CETANZ

Civil Engineering Testing Association of New Zealand

TECHNICAL REPORT ON

WEATHERING QUALITY INDEX OF COARSE AGGREGATE PROFICIENCY PROGRAMME

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This report serves to summarise the results of the 2009/2010 CETANZ Weathering Quality Index Proficiency.

Introduction

The Weathering Quality Index (WQI) has been used in New Zealand for over 40 years. It attempts to rate durability of an aggregate by applying cycles of attrition, wetting and drying to accelerate any breakdown that may occur in service. At the end of the test, fines produced passing the 4.75mm sieve and a cleanness value is carried out to assign an index ranging from AA to CC. The first letter being related to fines produced passing the 4.75mm, the latter is the cleanness value.

There have been some doubts about the accuracy of the weathering test within the civil testing industry. In an effort to investigate and quantify this variation, CETANZ decided to design a proficiency scheme.
In late 2009 CETANZ started its proficiency program with a number of large schemes. One of the first being the Weathering Quality Index Proficiency. In December 2009 Stevenson Laboratory volunteered to organise and distribute samples to over 30 Laboratories in New Zealand. Due to the nature of the test it was not possible to send out the normal three different type/levels of samples that would normally be expected of a full proficiency scheme. It was decided that this first attempt would act as more of a trial or initial investigation into the test method. In December 2009 samples were distributed to the following Laboratories:

AECOM - Hamilton
Babbage Consultants Ltd
Central Testing Services - Alexandra
Civil Engineering Laboratory Services Ltd - Nelson
Coffey Information - East Tamaki
Downer EDI Works - Auckland
Downer EDI Works - Christchurch
Downer EDI Works - Wellington
Fulton Hogan Laboratory - Auckland
Fulton Hogan Laboratory - Canterbury
Fulton Hogan Laboratory - Dunedin
Fulton Hogan Laboratory - Nelson
Fulton Hogan Laboratory - BOP
Fulton Hogan Laboratory - Waikato
Geotechnics - Auckland
Geotechnics - Tauranga
Higgins - Palmerston North
Northland Soil Mechanics & Testing - Whangarei
OPUS International Consultants - Auckland
OPUS International Consultants - Dunedin
OPUS International Consultants - Gisborne
OPUS International Consultants - Hamilton
OPUS International Consultants - Napier
OPUS International Consultants - New Plymouth
OPUS International Consultants - Rotorua
OPUS International Consultants - Tauranga
OPUS International Consultants - Wanganui
Stevenson Laboratory Ltd
Test Lab - Wanganui
Winstone Aggregate Ltd - Auckland Laboratory
Winstone Aggregate Ltd - Waikato Laboratory

Table 1 Test Results Received

Lab I.D.	% Sample Retained *nearest 0.1%*	Cleanness Value	WQI
1	90.4	75	CB
2	95.6	**93**	AA
3	94.0	91	BA
4	94.5	91	BA
5	91.1	87	BB
6	95.2	87	BB
7	93.3	87	**BB**
8	94.2	93	BA
10	93.0	87	BB
11	92.7	89	BB
12	94.4	68	BC
13	89.6	87	CB
14	91.7	91	BA
15	91.9	89	BB
16	93.9	87	BB
17	92.1	87	BB
18	89.6	75	CB
19	94.3	89	BB
20	96.1	91	AA
21	90.6	83	BB
22	89.6	79	CB
23	91.7	98	BA
24	92.8	91	BA
25	93.2	89	BB
26	93.3	85	BB
27	94.5	89	BB
28	92.5	95	BA
29	91.3	89	BB
30	93.3	88	BB
31	90.8	**92**	**BA**

* Red figures and numbers indicate that wrong category submitted. Results were checked and changed.

Laboratories were issued laboratory identification numbers by Keith Towl of IANZ so as to keep the identity of the laboratory confidential. All results were returned before the end of April 2010. Laboratory # 12 results were excluded as upon further investigation it was discovered that this laboratory may not have performed the test correctly and was not IANZ accredited for the test at that time. Laboratory # 9 did not return results.

