NZTA M04: 2024

Specification for Basecourse Aggregates

NZ TRANSPORT AGENCY
WAKA KOTAHI

Te Kāwanatanga o Aotearoa
New Zealand Government

1 General

1.1 Scope

This specification sets out requirements for unbound basecourse aggregate for use in pavements. Four classes of aggregate quality are described which should be selected on the basis of expected loading.

The Principal reserves the right to not accept aggregate materials that have been shown to perform poorly in service.

1.2 Quality

The aggregate producer shall establish, implement and maintain a quality system in accordance with this specification, NZTA Z08 specification and the requirements of AS/NZS ISO 9001. The quality system shall be certified and regularly audited by a JAS-ANZ registered agency.

All production, storage, sampling, testing and compliance of aggregates shall be fully documented, traceable and operated under a quality assurance system such as described by BPG05.

1.3 Testing

All sampling and testing required by this specification shall be undertaken in a laboratory accredited to NZS ISO/IEC 17025 with the sampling and testing carrying the endorsement of the accreditation agency.

Current test results shall be provided along with previous results to confirm consistency. See clause 6.

Additional testing can be performed by the Principal at any time as random verification tests (RVT). The aggregate producer or project contractor shall provide safe access and appropriate plant and equipment to facilitate independent sampling and testing agent(s) to the nominated stockpile available upon request. Such stockpiles may be located within a producer's quarry or as a bulk stockpile. Refer to M04 Notes clause 3.4.

2 Related Documents

2.1 General

The related documents shall be the most recent publication of the document unless a publication date is specifically referenced in this specification.

2.2 Waka Kotahi NZ Transport Agency

(a)	NZTA T15	Specification for Repeated Load Triaxial (RLT) Testing for Pavement Materials
(b)	NZTA T20	Ethylene Glycol Accelerated Weathering Test
(c)	NZTA T28	Test Method for the Determination of the Dry Density and Water Content Relationship of Aggregate
(d)	NZTA Z08	Standard for Inspection, Sampling and Testing

2.3 Standards New Zealand

(a)	NZS ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
(b)	NZS 4402	Methods of Testing Soils for Civil Engineering Purposes
(c)	NZS 4407	Methods for Sampling and Testing Aggregates
(d)	AS/NZS ISO 9001	Quality Systems – Requirements

2.4 Other

(a) Auff, A.A.: The Selection of Statistical Compliance Schemes for Construction Quality Control, Australian Road Research Board Special Report No. 30, 1986.
(b) Civil Contractors New Zealand CCNZ BPG05 Quality Assurance of Aggregates for Roads
(c) Standards Australia AS 1141.15 Method 15 Flakiness index

(d) Standards Australia AS 1141.22 Methods for Sampling and Testing Aggregates, Method 22 Wet/dry Strength Variation
(e) Transport for New South Wales RMS T276 Foreign Materials Content of Recycled Crushed Concrete

3 Aggregate Classes

This specification describes four aggregate classes to be selected on the basis of expected loading in the pavement. The Classes are defined in Table 1 below.

Table 1: Aggregate Classes

Aggregate Class	Duty
Class 1	Very Heavy
Class 2	Heavy
Class 3	Medium
Class 4	Light

The pavement designer will match the aggregate Class, or quality, to the expected duty in the pavement, i.e. where practical, higher Class aggregates are not intended for lighter duty applications unless there are good engineering, economic, environmental or cultural reasons to do so. The intention is to conserve the higher quality aggregates for pavements that require their superior properties.

Note: Higher Class aggregates are by definition compliant with lower Classes of material. For example, Class 2 aggregate can be supplied and used for Classes 2, 3 or 4 applications. Refer to NZTA M04 Notes for guidance on pavement loading for the aggregate Classes.

4 Source Properties

4.1 General

The basecourse aggregate shall be crushed from a nominated source material of sedimentary, igneous or metamorphic origin, including waterworn materials, alluvial gravel, quarried rock, recycled and/or manufactured materials.

The nominated source(s) material and production processes shall yield material that is sound, of uniform consistency and quality, free from soft or disintegrated stone or other deleterious materials.

4.2 Frequency of Testing

The properties of the rock used to produce the basecourse aggregate, i.e. petrographic analysis using X-ray diffraction (clause 4.3) and the strength and durability properties (clause 4.4), shall be sampled and tested for every 10,000m^3 (loose in stockpile measure) produced or at least once per year, whichever comes first. The source rock properties shall comply with the properties appropriate to the aggregate Class as specified below.

4.3 Petrographic Analysis

The mineralogy of the nominated unprocessed source material for use in subsequent basecourse production shall be determined by petrographic examination using X-ray Diffraction (XRD). Petrographic examination is only required for natural sources.

If the rock source or processing method is changed then the source properties shall be tested immediately. Acceptance of basecourse aggregate from the varied process shall be at the discretion of the Principal until the source properties are shown by test to comply with this specification.

Note: The requirement in clause 1.3 for laboratory accreditation is waived for XRD as there is limited (or no) availability from accredited laboratories.

4.4 Strength and Durability Testing

4.4.1 Crushing Resistance and Wet/Dry Strength Variation

The Crushing Resistance for the source rock shall be determined using the method of NZS 4407 Test 3.10. The percentage fines achieved at the specified load for the aggregate Class shall comply with the maximum specified in Table 2 below.

