

NOTES ON SUBBASE AGGREGATE SPECIFICATION TNZ M/3

These notes must not be included in the Contract Documents.

1. INTRODUCTION

There is no standard TNZ M/3 Specification for subbase aggregate. The variety of materials that will serve as satisfactory subbases is too wide to set a rational standard specification and custom written specifications must be used that match the design of each individual project. These notes set out the recommended format of the subbase specification, lay down certain minimum requirements and identify other requirements that may be necessary.

Notwithstanding these guidelines, optimal material utilisation, particularly involving stabilised materials, may require development of specifications beyond the scope of these notes. Transit New Zealand approval of such specifications shall be sought prior to their use.

The term "*subbase*" means that material used in the pavement between the subgrade and the M/4 "*basecourse*". As they are located well below the zone of intense wheel load induced stresses and strains and because they are confined by a superimposed layer of basecourse, subbase materials do not have to meet the stringent requirements of the M/4 basecourse specification.

These notes can be used in the development of a specification for use in conjunction with either the supply of subbase material or the supply and construction of a subbase layer.

2. GENERAL

Materials must be free from all non-mineral matter.

3. TESTING

A clause similar to that in TNZ M/4 should be included stating sampling method,

sources, sizes etc.

The place of sampling should be clearly identified in the specification, eg, quarry belt, stockpile or truck; from uncompacted pavement; from constructed pavement. Sampling from the constructed pavement is not recommended unless particularly non-durable materials are likely to be supplied.

If the subbase is potentially very variable it is worthwhile to require that a control sample be supplied to the site to which incoming subbase can be visually compared. The volume of the control sample should be at least 4 m³ and must be kept covered and protected from contamination throughout the period of the contract.

4. BROKEN ROCK

It should not be necessary to require that the material be crushed.

5. GRADING

5.1 Minimum Requirements

Maximum size must not be greater than 0.75 x (compacted layer thickness).

Maximum size must not be greater than 100 mm (or 106 mm standard sieve).

5.2 Envelopes Grading

There is no standard grading envelope for subbases and it is intended that grading be left as flexible as possible. Consideration should however be given to specifying some grading requirements to ensure that compactability is not too difficult and that reasonable densities can be obtained. Savings made in buying a material without any grading controls can easily be lost in the additional construction costs necessary to achieve adequate densities and surface shape. Laying and compaction considerations may result in a maximum particle size smaller than 0.75 x (compacted layer depth).

For reasonable workability and density the general form of the M/4 grading envelope should be followed. This can be achieved by expressing the particle size to be controlled as a proportion of the topline and applying the M/4 controls for the particle size of equal proportion. Control is best applied to the fraction passing ¼ topline. For example, assuming a 75 mm topline, control would be effected at 19 mm since $19/75 = 0.25$.

The equivalent M/4 fraction is 9.5 mm (37.5×0.25) with envelope limits of

43 and 57%. Control of subbase gradings can be somewhat looser than for the M/4 material so that the subbase specification would require between say 40 % and 65 % passing the 19 mm sieve.

These requirements can be more readily appreciated if the particle size distribution requirements are presented on log/log paper where well graded materials plot as straight lines. The slope of the straight line particle size distribution describes the coarseness or denseness of the grading. The M/4 grading envelope is bounded by lines of slope 0.41 and 0.63. Limits described by lines of slopes 0.40 and 0.70 are appropriate for sub-bases, and can be transferred to other topsizes by shifting the upper and lower bounds as pairs of parallel lines.

It is important that water is not trapped in depressions on top of any subbase layer. Subbase material should therefore be capable of being shaped to provide an even crossfall without birdbaths. This requirement can be relaxed if the material is very open and is unlikely to hold water, or if the layer immediately above is less permeable.

5.3 Free Draining Requirements

The subbase material immediately beneath the basecourse must meet certain permeability requirements. See section 7 (permeability) for details.

5.4 Subgrade Compatibility

At the subbase/subgrade interface the two materials should be compatible to prevent the intrusion of fine subgrade particles into the subbase which could in turn reduce the subbase CBR below the value assessed in the pavement design.

