Test Method Q010: Establishing the relationship between standard and subsidiary test methods

1 Source
This method is based on the principles adopted in AS 1289.2.3.1: Establishment of correlation - subsidiary method and the standard method. It also adopts a value of maximum standard error for the relationship between the standard and subsidiary methods as recommended from an internal departmental research investigation into moisture content determinations.

2 Scope
This method provides a means for determining the relationship between a standard test method and a subsidiary test method. It assumes a linear relationship and allows a test result from a subsidiary method to be corrected to the standard method result. The method is applicable to all test methods having standard and subsidiary forms, but assumes that repeatability values for both the standard and subsidiary methods are known.

3 Procedure
The procedure shall be as follows:

3.1 Select at least 10 representative samples of the particular material to be tested to cover the expected range in the test property in a reasonably even distribution. The samples shall be of sufficient size to allow testing using both the standard and subsidiary tests.

3.2 Subdivide each sample to obtain a representative test portion of appropriate size for each of the two test methods.

3.3 Perform the standard and subsidiary tests on the two test portions from each sample as detailed in the specified test methods.

3.4 Record the test results obtained from the standard test method as values of the dependent variable (y) and the corresponding test results obtained from the subsidiary test method as values of the independent variable (x).

4 Calculations
4.1 Assume the relationship between the dependent and the independent variables to be linear of the form:

\[ y = bx + a \]

where
- \( y \) = dependent variable (standard test method)
- \( b \) = slope of linear relationship
- \( x \) = independent variable (subsidiary test method)
- \( a \) = y intercept of linear relationship

4.2 Calculate the linear regression relationship as follows:

4.2.1 Calculate the slope of the linear relationship as follows:

\[ b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \]
where $b$ = slope of linear relationship
$n$ = number of pairs of test results
$\sum xy$ = sum of the products of the corresponding test results from the subsidiary and standard methods
$\sum x$ = sum of the test results from the subsidiary method
$\sum y$ = sum of the test results from the standard method
$\sum x^2$ = sum of the squares of the test results from the subsidiary method

4.2.2 Calculate the $y$ intercept of the linear relationship as follows:

$$a = \frac{1}{n}(\sum y - b \sum x)$$

where $a$ = $y$ intercept of linear relationship
$n$ = number of pairs of test results
$\sum y$ = sum of the test results from the standard method
$\sum x$ = sum of the test results from the subsidiary method

4.3 Calculate the standard error of the relationship as follows:

$$S_E = \left(\frac{\sum y^2 - a\sum y - b \sum xy}{n-2}\right)^{\frac{1}{2}}$$

where $S_E$ = standard error of the relationship
$\sum y^2$ = sum of the squares of the test results from the standard method
$a$ = $y$ intercept of linear relationship
$\sum y$ = sum of the test results from the standard method
$b$ = slope of linear relationship
$\sum xy$ = sum of the products of the corresponding test results from the subsidiary and standard methods
$n$ = number of pairs of test results

4.4 Calculate the maximum standard error for the relationship as follows (Note 6.1):

$$S_{E, \text{max}} = \left(s_1^2 + b^2 s_2^2 + 2bs_x^2\right)^{\frac{1}{2}}$$

where $S_{E, \text{max}}$ = maximum standard error for the relationship
$s_1$ = $0.36 R_{\text{stand.}}$
$b$ = slope of linear relationship
$s_2$ = $0.36 R_{\text{sub.}}$
Test Method Q010: Establishing the relationship between standard and subsidiary test methods

\[ s_x = \text{the larger of } s_1 \text{ and } s_2 \]

and

\[ R_{\text{stand.}} = \text{repeatability of the standard method} \]

\[ R_{\text{sub.}} = \text{repeatability of the subsidiary method} \]

4.5 Accept the calculated values of \( b \) and \( a \) provided that the value of \( S_E \) does not exceed \( S_{E,\text{max}} \).

4.6 Where the calculated value of \( S_E \) exceeds \( S_{E,\text{max}} \), obtain an additional data point(s) in accordance with Steps 3.1 to 3.3 and combine with the existing data. Analyse the combined test results in accordance with Steps 3.4 and 4.1 to 4.5.

4.7 Repeat Step 4.6 (with judicious elimination of data points if necessary) until the relationship determined from a minimum ten data points has an associated standard error which does not exceed the calculated maximum value.

4.8 Perform regular checks of the relationship by obtaining an additional data point in accordance with Steps 3.1 to 3.3 (Note 6.2).

4.9 Accept the relationship provided that:

a) Check data points fall within \( \pm 2 S_E \) of the linear regression (Note 6.3).

b) The distribution of check data points about the linear regression appears to be random, that is, not biased or skewed.

