NOTES FOR THE EVALUATION OF UNBOUND ROAD BASE AND SUB-BASE AGGREGATES

(These notes are guidelines only and must not be included in the Contract Documents).

1. SCOPE

These notes provide guidance for the Engineer to aid in their decision to reject or accept a material proposed for use a basecourse or sub-bases used on state highways and other roadways constructed in accordance with Transit New Zealand's *Performance Based Specification for Structural Design and Construction of Flexible Unbound Pavements* TNZ B/3 (provisional): 2000.

The intention is to enable less expensive locally available aggregates (with or without stabilisation) to be assessed for suitability as either a basecourse or sub-base material.

Contractors are required to guarantee the performance of their proposed material for the maintenance period of at least one year after construction. Therefore, any proposed material should not be rejected without careful consideration of local knowledge, other supporting information supplied by the Contractor, traffic, environment and information on the use of materials on other roads (private or local). Based on this other information, the Engineer may allow the Contractor to use proposed materials that do not meet the requirements of this Guideline.

These Guidelines are given Notes status as they are not to form any part of the Contract. This is to ensure that Transit New Zealand is not liable for any failures in the maintenance period resulting from the Contractors choice to use non-standard materials.

M/22 (Notes 2): 2000 provides additional information that should be referred to.

2. GENERAL

All sampling and testing shall be performed by an International Accreditation New Zealand registered laboratory; sampling must be performed in accordance with the methods detailed in NZS 4407: 1991 Part 2 or a laboratory that has accreditation under ISO/ICS Guide 25: 1990 "General Requirements for the Competence of Calibration and Testing Laboratories".

All basecourse or sub-base materials which does not comply with the requirements of this specification shall be rejected unless sufficient other supporting information is provided to prove a

material has adequate strength and durability.

2.1 References

AUSTROADS (1992) refers to the document *Pavement Design - A Guide to the Structural Design of Road Pavements.* Austroads, Sydney Australia. 1992.

The New Zealand Supplement (2000) refers to the *New Zealand Supplement to Austroads Pavement Design - A Guide to the Structural Design of Road Pavements(1992)*. Transit New Zealand, Wellington New Zealand. 2000.

3. BASECOURSE DEFINITION

3.1 General

A basecourse is the pavement material (stabilised or otherwise) forming the base defined as the upper 100 - 200 mm of aggregate in the pavement as shown in Figure 8.4 of AUSTROADS (1992). The minimum thickness of base required as per Figure 8.4 of AUSTROADS (1992) may be reduced by the thickness of any asphalt layer applied to the surface that has a thickness of ≥25 mm. There may be up to two basecourse layers.

3.2 Requirements for Unbound Basecourse

Pavement material will not be accepted as a basecourse if the material is determined to be bound by the following definition. The definition of bound applies to any aggregate/stabiliser combination that has sufficient tensile strength and shrinkage potential to result in cracks greater than 1.0 mm in width. Aggregate/stabiliser combinations considered bound are those that have an indirect tensile strength greater than 0.08 MPA when tested in accordance with NZS 3112: Part 2 Test 8 and shrinkage greater than 0.025% when tested in accordance with NZS 3112: Part 3 Test 3.

A stabilised aggregate that does not meet the above definition of an unbound basecourse can still be considered provided there is allowance in the design and costings for future maintenance resulting from patch sealing cracks (*see Section 8.2.5 of the 2000 NZ Supplement*).

3.3 Pavement Design

A unbound basecourse for the purposes of pavement design shall be considered as the base layer being an unbound aggregate with no bound properties. Any vertical moduli assigned to a basecourse layer for design shall be determined in accordance with AUSTROADS (1992) and the accompanying New Zealand Supplement (2000) and shall not exceed a value of 1000 MPa and more than 2 times the moduli of the underlying layer.

