

SECTION R6

Selected granular material-sub-base course

R6 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor, and in performing all operations in connection with the construction of a selected granular material sub-base course on a prepared subgrade, complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the applicable drawings and the directions of the Engineer's Representative.

R6 02 Materials

The Materials shall consist of: sand, gravel or a sand-gravel mixture obtained from the source or sources shown on the Drawings, or selected by the Contractor and approved by the Engineer's Representative. Preliminary approval of a source shall not mean that all material in the source is approved. The sub-base material as finally graded and compacted to the correct profile on the subgrade shall comply with the following requirements:-

Coarse Aggregate (that retained in 2mm (No. 10) sieve). Coarse aggregate shall consist of hard, durable particles or fragments of gravel free from dirt and other objectionable matter. It shall have a percentage of wear not exceeding 45 when tested in accordance with AASHTO standard method T96-74.

Fine aggregate (Passing the 2mm sieve). The fine aggregate shall consist of sharp natural sand or a well graded mixture of sharp natural sand, silt, clay, and stone dust or other similar binding or filler materials from approved sources.

It shall not contain more than 2% of organic matter when tested in accordance with test No. 8 or BS 1377. Soluble salts shall not be more than 10% when tested according to the Earth Manual of U.S Bureau of Reclamation Appendix E8 with maximum dilution of 1:50. The sulphate content in terms of SO₃, shall not be more than 5% by weight when tested in accordance with BS 1377 test No. 9 (i.e. gypsum content equals to 10.75%). The content of clay lumps (AASHTO T 112) shall not be more than 0.25%. The fraction passing the 0.075mm (No. 200) sieve shall not be greater than material passing the 0.425mm (No. 40) sieve.

The material passing the 0.425mm (No. 40) sieve when prepared in accordance with AASHTO T 146 and tested by the appropriate methods shall conform with the following requirements.

Property	Standard Method	Maximum
Liquid Limit	AASHTO T99	25%
Plasticity index	AASHTO T90-70	6%

Selected Granular Material – Sub-Base Course

When used for shoulders of roads without an impervious surfacing, and for a subbase layer which is kept uncovered as the surface course for several years, the liquid limit should not exceed 35% and the Plasticity index should fall in the range 4% to 9%.

The granular subbase shall be in accordance with table R6/1 Type A, B, C or D. The last one (type D) can be used for the stabilization of shoulders and for the replacement of unsuitable soil.

The grading type and total thickness shall be as shown on the drawings or described in the Bill of Quantities.

The grading as used in the work shall not vary from the low limit on one sieve to the high limit or the adjacent sieve, but shall be uniformly graded.

Table R6/1

Selected Granular Material – Grade Requirements

US Sieve Size		Percent Passing by Weight			
mm	Alternative	Type A	Type B	Type C	Type D
75	3 in	100			
50.0	2 in	95-100	100		
25.0	1 in		75-95	100	100
9.5	3/8 in	30-65	40-75	50-85	60-100
4.75	No. 4	25-55	30-60	35-65	50-85
2.36	No. 8	16-42	21-47	26-52	42-72
0.3	No. 50	7-18	14-28	14-28	23-42
0.075	No. 200	2-8	5-15	5-15	5-20

The California Bearing Ratio for Types B, C & D when tested in accordance with ASTM D 1883 using modified compaction shall not be less than 35% for type B, 30% for type C, & 20% for type D at 95% of the maximum density established according to AASHTO T180 or ASTM D 1557.

The material shall be laid and compacted to the requirements of Clause R6 12 and with the minimum of drying out or segregation.

Where the Contractor proposes to use the sub-base for construction traffic he shall at his own expense increase the thickness and strength of the sub-base to accommodate the method of construction and the type of plant and vehicles which he proposes to use. Such thickening shall be across the whole width of the carriageway, unless otherwise agreed by the Engineer's Representative.

The increased thickness of the sub-base course shall be achieved by lowering the formation level by an amount equal to the increase in thickness of the sub-base course.

R6 03 Sampling and testing

The sources of material shall be selected in advance of the time when the material will be required in the Work and adequate representative samples submitted to the Engineer's Representative for testing and preliminary approval not less than 20 days before such material is required for use in the Work.

The Employer will sample and test the materials on the site as frequently as deemed necessary. Any material found not to conform with the requirements, then or later: will be cause for rejection. All rejected material shall be removed and replaced by the Contractor with material meeting the requirements at no cost to the Employer.

R6 04 Equipment

All equipment, tools and machines used in the performance of the work shall be either new or in the top grade second hand condition and be subject to the approval of the Engineer, and shall be maintained in satisfactory working condition at all times.

