Review of M04 Specification for Basecourse Aggregates

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Te Kāwanatanga o Aotearoa
New Zealand Government

Some History

- NZ basecourse aggregate specifications date from the 1930s
- They evolved with experience and in response to growing traffic volumes
- The first ‘M/4’ was published by the National Roads Board (NRB) in 1958, based on basecourse aggregates observed to perform well
- M/4 evolved through the 1960s and 1970s, and finally into the current M/4: 2006.

Philosophy

- Material crushed from good quality rock
- Fines content low to prevent high pore water pressures developing under loading
- Fines quality controlled to exclude clay minerals
- Voids high enough to allow the compacted material to drain. Given our maritime climate, this is ‘highly desirable in the generally high moisture regime surrounding NZ pavements’
- Relatively clean final surfacings provide for a very good bond to a prime for first coat seal.

Why change the specification?

- Industry (AQA) identified that:
  - The current M/4 was effectively the default NZ basecourse aggregate specification
  - Premium rock is becoming more difficult to find and being used inappropriately
  - Controlling fines quality is essential
  - A series of four ‘classes’ of aggregate should be developed to match quality to pavement loading
- AQA technical committee prepared a draft
- A working group was set up, comprised of clients, industry and consultants
- Draft specification prepared.

“I want you to find a bold and innovative way to do everything exactly the same way it’s been done for 25 years.”

The draft proposes the following changes:

- Four Classes of aggregate depending on loading
- Class 2 is more or less the current M04 aggregate

Table 1: Aggregate Classes

Aggregate Class	Duty	Loading (ESA)
Class 1	Very Heavy	5×10^6 - 10^7
Class 2	Heavy	10^6 – 5×10^6
Class 3	Medium	10^5 – 10^6
Class 4	Light	$<10^5$

The draft proposes the following changes:

- Rock composition controlled by X-Ray Diffraction (XRD) instead of the subjective petrographic examination
- A test method is yet to be developed for XRD analysis

Table 2: Maximum Limits for Deleterious Minerals in Basecourse Source Rock

Aggregate Class	Deleterious Mineral Limits			
	Smectites	Halloysite	Kaolinite	Mica
Class 1	T	0%	T	T
Class 2	T	0%	T	T
Class 3	M	T	M	M
Class 4	M	M	M	M

Where:
M = Minor, XRD 100 - 300 counts (5% - 20%)
T = Trace, XRD <100 counts (0% - 5%)

The draft proposes the following changes:

- Crushing Resistance requirements linked to loading and Wet/Dry Strength Variation added

Table 3: Maximum Fines and Wet/Dry Strength Variation Achieved During Crushing Resistance Test

<table>
<tr><th>Aggregate Class</th><th>Specified Load (kN)</th><th>Percentage Fines Achieved (%)</th><th>Maximum Wet/Dry Strength Variation (%)</th></tr>
<tr><td>Class 1</td><td>200</td><td rowspan="4">10 maximum</td><td rowspan="3">30</td></tr>
<tr><td>Class 2</td><td>180</td></tr>
<tr><td>Class 3</td><td>130</td></tr>
<tr><td>Class 4</td><td>80</td><td>Not specified</td></tr>
</table>

The draft proposes the following changes:

- Ethylene Glycol Accelerated Weathering test added

Table 5: Ethylene Glycol Accelerated Weathering Test Requirements

Aggregate Class	Test Requirements
Classes 1, 2	30% maximum
Classes 3, 4	-

The draft proposes the following changes:

- More explicit rules around fines quality, and linked to loading

Table 7: Quality of Fines Testing Requirements

Aggregate Class	Fines Criteria to be Satisfied
Class 1	PI and CI, report CPL
Class 2	
Class 3	SE or CI or PI
Class 4	

Table 9: Clay Index Requirements

Aggregate Class	Clay Index
Class 1	3 maximum
Class 2	
Class 3	5 maximum
Class 4	

Table 8: Plasticity Index Requirements

Aggregate Class	Plasticity Index	Cone Penetration Limit
Class 1	5 maximum	Report
Class 2		
Class 3	10 maximum	
Class 4	15 maximum	