A bound basecourse can be designed using the tensile fatigue criterion in AUSTROADS (1992). Life after fatigue cracking is acceptable provided there is allowance in the design and costings for future maintenance resulting from patch sealing cracks (*see Section 8.2.5 of the 2000 NZ Supplement*).

4. BASECOURSE SOURCE PROPERTIES

4.1 Source Sampling

Tests shall be performed on samples recently produced and be representative of the normal processing methods.

4.2 Durability

To meet the requirements of durability a basecourse material shall comply with either: both Clauses 4.2.1 and 4.2.2 ***OR*** Clause 4.2.3. Checking for compliance with Clause 4.2.3 is only necessary where the proposed basecourse aggregate would not comply with Clauses 4.2.1 and/or 4.2.2.

4.2.1 Crushing Resistance

All *parent* aggregate (free from any stabilisers) that will be used in the basecourse shall comply with this Clause. Material sourced from aggregate complying with this Clause must contribute to at least 80% by weight of the sub-base material.

When tested in accordance with NZS 4407: 1991, Test 3.10, *The Crushing Resistance of Coarse Aggregate Under a Specified Load*, less than 10% fines passing 2.36 mm sieve size shall be produced under a load of 130 kN. The loading requirement can be reduced to 60 kN for pavements with a design traffic life of less than 1×10^6 ESA.

4.2.2 Weathering Resistance

All *parent* aggregate (free from any stabilisers) that will be used in the sub-base shall comply with this Clause. Material sourced from aggregate complying with this Clause must contribute to at least 80% by weight of the sub-base material.

The aggregate shall have a quality index of AA, AB, AC, BA, BB, CA when tested in accordance with NZS 4407: 1991, Test 3.11 *The Weathering Quality Index of Coarse Aggregate.*

4.2.3 Weathering Resistance of Aggregate/Stabiliser Combinations

A basecourse layer consisting of a aggregate/stabiliser combination shall comply with this Clause if

the basecourse material would not comply with Clauses 4.2.1 and/or 4.2.2.

The soil-cement losses for a basecourse material (with 100% of the intended stabiliser content) after 12 cycles of the wet dry test in accordance with ASTM D 559 - 96 *Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures* shall not exceed 10 percent and the soil-cement losses for a basecourse material with a stabiliser content of 90% of the amount intended to be used after 12 cycles of the wet dry test in accordance with ASTM D 559 - 96 *Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures* shall not exceed 20 percent.

The soil-cement losses for basecourses of stabiliser contents not tested in accordance with ASTM D 559 - 96 maybe determined by linear interpolation between two test results.

5.0 BASECOURSE PRODUCTION PROPERTIES

Production properties of the basecourse shall be assessed by the testing specified in Clause 5.1 on representative samples of the basecourse. The testing specified in Clause 5.2 shall be used to confirm the basecourse produced is the same as the basecourse tested in Clause 5.1.

Representative samples of the basecourse may be taken from the conveyor belt, bin, stockpile or truck. Representative samples of the basecourse shall be obtained in accordance with NZS 4407 : 1991

All basecourse delivered to site shall comply with the requirements detailed in Clauses 5.1, 5.2 and 5.3.

5.1 Deformation Resistance

The in service behaviour of deformation resistance of the produced aggregate is to be evaluated by either: the Repeat Load Triaxial (RLT) Test equipment or through demonstration of acceptable performance (minimal rut depth and no shallow shear failures) used on other roads or at CAPTIF (Transit New Zealand's test track) constructed using the proposed basecourse.

5.1.1 Repeat Load Triaxial (RLT) Test

The Contractor may vary all of the conditions of the RLT test to those stated below including using a different standard to *AS 1289.6.8.1 – 1995* if it can be demonstrated that the test conditions chosen are more accurate and more representative of the in-service conditions.