The variation in aggregate strength when determined using dry, and saturated surface-dry (SSD) aggregate shall be determined using the methods of NZS 4407 test 3.10 and AS 1141.22. The aggregate shall have a maximum Wet/Dry strength variation as specified in Table 2 below but see Note following.

Table 2: Maximum Fines and Wet/Dry Strength Variation Achieved During Crushing Resistance Test

<table>
<tr><th>Aggregate Class</th><th>Specified Load (kN)</th><th>Percentage Fines Achieved (%)</th><th>Maximum Wet/Dry Strength Variation (%)</th></tr>
<tr><td>Class 1</td><td>180</td><td rowspan="4">10 maximum</td><td rowspan="3">30</td></tr>
<tr><td>Class 2</td><td>130</td></tr>
<tr><td>Class 3</td><td>130</td></tr>
<tr><td>Class 4</td><td>80</td><td>Report</td></tr>
</table>

Note: Where low quantities of fines are generated by the Crushing Resistance test, an apparent non-compliance can sometimes be returned for the Wet/Dry strength variation arising from precision limitations of the test. Consequently, if the Percentage Fines Achieved is 2% or less, the Wet/Dry strength variation requirements are waived.

4.4.2 Weathering Quality Index

The source rock shall comply with the Weathering Quality Indices of Table 3 below when tested using the method of NZS 4407 Test Method 3.11 Weathering Quality Index Test.

Table 3: Weathering Quality Index Requirements

Aggregate Class	Weathering Quality Index
Class 1	AA, AB or BA
Classes 2, 3, 4	AA, AB, AC, BA, BB or CA

4.4.3 Ethylene Glycol Accelerated Weathering

When tested in accordance with NZTA T20, the Ethylene Glycol Accelerated Weathering test, the source rock used for the production of Class 1 and Class 2 aggregate shall have a proportional change not exceeding 30%.

Table 4: Ethylene Glycol Accelerated Weathering Test Requirements

Aggregate Class	Test Requirements
Classes 1, 2	30% maximum
Classes 3, 4	Not required

Note: Where low quantities of fines are generated by the crushing of the control specimens (dry condition) in NZTA T20, an apparent non-compliance can sometimes be returned for the Ethylene Glycol Accelerated Weathering arising from precision limitations of the test. Consequently, if the average percentage fines achieved for the dry condition crushing is 2% or less, the Ethylene Glycol Accelerated Weathering test requirements are waived.

5 Production Properties

5.1 General

Production properties of the aggregate shall be assessed by the testing specified by the following clauses on representative samples of the processed finished aggregate, being representative of current extraction and production techniques using the nominated source rock.

5.2 Frequency of Testing

During routine production the rate of obtaining samples from lots shall be a minimum of five samples per lot, evenly spread over the production run or one sample per 1000m³ (loose in stockpile measure), whichever is greater. The intervals between sampling shall be evenly spread over the production run.

5.3 Production Property Sampling and Testing

Aggregate produced to comply with one (or more) of the aggregate Classes of this specification shall be regularly tested. The aggregate shall comply with the criteria relevant to the appropriate aggregate Class as follows.

Representative samples of aggregate shall be obtained in accordance with NZS 4407 section 2, using sub-method 2.4.6.3.2 (stockpiles of well-graded aggregate, machine method) or 2.4.6.4 (basecourse stockpiles constructed by run-over spreading) as appropriate to the stockpile construction.

Notes: The sub-method numbers refer to the 2015 version of NZS 4407 and could change in future updates.

Sampling of aggregate from plant conveyers is permitted where modern, purpose-designed automatic belt sampling devices are installed. The laboratory shall develop and be accredited for an in-house sampling method using the belt sampling devices.

The sampling shall be accredited in laboratory test reports.

Where samples from uncompacted freshly spread layers in the field are required for testing, the method of NZS 4407 section 2, sub-method 2.4.7 (clause number for 2015 version) shall be used to take the sample.

The aggregate shall be produced in lots. A production lot is defined as a continuous production run, where the plant configuration and aggregate feedstock remain essentially unchanged. Where the aggregate in a stockpile is visibly different to earlier production the aggregate shall be treated as a separate lot, stored and sampled separately.

For the purposes of acceptance testing, test results shall be from the same lot and not older than the test result age, based on the sample date in Table 5 below.

Table 5: Maximum Age of Production Test Results

Aggregate Class	Test Result Age (months)
Class 1	6
Class 2	
Class 3	12
Class 4	

Where the sample date is greater than the age permitted in Table 5 then the basecourse shall be resampled and the quality of fines tested to confirm compliance with the requirements of clause 5.4 for the appropriate aggregate Class. One sample shall be tested for every 2000m³ of aggregate in the stockpile and comply with the quality of fines requirements for the specific Class of aggregate.

5.4 Quality of Fines

5.4.1 General

The quality of the fines in the basecourse aggregate shall comply with the requirements of this specification. The quality of the fines shall be assessed by the following tests as appropriate: Sand Equivalent (SE), Clay Index (CI), Cone Penetration Limit (CPL) and Plasticity Index (PI), given in Table 6 and specified in clauses 5.4.2, 5.4.3 and 5.4.4

Table 6: Quality of Fines Testing Requirements

Aggregate Class	Fines Criteria to be Satisfied
Class 1	PI and CI, report CPL
Class 2	
Class 3	SE or CI or PI
Class 4	

5.4.2 Plasticity Index

Determine the Plasticity Index for the aggregate using the method of NZS 4407 Test 3.4. The plasticity index of the fraction of basecourse passing the 0.425mm sieve shall not be greater than the values shown in Table 7. Report the Cone Penetration Limit, NZS 4407 method 3.2, with the Plasticity Index result.

