

Low Carbon Waste-Based Geopolymer Pavements

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The Challenge

- **RAP underutilization:** Conventional rigid pavements limit RAP to 20%, leaving 80% for lower-value disposal
- **Waste clay burden:** Major infrastructure projects generate millions of tonnes of excavated clay
- **Carbon cost:** Portland cement production = 8% of global CO₂ emissions
- **Specification gap:** Current binder chemistry cannot tolerate high RAP + waste clay simultaneously without performance loss

The Geopolymer Solution

Motivation: Develop geopolymer and LC3 binder systems that enable 100% RAP incorporation and 30% excavated clay reuse, reducing virgin aggregate demand, binder carbon emissions, and landfill waste.

Overall Objectives:

- Reduce binder-related carbon emissions
- Maximize RAP and waste clay integration into rigid pavements.
- investigate possible crack repair abilities of GP-based binders

Geopolymer Mortar Design

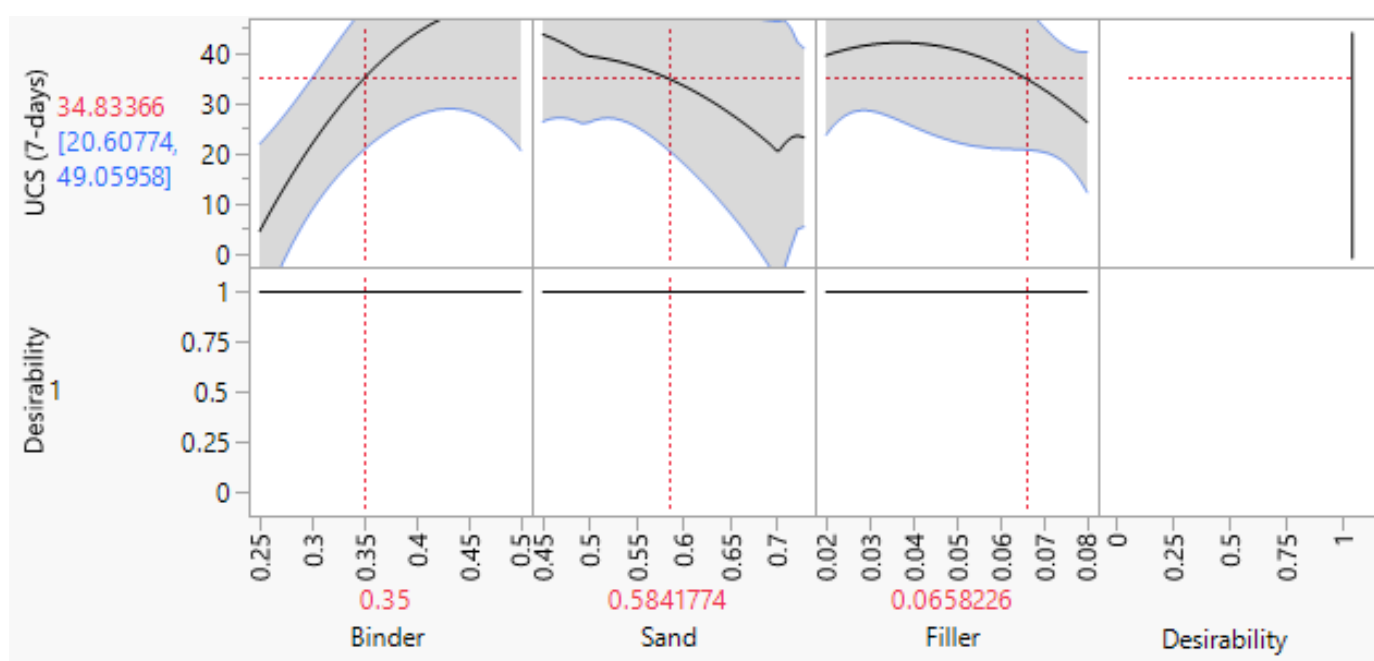


Figure 1. Mixture profiler indicating various strengths obtained for different mixture designs. The red dotted lines for instance indicate that a mortar having 35% binder, .58.4% sand and 6.5% filler will have a strength of approximately 35 MPa after 7-days curing.

