CETANZ

Civil Engineering Testing Association of New Zealand

TECHNICAL REPORT ON

SCALA DYNAMIC CONE PENETROMETER IRREGULARITY

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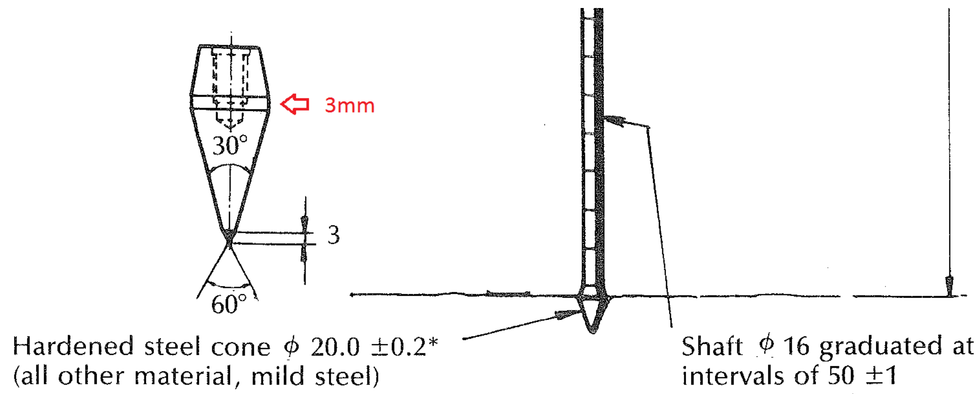
SCALA DYNAMIC CONE PENETROMETER IRREGULARITY

1. Introduction

It has come to the attention of the Civil Engineering Testing Association of New Zealand (CETANZ) through its Technical Working Group that there is an irregularity in the size of the shoulder (cylindrical length) of the New Zealand manufactured scala cones.

The illustration in NZS4402 (see fig. 1 below) does not show the dimension of the shoulder. The equivalent Australian test method uses an identical figure, also without this dimension.

Figure 1 Scala cone tip critical dimensions



NOTE –
(1) All linear dimensions are in millimetres (not to scale).
(2) Essential dimensions are indicated by an asterisk.
(3) This design has been found satisfactory but alternative designs may be employed provided the essential requirements are fulfilled.
(4) Similar equipment has sometimes been referred to in New Zealand as the Scala Penetrometer.

Fig. 6.5.2
DYNAMIC CONE PENETROMETER

If the above drawing is to scale,the length of the shoulder can be assumed to be around 3mm. However, a survey of New Zealand suppliers of this equipment, indicated the size to lie in a range of 10mm to 13mm. Australian suppliers reported a range of 3mm to 5mm.

Scala, the inventor of the Scala Dynamic Cone Penetrometer worked in Melbourne, where the local suppliers manufacture cones with a 3mm long cylinder.

ASTM D6951-03 Standard Test Method for Use of the Dynamic Cone Penetrometer in shallow pavement applications quotes a 3mm vertical side. Additionally, the ASTM cone is at a 60° angle compared to NZS cones which have a 30° angle.

It appears that the longer length in New Zealand is historical and may be due to it being easier to manufacture. This difference, however, can have an impact on strength measurements and therefore may affect the construction and engineering industry. CETANZ has therefore taken it upon itself to investigate the significance of the difference in dimensions before any change in the manufacture of the cones is suggested.

2. Investigation

A prototype cone with a 3mm shoulder was manufactured and used in a number of field trials and laboratory tests to measure the difference in strength results. This was tested against an existing cone with a 13mm shoulder.

Figure 2 Scala Cone Tips - Prototype (left) and Existing (right)

a. Dynamic Tests

The first trial was to perform scalas in the field adjacent to each other with the different cones. Four sites were identified and staff from both Stevensons and Geotechnics laboratories in Auckland carried out field tests to 900mm depth recording blows per 50mm. The top 150mm data was ignored due to lack of confinement and differences in surface compaction.

Measuring blows per 50mm, results from using the prototype cone ranged from +0.8% to -9.2%, indicating a resistance loss. When this was reported as inferred CBR, the values ranged from 0% to -10.3% and with the rounding of the inferred CBR results ranged from 0% to -14.3%. A summary of the results is in Table 1 below.

Table 1. Dynamic Comparison of Prototype and Existing Cones

1. Blows per 50mm comparison of prototype scala cone to existing scala cone.

	Average blows per 50mm over 900mm (excluding top 150mm)			
Laboratory	Stevensons	Geotechnics	Geotechnics	Geotechnics
Site	#1	#2	#3	#4
Existing cone	3.5	2.59	1.73	1.33
Prototype cone	3.23	2.45	1.57	1.34
Resistance loss of prototype cone (%)	**-7.7**	**-5.4**	**-9.2**	**0.8**

