



# QUALITY ASSURANCE OF AGGREGATES FOR ROADS

**RNZ 9805:2009**

Guidelines developed by  
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In conjunction with  
**Aggregate and Quarry Association  
of New Zealand Inc.**  
**New Zealand Transport Agency**

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## 1. Scope

This guideline covers the systems and procedures recommended by Roding New Zealand (RNZ), for the quality assurance of aggregates\* for roads. The guideline was developed in consultation with the Aggregate and Quarry Association of New Zealand (AQA) and the New Zealand Transport Agency (NZTA, formerly Transit New Zealand). It is assumed that the aggregate producer should have a formal quality plan system in operation in each quarry<sup>†</sup>, detailing the quality control procedures to be used for sourcing rock<sup>‡</sup> and for controlling quality of each of the aggregates produced. Recommendations for developing and implementing a quality plan or system are provided in the appended explanatory notes, see sections 13 and 14.

The quality plan or system should cover all quality aspects of source material handling, aggregate processing, stockpiling and transportation, including methods and frequency of sampling and testing to be used, and should also identify key responsibilities. See appendix notes 13.1, 13.2, and 13.3.

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\* "Aggregates" are defined as rock that has been processed by crushing and screening into products for road construction.

† A "Quarry" is defined as a place from which rock is extracted for construction purposes and includes gravel pits, river beds and steel slag stockpiles.

‡ "Rock" and "Stone" are defined as the hard material of the earth's crust. Melter and Electric Arc Furnace Slag are included in the definition of "rock" for the purposes of this guideline.

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## 2. Related Documents

- 2.1 BS EN 1097-8 Tests for Mechanical and Physical Properties of Aggregates. Determination of the Polished Stone Value
- 2.2 AS/NZS ISO 9001 Quality Management Systems - Requirements
- 2.3 NZS ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories
- 2.4 NZS 4407 Methods of Sampling and Testing Road Aggregates
- 2.5 NZTA M/3 Notes on Sub-base Aggregate Specification
- 2.6 NZTA M/4 Specification for Basecourse Aggregate
- 2.7 NZTA M/6 Specification for Sealing Chip
- 2.8 NZTA M/10 Specifications for Asphaltic Concrete
- 2.9 NZTA M/22 Guide to the Evaluation of Unbound Road Base and Sub-Base Aggregates (provisional).
- 2.10 NZTA P/11 Specification for Open Graded Porous Asphalt
- 2.11 NZTA Q/1 Specification for Quality Assurance for Chip sealing
- 2.12 NZTA Q/2 Specification for Quality Assurance for Hot Mix Asphalt
- 2.13 NZTA T/15, Specification for Repeated Load Triaxial Testing (RLT) of Unbound and Modified Road Base Aggregates

### 3. Control of Source Quality

In most quarries, source rock properties<sup>§</sup> vary depending on location within the quarry. It is necessary for aggregate producers to regularly check that the source rock is of adequate quality for the intended finished products especially when the location of the source is changed within a quarry. See appendix note 13.2.

To comply with this guideline:

- a) The aggregate producer should clearly identify any zones of the quarry that have significantly differing rock properties.
- b) The aggregate producer should test the source rock properties for each of the zones of the quarry identified in (a) above, that are currently being used, either in accordance with the specific requirements of a customer, or with appropriate test methods selected from the following suggested list<sup>\*\*</sup>:
  - i. **Crushing Resistance:** NZS 4407 Test 3.10, "The Crushing Resistance of Coarse Aggregate Under a Specified Load".
  - ii. **Weathering Quality Index:** NZS 4407 Test 3.11 "The Weathering Quality Index of Coarse Aggregate".
  - iii. **Polished Stone Value:** BS EN 1097-8 "Tests for Mechanical and Physical Properties of Aggregates. Determination of the Polished Stone Value".
  - iv. **Abrasion Resistance:** NZS 4407 Test 3.12. "The Abrasion Resistance of Aggregate by Use of the Los Angeles Machine".
  - v. **Chemical Analysis and Potential Expansion from Hydration Reactions:** BS EN 1744-1 (For Melter and Electric Arc Furnace Slag only.)
  - vi. **California Bearing Ratio:** Compaction method: NZS 4402 Test 4.1.3 "NZ Vibrating Hammer Compaction Test at Optimum Water Content. CBR Method; NZS 4407 Test 3.15. The California Bearing Ratio Test (without a surcharge soaked for 4 days).
  - vii. **Petrographic Examination:** Guidelines given in ASTM C295, "Standard Practice for Petrographic Examination of Aggregate for Concrete".
- c) The minimum frequency of such testing is one test per property per 10,000m<sup>3</sup> of source material, or per annum, whichever is least, for each zone that is operated during that period. If a comparative petrographic examination of the current aggregate and samples from the material successfully tested within the previous two years, shows that there has been no significant change in the material, the frequency of testing may be reduced to once every four years. See appendix notes 13.1, 13.2.
- d) Source rock testing for the criteria listed in (b) above, should be performed by a laboratory which is accredited to NZS ISO/IEC 17025.
- e) When a Polished Stone Value (PSV) test is carried out, rock particles from the same production run of the same zone of the quarry should also be tested for crushing resistance and the result recorded with the PSV results.
- f) Sampling should be carried out by IANZ accredited personnel only in accordance with the appropriate methods set out in NZS 4407. See appendix note 13.1.

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<sup>§</sup> "Source Rock Properties" are the test properties of the rock to be used in roading aggregate manufacture.

<sup>\*\*</sup> All the listed tests should be carried out unless it can be demonstrated from existing records that a particular property never varies significantly or is irrelevant to the particular product.

- g) The aggregate producer should keep accurate records of all sampling and testing and clearly show to which zones within the quarry they refer. The quality plan or system should state who holds the records.
- h) The aggregate producer should set out in the quality plan, control limits for each test property in accordance with section 11 of this guideline.
- i) Where statistical quality control analysis indicates a systematic non-compliance has occurred or is likely to occur, the aggregate producer should identify the cause of this occurrence, take remedial action, if necessary, and then re-test to confirm the trend is contained. See appendix note 13.2
- j) Petrographic examinations should be performed by persons who are qualified by education and experience to employ techniques for the recognition of the characteristic properties of aggregates and minerals.

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## 4. Control of Production Quality

The aggregate production process should be carefully controlled and the quality of aggregate should be continually monitored both visually and by regular spot-check testing. Finished products should be routinely tested for compliance with customer specifications or requirements (see sections 7 - 10 of this guideline).

To comply with this guideline:

- a) The aggregate producer should set out in the quarry quality plan who should be responsible for determining plant settings and screen sizes etc. for each production run.
- b) The aggregate producer should set out in the quality plan "key indicator properties"<sup>††</sup> for each aggregate type and the minimum levels and maximum variations allowable for those properties.
- c) The aggregate producer may carry out regular spot check testing of the "key indicator properties" to ensure that quality and consistency of the manufactured products are "fit for purpose" and are likely to meet the specifications or specific requirements of the customer. Appropriate test methods and test frequencies should be selected for each key indicator property.
- d) The aggregate producer should carry out regular finished product testing in accordance with sections 7 - 10 of this guideline, to ensure that quality and consistency of the manufactured products are "fit for purpose" and/or meet the specific requirements of the customer. Testing of finished products should be performed by a laboratory which is accredited to NZS ISO/IEC 17025.
- e) Testing for "key indicator properties" should be performed by a testing facility which has at least an AS/NZS 9001 registered quality assurance system and which annually verifies its test results with an accredited laboratory.
- f) Sampling should be carried out by IANZ accredited personnel only in accordance with the appropriate methods in NZS 4407. See appendix note 13.1.
- g) The aggregate producer should keep accurate records of all sampling and testing.
- h) The aggregate producer should set out in the quality plan, control limits for each test property (both for key indicator properties and for finished product properties) in accordance with Section 10 of this guideline.
- i) Where quality control analysis indicates a systematic non-compliance has occurred or is likely to occur, the aggregate producer should identify the cause of this occurrence, take remedial action, if necessary, and then re-test to confirm the trend is contained. See appendix note 13.2.