Blade Graders. Blade graders shall have an adjustable blade for slopes and shall be self-propelled. Other approved suitable spreading equipment may be used.

Sprinkling Equipment. Sprinkling equipment shall be suitable for applying water uniformly and at controlled quantities to variable widths of surface.

Transporting and Mixing Equipment. The mixing equipment shall be of an approved type that will collect and thoroughly mix the material that has been spread on the subgrade or the material transported to. a spreader-mixer. The addition of water shall be metered and the mixing controlled so that the resulting mixture is entirely uniform and at the specified moisture content for maximum density.

Transport vehicles carrying plant-mixed material shall have a capacity suited to the output of the mixing plant and the site conditions, and be capable of discharging cleanly. Material when mixed shall be removed at once from the mixer, transported directly to the point where it is to be laid and protected from the weather, both during transit from the mixer to the laying site and whilst awaiting tipping.

Compaction Equipment. Compaction equipment shall be of the most suitable type for compacting the sub-base material to the density specified and can comprise smooth wheeled power rollers, pneumatic tired rollers, rubber-tired compactors, vibratory rollers, vibrating-plate compactors or vibro tampers, all operated to the specified number of passes to achieve the maximum specified density obtained in trials on the materials.

R6 05 Operation of quarries, pits and stockpiling

All strata and pockets of unsuitable material overlying or occurring in the deposit shall be hauled to spoil. The method of processing and blending the material and of operating the pit shall be changed or modified to obtain material conforming to the specified requirements as directed by the Engineer's Representative.

Approved sand may be stockpiled in the manner and at the locations approved by the Engineer's Representative. Prior to stockpiling, storage sites shall be cleared and leveled by the Contractor.

In sand and gravel pits, or works stockpiling areas which are close to the water table, precautions shall be taken against contamination by crystal mush or surface crusts on a pit floor or other stockpile area by the provision of an approved impervious membrane before stockpiling.

R6 06 Weather limitations

Sub-base shall be constructed only when weather conditions do not detrimentally affect the quality of the finished formation. It shall not be placed when the temperature is below 3°C. Any area of the sub-base that are damaged by the effects of freezing temperatures or other weather conditions during any phase of construction shall be completely scarified, re-shaped and re-compacted in conformance with the requirements of this Specification without additional

R6 07 Preparation of sub grade

Prior to construction of the sub-base course, the previously prepared formation shall be cleaned of all foreign substances, freed from mud and slurry and properly shaped and compacted by rolling to an even and uniform surface as shown on the Drawings. Any ruts or soft yielding spots which occur in the sub grade, any area having inadequate compaction, or any deviation of surface from the requirements specified shall be corrected by scarifying, removing and/or adding approved material, re-shaping and re-compacting the unsatisfactory areas to the required density and to the established line and grade. Appreciable irregularities in the surface of the subgrade shall be corrected by blading and rolling, adding water where necessary.

R6 08 Grade and alignment control

Grade and alignment control stakes shall be furnished, set and maintained by the Contractor, subject to checking by the Engineer's Representative, in order that the work shall conform to the lines, grades and cross-sections shown on the Drawings. The stakes shall be set in rows on and parallel with the centerline of the pavement and spaced so that string lines may be stretched between them, but in no case more than 15m apart.

R6 09 Placing and spreading

Where the sub-base course thickness exceeds 20cm, it may be constructed in two or more layers of equal thickness depending on the compaction equipment available. No superimposed layer shall be placed before the previous layer has been approved by the Engineer's Representative.

All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Sub-base material shall be spread using a mechanical spreader or spreader box operated with a mechanism which levels off the material to an even depth.

A templet cut to the camber or crossfall of the finished course shall be used for checking.

R6 10 Mixing

Mixing shall be accomplished in one or more passes of the mixer through the material, but in any event shall be continued until the resulting mixture is entirely uniform and of proper moisture content. If at any time the material is excessively moistened during construction, it shall be aerated by re-mixing until the moisture content is acceptable. Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirements specified, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly mixed into the sub-base material, adding water as required to obtain the specified density.

Any other satisfactory method of mechanical mixing of the sub-base materials may be employed subject to the approval of the Engineer's Representative.

R6 11 Compaction

Each layer shall be compacted until the entire depth of the course is at least 95 per cent of density at optimum moisture as determined by AASHTO T180-74 or 95 per cent of the maximum dry density achieved in the BS Compaction Test 4-5kg rammer (Test 12) in BS 1377(1975).

Compaction shall be completed as soon as possible after the material has been spread.

The surface of any layer of material shall on completion of compaction be well closed, free from movement-under compaction plant and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

R6 12 Thickness and finish

The surface of each sub-base course shall be properly shaped to a smooth uniform surfaced parallel to the finished surface of the carriageway and shall not vary more than 2cm when tested with a 4m straight edge.

