Testing, Quality Control and Quality Assurance

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Testing

Types of Testing

In civil engineering work, there are two types of testing:

• Control testing
• Acceptance testing.

The contractor’s staff carry out control testing during the progress of the work, to ensure that the materials and/or processes will meet the required standards.

The resident engineer carries out acceptance testing to ensure that the finished work complies with the specification and/or the drawings, before approval.

The results of the acceptance tests should provide an accurate picture of the quality of the work. To achieve this, sampling and testing should be carried out:

• only in accordance with the specified test method
• to the degree of accuracy required by the test method
• promptly and at the proper time.
• without causing obstruction to the contractor’s workforce.

Selection of Samples

A number of samples are collected for testing; the location and timing of sampling has been purposely designed to represent a section of the work, a consignment of material, or a process.

The samples taken should be representative of the material to be tested, and the number and frequency should be in accordance with the specification.

The required sample size will vary, depending on the tests proposed. (This is discussed further in a later section).

Samples that are taken for testing should be clearly marked, so that they show the:

• project name or identifying number
• location on the job
• type of material
• name of the person who took the sample
• method used in taking the sample
• date and time of collection.

Testing is expensive and takes time; the frequency and extent of testing should therefore be carefully chosen and planned, to assess the compliance of completed work without adding unnecessary costs or delays.
A testing strategy established at the commencement of the work should be reassessed if a high degree of uniformity becomes evident during construction or, alternatively, if unexpected variability of materials or processes is identified.

Responsibility for Testing

The following people may undertake testing:

- The resident engineer’s soil testing staff
- An independent materials consultant
- The contractor, using a registered laboratory.

Regardless of who performs the testing, the inspector must order the testing of work for acceptance purposes, but can only do so after the contractor has advised in writing that a section of work has been completed.

Where persons other than the resident engineer’s staff carry out testing, the inspector should be present during the performance of the site test, or when a sample is taken (e.g. for laboratory testing). The inspector should independently record the location, type and significant features of each test or sample.

The resident engineer for the project must be advised of the results of all acceptance tests, regardless of who carried them out. The resident engineer should then pass on the results to the contractor’s representative as soon as possible. In doing so, the engineer will inform the contractor of one of the following outcomes of testing:

- The test results show non-compliance with the specified requirements and the work or materials is rejected outright. (This must be advised in writing).
- The work or materials are accepted on a conditional basis, subject to the contractor’s undertaking certain rectification work. (This must be advised in writing).
- The test results comply with the specified requirements and the work is accepted.

The test results should be placed on the record, and summarised diagrammatically on a site plan if appropriate. They will be incorporated into the job documents at the completion of the contract.
Variability of Test Results

When test results are being evaluated, one test tells us nothing about the variability of a process. Test results should therefore be considered in groups.

The use of a run chart is one way of evaluating results. The results shown in the two graphs, following, are from a series of compaction tests from a road-construction job.

The seven results in the first graph are highly variable, and fall on either side of the acceptance limit. This shows that the process is not under control. The work corresponding to these results would not be acceptable.

The results in the second graph are more uniform, and do not vary as much extent from the limit. They are all above the limit and therefore are acceptable. They also show that the process is under control.

The graphs also show how the frequency of testing may be varied as the results change. In the case of the first graph, testing would have to be carried out at frequent intervals (e.g. five to six tests per day). However, when the process starts to produce results as shown in the second graph, testing can be reduced to two or three per day.

![Graph 1](image1.png)

- Minimum Limit
- %Compaction
- Test Number
- Poor Compaction
- Recompact
- (Change Compaction Method)
- Graph 1

![Graph 2](image2.png)

- Minimum Limit
- %Compaction
- Test Number
- Good Compaction
- Accept
- Graph 2
Supplied Materials

Either the principal or the contractor may supply materials for contract work.

Materials Supplied by Contractor

The inspector should ensure that all materials comply with the specification and are consistent with other loads or batches of the same material.

In addition, as part of the routine inspection, the inspector should ensure that the materials are handled correctly and the selected processes produce the work to the required standard.

Materials Supplied by Principal

The principal in this case normally undertakes the testing of the materials to ensure that they are in accordance with the specification, before delivery to the contractor.

The inspector, along with the contractor’s representative, measures and agrees on the quantities to be supplied. On delivery of the materials to the contractor, the inspector collects the receipts for the material.

The principal bears the cost of the material. Even though the principal has supplied the material, the contractor still carries the responsibility for placing it on the job and achieving the required end product.

Quality Control and Acceptance

In civil engineering, quality control and acceptance is concerned with ensuring that the specified work is produced in a uniform and controlled manner. Quality control is achieved by applying the following processes to operations and processes:

• observation
• measurement
• sampling and testing
• interpretation
• planning, and
• control.

Inspectors are not directly responsible for the setting up and direct supervision of the selected construction processes. However, they do need a full appreciation of the methods used, as they are responsible for acceptance of the completed work. In addition, the inspector is part of the total site organisation and can provide assistance and advice to the contractor.
Job Planning and Control

All works construction must be carefully planned, so that it meets the specified end result as economically as possible. This means taking quality, time, cost and resources into account. For the inspector, quality is a prime concern. To ensure that quality targets are met, the inspector must:

- study the contract documents to determine the required standard of quality.
- plan site inspections so that the work/material is checked at each stage of the process
- gain a full appreciation of the materials, processes and methods (including plant) used in construction.

The contract documents are an important source of information about the required quality standards. The specifications will set the standards that are to be achieved, and these standards are the minimum required in order to satisfy the principal’s requirements. These are the standards the contractor has to achieve within certain limits, but is not expected to exceed.

An inspector carrying out his or her duties effectively should know the:

- source of the materials being used. (If necessary, they should arrange for tests to be carried out at the source).
- use to which the materials will be put.
- processes and/or methods of construction that will be used to achieve a work quality that is within the limits set by the specifications.

Inspections

One of the main responsibilities of the inspector is to detect any deficiencies before they become serious.

The following general guidelines are applicable to inspection work:

- Inspections must be timely, thorough and systematic. Read and understand the relevant clauses of the specifications and know the details of the work as set out in the drawings. Make a list of points which must be checked.
- Make close inspections at the start of operations. For example, it is better to condemn 10m$^3$ of faulty material at the start, or to leave the problem unresolved and condemn 1000m$^3$ later?
- Plan the testing and sampling of a job, so that the required information is available promptly and efficiently.
- When deficiencies occur, decide immediately what corrective action is required and inform the contractor both verbally and by site instruction.
Effective Use of Materials

The work will only be completed successfully to the requirements of the contract documents if the correct materials are used, and are used effectively. The inspector must therefore ensure that:

- materials of the correct types are ordered, especially if the principal is supplying them.
- samples of cement and aggregates used to make concrete are taken regularly at the mixing plant, as well as samples of the mix from the job site.
- the finished product is tested.

Where raw materials are being tested, sampling and testing work should be carried out at the source of the materials.

Even if the raw materials are acceptable, the process or methods of construction may not achieve the required end result. For example, if concrete is not compacted correctly or too much water has been added on site, the concrete may not achieve its specified strength.

Controlling Quality

It is the contractor’s responsibility to ensure the correct quality standards are achieved. However, the inspector also has the responsibility of ensuring, by inspection, sampling and testing, that the quality is uniform and within the required standards.

This task will be easier if the inspector is:

- firm, and insists that the materials used and the work performed comply with the specifications. If poor standards are detected early in the job, it will be easier to get subsequent work carried out satisfactorily.
- familiar with tests and test requirements, understands the implications of the results, and is able to relate results to construction requirements.

