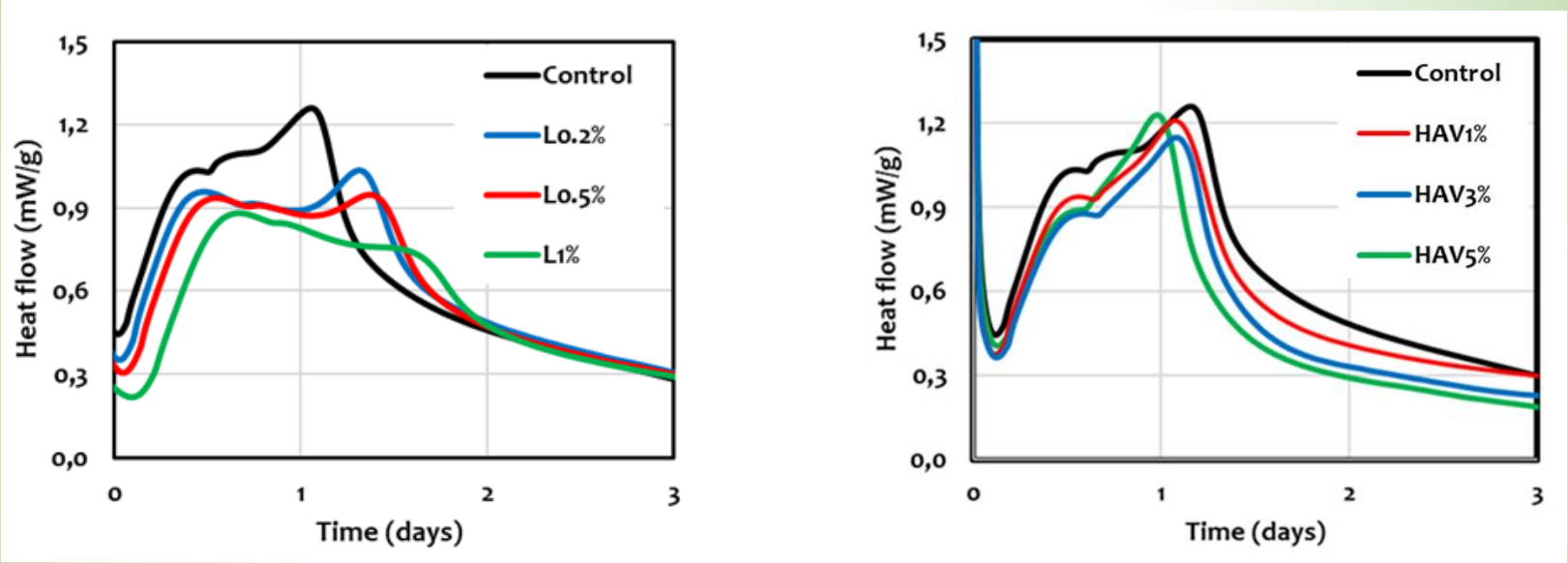
WVO



- Significant decrease in spread flow.
- Total loss of fluidity with CEM III at 5%

ANALYSIS OF EFFECTS

➢ Effect on Hydration

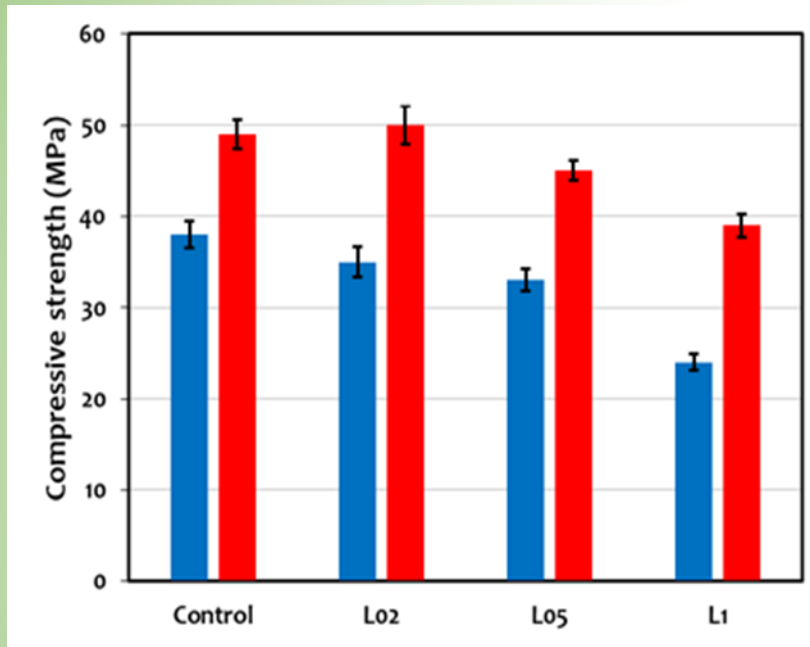


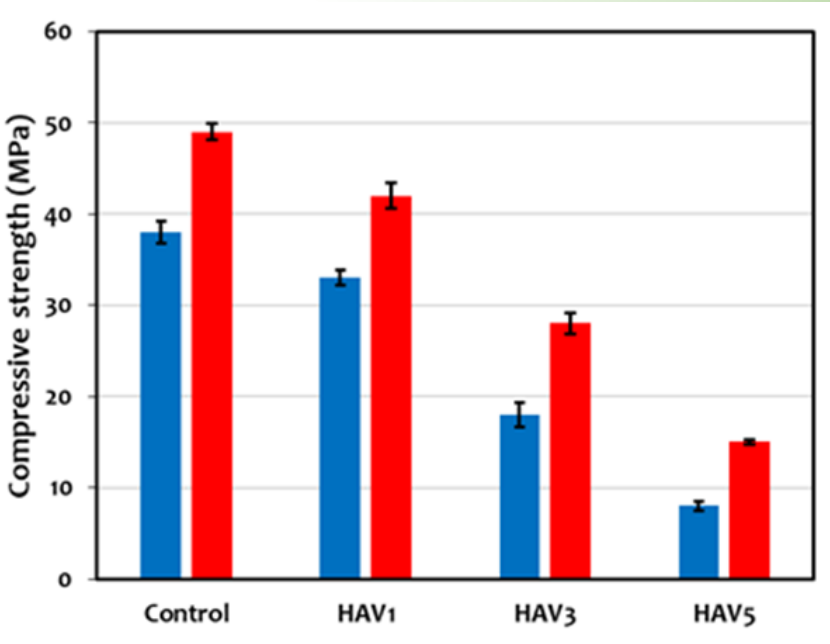
- Lignin: Progressive delay and reduction of the hydration peak with dosage
- HAU oil: Moderate reduction of peak intensity even at higher dosages

→ Lignin affects hydration much more severely than HAU oil.