The entire work must be constructed to the exact position and level in conformity to the lines and grades shown on the Drawings. The tolerance for level is + 1 cm to -2)cm.

The completed sub-base courses will be tested for the required thickness and surface before acceptance. The tolerance for thickness is +10% to -15%, Any areas of the completed sub-base having a compacted thickness less than the thickness shown in the respective items of the Bill of Quantities and/or on the Drawings or where any tolerance is exceeded shall be rectified by scarifying the top 7.5mm, reshaping with added material and re-compacting all to the Specification. This area treated shall be not less than 30m long and 2m wide or such length to be determined by the Engineer's Representative as necessary to obtain compliance with the Specification. Skin patching of an area without scarifying the surface to permit proper bonding of the added material will not be permitted

R6 13 Maintenance

The completed sub-base course shall be maintained in an acceptable condition at all times, as directed by the Engineer's Representative prior to the construction of the road base. Traffic will not be permitted on the sub-base during the rainy season,

R6 14 Measurements

The unit of measurement for the sub-base course shall be the square meter. The number of square meters shall be the accepted sub-base course as measured in place. Measurement shall not include any areas in excess of those shown on the Drawings, except for any areas authorized by the Engineer in writing,

R6 15 Payments

The area of sub-base course, determined as specified in Clause R6 14 will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub-base course, including preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labor: the handling, mixing, manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures: maintenance: and for furnishing of all other labor, and incidentals necessary for the completion of the work required by this Section of the Specification,

SECTION R6E

Soil cement stabilized sub grade, sub-base or base

R6E 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor and in performing all operations in connection with constructing soil cement stabilized subgrade, sub-base layer or base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R6E 02 Materials

1. **General:** The mix-in-place method of construction will only apply to sites with naturally occurring sand, gravel, or sand and gravel mixture, unless otherwise provided in the Special Specification of Particular Application. For the stationary plant method of construction, the materials shall comply with the Specification or materials from any other sources selected by the Contractor shall be subject to the approval of the Engineer's Representative.

2. **Soils:** Soils are divided into two groups according to their type:

- (i) **Silty and clayey soils** (for sub grade). When this type of soil is used for cement stabilization it shall fulfill the following requirements:
 - (a) Maximum liquid limit 45%
 - (b) Maximum plasticity index 20%
 - (c) Ph value of soil-cement tested in accordance with BS 1924 (1975) not less than 12· 1
 - (d) Maximum content of soluble salts
 - Sulphates 4%
 - Chlorides 8%
 - (e) Finer than 0.002 mm (clay) below 35%

If the soil at the site does not meet the conditions mentioned under (c), the soil shall be improved on the basis of laboratory testing by adding calcium chloride up to 2% of the weight of the dry soil. The addition of calcium chloride might help in achieving the strength requirement.

- (ii) **Sandy and gravelly soils.** Sandy and gravelly soils used for cement stabilization shall fulfill the following requirements:
 - (a) Passing maximum size 50mm sieve 100%
 - (b) Passing 5mm (No.4) sieve above 50%
 - (c) Passing 0.4mm (No. 36) sieve above 50%
 - (d) Passing 0.075mm (No. 200) sieve below 5%
 - (e) Finer than 0.002mm (Clay) below 3%

Soils which do not meet these requirements shall be subject to the approval of the Engineer's Representative, whose decision will be made following laboratory testing.

- (iii) **Cement** : The cement to be used for stabilization shall be Portland cement, or sulphate resistant cement as directed by the Engineer's Representative according to the results of laboratory tests. The Portland cement shall conform to the requirements of BS 12 Part 2 (1971) Portland cement (ordinary and rapid hardening), BS4027 Part 2 (1972), or to AASHTO M85-74 Type V for High Sulphate Resistant Portland Cement.

For storage of cement at least two silos shall be used. Before recharging a silo it shall be emptied completely and cleaned. During the time of charging a silo shall not be used for batching. The silos and all batching devices shall be maintained regularly.

At the time of use all cement shall be free-flowing and free of lumps. Under normal circumstances cement shall not be stored for a longer period than four months. Any cement that has remained in store for a period in excess of four months, or of which there is any doubt as to its quality, shall be re-tested by standard mortar tests to determine whether it still meets the requirements of BS4027 Part 2 (1972). No such cement shall be used in the Works without the approval of the Engineer's Representative.

- (iv) **Water**: The water to be used for cement stabilization shall be clean and free from injurious substances. Water from doubtful sources shall not be used until tested as specified in AASHTO T26-72 and approved by the Engineer's Representative.