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<sup>††</sup> "Key indicator" properties are test properties that give an indication of product quality. Tests may be limited to abbreviated parts of standard test methods such as the percentage passing one particular sieve.

## 5. Control of Aggregate Handling

When aggregates are transported and delivered into a stockpile within the quarry or on to a construction site, they can be subject to change due to the effects of particle degradation, contamination and segregation.

To comply with this guideline:

- a) The aggregate producer's quality system or quality plan should detail methods for handling and storage of aggregates that should minimise the effects of particle degradation, contamination, and segregation.
- b) The aggregate producer and/or customer should carry out regular spot-check testing of "key indicator properties" of re-handled products within the quarry and products delivered by the quarry to construction sites to demonstrate that the controls in place to minimise the effects of handling, transportation or storage of product are effective. See appendix notes 13.1, 13.2.
- c) Testing for "key indicator properties" should be performed by a testing facility which has at least an AS/NZS 9001 registered quality assurance system and which annually verifies its test results with an accredited laboratory.
- d) Sampling should be carried out by IANZ accredited personnel only in accordance with the methods in NZS 4407. See appendix note 13.1.
- e) The aggregate producer should keep accurate records of all sampling and testing.
- f) Where spot-check key indicator test values suggest that the handling, transportation and storage controls are not effective, the aggregate producer should identify the cause of the non-compliance and take remedial action, if necessary, and re-test the product in accordance with sections 4(d) and 4(e) of this guideline to confirm compliance. See appendix note 13.2.

## 6. Blended Aggregates

Aggregates may be mixed together to produce a combined product to meet a particular customer's requirements. Any such blend should be treated as if it were a normal quarry product and should be subjected to similar process controls as detailed in section 5, Control of Aggregate Handling, in addition to routine finished product testing as detailed in sections 7 - 10 of this guideline.

In addition the requirements of section 4, to comply with this guideline:

- a) The aggregate producer's quality system or quality plan should detail methods for handling, storage, mixing and testing of such blends.
- b) The aggregate producer should carry out periodic sampling and testing of the finished blends to demonstrate that the blending processes used accurately produce consistent products with predictable properties. The "standard" frequency of such testing is one per 500 m<sup>3</sup>. See appendix notes 13.1, 13.2.
- c) The aggregate producer should keep accurate records of all testing and quantities of components blended and stockpiled.

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## 7. Sealing Chip Aggregates

To comply with this guideline:

- a) The aggregate producer should carry out regular finished product testing to ensure that quality and consistency of the manufactured products are "fit for purpose" and/or meet the specific requirements of the customer. Sampling should be carried out by IANZ accredited personnel only in accordance with the methods in NZS 4407 and testing should be performed by a laboratory which is accredited to NZS ISO/IEC 17025. Appropriate test methods include:
  - i. **Cleanness:** NZS 4407 Test 3.9 "The Cleanness Value of Coarse Aggregate".
  - ii. **Size and Shape:** NZS 4407 Test 3.13 "The Size and Shape of Aggregate Particles".
  - iii. **Broken Face Content:** NZS 4407 Test 3.14 "The Broken Face Content of Aggregate".
  - iv. **Sieve Analysis:** NZS 4407 Test 3.8 "The Particle Size Distribution of an Aggregate".

The "standard" frequency of such finished product testing is one test per property per 500 m<sup>3</sup>. See appendix notes 13.1, 13.2.

- b) The aggregate producer and/or customer should carry out appropriate spot check testing of key indicator properties as detailed in section 4 above (e.g. percentage passing the 2.36mm sieve) to demonstrate that the controls in place to minimise the effects of any further handling, transportation or storage are effective.

The frequency of such spot check testing should be one test per property per 1000 m<sup>3</sup> delivered.

