

## Draft Guidelines for the Sampling and Testing of Stabilised Materials during Construction

### 1 Introduction

#### 1.1 Objective

This guide is intended to provide a basis for sampling and testing stabilised materials during construction of a road pavement. It is applicable to:

- fine grained as well as granular soils,
- a range of different stabilisers including lime, cement and bitumen, and
- materials stabilised to different levels from modified to heavily bound.

The guide should facilitate the design of a test programme for use in a performance based contract under which the Contractor is responsible for the selection of the processes, materials and equipment necessary to obtain the specified results. If the results do not meet the requirements the Contractor has to change the process, material or equipment until the specified result is obtained.

The specification for a performance-based contract will require the preparation of a design and specification for the construction of a section of work. It will also specify that a Quality Plan should be produced.

#### 1.2 Definitions

	Definition
Engineer	Professional engineer or other one person identified in the Contract Documents.
Designer	Professional engineer responsible for the design of the pavement.

#### 1.3 Variability of Material

The variability of the materials used in road construction makes it difficult to achieve a consistent level of quality. In addition most of the material properties assumed in the design cannot be precisely measured in the field. At best, a number of indicative field tests have to be used to provide a degree of confidence that the design assumptions have been met.

Lack of uniformity in construction will sooner or later result in an increase in roughness in the surface of the road. For this reason it is important to ensure that a product meets the specified standard, and that the variability of the product is within acceptable limits.

The variability problem is dealt with in two ways. In the first instance by gathering an appropriate number of samples and secondly by ensuring that the range of the results lies within acceptable limits.

The number of samples will vary depending on:

- size of the project,
- variability of the material,
- importance, difficulty, duration and cost of the particular test,
- cost and time to sample the material.

The allowable range of the results should take into account:

- importance of the test,
- effect of variation on performance,
- practical limits of accuracy of the particular test.

#### **1.4 Test Regimes**

The current TNZ design manual (AUSTROADS Pavement Design) recommends that program CIRCLY be used for the design of pavements. Input parameters for this program include resilient modulus. It is also assumed that the materials have the required level of durability to more than just survive the design life. No test that can be carried out during construction will provide a measure of resilient modulus nor is there one that can predict durability.

Most of the tests carried out prior to and during construction are designed to confirm that the basic physical properties of a material such as particle hardness, particle size distribution, etc. are better than those of the material modeled in the design. If the physical properties correspond, it is likely that by the end of construction, the engineering properties will meet the designer's requirements.

#### **1.5 Pavement Performance**

ARRB Research Report ARR No 256 suggests that density and deflection are important indicators of long term performance of the pavement. It is suggested that the characteristic value of deflection is the Mean plus two standard deviations and that for relative compaction it is the Mean minus one standard deviation.

The ARRB research also indicated that the deflection of the subbase had a significant influence on the deflection of the final pavement while the influence of such things as density, moisture content, grading, were much less significant.

The tests carried out at the end of construction are intended to show that the pavement as a whole has the necessary level of stiffness and an acceptable level of roughness.

#### **1.6 Testing Materials During Construction**

The results of tests carried out during construction should confirm that the quality of the materials and their performance characteristics exceed the requirements specified by the pavement designer.

The nature of the tests and the results achieved will vary dependant upon the type of material used and the level of stabilisation. Some tests are common to all stabilisation processes including the application rate of the stabiliser, the efficiency of the mixing operation, water content and the in situ density at the end of compaction.

Field test equipment such as the Shear Vane, Clegg Hammer and Loadman Deflectometer can also be used to monitor quality.

The records kept during construction must include the area represented by each sample. In the event of an unsatisfactory test result it must be possible to locate the area from which the particular non-complying sample was taken.

The ultimate test of construction in terms of the design will be the stiffness and uniformity of the completed pavement.

## **2 Construction Tests Common to all Types of Stabilisation**

### **2.1 Application Rate**

#### **2.1.1 Batch Mixing**

For important projects the application rate of stabiliser, for batch mixing through a stationary mixer and the mass of soil stabilised, should be controlled by suitable automatic batch weighing equipment. The Contractor should be able to provide a record from the weighing equipment to demonstrate that the correct application rate has been used and that an appropriate level of uniformity has been maintained.