The purpose of the scheme was to:

1. Provide results that should enable participants to improve their performance.
2. Provide information relevant for calculation of uncertainty.
3. Contribute to confidence of mutual users of Civil Engineering Laboratories.
4. Identify problems with, or between, Laboratories.
5. Provide an indication of the industry's ability to perform the test method.
6. Potentially identifying needs for test method improvement.

Sample preparation

Stevenson Laboratory retrieved a large bulk sample (1100kg+) of Subbase GAP 65 Greywacke from Drury Quarry. The bulk sample was well mixed as it had been produced by a continuous Pugmill mixing plant. The bulk sample was split into individual 22kg samples using quartering and riffle box methods.

Instructions. Each Laboratory was asked to assign one technician to the preparation and testing of the Weathering Quality Index on the sample provided. This required each Lab to wash and screen the sample as per the test standard before the test commenced. Laboratories were asked to return the results on the Results Return form provided.

Test results (Table 1) were received from 30 laboratories among which 29 laboratories are registered by IANZ for this test. One result identified as “BC” is from lab 12 which is not IANZ accredited. This will be excluded in the following analysis.

Methodology of the analysis

This analysis is based on the statistical measures of Z-Score, normal distribution curve and the Z-Test.

Z-Score is a statistical measure that quantifies the distance (measured in standard deviations) a data point is from the mean of a data set.

The normal distribution curve: a normal data point is data that falls within ±2 Z Scores, i.e., two standard deviations from the mean value. A normal distribution curve will demonstrate how the data set distributes along the Z score. The more data points that are distributed around 0 Z scores, the better the data set in terms of the accuracy.

On the other hand, a highly dispersive curve shows that the data in the data set do not agree well. Refer to Graph 2-4.

The Z-Test represents the probability that the sample mean would be greater than the observed value average.

Test result interpretation

1. Overall

Graph 1 contains all data points (exclusive of lab 12) which are graphed on the WQI chart in the test method. 80% of the data sits in a cluster. The red dot is the average point.

Overall, the cleanness value has a range of 30 and percentage passing 4.75mm sieve (PP4S) range of 6.5.

2. Percentage Passing 4.75mm Sieve (PP4S)

72% of the PP4S test results are within ±1 Z Scores and 28% are within ±2 Z Scores. There are no results outside of ±2 Z Scores, i.e. outliers. Refer to Table 3.

The range of 6.5% for PP4S is about twice the accuracy precision of the sieving test proficiencies, as per ASTM C136, which gives acceptable accuracy of 3.4% for Multi-laboratories. Therefore, the discrepancy generated by the WQI test method can be safely assumed at about ±1.5% from average or at range of 3%. This is rather insignificant and considered to be good. The matter will not be discussed further in this report.

Graph 2: Plots the PP4S test results and z scores on a normal distribution curve.

3. Cleanness Value (CV)

83% of the CV results are within ±1 Z Scores and 17% are within ±2 Z Scores. One result is outside of ±3 Z Scores which is excluded from this analysis (Lab 12). Refer to Table 4.

For CV, the range of 30 seems to be excessive. It is worth noting, if the two highest results and the four lowest results are discounted (refer to Graph 1), the rest of the results will have cleanness value range of 10 which is considered to be a more acceptable range for this test.

Graph 3: plots cleanness value results and Z Scores to the normal distribution curves at presentable scale and Graph 4 and Graph 2

have same scale on Y axis for comparison purposes.

Comparing Normal Distributions of Graph 2 with Graph 4, it is not difficult to find that CV results (peak value of 0.06) are much more dispersed than PP4S (peak value of 0.22). The smaller the peak value, the more spread out the data. Therefore less accurate.