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
(Binder-0.25)/0.28	36.461283	1.944778	18.75	0.0339*
(Sand-0.45)/0.28	23.039009	1.398348	16.48	0.0386*
(Filler-0.02)/0.28	-563.1383	120.8948	-4.66	0.1346
Binder*Sand	44.069442	7.016944	6.28	0.1005
Binder*Filler	805.32534	152.2973	5.29	0.1190
Sand*Filler	616.13232	153.5176	4.01	0.1555

Table 1. Binder and sand amount significantly affect UCS



Figure 2. Geopolymer mortar reference cubes @ 7 days

100% RAP Pavement

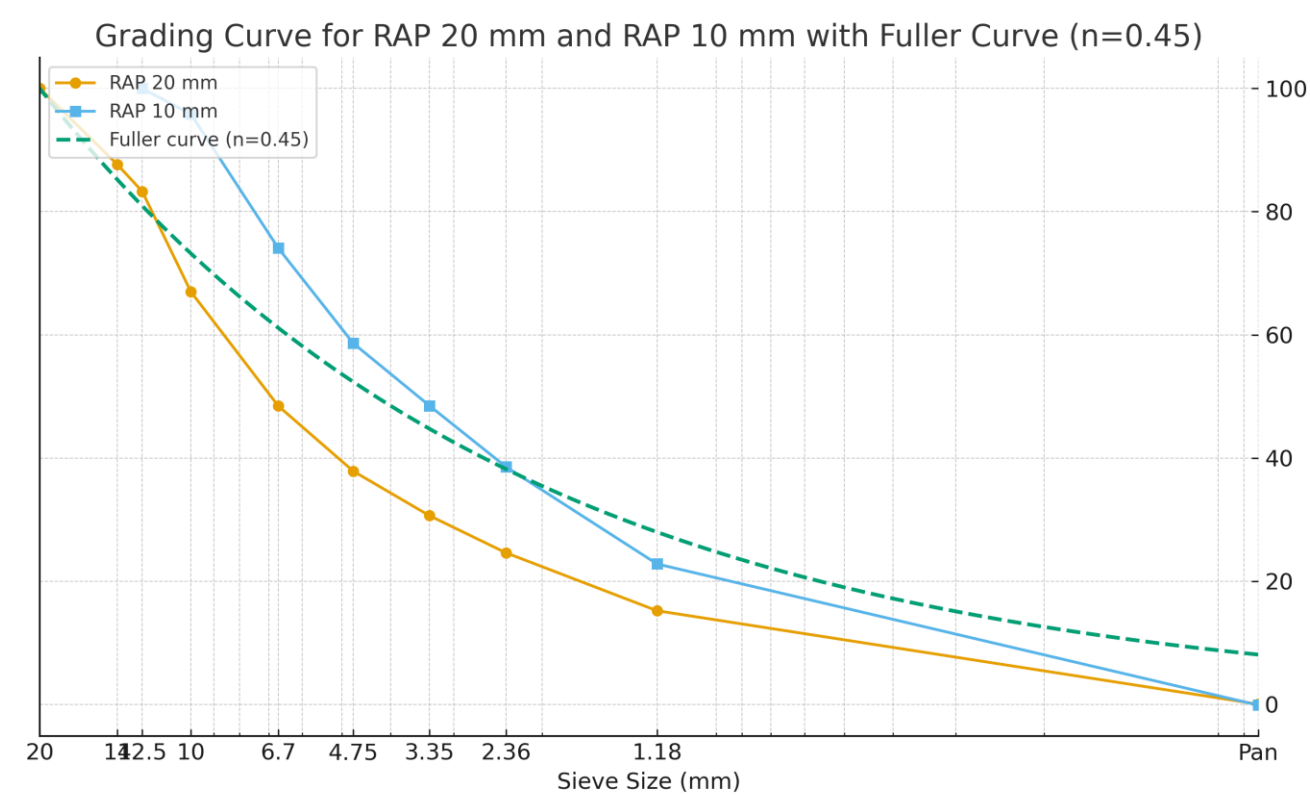


Figure 3. Standardized curve for different RAP sources

Table 2. Compressive strength of LC3-based rigid pavements

Binder %	RAP fine %	RAP coarse%	UCS 7 days
30	42	28	13.2
31.5	42	26.5	13.9
35	15	50	16.1
55	17.5	27.5	20.7
55	15	30	19.0
55	20	25	24.5
44	31	25	16.9
33	42	25	17.4
32.5	17.5	50	16.4
30	20	50	15.34
45	15	40	20.00
30	31	39	17.82

