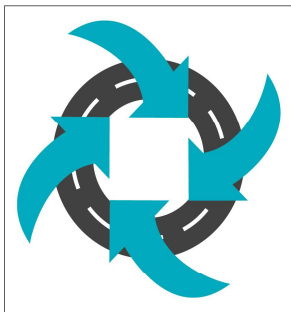


Evaluation of the Austroads Grading Envelope for Host Materials to be Treated with Foamed Bitumen

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Stabilised Pavements of Australia



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Agenda

Introduction

Research Hypothesis

Background

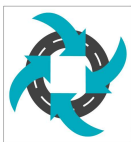
Research Methodology

Results

Conclusions

Recommendations

Additional Research



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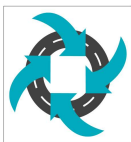
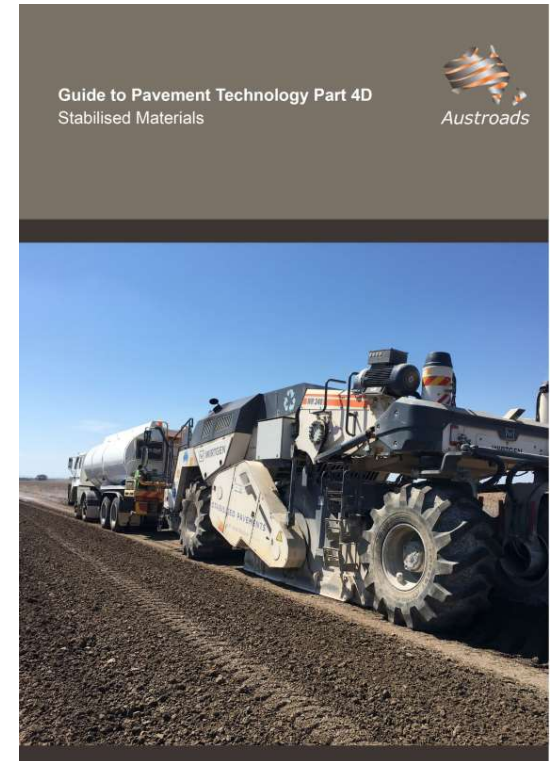
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Introduction

- One of the main properties of host materials in the evaluation for suitability of being treated with foamed bitumen (in situ or ex situ) is the particle size distribution.
- Recommended upper and lower limits have been published by Austroads in their current form since 2019 which were altered (i.e. the envelope was 'shifted') since the previous 2006 publication of AGPT4D.
- Often asset owners and/or designers make significant decisions around treatment selection based on the existing material PSD.

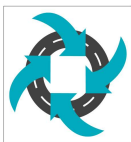


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Research Hypothesis

- It is hypothesized that materials that exhibit a PSD outside of the current recommended grading envelope can achieve satisfactory moduli without altering the existing material properties (i.e. through addition of other granular materials).
- Enabling a wider PSD envelope will provide opportunities for asset owners to consider foamed bitumen treatments in more applications and/or with reduced capital outlay due to less imported material requirements.



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Background

Current (2019) PSD Envelope from AGPT4D

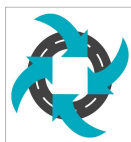
Table 5.2: PSD envelopes for bituminous binders

% Passing sieve (mm)	Initial daily ESA < 1000	Initial daily ESA ≥ 1000
37.5	100	100
19.5	80–100	87–100
9.5	55–90	67–88
4.75	40–70	50–65
2.36	30–55	38–50
0.425	12–30	16–26
0.075	5–20	8–16

Previous (2006) PSD Envelope from AGPT4D

Table 5.4: Particle size distribution envelopes for bituminous binders

% Passing sieve (mm)	Zone A (Ideal particle size distribution)	Zone B (fine material)	Zone C (coarse material)
26.5	73-100	100	<73
19.5	64-100	100	<64
9.5	44-75	>75	<44
4.75	29-55	>55	<29
2.36	23-45	>45	<23
1.18	18-38	>38	<18
0.6	14-31	>31	<14
0.3	10-27	>27	<10
0.15	8-24	>24	<8
0.075	5*-20	>20	<5*

