



BEST PRACTICE NEW ZEALAND GUIDELINE FOR THE SUPPLY OF RECYCLED CONCRETE MATERIALS FOR USE IN PAVEMENTS AND OTHER CIVIL WORKS

1. SCOPE

This Guideline sets out the recommendations for the supply of recycled materials for use in the following:

- pavements for lightly /medium trafficked roads as defined below
- basecourse materials for pavers to be used in pedestrian areas, car parks, shopping malls etc.
- general filling behind kerb and gutter, retaining wall and beneath grassed areas.
- bulk filling or embankment filling for construction of roadways across low lying areas.
- backfilling for surface and stormwater drainage lines and drainage structures.

Materials for use in heavily trafficked roads such as motorways, major highways, urban arterial roads or distributor roads are not specifically covered by this guideline. They are dealt with in specifications produced by Transit New Zealand.

The guideline does not deal with recycled asphalt or blends of recycled asphalt pavement materials and does not cover the use of recycled concrete aggregate for production of concrete.

The guideline covers materials consisting predominantly of recycled crushed concrete productions.

There are numerous other potential uses for recycled concrete products in engineering construction and the list above is not expected to limit the utilisation of the product. It simply illustrates the areas where the greatest potential exists for recycling concrete products to avoid land filling of a valuable resource.

The guideline is limited to crushed concrete products without any additional strength enhancing agents. In pavement construction there is the opportunity to utilise recycled crushed concrete products with additives such as slag, cement, lime, flyash etc., or a blend of some or all of these materials to form lightly or heavily bound layers.

In these circumstances the designer should consider the fatigue characteristics of stabilised recycled materials to determine whether shrinkage/or block cracking may present problems with the life of the pavement. Similarly, some additives can be used to alter the plasticity characteristics of a 'run of crusher' product to make it more suitable for use. Nothing in this is guideline limits the scope for adopting innovative strategies for blending materials to achieve a desired outcome.

2. DEFINITIONS

The terminology used throughout this guideline is defined as follows:

- Basecourse Materials - the layer of a pavement immediately above the subgrade or subbase and directly below the pavement wearing surface extending for the full width of the pavement.
- Sub-base Material - One or more layers of material placed over the subgrade and below the Basecourse layer and shoulder of a road pavement.
- Bulk Filling - Material used to raise levels of sites such as road embankments or for levelling purposes prior to building construction : and
- Drainage Medium - Backfilling for stormwater drainage lines or subsurface drainage. In these circumstances there may be a need to also use geofabric depending upon local soil conditions. This material may also be used behind retaining walls and shall be free draining to prevent moisture building up around and behind the particular structure under consideration.
- General Filling – A blend of recycled concrete product used as backfilling behind kerb and gutter, retaining walls etc., and behind grassed areas.
- Paver Base – A material with 7 mm maximum particle size used as a base layer for pavers in pedestrian areas or on lightly trafficked access ways.
- Equivalent Standard Axles (ESA) – The number of Standard axle load repetitions of 8.2 tonne which has the same damaging effect on a pavement as the load under consideration.
- Footpath / Cycleway – These will be classified as pavements which will be subject to loads from occasional service vehicles such as 1 tonne utilities.
- Lightly Trafficked Roads – Roads which are subjected primarily to passenger vehicles only and less than 100 commercial vehicles per lane per day. The expected maximum traffic loading is 5×10^5 ESA in the overall pavement life.
- Medium Trafficked Roads – Roads which are subjected to between 100 and 500 commercial vehicles per lane per day. The expected maximum traffic load is 5×10^5 to 5×10^6 ESA.
- Heavily Trafficked Roads – Roads with traffic loading greater than 5×10^6 ESA.

