

SECTION 28 WEARING SURFACES

Replace the whole of Section 28 with :

28.1 Aggregates for Asphaltic Concrete

28.1.1 Coarse Aggregates (Aggregates retained on 2.36mm sieve)

- a) Coarse aggregates for asphaltic concrete shall be clean hard durable and angular crushed rock or crushed gravel. At least 60% by weight of the aggregate shall consist of crushed pieces having two or more faces produced by fracture;
- b) The aggregates shall conform to the relevant quality requirements of **Table 28.1**.

28.1.2 Fine Aggregates (Aggregates Passing 2.36mm Sieve)

Fine aggregates for asphaltic concrete shall be approved clean naturally occurring sand or quarry fines free from clay, loam, loosely bonded aggregates and other foreign matter. The aggregates shall conform to the relevant quality requirements of **Table 28.1**.

28.1.3 Mineral Filler

- a) Shall conform to the requirements of AASHTO M17-70 Mineral filler for Bituminous Paving mixtures;
- b) Shall be dry and free from aggregations of fine particles.

28.1.4 Acceptance Testing

- a) As soon as practicable after the commencement of the contract the Contractor shall inform the Engineer of his proposed sources of aggregates for asphaltic concrete and supply representative samples and the required test results as detailed in Table 28.1 and AASHTO M17-70 for the Engineer's approval;
- b) The Engineer may attach conditions to his approval limiting the sections of the Works in which the particular aggregates may be used or limiting its use in combination with other materials. The Contractor shall take all necessary measures to ensure that the Engineer's conditions are met;
- c) If during the course of the works there is any significant physical or chemical change in the aggregates supplied, the Engineer may withdraw his approval and require the Contractor to propose an alternative source and again submit samples and test results for his approval. To avoid the delays caused by this process, the Contractor may initially submit the samples and test results from alternative sources for the Engineer's approval. The Contractor shall be solely responsible for ensuring that adequate supplies of approved aggregates are available when required;
- d) Unless otherwise instructed by the Engineer the aggregates in use shall be tested in an approved laboratory at a frequency not less than that set out in **Table 28.2**;

- e) No aggregates shall be used for bituminous surfacings unless the Engineer has given his approval to:
- i) The source of supply
 - ii) The chemical and physical properties of the aggregate.

Table 28.1 Tests for Aggregates for Asphaltic Concrete

Characteristic	Test	Specification Limits	
Course Aggregates			
<ul style="list-style-type: none"> • Aggregate Crushing Value • Ten Percent Fines Value • Broken faces (retained 4.75mm sieve) – 2 or more faces • Clay lumps and Friable Particles • Lightweight Pieces • Magnesium Sulphate Soundness (5 cycles) • Flakiness Index • Elongation index • Water Absorption • Adherent Coating on Aggregate after First Dry Sieving on 0.075 mm sieve • Coating and Stripping of Bitumen 	STP 7.7	Less than 30%	
	STP 7.8		125 KN
	AASHTO T112	75%	
	AASHTO T113	2% maximum	
	AASHTO T104	1% maximum	
	BS 812: PART 1: 1975 Para 7.3	Maximum 12% loss	
	BS 812: PART 1: 1975 Para 7.4	25% maximum for all fractions	
AASHTO T85	25% maximum for all fractions		
AASHTO T11	2% maximum		
AASHTO T11	0.5% maximum		
AASHTO T182	Minimum 95% retained.		
Fine Aggregates			
<ul style="list-style-type: none"> • Clay Lumps and Friable Particles • Lightweight Pieces • Water Absorption • Plasticity Index (passing 0.425mm sieve) 	AASHTO T112	3% maximum	
	AASHTO T113	1% maximum	
	AASHTO T84	2% maximum	
	AASHTO T90	Less than 6%	
Combined Aggregates			
<ul style="list-style-type: none"> • Gradation (% passing by weight) 	AASHTO T27, T11	Sieve Size	% passing
		19 mm	100
		12.5 mm	80 - 100
		9.5 mm	70 - 90
		4.75 mm	50 - 70
		2.36 mm	35 - 50
		0.60 mm	13 - 23
		0.15 mm	8 - 16
0.075 mm	4 - 10		

Note : STP = Tests as described in "Standard Laboratory Test Procedures Manual for Quality Control Laboratories", BRRL, June 1983.