The test shall be carried to standards in AS 1289.6.8.1 - 1995 "*Methods of testing soils for engineering purposes: Soil strength and consolidation tests - Determination of the resilient modulus and permanent deformation of granular unbound pavement materials*"

with the following exceptions:

- The test conditions shall be undrained and saturated at 100% *(or at optimum moisture content if it can be demonstrated through the design of within pavement drainage that full (100%) saturation of the pavement materials will not occur over the life of the pavement).*

- The sample shall be compacted to lesser of the, 95% Maximum Dry Density in accordance with NZS4402:1986 Test 4.1.3 or the expected maximum density achievable in the field and if stabilised cured for no longer than 7 days.

- The sample shall be tested for at least 50,000 cycles in the permanent deformation stage.

- The pore pressure at rest shall be measured and reported.

- The specimen size shall be 150 mm diameter, 300 mm length and when using 40 mm top size aggregate the material shall not be scalped

- The stress conditions for the permanent deformation test shall be the same or more severe than a deviator stress of 425 kPa and a confining stress of 125 kPa. The sample shall be unconsolidated.

The basecourse is considered to have passed if the results of the permanent strain RLT tests show the basecourse material exhibits stable behaviour. Stable behaviour is defined as a decreasing rate of permanent strain accumulation on a permanent strain vs number of cycles graph.

5.2 Minimum CBR

The basecourse when tested in accordance with NZS 4402: 1986, Test 6.1.1, *Determination of the California Bearing Ratio (CBR): Standard laboratory method for remoulded specimens,* the specimen shall have a minimum CBR value of 80%.

Basecourses with aggregate/stabiliser combinations shall be tested after 7 days of curing.

5.3 Variation Control

The grading, sand equivalent, proportion of broken faces and any stabiliser added has a significant effect on the in service performance of the basecourse. The Contractor shall demonstrate through their Quality assurance plan that 95 % of the basecourse produced from normal operations will have, a particle size distribution more open, a higher sand equivalent value, a higher proportion of broken faces and a higher stabiliser content than the basecourse tested for compliance with Clauses 5.1 and 5.2.

5.3.1 Sand equivalent

Tested according to NZS 4407: 1991, Test 3.6 *Sand Equivalent.*

5.3.2 Broken Face Content

Tested according to NZS 4407: 1991, Test 3.14 *Broken Face Test*.

5.3.3 Particle size distribution

Tested according to NZS 4407: 1991, Test 3.8.1 *Wet Sieving Test*

5.3.4 Stabiliser Content

Stabiliser type and content determined as a percentage of the dry mass of the basecourse.

5.4 Production Sampling

Stored basecourse shall be subdivided into lots so that basecourses of visible difference are sampled and tested separately.

The Engineer may require some or all of the production property tests to be performed in addition to the testing frequencies stated below. Should the test results show that the basecourse complies with this specification, testing will be at the Principal's cost, otherwise testing will be at the cost of the Contractor.

5.4.1 Sampling for Compliance with Clauses 4.2, 5.1, 5.2

Compliance with Clauses 4.2, 5.1 and 5.2 shall be considered a source property of the basecourse produced.

5.4.2 Sampling for Variation in Production

The rate of obtaining samples from lots for variation testing as per Clause 5.3 shall be as in the Table 2.

Table 2: Minimum sampling rate for variation of production property tests

Lot Size		Number of Samples
From	To	

1 m^3	400 m^3	2
400 m^3	1500 m^3	3
1500 m^3	4000 m^3	4

Where the lot size exceeds 4000 m^3 additional testing shall be at the rate of one sample for every 1000 m^3 .

6. SUB-BASE DEFINITION

6.1 General

A sub-base is any pavement material layer (stabilised or otherwise) below the basecourse defined in Clause 3 but above the subgrade and/or subgrade improvement layer. There can be more than one sub-base layer provided this specification, AUSTROADS (1992) and the accompanying New Zealand Supplement (2000) are complied with for all sub-base layers. In particular, for any sub-base layers considered as an unbound aggregate the minimum cover requirements of Section 8.3.2 *Pavement Composition* of AUSTROADS (1992) shall be complied with.