Large Crack Repair Binder

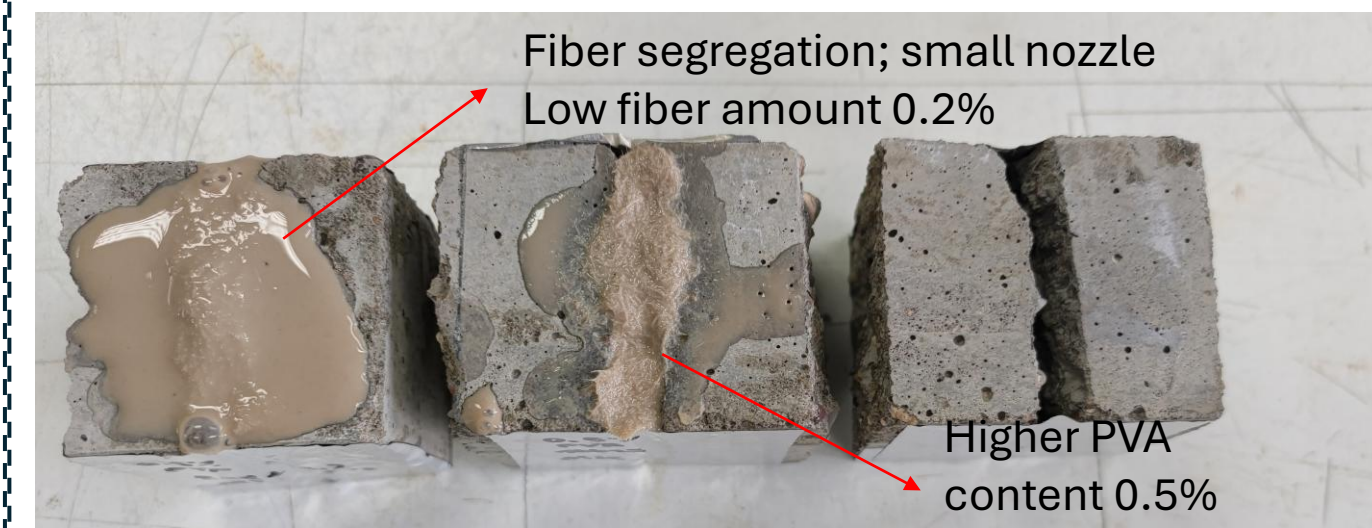
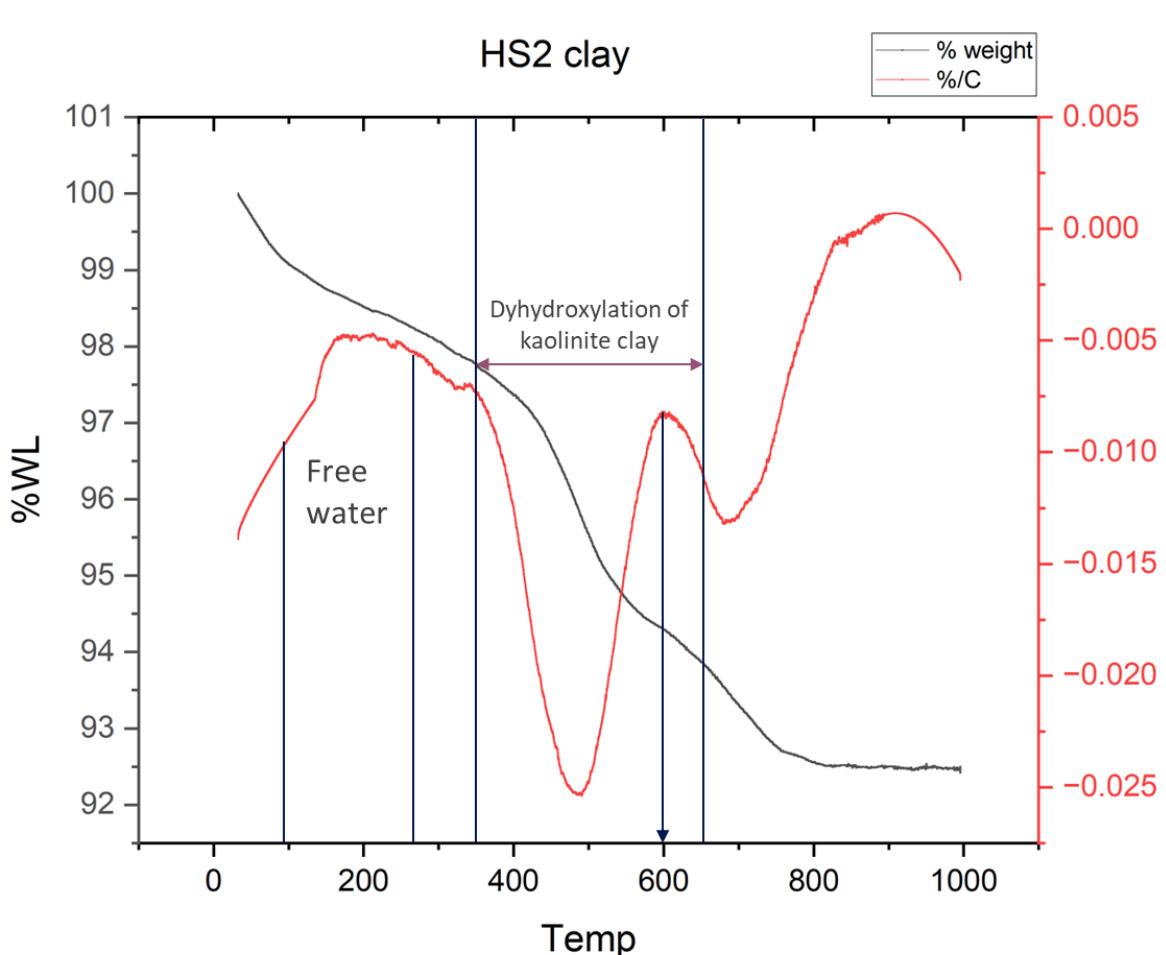


Figure 5. Geopolymer binder as crack repair agent

- 30-40 MPa @ 24 hours of curing
- Heat curing applied for 3 hours @ 60 C
- Addition of 0.06% by volume of PVA fibers chopped to 1-2 mm in size



Figure 4. LC3-based rigid pavement containing 100% RAP



HS2 Clay Calcination

Figure 6. Thermal analysis indicates 30% reactivity of HS2 clay after calcination

Outcomes

- 100% RAP rigid pavement with 40–50 MPa @ 28 days proven feasible
- Excavated clay upgraded from waste to reactive precursor (up to 30% replacement)
- Low-carbon PVA-fibre repair binder with rapid strength gain developed

Acknowledgements

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