In civil engineering construction, numerous factors can affect the quality of a job, all of which require close attention while work is in progress.

Process control requires supervision and inspection, irrespective of the size of the work. This requires a program of systematic observation, testing and measurement, to achieve the required end result.
Example of Process Control

The following example shows the considerations required for process control. The job involves construction of a road pavement where the bottom course materials are mixed, and water is added on site, as shown in the following drawing.

To achieve satisfactory results, the contractor must:

- ensure that the materials are spread uniformly over the pavement box at the required rate and depth of loose layer.
- see that the correct quantity of water is mixed into the gravel, to bring it to the best moisture or optimum moisture content for rolling.
- compact the layer to the required density using selected plant.
- achieve the uniformity necessary to build a lasting and smooth-riding pavement.
This will involve:

• uniform mixing of water and gravel
• uniform spreading to correct depth without segregation
• uniform coverage of area by the compaction plant.

To ensure that the specified requirements are being achieved, the following tests and measurements are taken:

• Sampling of material, to check that it conforms to the grading specifications and to determine optimum water content for the specified density. (The samples for these tests should be taken from the gravel pit).
• Checking of the width, level, cross-fall and depth of pavement. (It is always advisable to check dimensions before undertaking strength tests. If the work has to be altered and/or disturbed this, could alter the strength properties).
• Density testing and checking of in-situ moisture content.
• Checking of the surface and cross-fall tolerances.

All involved in road construction should remember that, when the job has been completed, will be used by a customer, who is demanding a lasting and smooth-riding pavement for their investment of tax and registration dollars.

Test Results and Quality

No matter how well a job is controlled, variations in the properties of materials, processes and construction techniques will occur.

Testing of Properties of Materials

One test, by itself, tells us nothing about the variability of the material or process. It is necessary to consider a number of test or sample results before we can determine their variability by analysis.

For example, the solid ingredients in a concrete or asphalt mix are obtained from naturally occurring materials. These have inherent variations in chemical and mechanical properties which influence, in varying degrees, the resulting mixes.

In addition, the methods used in proportioning and batching the ingredients, and in using, handling and compacting the materials, will also cause variations in the finished product.

Physical qualities or properties that may be tested include:

• compressive strength, i.e. concrete cylinders
• stability and flow of asphalt, i.e. test pats.
• crushing strength of aggregates
• compaction, i.e. road pavements, concrete.
• tensile strength, i.e. reinforcement steel.
Case Study 1 (see separate section at end of manual) show how failure to conduct tests according to schedule can lead to the inclusion of non-conforming material into the job. In the case described, it could not be reprocessed to a conforming product and had to be removed at the supplier’s cost.

**Use of Statistical Techniques**

When tests are carried out to evaluate the qualities of any construction materials, the results show a variation in a random manner about an average value. Practical experience has shown that no two sets are normally identical.

Because of this, simple statistical techniques are used to reveal the extent to which the individual results vary as members of a large group.

The most common measurements of variation are:

- mean or average
- range
- standard deviation.
- coefficient of variation.

Examples of calculations involving standard deviation are shown in Case Studies 2 and 3 at the end of this manual.

The following discussion assumes that you have a basic understanding of the theory of statistics. Even if you do not, the calculations shown can be understood by following the instructions and using basic mathematics.

**Mean or Average**

The mean (μ) is calculated by adding the values (x) of the test results and dividing by the number (n) of tests.

For example, the values of seven concrete test cylinders that have been crushed to determine the crushing or compressive strength were 15, 18, 21, 23, 17, 20, and 16 MPa.

The mean compressive strength,  
\[ \mu = \frac{\sum x}{n} \]

\[ = \frac{130}{7} \]

\[ = 18.57 \text{ MPa} \]
**Range**

The range of a set of test values is the difference between the highest and lowest values of the test results.

For example, six compaction tests taken on the sub-grade of a road pavement showed 90%, 92%, 96%, 91%, 94%, and 98% of the standard compaction.

The range of these values would be between 90–98%, with 90% being the lowest value and 98% the highest.

In any range of values, the results are more likely to be near the average value of the range (e.g. in this case, 93.5%) than at the extremes.

**Standard Deviation**

While range is a useful tool in the evaluation of tests, we can obtain more precise measurements of variation by using either standard deviation or coefficient of variation. Both of these are methods are used to calculating the degree of divergence of the results from the mean.

The mean and standard deviation go together. The same numbers are used to determine their values. The mean gives the centre of distribution. The standard deviation measures how far the distribution spreads out from the mean value.

Standard deviation is used where materials and tolerances are accepted within a specified range and limits.

The standard deviation shows the dispersion of values around a mean. The greater the dispersion, the larger the standard deviation.

**Coefficient of Variation**

The coefficient of variation is the standard deviation expressed as a percentage of the mean.

\[ C\text{ of } V = \frac{SD}{\mu} \times 100\% \]

The coefficient of variation is useful because it directly measures variability. If the result is high, quality is poor. If it is low, quality is high.
Measurement

One of the roles of inspecting staff is to measure and accept the location and size of particular items of work. This role is especially important for:

- Formwork, before a concrete pour is approved
- Foundation location and formwork
- Falsework, before a concrete pour
- Pavement box dimensions and pavement depths, before the next pavement layer is constructed
- Centre line and position of a bridge structure
- Holding down bolt positions for steel columns or frames.

All of these measurements are required as part of the control and acceptance testing procedures. Either the inspector or the surveyor, or a combination of both, performs this work, depending on the type and size of the work that requiring a dimensional check. For example:

- In bridge construction, before pile-driving begins, the contractor will normally request a surveyor to check the acceptance of the bridge centre line and pile locations.
- However, the inspector would check that formwork for the foundation blocks conforms to the dimensions shown in the drawings. If they are correct, the pour would then be approved. It would be very expensive to check the dimensions of the finished work and find that they were incorrect.

Both of these examples show how important it is to plan acceptance of the work as a staged process.

These measurement procedures are similar to those undertaken for progress payments, final payments and acceptance of work. The subject of measurement will be dealt with more fully in later discussion.

Sampling and Testing

A large number of tests have been designed for use in civil engineering work. All specifications normally refer to the type of tests that will be undertaken on the job, and the size of sample required.

Sources of Tests

The specification will normally identify the tests required and nominate the reference document that describes the test. Three major reference documents are used to nominate tests:

- Standards produced by the Standards Association of Australia
- The principal’s materials and test manuals
- The detailed specifications for the work including any special provisions.
Unless it is a specific type of test, the first two are the most commonly used and, in a majority of cases, the Australian Standards are given preference.

**Example— Testing Specification for Embankment Construction**

The following is an example of a specification clause from a standard document outlining the details required for acceptance. The clause uses a process-type specification initially (i.e., horizontal layers, maximum thickness etc.), but concludes with a statement of the acceptance criterion.

6.04. Embankments shall be carried up in horizontal layers extending across the embankment of not greater than 300 mm thickness (loose measurement) and shall be compacted by rolling until the dry density is not less than 90% of the material’s maximum dry density when tested in accordance with AS 1289 (using modified compaction).

AS 1289 is the Australian Standard entitled ‘Methods of Testing Soils for Engineering Purposes’ and provides information on:

- Preparation of samples
- Determination of moisture content
- Determination of dry density
- Determination of dry density/moisture content
- The apparatus to be used and its calibration
- Procedures for the tests.

**Example— Sampling Specification for In-Situ Concrete**

10.06. Samples for in-situ concrete shall be distributed evenly over the number of batches. Except as shown below, the minimum frequency of sampling of the concrete for each class placed on any day in the job shall be accordance with either clause 7.2.2 in AS 1379–1973 (Ready-Mixed Concrete, Metric Units) or clause 20.2.2 in AS 3600 (Concrete Structures), as appropriate.