Table 10: Requirements for the Sand Equivalent

Aggregate Class	Sand Equivalent
Class 3	30 minimum
Class 4	25 minimum

The draft proposes the following changes:

- A new criterion for Flakiness Index has been added and Broken faces limits adjusted for loading

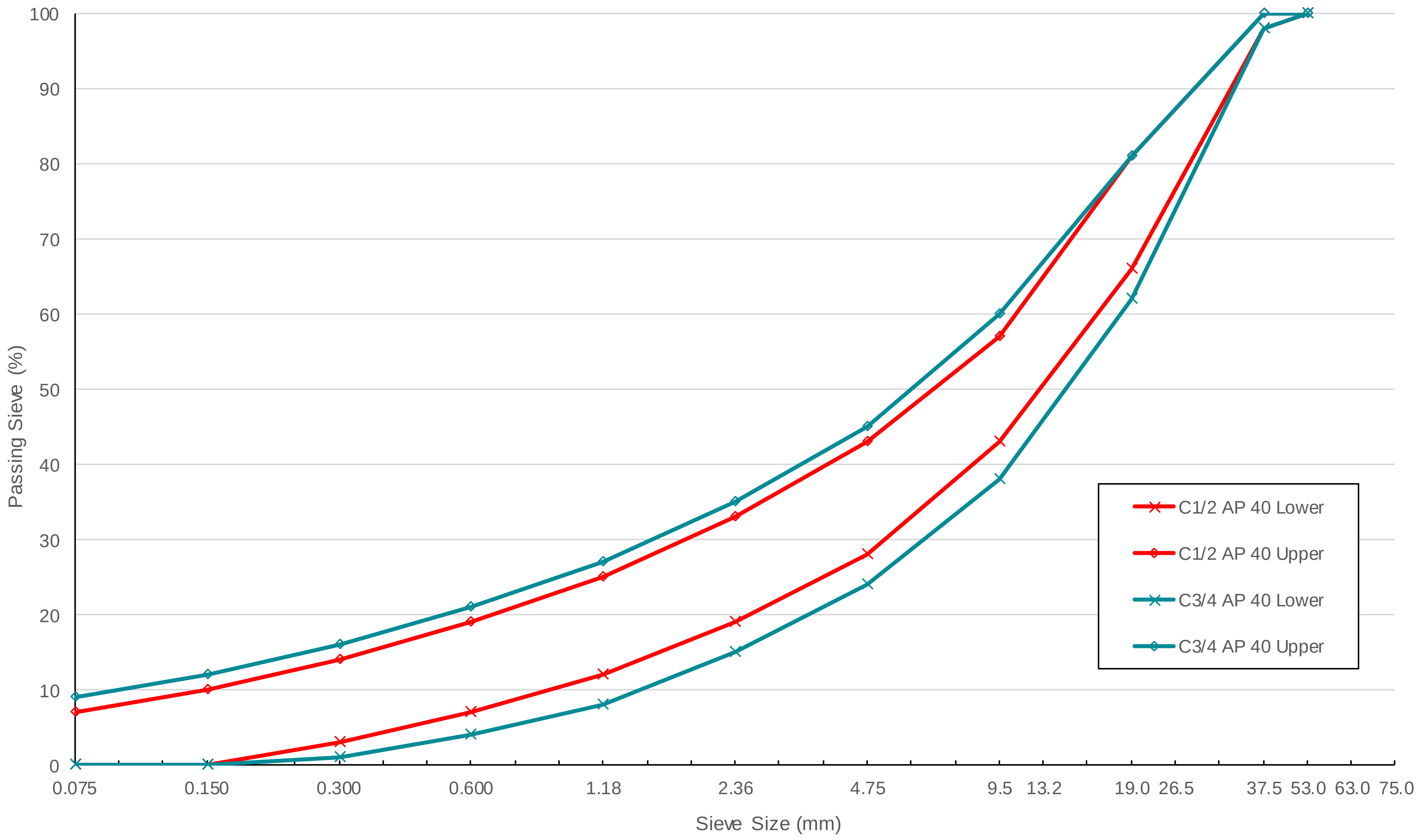
Table 11: Minimum Broken Faces Requirements