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## 8. Aggregates for Hot Mix Asphalts

To comply with this guideline:

- a) The aggregate producer should carry out regular finished product testing to ensure that quality and consistency of the manufactured products are "fit for purpose" and/or meet the specific requirements of the customer. Sampling should be carried out in accordance with the methods in NZS 4407 and testing should be performed by a laboratory which is accredited to NZS ISO/IEC 17025. Appropriate test methods would typically be selected from the following:
  - i. **Sieve Analysis:** NZS 4407 Test 3.8 "The Particle Size Distribution of an Aggregate".
  - ii. **Broken Face Content:** NZS 4407 Test 3.14 "The Broken Face Content of Aggregate".
  - iii. **Sand Equivalent:** NZS 4407 Test 3.6.
  - iv. **Clay Index** (Fraction < 0.075mm): NZS 4407 Test 3.5
  - v. **Cleanness:** NZS 4407 Test 3.9 "The Cleanness Value of Coarse Aggregate".
  - vi. **Size and Shape:** NZS 4407 Test 3.13 "The Size and Shape of Aggregate Particles".

The "standard" frequency of such testing is one test per property per 1000 m<sup>3</sup>. See appendix notes 13.1, 13.2.

- b) The aggregate producer and/or customer should carry out appropriate spot check testing of key indicator properties as detailed in section 4 above (e.g. percentage passing the 2.36mm sieve) to demonstrate that the controls in place to minimise the effects of any further handling, transportation or storage are effective.

The frequency of such spot check testing should be one test per property per 1000 m<sup>3</sup> delivered. See appendix notes 13.1, 13.2.

## 9. Aggregates for Pavement Basecourse

To comply with this guideline:

- a) The aggregate producer should carry out regular finished product sampling and testing to check that the products meet the relevant requirements of the customer. Sampling should be carried out in accordance with the methods in NZS 4407 and testing should be performed by a laboratory which is accredited to NZS ISO/IEC 17025. Appropriate test methods would typically be selected from the following:
  - i. **Sieve Analysis:** NZS 4407 Test 3.8 "The Particle Size Distribution of an Aggregate".
  - ii. **Broken Face Content:** NZS 4407 Test 3.14 "The Broken Face Content of Aggregate".
  - iii. **Sand Equivalent:** NZS 4407 Test 3.6.
  - iv. **Clay Index** (Fraction < 0.075mm): NZS 4407 Test 3.5
  - v. **California Bearing Ratio:** Compaction method; NZS 4402 Test 4.1.3 "NZ Vibrating Hammer Compaction Test at Optimum Water Content". CBR Method; NZS 4407 Test 3.15. The California Bearing Ratio Test (without a surcharge for at least 4 days).
  - vi. **Repeated Load Triaxial Testing:** NZTA T/15 "Repeated Load Triaxial Test for Road Basecourse".
  - vii. **Plasticity Index:** NZS 4407 Test 3.4 "The Plasticity Index"

The "standard" frequency of such sampling and testing is set out in the table below (also see appendix notes 13.1, 13.2.):

Production Run Size	No. of Samples
Up to 400 m <sup>3</sup>	2
400 m <sup>3</sup> - 1500 m <sup>3</sup>	3
1500 m <sup>3</sup> - 4000 m <sup>3</sup>	4
Over 4000 m <sup>3</sup>	1 per 1000 m <sup>3</sup>

- b) The aggregate producer and/or customer should carry out appropriate spot check testing of key indicator properties (see section 4 above; e.g. percentage passing the 4.75mm sieve) to demonstrate that the controls in place to minimise the effects of any further handling, transportation or storage are effective.

The frequency of such spot check testing should be one test per indicator property per 1000 m<sup>3</sup> delivered. See appendix notes 13.1, 13.2.

## 10. Aggregates for Pavement Sub-base Layers

To comply with this guideline:

- a) The aggregate producer should carry out regular finished product testing to check that the products meet the general principles set out in NZTA M/3 Notes (or, if appropriate, NZTA M/22, Notes for the Evaluation of Unbound Road Base and Sub-Base Aggregates) and/or any specific requirements of a project or customer. Sampling should be carried out in accordance with the methods in NZS 4407 and testing should be performed by a laboratory which is accredited to NZS ISO/IEC 17025.

The “standard” frequency of such testing is one per 1000 m<sup>3</sup>. See appendix notes 13.1, 13.2.