ANALYSIS OF EFFECTS

➢ Effect on compressive strength



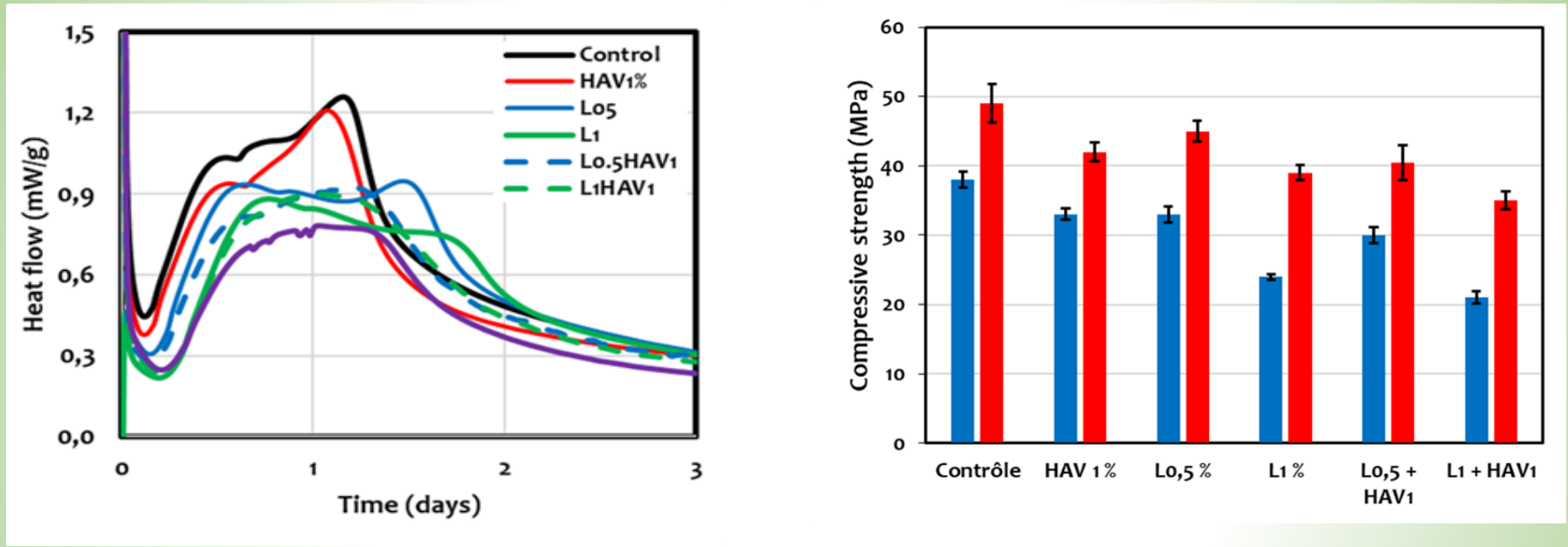


- Progressive strength reduction.
- Acceptable performance up to 1%

- Stronger reduction for high rates
- Air entrainment → increased porosity

ANALYSIS OF EFFECTS

➢ Combined Effect of WVO Oil and Lignin



- No negative synergy: effects simply add up.
- Compressive strength decrease corresponds to the sum of individual impacts

PERSPECTIVES

Microstructural Analysis:

- Complete XRD,ESEM, TEM, Micro and Nano Analysis TGA, and porosity measurements.

Concrete-Scale Assessment:

- Evaluate fresh properties, strength, and durability.
- Measure thermal conductivity.
- Validate optimal incorporation rates.

