Specific Accreditation Guidance

Infrastructure and Asset Integrity

Technical issues in geotechnical testing

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Technical issues in geotechnical testing

This document presents information on technical matters that commonly arise during NATA assessments in relation to the testing of soils and aggregates.

While it is hoped that the information will provide useful insight for these technical matters, this document only serves as guidance. It does not include accreditation criteria for geotechnical testing facilities.

This document is included as a reference in the NATA Accreditation Criteria (NAC) package for Infrastructure and Asset Integrity.

The following topics are considered:

1. test sieves;
2. oversize materials;
3. assignment of MDD and OMC;
4. one-for-one testing;
5. Level 1 earthworks testing (AS3798);
6. quality assurance activities;
7. seating loads for CBR testing;
8. reporting of bearing ratios for more than one penetration value;
9. spread of points when testing for liquid limit;
10. rounding of results;
11. verification of nuclear gauges following calibration;
12. thermometers for heat of neutralisation tests;
13. equipment compliance, checks and traceability guide for specialised tests;
14. depth of testing - nuclear gauges;
15. Perth sand penetrometer testing.

1 Test sieves

Initial calibration of test sieves

The measurement of particle size using test sieves is required in several commonly used Australian Standards and state road authority methods, for example AS 1141, AS 1289, AS 2350, AS 2891, etc.

Some of these Standards call for using test sieves as specified in AS 1152, which has now been withdrawn. Sieves complying with ISO 3310 Parts 1, 2 and 3 are considered acceptable alternatives to those specified in the superseded Standard AS 1152.

Sieves need to be calibrated as the aperture openings have been shown to contribute significantly to the measurement uncertainty for particle size distribution tests and other tests where the amount retained or passing a sieve is critical to the test result, such as wet/dry strength tests.

In the case of washing sieves, calibration may be demonstrated by providing a calibration report for the batch wire mesh from which the sieve was manufactured based on a further statement of conformity to the standard (stating the sieve was made from that batch of material).

If a facility chooses to calibrate sieves in-house, the process for doing so will be reviewed during a NATA assessment (refer *NATA General Accreditation Criteria: Equipment assurance, in-house calibration and equipment verification*). For fine woven wire sieves, such procedures could be based upon the approach detailed in Clause 5.4 of the *United Kingdom Accreditation Service Publication: Lab 22 – Traceability: Test Sieves*.

If in-house checks are undertaken based on comparison with reference sieves, such reference sieves will first need to be calibrated and controls established to preserve the integrity of the reference sieves (as a guide, it can be expected that reference sieves will experience wear within 200 uses after which continued use as a reference sieve would be compromised).

Ongoing checks of sieves

All sieves are subject to wear, so verification is required at suitable intervals to ensure continued compliance. These intervals will depend upon the type of the sieve and the amount of use.

If there are signs of wear or deterioration at any time, the sieve should not be used until adequate checks have been made to confirm continued compliance with the requirements of the relevant standard.

2 Oversized materials

AS 1289.0 states in Section 5:

> *With the exception of a soil classifications test and some soil compaction and density tests, soils with a greater proportion of material than 20% retained on a 37.5 mm AS 1152 sieve cannot be usefully examined by the methods in AS 1289.*

The excepted soil classification test referred to here is AS 1289.3.6.1, and the excepted compaction and density tests are AS 1289.5.5.1 and AS 1289.5.3.5.

In general, test results obtained with the more oversized material than those stated in the test methods should be regarded as questionable without a robust validation process. In any case, such departures from the method would need to be reported, for example, by highlighting within the report that the method was being used outside its defined scope of applicability.

3 Assignment of maximum dry density (MDD) and optimum moisture content (OMC) values

AS 1289.5.4.1 allows assigned values of MDD and OMC to be used to determine the dry density ratio (DDR) and moisture ratio (MR).