R6E 03 Mix design

Before starting the work of stabilization, the proposed mix design shall be submitted by the Contractor for the approval of the Engineer's Representative. The mix design shall indicate the exact percentage of cement and water to be used so as to obtain a mixture with the following properties. The mix design shall be in accordance with AASHTO T134.

1. The compressive strength of one set of 3 test specimens shall be 25 to 50kg/cm² after storage in a box with minimum humidity 95% for a period of 7 days. The moulding shall be in accordance with AASHTO T134 and the testing shall be in accordance with AASHTO T22.
2. The maximum permissive swelling of volume shall be 2% and the maximum loss in weight 8%. (Testing shall be performed in accordance with AASHTO T135-70).
3. Tolerances allowed on the site.
Cement content - 1 to + 2% of that given in the mix design
Water content 0 to + 2% of that given in the mix design

R6E 04 Composition of mixture

The granular material shall be mixed with sufficient cement to provide a crushing strength to the requirements stated in this Clause.

The cement content shall be determined at the laboratory so that the minimum compressive strength is 25 kg/cm² and an average compressive strength of the test specimens is 35kg/cm² minimum at 7 days.

The moisture content of the mixed cement stabilized material shall be not less than the optimum as determined by the Vibrating Hammer Method Test of BS 1924, (1975) nor more than 2 per cent above the optimum as determined by this test or such higher value as may be agreed by the Engineer's Representative on the basis of the preliminary trial. (This test is identical to Test 14 of BS 1377 (1975) for soil susceptible to crushing during compaction.

Alternatively tests shall be carried out in accordance with AASHTO T134-70 at the optimum moisture content. The samples shall be kept moist for 7 days in a storage box located in the shade at the site of the Works. Before crushing, the samples should be kept for 2 hours in the water. A swelling test shall be performed according to AASHTO T 135.

The permissible swelling shall be 2% in volume and the maximum loss of weight shall be 8%.

The tests shall be made for each type of material subject to cement stabilization.

R6E 05 Equipment and method of stabilization

Equipment, tools and machines used in the performance of the work covered by this Section of the Specification shall be subject to the approval of the Engineer's Representative and shall be maintained in a satisfactory working condition at all times.

The thickness of layer to be stabilized shall be not less than 8cm when compacted. If the compacted thickness does not exceed 20cm and provided the plant meets the requirements specified in this Clause, the material may be constructed in one layer using either stationary plant or mix-in-place for the mixing process. If the course to be stabilized exceeds 20cm in thickness when compacted it shall be constructed in two or more layers each within the range 8 to 20cm in compacted thickness. When two or more layers are employed the mix-in-place process will be permitted only for the construction of the bottom layer.

Cement stabilized subgrade, sub-base or base shall be constructed only when the atmospheric temperature is above 4°C and when the weather is not rainy.

R6E 06 Stationary plant method of construction

If stationary plant is used it shall be of the power driven paddle or pan type and may be of the batch or continuous type

If batch mixers are used the appropriate measured amounts of material and cement shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range specified in this Clause. Special care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers the cement is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized. Mixing shall be continued until the mixture has the uniformity required by this Clause and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer's Representative after satisfactory preliminary trials.

If continuous mixing is used the paddles, baffles and rate of feed of materials shall be adjusted to give a uniformly mixed material.

If a spray is used for distributing water into the mixer, it shall be adjusted to give uniformity in moisture content throughout the mix.

R6E 07 Mix-in-place method of construction

The plant used for pulverizing and mixing the stabilized material will be approved by the Engineer on the basis of preliminary trials to establish that the plant is capable of producing the degree of mixing and uniformity of stabilized material specified in this Clause to the full thickness of the layer being processed. For granular materials both single and multi-pass equipment may be used.

The mixers shall be equipped with a device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times. The cement shall be spread ahead of the mixer by means of a cement spreader, fitted with a device to ensure a uniform and controllable rate of spread of cement both transversely and longitudinally.

If multipass processing is employed, the naturally occurring granular material shall first be pulverized to the required depth with successive passes and the moisture content adjusted if it is more than 3 per cent below the value required for compaction. The cement shall then be spread and mixing continued with successive passes until the required depth and uniformity of processing has been obtained.

If it is necessary to adjust the moisture content of the material to the optimum for compaction, water shall be added during the mixing operation using a water sprayer of such design that the water is added in a uniform and controllable manner both transversely and longitudinally.

The mixing machine shall also be set so that it cuts slightly into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

The Engineer may approve the use of scarifier or prepariser ahead of the mixer.

The output of the mixing plant shall be such that a minimum rate of 22 linear meters per hour measured longitudinally of completed stabilized layer can be maintained in order to permit satisfactory compaction of the material.