LINGNIN AND WASTE VEGETABLE OIL (WVO) IN GREEN ASPLHALT

Lignin

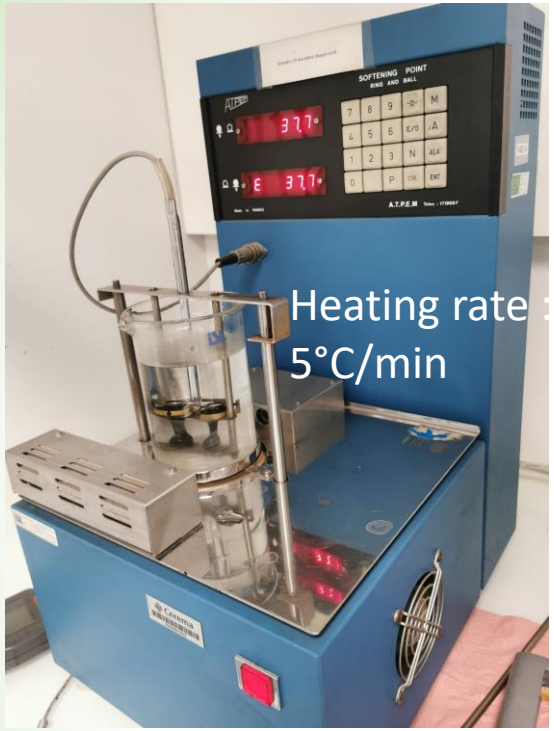
Waste cooking oil

Valorization of used cooking oil

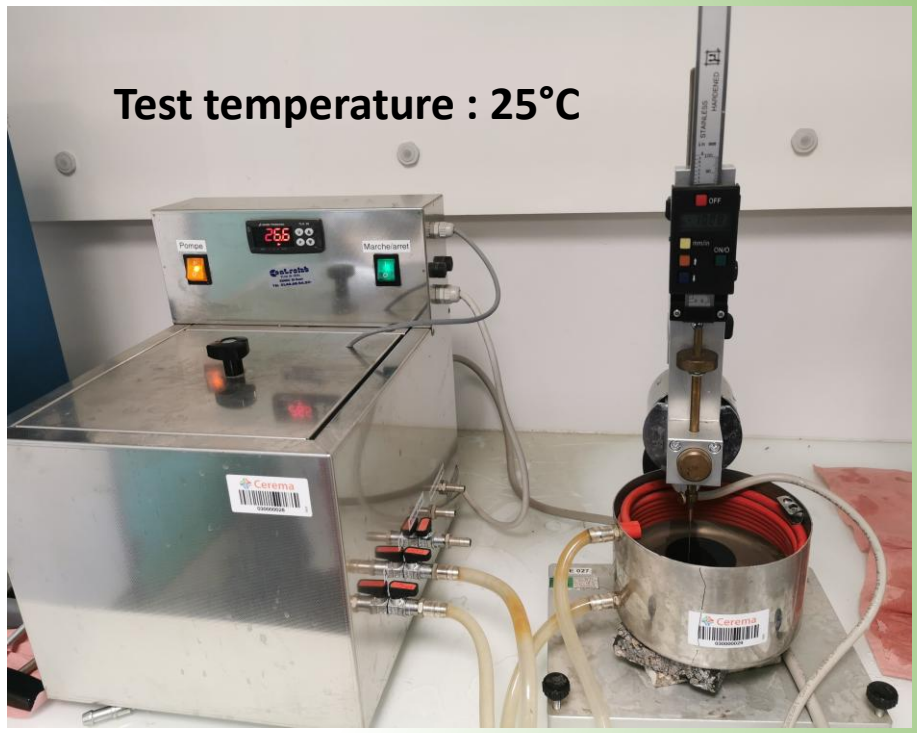
Bitumen

conventions properties of binders for mix and road pavement design

3 minutes mixing of bitumen + waste cooking oil



- Assessment of the softening temperature of binders



Assessment of the penetration grade of binders

Property	Testmethod	Unit	20/30	35/50	50/70	70/100	160/220
Penetrability at 25 °C	EN 1426	0,1 mm	20 – 30	35 – 50	50 – 70	70 – 100	160 – 220
Softening point	EN 1427	°C	55 – 63	50 – 58	46 – 54	43 – 51	35 – 43

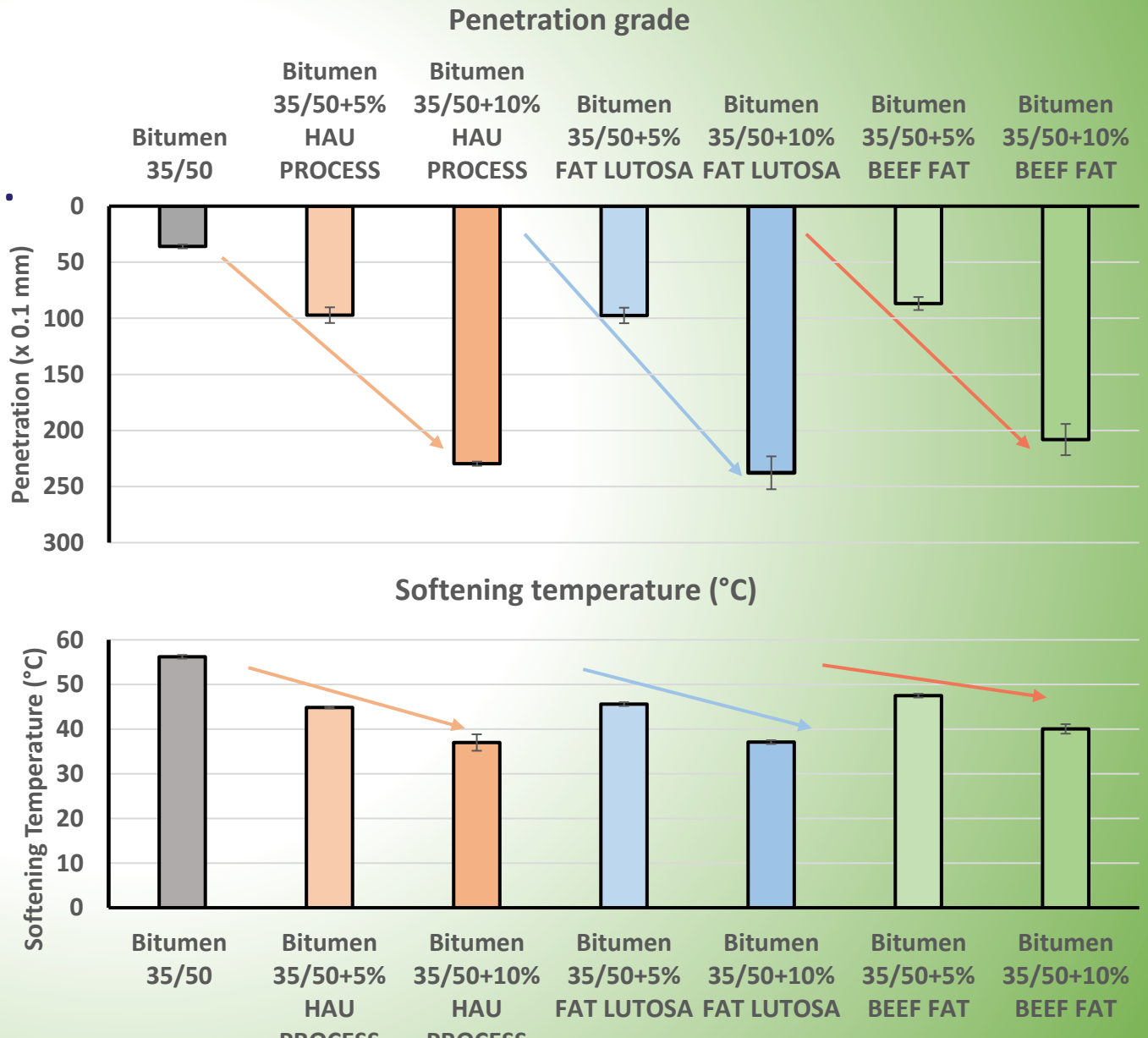
Target penetration grade possible for roads design with reclaimed asphalt