In the situation where the mixer is manually controlled, the Contractor should be in a position to convince the Engineer that an appropriate control procedure is in place. He should also be able to produce detailed records of the quantity of materials used and any variation in the batch mixing time.

For smaller projects, say one days work or less, the application rate of stabiliser should be controlled by weight while the aggregate processed could be controlled by volume.

#### **2.1.2 In situ Mixing**

Where in situ mixing with a rotary hoe is used, the Contractor should check the application rate by collecting samples from behind the spreader. Stabiliser materials applied in granular form should be captured on a metre square mat laid on the area to be stabilised. The quantity of liquid stabilisers should be collected on a metre square tray. In each case the quantity of stabiliser collected should be within the range specified by the Designer.

The depth of mixing should be checked frequently in the initial stages to determine any variation. Thereafter it should be checked at five locations equally spaced along the line of each pass of the hoe.

#### **2.1.3 Mixing**

The efficiency of the mixing operation is difficult to check. Most authorities suggest a visual inspection be carried out before the material is compacted. The addition of a stabiliser is likely to change the colour of the material so that uniformity of mixing can be judge on the uniformity of the colour of a sample taken from a batch mixer or as exposed say, in a shallow test pit.

The amount of mixing required should be decided at the following times

- start of a new job,
- start of each days work,

- when a new type of soil or aggregate is encountered,
- when a different piece of mixing equipment is brought to the site,
- when the depth of in situ hoeing is changed, or
- when a new batch of stabilising material is brought on to the site.

The amount of mixing required should then be converted to a particular rate of progress at a set mixing rate.

The mixing time for both types of mixing plant should be in excess of that required to ensure that the stabilising material is fully mixed with the soil. Records of batch mixed materials should record the production rate of the plant and the elapsed time between the start and finish of each batch. Those for in situ mixed material should note the area stabilised, the number of passes, the rotational speed of the hoe and the velocity of the stabiliser.

#### **2.1.4 Water Content**

The process of stabilisation with lime and/or cement, depends on having sufficient water available to completely hydrate the chemical additive and maintain the stabilised material at optimum water content for compaction. Stabilisation with liquids such as bitumen will introduce more liquid into the system than may be required. In this process it may be necessary to dry the soil before compaction is commenced.

It is therefore important to monitor the water content to ensure that the stabilised soil is brought to and maintained at optimum water content for compaction. It should be checked frequently throughout the process to ensure that the any significant variations are detected and corrected.

#### **2.1.5 Compaction Control**

The control of compaction is one of the most important aspects of the construction of the pavement. The stiffness and overall performance of a layer is dependent on the density achieved during construction.

The insitu density and water content should be determined using NZS 4402 test 5.1 or NZS 4407, Test 4.2 as appropriate. The results must be within the allowable range of values specified by the Designer.

Where the nuclear density gauge is utilized it is important that it be calibrated for the particular soil plus additive used in the field.

Compaction can be monitored using the Clegg Hammer or similar device, but the ultimate acceptance test should be either a minimum dry density or an in situ modulus value (Loadman or FWD).

#### **2.1.6 Layer Modulus**

The modulus of the stabilised layer can be measured in situ using a Loadman or trailer mounted deflectometer or estimated from the results of an in situ CBR test.

An adequate period of time should be provided so that the material can be tested after the required curing period has expired. Any cover applied to the layer to facilitate curing should be removed temporarily to expose the surface for testing.

## 2.2 Specific Construction Tests

### 2.2.1 Fine grained soils

#### 2.2.1.1 Modified Soil

Most clays, silts and sands are amenable to stabilisation with lime, cement or bitumen (and possibly mixtures of these). However some may not react with a particular stabiliser or it may be difficult to achieve the required level of dispersion of the stabiliser through a particular soil.

The soil must first be hoed to break it down so that 80 – 90 percent passes a 26.5mm sieve.

The shear strength of a material is normally accepted as being satisfactory if the material meets a specified CBR value.

Durability and weathering resistance are not considered to be a problem related to stabilised fine grained soil in New Zealand and these factors do not have to be addressed further.

