ROAD PAVEMENTS FORUM

Exploring Technical Lignins for Sustainable Pavement Materials: From Imported Additives to Local Innovation

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Lignin, what is it?

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- Biopolymer found in the cell walls of plants
- Present in spent pulping liquors - waste streams from the paper and pulp industry
- Chemical and physical characteristics impacted by parent material (hard vs softwood), pulping process, and subsequent processing
- Not widely valorised due to chemical complexity and low reactivity
- Literature has shown potential as a partial substitute for bitumen (i.e. bitumen extender)

Lignin, what is it?

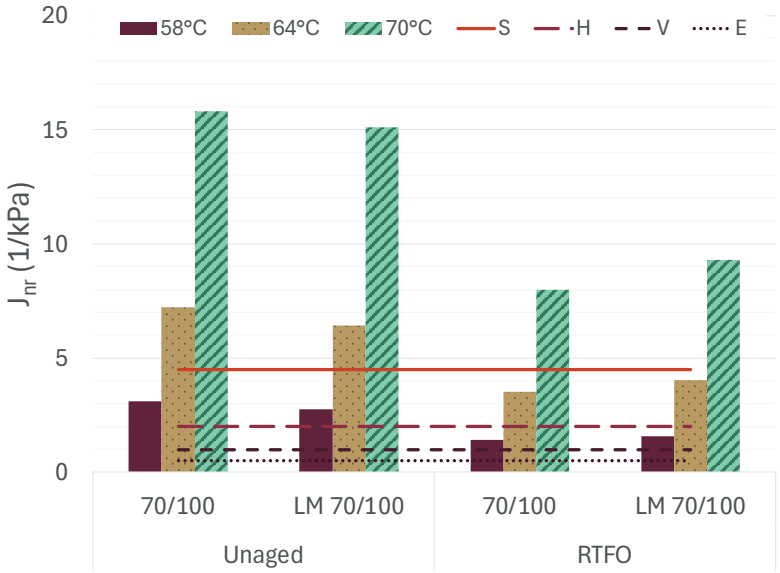
- Classification varies depending on the pulping process
- These byproducts are referred to as ***technical lignins***
  - Kraft: hydrophobic; moderate sulphur content (1-3%); most common
  - Lignosulfonates: classified by counter-ion; high sulphur content (3-8%); amphiphilic, water-soluble; 90% of commercial lignin
  - Soda: hydrophobic; sulphur-free
  - Organosolv: hydrophobic, high-purity, sulphur-free
- Industrial applications vary by type: fuels, polymers (resins, fibres), binders (adhesives, surfactants, concrete admixtures)…

Exploring the impacts of calcium lignosulfonate (CLS) on asphalt

CLS as a bitumen extender

(Murphy, 2024)

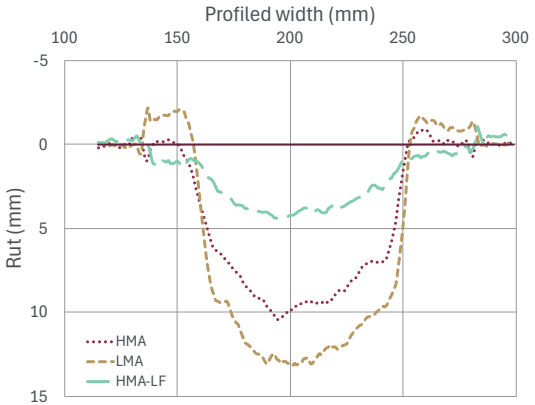
- Wet addition -> 20% by mass

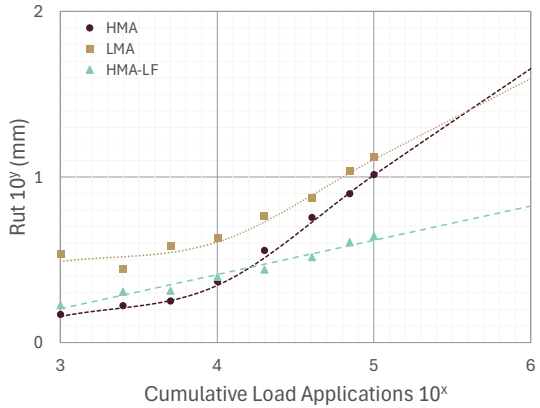


CLS as a filler in asphalt

(Murphy, 2024)

- Dry addition -> 0.4% by mass (equivalent to volume of 1% cement)