4. Conclusion

- The PP4S seems to be reasonably consistent, with 79% of the results grouped well in the category B. Refer to Table 2.
- One could assume that the PP4S test methods are acceptable while the cleanness value results need improving to achieve a higher accuracy.
- The CV results are spread mostly across two categories A and B. see Graph 4.
- The Graph 2 and Graph 4 have the same vertical scale. Graph 4 has much greater spread than Graph 2. The ±1 and ±2 Z score areas of Graph 2 cover far greater area than that of Graph 4. Therefore, the conclusion can be drawn that the cleanness value results are far from consistent.
- Possible cause of spread of CV data is subject for further discussion. However, the following factors may be contributing:
  i. Method of rolling
  ii. Sample preparation
  iii. How the water was treated at each stage of the testing.
  iv. The boiling of the water
  v. Uncertainty of Measurement of CV Test

5. Where to go from here

- Further study should be performed to identify why the cleanness value test has such a large discrepancy when done as part of WQI test. Is it caused by the cleanness value test methodology itself or any part of the weathering test methodology?
- An analysis on a large scale interlab of cleanness value test including 4 samples with a CV of approximately 90 would be helpful in deciding the root cause.

Acknowledgement:

Jayden Ellis from Stevenson Laboratory and Steven Anderson from Geotechnics have been involved in compiling and editing. Both of them are in the CETANZ Technical Group.

Table 2 Percentage of results in each category				
	PP4S	Percentage	CV	%
A	2	7	10	34
B	23	79	19	66
C	4	14	0	0
Total	29	100	29	100

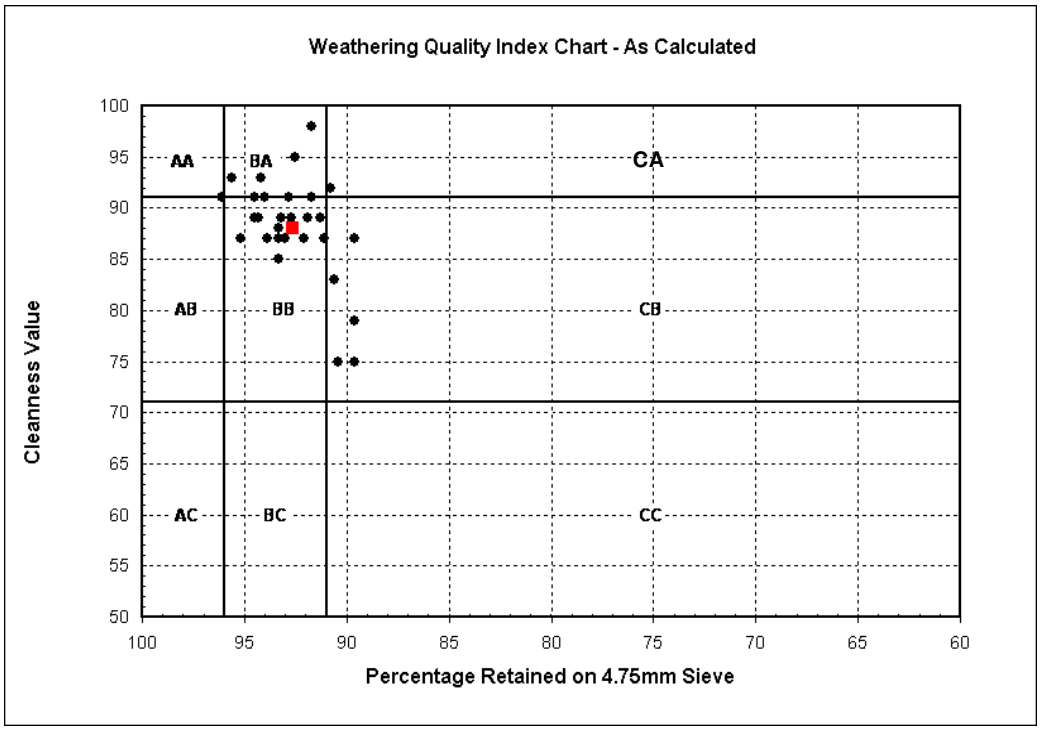
Table 3 PP4S Z Score Distribution		
	No	%
≤ 1 Z Scores	21	72
1- 2 Z Scores	8	28
> 2 Z Scores	0	0
Total	29	100