The designated classes of material to be used in this specification are as follows:

- | | |
|-----------|---|
| * Class A | - suitable for use on either lightly or medium trafficked roads as either basecourse or sub-base: |
| * Class B | - for use as a base layer for pavers in pedestrian areas, car parks, shopping malls etc; |
| * Class C | - general filling behind kerb and gutter, retaining walls or beneath grassed areas; |
| * Class D | - bulk filling for urban and rural development or for construction of embankments: and |
| * Class E | - backfilling for subsoil drains and stormwater pipes. |

3. STANDARDS

In carrying out conformance testing the current issue of the following standard shall be used unless otherwise specified:-

NZS 4407, 3111, 3112 (Ed Pak to supply)

4. SOURCES OF RECYCLED MATERIAL.

The Producer will ensure the materials do not contain asbestos.

Recycled materials shall consist of particles crushed from concrete, brick, masonry roof tile (concrete or terracotta), ceramic tile or rock. Uncrushed concrete normally is composed of rock fragments coated with cement paste mixed with sand and/or filler. It is usually a consistent material produced in a controlled manner to tight tolerances of grading and cement content. The concrete to be crushed for recycled materials shall be of similar high quality.

Crushed concrete shall be crushed from clean, hard, durable and angular fragments of concrete. The addition of fines not produced from crushing concrete is permitted providing the end product complies with the requirements of this guideline, should the blending of additional fines be required. The nature and source of these fines shall be specified at the time of tendering.

Bricks shall be kiln fired clay bricks which may have cement or lime mortar adhering to them. Roof tiles shall be concrete or baked clay tiles which may be glazed. Ceramic tiles shall be limited to the percentage shown in Table 1.

5. MATERIAL QUALITY

Each material class shall conform to the properties outlined in Table 1. The Supplier should produce test certificates from a credible facility confirming that the material complies with the guideline. The recommended minimum testing requirements are set out in Section 8.

Table 1 Guideline Requirements

Class	A			B	C	D	E
Material	GAP65	GAP40	GAP20	Paver Base	General Fill	Bulk Fill	Drainage Medium
<u>Sieve Size (mm)</u>	<u>% Passing Sieve Size (mm)</u>						
100	100					100	
63							
53						80-100	100
37.5	55-80	100				70-90	75-95
26.5						60-80	55-80
19.0	36-65	60-80	100				
13.2					100	40-70	20-45
9.5	20-50	35-65	45-75				10-25
6.7				100	70-100	30-60	
4.75	10-35	20-45	25-55	95-100			
2.36				80-100	40-65	20-50	0-2
1.18	2-20	2-25	2-30	50-95			
0.600				25-60			
0.425					10-30	10-35	0
0.300				10-30			
0.150				0-15			
0.075	0-6	0-7	0-8	0-10	5-20	5-20	
INDEX PROPERTIES:							
Liquid Limit	30 max	30 max	25 max	30 max	30 max	35 max	N/A
Plasticity Index (PI)	9 max	9 max	9 max	12 max	15 max	15 max	N/A
% passing 0.425mm sieve x (PI)	130 max	160 max	180 max	450 max	450 max	500 max	N/A
STRENGTH PROPERTIES:							
Crushing Resistance (Minimum)	130 kN	130 kN	130 kN	-	-	-	-
California Bearing Ratio % (CBR)	30 min	30 min	30 min	N/A	N/A	N/A	N/A
Unconfined Compressive Strength (MPa)	3.5 max	3.5 max	3.5 max	3.5 max	N/A	N/A	N/A
OTHER MATERIAL (Max % by mass):							
Asbestos	0	0	0	0	0	0	0
Wood, organics, etc	0.2	0.2	0.2	0.5	0.5	0.5	0.5
Plastic, plastic cloth, clay lumps	1	1	1	2	4	4	1
Metal, glass, ceramics	5	5	5	10	15	15	10
Clay brick, tile, crushed rock, masonry	30	30	30	40	40	40	40
Total non-aggregate material (max %)	5	5	5	10	15	15	10

The requirement for a maximum unconfined compressive strength is to ensure that the residual cementitious binder in the crushed products does not cause the pavement to act as a semi rigid structure and hence suffer possible fatigue cracking.