(a) For concrete to be deposited in ‘critical elements’, as designated on the contract drawings by the superintendent:

<table>
<thead>
<tr>
<th>Ready-mixed concrete</th>
<th>Site-mixed concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>One sample per truck</td>
<td>One sample per 4 m³</td>
</tr>
</tbody>
</table>
(b) For other elements placed continuously between construction joints:

<table>
<thead>
<tr>
<th>Ready-mixed concrete</th>
<th>Site-mixed concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>One truck— one sample</td>
<td>One batch— one sample</td>
</tr>
<tr>
<td>2–5 trucks— 2 samples</td>
<td>2–5 batches— 2 samples</td>
</tr>
<tr>
<td>6–10 trucks— 3 samples</td>
<td>6–10 batches— 3 samples</td>
</tr>
<tr>
<td>11–20 trucks— 4 samples</td>
<td>11–20 batches— 4 samples</td>
</tr>
</tbody>
</table>

For each individual 10 trucks or batches— one sample.

**Use of Australian Standards in Specification**

The two examples show that the information required for both sampling and testing is detailed in the relevant specification. They both identify the relevant Australian Standard which contains the specific details of the testing and acceptance procedures for the work involved.

Usually, there will be additional clauses of a general nature contained elsewhere in the contract documents related to acceptance and testing, and inspectors should be familiar with these. These other reference locations include:

- Conditions of tendering
- General conditions of contract.

**Example— Conditions of Tendering**

The example comes from a standard set of conditions of tendering used by a Queensland local government.

**Quality Considerations.** The council has adopted a policy of implementing the provisions of Australian Standards AS 3901, AS 3902, AS 3903–1987 and AS 3904.2–1990 to control the quality of goods and services produced or supplied for the council's use.

Tenderers assessed and certified to any of these or other appropriate standards are preferred. Copies of the certification shall be provided as part of the tender documentation.

Where a tenderer has not been assessed, documentary evidence will be required outlining the tenderer’s organisational and supervisory structures and will include copies of work procedures and inspection manuals applicable to the work to be undertaken. Details should also include the number of personnel to be employed and the number, qualifications and experience of supervisors appointed to maintain the standards specified.

It shall be the tenderer’s responsibility to ensure the quality of work performed and that the procedures applied comply with the Australian Standards. Documentary evidence to this effect shall be produced upon request by the supervising officer, or
an authorised council representative, to show that the appropriate quality standard has been complied with.

During the period of the contract an authorised council officer may, from time to time, inspect the work performed by the contractor. Any deficiencies noted shall be rectified at the contractor’s expense and within the time stipulated.

In this example, the requirement is to include a construction quality program to control the work. (This general procedure is discussed in more detail later).

**Example — General Conditions of Contract**

As with the conditions of tendering, the general conditions of contract will normally contain clauses relating to acceptance and testing. For example, AS 2124 includes Clauses 29, 30 and 31 that relate to materials and testing.

Clause 29.3 provides for the contractor to supply to the resident engineer details of the materials that he proposes to use on the project. This list includes particulars of:

- the mode and place of manufacture
- the source of supply
- the performance of capacities
- other information.

Clause 30.3 allows the resident engineer to direct a variation to overcome the problem of defective work, having regard to who will bear the costs.

Clause 30.4 allows for the acceptance of the defective work or materials, but at a reduced cost. The valuation of any such work shall be taken into consideration when calculating compensation for the loss of the asset.

An example of this latter situation in which Clause 30.4 may be invoked occurs in the case of substandard pavement construction, as shown below.

**Example — Substandard Material**

If a contractor used substandard road material in the construction of a pavement and it proved to be marginally defective, the principal may decide to accept the work, but at a reduced cost. The valuation would take into account the:

- loss of pavement life.
- degree of variation of material from the specified requirements— i.e. grading defects.
- degree of variation of the finished product— i.e. density, surface tolerance, dimensions.
Procedures for Testing and Sampling

Clause 31 (Examination and Testing) describes the procedures for examination, testing and measurement of work.

Covering Up

Because covering up of the work may be a problem in many situations, the superintendent may direct the contractor not be to cover up or make inaccessible any part of the works under the contract, without approval. If the work is covered up prematurely, there is a provision allowing opening up of the works for inspection.

In addition, work that has been completed may be pulled down, if it covers work that requires testing. The contractor bears the costs.

Cost of Testing and Sampling

Clause 31.7 establishes four situations where the contractor must bear the costs of testing.

They include cases where the:

• contract stipulates that the contractor bears the cost.

• tests show that the materials are not in accordance with the contract documents.

• tests could not be carried out due to the action of the contractor (i.e. covering up work before it was tested).

• test is consequent upon a failure of the contractor to comply with the requirements of the contract.

These examples show that variations between standard documents do occur.

It is therefore essential to read and have a good understanding of the documents used for the work on which you are employed.
Programming Tests and Sampling

Allowances for Time Taken to Conduct and Provide Results from Tests

Where the superintendent is responsible for quality control, and the resident engineer has been delegated the responsibility for acceptance testing, the duties of an inspector will include:

- organising testing by soil technicians or soil testers
- undertaking testing and/or sampling.

Two people can order or request tests:

- The superintendent can order a test to be undertaken at any time during the contract.
- On completion of works, the contractor may request a test or measurement, before proceeding to the next phase of the work. These tests, if undertaken by the resident engineer, are normally acceptance tests. However, prior to the completion or request for an acceptance test, the contractor should have undertaken control tests to ensure that the work had achieved the desired standard and/or dimensions.

Before conducting a test under the contract, the superintendent or the contractor must give reasonable notice in writing to the other of the time, date and place of the test.

Most specifications include a requirement to make allowances for the time required to undertake the tests and provide the result.

Example of Time Provisions — Density Testing

All density tests shall be carried out by the principal at no cost to the contractor. Up to three (3) working days may be required to carry out and obtain the results of the tests. One day’s notice is required to undertake tests. If the first test fails to achieve the required standard set out in the specification, the contractor is responsible for the costs of subsequent tests.

This clause provides advice on:

- who will undertake the test
- who will pay for the acceptance test
- the time span for taking the test and providing a result
- the notice required to undertake the test
- the cost of subsequent tests.

The inspector must ensure that the program of testing is based upon the specified requirements, otherwise the contractor can undertake the tests on his or her own behalf, and may claim damages against the principal.
The principal must promptly provide the results of the tests to the contractor. If there is delay, the contractor can claim an extension of time to the contract, or may be able to claim costs resulting from the delay.

Quality Assurance

Quality systems are becoming widespread in the construction industry. In today’s highly demanding environment, contractors are under pressure to compete on both price and quality. Contractors are now being forced to ask themselves the question “Are we doing it right?” where once the question was ‘have we got it right?’

But what is quality?

Definitions

The following definitions are important when attempting to understand what a quality system does.

‘Quality’ is the totality of features and characteristics of work that affect its ability to satisfy a defined requirement.

‘Quality Assurance’ includes all planned and systematic actions, including verification, that give the customer confidence in the product, and in its ability to satisfy defined requirements. Quality assurance involves producing and keeping documentary evidence to show that the defined quality had been achieved.

Purpose of a Quality System

The purpose of a quality system is to ensure that the final product or service is:

- ‘fit for the purpose’
- supplied at a realistic price
- supplied in the most cost-effective and efficient manner.

A quality system includes all activities aimed at managing, planning, controlling and improving the quality performance of an organisation. The quality system provides the customer with assurance that the product or service is of a desirable standard.