Table 7: Plasticity Index Requirements

Aggregate Class	Plasticity Index	Cone Penetration Limit
Class 1	5 maximum	Report
Class 2		
Class 3	10 maximum	-
Class 4	15 maximum	

5.4.3 Clay Index

Determine the Clay Index of the basecourse aggregate using the method of NZS 4407 Test 3.5. The Clay Index shall not be greater than the values shown in Table 8.

Table 8: Clay Index Requirements

Aggregate Class	Clay Index
Class 1	3 maximum
Class 2	
Class 3	5 maximum
Class 4	

5.4.4 Sand Equivalent

The Sand Equivalent shall be tested using the method of NZS 4407 Test 3.6. The washing process described in NZS 4407 clause 3.6.6.2 shall be used to prepare the test sample. The Sand Equivalent shall not be less than the values shown in Table 9.

Table 9: Requirements for the Sand Equivalent

Aggregate Class	Sand Equivalent
Class 3	30 minimum
Class 4	25 minimum

5.5 Broken Faces Content

Determine the Broken faces Content for the aggregate using the method of NZS 4407 Test 3.14. Divide the basecourse aggregate into the following subfractions and determine the Broken Faces Content for each subfraction:

(a) 37.5mm to 19.0mm
(b) 19.0mm to 9.50mm
(c) 9.50mm to 4.75mm.

The Broken Faces Content for each subfraction shall not be less than the minimum values in Table 10 below.

Table 10: Minimum Broken Faces Requirements

Aggregate Class	Broken Faces Content
Class 1	70% minimum
Class 2	70% minimum
Class 3	50% minimum
Class 4	Not required

Basecourse aggregates produced from hard rock quarry sources using angular and broken feedstock need not be tested for Broken Faces Content. In this instance the Broken Faces Content is assumed to be 100%.

5.6 Flakiness Index

Determine the Flakiness Index for the aggregate using the method of AS 1141.15. The Flakiness Index shall comply with the requirements of Table 11 below:

Table 11: Aggregate Flakiness Index

Aggregate Class	Flakiness Index
Class 1, 2	35% maximum
Class 3, 4	Not required

5.7 Particle Size Distribution

5.7.1 AP 40 Aggregate

Determine the Particle Size Distribution of the basecourse aggregate using NZS 4407 Test 3.8.1.

Table 12: AP 40 Aggregate Particle Size Distribution Envelopes

Sieve Size (mm)	Particle Size Distribution Limits	
	Classes 1 and 2	Classes 3 and 4
53.0	100	100
37.5	98 - 100	98 – 100
19.0	66 - 81	62 – 81
9.50	43 - 57	38 – 60
4.75	28 - 43	24 – 45
2.36	19 - 33	15 – 35
1.18	12 - 25	8 – 27
0.600	7 - 19	4 – 21
0.300	3 - 14	1 – 16
0.150	0 - 10	0 – 12
0.075	0 - 7	0 - 9

Calculate the Particle Size Distribution Curve Shape Control from the particle size distribution test results.

Table 13: Particle Size Distribution Graph Curve Shape Control Limits (Classes 1 and 2)

Size Fraction (mm)	Allowable Range (%)
19.0 - 4.75	28 - 48
9.50 - 2.36	14 - 34
4.75 - 1.18	7 - 27
2.36 - 0.600	5 – 21
1.18 - 0.300	3 – 17
0.600 - 0.150	2 - 14

5.7.2 AP 20 Aggregate

Determine the Particle Size Distribution of the basecourse aggregate using the method of NZS 4407 Test 3.8.1.

Table 14: AP 20 Aggregate Particle Size Distribution Envelopes

Sieve Size (mm)	Particle Size Distribution Limits		
	Class 1	Classes 2 and 3	Class 4
26.5	-	100	100
19.0	-	98 - 100	98 – 100
9.50	-	55 - 75	50 – 80
4.75	-	33 - 55	29 – 61
2.36	-	22 - 42	19 – 46
1.18	-	14 - 31	11 – 35
0.600	-	8 - 23	5 – 26
0.300	-	4 - 17	3 – 19
0.150	-	0 - 12	0 – 15
0.075	-	0 - 8	0 - 11

Note: There is no Class 1 category for AP 20 basecourse aggregate.

Calculate the Particle Size Distribution Curve Shape Control from the particle size distribution test results.

Table 15: Particle Size Distribution Graph Curve Shape Control Limits (Classes 2 and 3)

Size Fraction (mm)	Allowable Range (%)
9.50 - 2.36	20 - 46
4.75 - 1.18	9 - 34
2.36 - 0.600	6 - 26
1.18 - 0.300	3 - 21
0.600 - 0.150	2 - 17

5.7.3 Determination of Compliance

Assess the compliance of the aggregate particle size distribution by using the statistical process control tools described in clause 6 below.

6 Determination of Particle Size Distribution Compliance

6.1 General

Compliance of aggregates to the particle size distribution requirements of this specification shall be determined using statistical analysis. The statistical analysis shall include the results of all testing except as allowed by clause 6.2.7.