The guideline requirements for grading given in Table 1 show the limit for each individual sieve size. The grading curve shall be reasonably smooth and free from abrupt changes from one side of the grading envelope to the other to avoid gap grading.

The product (% passing 0.425mm sieve x PI) is specified to ensure that both individual properties are not at the upper limit of the specified range. If the percentage passing 0.425mm sieve is near the upper limit there must be an appropriate reduction in the Plasticity Index to ensure that the material does not have the potential to lose strength on saturation.

6. BLENDED AGGREGATE.

Aggregates may be mixed together to produce a combined product to meet a particular purchaser's requirements.

To comply with this guideline:

- (a) The aggregate producer's quality system or quality plan will detail methods for handling, storage, mixing and testing of such blends.
- (b) The aggregate producer will carry out periodic sampling and testing to demonstrate that the blending processes used accurately produce consistent products with predictable properties. The "standard" frequency of such testing is one per 500 m³. (See Notes 1 & 2.)
- (d) Sampling and testing will be carried out in accordance with the appropriate methods in NZS4407. (See Note 1.)
- (e) The aggregate producer will keep accurate records of all testing and quantities of components blended and stockpiled.

7. CONTAMINANTS

The supplier shall have in place screens and storage facilities so as to keep contaminants in the final product to an absolute minimum. Only small amounts of timber, steel and plastic will be allowed as indicated in Table 1. Under no circumstances shall the material contain any asbestos fibres.

8 SUPPLY FROM CERTIFIED STOCKPILES

Material may be supplied from stockpiles which have been previously tested and shown to confirm to the requirements of this guideline. Certified stockpiles shall be created to prevent segregation or mixing with other materials and shall be clearly labelled. The Supplier should provide testing in accordance with Table 2 below and should verify that the material being supplied is from a certified stockpile.

Once a stockpile has been tested and certified further materials shall not be added to the stockpile unless the additional material is tested and shown to conform to the guidelines

Delivery dockets shall be provided for each truckload of materials identifying the material type, the certified stockpile, the suppliers name and the weight of material being delivered.

9 SAMPLING AND TESTING (QUALITY ASSURANCE)

It is the responsibility of the Supplier to provide test certificates for each material class prior to delivery. The recommended minimum sampling and testing requirements are set out in Table 2.

Table 2- Minimum Number of Tests per cu.m. of Material

Test	Class A	Class B	Class C	Class D	Class E
Grading	3	2	2	2	2
Index Properties	3	2	2	2	2
Strength Properties	1	1	1	1	1
Particle Shape	3	2	1	1	1
Foreign Material	1	1	1	1	1

EXPLANATORY NOTES:

As described in the “Scope”, this guideline covers recommended quality assurance procedures when manufacturing, handling and stockpiling aggregates for road surfacing work.

In the past, much frustration has been experienced by producers and contractors alike when stockpiles of material have been “rejected” by a client on the basis of a single sample. Generally, the 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 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 approach provide the customer with much more data to assure him of the quality of his purchase, but it also provides the producer with an on-going measure of the performance of his plant, enabling him to make adjustments to keep the production within specification and the plant producing economically.

To make this system work, several things are essential:

1. The producer must draw up a quality plan for the aggregates. This plan will set out for example:
 - Who determines the part of the quarry from which the source rock will be drawn and what limitations apply.