To ensure compatibility a layer at least 75 mm thick should meet the following requirements:

$$\frac{d_{15}(\text{subbase})}{d_{85}(\text{subgrade})} < 5$$

$$\frac{d_{50}(\text{subbase})}{d_{50}(\text{subgrade})} < 25$$

or (for subgrades of medium and high plasticity clays)

$$\frac{d_{15}(\text{subbase})}{d_{85}(\text{subgrade})} < 5$$

$$\frac{d_{60}(\text{subbase})}{d_{20}(\text{subgrade})} < 20$$

d 10

where d 15 is the sieve size 15% of the material passes.

Instead of ensuring compatibility an alternative acceptable strategy is to assume that some subgrade intrusion is going to take place and to check that the assessed reduction in CBR for the "*intrusion zone*" at the bottom of that subbase layer does not invalidate the pavement design.

6. BEARING STRENGTH

The TNZ S/4 Pavement Design method uses the subbase CBR to determine the cover required over any layer. It assumes that at least 90% of the material will have CBRs in excess of the design value.

6.1 CBR Test

CBR tests shall be made on randomly selected samples tested and soaked according to NZS 4402 Part 2P:1981 Test 18(A), except that CBR values shall be reported to the nearest 1 in all cases thus modifying the requirement of clause 5.1.1.7(g) of the specification. The test samples should be surcharged to simulate the cover over the subbase in the pavement.

For the acceptance or rejection of an isolated unit of material one CBR test shall be performed, and the item accepted provided the CBR value is not less than the design value.

For the checking of larger quantities or areas the size of the lot (pavement area or unit of production) to be accepted or rejected shall be defined by the Engineer, and three to five tests carried out.

The size of the lot will be based on the Engineer's assessment of a lot which has homogeneous characteristics.

Let	c	=	a CBR value
	C	=	mean value of CBRs
	C _d	=	design CBR
	n	=	sample size
	s	=	standard deviation
ie,	s	=	square root ((sum of (c-C) ²)/(n-1))
	k	=	acceptability constant.

Then the lot will be accepted provided C is not less than $C_d + ks$, in which k is given in the following table:

n	k
3	1.3
4	1.2
5	1.1

This procedure gives for all sample sizes a 10% consumer (Engineer's) risk of accepting a situation in which 37% of CBR's values are below the design value. The producer (Contractor's) risk that an acceptable situation (just 10% of CBRs below design limit) be faulted varies from 42% for $n = 3$ to 33% for $n = 5$. This last fact shows the benefit of a larger sample size.

It should be noted that the acceptance criterion described above can be used to select a revised design CBR appropriate to the sample data. The revised design $CBR = C - ks$.

The CBR test samples should be compacted to densities and at moisture contents approximating those applying during construction. This is especially important when the sand equivalent of the material is less than 40 (when tested according to NZS 4402 Part 1:1980 Test 7) and there is more than 10% passing the 425 Fm sieve.

6.2 Waiving of CBR Test

The CBR test is performed only on that fraction passing the 19 mm sieve. If there is not sufficient of this fraction to fill the holes between the larger sized particles the CBR of the passing 19 mm material will have little effect on the stability of the subbase. This condition will apply for material with a topsize of 37.5 mm or less when the weight passing the 19 mm sieve is 55% or less, and for material with a topsize between 37.5 mm and 106 mm when the weight passing the 10 mm sieve is 25% or less.

In such cases and where the crushing resistance is greater than 100kN (when tested in accordance with NZS 3111:1980 Section 14), then the CBR test can be waived and the material can be assumed to have a CBR in excess of 40.

7. PERMEABILITY

Subbase material immediately beneath the M/4 basecourse layer must meet two permeability requirements:

- (a) The drainage channels in the voids of the material must be sufficiently large to prevent the adverse build up of pore pressure when the material is subject to traffic loads. This requirement is best satisfied by specifying a minimum Sand Equivalent value:

A subbase material with a CBR of more than 15 may be incorporated in a pavement at a depth appropriate to that CBR only if its Sand Equivalent is greater than 40 or if there is less than 10% by weight passing the 425 Fm sieve.

- (b) To ensure that the M/4 basecourse layer is kept in an unsaturated condition the subbase layer immediately beneath the basecourse must have a permeability of at least 10^{-4} m/s for a depth as indicated on the TNZ S/4 design chart (for unbound pavements this is 60 to 170 mm according to design loading). This order of permeability will not be hard to achieve if the weight passing the 150 Fm sieve is controlled.

