CETANZ

Civil Engineering Testing Association of New Zealand

TECHNICAL REPORT ON

SAND EQUIVALENT TEST PROFICIENCY 2010

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SAND EQUIVALENT PROFICIENCY 2010

1. Introduction

In 2010 CETANZ organised and ran an inter-laboratory proficiency scheme on the Sand Equivalent test, designed to achieve the following outcomes:

1. Provide results that should enable participants to improve their performance.
2. Provide information relevant for calculation of uncertainty.
3. Identify variation caused by different standard preparation methods
4. Gather information from laboratories about their chosen methodology for testing the SE

The following Laboratories participated in the scheme:

AECOM
Bitumen & Pavement Ltd
Central Testing Services
City Care Laboratory
Civil Engineering Laboratory Services
Coffey Information – East Tamaki
Downer Auckland
Downer Christchurch
Downer Mt Maunganui
Downer Wellington
FH Auckland
FH Bay of Plenty
FH Canterbury
FH Hamilton
FH Nelson
FH Dunedin
Geotechnics Tauranga
Holcim Auckland
Holcim Hastings
Material Advisory Testing Services
Northland Soil Mechanics & Testing – Whangarei
Opus Gisborne
Opus Hamilton
Opus Napier
Opus New Plymouth
Opus North Harbour
Opus Rotorua
Opus Tauranga
Opus Whanganui
Opus Whangarei
Stevenson Laboratory
The Isaac Construction Co. Ltd.
Testlab Wanganui
Winstone Aggregates – Auckland
Winstone Aggregates – Waikato

To ensure anonymity of results each laboratory was assigned a unique identifier by Keith Towl of IANZ. Of the participating laboratories only Laboratory #18 and Laboratory #30 failed to return results yielding 33 participants.

2. Sample Preparation

Winstone Aggregates' Auckland Laboratory sampled and prepared material for testing. Three materials were tested, each with the two preparation methods allowed by the standard. The materials tested were:

Flat Top Quarry – GAP25
Puketutu Island Quarry – GAP20
Hunua Quarry – GAP20

The selection of materials was designed to give a range of results from a range of materials from a clean Basalt (Puketutu Island) through a typical Greywacke (Hunua) to a Weathered Basalt (Flat Top).

A bulk sample was collected from each quarry and then split into small portions through a riffle box. Each sample was bagged and sealed before couriering to participating labs

3. Testing

Laboratories were asked to complete two full tests on each material in accordance with the standard method

One was to be prepared by the "brushed" method, where the portion of the test sample retained on a 4.75m test sieve is rubbed and brushed to clean the large particles of fines. This fine material is then added to the other material passing the 4.75mm

The second was to be prepared using the "washed" method. This is used in instances where rubbing and brushing can not remove fine particles from the material retained on the 4.75mm test sieve. This preparation involves washing the large particles with a minimal amount of distilled water, collecting all of the wash water, reducing the water content and then mixing with the rest of the material passing the 4.75mm test sieve.

4. Results

A summary of results is included in Appendix 1. 33 results are included in the analysis of the results with 2 laboratories submitting non IANZ endorsed results. Appendix 2 contains a breakdown of z-scores for each labs results to allow individual laboratories to evaluate their own performance.

For the analysis of results all results were included. There were results present that potentially could be considered outliers. Difficulties with defining an outlier and the importance of representing the full range of results have meant these numbers have been retained.

5. Analysis

Graphs 1-3 show the results for the 3 different materials included in the program. Each chart distinguishes the results obtained from the "brushed" method from those obtained using the "washed" method.
As expected each material produced clusters of results around different values. There were clear and relatively consistent differences between results obtained using the two preparation methods used in the method.
Before looking in too much detail at the impact of specimen preparation we will look briefly at the overall results.