Table 28.2 Frequency of Aggregate Testing for Asphaltic Concrete

Description	Test	Minimum Frequency
Coarse Aggregates	<ul style="list-style-type: none"> • Aggregate Crushing Value (STP 7.7) • Ten Percent Fines Value (STP 7.8) • Broken Faces • Clay Lumps, etc. (AASHTO T112) • Lightweight Pieces (AASHTO T113) • Soundness (AASHTO T104) • Flakiness Index (BS 812) • Elongation index (BS 812) • Water Absorption (AASHTO T85) • Adherent Coating (AASHTO T11) • Coating and Stripping (AASHTO T182) 	<ul style="list-style-type: none"> 1 per 500 m³ 1 per 500 m³ 1 per 500 m³ 1 per 500 m³ 1 per 500 m³ 1 per 1000 m³ 1 per 500 m³ 1 per 500 m³ 1 per 500 m³ 1 per 500 m³ 1 per 500 m³
Fine Aggregates	<ul style="list-style-type: none"> • Clay Lumps, etc. (AASHTO T112) • Lightweight Pieces (AASHTO T113) • Water Absorption (AASHTO T84) • Plasticity Index 	<ul style="list-style-type: none"> 1 per 250 m³ 1 per 250 m³ 1 per 500 m³ 1 per 250 m³
Combined Aggregates (Job Mix Formula Proportions)	<ul style="list-style-type: none"> • Gradation (AASHTO T27, T11) 	1 per day of hot mix production
<ul style="list-style-type: none"> • Cold Bin Aggregates • Hot Bin Aggregates 	<ul style="list-style-type: none"> • Gradation (AASHTO T27, T11) • Gradation (AASHTO T27, T11) 	<ul style="list-style-type: none"> 1 set per day of hot mix production 1 set per day of hot mix production

28.1.5 Storage of Aggregates

- a) The various fractions of the coarse aggregates and the fine aggregate shall be stored separately on a concrete or other approved surface laid to a sufficient slope to ensure drainage; aggregates shall not be stockpiled directly on natural ground or soils.
- b) Aggregates shall be stock piled and handled by methods which ensure uniform grading of the materials, care being taken to avoid crushing, mixing with other materials, segregation or contamination by extraneous materials;
- c) Aggregates which have been washed shall be kept in storage for at least 24 hours to ensure adequate drainage;
- d) Aggregates which have suffered contamination, segregation or otherwise fail to comply with the specification shall be rejected by the Engineer and removed from site unless the Engineer permits the Contractor to reprocess or wash such aggregates and resubmit them to the Engineer for approval.

28.1.6 Grading of Aggregates for Asphaltic Concrete

- a) Combined aggregates for asphaltic concrete shall be well graded lying within the envelope specified in Table 28.1.

28.2 Aggregates for Surface Dressing**28.2.1 General**

Aggregates for surface dressing shall be single sized aggregates conforming to the general provisions of:

Article 28.1.1. Coarse aggregates and the relevant test requirements of Table 28.1 and Table 28.2.

Article 28.1.3. Acceptance and Testing

Article 28.1.4. Storage of Aggregates

28.2.2 Grading of Aggregates for Surface Dressing:

- a) Grading of single size aggregates for surface dressing shall conform to Table 28.4.

Table 28.4 Single Size Aggregates for Surface Dressing:

Passing B.S. Sieve	Nominal Size mm		
	10/14	6/10	3/6
20mm	100		
14mm	85-100	100	
10mm	0-30	85-100	100
6.3 mm	0-7	0-30	85-100
5mm		0-10	
2.36mm	0-2	0-2	0-10
75 microns	0-1	0-1	0-1

- b) The surfaces of the aggregates shall be free from dust and contamination from other materials. Representative samples of the aggregates shall be tested in accordance with TRRL Overseas Road Note 3 Appendix 3. On the basis of these tests the Engineer may direct that a suitable adhesion agent should be used.