2. Inferred CBR comparison of prototype cone to existing cone

	Average CBR over 900mm (excluding top 150mm)			
Laboratory	Stevensons	Geotechnics	Geotechnics	Geotechnics
Site	#1	#2	#3	#4
Existing cone	15.1	10.8	6.8	5.1
Prototype cone	13.8	10.1	6.1	5.1
Resistance loss of prototype cone (%)	**-8.6**	**-6.5**	**-10.3**	**0.0**

3. Inferred CBR (rounded) comparison of prototype cone to existing cone

	Average CBR over 900mm (excluding top 150mm)			
Laboratory	Stevensons	Geotechnics	Geotechnics	Geotechnics
Site	#1	#2	#3	#4
Existing cone	15	11	7	5
Prototype cone	14	10	6	5
Resistance loss of prototype cone (%)	**-6.7**	**-9.1**	**-14.3**	**0.0**

b. Static Tests

In order to further quantify the results in controlled laboratory conditions, we set up a test using a loading frame with a load cell to push a cone into compacted soil. We prepared two specimens from a silty CLAY in CBR moulds and checked their relative strength. Mould 1 had a vane shear strength of 88kPa which we intended to use for testing with the prototype cone. Mould 2 had a shear strength of 90kPa which we tested with the existing cone.

After the shear vane test, we also performed a dynamic scala test in each mould, measuring the length driven after one blow. The prototype cone travelled 100mm with one blow and the existing cone travelled 88mm with one blow. This indicated a loss of resistance of -13.6% for the prototype cone. Table 2 below summarises these results.

Table 2. Strength of compacted material used in static penetration test

Test	**Prototype Cone**	**Existing Cone**	**Prototype Cone Loss in Penetration Resistance (%)**
Mould	1	2	
Average vane shear strength of soil in mould (kPa)	88	90	
Scala in the CBR mould	1 blow/100mm	1 blow/88mm	13.6

The test configuration for the static push is seen in Figure 3 below.

Figure 3 Test configuration

The maximum loading machine penetration rate of 3.5mm per minute was chosen in order to prevent drainage or dissipation of pore pressures. Table 3 below contains the test data.

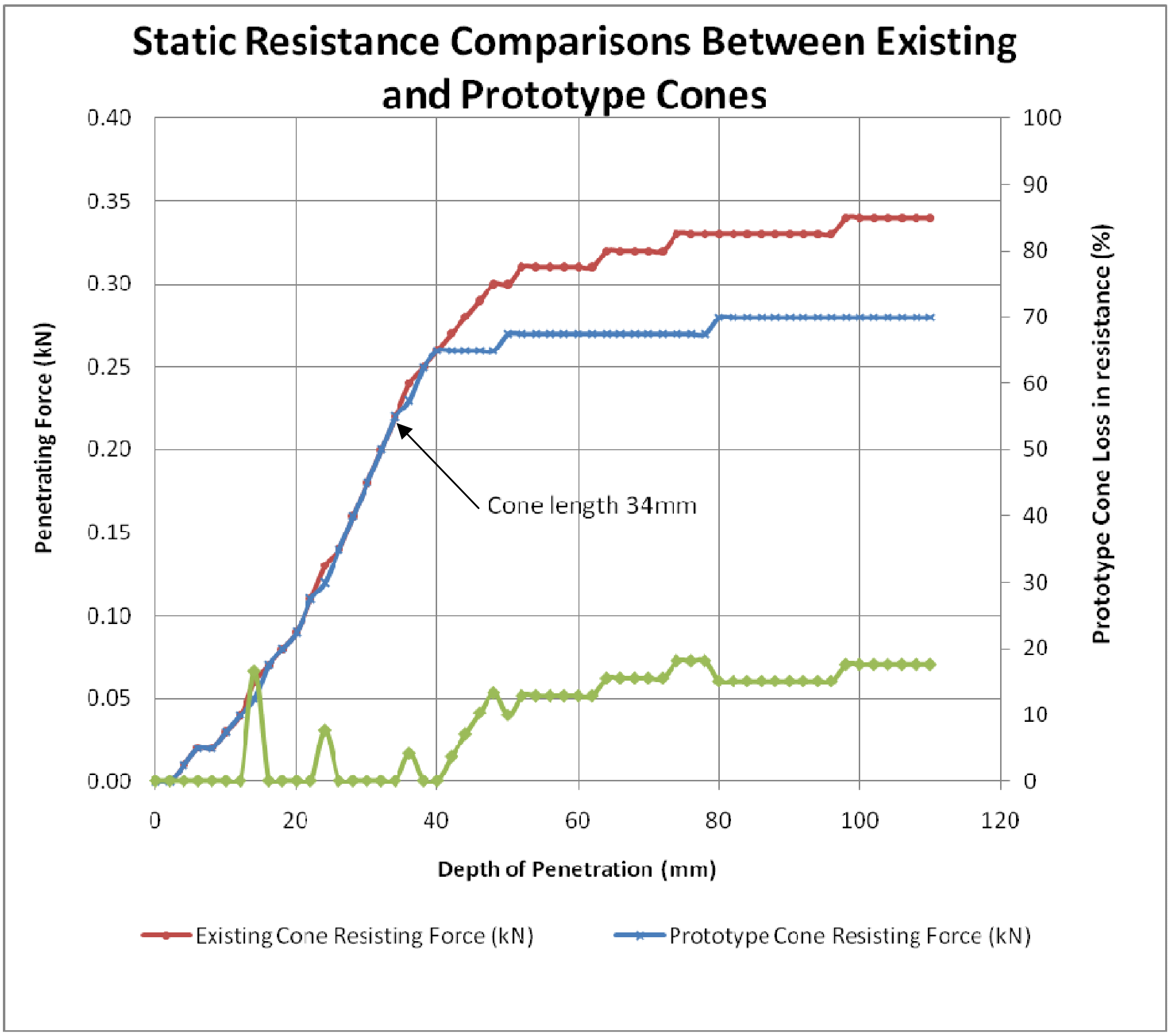
Table 3. Static Scala Cone Penetrating Soil in CBR Moulds.