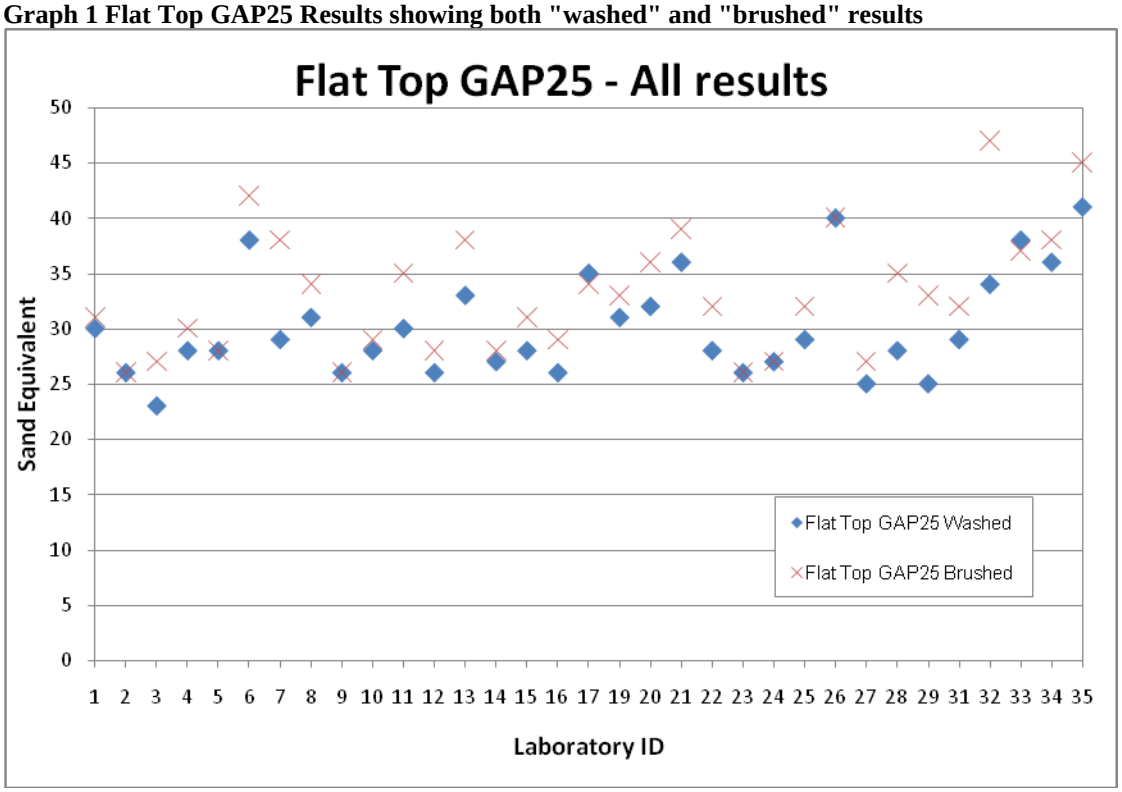
Flat Top GAP25

Table 2 Flat Top GAP25 Sand Equivalent Statistical results.

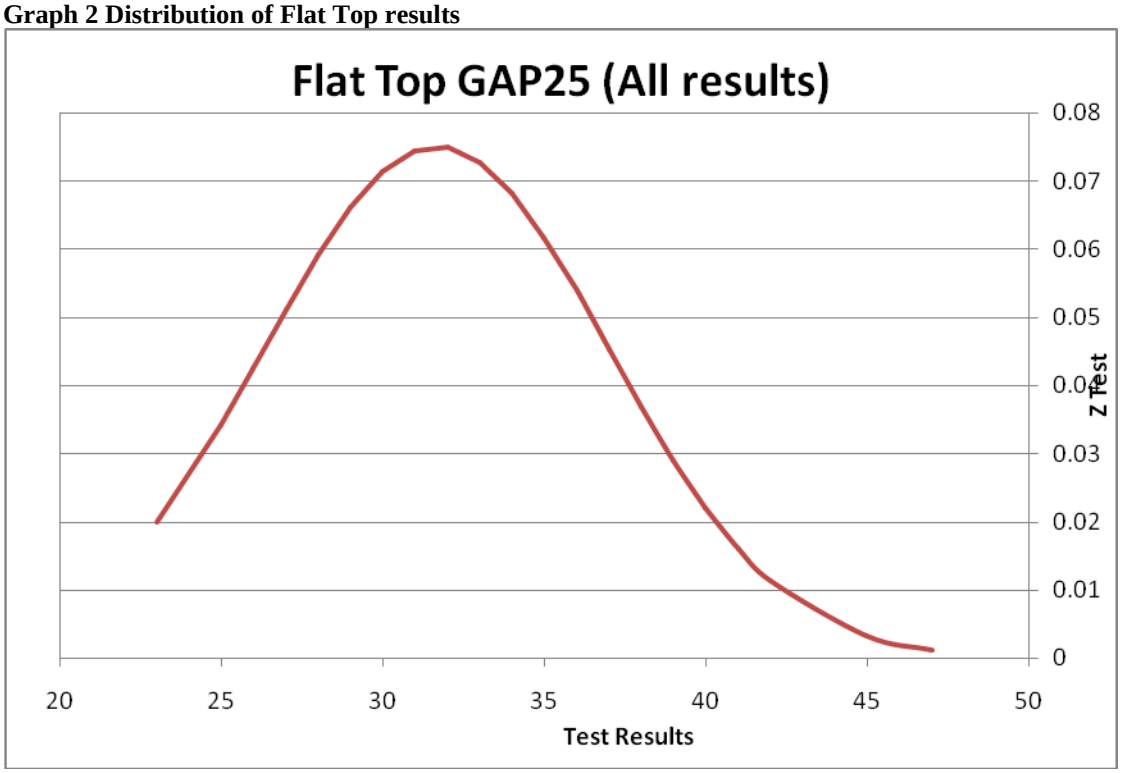
Mean	Standard Deviation	Range	Median
31.7	5.3	24	30.5

Table 2 gives a breakdown of results pertaining to the Flat Top material. The difference between the Mean and the Median indicates that although the results approximately fit a normal distribution there is some skewing caused by higher values. Flat Top's results are graphed in full in Graph 1. Of the Flat Top results, 64% fell within ±1 Z-score, 97% within ±2 Z-scores and 3% over ±2 Z-scores, at this point no results were excluded.