6.2 Bound or Unbound Aggregate

A sub-base can be either an unbound aggregate or a bound aggregate layer as per the following definitions:

- ***unbound aggregate***: this includes any: unbound aggregates that do not have any stabilisers added; bound aggregate layers where their tensile fatigue life has been consumed; any aggregate/stabiliser combinations considered for the purposes of pavement design to be equivalent to an unbound aggregate; and/or any material that is not defined as bound as per the definition below.

- ***bound aggregate***: this includes any sub-base layer that has been assigned a modulus value of more than twice the underlying layer (i.e. does not comply with Section 8.2.2 of AUSTROADS, 1992).

6.3 Pavement Design

The requirements of AUSTROADS (1992) and the accompanying New Zealand Supplement (2000) shall be complied with.

To ensure a minimum depth of a sub-base material complying with this specification is used in the pavement, for design purposes the CBR (California Bearing Ratio) assigned to the subgrade and/or subgrade improvement layer shall not exceed 15% (or exceed a vertical modulus of 150 MPa).

6.4 Minimum Cover

All sub-base layers shall be covered by a minimum depth of basecourse as defined in Clause 3 plus any additional depth of material required to satisfy the requirements of Section 8.3.2 *Pavement Composition* of AUSTROADS (1992) where the CBR of a sub-base is measured in Clause 8.2 of these Notes.

7. SUB-BASE SOURCE PROPERTIES

7.1 Source Sampling

Tests shall be performed on samples recently produced and be representative of the normal processing methods.

7.2 Durability

To meet the requirements of durability a sub-base material shall comply with either: both Clauses 7.2.1 and 7.2.2 ***OR*** Clause 7.2.3. Checking for compliance with Clause 7.2.3 is only necessary where Clauses 7.2.1 and/or 7.2.2 were not complied with.

7.2.1 Crushing Resistance

All *parent* aggregate (free from any stabilisers) that will be used in the sub-base shall comply with this Clause. Material sourced from aggregate complying with this Clause must contribute to at least 80% by weight of the sub-base material.

The *parent* aggregate when tested in accordance with NZS 4407: 1991, Test 3.10, *The Crushing Resistance of Coarse Aggregate Under a Specified Load,* less than 10% fines passing 2.36 mm sieve size shall be produced under a load of 60 kN.

7.2.2 Weathering Resistance

All *parent* aggregate (free from any stabilisers) that will be used in the sub-base shall comply with this Clause. Material sourced from aggregate complying with this Clause must contribute to at least 80% by weight of the sub-base material.

The *parent* aggregate shall have a quality index of AA, AB, AC, BA, BB, CA when tested in accordance with NZS 4407: 1991, Test 3.11 *The Weathering Quality Index of Coarse Aggregate.*

7.2.3 Weathering Resistance of Aggregate/Stabiliser Combinations

A sub-base layer consisting of a aggregate/stabiliser combination shall comply with this Clause if Clauses 7.2.1 and/or 7.2.2 are not complied with.

The soil-cement losses for a sub-base material (with 100% of the intended stabiliser content) after 12 cycles of the wet dry test in accordance with ASTM D 559 - 96 *Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures* shall not exceed 10 percent and the soil-cement losses for a sub-base material with a stabiliser content of 90% of the amount intended to be used after 12 cycles of the wet dry test in accordance with ASTM D 559 - 96 *Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures* shall not exceed 20 percent.

The soil-cement losses for sub-bases of stabiliser contents not tested in accordance with ASTM D 559 - 96 maybe determined by linear interpolation between two test results.