This requirement can be waived if a suitable material is unreasonably expensive and the design loading is less than 1×10^5 EDA.

**EXAMPLE OF CUSTOM WRITTEN SPECIFICATION
FOR SUBBASE MATERIAL**

A pavement has been designed for a 20 year design loading of 5×10^5 EDA, the CBR of the subgrade being 5. The TNZ S/4 design chart was referred to, and a survey of available materials suggested the following layer thicknesses and choices of materials.

M/4: 140 mm

Upper subbase: 135 mm Consisting of run-of-crusher with CBR = 80, SE = 45, tosize = 40 mm, and 5% passing the 425 Fm sieve. The grading is indicated on figure 1.

Lower subbase: 215 mm Consisting of quarry strippings with CBR = 40, SE = 20, tosize = 60 mm, and 14% passing the 425 Fm sieve. The grading is indicated on figure 2.

The upper subbase thickness is in conformity to the S/4 permeability requirement. The work will be free from traffic during construction.

The designer has assumed that the bottom 145 mm of the quarry strippings may be subject to subgrade intrusion, possibly reducing the effective CBR to 10. No specific transition layer has therefore been thought necessary.

Specifications for materials satisfying the design requirements are attached. These example specifications define minimum characteristics, enabling prospective tenderers to consider materials other than those identified above. Double brackets enclose comments which are not part of the specification.

EXAMPLE OF SPECIFICATION FOR UPPER SUBBASE

1. GENERAL REQUIREMENTS

The subbase aggregate shall be free from all non-mineral matter.

2. TESTING

- (a) Tests to check compliance with the bearing strength requirements of this specification shall be carried out on samples randomly selected from a truck or stockpile at the site of works. Tests to check compliance with all other requirements of this specification shall be carried out on representative samples selected from bin, stockpile or truck. Representative samples shall weigh at least 30 kg.
- (b) Unless otherwise stated or implied below the following requirements shall be met by every representative sample tested.
- (c) The Contractor shall deliver a control sample, from the source approved at acceptance of tender, to the site in a covered location approved by the Engineer. The control sample shall have a volume of not less than 4 m³ and shall be supplied, covered, and finally disposed of at the Contractor's expense. The control sample must meet the requirements of this specification before any material is placed in the work.

All subbase aggregate supplied under this contract must come from the approved source and if a field examination indicates that any material is of inferior quality to that in the control sample the Contractor shall immediately suspend all delivery until laboratory tests show that the material does comply with the specification. If the Contractor elects to continue delivery the position of the material in the work must be marked and if any of the material fails to meet the specification the whole amount shall be removed from the site at the Contractor's expense.

3. GRADING

The material shall be well graded so as to comply with the bearing strength requirements of clause 4, and 100% by mass of the material shall pass the 75 mm standard sieve ((to be placed in one 135 mm layer)).

At least 45% by mass shall pass the 19 mm standard sieve (ensures reasonably fine material in the upper layers).

Not more than 70% by mass shall pass the 9.5 mm standard sieve ((ensures sufficient coarse material)).

Not more than 10% by mass shall pass the 425 Fm standard sieve ((therefore sand equivalent is not critical)).

((The implications of these criteria are shown on the attached figure 1.))