6.2 System Elements

6.2.1 General

The statistical analysis system shall be comprised of at least the elements specified below. The system shall assess the compliance of up to 30 particle size distribution tests per lot carried out during production. Acceptance of the aggregate shall be determined as specified by clause 6.3 below.

Calculate Control Limits for each sieve in the data set as in 6.2.4 below. The control limits are defined as particle size distribution envelope limits mid-point plus and minus three times the standard deviation of the data set. Similarly, Warning Limits can be calculated and plotted as mid-point plus and minus two times the standard deviation of the results.

A spreadsheet is available from NZTA Waka Kotahi (contact pavements@nzta.govt.nz) that provides process control graphs and compliance analysis against the requirements of this specification.

6.2.2 Individual Test Sieves

Determine the cumulative percentage passing for each test sieve specified in Table 12 (for AP 40 aggregate) or Table 14 (for AP 20 aggregate) or a regional basecourse aggregate as appropriate.

Note: A graphical plot may be useful to detect trends in production. See M04 Notes for an example.

6.2.3 Rolling Average Particle Size Distribution

The rolling average of the particle size distribution for five consecutive samples tested shall be calculated for each test sieve. The average particle size distribution for each sieve in the data set shall be compared against the particle size distribution limits of Table 12, Table 14 or a regional basecourse aggregate as appropriate.

Note: A graphical plot may be useful to detect trends in production. See M04 Notes for an example.

Calculate a compliance score for the rolling average of five results compared with the particle size distribution limits of Table 12 or Table 14 or the regional variants allowed by clause 8 as appropriate. Each individual result may be scored as compliant if all of the results for the particle size distribution fall within the specified limits.

Note: A spreadsheet is available from Waka Kotahi that calculates the rolling average of five particle size distribution results and the compliance score.

6.2.4 Process Control Limits

Calculate the sample standard deviation (s_{n-1}) for each sieve for a series of test results. Calculate control limits for each sieve based on the specification centre (the mean of the specified limits of Table 12, Table 14 or the appropriate limits from the regional variants of clause 8, as appropriate, ± 3 times the standard deviation s.

Note: At least 17 test results may be necessary for reliable control limits to be determined. Warning limits can also be calculated based on the specification centre ± 2s. They can be a useful tool to monitor quality.

6.2.5 Individual Test Result Particle Size Distribution Characteristic Value

Determine the Characteristic Value for the cumulative percentage passing each test sieve used for the particle size distribution using the following procedure:

(a) Calculate the mean value for the particle size distribution results for each test sieve.
(b) Calculate the sample standard deviation (s_{n-1}) for the particle size distribution test results for each test sieve.
(c) Determine the Acceptance Constant (k), depending on the number of samples tested, from Table 16
(d) Calculate the Lower Characteristic Value (LCV) and Upper Characteristic Value (UCV) for each test sieve using the following formulae:

$$LCV = mean - (k \times s)$$

$$UCV = mean + (k \times s)$$

Note: A spreadsheet is available from NZTA Waka Kotahi that plots the process control curves and calculates particle size distribution characteristic values.

Determine the lower and upper characteristic values for each test sieve and assess against the limits of Table 12 (for AP 40 aggregate), Table 14 (for AP 20 aggregate) or the appropriate regional variant for the appropriate aggregate Class.

Table 16: Characteristic Value Acceptance Constants (k)

Number of Samples	Acceptance Constant (k)	Number of Samples	Acceptance Constant (k)	Number of Samples	Acceptance Constant (k)
2	0.403	12	0.863	22	0.959
3	0.535	13	0.877	23	0.965
4	0.617	14	0.890	24	0.972
5	0.675	15	0.901	25	0.978
6	0.719	16	0.910	26	0.982
7	0.755	17	0.919	27	0.987
8	0.783	18	0.928	28	0.993
9	0.808	19	0.937	29	0.997
10	0.828	20	0.946	30	1.002
11	0.847	21	0.952		

6.2.6 Shape Control Characteristic Values

Determine the Characteristic Value for the curve Shape Control, calculated from the cumulative percentage passing each test sieve using the following procedure:

(a) Calculate the mean value for the particle size distribution curve shape control result for each test sieve range.
(b) Calculate the sample standard deviation (s_{n-1}) for the particle size distribution curve shape control results for each test sieve range.
(c) Determine the Acceptance Constant (k), depending on the number of samples tested, from Table 16
(d) Calculate the Lower Characteristic Value (LCV) and Upper Characteristic Value (UCV) for each sieve size range using the following formulae:

LCV = mean - (k x s)

UCV = mean + (k x s)

Note: A spreadsheet is available from Waka Kotahi that plots the process control curves and calculates particle size distribution and curve shape characteristic values.

Determine the lower and upper characteristic values for each sieve size range and assess against the limits of Table 13 (for AP 40 aggregate), Table 15 (for AP 20 aggregate) or the appropriate regional variant for the appropriate aggregate Class.

6.2.7 Data Cleansing

The Characteristic Value method to determine compliance with this specification tolerates some particle size distribution results that fall outside of the limits of Table 12 or Table 14 or a regional variant. This recognises normal variability in production, sampling and testing.

Consequently, it is mandatory for all particle size distribution test results to be included in the Characteristic Value analysis.

However, there are specific instances where particle size distribution test results may be removed from the analysis as follows:

(a) Where non-compliant aggregate has been identified and completely removed from the aggregate stockpile.
(b) Where identified errors in sampling and testing have returned a non-representative non-compliance.