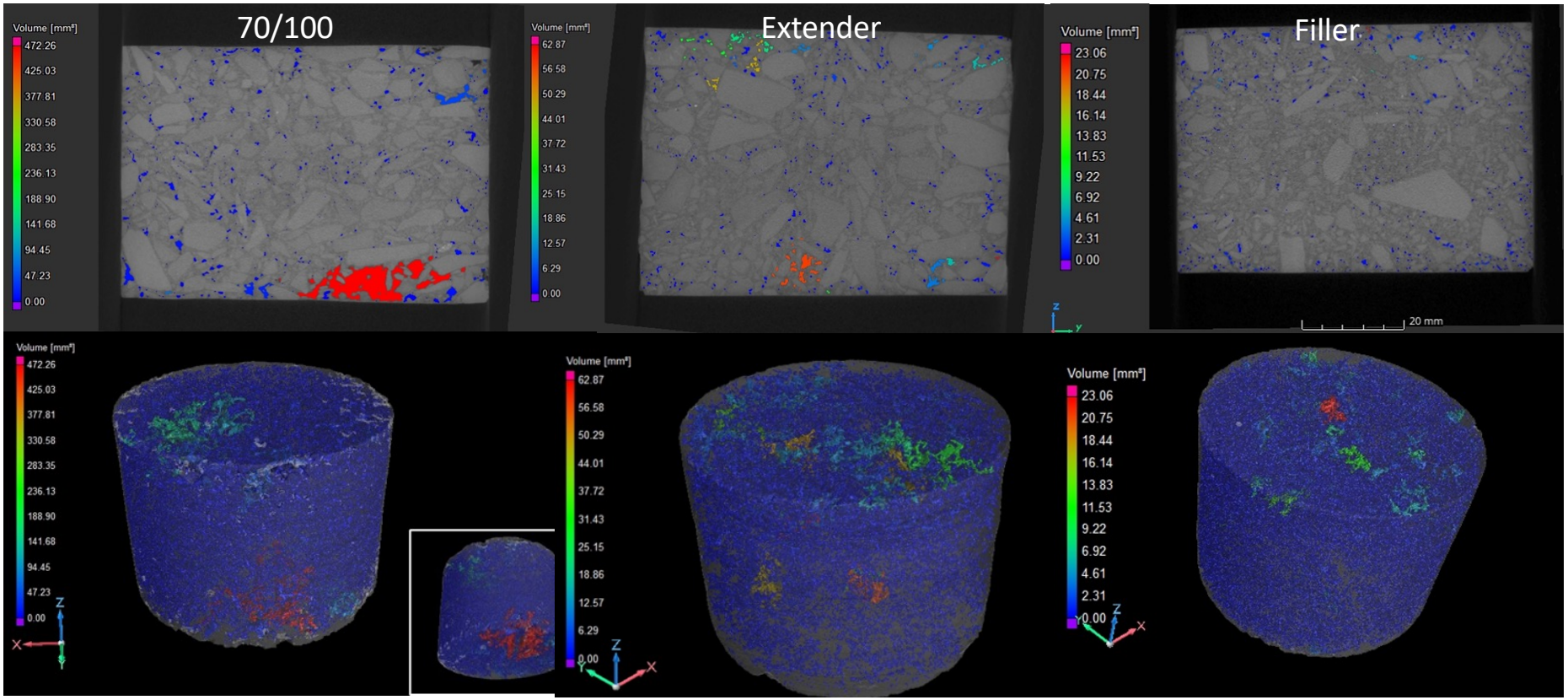




Asphalt Mix Type	P_b (%)
S-HMA	4.98
LMA	5.59
HMA-LF	5.06

CLS, extender or filler?

(Murphy, 2024)



CLS, extender or filler?

- From literature:
  - Extender / wet method: observed that lignin remains partially in a separate phase
  - Filler replacement / dry method: Increased binder extraction, believed to be a result of lignosulfonate assimilation into the binder
  - Suggests functions as both a partial extender and a filler in asphalt
  - Extent of integration appears to depend on the method of incorporation, solubility

E. Gaudenzi, F. Cardone, X. Lu, and F. Canestrari, 2023. "The use of lignin for sustainable asphalt pavements: A literature review," Construction and Building Materials. https://doi.org/10.1016/j.conbuildmat.2022.129773

L. Van den Kerkhof, P. Herrington, J. Wu, and W. Turvey, 2021. "Bitumen Alternatives". WSP New Zealand. Available at: https://www.nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Resource-efficiency/Research-projects/bitumen-alternatives-report-31-august-2021.PDF

Hobson, Cliff (2017). "Evaluation of lignin as an antioxidant in asphalt binders and bituminous mixtures". Kansas. Dept. of Transportation. Bureau of Research. Available at: https://rosap.ntl.bts.gov/view/dot/31856.