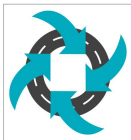
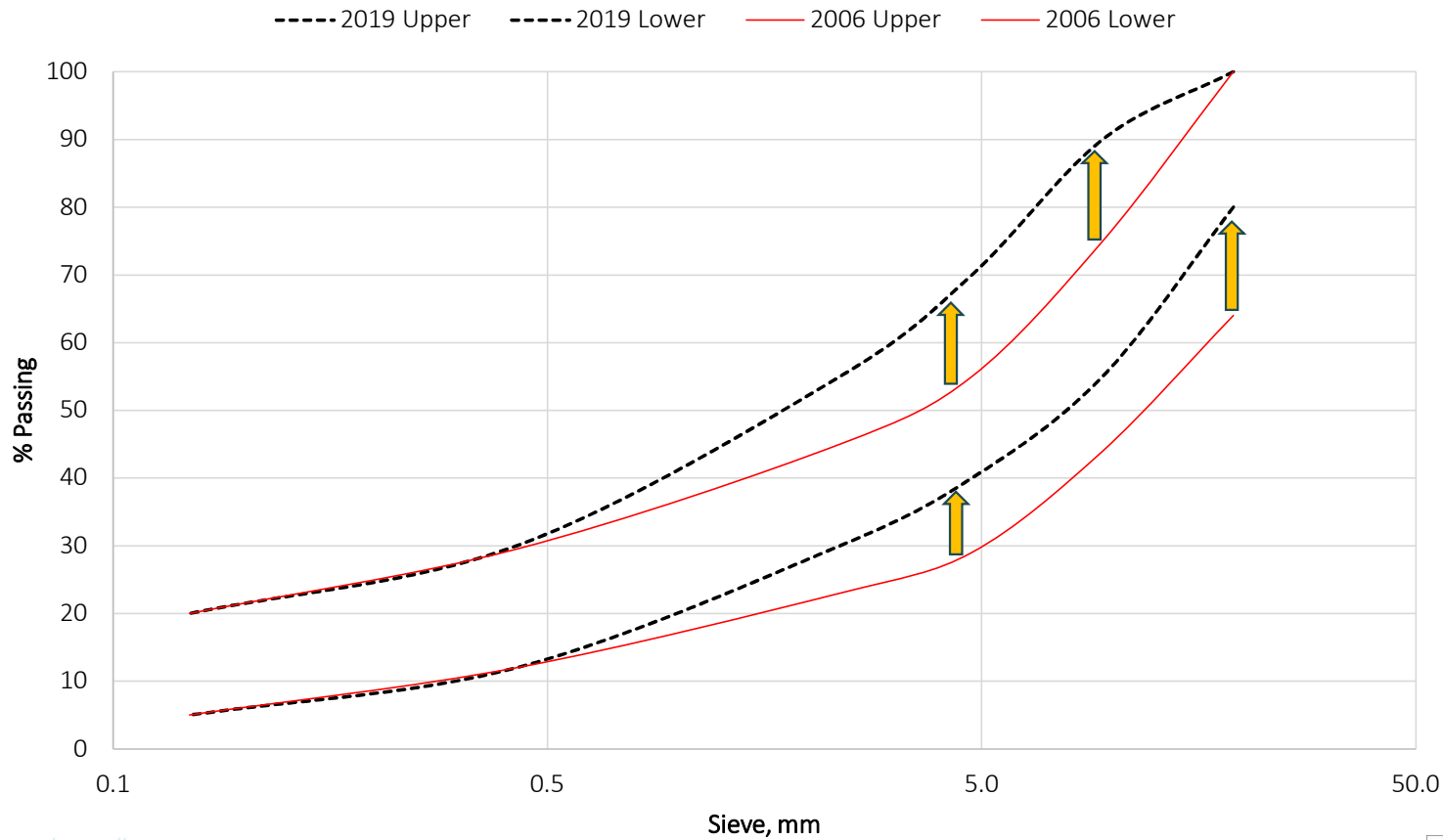


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AGPT4D 2006 v 2019 PSD Envelopes



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Technical Basis for the Change

Review of Foamed Bitumen Stabilisation Mix Design Methods

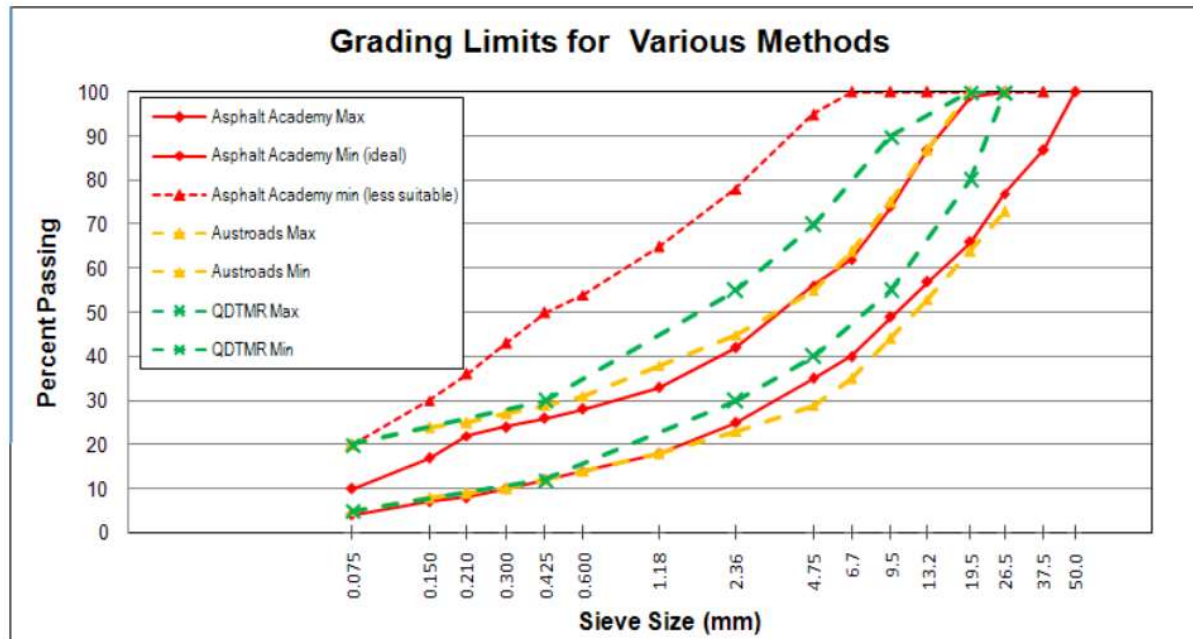


Figure 2.4: Grading envelope for foamed bitumen

Austroads Technical Report, AP-T178/11
Review of Foamed Bitumen Stabilisation Mix design Methods