The net effect of a quality system is to transfer the responsibility for the finished product to the contractor.
Changes Resulting from the Introduction of Quality Systems

In the past, the resident engineer controlled the quality of work undertaken by contract, by using acceptance testing and inspections as a basis for decisions. Contractors now have to accept this responsibility, where previously they were reluctant to carry out control testing.

The usual situation in the past was for the contractor to await the results of the resident engineer’s verification tests, and to become interested in testing only if disputes arose. The past approach was to disprove the results of tests, in an effort to avoid rectification or repeat work and therefore to minimise costs or justify a claim.

When a quality system is implemented, both the resident engineer’s and the contractor’s staff must change their attitudes towards testing, acceptance and rejection of work.

The resident engineer’s staff, especially the inspector, must recognise that the quality of work is clearly the responsibility of the contractor. In doing so, the inspector will no longer have the power to give directions about conformance or non-conformance.

However the inspector still has a duty, in an advisory capacity, to inform the contractor of a non-conformance, and to wait for the contractor’s advice about rectification.

The role of the inspector has therefore changed. The inspector has become:

• an observer
• a recorder and checker of activities
• a construction auditor, ensuring that the contractor is conforming with the quality system and quality plan
• an audit tester and checker.

Elements of a Construction Quality System

The quality manual and the quality plan are the major elements of a quality system.

Quality Manual

The quality manual is a document stating the organisation’s quality policy and describing the quality system of an organisation. Usually, the system is based on an international standard, such as ISO 9001–2000 Quality Management Systems. It is not project-specific.

Quality Plan

The quality plan sets out, for a particular product, project or contract, the specific practices, resources and activities that will be applied to ensure the project meets the quality standard stated in ISO 8402–1994.

It is normally prepared by the contractor, on the basis of guidelines and requirements set out in the tender documents.
Headings in a Quality Plan

The following are typical headings in a quality plan:

- Quality assurance requirements
- The contractor’s quality statement
- The contractor’s method statements
- Checklists
- Use of checklists
- Schedule of checklists applicable to each type of work
- Testing requirements
- Hold points
- Procedures in the event of non-conforming work
- Non-conformance reports
- Methods of field lot definition
- Definition of mandatory points
- Details of measurement and payment.

Data Included in the Quality Plan

In the quality plan, the generalised material presented in the quality manual is adapted to suit the needs of a specific project. It contains such data as:

- management policies, objectives and responsibilities for quality on the project
- an organisation chart defining who is responsible for quality and the relationships between members of the contractor’s staff
- the methods to be used by the contractor to verify the quality of the work and to show that it complies with the contract requirements
- the name of the contractor’s quality representative (CQR)
- administrative details.

The procedures for verifying quality and compliance usually include details of:

- the contractor’s testing organisation
- survey control methods
- construction method statements
- hold points.
Checklists in the Quality Plan

The checklists are the core component of the program and there are normally two types:

- Procedural checklists
- Verification checklists.

Procedural checklists enable the contractor to identify each activity that must take place during the construction process. The following checklist for pavement—crushed rock is an example.

On completion, each activity is signed by the supervisor in charge of the work. This makes the person fully responsible and accountable for the inspection and verification of the completed work.

The contractor’s quality representative completes the verification checklists as proof that the work has been completed in accordance with the contract requirements. The representative normally includes the results of any tests or measurements that have been carried out, to verify their compliance (or otherwise) with the specified requirements.

A quality verification checklist for pavement—crushed rock follows as an example.

Submission of Checklists to the Resident Engineer

Both checklists are submitted to the resident engineer or inspector.

Examples of procedural checklists include those completed:

- major items of work
- daily
- for work spanning several days
- on request, and on completion of the work.

Examples of verification checklists include those completed:

- within 24 hours of completion of work
- when the contractor wants to proceed past a hold point.

Hold Points

A hold point is a dividing line between critical elements of work which require acceptance before other work can proceed. For example, the completion of the foundation of a building column or of the sub-base of a road pavement would normally be hold points.
Job No: ______________________ Lot No: _____________________________

CHECKLIST: PAVEMENT— CRUSHED ROCK

Commencement Date: ______________________

Job No: ______________________ From: ______________ T o: ____________

Layer Thickness: ______________ Approx Volume: ______ Approx Area:_____

<table>
<thead>
<tr>
<th></th>
<th>Checked by</th>
<th>Verified by</th>
<th>Non-conformance report no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
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<td>2.</td>
<td>Materials</td>
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<td>(a) source</td>
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<td>(b) materials properties</td>
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<td>3.</td>
<td>Subgrade</td>
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<td>4.</td>
<td>Preliminary Construction Trial:</td>
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<td>*Required Compaction Trial Conforms</td>
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<td>Test Results</td>
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<td>*Density</td>
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<td>*Materials Properties</td>
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<td>*Surface Evenness</td>
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<td>6.</td>
<td>Results and Analysis Attached</td>
<td></td>
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<tr>
<td>7.</td>
<td>Work completed</td>
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</tbody>
</table>

SIGNED ______________________________________       __________________

(DATE)

COMPLETION DATE______________________________

APPROVED TO PROCEED WITH NEXT OPERATION

QAR __________________________   (DATE)__________________

(NON CONFORMANCE/S— RECTIFIED/APPROVED)
QUALITY VERIFICATION CHECKLIST: PAVEMENT—CRUSHED ROCK

LOT NO__________

LOCATION: _____________________ FROM: ___________ TO: ___________

Layer Thickness: _____________ Approx Volume: _______ Approx Area: _______

<table>
<thead>
<tr>
<th></th>
<th>Conform YES/ NO</th>
<th>Non-conformance report no.</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
<td>Source of Material</td>
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<td>3</td>
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<td>4</td>
<td>Preliminary Construction Trial:</td>
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<td></td>
<td>*Required Compaction Trial Conforms</td>
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<tr>
<td>5</td>
<td>Test Results</td>
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<td>*Density</td>
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<td>*Material Properties</td>
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<td>*Surface Evenness</td>
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<tr>
<td>6</td>
<td>Results and Analysis Attached</td>
<td></td>
</tr>
</tbody>
</table>

APPROVAL TO PROCEED WITH NEXT OPERATION ___________YES/NO

I HEREBY CERTIFY THAT THIS LOT DOES/DOES NOT CONFORM WITH THE REQUIREMENTS OF THE CONTRACT DOCUMENTS.

SIGNED: ________________________

QAR                  DATE
Testing

The contractor has a legal responsibility for undertaking the program of testing and checking to ensure that the works conform to the contract documents. The amount of quality-control testing the contractor undertakes must be in accordance with minimum standards specified in both the specifications and the quality plan.

The contractor is at liberty to undertake any additional testing and checking that he or she may consider necessary. However, this is always done at the contractor’s own cost.

The resident engineer must be satisfied that the contractor’s proposals for testing meet the contract requirements. The engineer has the power to stop any work from proceeding until the contractor meets these requirements.

Testing by the Resident Engineer

The resident engineer retains the right to carry out (or have carried out on his or her behalf) audit tests to check that the works being undertaken by the contractor conform to and meet the desired standards. Audit tests are in addition to any process or quality control testing undertaken by the contractor.

The results of the audit tests are paramount in the event that they differ greatly from the contractor’s results. This provision is normally included in the contract documents.

When any process or quality control testing undertaken by the contractor fail, the contractor will normally complete a non-compliance report. The contractor is requested to complete and submit a similar report when an audit test fails.

Non-Conformance Report

An example of a generic non-conformance report form follows.

This report is completed when:

• the contractor’s tests or checks show that the work does not conform to the desired standards

• the resident engineer’s audit tests or checks show that the work does not conform to the desired standards or measurements.