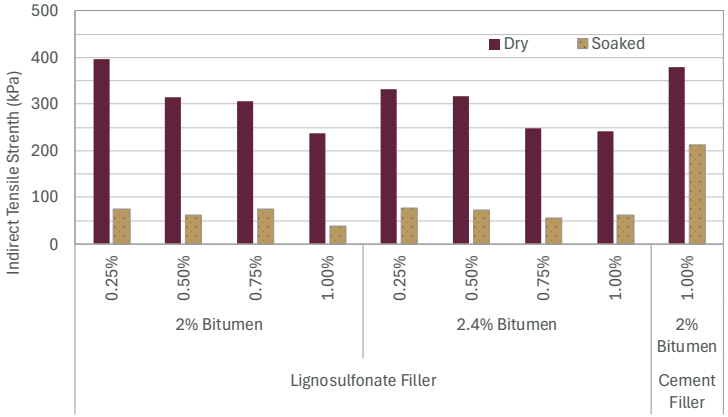
Does the positive impact extend to CLS as filler material in BSMs?

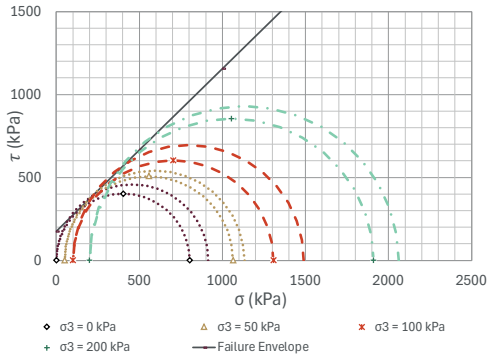
CLS as filler replacement in BSMs

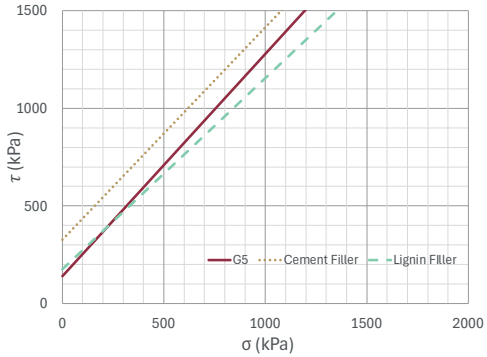
(Mbisa, 2025)

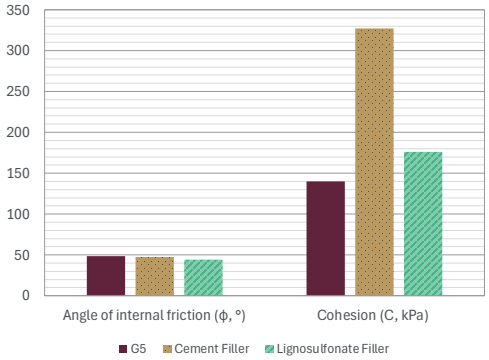
- Control: G5 base material with 2% foamed bitumen and 1% cement

Mix Design	Binder Content	Filler
Standard BSM2	2%	1%
BSM2 with bio-filler	2%, 2.4%	0.25%, 0.5%, 0.75%, 1%









CLS as filler replacement in BSMs

Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
forward together
sonke siya phambili
saam vorentoe

(Mbisa, 2025)

- Wet strength is a major challenge
- Ideas on how to improve
  - Consider longer curing times for bio-stabilisers?
  - Perhaps bitumen emulsion?