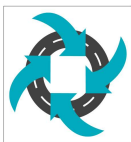


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Research Methodology

- This was a desktop study that evaluated a series of foamed bitumen mix design trial results and compared the strengths against the PSD of the existing material.
- The key variable was the 3-day soaked modulus.
- All trials evaluated had <1,000 initial daily ESA's.
- Results from 104 trials were examined by plotting the 3-day soaked modulus against the existing material PSD.



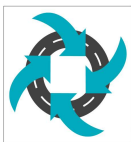
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Research Methodology cont...

- Material samples from the 104 trials came from QLD, NSW, SA, TAS and WA.
- The majority of trials were from site won material samples.
- All Trials were tested by either QLD DTMR, TfNSW, Construction Sciences, Pavement Technology Centre or New World Laboratories.
- All tests were conducted between 2019-2023.

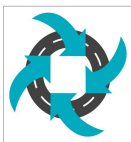


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Research Methodology cont...

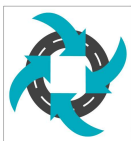
- Test methods employed were:
 - TMRs' Q135C, Q135A, Q142A
 - AS1289.2.1.1, AS1289.5.2.1
 - Austroads' AGPT/T301, 302, 303, 305
 - TfNSW T111
- Several plots were generated where the 3-day soaked moduli were grouped as follows:
 - $\leq 1500\text{MPa}$
 - $1500\text{-}2000\text{MPa}$
 - $\geq 2000\text{MPa}$



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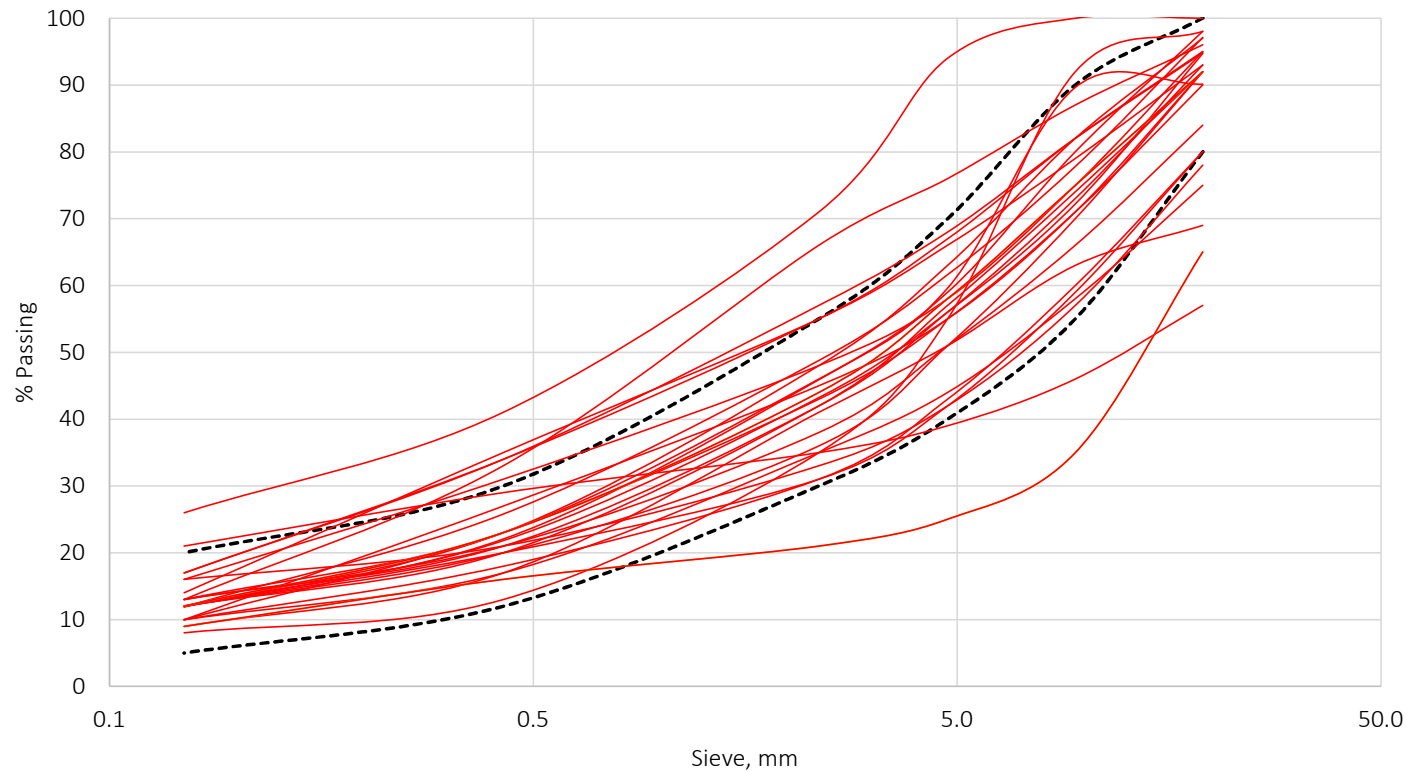
Mix Design Trial Pats