R6E 08 Compaction

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with approved rollers. Compaction shall continue until the entire depth and width of the subgrade or sub-base is uniformly compacted to the minimum density of 95% modified AASHTO according to AASHTO T134-70. The compaction shall be completed as soon as possible after mixing, normally within two hours. This period depends mainly on the setting time of cement and the weather conditions.

The minimum state of compaction to be attained will be determined by the Preliminary Trial to meet the requirements of Clause R6-11.

Compaction shall not take place after cement hydration and any soils cement material which has been mixed or deposited after cement hydration shall be removed and replaced with fresh material mixed and treated in accordance with the requirements of this Section.

R6E 09 Preliminary trial

At least 10 days before the main work of stabilization is started, the Contractor shall construct an area of stabilized material of 400-80001' as a preliminary trial at a location to be approved by the Engineer's Representative. For this trial, the Contractor shall use the materials, mix proportions, mixing layer compaction plant and construction procedure that he proposes to use for the main work.

The preliminary trial is to test the efficiency of mixing, spreading and compaction plant and the suitability of the methods and organization proposed by the Contractor. The results of the dry density measurements made in the stabilized trial area will be used to confirm the moisture content and minimum state of compaction to be attained in the main stabilization work.

R6E 10 Thickness and finish

The surface of the subgrade and each sub-base course or base shall comply with the requirements of Clause R6 12. Any modification to meet the Specification shall be completed, together with the compaction, within two hours after mixing and any removal of, or making good to deficient areas will be at no cost to the Employer. The thickness shall be as shown on the Drawings or as directed by the Engineer's Representative and shall comply with the following requirements:

- (i) The tolerance for level shall conform to Clause R5 12 (2) for Earthworks and Table R 9/6 as amended for other layers of construction.
- (ii) In-situ dry density of compacted layers minimum 95% modified AASHTO according to AASHTO T134-70.
- (iii) The smoothness of the finish surface shall not vary by more than 2cm when tested with a 4m straight edge.
- (iv) The maximum tolerance of the crossfall shall be $\pm 0.5\%$.

R6E 11 Curing and maintenance

After compaction the stabilized subgrade, the sub-base layer or base shall be protected against drying out by keeping it continuously damp or wet for a period of at least 3 days or by coating with an approved curing material as directed by the Engineer's Representative. The rate of application of the curing material shall be as directed by the Engineer's Representative.

The completed cement stabilized subgrade, sub-base or base shall be maintained in an acceptable condition at all times, as directed by the Engineer's Representative, prior to the construction of the base course.

No vehicular traffic shall run on the stabilized subgrade, sub-base layer or base until the curing period as directed by the Engineer's Representative has elapsed, with a minimum no-traffic period of 7 days.

One day shall be added to the period which would otherwise be required before running traffic of any sort on it for each night on which the temperature of the surface of the layer in

question falls to 0°C or below.

R6E 12 Sampling and testing

Tests shall be made as often as deemed necessary to ensure compliance with the requirements of this Specification and in accordance with Clause R603.

The minimum number of tests shall be generally as follows:

For every 5,000m² of completed stabilized layer immediately after completion of compaction:

Insitu density	AASHTO T191-61 (1974) or AASHTO T205-64 (1974) or AASHTO T238-73
Grading Test	AASHTO T27-74
Cement Content Test	AASHTO T211-65 (1974)

For every 10,000m' of completed stabilized layer or for one day's run:

One set of 3 test specimens for testing the compressive strength, grading and curing of specimen according to Clause R6 E03.

The material shall be taken from the construction site before compaction.

For every 50,000m² of completed stabilized layer:

One moisture density relation test AASHTO T134-70 with material taken fresh from the construction site.

The thickness of the stabilized layer shall be checked while determining the in-situ density.

R6E 13 Measurement

The unit of measurement for payment shall be the square meters of completed and accepted subgrade, sub-base or base as measured in place. Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorized by the Engineer in writing.

R6E 14 Payment

The square meters of subgrade, sub-base or base, determined as specified in Clause R6E 13, will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub-base course, including preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labor; the handling, mixing, manipulating, placing, shaping, compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance including the protection of stabilized layers; and the furnishing of all other labor and incidentals necessary for the completion of the work required by this Section of the Specification.

SECTION R6F

Lime stabilized subgrade or sub-base

R6F 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor and in performing all operations in connection with the construction of lime stabilized subgrade or sub-base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and the applicable Drawings and the directions of the Engineer's Representative.