Penetration (mm)	Prototype Cone Resisting Force (kN)	Existing Cone Resisting Force (kN)	Prototype Cone Loss In Resistance (%)	Penetration (mm)	Prototype Cone Resisting Force (kN)	Existing Cone Resisting Force (kN)	Prototype Cone Loss In Resistance (%)
0	0.00	0.00	0.0	56	0.27	0.31	12.9
2	0.00	0.00	0.0	58	0.27	0.31	12.9
4	0.01	0.01	0.0	60	0.27	0.31	12.9
6	0.02	0.02	0.0	62	0.27	0.31	12.9
8	0.02	0.02	0.0	64	0.27	0.32	15.6
10	0.03	0.03	0.0	66	0.27	0.32	15.6
12	0.04	0.04	0.0	68	0.27	0.32	15.6
14	0.05	0.06	16.7	70	0.27	0.32	15.6
16	0.07	0.07	0.0	72	0.27	0.32	15.6
18	0.08	0.08	0.0	74	0.27	0.33	18.2
20	0.09	0.09	0.0	76	0.27	0.33	18.2
22	0.11	0.11	0.0	78	0.27	0.33	18.2
24	0.12	0.13	7.7	80	0.28	0.33	15.2
26	0.14	0.14	0.0	82	0.28	0.33	15.2
28	0.16	0.16	0.0	84	0.28	0.33	15.2
30	0.18	0.18	0.0	86	0.28	0.33	15.2
32	0.20	0.20	0.0	88	0.28	0.33	15.2
34*	0.22	0.22	0.0	90	0.28	0.33	15.2
36	0.23	0.24	4.2	92	0.28	0.33	15.2
38	0.25	0.25	0.0	94	0.28	0.33	15.2
40	0.26	0.26	0.0	96	0.28	0.33	15.2
42	0.26	0.27	3.7	98	0.28	0.34	17.6
44	0.26	0.28	7.1	100	0.28	0.34	17.6
46	0.26	0.29	10.3	102	0.28	0.34	17.6
48	0.26	0.30	13.3	104	0.28	0.34	17.6
50	0.27	0.30	10.0	106	0.28	0.34	17.6
52	0.27	0.31	12.9	108	0.28	0.34	17.6
54	0.27	0.31	12.9	110	0.28	0.34	17.6

34* Cone tip length

Figure 4 below is a graphical presentation of the results.

Figure 4 Static resistance comparison between existing and prototype cones



The graph indicates a slight change in the penetration force at 34mm which is also the length of the cone. At 37mm we would expect divergence of the two force plots to start, but it does not appear to happen until it gets to 40mm. After 40mm penetration, there is a clear difference in the penetration resistance between the two cones up to a maximum of -17.6% loss of penetration resistance at 110mm depth.

3. Summary

The scala penetrometer test as detailed in NZS 4402:1998 supplement Test 6.5.2 omits the dimension of the cone shoulder (cylindrical length). The dimension should be 3mm, whereas the New Zealand manufactured cones are typically 10mm to 13mm. CETANZ undertook an investigation using a prototype cone with a 3mm shoulder and compared results using an existing cone with a 13mm shoulder. Results from both investigations into dynamic and static tests indicate an expected loss in penetration resistance from +0.8% to -17.6% with more weighting to the larger losses in strength.

The implications of this are:

a) The scala to CBR correlations developed from Australian studies will be incorrect.
b) A change to cones with a 3mm shoulder will produce lower values, which will impact on construction effort when compacting roads and earthworksThe impact of friction is a reminder to over bore each 1m scala rod length with a hand auger to eliminate the friction caused by rod adaptors.

4. Recommendations

It is recommended that –

a) this report be circulated to CETANZ members to inform them of this irregularity;
b) the report be passed to other potentially affected parties such as IANZ, Roading NZ, NZTA, IPENZ and the NZ Geotechnical Society, for their comment; and
c) after feedback is received, manufacturers, laboratories and Standards NZ are advised of any decision to change scala cone dimensions.

5. 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 replaces New Zealand standards or requirements of project specifications. 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.

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