SUPPORTING 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 are guidelines only and do not need to be strictly adhered to. Contractors may submit other supporting information for the Engineers agreement on the use of their material. Assistance is available prior or during the tender process to Contractors and Engineers from Transit Head Office on material development and associated supporting information by contacting:

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These Notes will enable non-standard locally available aggregates (with or without stabilisation) to be assessed for suitability as either a basecourse or sub-base material for a contract using TNZ B/3 *Performance Based Specification for Structural Design and Construction of Flexible Unbound Pavements.*

The performance of basecourses and sub-bases cannot be fully assessed in the laboratory and for this reason, material meeting the requirements of these notes should only be used in roads constructed in accordance with Transit New Zealands *Performance Based Specification for Structural Design and Construction of Flexible Unbound Pavements* TNZ B/3 (provisional): 2000. TNZ B/3 requires the Contractor to be responsible for the performance of the road constructed for at least 12 months. Due to the increase in risk to the Contractor it is expected that alternative materials complying with TNZ M/22 Notes will only be used where from experience Contractors are confident they will provide adequate performance in the constructed pavement and not be detrimental to the performance of the surfacing.

The objective here is not to simply find the cheapest material that passes the TNZ M/22 Notes but rather a material where there is some confidence that it will provide adequate performance in the constructed pavement.

Quality Assurance

All quarry operations producing aggregate should have a Quality Assurance plan.

It is the responsibility of the contractor to demonstrate evidence of quality controls to clients and the Engineer and for aggregate producers to provide proof of compliance to the contractor.

2. GENERAL

The required stiffness and/or CBR of a basecourse or sub-base is usually governed by the pavement design and hence the reference made to AUSTROADS (1992) and the accompanying New Zealand Supplement (1997).

3. BASECOURSE DEFINITION

3.1 General

For adequate shear strength and sufficient cover to guard against shrinkage cracks in the underlying sub-base appearing at the surface a minimum thickness of basecourse is required. Since a asphalt layer has a shear strength greater than that of basecourse provision has been made to allow the asphalt layer to act as part of the minimum requirements of a basecourse. If the thickness of the asphalt layer is 150 mm then a basecourse layer is probably not needed.

3.2 Requirements for Unbound Basecourse

To ensure cracking does not reflect through the surfacing the tensile strength and the shrinkage of the basecourse has been limited.

3.3 Pavement Design

The modulus value of the basecourse was limited because the aggregate/stabiliser combinations may show in the laboratory to have a modulus of say a 1500 MPa. However, this layer will crack during the construction of the pavement and the resulting modulus will not be any better than the modulus of a good quality unbound aggregate (free of stabilisers).

4. BASECOURSE SOURCE PROPERTIES

Source Property testing

Prescribed source property testing frequencies have been removed from the specification. This takes into account the fact that aggregate sources range from very consistent to highly variable. Source property test frequencies should be dictated by the history of test results and the following general precept used as a guideline:

- If test results are consistent over the previous n years then source property testing shall take place every n years; for crushing resistance this is n x 0.5 years.

  where n = 1, 2 , 3, 4 or 5; five years is the maximum period that can pass between tests.

For example, if results were not consistent between 1996 and 1997, testing should take place again in 1998; if results were consistent in 1996 and 1997 but differ from those in 1995, testing should take place in 1999.

Consistent is defined as:

- Crushing Resistance: within 2% fines (at 130 kN) or within 30kN (10% fines value).
- Weathering Resistance: no change in quality index.

4.1 Source Sampling

Tests are required on samples of the *parent* aggregate (free from any stabilisers) to ensure these materials will not break-down before the end of the design life. A minimum amount of parent aggregate was specified as there was a concern that a cemented clay material with say only a couple of strong stones present could meet the requirements of this specification. Alternatively, the stabilised material may be tested for durability.

4.2 Durability

4.2.1 Crushing Resistance

The crushing resistance is the same as specified in TNZ M/4: 1995. A lower crushing resistance has been allowed for low traffic volume roads in recognition of TNZ M/4: 1995 allowing the use of regional basecourses with this low crushing resistance.

Before rejecting a material that has not met the crushing resistance criteria consideration should be given to the performance of this product in other roads and of its soaked CBR value.

4.2.2 Weathering Resistance

The weathering resistance is the same as specified in TNZ M/4: 1995.