Graph 1 Flat Top GAP25 Results showing both "washed" and "brushed" results



Graph 2 Distribution of Flat Top results



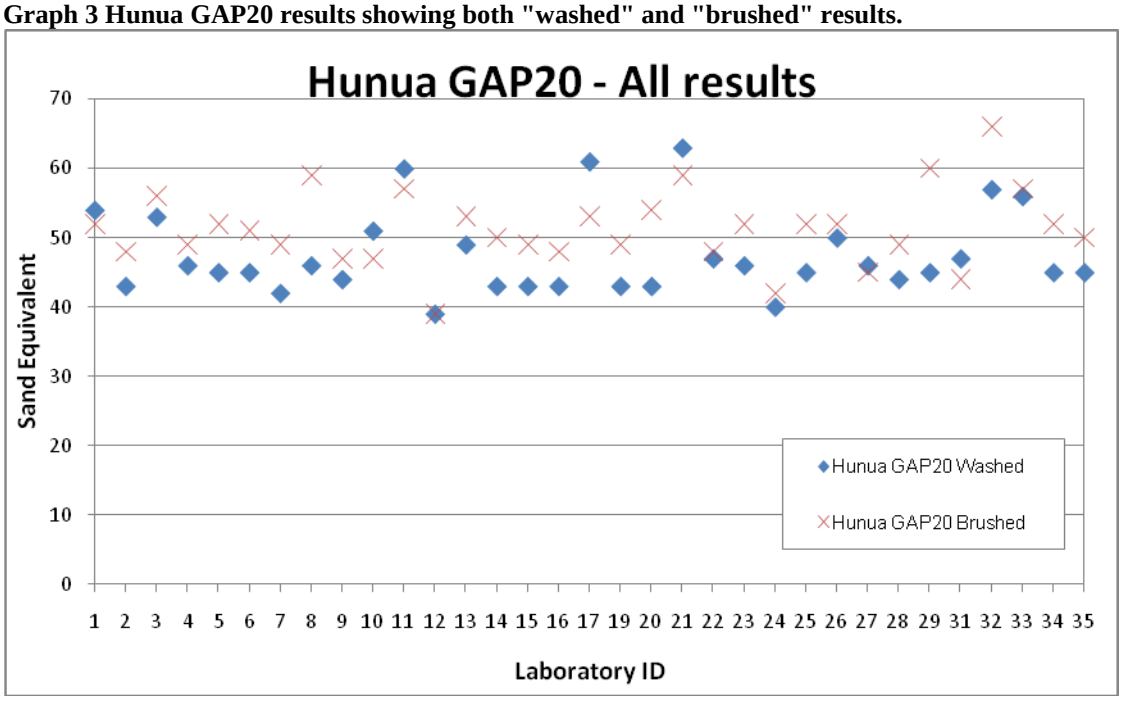
Hunua GAP20

Table 3 Hunua GAP20 Sand Equivalent Statistical results.

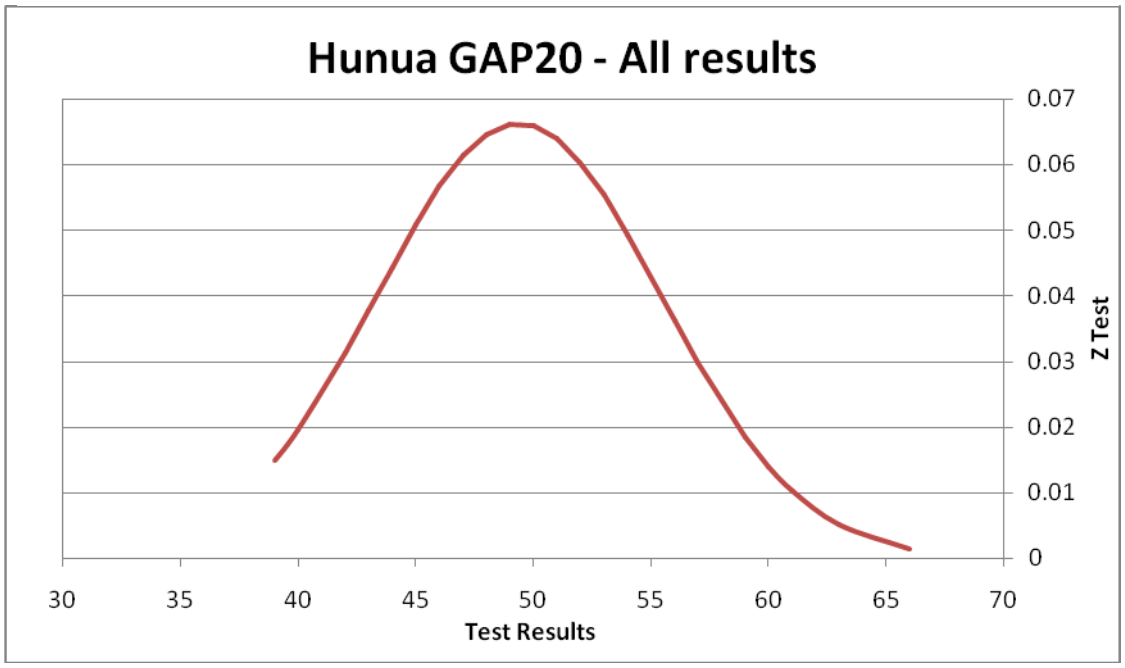
Mean	Standard Deviation	Range	Median
49.4	6.0	27	49

The GAP20 from Hunua yielded a higher spread of results than the Flat Top material as evidenced by the higher standard deviation. These were however more evenly distributed around the mean. Hunua's GAP20 results are shown in Graph 2. To try and look for outliers, Z-scores were again employed on the Hunua data set. Similar numbers were seen as on the Flat Top data: 65% within ±1 Z-scores, 97% within ±2 Z-scores and 3% over ±2.

Graph 3 Hunua GAP20 results showing both "washed" and "brushed" results.