28.3 Penetration Grade Bitumen**28.3.1 Penetration Grade Bitumen for Asphaltic Concrete**

Penetration Grade Bitumen for asphaltic concrete shall conform to the requirements of :

- AASHTO M20-70 Penetration graded Asphalt Cement Grade 60-70

28.3.2 Penetration Grade Bitumen for Other Purposes

Penetration Grade Bitumen for use in the manufacture of cut back bitumens shall conform to the requirements of:

- AASHTO M20-70 Penetration Graded Asphalt Cement Grade 85-100

28.3.3 Manufacturer's Certificate

Each consignment of bitumen shall be accompanied by a certificate from the manufacturer stating the penetration, flashpoint, ductility, solubility, loss on heating, penetration of residue, ductility of residue and the specific gravity test values of the current batch. Copies of each certificate shall be handed to the Engineer for review and approval. The Engineer may instruct supplementary audit testing at his discretion.

The bitumen shall be homogeneous, free from water and shall not foam when heated to a temperature of 175°C.

28.4 Cut Back Bitumens**28.4.1 Commercially Manufactured Cut Back Bitumens**

If available these shall comply with the requirements of:

- i) AASHTO M81-70 cut back asphalt (rapid curing type);
- ii) AASHTO M82-73 cut back asphalt (medium curing type);

Intended Uses:

- i) Tack Coat RC70, RC250, MC70, MC250
- ii) Prime Coat MC30, MC70
- iii) Surface Dressing MC3000

28.4.2 Commercially Manufactured Cut Back Bitumens not Available

- a) Commercially manufactured cut back bitumens may not be available in Bangladesh. If this is the case at the time of contract the cutting back of approved commercially manufactured penetration grade bitumen with commercially available kerosene or diesel oil may be permitted by the Engineer if he is satisfied as to the method of mixing and the proportions of and effectiveness of the mix.
- b) The cut back shall be produced by mixing commercially manufactured penetration grade 85-100 asphalt cement bitumen as specified in Article 28.3.2 and commercially available diesel oil free from dirt and other impurities (diesel is preferred to kerosene as being less flammable).
- c) Guidance as to mix proportions is given in TRRL. Overseas Road Note 3. "A guide to surface dressing in tropical and subtropical countries".

- d) The test properties of the mixtures should conform to the properties of the medium curing cut back asphalts given in Article 28.4.1 for the purpose to which they are to be applied.
- e) In the case of mixtures used for surface dressing the amount of diesel added to the mixture may be varied if necessary to take account of the required kinematic viscosity of the mixture against road temperature at the time of laying, as described in Overseas Road Note 3.
- f) The proposed mix proportions shall be subject to the approval of the Engineer after a site test to demonstrate their suitability for the use to which they are to be put.

28.4.3 Production of Cut Back Mixtures

- a) The Contractor shall submit his proposed method of producing the cut back mixture to the Engineer for his approval.
- b) Mixing of the cut back shall only be carried out in approved bitumen storage devices fitted with burners temperature recording devices and circulating pumps.
- c) Strict precautions shall be taken at all times to prevent fire and the diesel or other cuffed back material shall be stored in sealed drums away from fires or other naked flames. Fire fighting appliances shall be ready for use and located within 30 meters.
- d) The mixing process shall be carried out only by experienced staff.
- e) Once produced the cut back shall not be held for long periods at a temperature in excess of 110°C.

28.4.4 Manufacturer's Certificate, Testing and Storage

- a) Each consignment of commercially manufactured cut back shall be accompanied by a certificate from the manufacturer stating the grade of Cut Back Bitumen supplied and the specific gravity of the current production.
- b) The mixed cut backs shall be stored in clean steel drums of the type and quality used for fuel oil deliveries. Drums shall be fitted with air tight screwed stoppers.