Aggregate Class	Broken Faces Content
Class 1	70% minimum
Class 2	70% minimum
Class 3	50% minimum
Class 4	-

Table 12: Aggregate Flakiness Index

Aggregate Class	Flakiness Index
Class 1, 2	35% maximum
Class 3, 4	Not required

M04 Aggregate Particle Size Distribution



The draft proposes the following changes:

- Requirement for Repeated Load Triaxial testing (RLT) for Class 1 and 2, but CBR retained for Class 3 and 4

Table 17: Basecourse Repeated Load Triaxial Criteria

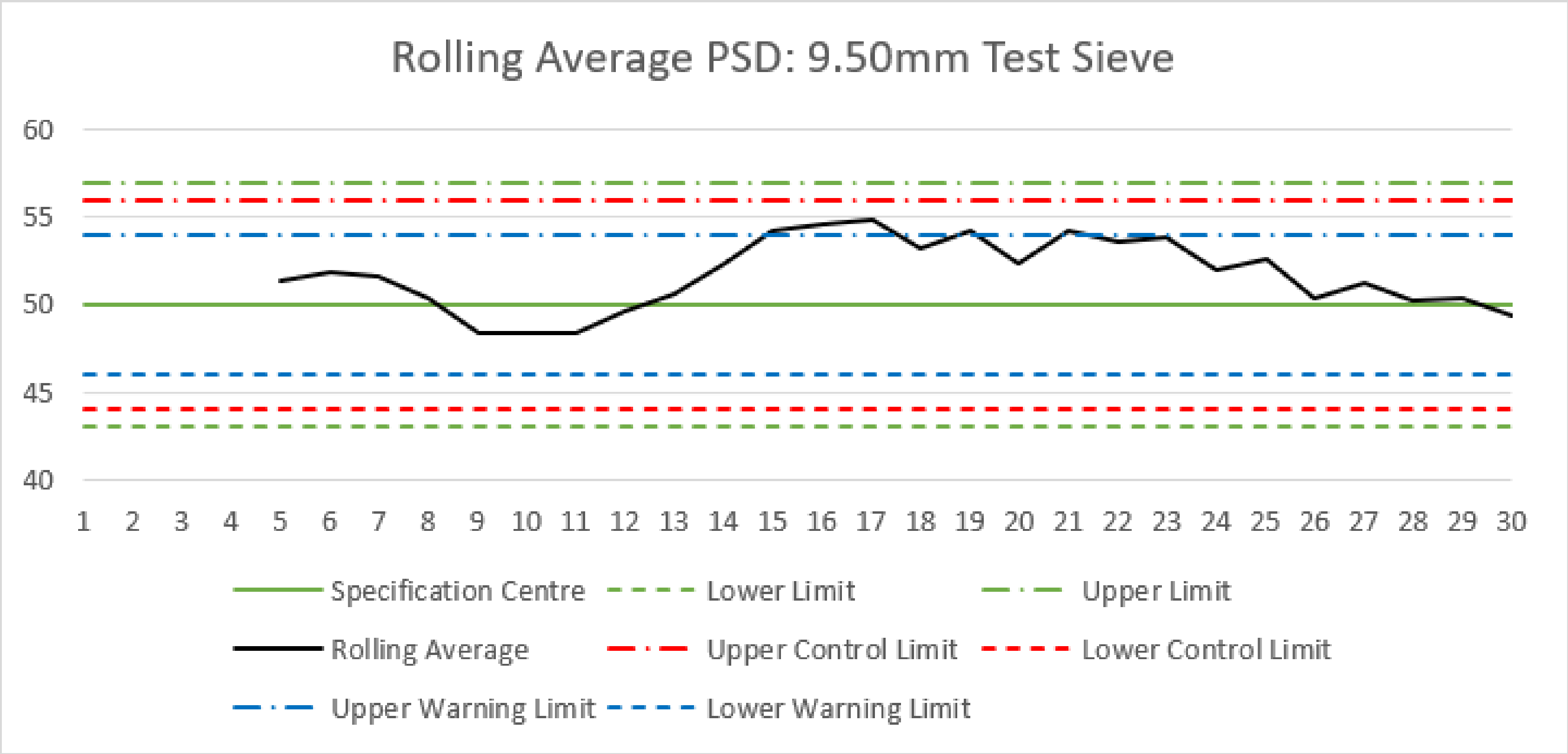
Aggregate Class	Maximum RLT Average Slope %/1M 1st 5 stages – soaked/undrained	Maximum RLT Average Slope %/1M 1st 5 stages – dry/drained
Class 1	1.5	0.5
Class 2	-	0.5