In both cases, a copy of the report is submitted to the resident engineer. The report gives reasons why the work was not up to the specified standard and describes what action is being taken to rectify the work.

When a contractor undertakes a test, he or she is paid for it at a listed schedule rate. Therefore when work fails, the contractor either carries out the second test at his or her own cost or, if it is specified in the manual, the principal may support the additional cost.
REPORT ON NON-CONFORMING WORKS

SCHEDULE: ________________________________
LOT NO: ________________________________
JOB NO: ________________________________
DATE: ________________________________
REPORT NO: ________________________________

DESCRIPTION

LOCATION: ________________________________

INSPECTION/TEST SERIAL NO. DATED:

DETAILS OF NONCONFORMANCE & RECOMMENDATIONS:

<table>
<thead>
<tr>
<th>SERIOUSNESS</th>
<th>MAJOR</th>
<th>MINOR</th>
<th>INCIDENTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Reject/rework required)</td>
<td>(acceptable with rectif)</td>
<td>(acceptable without rectif)</td>
</tr>
</tbody>
</table>

REPORT BY: ________________________________
(CQR)

Proposed Actions
Rejection/Rectification and Preventative

DETAILS: ________________________________

COST OF RECTIFICATION: ________________________________

APPROVED: ________________________________
RESIDENT ENGINEER

FURTHER NOTIFICATIONS: ________________________________
Contractor’s Testing Facilities

It is now accepted practice for all testing facilities to be accredited by the National Association of Testing Authorities (NATA), or by a similar organisation. All test results are entered on NATA certificates. Using this approach, it is possible to ensure that an independent authority checks staff, laboratories and equipment on a regular basis.

The contractor is required to give the resident engineer or representative unhindered access to all laboratories and testing facilities during normal working hours, and to allow the inspector to attend and observe tests, checking and sampling on the work site.

Payment for Tests

Payments for tests are normally made in two parts:

- a lump sum for establishing and running a quality program
- according to a schedule of rates for materials testing and checking.

Payment is only made for those tests that pass and indicate compliance with the contract documents. Normally, the contract documents clearly state the frequency and number of tests, so that these do not become items of dispute.

The resident engineer has discretion to alter the number and frequency of tests to meet changed circumstances.

The contractor, the superintendent and the inspector all have responsibilities related to payments for tests.

Contractor’s Responsibilities for Testing and Payment

- Plan, develop, maintain and operate a quality system that is satisfactory to the principal.
- Employ a quality assurance representative approved by the superintendent.
- Develop procedural and verification controls to satisfy the requirements of the quality system.
- Prevent, properly detect and correct work which does not conform to the contract documents.
- Establish similar quality programs with materials and manufactured components suppliers.
Superintendent’s Responsibilities for Testing and Payment

- Assess and approve the contractor’s quality plan.
- Approve or reject the contractor’s nominated CQR person.
- Ensure that the contractor carries out the work with emphasis on quality, time, performance and safety, by maintaining an audit program.
- To see and accept components and materials before they are placed in the work.
- Ensure that the contractor complies with the quality system.
- Approve or reject work that the contractor has verified as conforming to the contract documents.
- Accept or reject works submitted as non-conforming, and approve or reject the contractor’s proposed rectification procedures.

Inspector’s Responsibilities for Testing and Payment

- To observe work carried out by the contractor and ensure that the contractor carries out the work with emphasis on quality and performance, and using safe construction practices.
- Act in an advisory capacity to the contractor, especially where the methods adopted may lead to non-conformance.
- Observe tests and checks undertaken by the contractor, and ensure that they are being carried out in accordance with the quality plan.
- Record and report to the resident engineer any work that is not being undertaken in accordance with the quality manual and contract documents.
- Undertake or organise audit tests and checks, as instructed by the resident engineer.

Effects of Quality Assurance on the Role of Inspecting Staff

Construction contracts usually involve a person who has a responsibility for inspections, whether of the work performed by a contractor for the principal (in a government contract) or by subcontractors for the contractor (in a private contract).

The basic duties and responsibilities of the inspector have not changed since the introduction of quality assurance. However, the responsibility for carrying out testing and checking work has changed. In the system that applied before quality assurance, the inspector was directly responsible for testing and acceptance of work; under a quality management system, this may be the contractor’s or subcontractor’s responsibility, depending on the wording of the contract.

The inspector is still required to observe the work, and to prepare and evaluate the various reports. These may now include checklists, verification and test reports, and the daily diary of events on the job site.
There are two reasons why the inspector has an on-going role following the introduction of quality assurance into contracts. Both of these reasons are applicable to both types of contract administration:

- Without the inspector, there will normally be no other person who can directly or continuously represent the principal or contractor at the job site. (This also applies to small contracts where the inspector may only visit for a limited period on a daily basis). The inspector must therefore act as the “ears and eyes” of his or her employer.

- It is not enough to simply leave quality and materials assurance entirely in the hands of the contractor or subcontractor. Many engineers and architects seem to believe that if a design is adequate, and the plans and specifications are carefully prepared, the field construction will take care of itself. Audit testing enables the principal or contractor to satisfy him or herself that an effective quality system is being employed.

The inspector’s duties and responsibilities are to ensure that the project is substantially in accordance with the requirements of the contract documents. The inspector’s role in the process of testing and auditing may be summarised as follows:

- In contracts where the resident engineer or contractor is responsible for inspection and testing of completed work, the inspector is fully responsible for organising and carrying out the inspection and tests.

- In contracts where quality assurance is being implemented, the inspector observes the tests organised and undertaken by the contractor or subcontractors, but is only responsible for any audit testing as directed.

It is important to remember that most contracts include a process for handling disputes. These may arise from testing and quality assurance, as much as they may from any other part of the contract. A person who has an inspecting role on site, whether for the resident engineer or for the contractor, must be flexible—within reason.

The only way to learn and apply the appropriate degree of flexibility is to gain experience over a number of contracts. Over a period of time, inspecting staff become more aware that the degree of flexibility the parties agree to adopt when interpreting the wording of the contract is a variable amount—it changes from one contract to the next.

All parties to the contract must remember that, while the need for inspection is clearly spelt out in the contract documents, the inspector’s word is not law. Contractors’ representatives or quality representatives may feel that there are good reasons to question or dispute an inspector’s decision. If so, they would be fully entitled to appeal to higher authority, or ask that the question be handled through the dispute resolution procedures.
Content of a Project Quality Plan

The project quality plan sets out, for a particular product, project or contract, the specific practices, resources and activities that will be applied to ensure the project meets the quality standard stated in ISO 9001–2000 (Quality management systems).

It is normally prepared by the contractor, on the basis of guidelines and requirements set out in the tender documents.

A typical list of headings in a project quality plan written for a road construction project would include:

- Project quality statement
- Responsibilities of contractor’s project staff
- Nominees
- Documentation
- Procurement
- Inspection and test plan
- Incoming inspection
- Measuring and testing equipment/facility
- Transport, handling and storage
- Records
- Procedures for non-conformance
- Procedures for corrective action
- Other provisions.

Project Quality Statement

This is a statement of the contractor’s commitment to the principles of quality and their application to the nominated construction project. A typical statement might be:

The policy of the contractor is to provide workmanship and products of the quality that satisfies the requirements of the client specifications, applicable codes and standards and to comply with the company’s quality policy statement.

For the execution of this project, all personnel associated with quality control and assurance shall be made familiar with this quality plan in terms of requirements. Works shall be performed in accordance with the requirements of this quality plan, based on AS/ISO 9002 with reference to AS2900 Cat B.
Responsibilities of Contractor’s Project Staff

This section of the plan spells out the responsibilities of members of the contractor’s staff who are required to play a role in ensuring project quality. The relevant staff may include any or all of the following:

- Project manager
- Project engineer
- Contractor’s quality representative (CQR)
- Foreman
- Subcontractors
- Day labour.