Auditable records must be kept, and produced on request, of any removal of results from the analysis.

6.3 Compliance of Aggregate Particle Size Distribution

6.3.1 General

Aggregate shall be considered compliant with the particle size distribution requirements of this specification if testing demonstrates compliance with either or both of clause 6.3.2 and 6.3.3.

6.3.2 Single Test Results

Where a single test report has been provided the particle size distribution shall be considered compliant if:

(a) The results fall within the specified limits of Table 12 (for AP 40 aggregate) or Table 14 (for AP 20 aggregate) for the appropriate Class or the relevant regional variant, and
(b) For Class 1 and 2 aggregates, the particle size distribution results comply with the curve shape control requirements of Table 13 or Table 15 as appropriate.

Note that a single test report may not fully represent the quality of a stockpile of basecourse aggregate. Refer to clause 5.2 for specified sampling and testing frequency.

6.3.3 Multiple Test Results

For 2 to 30 test results for an individual Lot, the aggregate shall be considered compliant with the particle size distribution requirements of this specification if:

(a) The Lower Characteristic Value and the Upper Characteristic Value for the percentage passing each test sieve fall within the limits of Table 12 (for AP 40 aggregate) or Table 14 (for AP 20 aggregate) or the relevant regional variant for the appropriate aggregate Class, and
(b) For Class 1 and 2 aggregates, the particle size distribution shape control Lower and Upper Characteristic Values comply with the curve shape control requirements of Table 13 or Table 15 as appropriate, and
(c) For data sets of five or more results the compliance score for rolling average of five characteristic values is not less than 100%.

7 Performance-Related Properties

7.1 General

The performance-related properties of the aggregate shall be assessed to assist design and construction of pavements.

Strength and deformation resistance tests defined in clause 7.2 shall be sampled and tested at a rate of one set of testing for every 10,000m^3 (loose in stockpile measure) from a representative sample of the processed finished aggregate.

Maximum Dry Density, Optimum Water Content and Solid Density tests defined in clause 7.3 shall be sampled and tested at a rate of one set of testing for every 5,000m^3 (loose in stockpile measure) from a representative sample of the processed finished aggregate.

7.2 Strength and Deformation Resistance

7.2.1 General

The basecourse aggregate strength and deformation resistance for Class 1 and Class 2 basecourses shall be assessed by NZTA T15 the Repeated Load Triaxial (RLT) test. The basecourse aggregate strength and deformation resistance for Class 3 and Class 4 basecourses shall be assessed by NZS 4407 Test 3.15 California Bearing Ratio (CBR) or the Repeated Load Triaxial test. Refer to clause 7.2.2 below for the minimum requirements for the Repeated Load Triaxial test properties. Refer to clause 7.2.3 for the minimum requirement for the California Bearing Ratio.

7.2.2 Repeated Load Triaxial Test

Use NZTA T15 to determine the rutting life and aggregate category. Refer to NZTA T15 for specimen density and moisture content requirements. Class 1 and 2 aggregates (and if tested, Class 3 and 4) shall meet the requirements of Table 17 below.

Table 17: Basecourse Repeated Load Triaxial Criteria

Aggregate Class	Maximum RLT Average Slope %/1M 1st 5 stages – soaked/undrained	Maximum RLT Average Slope %/1M 1st 5 stages – dry/drained
Class 1	1.5	0.5
Class 2	-	0.5

Notes:

(a) Repeated Load Triaxial Testing is intended for unbound or unmodified aggregate materials.
(b) MESA = 5 / % average slope 1st 5 stages, dry/drained.

7.2.3 The California Bearing Ratio Test

If the California Bearing Ratio (CBR) test is used to assess the bearing properties of the basecourse aggregate, the sample shall be prepared as follows.

(a) The test specimens shall be compacted in accordance with NZTA T28 at optimum water content, and
(b) The specimen shall be tested in accordance with NZS 4407 Test 3.15 without a surcharge and soaked for at least four days.

For Class 3 and 4 aggregates, the soaked CBR of the basecourse aggregate shall comply with the minimum value in Table 18 below.

Table 18: Basecourse aggregate strength and deformation resistance

Aggregate Class	California Bearing Ratio
Class 3	80% minimum
Class 4	

7.3 Density Testing

7.3.1 Determination of the Maximum Dry Density and Optimum Water Content

The maximum dry density (MDD) and optimum water content (OWC) relationship shall be determined for the basecourse aggregate using the method of NZTA T28. The MDD and OWC figures obtained shall be used in the California Bearing Ratio and Repeated Load Triaxial testing detailed in clauses 7.2.2 and 7.2.3 above.

Determine and report the aggregate Solid Density with this test (see 7.3.2 below).

7.3.2 Solid Density

Solid Density shall be tested using the methods of NZS 4407 test 3.7. Where both methods are used calculate the combined Solid Density using the following formula:

$$\rho_s = \frac{1}{\frac{Pc}{\rho_c} + \frac{P_f}{\rho_f}} \qquad t/m^3$$

Where: ρ_s = the combined solid density

P_c = the percentage of coarse aggregate (expressed as a decimal)

ρ_c = the solid density of the coarse aggregate fraction (t/m³)

P_f = the percentage of fine aggregate (expressed as a decimal)

ρ_f = the solid density of the fine aggregate fraction (t/m³)

Report the combined solid density to three significant figures, from NZS 4407 tests 3.7.1 and 3.7.2 in conjunction with the maximum dry density and optimum moisture content testing (see 7.3.1 above).