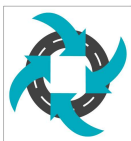
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Results: PSD Curves for $E_s \leq 1500 \text{MPa}$



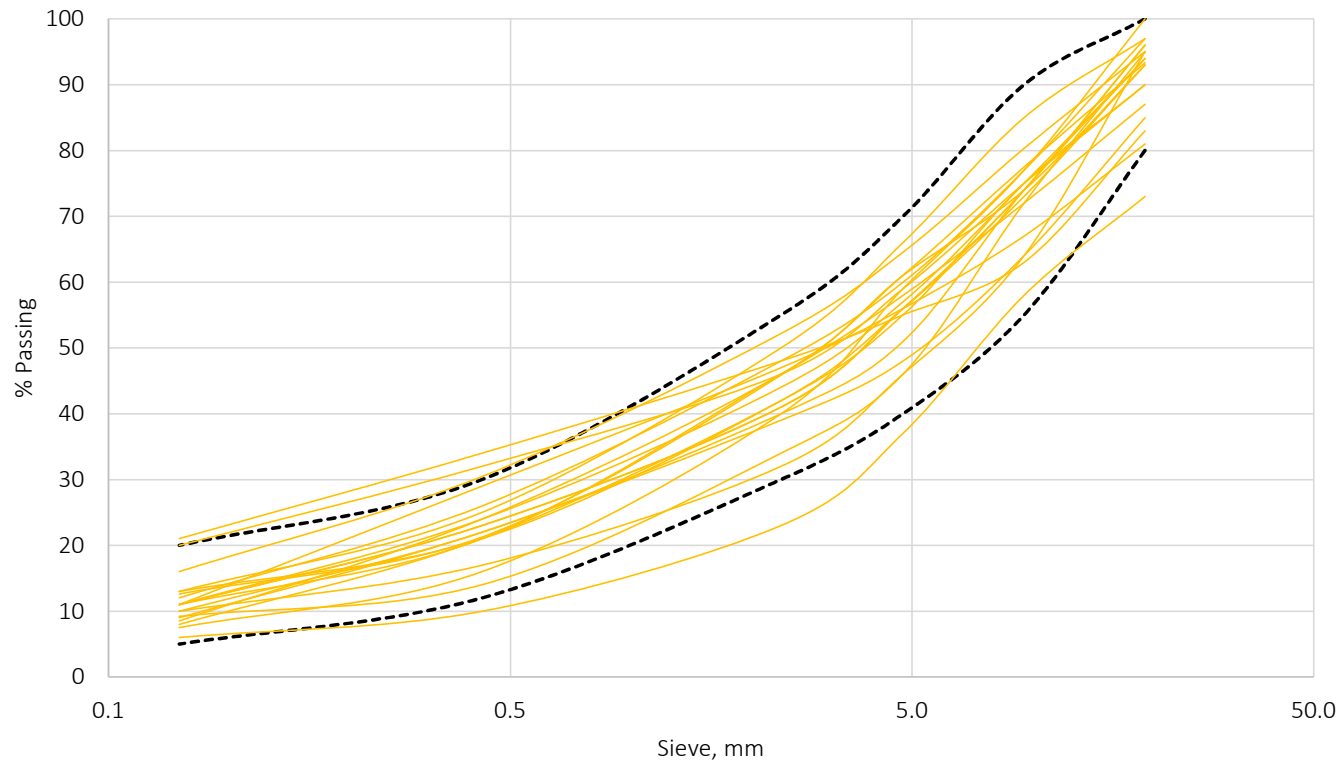
28 test results



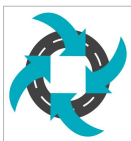
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Results: PSD Curves for $1500\text{MPa} < E_s \leq 2000\text{MPa}$