Where the facility reporting the results is not responsible for the assigned values contributing to the reported result, specific provisions are needed to retain integrity in the process. In particular, assigned values from a well-controlled production of crushed rock may be reported by one NATA-accredited facility (LAB 1) and then used by another NATA-accredited facility (LAB 2) for calculating DDR and MR based upon the field density and moisture content values determined by that facility (LAB 2), provided that:

a) adequate reference is made to the assigned value test report from LAB 1 (refer to *NATA General Accreditation Criteria: ISO/IEC 17025 Standard Application Document,* Clause 7.8.2.1) and the date of the report;

b) (i) the facility producing the assigned values (LAB 1) has a procedure for verifying the values are representative of the material supplied and compacted in place (i.e. tests on stockpiled material are not acceptable unless required by the specification);

(ii) the facility using the assigned values (LAB 2) has a procedure to verify that the field tests pertain to the material for which the assigned values are reported and that the most recent assigned values are used.

4 One-for-one testing

AS 3798 and AS 1289.5.4.1 require that, for each field density site that is tested, a laboratory compaction test be performed to determine the field density ratio. However, AS 1289 permits the use of less than one-for-one testing, such as the assignment of a laboratory maximum dry density, in circumstances where the material has been found to be consistent as defined in either AS 1289.5.4.2 or AS 1289.5.4.3.

In earthworks, the laboratory maximum dry density (MDD) may commonly vary from 1.90 t/m^3 to 2.20 t/m^3 due to the variability in the naturally occurring soils alone.

Where one-for-one testing is not applied strictly in accordance with the applicable Australian Standards, derived methods permitting this practice may not be able to be reasonably validated, and the measurement uncertainty is unlikely to be amenable to reliable calculation. Therefore, NATA accreditation is not offered for such activity, and any such testing is regarded as outside the scope of accreditation.

5 Level 1 Earthworks testing (AS 3798)

Results on activities not covered by a facility's scope of accreditation must be identified accordingly when included in endorsed reports, which include results on other activities covered by the scope of accreditation. Refer to *NATA General Accreditation Criteria: Use of the NATA emblem, NATA endorsement and references to accreditation*.

Where accreditation for inspection of earthworks testing to AS 3798 is not held under NATA's Inspection Program (ISO/IEC 17020), accreditation cannot be claimed for AS 3798.

6 Quality Assurance Activities (QAA)

Acceptance of proficiency testing outcomes based on z-score analysis alone may be problematic in the particular case of CBR testing, due to consistently wide z-score ranges quoted as satisfactory for various published CBR programs.

Caution must also be applied when the number of participants is small or when there are outliers in the dataset.

Facilities are encouraged to consider critically the results of their proficiency testing and quality assurance program participation. Any deviation from the published program Mean of a magnitude holding significance from an engineering perspective could be considered as warranting further investigation, regardless of participation deemed to be satisfactory based on z-score analysis alone.

Such investigation might involve an initial determination of whether the repeatability of the test by a single operator aligns with that achieved for the quoted homogeneity testing and whether the repeatability between operators in the facility falls within an appropriate range (typically not more than twice the range achieved in the homogeneity testing).

Possible sources of systematic error between one facility and another that may be worth investigating for CBR testing include:

- non-representative splitting of sub-samples;
- variation in moulding moisture content;
- curing of samples before moulding and after the addition of moisture;
- method of compaction using full blows of the compaction hammer and achievement of layer heights within specification;
- distribution of hammer blows across the specimen;
- time between removal from water bath and commencement of testing;
- reading of load ring and correct conversion of values to load;
- determination of curve offsets.

Validity of QAA acceptance criteria with small numbers of data points

- If a facility's acceptance criteria is +2SD, where n=3, they will never reject a result. If you have n values, the ratio of the distance from the mean divided by the SD can never exceed (n-1)/sqrt(n). This matters the most with small datasets. For example, if n=3, no data point can possibly be more than 1.155*SD from the mean, so it is impossible for any value ever to be more than 2 SDs from the mean. Such a rule is therefore not fit for purpose.
- The critical values for the Qtest (https://en.wikipedia.org/wiki/Dixon%27s_Q_test) apply to low values of n (down to n=3), and so this is a possible justifiable test to use to determine if a value is an outlier. Where n>5, Grubbs test could also be used.