R6F 02 Materials

1. **General:** The mix-in-place method of construction will only apply to sites with naturally occurring heavy clay soils, clayey gravels or soils containing a sufficient proportion of clay to enable satisfactory stabilization with lime, unless otherwise provided in the Special Specification of Particular Application. For the stationary plant method of construction the materials shall comply with the Specification or materials from any other sources selected by the Contractor shall be subject to the approval of the Engineer's Representative.

Lime stabilization has been successfully used in clayey soils which have a plasticity index greater than 8. This type of stabilization can only be used for soils which contain a high percentage of clay or silty clays.

2. **Lime:** The lime to be used for stabilization shall be calcium hydroxide (slaked or hydrated lime) or calcium oxide (quicklime) conforming to the requirements for building lime as Table R6F/ I, or lower quality lime produced from temporal' burning pits or kilns when approved by the Engineer's Representative.

TABLE R6F/I
SPECIFICATION REQUIREMENTS FOR LIME

Property	LIME	
	Quicklime (CaO)	Hydrated Lime (Ca(OH) ₂)
Calcium and magnesium oxides	Not less than 92 percent	Not less than 95 percent
Carbon dioxides - at kiln -elsewhere	Not more than 3 percent	Not more than 5percent Not more than 7percent

The properties of lime shall be in accordance with AASHTO M 216 and shall be tested in accordance with AASHTO T219,

3. **Water:** The water to be used for lime stabilization shall be clean and free from injurious substances, potable water is preferred and organic water not permitted. Water

from doubtful sources shall not be used until tested as specified in AASHTO T26-72 and approved by the Engineer's Representative.

R6F 03 Composition of mixture

1. **General:** The soils containing clay shall be mixed with sufficient lime to provide a crushing strength to the requirements of this Clause: this should normally be between 3% and 8% lime content and as a guide trials should commence at 1% of lime for each (by weight of dry soil) 10% of clay in the soil.

The lime content shall be determined by laboratory mixing and tests so that the average compressive strength of any ten consecutive field determinations is not less than 1.0 N/mm^2 with not more than two results below this figure and no result less than 0.7 N/mm^2 at 7 days as specified in the Special Specification for Particular Application

The moisture content of the mixed lime stabilized material shall be in accordance with the tests in Clause R6E 03.

2. **Testing:** The following tests shall be carried out on the soils to decide on their suitability for use in the mixture.

- | | |
|----------------------------|-------------------------|
| (i) Particle size analysis | AASHTO T88 |
| (ii) Atterberg limits | AASHTO T89 & AASHTO T90 |
| (iii) Acidity | BS 1377, Test No. 11 |
| (iv) Compaction test | AASHTO T99 |
| (v) Natural water content | AASHTO T93. |

3. **Mix Design:** The mix design shall be worked out in the laboratory and it shall state the following. The mix design shall be in accordance with AASHTO T220.

- (i) The percentage of lime and water (optimum content and tolerances).
- (ii) The density of lime stabilization mixture minimum 95% modified AASHTO T220.
- (iii) The required results of the compressive strength at 7 days, which shall not less than 1.0 N/mm^2
- (iv) The minimum number of tests to be carried out.

R6F 04 Equipment and method of stabilization

The requirements of this Section shall be in accordance with Section R6E_

When using calcium oxide (quicklime), its caustic nature will require special consideration in handling, since it will attack equipment corrosively and precautions shall also be taken against the risk of severe skin burns to personnel.

Suitable handling methods shall be used, such as fully mechanized or bottom dump handling equipment, or protective clothing worn by the operators. Working operations should take into account the wind direction to minimize the dust problem and consequent eye or skin irritation to any personnel involved or in the vicinity.

Even when calcium hydroxide (slaked or hydrated lime) is used, care must be taken

against the effects of prolonged exposure to the skin.

R6F 05 Stationary plant method of construction

The requirements of this Section shall be in accordance with Section R6E.

R6F 06 Mix-in-place method of construction

The requirements of this Section shall be in accordance with Section R6E.

R6F 07 Compaction

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with approved rollers. Compaction shall continue until the entire depth and width of the subgrade, sub-base or base is uniformly compacted to the minimum density of 95% mod. AASHTO according to AASHTO T220.

If quick lime is used, it shall not be permitted to compact the layers immediately after spreading the lime, because the hydration of the lime will cause damage to the compacted layers. The time within which the compaction shall be completed will be estimated in the laboratory. The dry density of the compacted layers shall not be less than 95% of the maximum dry density determined in the laboratory.

Compaction shall not take place after lime hydration and any lime stabilized material that has been mixed or deposited after lime hydration, shall be removed and replaced with fresh material, mixed and treated in accordance with the requirements of this section.

R6F 08 Preliminary trial

The requirements of this Section shall be in accordance with Section R6E.