Otherwise, determine a new relationship in accordance with this test method.

5 Reporting

Report the following values and general information:

5.1 The relationship between the standard and subsidiary test methods in the form: \( y = bx + a \). The values of \( a \) and \( b \) shall be reported to a number of significant figures which exceeds by one that normally reported for the standard and subsidiary tests.

5.2 Standard and subsidiary test methods used.

5.3 Test property range tested.

6 Notes on method

6.1 The appropriate value of maximum standard error will be dependent on test method variation but may also be affected if the corrected test result is to be used in further calculations. In the case of moisture content measurement where the repeatability values for the standard and subsidiary methods are presently unknown, a value of 0.6% should be adopted for the maximum standard error.

6.2 The frequency of checks on the relationship will be dependent on the number of subsidiary tests performed and the variability of the test material. For high testing frequency, the number of check tests should be about one per hundred or once per week, whichever is the lesser. This number should be increased to about one in 10 for infrequent testing.

6.3 It is expected that, in the long term, check data points will fall beyond \( \pm 2 S_E \) of the linear regression relationship in about one case in twenty. If this frequency of failure is observed, the existing relationship may be assumed to be valid.
Test Method Q020: Calculation of characteristic value of a lot

1 Source

This method is based on the process for calculation of characteristic value as detailed in the following Department of Transport and Main Roads Technical Specifications:

- MRTS01 Introduction to Technical Specifications
- MRTS04 General Earthworks
- MRTS30 Asphalt Pavements
- MRTS40 Concrete Base in Pavements

2 Scope

This method provides a means for calculating a characteristic value determined by the analysis of several individual test results, tested using the same methods, using a statistical process. The characteristic value may then be used to determine the compliance of a product.

3 Procedure

The procedure shall be as follows:

3.1 Perform the requested tests, using the same test methods, as detailed in the specified test methods (Notes 6.1, 6.2 and 6.3).

3.2 Using the reported values perform the calculations detailed in Section 4.

4 Calculations

4.1 Calculate the mean of the individual test results as follows:

\[ \bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i \]

where

- \( \bar{X} \) = mean of the individual test results for i=1, 2, 3,…, n
- \( n \) = number of test results
- \( X_i \) = the individual test result for i=1, 2, 3,…, n

4.2 Calculate the standard deviation of the individual test results as follows:

\[ s = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left( X_i - \bar{X} \right)^2} \]

where

- \( s \) = standard deviation of the individual test results for i=1, 2, 3,…, n
- \( n \) = number of test results
- \( X_i \) = the individual test result for i=1, 2, 3,…, n
- \( \bar{X} \) = mean of the individual test results
4.3 Calculate the characteristic value using the appropriate method as follows:

4.3.1 For a minimum limit:

\[ CV = X_{av} - ks \]

where

\[ CV = \text{characteristic value} \]

\[ X_{av} = \text{mean of the individual test results} \]

\[ k = \text{an acceptance constant dependent upon the number of tests (Refer to Table 1 or 2)} \]

\[ s = \text{standard deviation of the individual test results} \]

4.3.2 For a maximum limit:

\[ CV = X_{av} + ks \]

where

\[ CV = \text{characteristic value} \]

\[ X_{av} = \text{mean of the individual test results} \]

\[ k = \text{an acceptance constant dependent upon the number of tests (Refer to Table 1, 2, 3 or 4)} \]

\[ s = \text{standard deviation of the individual test results} \]

5 Reporting

5.1 Report the following values rounded as detailed in Table 5:

5.1.1 Characteristic value of the individual test results.

5.1.2 Mean of the individual test results.

5.1.3 Standard deviation of the individual test results.

5.2 Report the following additional values:

5.2.1 Number of individual tests.

5.2.2 Acceptance constant \( k \) used to the nearest 0.001 for Table 1, 2 or 3 and 0.01 for Table 4.

6 Notes on method

6.1 This method is usually applied to the results of Test Methods Q134, Q140A, Q146, Q311, Q314 and Q482.

6.2 For example, when determining the relative compaction of asphalt, the method used to determine the compacted density may be one of Q306A, Q306B, Q306C, Q306D or Q306E.