Target penetration grade for roads design

1st investigations : Convention tests on bituminous binders

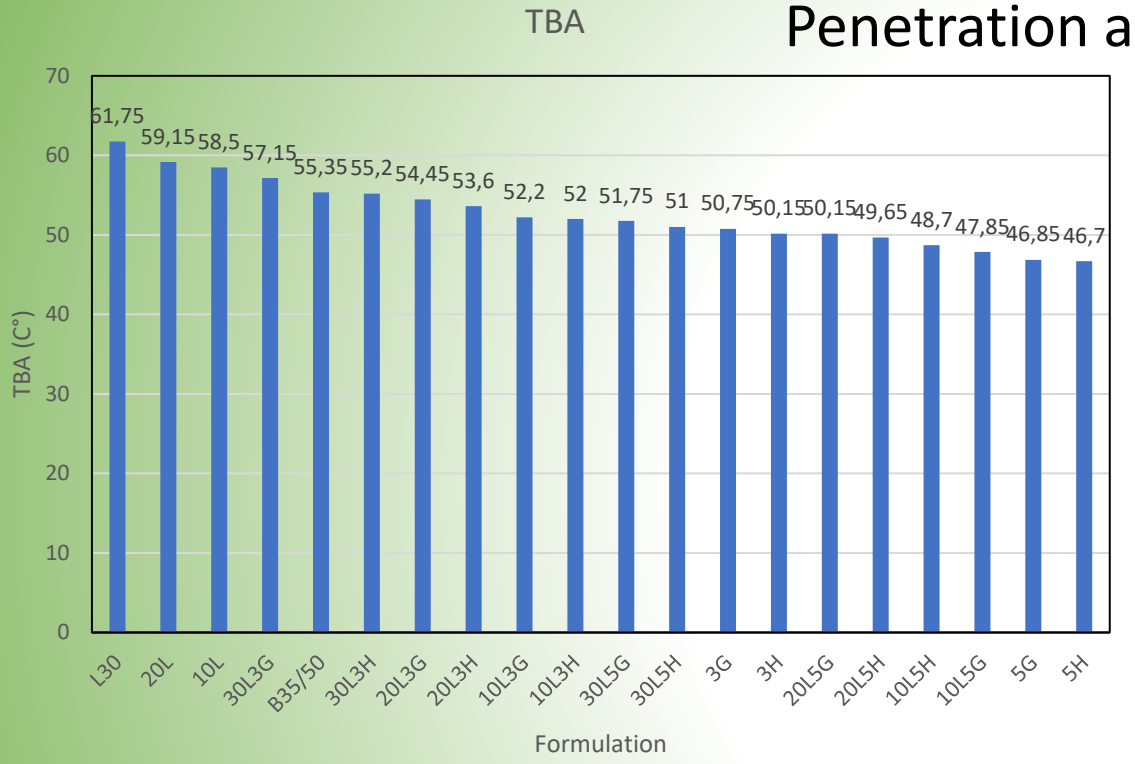
- Increasing the residue content results in the softening of bitumen.
  - i.e increase of the penetration grade
  - leading to a change in the bitumen grade from 35/50 to 70/100 and 160/220 according to the waste cooking oil content

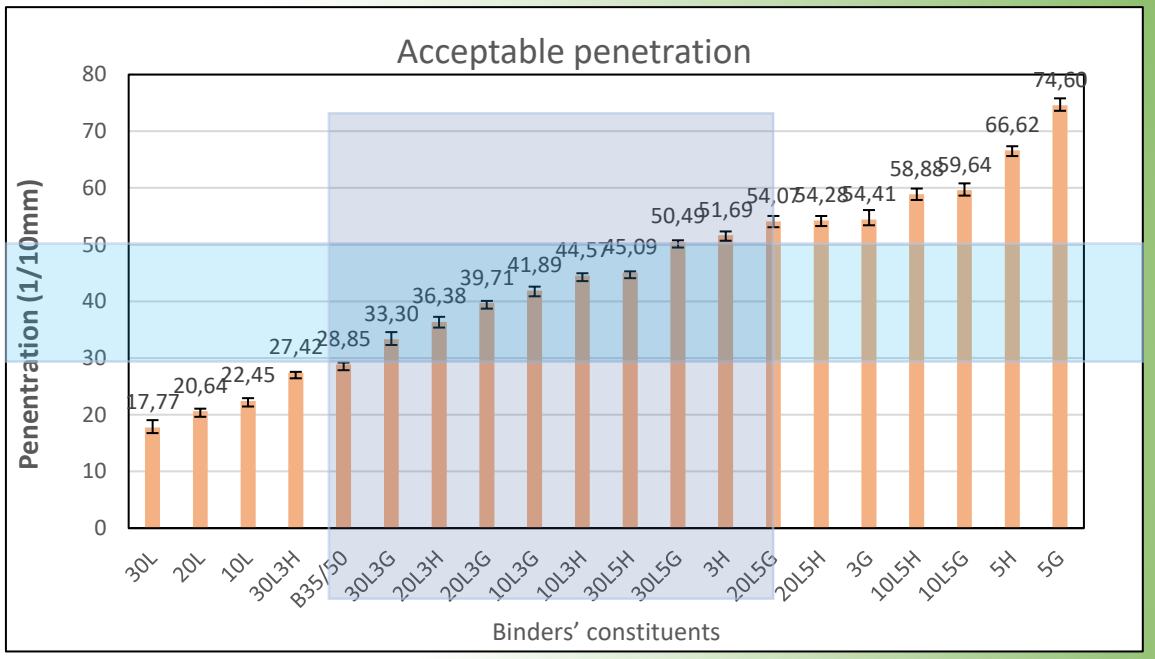
- Increasing the residue content results in the decrease of the softening temperature bitumen.