28.5 Bituminous Emulsions**28.5.1 Commercially Produced Bituminous Emulsions**

- a) Shall comply with BS434 - 1984. Bitumen Road Emulsions (Anionic and Cationic) Part I Specification for bitumen road emulsions;

- b) Use of bitumen emulsions for road works shall comply with 85434 Part 2 Code of Practice for Bitumen Road Emulsions:

<u>Use</u>	<u>Emulsion Class</u>	
Tack Coating	Anionic AI-40	Cationic KI-40
Prime/Seal Coat Cement Bound Materials only	AI-60 AI-55	KI-60
Surface Dressing	AI-60 A 1-55	KI-60

28.5.2 Manufacturer's Certificate, Storage and Testing

- a) Each consignment of bitumen emulsion shall be accompanied by a certificate from the manufacturer stating the grade of bitumen emulsion being supplied together with relevant test results. Copies of each certificate shall be handed to the Engineer;
- b) Bitumen emulsion shall be stored in clean steel drums of the type and quality used for fuel oil deliveries. Drums shall be fitted with a water tight screwed stopper.
- c) Bitumen emulsion shall be used as soon as possible after manufacture. If the storage period exceeds one month the drums shall be turned or inverted at least once a month. Containers shall be well rolled to agitate the contents before use;
- c) Bitumen emulsions shall be sampled and tested on arrival and shortly before each use in accordance with (BS 434 Part-1 1984).

28.6 Asphaltic Concrete

28.6.1 General

Materials for Asphaltic concrete shall conform to the requirements of:

- a) Article 28.1 Aggregates for Asphaltic concrete;
- b) Article 28.3.1 Penetration grade bitumen for Asphaltic concrete.

28.6.2 Laboratory Mix

Trial laboratory mixes shall be produced within the specified limits in accordance with the Marshall Method. Standard Marshall specimens shall be made and tested, all as specified in the current edition of "Mix Design Methods for Asphaltic concrete and other Hot-Mix Types", (MS2) published by the Asphalt Institute, USA except in cases of differences from this specification, when the latter shall prevail. Sets of Marshall Test specimens shall be prepared and tested for a range of bitumen contents from 5.0% to 7.0% at 0.5% intervals. The results will be analyzed to determine the optimum bitumen content. A further trial laboratory mix will be prepared using the selected optimum bitumen content, and tested.

28.6.3 Mix Properties

Asphaltic concrete when compacted with 75 blows of a standard Marshall hammer at both top and bottom of the sample shall have the test properties detailed in **Table 28.5** when tested in accordance with the relevant ASTM Test.

Table 28.5 Job Mix Properties

Test	Unit	Wearing Course	
		Max.	Min.
Stability (Marshall) (AASHTO T245)	KN	10.0	7.5
Flow (Marshall) (AASHTO T245)	mm	4.5	2.5
Air voids In Mix (Calculation)	%	5	3
Aggregate voids Filled with Bitumen	%	85	75
Immersion Test Retained Strength (Marshall) (AASHTO T165)	%		75
Bitumen Content (as % weight of total mix)	%	6.5	5.5

In addition, the stability (in kN) divided by the flow (in mm) shall not be less than 2.5.

28.6.4 Job Mix

Following the laboratory mix trials described in Article 28.6.3, the Contractor shall prepare and submit a comprehensive report to the Engineer containing all the test results and details of the optimum "laboratory mix" that is proposed to be used in a production trial from the Asphalt Mixing Plant. The Engineer shall review the report and either approve the recommendation or instruct the Contractor to carry out further laboratory trials.

Once the Contractor has received written approval from the Engineer for the optimum "laboratory mix" the Contractor shall proceed with a **production trial** using the Asphalt Mixing Plant. The Contractor shall arrange detailed tests on the production trial mix to confirm whether the mix meets specification requirements. The results of production trial shall be reported to the Engineer who will then either approve the production trial mix as the "**job mix**" or instruct the Contractor to carry out further production trials. Once the "job mix"

has been approved by the Engineer, the Contractor can commence production and undertake the paving trial described in Article 28.6.11.

28.6.5 Plant Mix Tolerances

The material to be placed in the permanent works will be deemed acceptable only if the results of the specified tests carried out show that departures from the approved "Job Mix" fall within the tolerances given in Table 28.6.