R6F 09 Thickness and finish

The surface of the subgrade and each sub-base course or base shall comply with the requirements of Clause R6 12. Any modification to meet the Specification shall be completed, together with the compaction, within 1½ hours after mixing and any removal of, or making good to deficient areas will be at no cost to the Employer. The thickness shall be as shown on the Drawings or directed by the Engineer's Representative and shall comply with the following requirements:

1. The tolerance for level shall conform to Clause R5 12(2) for earthworks and Table R9/6 as amended for sub-base.
2. The smoothness of the finished surface shall not vary by more than 3cm when tested with a 4m straight edge.
3. The maximum tolerance of the crossfall shall be $\pm 0.5\%$

R6F 10 Sampling and testing

The requirements of this Section shall be in accordance with Clause R6E 12 for soil cement stabilization, except that the test for cement content shall be omitted and AASHTO T232 Determination of Lime Content shall be substituted.

R6F 11 Measurements

The unit of measurement for payment shall be the square meter. The area shall be the square meters of completed and accepted subgrade or sub-base course as measured in place. Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorized by the Engineer in writing.

R6F 12 Payment

The area of subgrade or sub-base course at the depth specified in the Special Specification of Particular Application, determined as specified in Clause R6F 11, will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub-base course, including preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labor; the handling, mixing, manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance; and for furnishing of all other labor and incidentals necessary to complete the work required by this Section of the Specification.

SECTION R6G

Bitumen stabilized subgrade or Subbase

R6G 01 Scope

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor and in performing all operations in connection with construction of bitumen stabilized subgrade, sub-base or base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and the applicable drawings and the directions of the Engineers Representative.

R6G 02 Materials

The mix-in-place method of construction will only apply to sites with naturally occurring sand, or sand and gravel mixture, unless otherwise provided in the Special Specification of Particular Application. For stationary plant method of construction the material shall comply with the Specification or other sources selected by the Contractor and approved by the Engineer's Representative.

The material shall be such as:-

Passing O- 075mm (No. 200 sieve) shall not exceed 30%.

Liquid Limit shall not exceed 30%.

Plasticity index shall not exceed 15%.

Bitumen: When the moisture content of the sand necessitates drying or heating and the stationary plant method of construction is therefore used, the bituminous material shall comply with the requirements of Clause R902-5 for hot mix asphalt concrete, or can be a viscous cut-back that requires heating.

In dry areas where the natural moisture content of the sand is low the bituminous binder shall be a proprietary fluid cut-back bitumen in accordance with Clause R8 02-2. The use of bitumen emulsion or foamed penetration grade bitumen will be subject to the approval of the Engineer's Representative after trials for bitumen stabilization referred to in the Special Specification for Particular Application.

In wet areas the drying may be accomplished, when directed and approved by the Engineer's Representative, by the use of up to 2 per cent of hydrated lime in conjunction with a cut-back bitumen containing special acids to re-act with the lime.

The stabilizing agent to be used shall be cut back bitumen RC 70 or RC 250 or RC 800 complying with AASHTO M81 or MC70 or MC250 or MC800 complying with AASHTO M82. Cationic emulsified bitumen SS Type complying with AASHTO M208 may also be used.

The choice of stabilizing agent shall be made on the basis of Laboratory trials taking into account the type of soil, climatic conditions of the site and the available equipment.

R6G 03 Composition of mixture

Bitumen-soil mixtures shall be ascertained by laboratory trial mixes using the procedure for determining the compressive strength of bituminous mixes in compliance with AASHTO T167. This test is to be carried out in such away as to ensure that the optimum composition of the mix is established.

The laboratory trial mixes shall have as a minimum the compressive strength and Marshall Stability shown in Table R6G/1 after being air cured for a period of 7 days. Testing shall be in accordance with AASHTO T167.

TABLE R6G/1

	Sub-grade	Sub-base
Compressive Strength at 25° C	1N/mm ²	2 N/mm ²
Marshall Stability at 60° C	1 KN	2 KN

The Index of Retained Strength when tested in accordance with AASHTO T165 shall not be less than 70%.

On the basis of the results of the laboratory trial mixes site trials shall be carried out to establish the exact percentage and temperature of binder to be used and to determine the suitability of the equipment that it is proposed to use. The cost of these trials is to be included in the rates for Bitumen Stabilized mixtures.

R6G 04 Equipment and method of stabilization

Equipment, tools and machines used in the performance of the work covered by this Section of the Specification shall be subject to the approval of the Engineer's Representative and shall be maintained in a satisfactory working condition at all times.

The mix-in-place method of construction may be adopted where the use of low viscosity binders, i.e. cut-back or bitumen emulsion are found suitable when approved by the Engineer's Representative.