Graph 4 Distribution of Hunua results



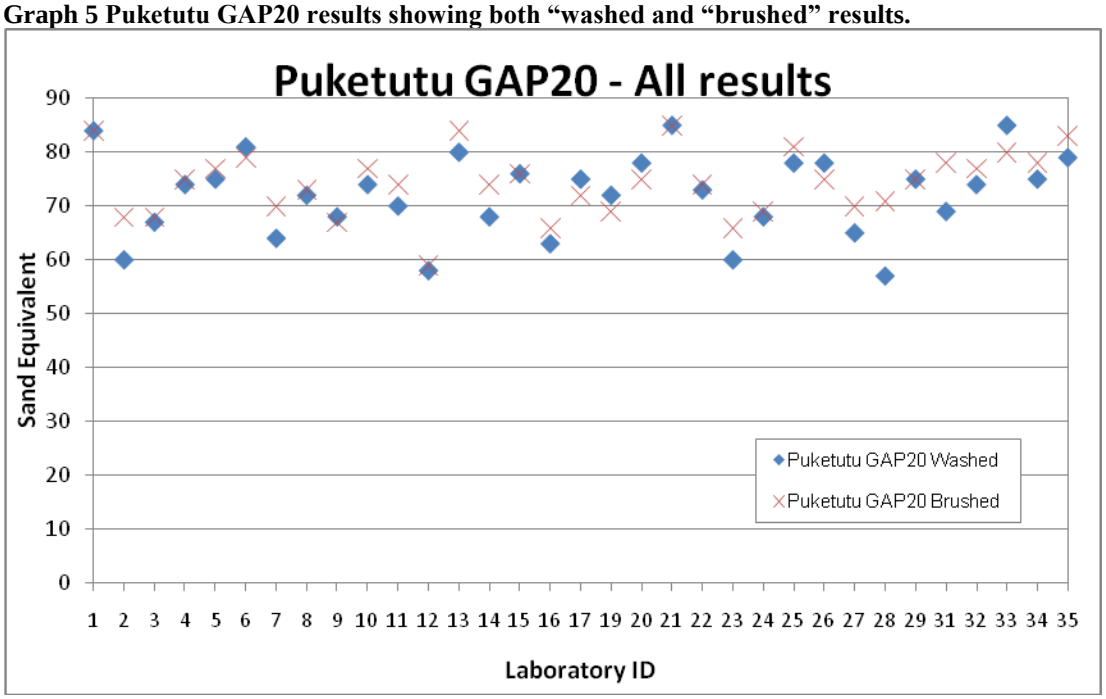
Puketutu Island GAP20

Table 4 Puketutu GAP20 Sand Equivalent Statistical results

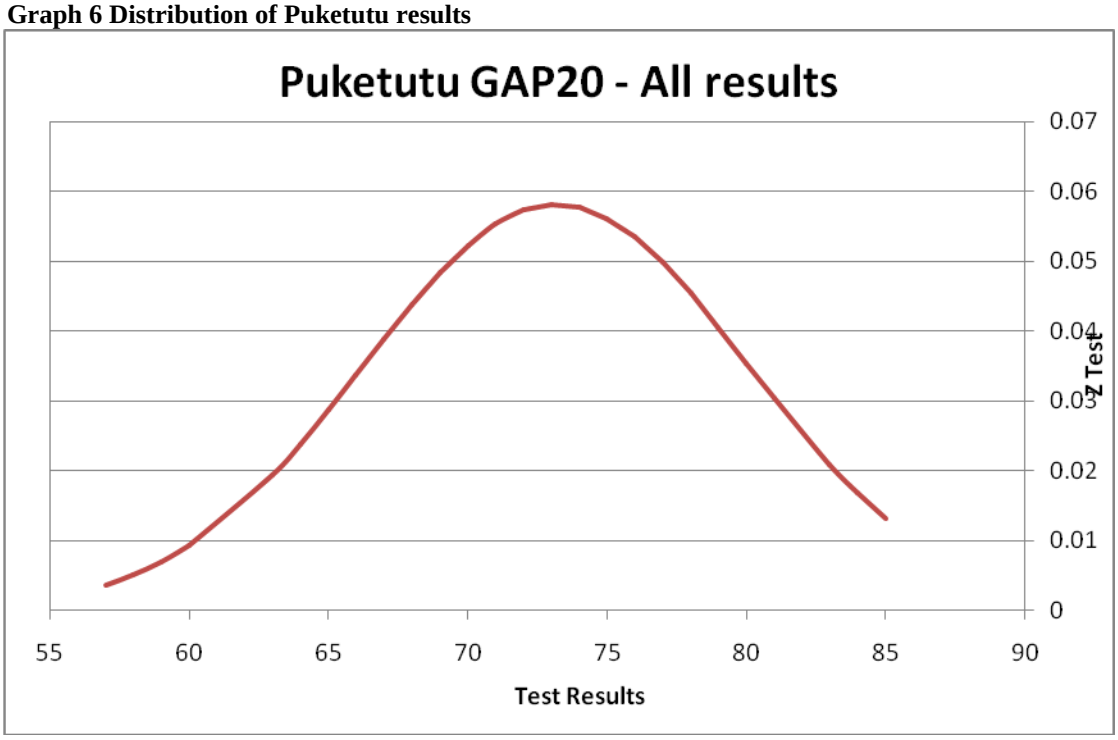
Mean	Standard Deviation	Range	Median
73.2	6.9	28	74

The cleanest material tested was the Puketutu Island GAP20. These results were the most widely distributed set of results in the series, however the distribution still could be described as normal indicating that the results were influenced more by the material rather than individual labs performing the test differently or incorrectly. 71% of the results fell within ±1 Z-score, 95% within ±2 Z-scores and 5% outside ±2. None were outside ±3 which again indicates a wider spread of results that are still valid.

Graph 5 Puketutu GAP20 results showing both "washed and "brushed" results.



Graph 6 Distribution of Puketutu results



The distribution of results seems to indicate that for each material tested the results are reasonably dispersed.
Each material displays some slight skewness in its distribution, in each instance this seems to be down to heavy tails on the distribution rather than a more general skewing of data.
There is also a suggestion that the cleaner the material more dispersed the results are likely to be. This is indicated by slightly lower maximum distribution numbers for the cleaner materials (over 0.7 for Flat Top down to less than 0.6 for Puketutu)

Preparation Method

A key aim of this study was to examine the differences in SE results caused by the test preparation method. Overall the difference in results averaged out at 2.9, which while significant was not as high as expected.

Table 5 Sand Equivalent Statisitical results seperated by preparation method.