20 test results

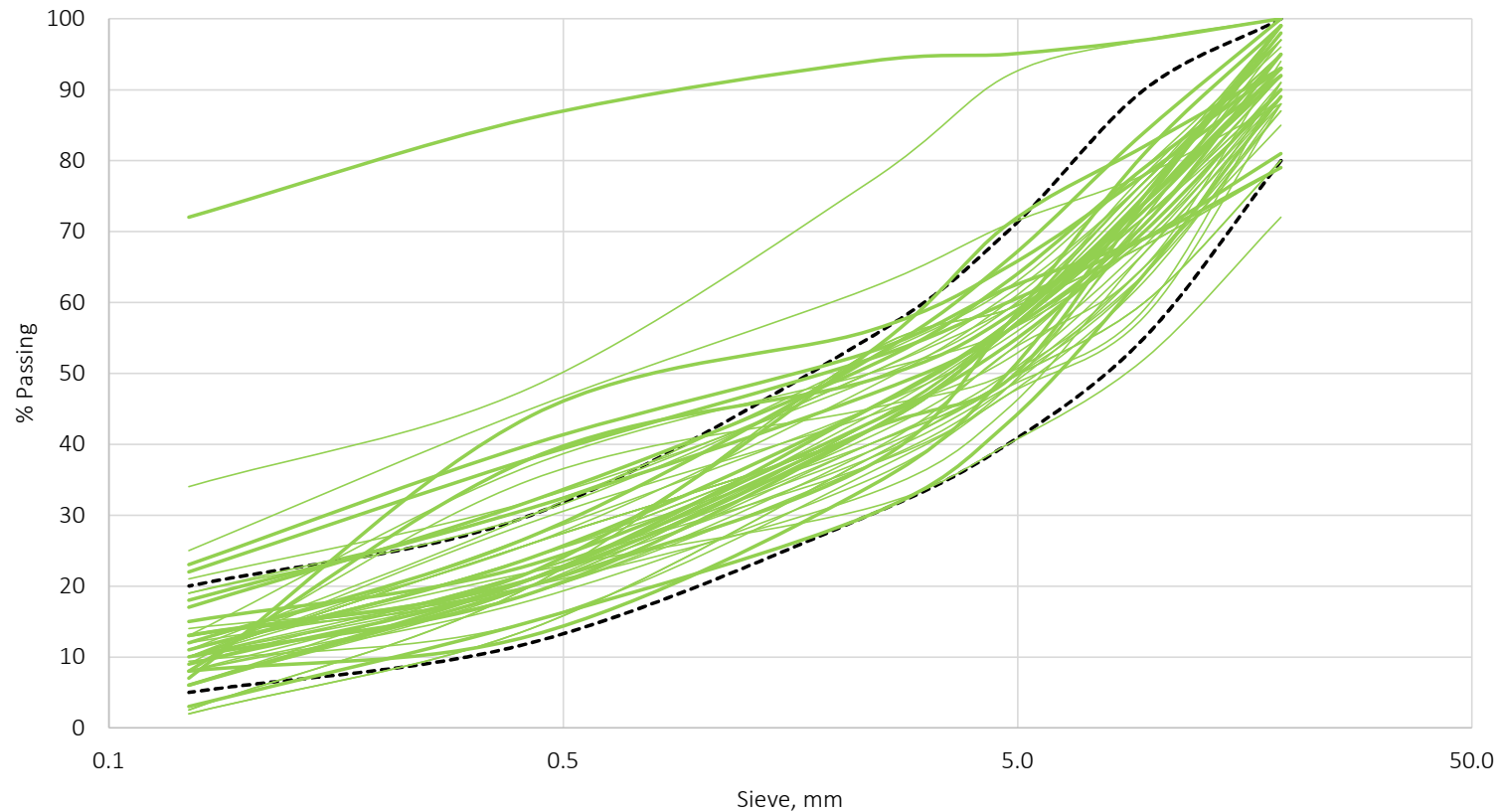


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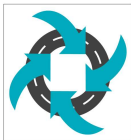


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Results: PSD Curves for $E_s > 2000\text{MPa}$