Where stabilization with penetration grades binders is necessary the stationary plant method of construction will be used.

R6G 05 Stationary plant method of construction

The mixing plant and pavers shall meet the general requirements of Clause R905.

R6G 06 Mix-in-place method of construction

Mix-in-place bitumen stabilization will be subject to the approval of the Engineer's Representative to ensure full control of the bitumen content, the completeness of mixing

and processing depth.

Tests with multi-pass equipment of a simple character will be approved by the Engineer's Representative and can involve the use of a bitumen distributor and blade grader only.

Purpose-built single-pass stabilization machines may be used, subject to the availability of a reserve machine in the event of mechanical breakdown, to ensure avoidance of complete stoppage of work.

R6G 07 Compaction

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with rubber or pneumatic tired rollers. Compaction shall continue until the entire depth and width of the base is 'uniformly compacted to give soaked unconfined compressive strengths as specified in the Special Specification of Particular Application according to the design requirement to meet the traffic loading. The tire marks can be removed on the final surface by use of a steel-tired tandem roller.

R6G 08 Preliminary trial

Preliminary trials shall be carried out in accordance with Clause R6E 09.

R6G 09 Thickness and finish

The surface finish and thickness of the layers shall conform to Clause R6E 10 as amended.

R6G 10 Curing and maintenance

The need for curing will depend upon the type of bitumen binder used. and in the case of mix- in-place construction, the stabilized soil may be left uncompacted after pulverizations and mixing to allow a period of evaporation of volatiles. Such aeration before compaction increases stability and decreases water absorption particularly in fine grained sands when temperatures are low. Test procedures for stability tests should, when directed by the Engineer's Representative, include a curing period after compaction to allow for evaporation and to ascertain the pattern of behavior for certain binders during preliminary trials at various temperatures as specified in Clause R6G 03 and the Special Specification for Particular Application.

Lean mixes of bitumen sand shall be primed in accordance with Section R8A for protection against abrasion before surfacing or surface dressing.

R6G 11 Weather limitations

The laying Of bituminous-sand courses shall generally comply with the requirements of Clause R9 12.

R6G 12 Sampling and testing

Sand and sandy soils, bitumen and bituminous mixtures shall be tested as frequently as deemed necessary by the Engineer's Representative to check compliance with Clauses 6G 02 and 6G03. Samples of the plant mixtures shall be taken at the plant and/or on the working site as specified to determine if the mixtures conform to the job-mix formula requirements and all temperatures shall be checked.

1. Testing bituminous Binders.

Cut back bitumens shall be tested in accordance with the following:-

- | | |
|------------------------------|-------------|
| (i) Sampling | AASHTO T40 |
| (ii) Distillation | AASHTO T78 |
| (iii) Flash Point | AASHTO T79 |
| (iv) Saybolt-Furol Viscosity | AASHTO 72 |
| (v) Kinematics Viscosity | AASHTO T201 |
| (vi) Absolute Viscosity | AASHTO T202 |

Cationic emulsified bitumens shall be tested in accordance with AASHTO T59.

2. Sampling and Testing Bituminous Stabilized Mixtures:-

The preparation of standard specimens of soil, asphalt mixtures suitable for the required test method when using fine grained soils and liquid or emulsified asphalt shall be done according to ASTM D 4223.

A minimum of one set of three samples shall be taken from every 2500m² of completed stabilized layer immediately after completion of compaction. Other samples shall be taken as directed by the Engineer's Representative. The insitu density is to be in accordance with one of the following Standards.-

AASHTO T191 or
AASHTO T205 or
AASHTO T230 or
AASHTO T238

The in situ density shall not be less than 95% of bulk density of the laboratory mix. The thickness of the stabilized layer shall be checked while determining the in situ density.

For every 5000m² or one day's run of completed stabilized layer the following tests shall be carried out:-

- (i) Composition of the mix by extraction in accordance with AASHTO T164.
- (ii) Compressive strength from samples preferably taken from the uncompacted layer.
- (iii) Marshall Stability from samples preferably taken from the un compacted layer.

- (iv) All criteria shall conform to those established for the approved trial area (Clause R-6G 03).

R6G 13 Measurement

The unit of measurement for payment shall be the square meter. The area shall be the square meters of completed and accepted subgrade or sub-base as measured in place. Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorized by the Engineer in writing.

R6G 14 Payment

The area of subgrade or sub-base, determined as specified in Clause R6G 13 will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the subgrade or sub-base including surface preparation, the furnishing of all materials, supplies, plant, equipment, tools and labor; the handling, mixing, manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance; and for furnishing of all other labor and incidental necessary to complete the work required by this Section of the Specification.