Extending the scope to South African technical lignins

SA technical lignins as extenders

(Vermeulen, 2025)

- Preprocessing: acid precipitation vs spray-dried
- Scouting tests: Blend 10% with 50/70
- Evaluate higher blending ratios for selected extender

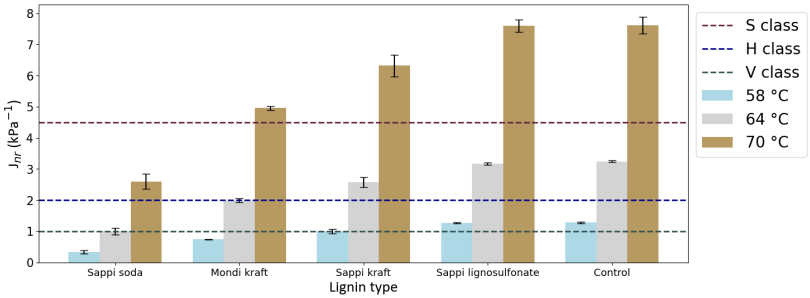
Lignin type	Biomass origin	Supplier
Kraft	Eucalyptus (Hardwood)	Sappi, Ngodwana
Kraft	Eucalyptus (Hardwood)	Mondi, Richards Bay
Sodium lignosulfonate	Eucalyptus (Hardwood)	Sappi, Tugela
Soda	Sugarcane Bagasse	Sappi, Stanger

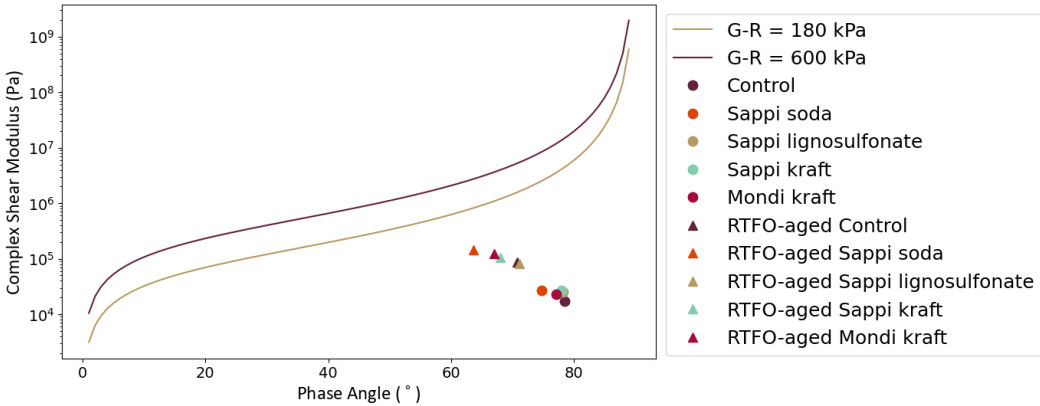
Rheology

(Vermeulen, 2025)

- Improves or maintains high temperature behaviour without significant impacts on low temperature or ageing indicators

Blend	Continuous grade
Control	64-22
Sappi lignosulfonate	65-23
Sappi kraft	65-22
Mondi kraft	65-20
Sappi soda	66-21

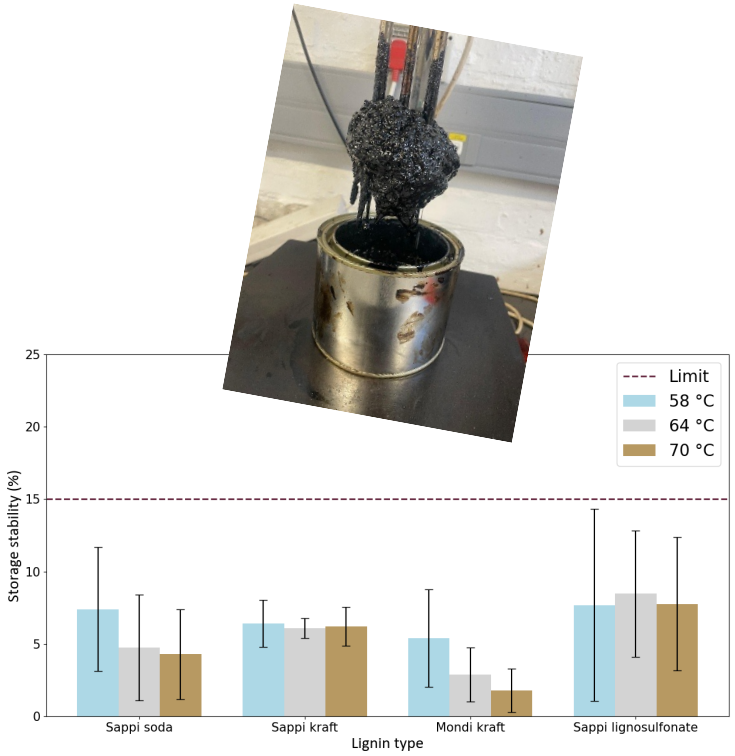




Other observations & gaps

(Vermeulen, 2025)