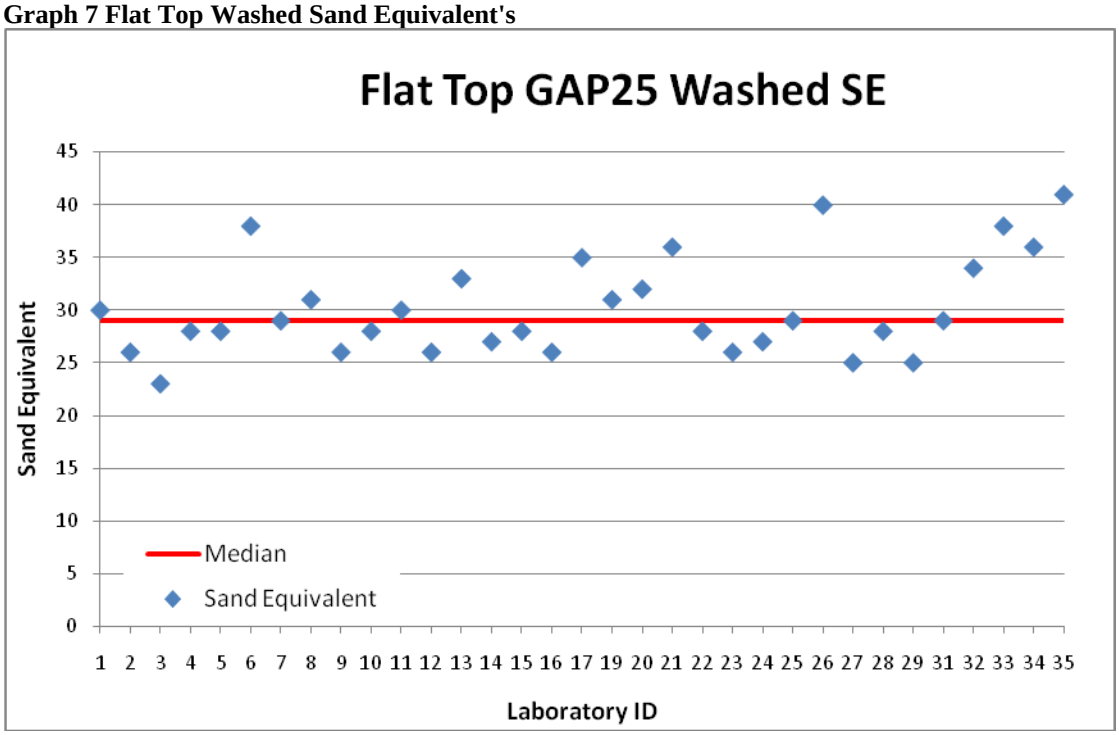
Material	Preparation	Mean	SD	Range	Mean difference between preparation	%within ±1 Z-score	%within ±2 Z-scores	% > 2 Z-scores	95% confidence interval
Hunua GAP20	***Brushed***	51.2	5.4	27.0	3.6	69.7	93.9	6.1	10.1
	Washed	47.5	6.1	24.0		75.8	90.9	9.1	12.6
P22 GAP20	***Brushed***	74.2	6.0	26.0	2.1	66.7	97.0	3.0	12.2
	Washed	72.1	7.6	28.0		66.7	100.0	0.0	19.6
Flat Top GAP25	***Brushed***	33.1	5.6	21.0	2.9	66.7	93.9	6.1	10.6
	Washed	30.2	4.7	18.0		69.7	93.9	6.1	7.5

The results for each material were collated and then filtered to allow assessment of the various results as a stand-alone data-set.

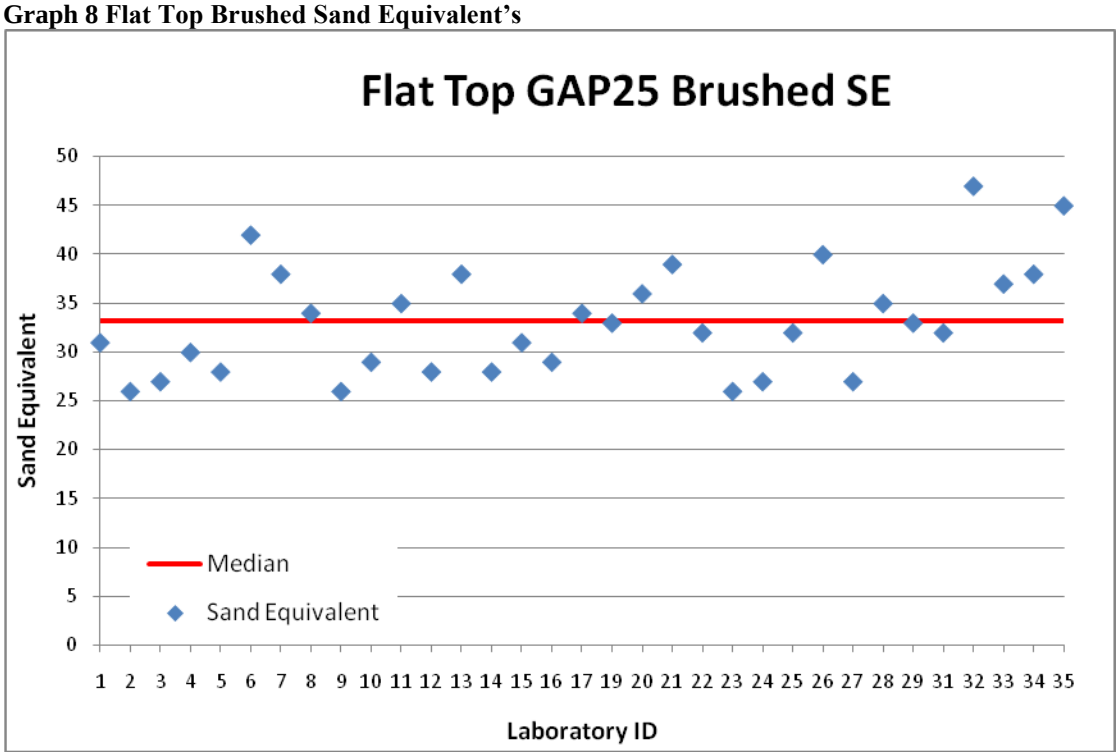
As expected in each case the Mean Sand Equivalent Value for washed specimens was lower when compared with brushed specimens. There was an average decrease of 2.88 which didn't appear to vary dependent on the material being tested. The results indicate that the SE value should be consistently lower when a sample is washed rather than brushed during preparation.
This reduces the usefulness of brushing as a preparation method. However it is important to note that for 2 of the 3 materials tested, the 95% confidence interval actually increased for the washed samples. This indicates that results using the Brushed method are potentially less accurate or more sensitive.