4.2.3 Weathering Resistance of Aggregate/Stabiliser Combinations

This Clause will determine the amount of cementitious stabiliser required to protect the marginal aggregate from break-down over the design period. The requirements came from the: *Soil-Cement Laboratory Handbook*. Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-1083, USA. 1992. As quoted from the Soil-Cement Laboratory Handbook:

> *The criteria are based on considerable laboratory test data, on the performance of many projects in service, and on information obtained from the outdoor exposure of several thousand specimens. The use of these criteria will provide the cement content required to produce hard, durable soil-cement, suitable for base-course construction of the highest quality.*

The South Africans use a modified version of this test, which includes a mechanical device to do the brushing of the sample. This reduces the variability for repeatable results and is currently being investigated.

5.0 BASECOURSE PRODUCTION PROPERTIES

5.1 Deformation Resistance

Contractors are recommended to gather data on the performance of their product in actual roads. This will give a better indication of a materials deformation resistance than the Repeat Load Triaxial (RLT) test which only approximates the conditions in the road.

A material of substandard strength is likely to deform within the first year in the road. During this period any deformations are required to be repaired by the Contractor. Therefore, Engineers should be more concerned with the long term durability of a material rather than its deformation resistance when evaluating a material.

5.1.1 Repeat Load Triaxial Tests

The Repeat Load Triaxial (RLT) Test specified is a comparative test to good quality aggregate complying with TNZ M/4: 1995. Significant differences between permanent strain results can occur for the same material tested on different RLT devices (APRG, 1997). However, the RLT result gives an indication of a materials expected performance and some confidence that the material proposed by the Contractor is not “rubbish”. This is considered acceptable as the best test is the first year in the road, where the Contractor takes the risk.

The RLT test conditions quoted may be varied if the Contractor believes that this will be more indicative of the actual conditions in the road. This will also give Contractors more confidence in the performance of their material.

These RLT test conditions do not necessarily represent the same test conditions for determining the resilient modulus of a material for design. RLT test conditions for determining the modulus of a

material for design should be those that are representative (stress level, moisture, sample size etc) of the materials intended use in the pavement. These representative test conditions may be different to those in any standards for RLT testing.
APRG. 1997. *A Summary Report on Interlaboratory Precision Study of Resilient Modulus and Permanent Strain Testing by: APRG Working Group of Repeated Load Triaxial Test Users.* AUSTROADS NSRP Project NT & E 9520. No. APRG 97/01 (MA), February 1997. arrb Transport Research Ltd, Melbourne, Australia.

The RLT is regarded as a source property test.

Repeated load triaxial tests have been introduced to identify and quantify the difference between various aggregate sources and methods of production.

The M/4 : 1995 tests have been retained to show that the material tested is the same as the material being produced without the need for further costly RLT tests.

The Weathering quality index test has been kept as the RLT test will not distinguish between aggregates with differing weathering characteristics, a more durable material classified as AA in the Weathering quality index test could appear similar to a material with a CA classification. Designers need to be particularly aware of this point. The generation of fines will have a significant impact on the future performance of the pavement.

Section 5.4 indicates that the RLT test will need to be on the 95% confidence interval of the material produced. This means that the material used will have a 95% chance of being better than the tested. Better means that there will be a more open grading, a higher proportion of broken faces and higher Sand Equivalent value. All of these are considered to result in a material more resistant to shear stresses.

The removal of limits on the gradation envelope means that it is possible to produce an aggregate gradation that will produce good results in the RLT test but be very difficult to compact in the field. The M4 : 1995 specification still provides a good guide to achieving a sound base-course.

Care will need to be taken that the density tested in the RLT is achievable in the field. It is the contractors responsibility to nominate the density that will be achieved. It would normally be expected that this would be 95% of MDD for basecourse. Where field densities can not match RLT test densities addition RLT tests will be required to model the pavement accurately.

Figure one shows that the material can be consider as M/4 : 1995 if the slope of the permanent strain vs log N plot is below a certain value. If this is the case then the pavement design can be conducted to the normal AUSTROADS (1992) standard using the Subgrade fatigue criterion.

The value of 0.32 used for slope of the RLT test has been determined by testing of a M/4 : 1995 material compacted to 95% MDD and tested under saturated, undrained conditions where the sample has not been consolidated before testing, ie the effective confining stress is zero. As experience with this test is gained this value may need to be modified.

5.2 Minimum CBR

Although the Repeat Load Triaxial Test or road trials will ensure the basecourse has sufficient strength it was considered to be a good idea to also include a minimum CBR requirement in the piloting stage of this specification.

5.3 Variation Control

The Contractor is required to determines the recipe of the basecourse or sub-base proposed. This recipe needs to be provided to allow the basecourse or sub-base that is being supplied for construction to be checked that it is the same material that was used to pass the test.

5.3.1 Sand equivalent

5.3.2 Broken Face Content

5.3.3 Particle size distribution

5.3.4 Stabiliser Content

The amount of stabiliser content and type needs to be known to ensure during construction the same type and amount of stabiliser is added to the basecourse.

