

A New Control Stone for the Polished Stone Value Test

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This paper outlines the results of a project carried out on behalf of the NZ Transport Agency to identify a new control stone for the PSV test. The full results will be available in a report currently in preparation.

Polished Stone Value Test (PSV)

- Frictional properties are measured using the polished stone value test (BS EN 1097-8:2009)
- Reference “control stone” required with known friction value after polishing
 - ❖ Supplied from a single quarry in the UK, sometimes difficult to source
 - ❖ UK changing sources, no local control
 - ❖ Is there a suitable New Zealand source?



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The frictional properties of aggregates used in road surfacings in NZ are controlled by the polished stone value test. The test involves polishing of aggregate sample by abrasion with a solid rubber tyre, grit and water. The friction of the polished aggregate is measured by the British Pendulum tester. A key element of the procedure is use of a reference or control aggregate. The control stone has a known friction value after polishing, it is run at the same time as the test aggregate and is used to correct for small deviations due to machine setup and different operators. The current control stone is obtained from a single UK quarry, it can sometimes be difficult and expensive to obtain in New Zealand. The UK source is changing and this was seen as an opportunity to explore the possibility of using a local New Zealand aggregate as a control stone.

PSV Test Procedure

- Aggregates of the correct size are selected (passing 10 mm, retained 7.2 mm sieve)
- Particles mounted so as to have a flat face upwards
- Aggregate is abraded (polished) using a solid rubber tyre, grit and water
- Resulting frictional properties measured with the British Pendulum tester



In the PSV test sized aggregates are mounted with flat faces upwards on a plate. This is abraded by a solid rubber tyre in the presence of water and grit. The friction of the plates after polishing are measured with a British Pendulum tester.

Control Stone Correction

- Control stone run simultaneously with test aggregate
- Control stone friction value corrected to 52.5
(mid point of the acceptable 49.5 to 55.5 range)
- Correction added to friction value of the test aggregate value to get final PSV result

$$PSV = S + (52.5) - C$$



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To correct for small variations due to the machine set up and operator the control stone is run at the same time as the test aggregate. The measured control stone friction value is corrected to be 52.5 (the true value for the control stone). This correction is added to the test aggregate friction value and rounded to obtain the final PSV result. The measured control stone value must fall within a range of 49.5 to 55.5, results outside of this range indicate a problem with the machine or test procedure.

Sourcing the New Control Stone

➤ Criteria:

- ❖ Friction value close to current control stone
- ❖ Consistent properties- variability less than or equal to current control stone

➤ Testing required to determine

- ❖ Acceptable range of the measured friction value
- ❖ Expected or true friction value



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Ideally the new control stone will have a friction value close to that of the existing stone (the specification requires a control stone to a PSV value in the 50 to 60 range), but the most important criterion is that the variability of the raw data be at least as good as the existing stone. Understanding the variability of the control stone is important as the correction applied to the results assumes that that variability, is small and the necessary correction is due only to machine/operator variability. If the error is a combination of machine and significant control stone variability then the control stone variability produces an error in the test stone value.

Sourcing the New Control Stone

- Miners Road Quarry
 - ❖ Operated by Fulton Hogan
 - ❖ Alluvial greywacke gravels
 - ❖ Five tonnes screened to approximate grading
 - ❖ Stored in pails (20 kg each)
 - ❖ Twenty pails selected at random