- b) The aggregate producer and/or customer should carry out appropriate spot check testing of key indicator properties (see Section 4 above) (e.g. percentage passing the 19mm sieve) to demonstrate that the controls in place to minimise the effects of any further handling, transportation or storage are effective.

The frequency of such spot check testing should be one test per property per 1000 m<sup>3</sup> delivered. See appendix notes 13.1, 13.2.

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## 11. Statistical Process Control

Aggregate producers operating under these guidelines should use statistical process control procedures to analyse test results for their source materials and finished products. The aim and intent of these statistical process controls is to provide confidence in product quality and promote continuous improvement leading to improved cost effectiveness.

Simple paper-based or spreadsheet-based data analysis systems are acceptable provided the following criteria are met. The statistical process control procedures should:

- a) Accumulate test results for each product, as set out in sections 3 - 9 above.
- b) Plot the results for each test criterion on a quality control chart as a time-based plot, allowing trends to be detected.
- c) Plot control limits for each test criterion based on the requirements of relevant NZTA specifications or on the specific requirements of the customer.
- d) Calculate the rolling average of the last three test results for each criterion and plot these as in (b) above.

The statistical process control procedures should be used to monitor trends in source material and product quality, allowing corrective actions to be taken before systematic non-compliances occur.

Unless an assignable cause is identified, corrective action should not be taken on the basis of any single, apparently non-compliant test result, but rather on the basis of trends indicated by the rolling average. Single non-compliant test results are not classed in themselves as systematic non-compliances, but may however indicate that increased testing frequency may be desirable. This approach should minimise the effect of natural variations due to sampling and testing procedures or other random events.<sup>‡‡</sup>

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<sup>‡‡</sup> The publication IG-3 from the Australian Asphalt Pavement Association provides guidance on this approach.

## 12. Compliance

It is the responsibility of the aggregate producer to provide a customer with evidence of compliance with the customer's specifications.

The aggregate producer's quality system or quality plan should define "compliance" with respect to a customer's specifications. Compliance may either be demonstrated using detailed sampling and testing of the quantity of material as delivered, or may consist of rolling averages of test results of the routine testing undertaken during the production and subsequent handling of the material. See appendix note 13.4.

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## 13. Appendix Notes

- 13.1 Wherever specifications or test methods are mentioned in this guideline, the reference is to the most recently-published version.
- 13.2 “Standard” sampling and testing frequencies stated in this guideline are intended as a reference standard only where there is no history of quality performance. In practice, sampling and testing frequencies should be set out in an aggregate producer’s quality plan and should depend on past history, current trends and the requirements of a customer. The quality plan or system should nominate the increased sampling frequencies that should be used in the event of non-compliance or adverse trends and the level to which frequencies may be reduced when results are consistent<sup>§§</sup> and compliant.
- Two years is the maximum period that should pass between any successive tests for each test property, except for consistent source properties as discussed in section 3(c).
- 13.3 For Polished Stone Values, source property testing should occur twice in the first year of production (6 monthly), and one year is the maximum period that should pass between tests.
- 13.4 Under the conditions of many road construction and maintenance contracts it is the responsibility of the contractor to demonstrate evidence of quality control of materials to the client. It follows that aggregate producers need to provide proof of compliance to the contractor.
- 13.5 The laboratories currently approved by NZTA for PSV testing are listed in NZTA M/6 Notes.

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<sup>§§</sup> “Consistent” is defined as:  
*Crushing Resistance: within 2% fines or within 30kN*  
*Weathering Resistance: no change in quality index*  
*Polished Stone Value: within 3 units.*

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## 14. Explanatory Notes

As described in the scope, this guideline covers recommended quality assurance procedures when manufacturing, handling and stockpiling aggregates intended for use in road pavement and surfacing work.

In the past, much frustration has been experienced by aggregate producers and contractors alike when stockpiles of material have been “rejected” by a client on the basis of a single sample. Generally, the aggregate producer knows that the material has shown compliance when tested during production.