8 Regional Basecourse Aggregates

8.1 General

For the regional basecourse aggregates and/or recycled material the M04 criteria shall apply except for variations as stated in the following tables specific to the regional aggregate. Where a value for a criterion is not included then the limit for the appropriate aggregate Class shall apply.

The regional basecourse aggregates may only be used in the geographic region as specified below. The use and source of regional materials must be clearly identified in the Contractor's tender. A methodology for dealing with any special considerations must also be included in the tender.

8.2 Napier River Gravels

Table 19: Napier River Gravel Regional Variation

Criterion	Napier River Gravel
Aggregate Class	Class 3
Broken faces Content NZS 4407 Test 3.14	
Size Fraction 37.5mm – 19.0mm	50% minimum
Size Fraction 19.0mm – 9.50mm	50% minimum
Size Fraction 9.50mm – 4.75mm	50% minimum
Particle Size Distribution, NZS 4407 Test 3.8.1	Percentage Passing Sieve
Sieve Size (mm)	AP40
37.5	-
26.5	78 – 100
19.0	-
9.50	-
4.75	-
2.36	-
1.18	13 – 25
0.600	10 – 19
0.300	7 – 14
0.150	5 – 11
0.075	3 - 8
Particle Size Distribution Curve Shape	
Size Fraction 19.0mm - 4.75mm	-
Size Fraction 9.5mm - 2.36mm	-
Size Fraction 4.75mm - 1.18mm	-
Size Fraction 2.36mm – 0.600mm	6 – 20
Size Fraction 1.18mm – 0.300mm	5 – 15
Size Fraction 0.600m - 0.150mm	2 - 12

8.3 Rotorua Rhyolite and River Gravels

Table 20: Rotorua Rhyolite and Part-Crushed River Gravels Regional Variation

Criterion	Rotorua	
	Rhyolite	Part-Crushed River Gravel
Aggregate Class	Class 4	Class 3
Crushing Resistance NZS 4407 Test 3.10	60kN minimum	130kN minimum
Broken faces Content NZS 4407 Test 3.14		
Size Fraction 37.5mm – 19.0mm	N/A	40% minimum
Size Fraction 19.0mm – 9.50mm	N/A	40% minimum
Size Fraction 9.50mm – 4.75mm	N/A	40% minimum
Quality of Fines		
Sand Equivalent, NZS 4407 Test 3.6, or	40 minimum, or	45 minimum
Clay Index, NZS 4407 Test 3.5, or	3.0 maximum, or	3.0 maximum if Sand Equivalent <45
Plasticity Index NZS 4407 Test 3.4	5.0 maximum	5.0 maximum if Sand Equivalent <45

8.4 Wanganui Shellrock

Table 21: Wanganui Shellrock Regional Variation

Criterion	Wanganui Shellrock
Aggregate Class	Class 4
Crushing Resistance NZS 4407 Test 3.10	50kN minimum
California Bearing Ratio NZS 4407 Test 3.15	120% minimum
Particle Size Distribution, NZS 4407 Test 3.8.1 Sieve Size (mm)	Percentage Passing Sieve AP40
37.5	-
26.5	-
19.0	-
9.50	-
4.75	70 maximum
2.36	-
1.18	50 maximum
0.600	-
0.300	-
0.150	-
0.075	10 maximum

8.5 Taranaki Andesites

Table 22: Taranaki Andesite Regional Variation

Criterion	Taranaki Andesite		
	65kN	85kN	100kN
Aggregate Class	Class 4	Class 3	Class 3
Crushing Resistance NZS 4407 Test 3.10	65 kN minimum	85kN minimum	100kN minimum

8.6 Wellington Greywacke

Table 23: Wellington Greywacke Regional Variation

Criterion	Wellington Greywacke
Aggregate Class	Class 3
Broken faces Content NZS 4407 Test 3.14	
Size Fraction 37.5mm – 19.0mm	60% minimum
Size Fraction 19.0mm – 9.50mm	60% minimum
Size Fraction 9.50mm – 4.75mm	60% minimum
Particle Size Distribution, NZS 4407 Test 3.8.1 Sieve Size (mm)	Percentage Passing Sieve AP40
37.5	95 – 100
19.0	58 – 85
9.50	30 – 65
4.75	15 – 45
2.36	10 – 35
1.18	8 – 25
0.600	5 - 20
0.300	3 – 15
0.150	0 – 10
0.075	0 - 8

8.7 Canterbury Alluvial Greywacke

Table 24: Canterbury Uncrushed Alluvial Greywacke

Criterion	Canterbury Alluvial
Aggregate Class	Class 4
Minimum Broken faces Content NZS 4407 Test 3.14 Size Fraction 37.5mm – 19.0mm Size Fraction 19.0mm – 9.50mm Size Fraction 9.50mm – 4.75mm	Not required
Particle Size Distribution, NZS 4407 Test 3.8.1 Sieve Size (mm)	Percentage Passing Sieve AP40
37.5	100
19.0	60 – 80
9.50	40 - 60
4.75	25 - 45
2.36	18 - 36
1.18	11 - 28
0.600	6 – 22
0.300	2 – 17
0.150	0 – 12
0.075	0 - 7
Particle Size Distribution Curve Shape	
Size Fraction 19.0mm - 4.75mm	22 - 49
Size Fraction 9.5mm - 2.36mm	14 - 36
Size Fraction 4.75mm - 1.18mm	9 - 29
Size Fraction 2.36mm – 0.600mm	6 – 24
Size Fraction 1.18mm – 0.300mm	4 – 19
Size Fraction 0.600m - 0.150mm	2 - 15

9 Recycled Materials

9.1 Recycled Crushed Concrete

9.1.1 Definition

Recycled Crushed Concrete (RCC) composed of rock fragments coated with cement with or without sands and/or filler, produced in a controlled manner by crushing waste Portland cement concrete to close tolerances of particle size distribution with minimal foreign material content.