6.3 Where Test Method Q306B is used initially to determine the relative compaction of asphalt but is subsequently found not to be applicable to one or more samples due to excessive water absorption, a combination of test results from Test Methods Q306B, and Q306C may be used.
### Table 1 - Acceptance constants (Q134 and Q146), (Q140A except MRTS04))

<table>
<thead>
<tr>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10</td>
<td>0.828</td>
<td>35</td>
<td>1.020</td>
</tr>
<tr>
<td>11</td>
<td>0.847</td>
<td>40</td>
<td>1.036</td>
</tr>
<tr>
<td>12</td>
<td>0.863</td>
<td>45</td>
<td>1.049</td>
</tr>
<tr>
<td>13</td>
<td>0.877</td>
<td>50</td>
<td>1.059</td>
</tr>
<tr>
<td>14</td>
<td>0.890</td>
<td>60</td>
<td>1.077</td>
</tr>
<tr>
<td>15</td>
<td>0.901</td>
<td>70</td>
<td>1.091</td>
</tr>
<tr>
<td>20</td>
<td>0.946</td>
<td>80</td>
<td>1.103</td>
</tr>
<tr>
<td>25</td>
<td>0.978</td>
<td>90</td>
<td>1.112</td>
</tr>
<tr>
<td>30</td>
<td>1.002</td>
<td>100</td>
<td>1.120</td>
</tr>
</tbody>
</table>

Note: Values falling between those listed in Table 1 may be determined by linear interpolation.

### Table 2 - Acceptance constants (Q140A for MRTS04)

<table>
<thead>
<tr>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.828</td>
<td>25</td>
<td>0.978</td>
</tr>
<tr>
<td>6</td>
<td>0.828</td>
<td>30</td>
<td>1.002</td>
</tr>
<tr>
<td>7</td>
<td>0.828</td>
<td>35</td>
<td>1.020</td>
</tr>
<tr>
<td>8</td>
<td>0.828</td>
<td>40</td>
<td>1.036</td>
</tr>
<tr>
<td>9</td>
<td>0.828</td>
<td>45</td>
<td>1.049</td>
</tr>
<tr>
<td>10</td>
<td>0.828</td>
<td>50</td>
<td>1.059</td>
</tr>
<tr>
<td>11</td>
<td>0.847</td>
<td>60</td>
<td>1.077</td>
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<td>12</td>
<td>0.863</td>
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<tr>
<td>13</td>
<td>0.877</td>
<td>80</td>
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<tr>
<td>14</td>
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<td>90</td>
<td>1.112</td>
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<tr>
<td>15</td>
<td>0.901</td>
<td>100</td>
<td>1.120</td>
</tr>
<tr>
<td>20</td>
<td>0.946</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Values falling between those listed in Table 2 may be determined by linear interpolation

Note 2: Characteristic values are not calculated where n < 5 in technical specification MRTS04
### Table 3 - Acceptance constants (Q311 or AS 2891.8)

<table>
<thead>
<tr>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
<th>Number of tests or measurements (n)</th>
<th>Acceptance constant (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.403</td>
<td>8</td>
<td>0.783</td>
</tr>
<tr>
<td>3</td>
<td>0.535</td>
<td>9</td>
<td>0.808</td>
</tr>
<tr>
<td>4</td>
<td>0.617</td>
<td>10 - 14</td>
<td>0.828</td>
</tr>
<tr>
<td>5</td>
<td>0.675</td>
<td>15 - 19</td>
<td>0.901</td>
</tr>
<tr>
<td>6</td>
<td>0.719</td>
<td>≥ 20</td>
<td>0.946</td>
</tr>
<tr>
<td>7</td>
<td>0.755</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4 - Acceptance constants (Q482)

<table>
<thead>
<tr>
<th>Number of cores per lot (n)</th>
<th>Acceptance constant (k)</th>
<th>Number of cores per lot (n)</th>
<th>Acceptance constant (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.48</td>
<td>11 - 15</td>
<td>1.35</td>
</tr>
<tr>
<td>6 - 7</td>
<td>1.42</td>
<td>16 - 40</td>
<td>1.32</td>
</tr>
<tr>
<td>8 - 10</td>
<td>1.38</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5 - Rounding intervals

<table>
<thead>
<tr>
<th>Test or measurement</th>
<th>Test method</th>
<th>Rounding value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilising agent content</td>
<td>Q134</td>
<td>0.1%</td>
</tr>
<tr>
<td>Relative compaction</td>
<td>Q140A</td>
<td>0.5%</td>
</tr>
<tr>
<td>Degree of saturation</td>
<td>Q146</td>
<td>1%</td>
</tr>
<tr>
<td>Relative compaction</td>
<td>Q314</td>
<td>0.1%</td>
</tr>
<tr>
<td>Air voids</td>
<td>Q311</td>
<td>0.1%</td>
</tr>
<tr>
<td>Relative compaction (concrete)</td>
<td>Q482</td>
<td>0.1%</td>
</tr>
</tbody>
</table>