Table 18: Basecourse Aggregate Strength and Deformation Resistance

Aggregate Class	California Bearing Ratio
Class 3	80% minimum
Class 4	

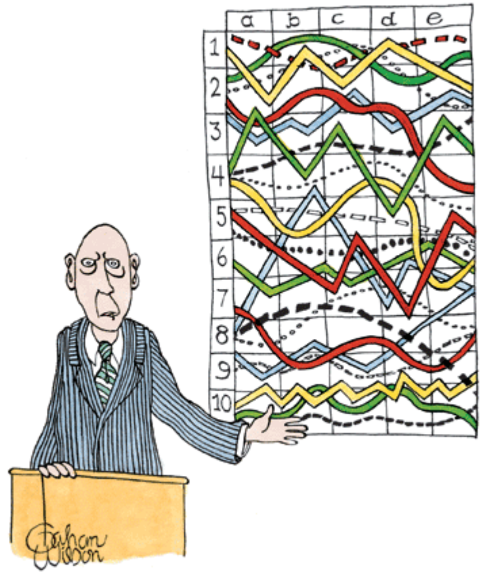
Production Quality Control and Acceptance Criteria

- Requirement to use process control tools and statistics to determine compliance



Production Quality Control and Acceptance Criteria

- Requirement to use process control tools and statistics to determine compliance. We've been talking about such an approach for over 30 years!!
- A statistical tool is used to calculate Lower and Upper 'Characteristic Values' for each sieve in a set of up to 30 gradings. This has advantages:
  - A set of results is looked at holistically
  - Minor or infrequent non-compliances are tolerated
  - No extra work – the test results are put into a spreadsheet
  - Uncertainty arising from sampling and testing effects are eliminated.
- The intent is to minimise the chances of good material being reject poor material being accepted.