8. SUB-BASE PRODUCTION PROPERTIES

8.1 Drainage requirements

Sub-base material within 100 mm of the overlying basecourse layer shall be more permeable than the base course in the pavement unless it has been demonstrated in the pavement design that drainage has already been taken into consideration. The permeability of both layers shall be estimated from the following equations:

$$k = \frac{1.636x10^{10} \cdot D_{10}^{1.478} \cdot n^{6.654}}{P_{(0.075)}^{0.597}}$$

$$n = 1 - \frac{r_d}{r_w \cdot G_s}$$

Where

k = *Permeability (m/s)*

n = *Porosity*

$D_{(10)}$ = *Effective sieve size (mm) that 10% of the material passes*

$P_{(0.075)}$ = *Percent passing 0.075mm sieve*

G_s = *Specific Gravity of the compacted aggregate*

r_w = *Density of water (kg/ m^3)*

r_d = *Dry Density of the compacted aggregate (kg/ m^3)*

8.2 Minimum CBR

The sub-base when tested in accordance with NZS 4402: 1986, Test 6.1.1, *Determination of the California Bearing Ratio (CBR): Standard laboratory method for remoulded specimens,* the specimen shall have a minimum CBR value needed to satisfy the requirements of Section 8.3.2 *Pavement Composition* of AUSTROADS (1992). For the sub-base layers placed directly beneath the basecourse layer as defined in Clause 3 the minimum CBR needed is 30%.

Sub-bases with aggregate/stabiliser combinations shall be tested after 7 days of curing.

8.3 Minimum Modulus for Bound Aggregates

For sub-bases with aggregate/stabiliser combinations that will be considered as a bound layer in the pavement design. It shall be demonstrated from laboratory tests (Unconfined Compressive Strength and/or Repeat Load Triaxial Tests) and using the procedures in AUSTROADS (1992) and the accompanying New Zealand Supplement (2000) that the sub-base will have a modulus ≥ the modulus assumed for the sub-base layer in the pavement design.

8.4 Variation Control

The grading, sand equivalent, proportion of broken faces and any stabiliser added has a significant effect on the in service performance of the sub-base. The contractor shall demonstrate through their

Quality assurance plan that 95 % of the sub-base produced from normal operations will have, a particle size distribution more open, a higher sand equivalent value, a higher proportion of broken faces and a higher stabiliser content than the sub-base tested for compliance with Clauses 7.2.3, 8.1, 8.2, and 8.3.

8.4.1 Sand equivalent

Tested according to NZS 4407: 1991, Test 3.6 *Sand Equivalent.*

8.4.2 Broken Face Content

Tested according to NZS 4407: 1991, Test 3.14 *Broken Face Test*.

8.4.3 Particle size distribution

Tested according to NZS 4407: 1991, Test 3.8.1 *Wet Sieving Test*

8.4.4 Stabiliser Content

Stabiliser content determined as a percentage of the dry mass of the sub-base.

8.5 Production Sampling

Stored sub-base shall be subdivided into lots so that sub-bases of visible difference are sampled and tested separately.

The Engineer may require some or all of the source and production property tests to be performed in addition to the testing frequencies stated below. Should the test results show that the sub-base complies with this specification, testing will be at the Principal's cost, otherwise testing will be at the cost of the Contractor.

8.5.1 Sampling for Compliance with Clauses 7.2, 8.1, 8.2, 8.3

Compliance with Clauses 7.2, 8.1, 8.2 and 8.3 shall be considered a source property of the sub-base produced.

8.5.2 Sampling for variation in production

The rate of obtaining samples from lots for variation testing as per Clause 8.4 shall be as in the Table 3.

Table 3: Minimum sampling rate for variation of production property tests

Lot Size		Number of Samples
From	**To**	
1 m^3	400 m^3	2
400 m^3	1500 m^3	3
1500 m^3	4000 m^3	4

Where the lot size exceeds 4000 m^3 additional testing shall be at the rate of one sample for every 1000 m^3 .

9. COMPLIANCE

Before commencement of supplies the basecourse and sub-base producer shall submit proof of compliance. Documentation shall be provided in accordance with the producer's quality plan.

10. BASIS OF MEASUREMENT AND PAYMENT

The basis of payment shall be on the final compacted volume of the aggregate in place with the method of measurement defined in the contract documents.