7 Seating loads for CBR testing

To achieve consistent readings when performing testing to AS 1289.6.1.1, seating loads of 50 N (for CBR values ≤ 30%) or 250 N (for CBR values > 30%) are considered to be the values inferred within the Standard, rather than the 'smallest possible load'.

8 Reporting of bearing ratios for more than one penetration value

AS 1289.6.1.1 Clause 10 (a) requires that only the greater bearing value calculated in Clause 9 (b) be reported as the CBR. In other words, the individual values for different penetrations are bearing ratios and not the CBR value. Therefore, when reporting results to AS 1289 6.1.1, the CBR value should be presented so that it cannot be confused with any other bearing ratio results that may also be reported.

9 Spread of points when testing for liquid limit

When testing the liquid limit of a soil to AS 1289.3.1.1 and AS 1289.3.9.1, the points selected should be as evenly spaced as is feasible. This is to avoid any possibility that multiple points might be inferred to represent ‘the same point’.

10 Rounding of results

As detailed in the *NATA General Accreditation Criteria: ISO/IEC 17025 Standard Application Document*, Clause 7.8.1.2, rounding shall occur at the final report stage unless otherwise required by the method. Rounding should be made to the level of precision specified in the reporting requirements of the method.

This principle would indicate that, when using data to make decisions during the tests (such as the selection of compaction mould size based on the amount of oversized materials or deciding which portions of an aggregate are to be used for determining flakiness index), unrounded figures should be used unless otherwise specified.

Similarly, in cases where results, which have been rounded, are reported for one test method and then subsequently used as the basis for calculations as part of a different test method, the resulting test report should make clear that original unrounded results were either not used or were not available unless the rounding protocols are specified within the test method itself.

11 Verification of nuclear gauges following calibration

When testing to AS 1289.5.8.1, or any other nuclear gauge method that relies upon internal gauge equations to produce test results, correct entry of the equations into the gauge microprocessor by the calibrating agency should be confirmed or subject to verification by the facility.

ISO/IEC 17025 Clause 6.4.4 states, "The laboratory shall verify that equipment conforms to specified requirements before being placed or returned into service.” This is especially pertinent since some calibration agencies do not update gauge equations as part of their calibration activities.

The facility’s secondary reference block can be used to obtain a density count at each depth for which the corresponding density can be calculated (according to the gauge equation stated in the calibration certificate) and compared with the displayed density reading at each depth. This will confirm that the gauge equation has been correctly entered into the gauge.

The same principle would apply to verifying the moisture equation.

Except in the case of brand new gauges, the density readings (and moisture readings, if applicable) described above can be compared with the secondary reference block readings taken before re-calibration so that any microprocessor anomaly which may have developed prior to re-calibration is identified (and the impact on previously conducted work assessed).

12 Thermometers for heat of neutralisation tests

When testing for the temperature rise of cement modified or stabilised soils and aggregates, the same thermometer used to develop the cement content versus temperature rise curve shall be used unless both the thermometer used for developing the curve and that used for measuring temperature rise have been calibrated to show they meet the requirements of the test methods. When a replacement thermometer is used, it will need to be calibrated

13 Equipment compliance, checks and traceability guide for specialised tests

- Concrete performance and asphalt performance tests have defined cycle times and/or shape of cycle curves, which need to be validated often by a calibration certificate, but a facility can check these using calibrated equipment.
- Benkelman beam tests (e.g. RMS (NSW) Method T160 require:
  - the truck mass to be certified, which can be performed by an NMI-certified weighbridge or a weighbridge that has been calibrated by an organisation holding a servicing licence from NMI;
  - tyre pressure checks using a validated gauge.
- Road roughness tests require laser and accelerometer checks labelled “calibrations” for road roughness testing in state road agency methods. The lasers and distance measuring devices may be calibrated by a NATA-accredited facility, but some road agencies have accepted the annual check on a recognised loop is satisfactory for traceability.
- Thermal conductivity/resistivity tests to ASTM D5334 states that metrological traceability can be provided using published value of thermal conductivity as the reference materials for this test, such as that for glycerol using the published value of thermal conductivity as the reference materials.
- Benkelman beam testing is usually from an NMI-certified weighbridge, or a weighbridge calibrated by an organisation holding a servicing licence from NMI.