Table 4 Cleannes Value Z Score Distribution		
	No	%
≤ 1 Z Scores	24	83
1- 2 Z Scores	5	17
> 2 Z Scores	0	0
Total	29	100

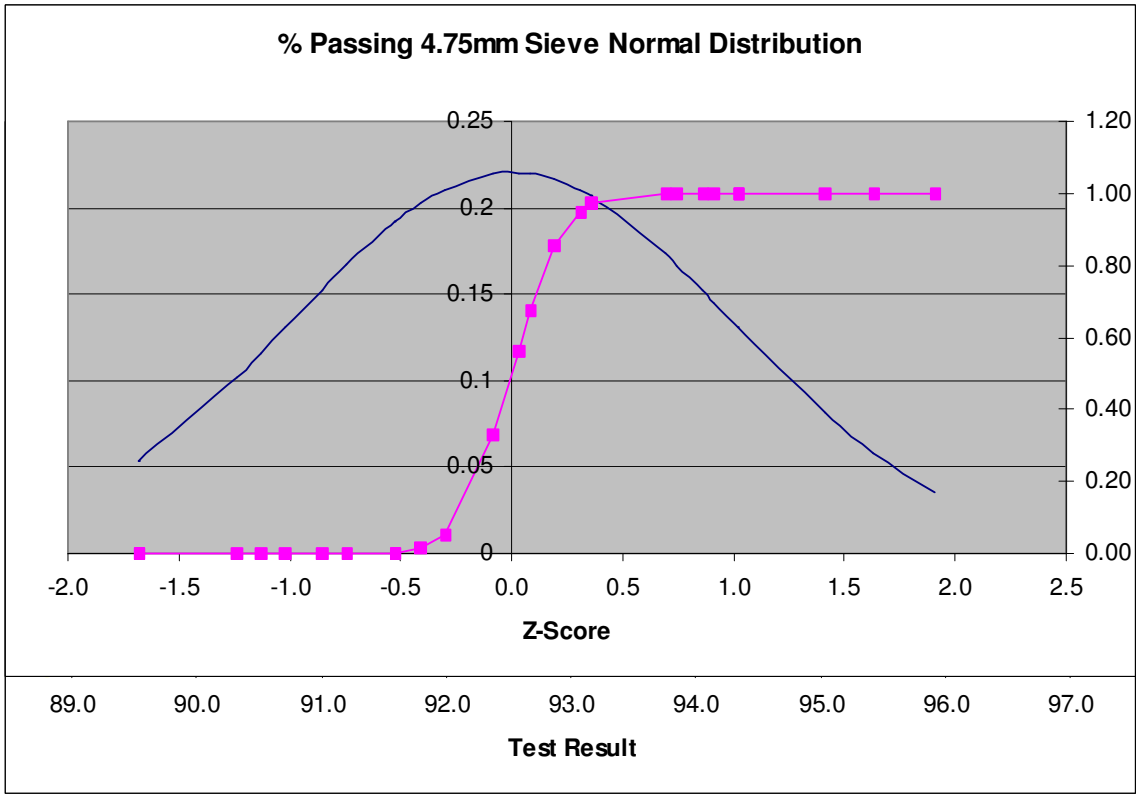
Table 5 Z Scores

Lab I.D.	% Sample Retained		Cleanness Value	
	%Ret	Z-score	CV	Z-score
1	90.4	-1.2	75	-2.6
2	95.6	1.6	93	1.0
3	94.0	0.7	91	0.6
4	94.5	1.0	91	0.6
5	91.1	-0.9	87	-0.2
6	95.2	1.4	87	-0.2
7	93.3	0.4	87	-0.2
8	94.2	0.9	93	1.0
10	93.0	0.2	87	-0.2
11	92.7	0.0	89	0.2
13	89.6	-1.7	87	-0.2
14	91.7	-0.5	91	0.6
15	91.9	-0.4	89	0.2
16	93.9	0.7	87	-0.2
17	92.1	-0.3	87	-0.2