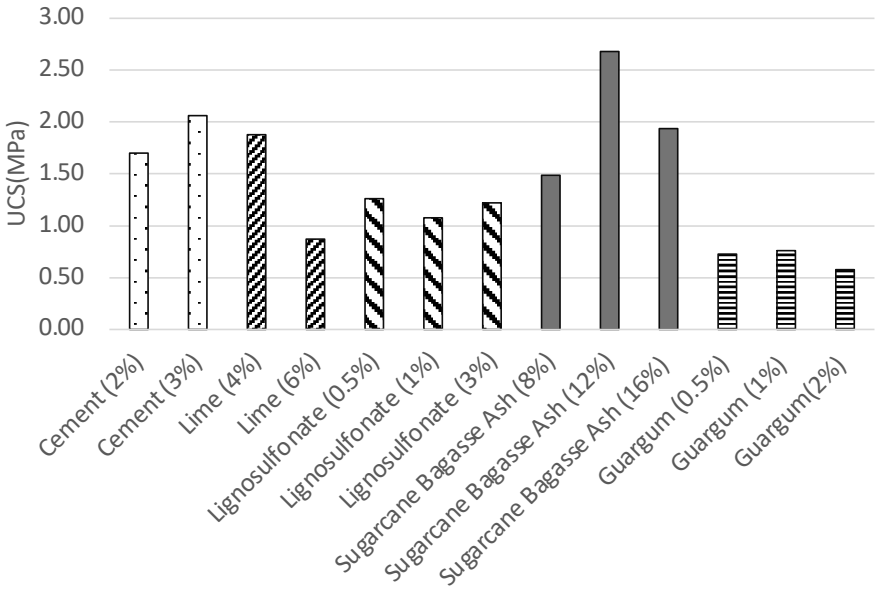
- General positive effects on both ITS dry and wet (all TSR > 80%)
- Storage stability at 10% vs phase separation challenges at higher blending ratios
- Effects of prolonged heating during shear mixing?
- Fatigue behaviour?
- Optimum ratios lignin and bitumen-dependent?

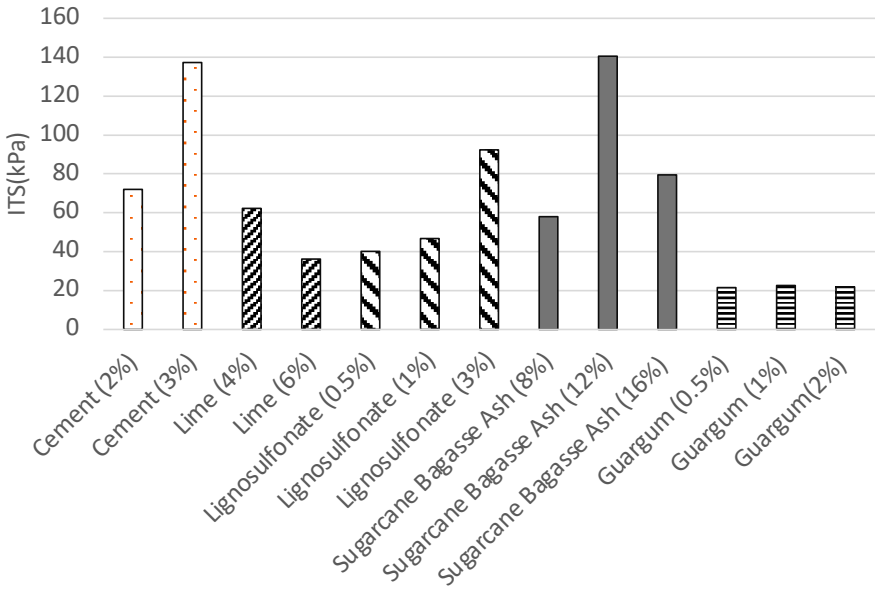


Potential as bio-stabilisers

Potential as a bio-stabiliser?

(Bosman et al, 2026)





Going forward

Recommendations

- To researchers
  - Explore the boundaries between extender and filler behaviour in asphalt
  - Rut resistance improved; evaluate fatigue behaviour
  - Investigate the impacts of curing time on strength development of bio-polymers and -stabilisers
  - Antioxidative effect in RA mixes?
- To industry
  - Work not complete, but heading in the right direction
  - Potential to develop local supply of bitumen extenders
  - Current specifications focus on strength development of traditional materials, such as cement, not biopolymers
  - Publish your work