Miners Road quarry Christchurch
Source: Quarry and Mining Magazine

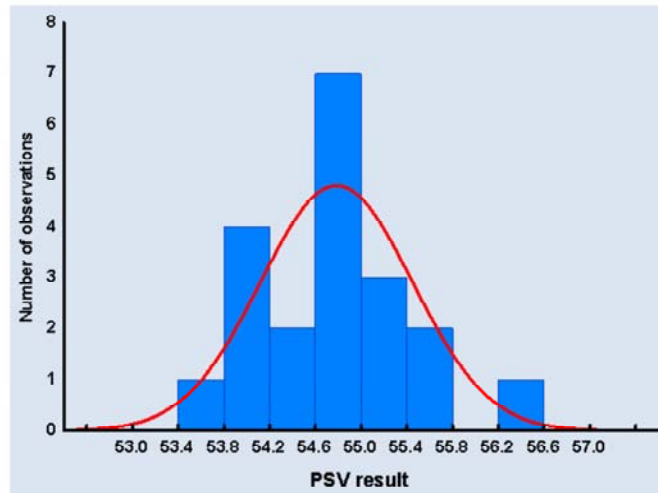


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Miners Road quarry was identified by the NZTA as a possible control stone source. To determine the consistency of the Miners Road aggregate twenty pails were selected and tested and compared to the UK control stone .

Variability

- Single laboratory and operator
- Data compared to current control stone
- Variability solely due to aggregate – machine/operator variability assumed the same for both



Twenty tests were conducted using a single operator and machine. The PSV to one decimal place (corrected using the UK control stone) is shown in the Figure. The mean was 55 units. This data includes variability from both machine/operator and UK control stone sources. To compare the aggregate variability alone the uncorrected friction values were compared to that of the UK stone.

Only two batches of the UK control stone were available in New Zealand. Tests done on the same machine by the same operator showed these to not be significantly different (95% confidence level). These were combined and the resulting sample assumed to be representative in terms of variability for the UK stone. It was also assumed that the machine/operator effects would be the same for both aggregates as both were tested simultaneously hence the observed variability would be due to the aggregate alone.

Variability

Friction value	UK control stone	Miners Road
Mean	54.2	56.7
Standard deviation	0.767	0.843
Range	2.8	3.1
<i>F-test for variances</i>	Variances not significantly different at the 95% confidence level	

The mean values are quite close but different at the 95% confidence level. Importantly the variances are not significantly different. So assuming the machine/operator error is the same in both cases, this means that that the inherent variability of the aggregates also is comparable. Hence the error introduced to the final PSV measurement should not be any greater using the Miners Road aggregate as control stone.

Interlaboratory Study

- Interlaboratory testing was carried out to determine an 'expected' value
 - ❖ Opus Research
 - ❖ Fulton Hogan Ltd Christchurch
 - ❖ Downers Hamilton
 - ❖ Vic Roads (Australia)
- Evaluated following ISO 13528 and ISO 5725
- Control stone value assigned by calculating a 'robust mean' of the PSV results



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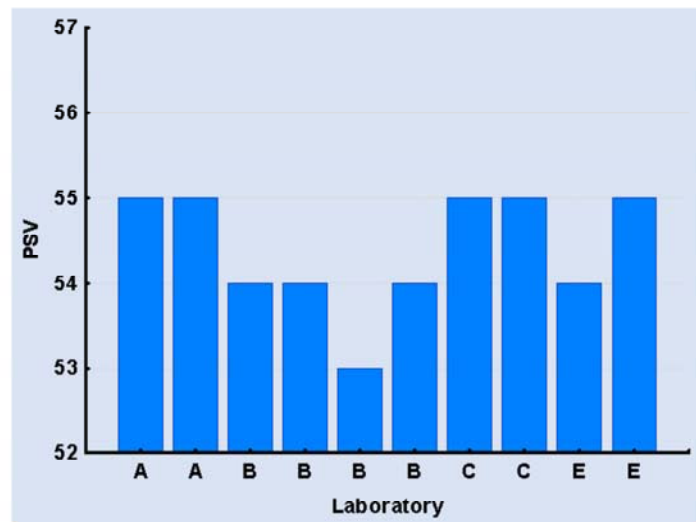
Interlaboratory testing was carried out using the Miners Road aggregate. The UK aggregate was used as control stone to calculate a PSV value that would become the new control stone value. All five labs known to be carrying out the test in New Zealand and Australia were invited to participate but only four were able to complete the testing. The results were analysed using standard methods to determine the expected value and reproducibility.