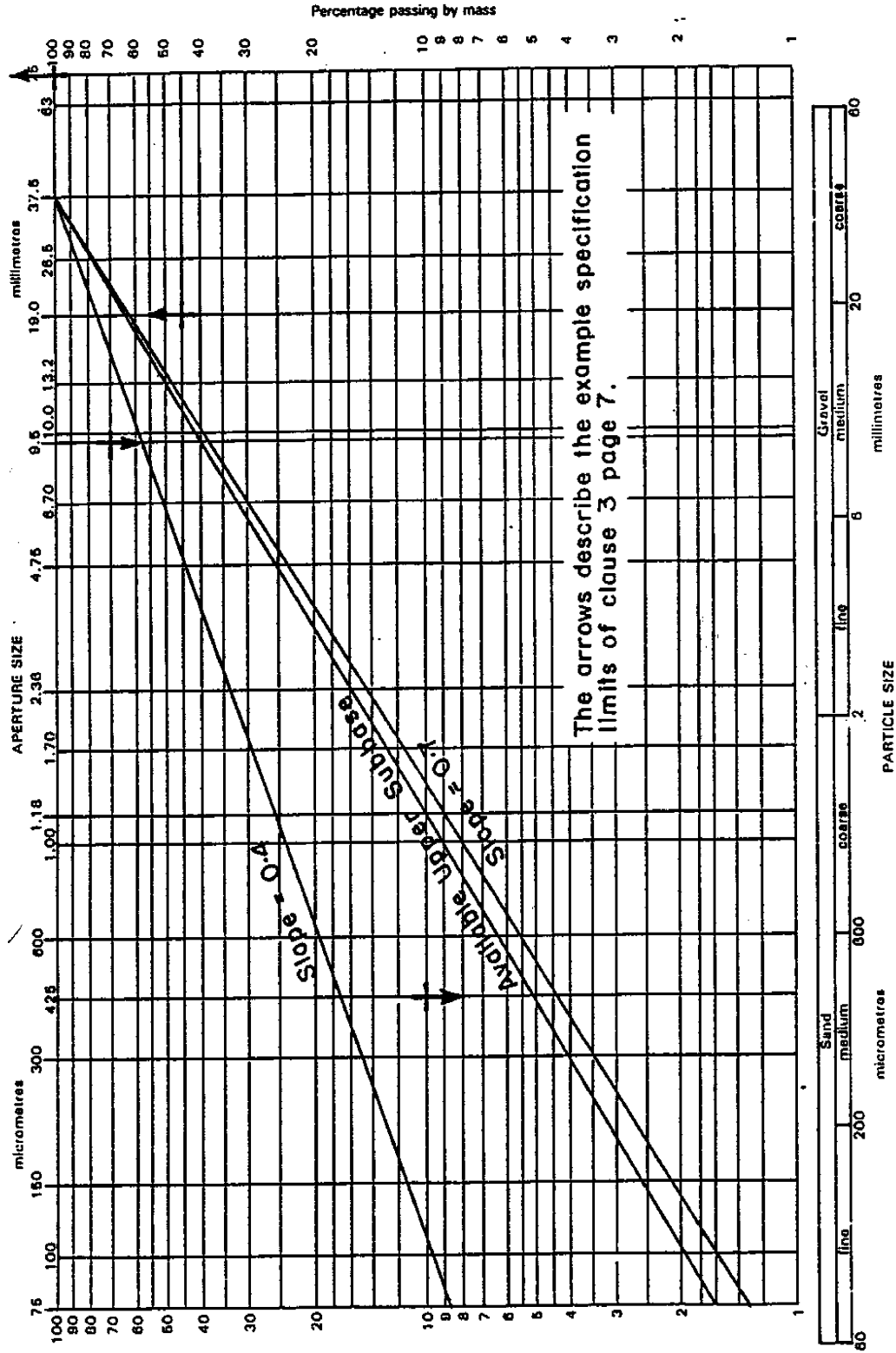
4. BEARING STRENGTH

Bearing strength determinations will consist of sets of three tests on samples randomly selected in accordance with clause 2 from a truck or stockpile at the site of works. The tests shall consist of soaked CBRs carried out according to NZS 4402 Part 2P:1981 Test 18(A). If the sample mean is C and the standard deviation is s then C must be not less than $40 + 1.3s$.

The bearing strength requirement may be waived at the discretion of the Engineer provided that the crushing resistance value is greater than 100 kN ((when tested in accordance with NZS 3111:1980 section 14)).

((If it is likely that particularly non-durable materials may be supplied, then consideration could be given to specifying that bearing strength samples should be obtained post-compaction during pavement construction. In general this should be avoided)).

Figure 1. Grading Criteria for Upper Subbase



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EXAMPLE OF SPECIFICATION FOR LOWER SUBBASE

1. GENERAL REQUIREMENTS

The subbase aggregate shall be free from all non-mineral matter.

2. TESTING

(As for upper subbase.)

3. GRADING

The material shall be well graded so as to comply with the bearing strength requirements of clause 4, and 100% by mass of the material shall pass the 106 mm standard sieve. No more than 50% by mass of the material shall pass the 4.75 mm standard sieve.