This guideline is based on the concept that it is better to test quarry materials regularly during production, to produce statistical evidence of compliance and to have the product accepted by the client on that evidence, rather than to run the risk of being accepted/rejected on the basis of a single stockpile sample. Not only does this 'quality-oriented' approach provide the customer with more and better data to assure them of the quality of their purchase, but it also provides the aggregate producer with an on-going measure of the performance of their plant and procedures, enabling them to make adjustments to keep the production within specification and the plant producing economically.

These guidelines were developed by the three supporting organisations because they believe that the 'quality-oriented' approach is best achieved if the aggregate producer has a formal quality plan or system in operation. The quality plan should cover all quality aspects of source material selection and handling, aggregate processing, stockpiling and transportation. The plan should also cover the methods and frequency of sampling and testing to be used, and identify responsibilities. A quality plan has to detail the method, resources and order of work for a product and service during a particular production run.

Typical requirements for quality systems and/or plans for quarries are outlined below.

### 14.1 Quality Systems and Plans - General

It is recommended that aggregate suppliers and quarry operators implement and maintain a quality assurance system which complies with at least the requirements of AS/NZS 9001 and that the procedures described in the guidelines are incorporated in such a system.

Where the aggregate producer does not maintain a system based on AS/NZS 9001 the producer should maintain a suitable documented system to the satisfaction of the customer to demonstrate the quality of the product.

The aggregate producer should draw up a quality plan for the aggregates, which at least comprises documented procedures for:

- a) Source identification and control
- b) Product identification and traceability
- c) Process control
- d) Inspection and testing
- e) Inspection and test status
- f) Control of non conforming product
- g) Corrective and preventive action
- h) Handling, and storage of product
- i) Control of quality records
- j) Who determines the part of the quarry from which the source rock should be drawn and what limitations apply.

- k) The production procedures such as plant settings and screen sizes, etc.
- l) The stockpile locations in the quarry and procedures used to avoid segregation and contamination.
- m) Aggregate blending procedures.
- n) Sampling and testing procedures and frequencies. These guidelines quote “standard frequencies” which are an agreed industry norm. When process control charts show that products from a particular source or plant are consistently compliant then sampling and testing frequency may be lowered to a reduced level as stated in the quality plan. It may also be that not every sample is tested. When testing shows that there are non-compliances, adverse trends or excessive variations, then testing frequency should be increased to a level higher than the “standard” frequency and this should also be stated in the plan. Actions should be taken to correct non-compliances, adverse trends or excessive variations.
- o) Any other criteria which may have a significant effect on quality.

The aggregate producer may expect a customer to periodically audit the quality plan or system by inspecting the quarry quality records and/or carrying out spot checks on the products. A non-complying test done as a spot check should not be reason to reject any material, but rather an “alarm-bell” to prompt investigation. It would be a good idea for a quarry to arrange regular audits from a suitably-qualified independent person or organisation for assurance that their quality system is working well.

All sampling and testing should be carried out to recognised standards and testing personnel should be properly trained. Carrying IANZ laboratory accreditation is the acceptable way of ensuring this competency.

“Source testing” is only required annually to check that rock properties have not changed. A new set of source properties should be established every time that a quarry face changes in its nature or rock is drawn from a “new” face.

Complete and accurate records should be kept of all sampling and testing.

Stockpile management is a critical component of a quality system or plan. Whenever a stockpile is moved, a spot check on quality should be made to demonstrate that there is no significant change in, for example, cleanness of sealing chip or grading of “All Passing” (AP) materials.

A quality plan system is good management and business practice. Those companies that have installed a quality system have found that it leads to better control of the business, fewer losses due to off-specification product and higher levels of customer satisfaction - provided that the system retains integrity and is used properly as an integral management tool.

## 14.2 Quality Policy

The quarry should have a quality policy that should:

- a) include a quality statement; and,
- b) outline the quality system regarding frequency of management reviews and internal quality audits.

## 14.3 Quality Management

Quarry management should appoint a person who should have defined authority and responsibility for ensuring that the requirements of the quality system or plan and of any

customers are implemented and maintained, including the management of non-conforming product.

The quality plan should outline authorities and responsibilities for quarry personnel, including management and verification of work affecting quality.