2nd Binders' formulation

Penetration and softening temperature

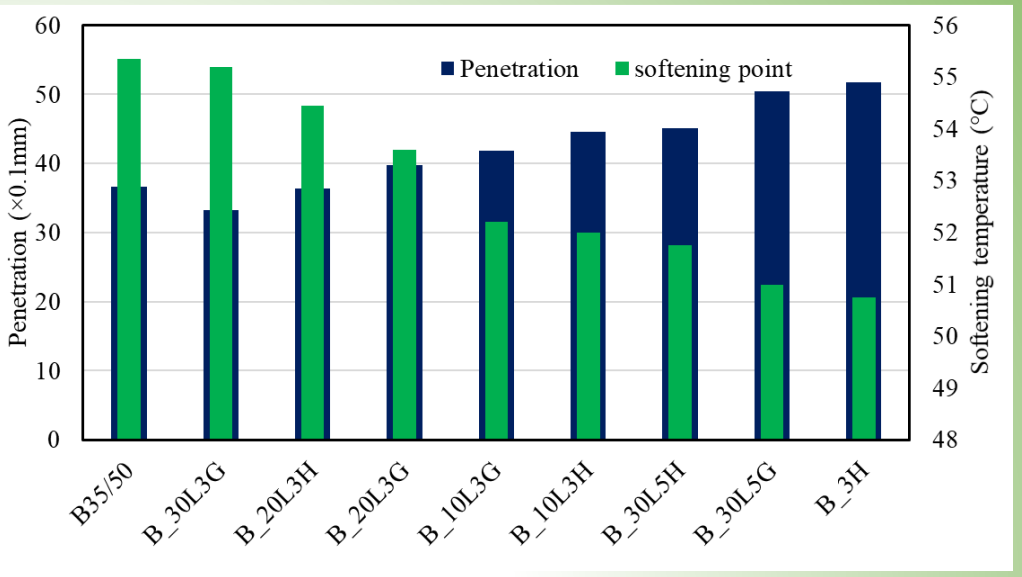


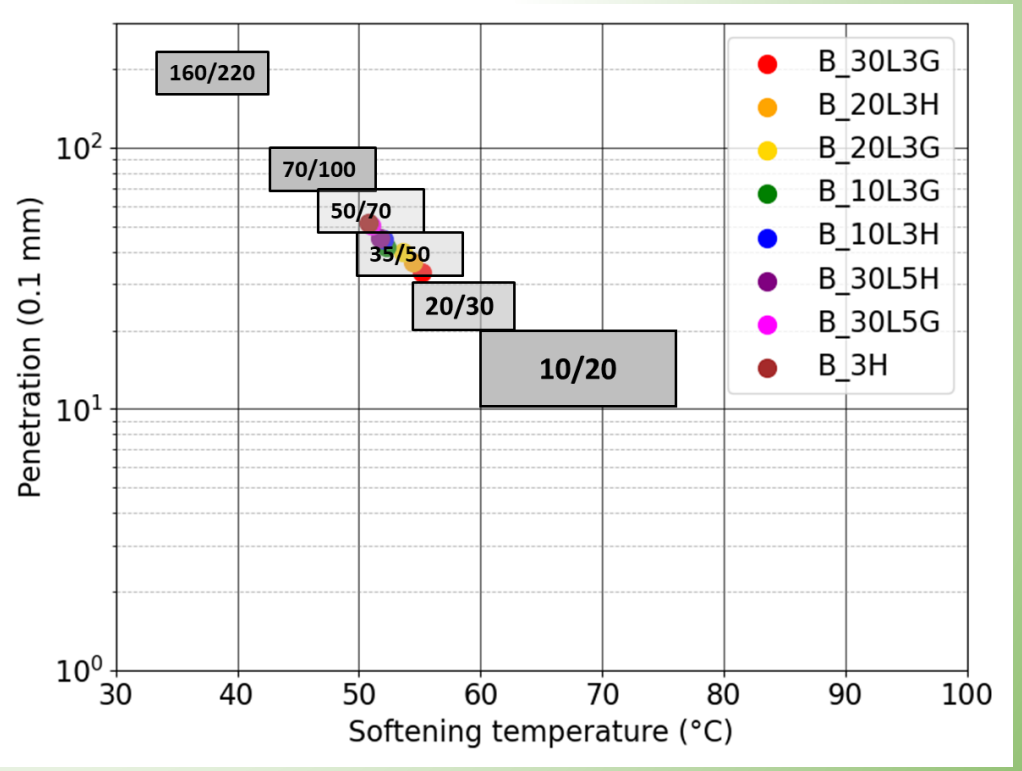


- Nine formulations exhibit an average penetration within the acceptance range (blue zone), thereby complying with the specified requirements.
- Among these nine formulations, the last two (30L5G and 30L5H) are located near the upper limit of the acceptance range.

Selection of ideal Binders’

Properties	Lignin content	Waste cooking oil content
Neat bitumen	-	-
B_30L3G	30% of lignin	3% of Beef fat
B_20L3G	20% of lignin	
B_10L3G	10% of lignin	
B_20L3H	20% of lignin	3% of Hav Process
B_10L3H	10% of lignin	