In addition, a plan prepared for a specific site may give the names of the individuals who are to fulfil the various roles, and their relationships within the company’s (or the project) organisational structure.

**Project Manager**

Typical responsibilities of the project manager (or an authorised nominee) usually include all site construction activities, including the preparation and implementation of technical procedures.

The project manager is generally given sufficient independence and authority to:

- Ensure that a quality system is maintained on the project.
- Recommend corrective and preventative actions specific to the project.
- Ensure that audits of the quality system are undertaken in accordance with the quality manual.
- Prepare project-specific quality plans.
- Carry out post-acceptance review of contracts and resolve any discrepancies that may arise.
- Approve changes to quality documents at the project level.
- Control inspection activities and quality documents in conjunction with the contractor’s quality representative (CQR).
- Report to the construction manager or nominee.
- Approve recommended corrective action and preventative actions.
Project Engineer

The project engineer or nominee may be responsible for site construction activities, including the preparation and implementation of technical procedures. The project engineer would normally have independence and sufficient authority to:

- Identify and document any quality problems
- Initiate solutions to the quality problem
- Stop the works, if such a decision becomes necessary, in order to prevent a quality problem from arising.
- Amend work method statements, to suit site conditions, upon concurrent approval from the client’s representative.

Contractor’s Quality Representative (CQR)

The CQR is responsible to the project engineer and has the authority to recommend and initiate solutions to the problems of quality, or verify the implementation of solutions. His or her responsibilities would normally include:

- Ensuring that all works are carried out in accordance with the contract documents.
- Initiating and finalising all documentation related to the quality of works.
- Programming of all inspections and testing required by the contract documents.

Foreman

The site foreman is responsible to the CQR for the workmanship of all operations under his or her control.

The foreman is required to implement the checklists relevant to any of the client’s work activities and to identify, and recommend solutions to, any quality problems.

Subcontractors

Subcontractors are generally responsible for ensuring their work conforms to the client’s requirements. In the absence of their own quality plan, they would normally use the contractor’s project quality plan.

Day Labour

Day labour workers would usually be required to report any quality defects they have found to the forepersons. They would normally have sufficient skills to enable them to carry out defect identification.
Nominees

The quality plan may include a statement about alternative arrangements that apply if quality checking/verification staff are absent from the works. Another person or persons may be nominated to perform this role. For example:

The project engineer or the CQR shall have the necessary authority to perform the quality checking or verification of any of the work activities.

Documentation Policy

Adequate documentation, to provide proof that work carried out and materials supplied were in conformity with quality requirements, is an essential feature of any quality control system. This section of the quality plan therefore describes:

- Responsibilities for maintaining documentation
- Which documents are controlled.

Responsibilities for Maintaining Documentation

A typical statement of responsibilities might be:

The project engineer or nominee shall be responsible for the maintenance of an up-to-date controlled document register that shall provide:

- Identification of the recipients of controlled documents
- Date of issue/receipts
- Current revision status (if applicable).

Controlled Documents

Documents that may need to be controlled as part of the quality control system may include:

- Quality manual
- Quality plan
- Client drawings and specifications
- General conditions of contract
- Safety manual.

The statement about controlled documentation may include responsibilities for ensuring that all superseded documentation is either withdrawn or destroyed.

Normally, a person (e.g. the project engineer) will have the authority to alter or revise any or all documents within the project quality plan. For example, it may be necessary to alter method statements or construction procedures as part of the execution of the contract.
Checklists

The checklists are the core component of the program and there are normally two types:

- Procedural checklists
- Verification checklists.

Procedural checklists enable the contractor to identify each activity that must take place during the construction process. The following checklist for Pavement— Crushed Rock is an example.

On completion, each activity is signed by the supervisor in charge of the work. This makes the person fully responsible and accountable for the inspection and verification of the completed work.

The contractor’s quality representative completes the verification checklists as proof that the work has been completed in accordance with the contract requirements. The representative normally includes the results of any tests or measurements that have been carried out, to verify compliance with the specified requirements.

A Quality Verification Checklist for pavement— crushed rock follows as an example.
Job No: _________________________Lot No: _____________________________

**CHECKLIST: PAVEMENT— CRUSHED ROCK**

Commencement Date: ______________________

Job No: _________________________From: ______________ T o: ____________

Layer Thickness: ______________Approx Volume: _______Approx Area:_______

<table>
<thead>
<tr>
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<th>Checked by</th>
<th>Verified by</th>
<th>Non-conformance report no.</th>
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<td>conform</td>
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<td>3. Subgrade</td>
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<td>4. Preliminary Construction Trial:</td>
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<tr>
<td>Conforms</td>
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<td>5. Test Results</td>
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<tr>
<td>*Density</td>
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<tr>
<td>6. Results and Analysis Attached</td>
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<tr>
<td>7. Work completed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signed ________________________________       __________________
(date)

Completion date____________________________

Approved to proceed with next operation

QAR _________________________ (DATE)__________________

(Non-conformance/s— RECTIFIED/APPROVED)
QUALITY VERIFICATION CHECKLIST: PAVEMENT—CRUSHED ROCK

LOT NO________

LOCATION: _____________________ FROM: ___________ TO: ___________

Layer Thickness: ___________ Approx Volume: _______ Approx Area:________

<table>
<thead>
<tr>
<th></th>
<th>Conform YES/NO</th>
<th>Non-conformance report no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Authorisation to Place Pavement Granted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Source of Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Subgrade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Preliminary Construction Trial:</td>
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<tr>
<td>*Equipment for compaction</td>
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<td></td>
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<tr>
<td>6. Results and Analysis Attached</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Approval to proceed with next operation ____________YES/NO

I hereby certify that this lot DOES/DOES NOT conform with the requirements of the contract documents.

SIGNED:__________________________________________

QAR ___________________________ DATE
Submission of Checklists to the Resident Engineer

Both checklists are submitted to the resident engineer or inspector (on state government contracts).

Examples of procedural checklists include those completed:
- for major items of work
- daily
- for work spanning several days
- on request, and on completion of the work.

Examples of verification checklists include those completed:
- within 24 hours of completion of work
- when the contractor wants to proceed past a hold point.

Hold Points

A hold point is a dividing line between critical elements of work which require acceptance before other work can proceed. Hold points may relate to:
- Some event that occurs during the course of construction
- Materials testing.

An example of an event during the course of construction that constitutes a hold point would be the unearthing of cultural relics. The completion of the foundation of a building column, or of the sub-base of a road pavement, would normally be hold points for materials testing.

Procurement

Materials and services used on the job must comply with the client’s specifications for the job. Because of this, a purchasing strategy is required. The strategy should be aimed at ensuring that all materials and services are provided by suppliers who are capable of meeting the client specifications. Following is an example of a strategy statement:

The selection of suppliers and subcontractors for the project has been primarily based upon their demonstrated ability to:
- comply with the specified quality requirements and the works programme
- work within the limitations imposed by the contractor’s contractual obligations
- provide an organisational structure and operational capability that facilitates compliance with the contractor’s contractual obligations.
Inspection and Test Plan

This part of the quality plan describes the relationships between the Inspection and Test Plan (ITP) and quality assurance. This subject is dealt with in greater detail in Section 14 of this topic.