#### **14.4 Safety Management**

The quarry quality system and/or quality plan should specify management procedures to comply with:

- a) Relevant industry codes of practice or guidelines;
- b) The Health and Safety in Employment (HSE) act;
- c) Customer requirements with regard to safety.

#### **14.5 Training**

The quality system and/or quality plan should outline training procedures that include:

- a) How training needs are established.
- b) What training is provided for all personnel whose activities may affect quality during production.

#### **14.6 Review**

A system should be put in place to review the quality plan and client requirements during each production run. The outcome of any review should be discussed and confirmed where appropriate by all parties concerned.

#### **14.7 Documentation**

The following procedures should be documented to verify compliance with the specifications.

- a) Inspection
- b) Testing
- c) Reporting programme
- d) Sample Retention

#### **14.8 Control of Non-Conforming Product**

Procedures showing how non-conforming products are prevented from being supplied to the customer should be outlined. Control procedures should provide for identification, documentation, evaluation, segregation (when practical), disposal or reprocessing of non-conforming product and notification to the parties concerned. Corrective action procedures and lines of communication should also be detailed.

#### **14.9 Control of Sub-Contractors' Supplies and Services**

Procedures for assessment and control of sub-contractors should be outlined for both supply and service. Previous performance records should be maintained and be made available for inspection by the customer if requested.

#### **14.10 Quality Control**

A quality control programme outlining methods to monitor all products that ensures compliance with customer's requirements should be included.

#### **14.11 Production Control**

Specifications may require that all materials are produced in accordance with a defined production quality plan. The requirements for production planning could include:

- a) reference specimens,
- b) production control tests,
- c) control charting of test data,
- d) establishment of traceable links between the test control data and the delivered product.

#### **14.12 Reference Specimens**

Reference specimens can be used to:

- a) establish changes in material types over time
- b) identify relevant types and durability of materials during production
- c) estimate proportions of marginal and unsound stone.

Where a system of reference specimens is used, they should normally be prepared when a quarry face or source is first assessed. Thereafter additional reference specimens should be prepared whenever previously un-sampled materials are encountered in subsequent assessments. The contamination or discolouration of the reference specimens over time mandates the preparation of new reference specimens.

Reference specimens are not generally collected for material which is obviously soft, friable or composed of clay. Where marginal and unsound stone is included in products, reference specimens should be prepared for each class of material.

The aggregate producer should maintain a register of reference specimens which defines:

- a) number of sets of reference specimens
- b) unique sample reference number for each reference specimen
- c) date of preparation of the reference specimen
- d) date at which reference specimen was discarded
- e) location of each set of reference specimens.

An up to date set of reference specimens should be maintained at the production site at all times.

The production plan should define the frequency at which visual comparisons are made between the reference specimens and the coarse aggregate required under the supply specification. The frequency of these comparisons should not be less than one (1) assessment per production lot. The production plan should define the procedure for conducting the comparison.

#### **14.13 Quality Control Charts**

Aggregate producers should maintain control charts and respond to significant shifts in quality. Production control charts should be maintained for all specified properties under the

specifications (e.g. grading, etc.). With respect to the requirements of the customer, the aggregate producer should maintain quality records and charts for:

- a) each material type
- b) each durability and strength test property arising from the source rock inspections and routine tests as required under the specifications.

The required documentation should apply to all products produced to customer's specifications.

Where a customer uses the aggregate producer's quality control test results as evidence of specification compliance, the customer should be supplied, on demand all control test data for the particular product type. This includes material delivered to other customers where such materials are from a common material type and production operation.

Data should on receipt, be plotted on charts showing "intervention limits" and "trend limits" as defined below:

**Intervention Limits:** All test values should lie within this range. A test value falling outside the limits should usually lead to re-sampling and re-testing to establish whether the trend limits have been exceeded. Note: each test property may not necessarily have both an upper and lower intervention limit - e.g. crushing resistance.

**Trend Limits:** The trend limits are set at 90% of the relevant intervention limits and are used to assess the likelihood of future values falling outside the intervention limits. The measure to which the trend limits is applied is the "rolling average" of the last 3 consecutive tests.]

Any significant change should be acted upon and such actions recorded.