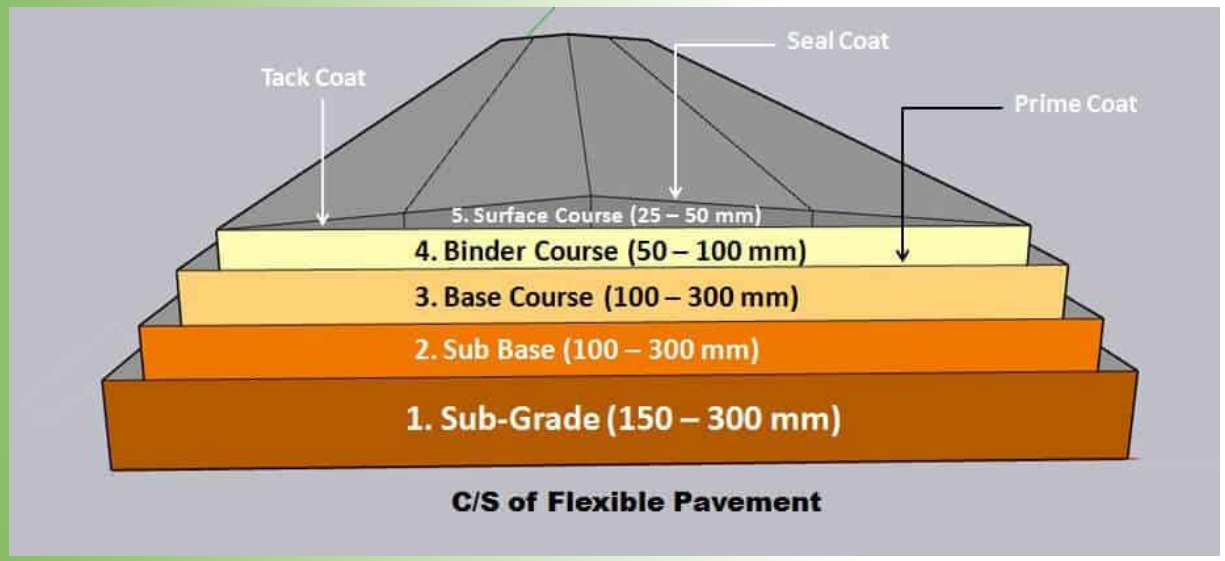


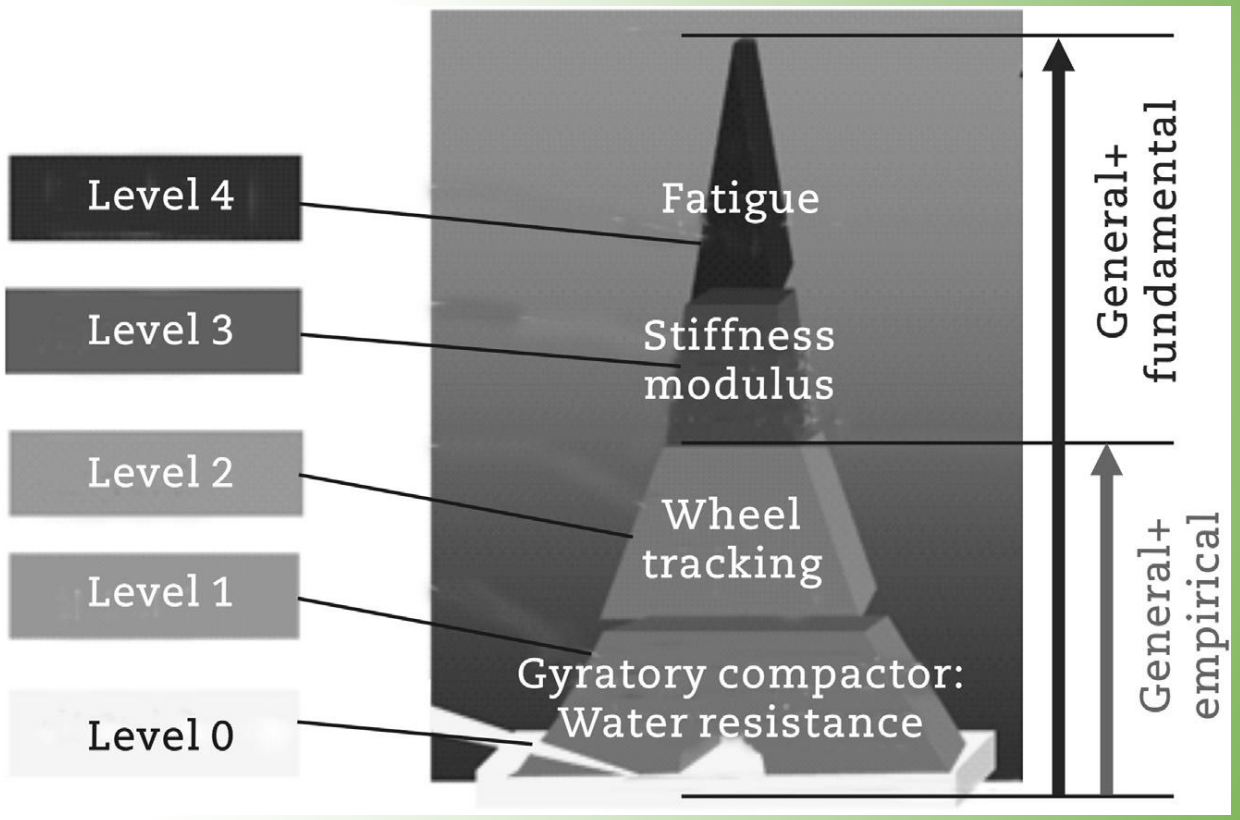


- The penetration–softening point diagram shows that all bio-based binders fall within the conventional 35/50–50/70 grade range.
- B_30L3G and B_20L3H appear to offer the most suitable balance between mechanical strength and temperature susceptibility, making them promising candidates for structural pavement applications.

Pavement design

Pavement structure



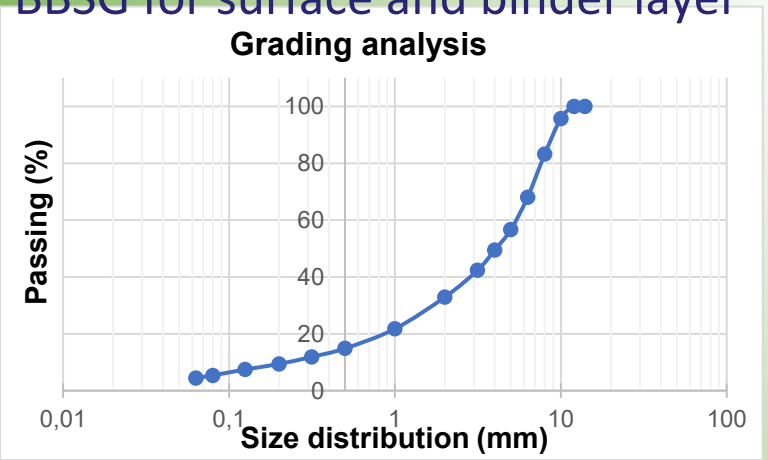


Mixture production and specimens compaction

Malaxage

Giratory compaction (PCG)

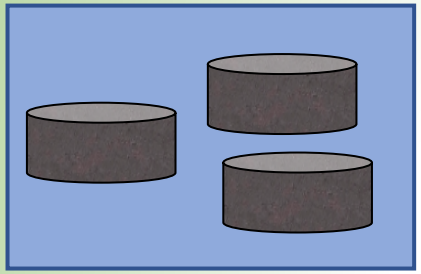
BBSG for surface and binder layer



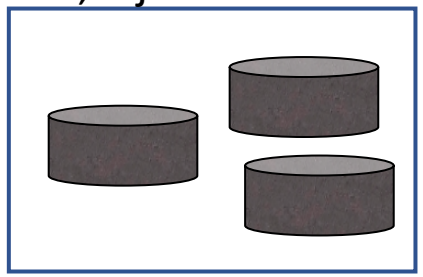
Water sensitivity assessment

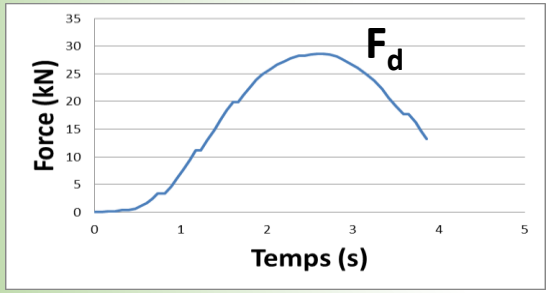
Water sensitivity & indirect tensile strength