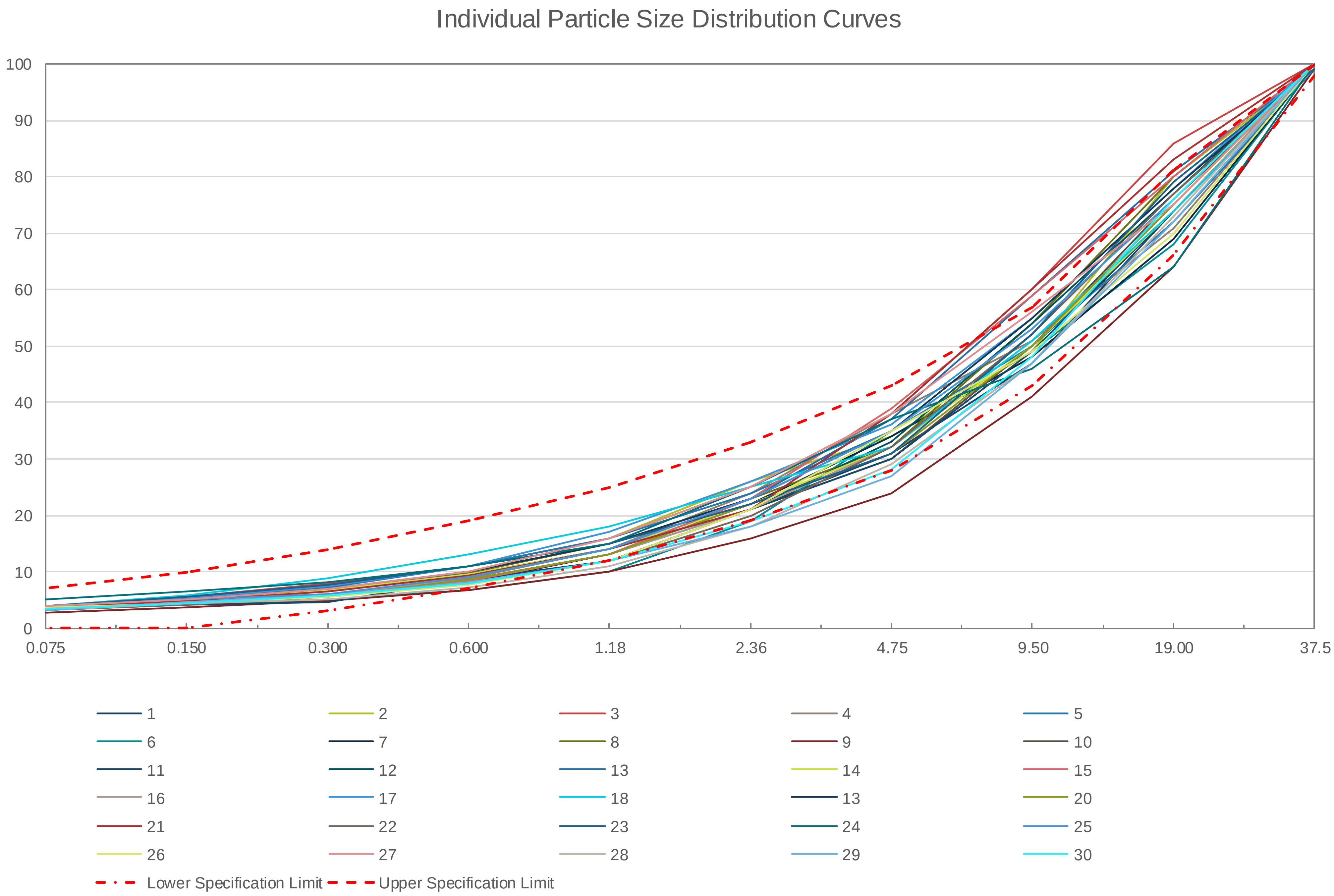


"I'll pause for a moment so you can let this information sink in."