The results, broken into material and preparation method are plotted on Graphs 7-12.

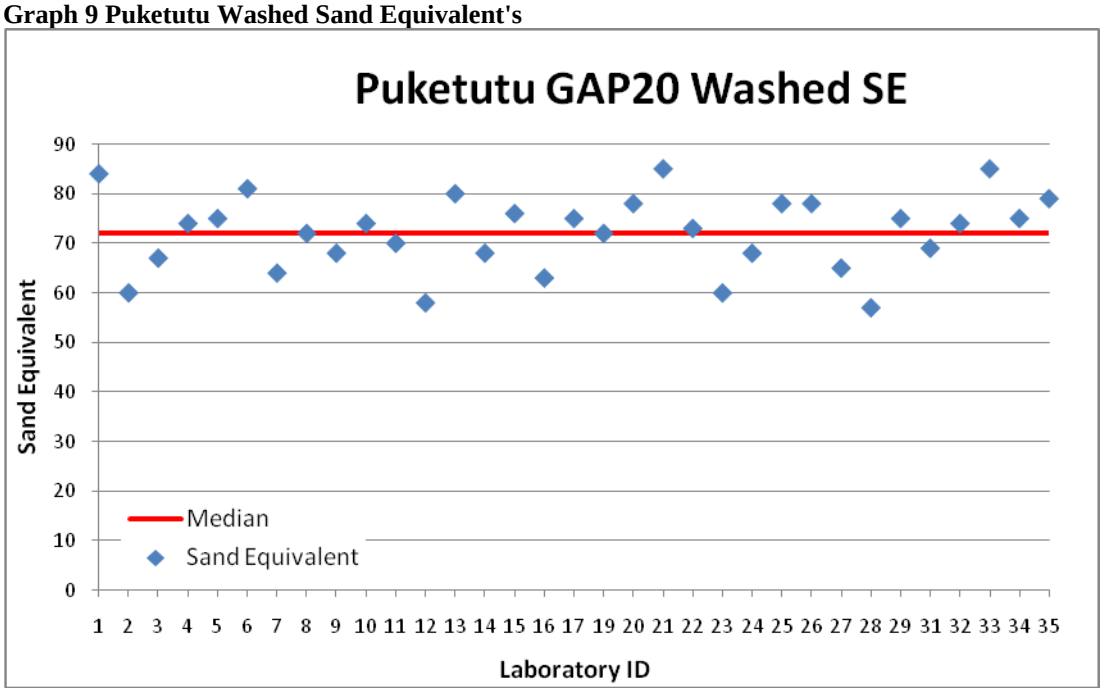
Graph 7 Flat Top Washed Sand Equivalent's



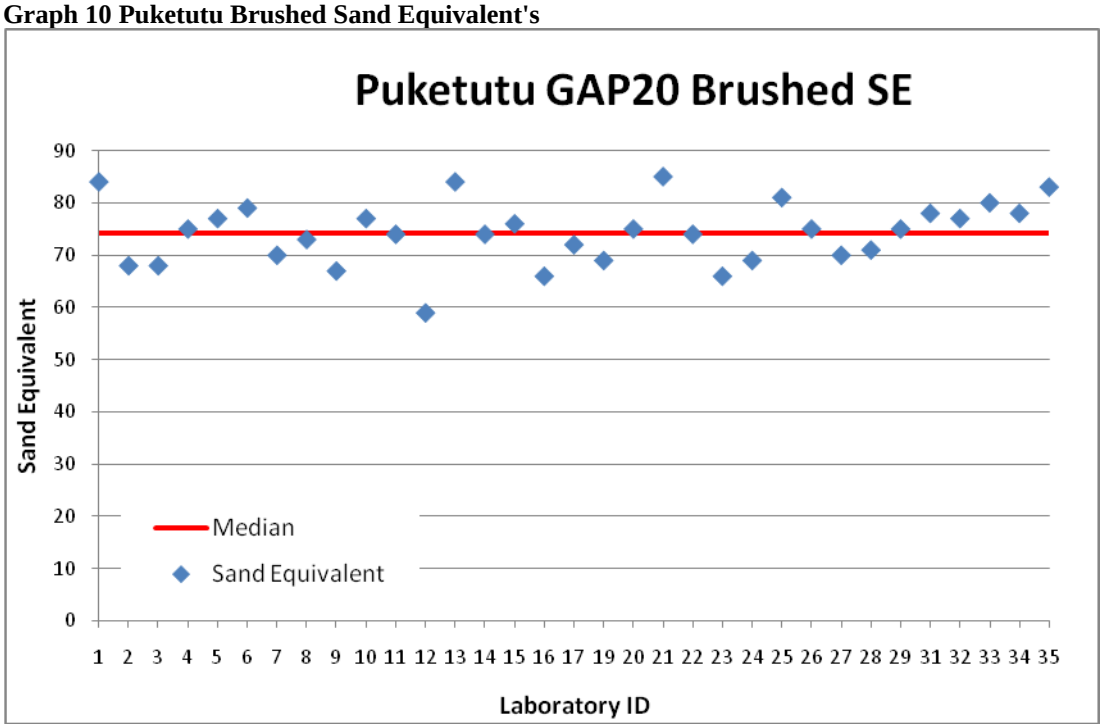
Graph 8 Flat Top Brushed Sand Equivalent's