18	89.6	-1.7	75	-2.6
19	94.3	0.9	89	0.2
20	96.1	1.9	91	0.6
21	90.6	-1.1	83	-1.0
22	89.6	-1.7	79	-1.8
23	91.7	-0.5	98	2.0
24	92.8	0.1	91	0.6
25	93.2	0.3	89	0.2
26	93.3	0.4	85	-0.6
27	94.5	1.0	89	0.2
28	92.5	-0.1	95	1.4
29	91.3	-0.7	89	0.2
30	93.3	0.4	88	0.0
31	90.8	-1.0	92	0.8

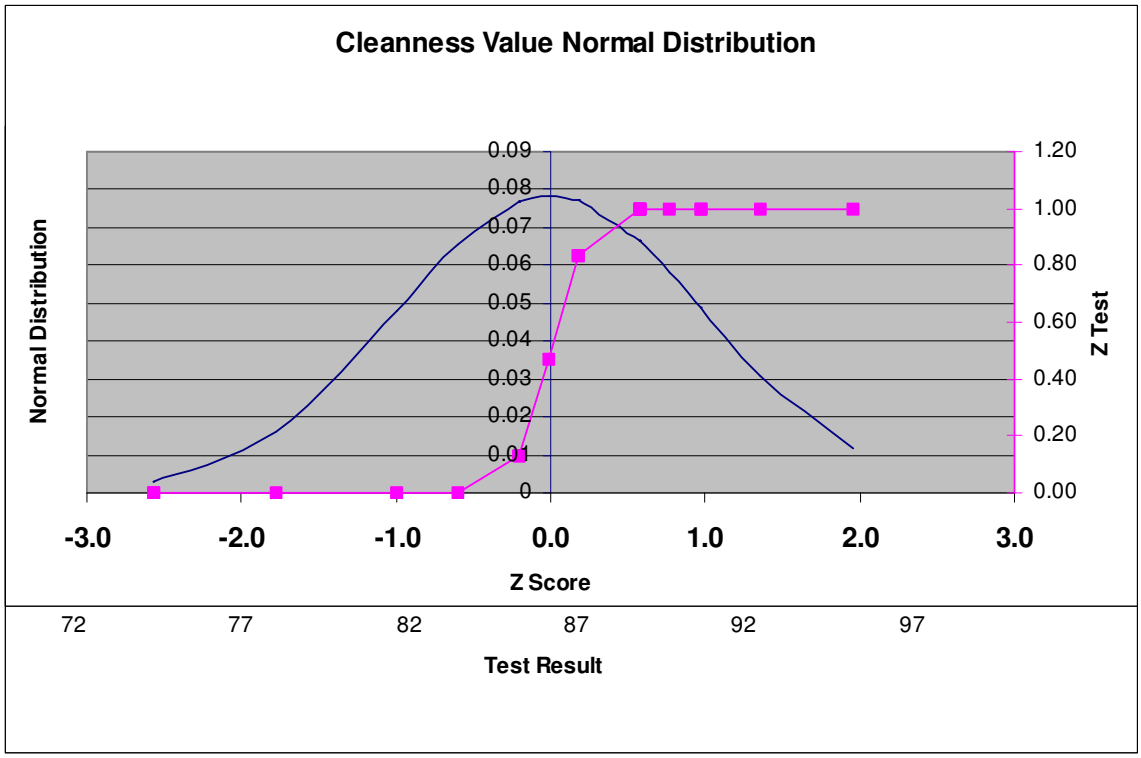
Graph 1 Plot of Cleanness Value vs PP4S -- Red dot is average of the results



Graph 2 Normal Distribution of PP4S



Graph 3 Normal Distribution of Cleanness Value



Graph 4 Normal Distribution of CV – Same Vertical Scale as Graph 2