Waka Kotahi M04 Basecourse Aggregate Compliance Calculator

Basecourse Aggregate Class: AP 40 Class 1

Sample Information				Particle Size Distribution									
Material Type	Lot	Sample Date	Test Result Reference	Sieve Size (mm) 37.5	19.0	9.50	4.75	2.36	1.18	0.600	0.300	0.150	0.075
AP 40 Class 1		11-Jan-19	1	99	74	47	31	21	13	8.6	5.8	4.2	3.2
AP 40 Class 1		18-Jan-19	2	99	80	49	34	26	16	10	6.8	4.8	3.6
AP 40 Class 1		15-Mar-21	3	100	86	60	38	25	16	11	7.8	5.5	4
AP 40 Class 1		14-Jun-21	4	100	71	51	38	24	14	8.9	6.1	4.6	3.7
AP 40 Class 1		16-Jun-21	5	99	72	50	35	24	16	11	7.2	5.3	3.8
AP 40 Class 1		16-Jun-21	6	100	68	49	35	19	10	6.8	5.1	4.1	3.4
AP 40 Class 1		17-Jun-21	7	100	69	48	34	22	13	8.1	5.9	4.6	3.7
AP 40 Class 1		18-Jun-21	8	100	80	54	32	23	15	9.9	6.8	4.9	3.8
AP 40 Class 1		18-Jun-21	9	99	64	41	24	16	10	6.8	4.9	3.6	2.7
AP 40 Class 1		21-Jun-21	10	99	76	50	30	21	14	9.6	6.7	4.8	3.6
AP 40 Class 1		24-Jun-21	11	99	74	49	30	21	12	8.6	4.6	4.1	3.6
AP 40 Class 1		24-Jun-21	12	100	77	54	33	21	12	8.1	6	4.9	3.9
AP 40 Class 1		29-Jun-21	13	99	81	59	37	23	14	9.6	6.9	5.1	4
AP 40 Class 1		30-Jun-21	14	100	74	50	32	22	14	9.6	6.7	5	3.6
AP 40 Class 1		5-Jul-21	15	100	80	59	39	23	13	8.3	5.7	4.3	3.3
AP 40 Class 1		6-Jul-21	16	100	74	51	32	21	13	8.7	6.1	4.6	3.5
AP 40 Class 1		12-Jul-21	17	100	78	55	36	26	17	11	7.4	5.3	4
AP 40 Class 1		14-Jul-21	18	99	74	51	32	25	18	13	8.8	5.8	3.9
AP 40 Class 1		15-Jul-21	13	99	78	55	35	23	15	10	7	5	3.6
AP 40 Class 1		23-Jul-21	20	100	75	50	31	22	13	8.7	5.5	4.5	3.4
AP 40 Class 1		27-Jul-21	21	100	83	60	38	21	14	9.3	6.6	4.9	3.7
AP 40 Class 1		28-Jul-21	22	99	77	52	32	20	12	7.9	5.5	4.1	3.3
AP 40 Class 1		17-Aug-21	23	99	79	52	31	22	15	11	7.6	5.5	4
AP 40 Class 1		24-Sep-21	24	100	64	46	37	25	15	11	8.1	6.4	5.2
AP 40 Class 1		27-Sep-21	25	100	76	53	35	23	14	9	6	5	4
AP 40 Class 1		1-Oct-21	26	100	70	49	35	21	12	7.7	5.5	4.4	3.7
AP 40 Class 1		1-Oct-21	27	100	75	56	38	25	16	10	6.9	5.2	3.9
AP 40 Class 1		28-Oct-21	28	100	73	47	29	18	11	7.2	5.2	4.4	3.3
AP 40 Class 1		1-Nov-21	29	100	72	47	27	18	12	8.2	5.8	4.7	3.1
AP 40 Class 1		1-Nov-21	30	100	76	48	28	19	12	7.8	5.7	4.3	3.4
Averages				99.6	75.0	51.4	33.3	22.0	13.7	9.2	6.4	4.8	3.7