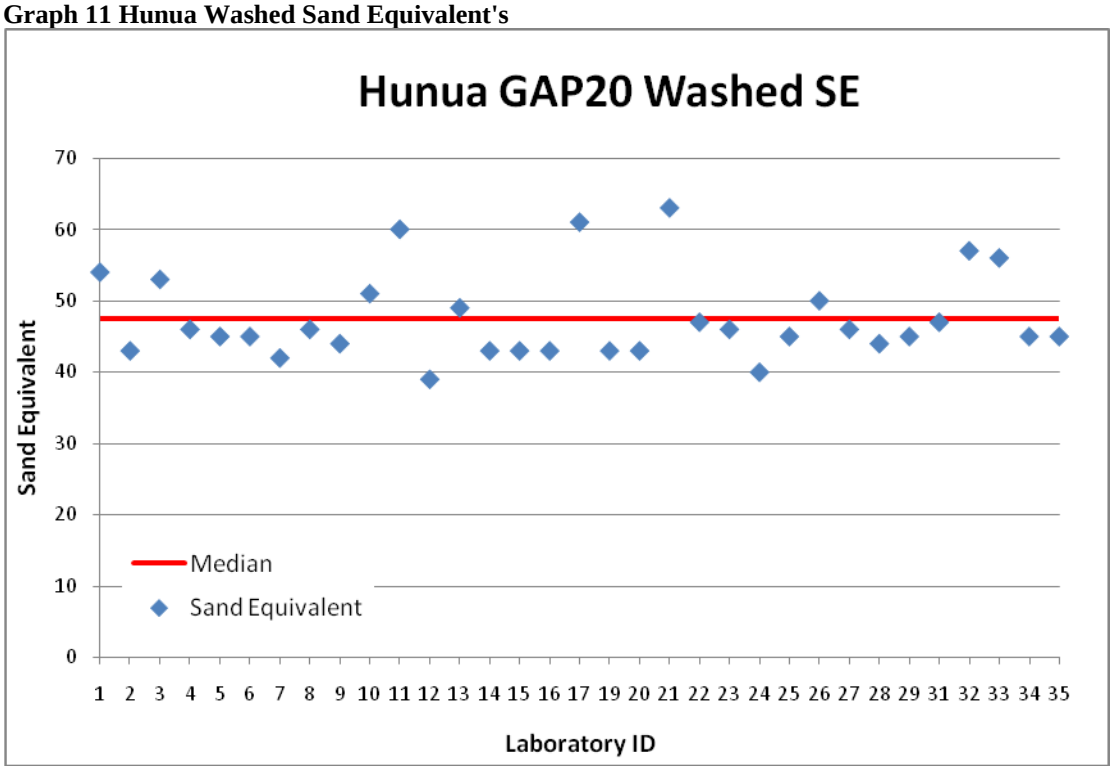
Graph 9 Puketutu Washed Sand Equivalent's



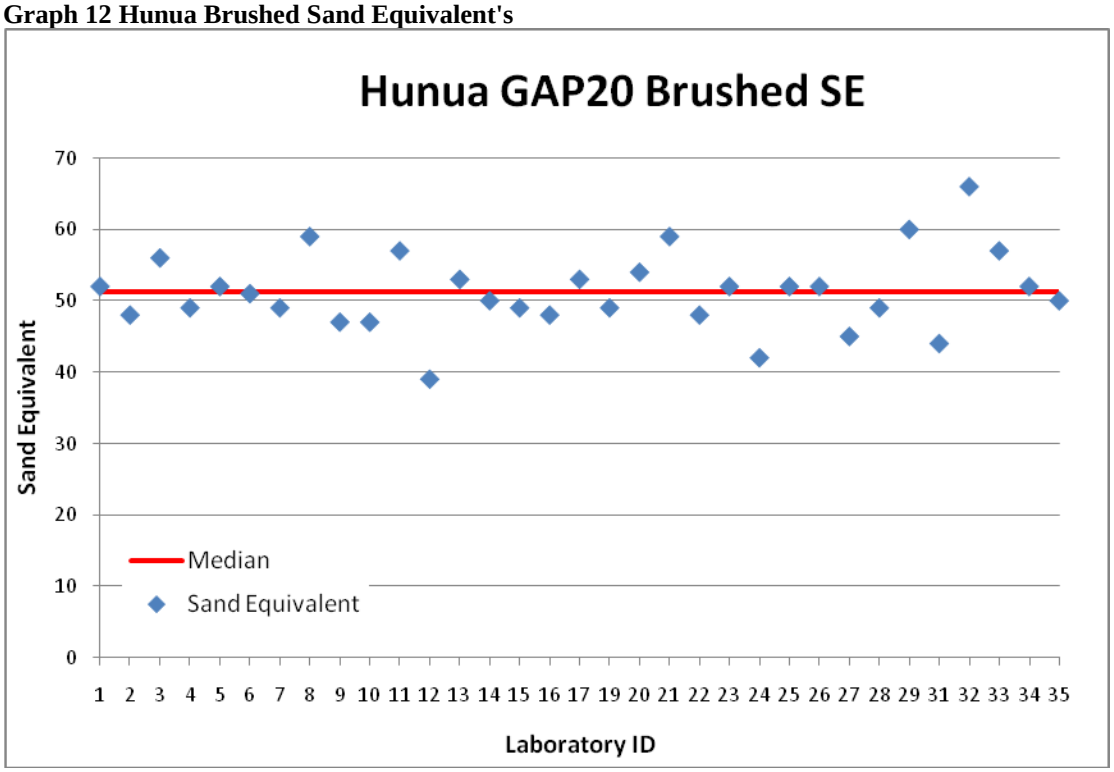
Graph 10 Puketutu Brushed Sand Equivalent's



Graph 11 Hunua Washed Sand Equivalent's



Graph 12 Hunua Brushed Sand Equivalent's



6. Conclusions

The results of the proficiency scheme have played out largely as expected.