Interlaboratory Study

➤ PSV results:

❖ Mean 54

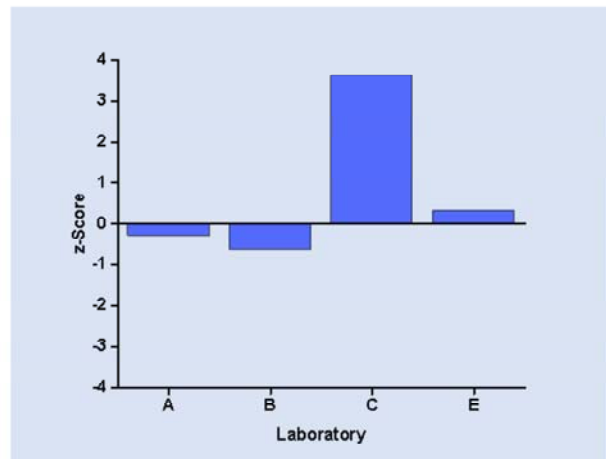
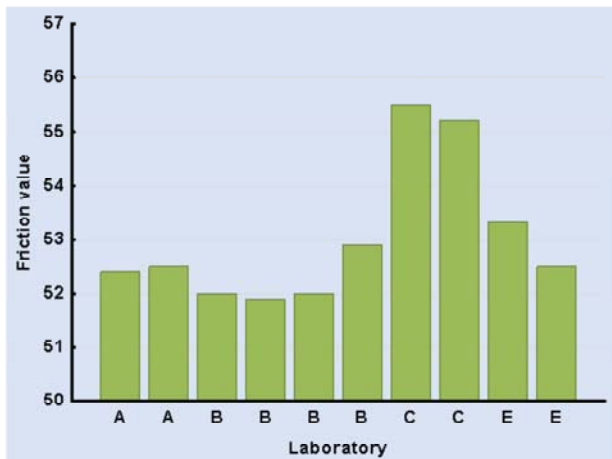
❖ Range 53-55



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The PSV results ranged from 53-55.

Interlaboratory Study



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There was a greater range in the uncorrected friction value data as shown in the Figure on the left. None of the results were outliers but the lab C results did apparently show a significant bias as shown in the plot of z-scores. This has to be interpreted though, in light of the small sample size and the close grouping of the other results. The UK control stone values for this lab were also well within the allowed limits so there is no reason to exclude the data.

The PSV data (calculated to one decimal place) were also analysed using Mandel's h and k statistics and Grubbs test but no significant outliers were found. These analyses are given in the report.

Interlaboratory Study

- Miners Road aggregate friction value: 54.7 ± 0.3
- Reproducibility limit: 1.4
- Suggested acceptable range: 51.7 to 57.7



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To calculate a control stone value for the the Miners Road aggregate the robust mean of the PSV data (recorded to one decimal place- not rounded) was calculated according to the 'consensus value from participants' procedure given in ISO 13528. The uncertainty in the mean at the 95% confidence level was 0.3. The result was very close to that of the UK control stone.

The between lab reproducibility limit is 1.4 units (95% confidence level). i.e. results by two labs could differ by up to 1.4 units without being suspect. The UK control stone value is allowed to range within 6 units; on this basis a range of 6 would also be acceptable for the Miners Road aggregate i.e. 51.1 to 57.7.

Conclusions

- Miners Road aggregate is satisfactory as a control stone
 - ❖ Variability similar than the current UK control stone
 - ❖ PSV falls in the 50-60 range
- New control stone value would be 54.7 (acceptable range 51.7 to 57.7)
- Caveat: Only a small number of laboratories involved



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The Miners Road aggregate is suitable as a replacement for the current UK control stone. The only caveat is that BS 1097-8:2009 requires at least 10 laboratories to set a new value. This was not feasible in the current case. Additional interlaboratory testing would be advisable in the medium term to confirm the results.

Thank you

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