The soaked CBR test is generally accepted as the main measure of stiffness and strength. The test should be carried out on material sampled from the mixer or from behind the hoe (as the case maybe). It should be compacted to the minimum density achieved in the field and at the field water content. The test method should be based on NZS Standard Compaction (NZS 4402:4.1.3). The stabilised sample should be cured for three days and then soaked for 4 days. Subsidiary tests could include Atterberg Limits, to characterise the soil. The minimum soaked CBR value should be not less than the design value plus 10%.

#### 2.2.1.2 Bound Soil

In most instances increasing stiffness and reducing the water sensitivity of clayey and silty materials by modification is all that is required. Excessive quantities of stabiliser can significantly increase the risk that cracking caused by shrinkage or fatigue will occur. However, in some instances the stiffness of sands and sandy silt will need to be increased to the lightly bound or even heavily bound category. In such cases the sampling and testing programme should follow that set down for granular material.

### 2.2.2 Granular Material

#### 2.2.2.1 Modified

The shear strength of the modified material is normally accepted as being satisfactory if the soaked CBR value exceeds the specified value. The method should be similar to that described in 2.2.1.1 above, except that the sample will have to be sieved to remove all material greater than 25mm.

The aggregate to be stabilised is unlikely to have the crushing resistance and weathering resistance values specified in TNZ M/4 and the strength of the material is unlikely to meet the requirements of the ASTM 559-96 test specified for bound material. It is therefore necessary to evaluate the weathering resistance in terms of the proposed use of the modified aggregate. After stabilisation the material to be used as basecourse or subbase should have the following properties:

Layer	Ten Percent Fines Value (kN)	Soaked CBR (%)	Clay Index (maximum)
Basecourse	130	100	3
Subbase	NA	30	5

The test should be carried out on material sampled from the mixer or from behind the hoe (as the case maybe). It should then be compacted to the minimum density achieved in the field and at field water content. The test method should be based on NZS Vibrating Hammer Compaction (NZS 4402:4.1.3). The stabilised sample should be cured for three days and then soaked for 4 days. The Clay Index test should be carried out on the material salvaged from the mould after the CBR test has been completed in order to replicate to some degree the processes that the material will be subjected to in the field.

Samples stabilised with bitumen should be cured in a dry environment for an appropriate period to permit the bituminous binder to set up. It should then be soaked for four days

Subsidiary tests include Particle Size Analysis, Atterberg Limits and/or Clay Index tests for aggregate identification purposes.

### **2.2.2.2 Bound**

AS 1141.51 Unconfined Compressive Strength Test (UCS) is the main test used to categorise cemented material. It should be carried out on 100mm diameter by 125mm long samples obtained from the treated layer using a diamond tipped core tube. Over length samples should be trimmed back to 125mm. The samples should be taken seven days after construction has been completed and then held for a further 21 days in a controlled humidity room. The UCS at 28 days should be compared with the values on which the design was based. Special criteria may be required for the evaluation of materials stabilised with slow setting binders. Such materials could continue to gain strength and stiffness for 6 – 12 months.

## **3 Post Construction Tests**

### **3.1 Introduction**

The completed road has to provide a level of service that is acceptable to Transit New Zealand. While the pre-construction and construction tests should provide a level of confidence that the materials and processes being used will provide a satisfactory product, it is necessary to confirm that the new pavement conforms to the designers expectations. This can be most readily achieved by comparing the deflection of the pavement with that calculated using Program CIRCLY.

### **3.2 Deflection**

The deflection of the pavement should be determined using a test procedure such as that set out in *TNZ T/1 Benkelman Beam Deflection Measurements, June 1977*. The  $D_{95}$  deflection should be not greater than that nominated by the Designer and no deflection shall exceed the Mean Value plus 2.5 times the Standard Deviation.

## **4 Quality Plan**

The Contractor will be required to prepare a Quality Plan describing the procedures it intends to put in place to ensure that the quality of the stabilised pavement exceeds the specified requirements. The purpose of such a plan is to describe the processes and organisation by which construction quality control will be obtained using visual inspection, control and record testing and reports. The plan involves the development of:

- an inspection plan,
- technical checklists,
- a list of selected standard control tests,

- a strategy for recording and analysis of test results, and
- reporting procedures.

The Plan should include a description of such things as:

- quality control procedures
- the type of tests to be used
- frequency of testing
- protocol for recording information
- protocol for dealing with out-of-spec items.