RCC fragments shall consist of clean, hard, durable, angular fragments of concrete.

Basecourse materials shall comply with the requirements of Table 25 this specification except variation to the specified limits is permitted provided the material meets the requirements of Repeated Load Triaxial assessed M04 basecourse for design traffic >5 x 10^6 ESA. Refer to clause 7.2.2 for RLT testing requirements. Such variations must be submitted to the Principal for their review and agreement. The recycled crushed concrete must be approved for use in pavements by the appropriate Regional Council.

Table 25 classifies RCC as Class 2 or Class 3 aggregate depending on the Crushing Resistance. RCC can be classified as Class 1 material if it meets the all the specified requirements for Class 1 basecourse aggregate.

Basecourse materials can be RCC, or blends of new aggregates with RCC. Where the percentage of RCC in the blend is 15% or less by weight then the specified properties for the appropriate Class of new aggregate shall apply. Where the RCC exceeds 15% in a blend then the requirements of Table 25 shall apply.

9.1.2 Foreign Materials

The percentages of foreign materials shall be determined by Transport for New South Wales RMS Test Method T276. The percentages of foreign materials shall not exceed the following percentages by mass:

(a) Type I Materials: Glass, brick, stone, ceramics and asphalt <3%;
(b) Type II Materials: Plaster, clay lumps and other friable material: <1%;
(c) Type III Materials: Rubber, Plastic, Bitumen, Paper, Wood and other vegetable or decomposable matter: <0.5%

No Type II or III materials may be retained on the 37.5mm or above sieves for RCC Basecourse materials.

In no circumstances shall the RCC product contain any asbestos or asbestos fibre.

Testing for foreign materials shall be at the minimum sampling rate for production property tests

Notes:

(a) RCC is generally non plastic as cement dust reacts with any plastic fines present.
(b) These requirements for RCC were based on the Transport South Australia's Pavement Material Specification Part 215.
(c) RCC shows comparable performance to high quality M04 aggregate as proven at NZTA's accelerated pavement testing facility CAPTIF.

Table 25: Requirements for Recycled Crushed Concrete Aggregates

Criterion	RCC 130kN Basecourse	RCC 110kN Basecourse
Aggregate Class	Class 2	Class 3
Crushing Resistance NZS 4407 Test 3.10	130kN minimum	110kN minimum
Broken faces Content NZS 4407 Test 3.14		
Size Fraction 37.5mm – 19.0mm	70% minimum	
Size Fraction 19.0mm – 9.50mm	70% minimum	
Size Fraction 9.50mm – 4.75mm	70% minimum	
Quality of Fines		
Sand Equivalent, NZS 4407 Test 3.6, or	(N/A)	
Clay Index, NZS 4407 Test 3.5, or	(N/A)	
Plasticity Index NZS 4407 Test 3.4	5 maximum	
Particle Size Distribution, NZS 4407 Test 3.8.1 Sieve Size (mm)	Percentage Passing Sieve AP40	
75	100	
63	100	
37.5	98 - 100	
19.0	76 - 94	
9.50	57 - 75	
4.75	38 - 58	
2.36	27 - 47	
1.18	19 - 39	
0.600	12 - 32	
0.300	6 - 26	
0.150	0 - 22	
0.075	0 - 14	
Particle Size Distribution Curve Shape		
Size Fraction 37.5mm - 9.5mm	-	
Size Fraction 19.0mm - 4.75mm	27 - 47	
Size Fraction 9.5mm - 2.36mm	17 - 41	
Size Fraction 4.75mm - 1.18mm	8 - 30	
Size Fraction 2.36mm – 0.600mm	6 - 24	
Size Fraction 1.18mm – 0.300mm	5 - 21	
Size Fraction 0.600m - 0.150mm	3 - 19	

Notes:

Stockpiles of RCC should be separated from water courses because of the alkaline nature of RCC leachate.

Where RCC aggregates are used in granular basecourse applications in conjunction with subdrains, the following procedures are recommended to reduce the likelihood of leachate precipitates clogging the drainage system:

(a) Wash the processed RCC aggregates to remove dust from the coarse particles.
(b) Ensure that any geotextile fabric surrounding the drainage trenches (containing the subdrains) does not intersect the drainage path from the base course, i.e. do not fully wrap drains to avoid potential plugging with fines.

The pH value of the RCC aggregate can exceed 11. This can be corrosive to galvanized or aluminium pipes placed in direct contact with the RCC. Galvanized or aluminium pipes shall not be used in RCC pavements.

9.2 Glenbrook Melter Aggregate

9.2.1 Requirements

Glenbrook Melter Aggregate (GMA or Melter Slag) is a co-product of the iron making operation at New Zealand Steel, Glenbrook. The material is processed to produce an AP40 aggregate complying to the standard NZTA M04 requirements. It must be approved for use by the appropriate Regional Council.