Our data gives us a mean Standard Deviation of 5.9 and an average 95% confidence value of 12.1.

ASTM D2419-09 states multi-laboratory precision for the method:

> For materials with a SE greater than 80, standard deviation of 4.4 and multi-laboratory results within 12.5.
> For materials with a SE less than 80, standard deviation of 8 and multi-laboratory results within 22.5

With the materials used in this scheme not giving us results above 80 we can not evaluate our results against the entire ASTM precision statement.

For materials with a Sand Equivalent less than 80, our standard deviation is less than the ASTM standard method which would suggest better than expected agreement between laboratories.

The preparation of samples, while producing slightly different results becomes a less significant factor in the context of the overall variability of the method. While a washed preparation will produce a lower result, the magnitude of difference seems relatively consistent across various materials. Perhaps more importantly the results generated in this scheme using the washed method appear to be less consistent, or more diverse, than those using the brushed method.

7. Further action

Advise stakeholders of uncertainty of the test method and use of subsequent data.

8. Referenced Documents

NZS4407:1991:3.6
ASTM D2419-09

9. Disclaimer

The information in this publication is to encourage high standards within the civil engineering testing industry. The information is intended as a technical report for CETANZ members only and in no way purports to be a robust statistical analysis. CETANZ cannot accept any liability of any sort for unsatisfactory site or laboratory work carried out by Companies who are members of CETANZ or organisations who claim to be following this report. CETANZ assumes no responsibility for any loss which may arise from reliance on the report and disclaims all liability accordingly. Specialist and/or legal advice should always be sought on any specific problem or matter.

Appendix 1

Raw results showing non IANZ endorsed numbers in blue

Lab ID	Hunua GAP20		Puketutu GAP20		Flat Top GAP25	
	Brushed	Washed	Brushed	Washed	Brushed	Washed
1	52	54	84	84	31	30
2	48	43	68	60	26	26
3	56	53	68	67	27	23
4	49	46	75	74	30	28
5	52	45	77	75	28	28
6	51	45	79	81	42	38
7	49	42	70	64	38	29
8	59	46	73	72	34	31
9	47	44	67	68	26	26
10	47	51	77	74	29	28
11	57	60	74	70	35	30
12	39	39	59	58	28	26
13	53	49	84	80	38	33
14	50	43	74	68	28	27
15	49	43	76	76	31	28
16	48	43	66	63	29	26
17	53	61	72	75	34	35
19	49	43	69	72	33	31
20	54	43	75	78	36	32
21	59	63	85	85	39	36
22	48	47	74	73	32	28
23	52	46	66	60	26	26
24	42	40	69	68	27	27
25	52	45	81	78	32	29
26	52	50	75	78	40	40
27	45	46	70	65	27	25
28	49	44	71	57	35	28
29	60	45	75	75	33	25
31	44	47	78	69	32	29
32	66	57	77	74	47	34
33	57	56	80	85	37	38
34	52	45	78	75	38	36
35	50	45	83	79	45	41

Appendix 2

Z-scores for each participant showing the number of standard deviations away from the material mean an individual results lies.

Lab ID	Hunua GAP20		Puketutu GAP20		Flat Top GAP20	
	Brushed	Washed	Brushed	Washed	Brushed	Washed
1	0.15	1.06	1.63	1.57	-0.38	-0.05
2	-0.59	-0.75	-1.04	-1.60	-1.28	-0.90
3	0.88	0.90	-1.04	-0.68	-1.10	-1.54
4	-0.41	-0.25	0.13	0.25	-0.56	-0.47
5	0.15	-0.42	0.47	0.38	-0.92	-0.47
6	-0.04	-0.42	0.80	1.17	1.59	1.67
7	-0.41	-0.91	-0.70	-1.07	0.87	-0.26
8	1.43	-0.25	-0.20	-0.02	0.16	0.17
9	-0.78	-0.58	-1.20	-0.54	-1.28	-0.90
10	-0.78	0.57	0.47	0.25	-0.74	-0.47
11	1.07	2.05	-0.04	-0.28	0.34	-0.05
12	-2.25	-1.40	-2.54	-1.86	-0.92	-0.90
13	0.33	0.24	1.63	1.04	0.87	0.60
14	-0.22	-0.75	-0.04	-0.54	-0.92	-0.69
15	-0.41	-0.75	0.30	0.51	-0.38	-0.47
16	-0.59	-0.75	-1.37	-1.20	-0.74	-0.90
17	0.33	2.21	-0.37	0.38	0.16	1.02
19	-0.41	-0.75	-0.87	-0.02	-0.02	0.17
20	0.51	-0.75	0.13	0.78	0.52	0.38
21	1.43	2.54	1.80	1.70	1.05	1.24
22	-0.59	-0.09	-0.04	0.12	-0.20	-0.47
23	0.15	-0.25	-1.37	-1.60	-1.28	-0.90
24	-1.70	-1.24	-0.87	-0.54	-1.10	-0.69
25	0.15	-0.42	1.13	0.78	-0.20	-0.26
26	0.15	0.40	0.13	0.78	1.23	2.09
27	-1.14	-0.25	-0.70	-0.94	-1.10	-1.11
28	-0.41	-0.58	-0.54	-2.00	0.34	-0.47
29	1.62	-0.42	0.13	0.38	-0.02	-1.11
31	-1.33	-0.09	0.63	-0.41	-0.20	-0.26
32	2.72	1.55	0.47	0.25	2.49	0.81
33	1.07	1.39	0.97	1.70	0.69	1.67
34	0.15	-0.42	0.63	0.38	0.87	1.24
35	-0.22	-0.42	1.47	0.91	2.13	2.31