56 test results

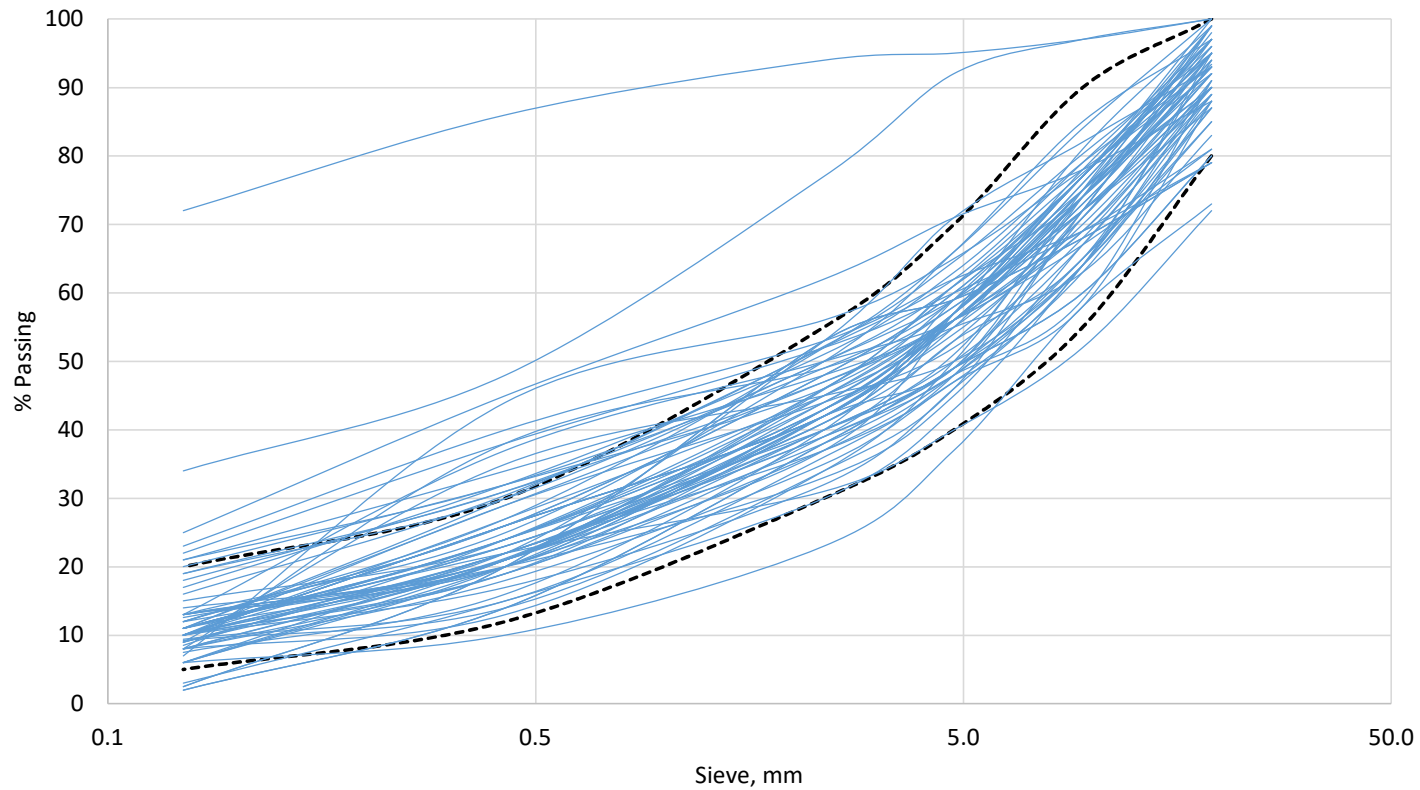


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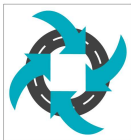


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Results: PSD Curves for $E_s = \text{All} > 1500\text{MPa}$



76 test results



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Research Conclusions

- 27% of materials with conforming PSD results showed low soaked modulus results. (<1,500MPa)
- 18% of results that exceeded 1,500MPa did not comply with the 2019 PSD envelope.
- 3-day soaked moduli results can achieve low and/or high results with a variety of existing material PSDs.
- PSD alone should not drive treatment selection and a wider PSD envelope should be considered.



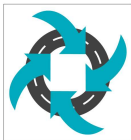
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Recommended PSD Curve (2023)