40°C, 3 jours dans l'eau



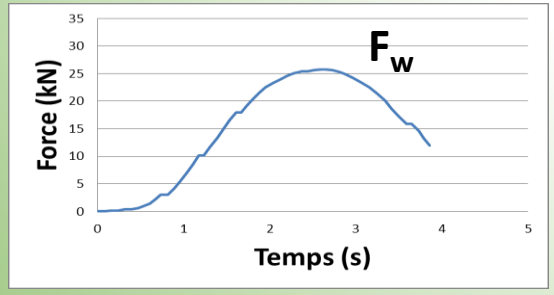
40°C, 3 jours dans l'air





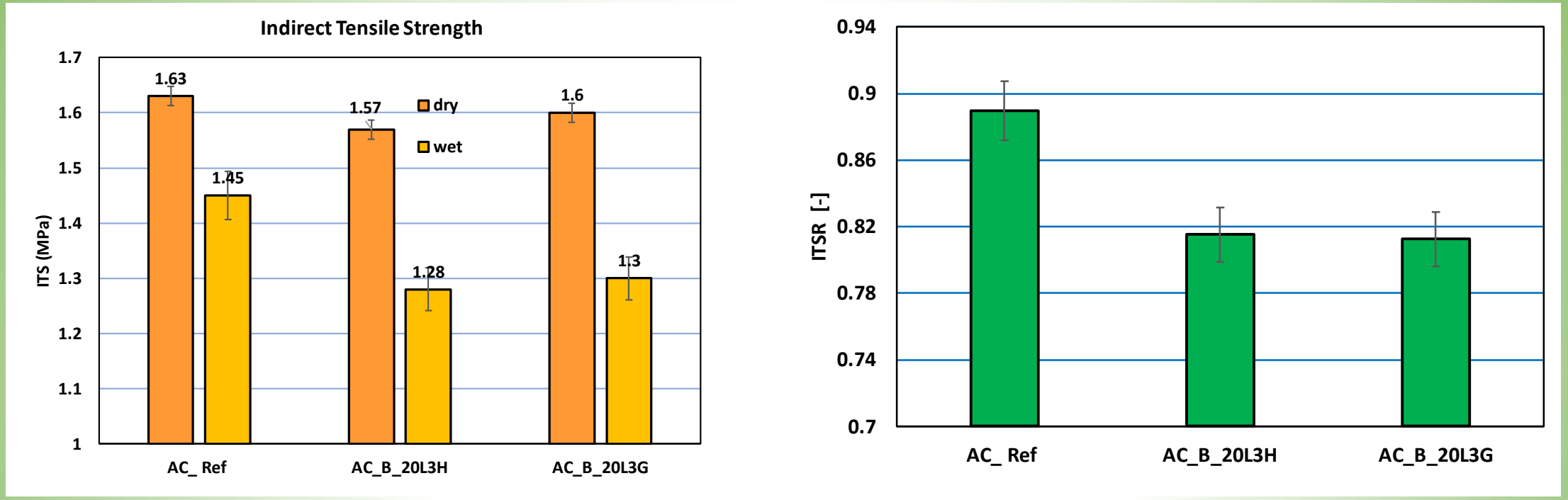
- ITS_d

$$ITSR = 100.\frac{ITS_w}{ITS_d}$$



- ITS_w

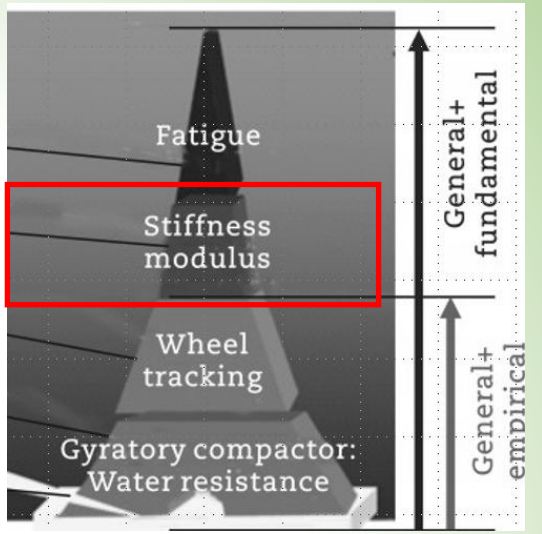
Water sensitivity assessment

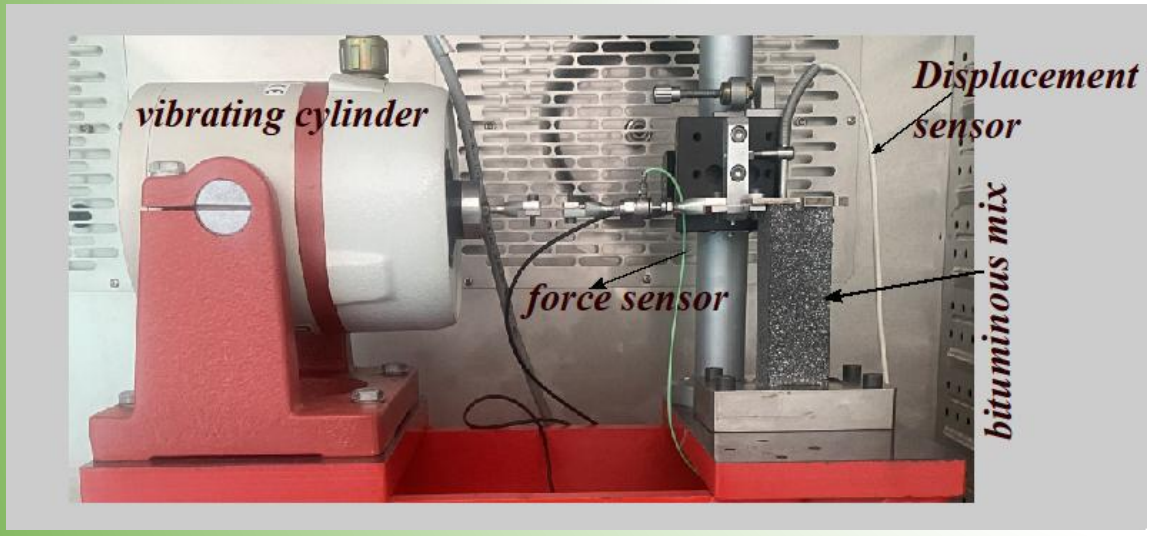


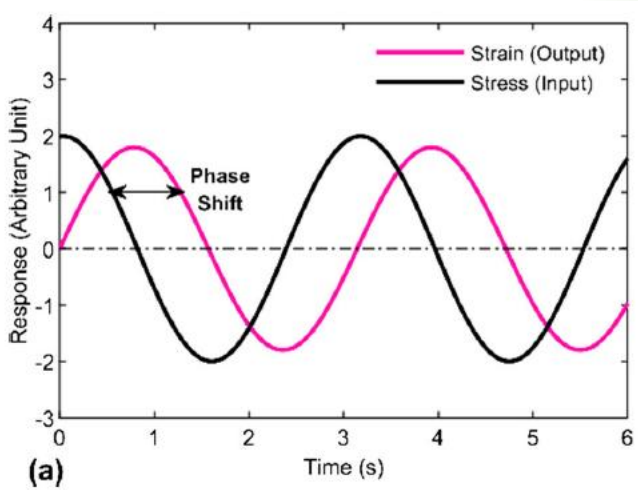
- The results represented indicate a slight decrease in indirect tensile strength (ITS) for mixtures containing the B_20L3H and B_20L3G binders compared with the reference mix (AC_ref).

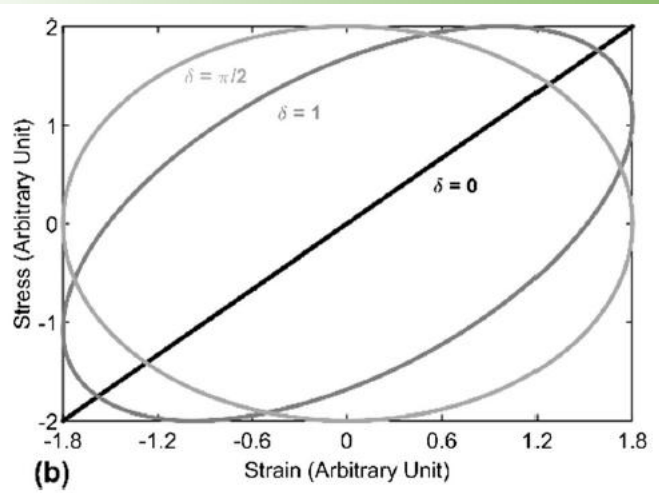