In order to ensure a consistent product, the GMA chemical composition should fall within the ranges below.

Table 26: Glenbrook Melter Aggregate Composition Limits

Compound	Concentration (%)
Calcium Oxide, CaO	10 – 20
Iron, Fe	0 – 10
Silicon Dioxide (“Silica”), SiO_2	9 – 15
Aluminium Oxide (“Alumina”), Al_2O_3	15 – 21
Manganese(II) Oxide, MnO	0.5 – 1.7
Magnesium Oxide, MgO	11 – 15
Titanium Dioxide, TiO_2	27 – 42
Chromium(III) Oxide, Cr_2O_3	0.2 – 0.6
Vanadium Pentoxide, V_2O_5	0.1 – 0.5

The Iron content is removed from the slag during the crushing process. The non-ferrous component of every production batch of sub-base and base course GMA must be analysed in an accredited laboratory for its chemical properties and at an interval of six months or 10,000m^3 of production (whichever occurs first), for the source properties to provide assurance that the GMA remains within the parameters specified in Table 26 above. The properties of the Glenbrook Melter Aggregate shall comply with the requirements of Table 27 below.

Table 27: Glenbrook Melter Aggregate Requirements

Criterion	Test Method	Requirement
Potential Expansion of Aggregates from Hydration Reactions	ASTM D4792	0.5% maximum at seven days
Other Parameters	-	In accordance with M04

9.2.2 Special Considerations

Stockpiles should be separated (a minimum distance) from water courses because of the alkaline nature of leachate.

While steel Slag aggregates are known to potentially clog geotextile fabric wrapped drains, the reduced amount of free lime in Melter Slag should reduce this risk. Where GMA is used in granular basecourse applications in conjunction with subdrains, ensure that any geotextile fabric surrounding the drainage trenches (containing the subdrains) does not intersect the drainage path from the base course, i.e. do not fully wrap drains (to avoid potential plugging with fines).

The pH value of the GMA generally ranges from approximately 8 to 10 in laboratory testing and 7.5 - 8 in the field; however, leachate from blast furnace and steel slags are often in these ranges and can exceed a pH value of 11. This can be corrosive to galvanized or aluminium pipes placed in direct contact with the slag. Galvanized or aluminium pipes must not be used in melter slag aggregate pavements.

While melter slags have reportedly good test results in terms of potential to swell, the use of GMA next to structures (such as bridge abutments) is not permitted.

9.3 Reclaimed Glass

9.3.1 General

Reclaimed glass, or “cullet” is produced from a range of glass products, including waste food and beverage containers, drinking glasses, window glass, or plain ceramic or china dinnerware. Reclaimed glass from hazardous waste containers, light bulbs, vehicle windscreens, fluorescent tubes or cathode ray tubes must not be used to produce cullet for use in basecourse aggregates.

Experience has shown that appropriately processed reclaimed glass is well suited for use in a basecourse aggregate. Adding glass to aggregate, in suitable proportions, provides environmental benefits without compromising the mechanical properties of the aggregate.

Up to 5% reclaimed glass (by mass) to be blended with natural or recycled aggregate for road base construction. The aggregate/cullet blend must comply with the requirements of the M04 specification except for the variations and additions provided in clause 9.3.

Up to 5% reclaimed glass can also be added to subbase aggregate in accordance with the relevant requirements of the M04 specification.

Proportions of cullet in excess of 5% may be used at the discretion of the Principal, provided that the requirements of the Repeated Load Triaxial test assessed M04 basecourse for design traffic >5 x 10^6 ESA as per this specification have been satisfied. Such applications are likely to be restricted to relatively low traffic volume projects and the material may be subject to higher standards with respect to contamination limits.

9.3.2 Requirements for Cullet

The cullet shall not contain more than 5% debris. Debris, such as paper, foil, plastic, metal, cork, food residue, organic matter, etc., can have a significant influence on the performance of the aggregate / glass material. The debris content shall be determined using the procedure described in RMS Test Method T276 (where “reclaimed glass” is substituted for “recycled concrete”).

The cullet shall be washed to eliminate objectionable odours and contaminants. When tested in accordance with NZS 4407 test 3.8.1 it shall comply with the particle size distribution limits of below.

Table 28: Particle Size Distribution Limits for Crushed Glass Cullet

Sieve Size (mm)	Passing Sieve (%)
9.50	100
4.75	70 – 100
2.36	35 – 88
1.18	15 – 45
0.300	4 – 12
0.075	0 - 5

Note: The Principal can approve alternative particle size distributions for the cullet provided the finished basecourse aggregate containing the cullet complies with the particle size distribution limits of Table 12.

The size fraction of the cullet retained on the 4.75mm sieve must not contain more than 1% of flat or elongated particles, i.e. particles with a maximum to minimum dimension ratio greater than 5:1. ASTM D4791 test is appropriate, except that the test sample shall be taken as the material retained on the 4.75mm sieve. Tests for compliance with grading, particle shape and contamination shall be carried out at a frequency of two tests (each) per cullet stockpile.

9.3.3 Requirements for Basecourse Aggregate

The basecourse aggregate prior to blending with the cullet shall comply with clause 4 of this specification. The basecourse aggregate blended with the cullet shall comply with the requirements of clauses 5 and 7 of this specification. The cullet shall be uniformly blended with the aggregate such that there are no concentrations of cullet in the aggregate.