Incoming Materials Inspection

The quality plan includes a statement of the requirements for inspection of incoming products and materials. A typical requirement might be:

- All incoming products and materials shall be identified and inspected on arrival to site and checked against the suppliers’ delivery documents.
- Where necessary, the suppliers’ delivery documents shall be rechecked against the contractual requirements and specification prior to acceptance of the delivered products.
- These inspections shall be carried out by the project engineer, CQR or the foreman of the associated works.

Measuring and Testing Equipment/Facility

This part of the plan states the contractor’s requirements for testing and testing equipment.

- Usually, a NATA-registered testing laboratory tests soil and concrete for compliance with the client’s specifications.
- Any items of measuring equipment kept on site are listed in the plan. Nominated instruments may be altered, depending on the availability, application and calibration status. The contractor’s staff are responsible for care of the equipment, so that it is not damaged by usage or handling, and that calibration is maintained.

Identification and Traceability

The contractor may use a system of lot numbers to keep track of materials included in critical work forming part of the contract, and use a system of lot coding. For example:

- The first two characters of the lot coding shall be letters and be used to classify the work activity.
- The following three characters shall be numbers starting at 001, which will be used to distinguish between similarly classified lots. For example, CW002 would represent the second lot of concrete work carried out for the project.
The table gives an example of a list of activities for which lot numbers may be allocated.

<table>
<thead>
<tr>
<th>Sample list of activities for which lot numbers may be allocated:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site establishment</td>
</tr>
<tr>
<td>Provision for traffic</td>
</tr>
<tr>
<td>Culverts, concrete pipe</td>
</tr>
<tr>
<td>Culverts, concrete box</td>
</tr>
<tr>
<td>Remove existing structures</td>
</tr>
<tr>
<td>Concrete pour</td>
</tr>
<tr>
<td>Kerb, kerb and channel</td>
</tr>
<tr>
<td>Gullies</td>
</tr>
<tr>
<td>Subsoil drains</td>
</tr>
<tr>
<td>Rock protection</td>
</tr>
<tr>
<td>Clearing and grubbing</td>
</tr>
<tr>
<td>Ground surface treatment (standard)</td>
</tr>
<tr>
<td>Ground surface treatment (special)</td>
</tr>
<tr>
<td>Roadway excavation</td>
</tr>
<tr>
<td>Drains and channels</td>
</tr>
<tr>
<td>Roadway embankment</td>
</tr>
<tr>
<td>Pavement – hot mixed asphalt</td>
</tr>
<tr>
<td>Sprayed bitumen surfacing</td>
</tr>
<tr>
<td>Road furnishings— guide posts</td>
</tr>
</tbody>
</table>

Each of the above activities has a lot identifier, in accordance with the contractor’s system of lot coding.

In any system of lot allocation, it is critical to clearly identify the boundaries and location of each lot. Usually, these are determined at the time of opening of the lot.
Where a system of lot coding is used, details of all lots are entered into a Lot Status Register at time of lot opening. The register provides the following information:

- Lot number
- Schedule item number
- Location (chainage)
- Indication of conformance/non-conformance
- Replacement lot numbers for non-conforming lots, as necessary
- Size of lot/quality
- Date opened/closed.

**Transport, Handling and Storage**

The quality plan will include a list of precautions that must be taken to:

- protect supplied materials from damage during transportation, handling and storage
- mark non-conforming materials detected at incoming inspection
- hold non-conforming materials separate to conforming product, until disposal.

**Record Keeping**

As stated in the contractor’s documentation policy, the maintenance of adequate documentation is an essential part of any quality control system. This section of the quality plan therefore describes:

- responsibilities for maintenance of the records
- storage and retrieval requirements
- purpose or aim of record-keeping (e.g. “to demonstrate the conformity of all works and materials to the contractual documents”).

The records kept in association with the contractor’s quality system may include:

- Site investigation reports
- Design sketches and drawings
- Specifications
- As-built drawings
- Completed quality records (ITPs, checklists)
- Non-conformance reports
- Details of corrective actions on system and repetitive deficiencies
- Subcontractor and supplier evaluations and comparisons
- Subcontractor’s quality system documentation
- Approved and superseded work procedures and methods
• Equipment calibration certificates
• Tests, approvals and audits of agencies and suppliers
• Functional test reports and data for permanent equipment and materials.

**Procedures for Non-Conformance**

The contractor will normally require reporting of detected non-conforming works. There may be requirements to report non-conformances to:

• the client’s representative, if the non-conformance is relevant to the final quality
• the contractor's corporate office for review by senior management.

The plan will specify the required form of reporting. Usually a non-conformance report includes any proposed procedures to prevent recurrence of the non-conformance (where causes are known).

**Procedures for Corrective Action**

The contractor will normally set up a procedure for any corrective action required as a result of detected non-conforming works. This procedure will be designed to ensure that, where possible, any corrective action:

• does not adversely affect other on-going operations
• deals with probable or identified causes of non-conformance.

**Other Provisions**

A variety of other provisions may be included in the contractor’s quality plan, such as:

• The use of statistical techniques to verify acceptability of work allotments of concrete and soils
• Training requirements for site personnel
• Project pre-start procedures as they relate to the quality plan
• Appendices to the quality plan.

Depending on the company’s requirements, the following may be included as appendices to the quality plan:

• A summary of the inspection and test plan
• Organisational chart for the project
• Environmental management plan
• Safety plan
• Details of the construction program
• Construction procedures (e.g. requirement for certain procedures to comply with Main Roads specifications)
• Standard forms used for quality documentation
• Documentation procedures (e.g. destination of forms, allocation of non-compliance numbers).

Relationship between Quality Plan and Inspection and Test Plan

Part of the quality plan describes how the overall requirements of the quality plan are met in detail through the provisions of the inspection and test plan.

For example:

Direct suppliers and subcontractors may be required to either provide their individual quality plan or ITP for approval and incorporation into the contractor's quality plan, or to comply with the contractor's ITP checklists. (The CQR would normally be responsible for checking this).

The CQR or nominee may be responsible for checking all incoming materials, to ensure suppliers are complying with specified requirements.

Inspection and testing of materials and work activities may be a requirement, and would need to be in accordance with the ITP for the relevant work activity.

A system of reference numbers, forms and checklists may be used for verification of inspection and testing activities. (See table below).

Any applicable hold points (i.e. those related to materials testing) may require written approval from the client's representative and would be outlined in the client documents and ITPs. Should the client's representative approve the works and be unwilling or unable to sign the quality documentation, a suitable record of the event may be noted, and the works may have to proceed on verbal approval.
Sample list of activities for which inspection and test reference numbers may be allocated:

<table>
<thead>
<tr>
<th>Concrete pipes and box culverts</th>
<th>Road furniture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-soil drains</td>
<td>Bituminous surfacing</td>
</tr>
<tr>
<td>Kerb, kerb and channel, lining to drains</td>
<td>Asphalt</td>
</tr>
<tr>
<td>Concrete pours</td>
<td>Landscaping</td>
</tr>
<tr>
<td>Clearing and grubbing / Ground surface treatment</td>
<td>PSC piling</td>
</tr>
<tr>
<td>Roadway excavation</td>
<td>PSC deck units</td>
</tr>
<tr>
<td>Roadway embankment</td>
<td>Bridge rail</td>
</tr>
<tr>
<td>Unbound pavements— Stockpile lot</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>Unbound pavements— Pavement lot</td>
<td>Bridge protection works</td>
</tr>
</tbody>
</table>

Such a list would normally be included in the quality plan as a summary of the inspection and test plan. Each item in the list is normally numbered, e.g. ITP12.

## Content of an Inspection and Test Plan

The inspection and test plan sets out, for each activity forming part of a particular product, project or contract, the inspections and tests that are required to meet the requirements of the quality plan.

A sample inspection and test plan for bridge protection works follows.