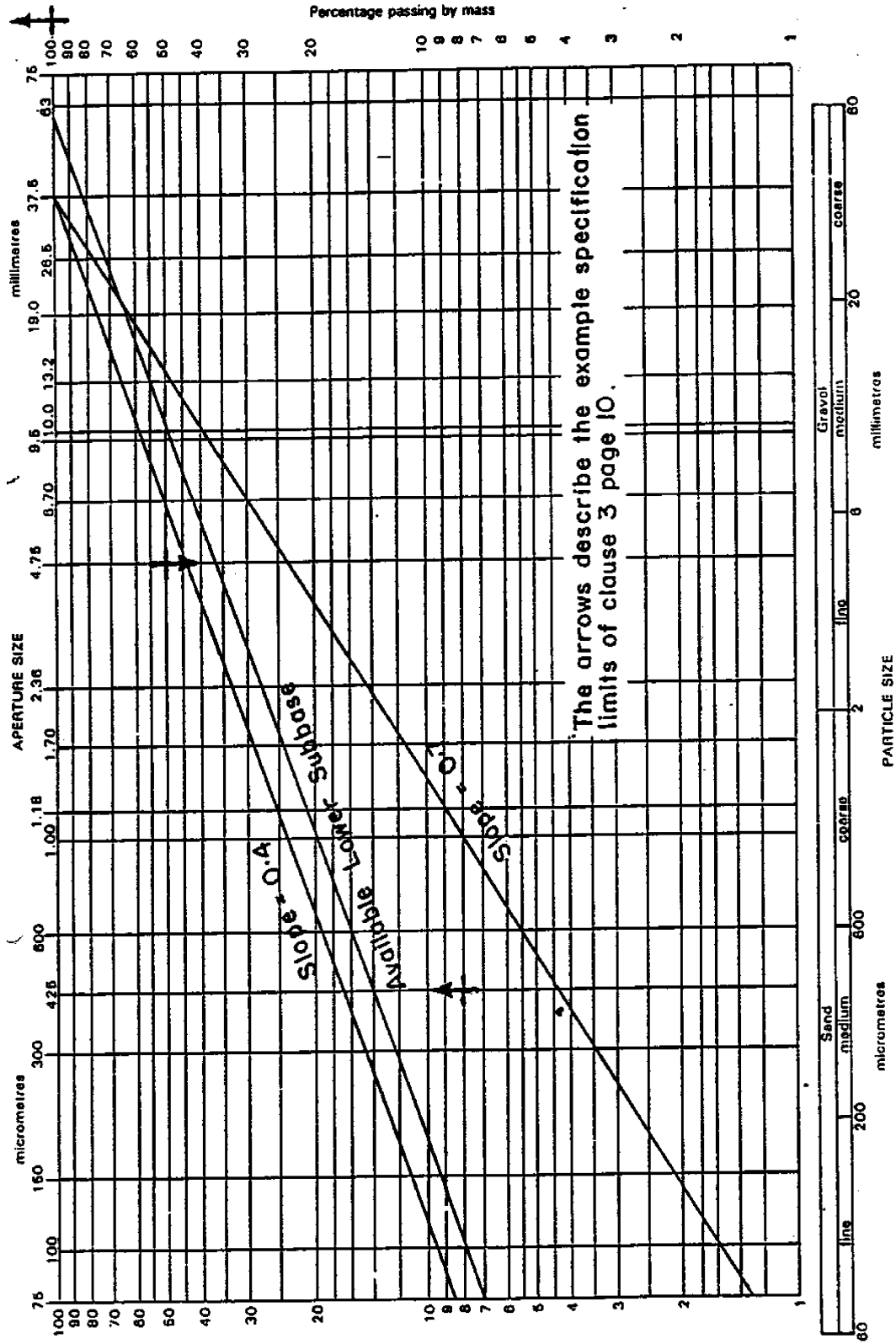
At least 8% shall pass the 425 Fm standard sieve ((this should be easily met and will ensure sufficient fines for compactability and to prevent excessive intrusion of the subgrade)).

((The implications of these criteria are shown on the attached figure 2.))

4. BEARING STRENGTH

(As for upper subbase except that) C must not be less than $15 + 1.3s$.

Figure 2: Grading Criteria for Lower Subbase



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