14 Depth of testing - nuclear gauges

When testing to AS 1289.5.8.1 using a nuclear gauge, it is important that the depth of the probe is placed to the full depth of the compacted layer of soil being tested as detailed in Clause 6 (c) and (e) of the Standard, i.e. the probe needs to be within the layer without entering the lower layer. Generally, this means that the probe should be placed no more than 25 mm less than the compacted layer depth.

Failure to place the probe as detailed in the Standard will mean that part of the layer is not tested, and the risk that this part of the layer is poorly compacted will increase the chance of premature failure of the construction.

When sampling soils from under the nuclear gauge for reference density testing, it is important the sample is taken from the full depth tested.

In a number of recent cases, the depth of the probe has been reported well outside this 25 mm difference, e.g. tests at 150 mm for a 300 mm layer.

In cases when testing has been undertaken, and it is found the probe has entered the next layer, the field density test needs to be repeated and a separate reference sample taken. If the un-compacted layer depth is known only or the compacted depth is unknown, the testing facility may drill a small core hole about 1 m away from where the probe is to be inserted into the soil to ascertain the depth of layer which is required to be reported in clause 8 (f).

Generally, an un-compacted layer of 300 mm of fill will compact to about 200 mm, but this would need to be confirmed for each project.

Due to the surface preparation of the constructed layer before testing, a small amount of material is removed from the top of the layer, and this soil needs to be taken into account when determining the depth of the layer.

In other cases, the facility has not had the nuclear gauge calibrated at sufficient probe depths to ensure that the method can be followed, e.g. a nuclear gauge calibrated at probe depths of 100, 150 and 300 mm would not be suitable for layer depths of 250 or 275 mm.

When reporting the probe depth and layer depth, the facility needs to be specific regarding what has been tested and what may be excluded.

A statement such as: “The customer requested the depth of testing”, or “density and moisture ratio results relate only to the soil to the depth of test and not to the full depth of the layer”, or similar, needs to be included on reports so that all information necessary for the interpretation of the results (ISO/IEC 17025 Clause 7.8.1.2) is available to the customer.

A simple request by a contractor to test at a specific depth usually does not ensure the method has been followed and is not sufficient reason to vary the test without explicitly indicating the deviation on the report.

15 Perth Sand penetrometer testing to AS 1289.6.3.3

The Perth sand penetrometer (PSP) test is limited to granular soils with a maximum particle size not exceeding 2 mm, as specified by the scope of AS 1289.6.3.3 *Methods of testing soils for engineering purposes - Method 6.3.3: Soil strength and consolidation tests - Determination of the penetration resistance of a soil - Perth sand penetrometer test.*

This method sets out the procedure for determining the resistance of a soil to penetration […]. Use of the method is limited to granular soils with a maximum particle size not exceeding 2 mm, and a layer thickness of at least 450 mm.

The measurement is made to a depth of 450 mm and no greater, and any results for greater depth that may be requested are not in accordance with the method and shall not be included in NATA-endorsed reports.

References

This section lists publications referenced in this document. The year of publication is not included as it is expected that only current versions of the references shall be used.

Standards

ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories

NATA publications

NATA Accreditation Criteria (NAC) package for Infrastructure and Asset Integrity

General Accreditation Criteria ISO/IEC 17025 Standard Application Document

General Accreditation Criteria Equipment assurance, in-house calibration and equipment verification

General Accreditation Criteria Use of the NATA emblem, NATA endorsement and references to accreditation

Other publications

United Kingdom Accreditation Service Publication: Lab 22 – Traceability: Test Sieves

Amendment Table

The table below summarises changes made to the document with this issue.

Section or Clause	Amendment
6	Clause made more general and additional item for validity of QAA criteria added
12	Additional clause
13	Additional clause
14	Additional clauses
15	Additional clauses
Whole document	Addition of Security Classification Label