The plan shows:

- The job identification (contract title)
- Document reference (ITP number)
- The required testing process or check, and its identification number
- Criteria on which acceptance of the materials will depend (e.g. Main roads specification)
- Frequency of testing
- Who is responsible for testing (subcontractor, contractor or client).

In the example shown, the contractor is required under the terms of the contract to conduct all materials testing for bridge protection works. Most of the required tests are either O (conducted by observation) or M (carried out by using a specified measure or test procedure).
<table>
<thead>
<tr>
<th>BASIC CONSTRUCTION SERVICES</th>
<th>INSPECTION AND TEST PLAN (ITP)</th>
<th>Document Ref.</th>
<th>ITP 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUALITY STANDARD TO AS9002</td>
<td>CONTRACT TITLE: Maleny Kenilworth Road</td>
<td>Approved:</td>
<td></td>
</tr>
<tr>
<td>SUBCONTRACTOR: MRS 11.03</td>
<td>CLIENT: Main Roads</td>
<td>Approval Date:</td>
<td></td>
</tr>
<tr>
<td>Notes:</td>
<td>ITP No: 19</td>
<td>Revision:</td>
<td>A</td>
</tr>
<tr>
<td>MRS 11.03 CL 48.4</td>
<td>Location: Contract 80/455/301</td>
<td>Revision Date: 19/12/02</td>
<td></td>
</tr>
<tr>
<td>Supp Spec 2654</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PROCESS/ CHECK</th>
<th>Process Number</th>
<th>Inspection Characters</th>
<th>Acceptance Criteria</th>
<th>Test Frequency</th>
<th>Inspection Procedure</th>
<th>INSPECTORATE</th>
<th>VERIFYING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services identified and protected</td>
<td>1</td>
<td>M</td>
<td>GPV16 signed</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Excavate to required limits</td>
<td>2</td>
<td>OM</td>
<td>Ref Drawings, measur</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Material ready to accept protection works</td>
<td>3</td>
<td>12</td>
<td>MRS 11.03 Cl 48.3</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Materials accepted</td>
<td>4</td>
<td>12</td>
<td>MRS 11.03 Cl 48.3</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Construct Toe Wall</td>
<td>5</td>
<td>12</td>
<td>MRS 11.03 Cl 48.3</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Rock spalls installed</td>
<td>6</td>
<td>12</td>
<td>MRS 11.03 Cl 48.3</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
<tr>
<td>Spalls grouted</td>
<td>7</td>
<td>12</td>
<td>Smooth even appearance</td>
<td>Lot</td>
<td></td>
<td>X</td>
<td>GPV19</td>
</tr>
</tbody>
</table>

Legend of Inspection Characteristics:

- S: Submission Req'd
- R: Records/Specification
- W: Witness Point
- C: Observation
- HOLD: Hold Point
- M: Measure/Test

REC

<table>
<thead>
<tr>
<th>PROCESS/ CHECK</th>
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<tr>
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</table>

Legend of Inspection Characteristics:

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- HOLD: Hold Point
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REC
Section 7 – Assessment Activities

For information on how these assessment activities may be used as part of the learning process, see the section on ‘Assessment’ in the ‘Topic Descriptor’ section at the front of this topic.

Theory Questions

The following questions allow you to assess your progress in understanding the material presented in Section 7. The questions may be of any of the following types:

• multiple choice (identify correct answer or answers)
• multiple choice (identify incorrect answer or answers)
• fill in the gaps in a sentence or statement
• identify a sentence or statement as TRUE or FALSE
• write a few sentences or a short paragraph.

Answers to the question are shown in the separate ‘Answer’ section.

Question 1

What are the two types of testing used in civil engineering?

__________________________________________________________

__________________________________________________________

Question 2

Name three people who may undertake testing?

__________________________________________________________

__________________________________________________________

__________________________________________________________

Question 3

Name four of the six quality control processes used for civil engineering.

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________
Question 4
Name two of the main responsibilities of an inspector when making inspections.

Question 5
After testing has been carried out, the engineer (or supervising officer) must inform the contractor of the outcome of the testing. What are the three possible outcomes?

Question 6
The measurements recorded for seven concrete test cylinders that have been crushed to determine the compressive strength were as follows:
16, 17, 22, 19, 17, 23, 20 mpa
What is the average value (otherwise known as the mean value) of these seven tests?
Question 7
List three items of work that may need to be measured before further work can continue.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Question 8
Name some of the physical qualities or properties that may be tested in material testing.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Question 9
Describe two or more situations where the contractor must bear the cost of testing.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Question 10
Briefly describe the purpose of the following types of checklist:

1. Procedural checklist

2. Quality verification checklist

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Question 11
Define ‘hold point’.


Question 12
Name three of the inspector’s roles.


Question 13
Which two people can order or request tests to be performed and when?


Question 14
Outline the purpose of a quality system.


Question 15
List the three desirable outcomes of a quality system.


Question 16

Name four groups of people on site who would usually have some responsibility for ensuring that the project meets the client’s quality requirements.

________________________________________

________________________________________

________________________________________

________________________________________

Question 17

Which of the following would normally be quality responsibilities of a contractor’s quality representative (CQR)?

- Ensure that a quality system is maintained on the project. □
- Ensuring that all works are carried out in accordance with the contract documents. □
- Ensure that audits of the quality system are undertaken in accordance with the quality manual. □
- Programming of all inspections and testing required by the contract documents. □
- Approve changes to quality documents at the project level. □

Question 18

Subcontractors would normally use the contractor’s quality plan for the duration of the project if they have not prepared their own quality plan.

- True □
- False □
Question 19
What is the reason for including the names of several quality nominees in a quality plan?

Question 20
Give three examples of documents that may need to be controlled as part of a quality plan.

Question 21
If the quality representative on site asks you to complete a procedural checklist, what would you expect it to contain and what is its main purpose?

Question 22
If a contractor wishes to proceed on work beyond a hold point, he or she would submit a verification checklist.

True □
False □
**Question 23**

Which of the following steps would be part of the correct procedure for on-site receival of materials from a supplier?

- Wave the delivery truck through the gate and direct the driver to the unloading point.  
- Check the incoming products or materials against the suppliers’ delivery documents.
- Place the incoming products or materials to one side, until there is time for complete identification and inspection.
- Refuse to allow unloading of materials on site until the project engineer, CQR or the foreman has carried out the required inspections.

**Question 24**

Why do contractors use a system of lot numbers to keep track of materials?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

**Question 25**

If incoming products or materials are identified as non-conforming, what procedures should be followed?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Question 26

Why is it advisable to have a documentation policy as part of a quality plan?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Question 27

A project quality plan often includes a procedure for taking corrective action required as a result of detected non-conforming works. What are the two requirements for corrective action to be successful?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Question 28

A project quality plan may include provisions for training of site staff who will be required to implement the plan.

True ☐

False ☐

Question 29

You have the inspection and test plan for ‘Road furniture’ for a civil construction project. What information does this document contain?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
**Question 30**

One of the checks required on the inspection and test plan for concrete pipes and box culverts is ‘Backfill material placed and compacted’. What does this mean?

- An inspection or test is required on concrete pipes and box culverts used in the project.  
- The numbers of concrete pipes and box culverts included in the finished work must be counted and compared to specification.  
- The numbers of cubic metres of backfill included in the finished work must be accounted for and compared to specification.  
- An inspection or test is required to confirm placement of backfill around concrete pipes and box culverts and that it has been compacted to specification.

**Question 31**

One of the criteria for acceptance of ‘Backfill material placed and compacted’ is shown on the inspection and test plan is “MRS 11.03”. What does this mean?