5.4 Production Sampling

Production sampling is similar to TNZ M/4 : 1995.

5.4.1 Sampling for Compliance with Clauses 4.2, 5.1, 5.2

5.4.2 Sampling for Variation in Production

The rate of obtaining samples from lots for variation testing is the same as in TNZ M/4 : 1995.

6. SUB-BASE DEFINITION

6.1 General

This Clause defines the position of a sub-base layer and allows more than one sub-base layer. The pavement design will govern the number of sub-base layers and their minimum CBR.

A subgrade improvement layer is a layer directly above the subgrade that was constructed from either stabilising the existing subgrade or importing other fill material (that does not comply with the sub-base requirements for crushing and weathering resistance).

6.2 Bound or Unbound Aggregate

There are rules for bound and unbound materials in AUSTROADS (1992). However, this Clause was added to avoid the situation where a stabilised sub-base layer placed on top of a subgrade of CBR 2 (or modulus of 20 MPa) is assigned a modulus of 700 MPa and assumed to be unbound. Although it can be proven in the laboratory that the stabilised sub-base material has a modulus of at least 700 MPa, when constructed over a weak subgrade the stabilised sub-base layer will crack like a biscuit and can only last as a 700 MPa material for a finite number of load cycles. The correct approach to designing a pavement with a stabilised sub-base layer is to design the layer as either a bound layer or a unbound layer (where the modulus is not more than double the modulus of the underlying layer) or model both cases. If the sub-base is treated as a bound layer (where it can probably be shown in the laboratory to have a modulus of at least 1500 MPa) then the life of that layer is determined using the tensile fatigue criterion in the New Zealand Supplement (1997) to AUSTROADS (1992). After the life of the bound layer has been consumed then the sub-base material resorts to unbound and the life of the pavement in the unbound state can be utilised.

For pavement design the sub-base should be either treated as a bound layer or a unbound layer but not something in between.

6.3 Pavement Design

To ensure the subgrade improvement layer does not become the sub-base a maximum strength assigned to that layer has been specified.

6.4 Minimum Cover

Since more than one sub-base layer is acceptable it is important to ensure that sub-bases with a CBR of less than 30 are covered by a adequate depth of stronger material and the basecourse.

7. SUB-BASE SOURCE PROPERTIES

See Clause 4 of these notes.

7.1 Source Sampling

7.2 Durability

7.2.1 Crushing Resistance

The requirement for crushing resistance is similar to TNZ M/4 : 1995. A minimum amount of parent aggregate was specified to avoid the situation of a stabilised clay with only a couple of stones present.

Before rejecting a material that has not met the crushing resistance criteria consideration should be given to the performance of this product in other roads and of its soaked CBR value.

7.2.2 Weathering Resistance

The requirement for crushing resistance is similar to TNZ M/4 : 1995. A minimum amount of parent aggregate was specified to avoid the situation of a stabilised clay with only a couple of stones present.

7.2.3 Weathering Resistance of Aggregate/Stabiliser Combinations

See Clause 4.2.3 of these supporting Notes.

8. SUB-BASE PRODUCTION PROPERTIES

8.1 Drainage requirements

The requirement for drainage is to ensure if water does enter the basecourse it can drain out through a sub-base of greater permeability. There is disagreement amongst the roading fraternity whether or not the sub-base requires a greater permeability than the basecourse and therefore there is provision to demonstrate other means of pavement drainage.

8.2 Minimum CBR

The minimum CBR required for the sub-base is governed by the pavement design.

8.3 Minimum Modulus for Bound Aggregates

This Clause is included to ensure that the modulus assumed in design for a bound layer is achieved in the sub-base material.

8.4 Variation Control

Since the Contractor determines the recipe of the sub-base that will meet the requirements of durability and the pavement design. This recipe needs to be provided to allow sub-base that is being supplied for construction to be checked that it is the same material that was used to pass this specification.

8.4.1 Sand equivalent

8.4.2 Broken Face Content

8.4.3 Particle size distribution

8.4.4 Stabiliser Content

The amount of stabiliser content and type needs to be known to ensure during construction the same type and amount of stabiliser is added to the sub-base.

8.5 Production Sampling

Production sampling is similar to TNZ M/4 : 1995.

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

8.5.2 Sampling for variation in production

The rate of obtaining samples from lots is the same as in TNZ M/4 : 1995.

9. COMPLIANCE

10. BASIS OF MEASUREMENT AND PAYMENT

In accordance with TNZ B/3 payment will be made per square metre of seal area.