Individual Particle Size Distribution Curves
100
90
80
70
60
50
40
30
20
10
0
0.075
0.150
0.300
0.600
1.18
2.36
4.75
9.50
19.00
37.5
1
2
3
4
5
6
7
8
9
10
11
12
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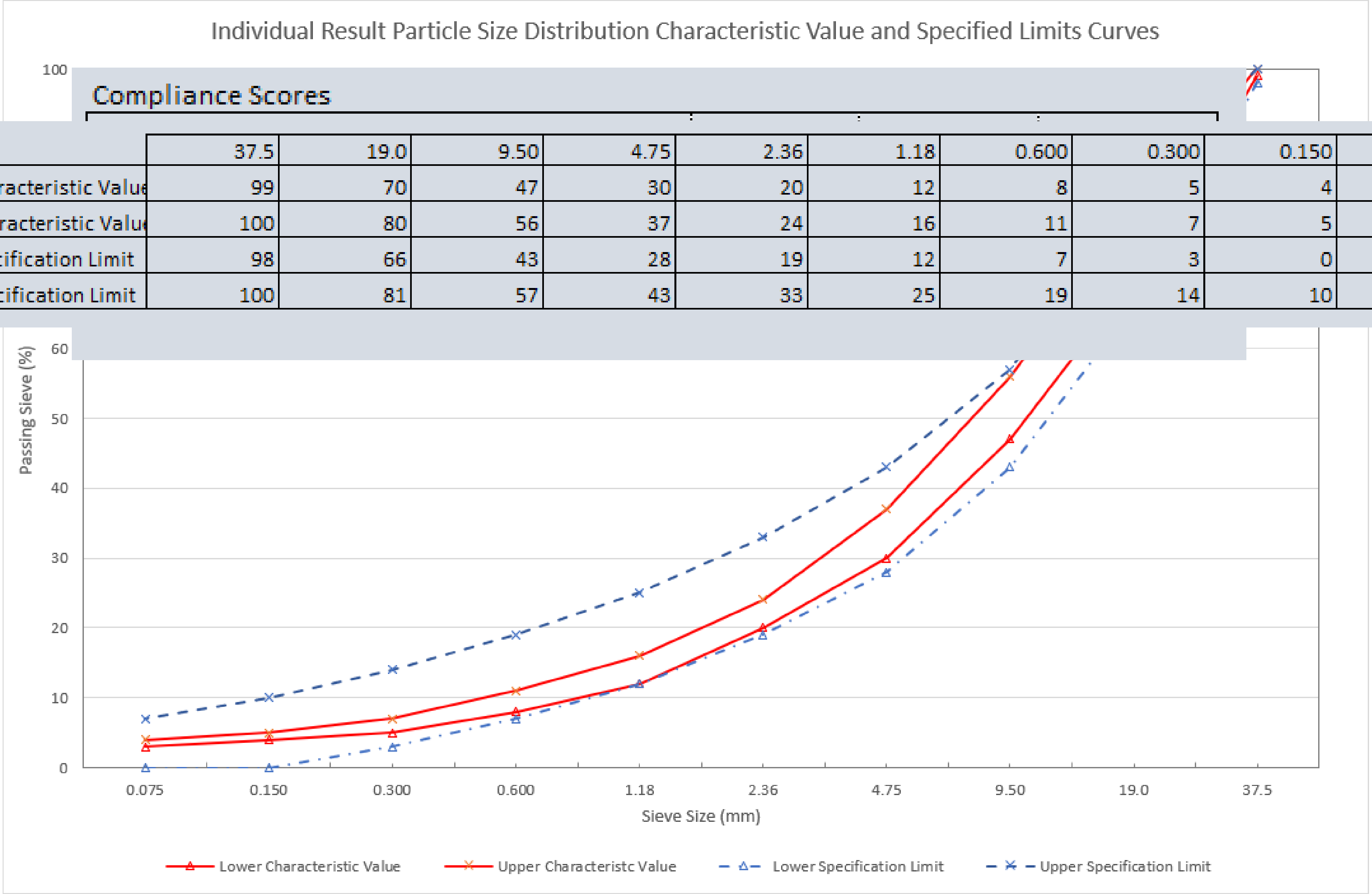
29
30
Lower Specification Limit
Upper Specification Limit



Compliance Scores

	37.5	19.0	9.50	4.75	2.36	1.18	0.600	0.300	0.150	0.075
Lower Characteristic Value	99	70	47	30	20	12	8	5	4	3
Upper Characteristic Value	100	80	56	37	24	16	11	7	5	4
Lower Specification Limit	98	66	43	28	19	12	7	3	0	0
Upper Specification Limit	100	81	57	43	33	25	19	14	10	7

To sum up

- Adding the aggregate Classes will widen the range of materials that can be used for pavements
- There's a bit more rigor with the testing, but…..
- Criteria have been widened for lower demand aggregates
- The use of process control and statistical acceptance tools will draw more value out of the good work that's being done, and
- The aim is to reduce the chances of good material being rejected, and poor material accepted.

Next steps

- The draft document is still a proposal
- A full consultation process will take place
- The acceptance rules may need fine tuning – but the intent is to take a statistical approach to assessing compliance.

The End