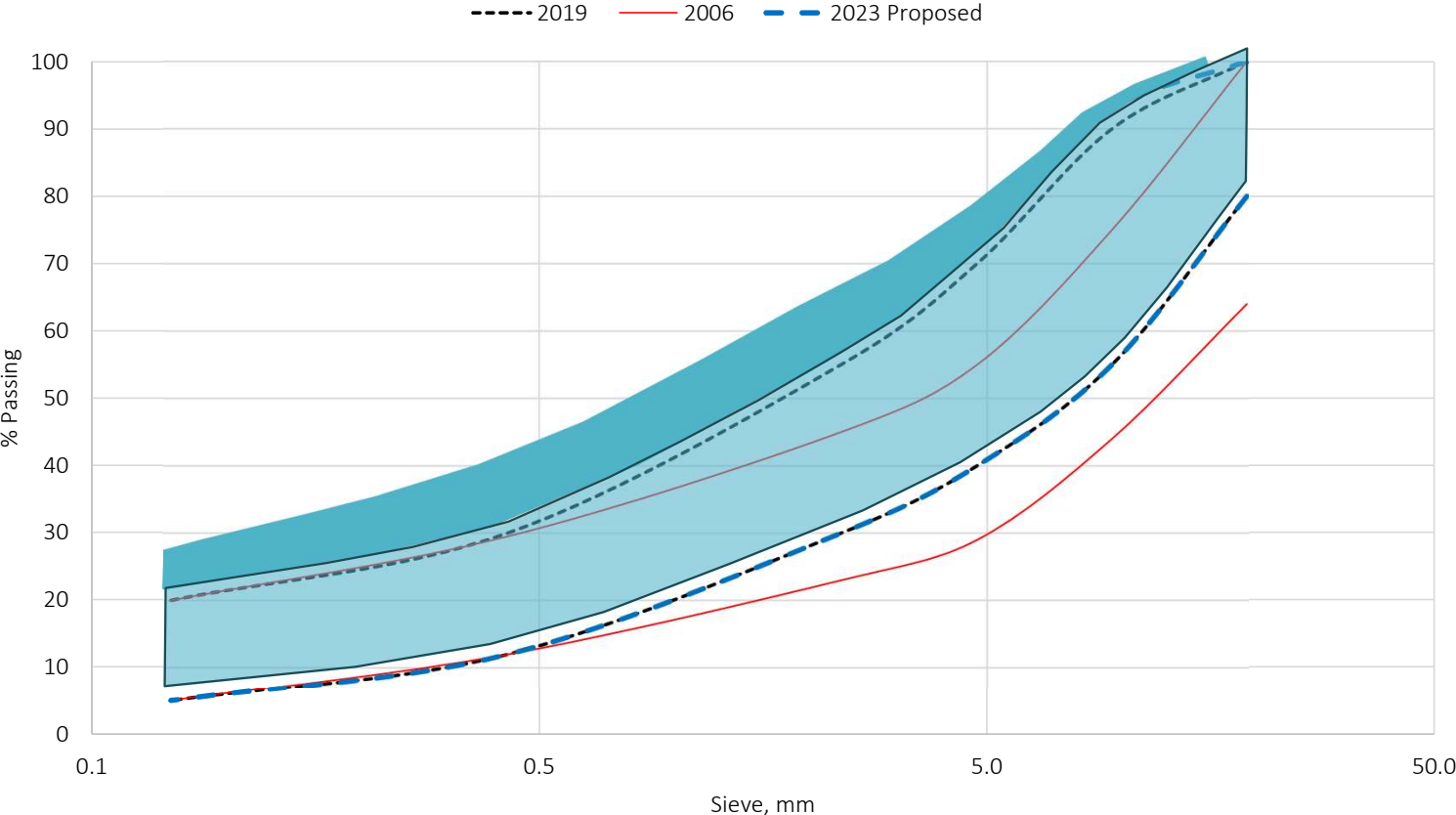


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PSD Envelopes, 2006 v 2019 v 2023



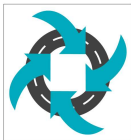
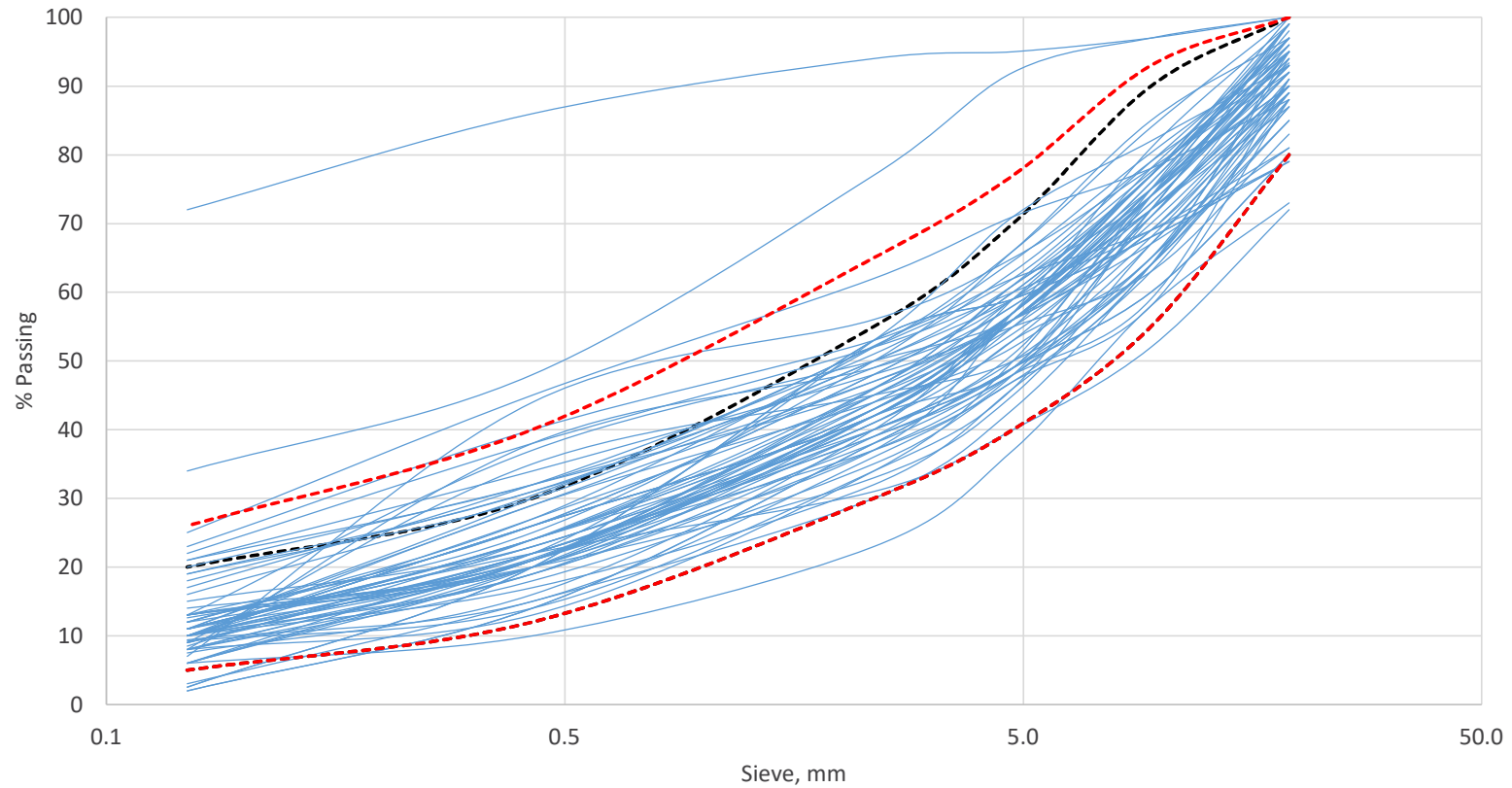
	Sieve, mm					
	19.0	9.5	4.75	2.36	0.425	0.075
2023 Proposed Upper	100	93	77	65	40	26
2023 Proposed Lower	80	55	40	30	12	5