- The production procedures such as plant settings and screen sizes, etc.
 - The stockpile locations in the quarry and procedures used to avoid segregation and contamination.
 - Aggregate blending procedures.
 - Sampling and testing procedures and frequencies that comply with the code. Note that the code quotes “Standard Frequencies” which are an agreed industry norm. When production from a particular source or plant has settled down and the test results are consistent, then sampling and testing frequency may be reduced to a level stated in the plan. (It may also be that not every sample is tested.) When testing shows that there are non-compliances or excessive variations, then testing frequency must be increased to a level higher than the standard, and this must also be stated in the plan.
 - Any other criteria which may have a significant effect on quality.
2. The producer should expect the contractor and/or the client’s representative 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 to assure them that their system is working well.
 3. All sampling and testing must be carried out to recognised standards and testing personnel must be properly trained. Carrying IANZ Laboratory Registration or having an accredited ISO Quality Assurance System is the acceptable way of ensuring this competency.
 4. Where a laboratory is accredited under an ISO QA System but not IANZ, it is necessary to also require regular “round robin” testing with other laboratories to assure consistency and reproducibility of results.
 5. “Source Testing” is only required annually (see *Note 2*) to check that rock properties have not changed. A new set of source properties must be established every time that a quarry face changes in its nature or rock is drawn from a “new” face.
 6. Complete and accurate records must be kept of all sampling and testing.
 7. Stockpile management is a critical component of quality system or plan.
 8. Whenever a stockpile is moved, a check on quality must be made to demonstrate that there is no significant change. e.g. Cleanness of sealing chip or grading of 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.

Quality Plans

A Quality Plan has to detail the method, resources and order of work for a product and service during a particular contract.

It is recommended that Aggregate Suppliers and Quarry Operators implement and maintain a Quality Assurance System and that the procedures described in these Guide Notes are incorporated in such a system.

Where the producer does not maintain a system based on ISO 9002 the producer should maintain a suitable documented system to the satisfaction of the Client to demonstrate the quality of the product.

Such a system shall at least comprise documented procedures for:

- product identification and traceability
- process control
- inspection and testing
- inspection and test status
- control of non conforming product
- corrective and preventive action
- handling, and storage of product
- control of quality records

1. QUALITY POLICY

- a.** include the Company's Quality Statement
- b.** outline the Quality System regarding frequency of Management Reviews and Internal Quality Audits.

2. CONTRACT ORGANISATION

Appoint a representative who will have defined authority and responsibility for ensuring that the requirements of the specifications are implemented and maintained, including management of non-conforming product.

Outline authorities and responsibilities for personnel. This must include the management and verification of work affecting quality.

3. SAFETY PROCEDURES

Specify procedures to comply with:

- relevant industry Codes of Practice or Guidelines;

- the Health and Safety in Employment Act;
- client specifications.

4. TRAINING PROCEDURES

Training procedures should be outlined and include:

- How training needs are established.
- What training is provided for all personnel activities affecting quality during production and construction.

5. REVIEW

A system must be put in place to review the Quality Plan and client requirements during the execution of the contract.

The outcome of any review shall be discussed and confirmed where appropriate by all parties concerned.

6. DOCUMENTATION

Documentation procedures for:

- inspection
- testing
- reporting programme
- retention

to verify compliance with the specifications.

7. CONTROL OF NON-CONFORMING PRODUCT

Outline procedures showing how product that does not conform to specified requirements will be prevented from being supplied to the contractor.

Control procedures shall provide for identification, documentation, evaluation, segregation (when practical), disposal of non-conforming product and for notification to the parties concerned.

Detail corrective action procedures and lines of communication.

8. CONTROL OF SUB-CONTRACTORS' SUPPLIES AND SERVICES

Outline procedures for assessment and control of sub-contractors both for supply and service. Maintain previous performance records and make available for inspection by the client if requested.

9. QUALITY CONTROL

Include a Quality Control programme outlining methods to monitor all product produced and used that ensures compliance with Specification.

9.1 PRODUCTION CONTROL

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

- reference specimens
 - production control tests
 - control charting of test data
- establishment of traceable links between the test control data and the

9.2 QUALITY CONTROL CHARTS

Producers should maintain control charts and to respond to significant shifts in quality.

Production control charts shall be maintained for all specified properties under the specifications (e.g. grading, etc.)

With respect to the requirements of the client, the Producer will maintain quality records and charts for:

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

The required documentation shall apply to all products produced to client specifications.

Where the Contractor uses the producer's quality control test results as evidence of specification compliance, the client shall 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 be plotted on charts on receipt of results. Any significant change should be acted upon.