- Nevertheless, the measured indirect tensile strength ratio (ITSR) values remain above the 0.7 threshold, thereby meeting the standard requirements for this type of material.

Stiffness modulus assessment

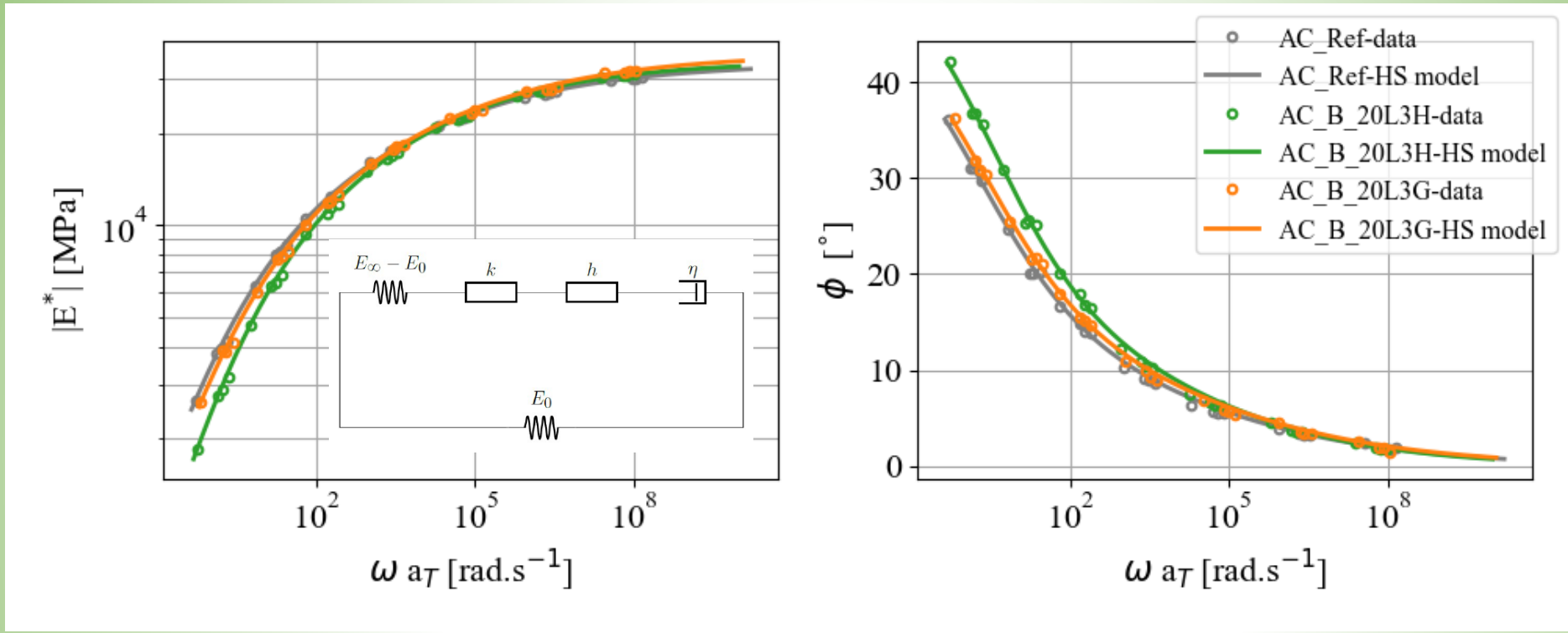








Stiffness modulus assessment



- The results indicate that the reference mixture (AC_ref) exhibits a slightly higher stiffness than the bio-modified mixture B_20L3H, while the difference is more pronounced for AC_B_20L3G;
- The phase angle (ϕ) evolution confirms this trend, with the highest values obtained for AC_B_20L3G;
- This suggests that the incorporation of waste oils, especially AC_B_20L3H, effectively reduces mixture stiffness.