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2023 PSD Envelope v All Results >1500MPa



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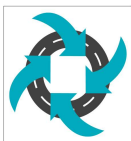
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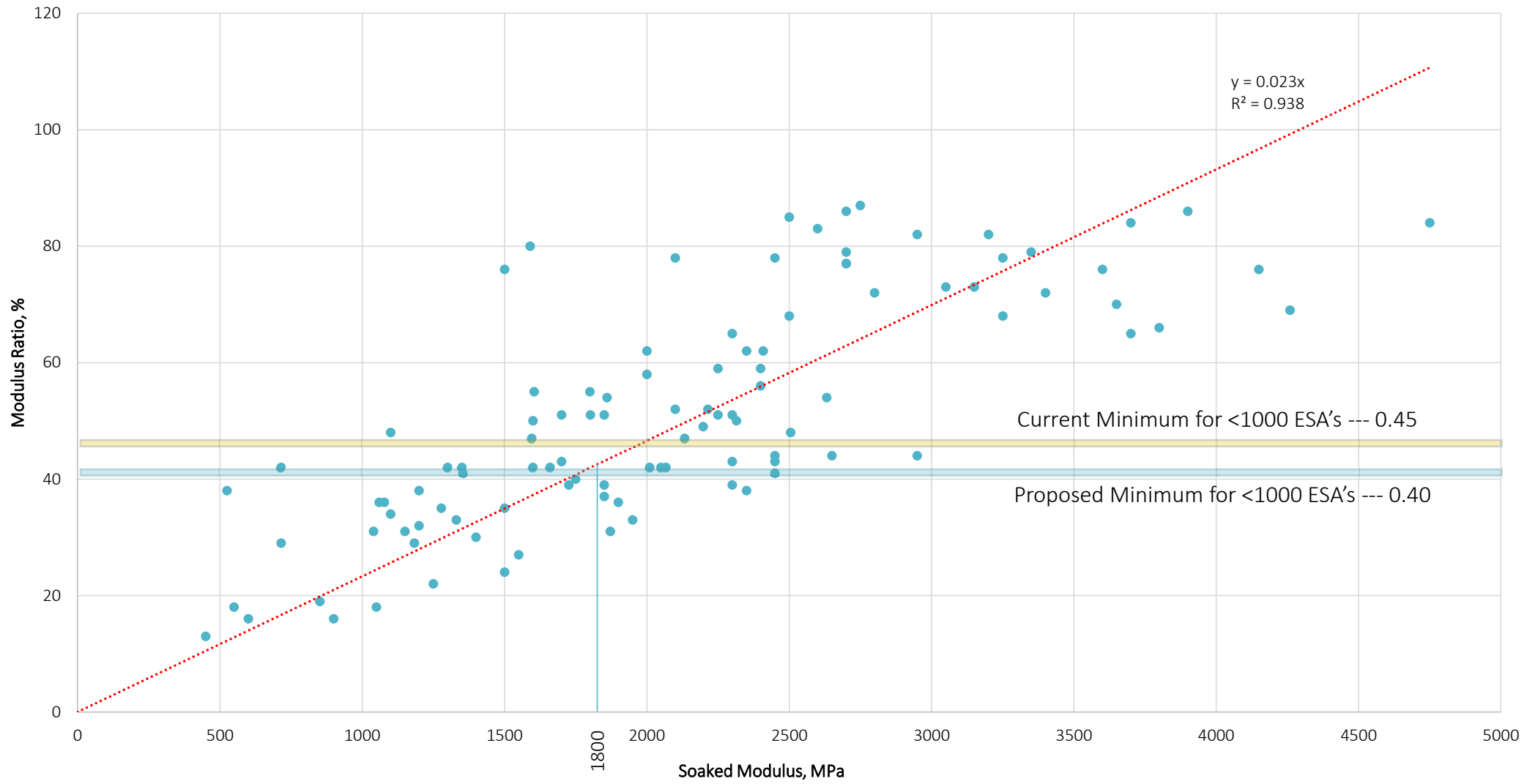
Additional Research

- An additional review was undertaken on the wet/dry modulus ratio requirement, currently stipulated as shown below:

Average daily traffic in design year of opening (ESA)	Minimum retained modulus ratio ⁽²⁾
< 100	0.40
100–1000	0.45
> 1000	0.50

- The results of the mix designs where the 3-day soaked modulus exceeded 1800MPa (considered acceptable for <1000 Daily initial ESA's) is shown over.





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Summary

- This review has focused on assessment of host materials to be treated with foamed bitumen in locations with <1000 initial daily ESA's.
- A revised PSD envelope has been presented, based off 104 test results from across Australia.
- A revised minimum target wet/dry modulus ratio of 0.40 has been presented.
- It is recommended that industry adopt this PSD envelope and minimum wet/dry modulus ratio.
- It is recommended that Austroads review both of these parameters in AGPT4D.



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