Table 28.6 Tolerances on Job Mix

Criteria	Wearing Course
Coarse Aggregate * Retained on 4.75 mm sieve	± 4%
Aggregate passing 4.75 mm but retained on 75 micron sieve *	± 3%
Aggregate and filler Passing 75 micron sieve *	± 1.5%
Bitumen Binder	± 0.2% but not less than 5.5%
Air voids in mix	± 1%
Voids filled with binder	± 5%
Marshall Stability	- 1 KN, + 2 KN
Marshall Flow	± 0.5 mm

* Tolerance on percentage by weight passing each sieve size as set down in Table 28.1.

The above tolerances are permitted provided that the Marshall Quotient (kN/flow (mm)) is greater than 3.

28.6.6 Temperature of Mixing and Laying

The mixing temperature for asphaltic concrete containing grade 60/70 penetration bitumen shall be between 145 and 165°C. The minimum initial compaction temperature at site of bituminous mixture containing grade 60/70 penetration bitumen shall be 125°C.

28.6.7 Mixing

At no time shall the temperature of bitumen in storage be permitted to exceed 165°C. Bitumen storage tanks shall all have accurate permanent temperature gauges which are operational at all times. Daily records shall be kept of stored bitumen temperature.

Mixing of the asphaltic concrete shall be carried out in a mixer of an approved type meeting

the requirements of AASHTO M 156 "Requirements for mixing plants for Hot Mixed Hot Laid Bituminous Paving Mixtures".

28.6.8 Plant for Transporting Laying and Compacting Asphaltic Concrete

Trucks for hauling asphaltic concrete shall have leakproof metal bodies. The inner surfaces of the truck shall be lightly sprayed with soapy water, thinned fuel oil, or paraffin oil to prevent adhesion of the asphalt. The trucks shall have well tied, tight fitting tarpaulin coverings to protect the asphaltic concrete from the weather. The trucks shall be well sprung and loaded in such a manner as to prevent segregation of the bitumen from the aggregates. Should segregation take place the Engineer will refuse to accept such asphaltic mixes.

The equipment used for spreading of asphaltic concrete shall be of mechanical and self powered types and capable of spreading the asphaltic mixture in accordance with the Specifications and Drawings. This equipment shall be capable of easy operation in reverse gear. The finisher shall be equipped with a device to confine the edges of the asphaltic concrete to true lines without the use of stationary side forms.

The finisher shall also be equipped with a device for smoothing and adjusting the longitudinal joint formed between traffic lines. The finisher shall be capable of accurately producing the pavement shape as given in the cross-section, and shall distribute the asphaltic concrete according to the specified thickness per square meter.

The finisher shall have means for heating the asphaltic concrete during spreading. The equipment shall operate in such a manner that the finished surface shall be smooth and even and without tracks or tearing or corrugations.

If during construction, it is found that the spreading equipment (finisher) leaves tracks or indented areas or other irregularities in the pavement surface, other equipment complying with the Specification shall be used.

The Contractor shall make arrangements to ensure that all equipment on the site is always maintained clean and free of bitumen. Arrangements shall be made to protect material which is to be used in the works against rain and wind blown materials.

28.6.9 Preparation, Laying and Spreading of Asphaltic Concrete

The material shall be laid only when weather conditions are favorable. The cost of removing and replacing any material damaged by rain or wind blown silt and sand shall be borne by the Contractor.

Prior to laying asphaltic concrete the laying surface shall be dry and shall be swept clean and free from all loose and foreign material.

Where asphaltic concrete is to be laid on top of an old existing asphaltic concrete surface, the existing asphaltic concrete surface shall be scarified to the approval of the Engineer and a tack coat applied in accordance with Article 28.6.13.

On new pavements, the aggregate base course layer shall have a prime coat applied in accordance with Article 28.8 and laying of asphaltic concrete shall not be placed until the

written approval of the Engineer has been given to the Contractor.

Asphaltic concrete shall be laid hot and spread by mechanical means, in one or more layers, depending upon results from the trial areas. The spreader shall be of an approved design and operated by skilled operators. During the process of spreading the rate of travel of the spreader shall not be in excess of 7m per minute.

In exceptional cases where finishers cannot operate due to structural obstacles, asphaltic concrete may be manually laid in small areas. In such cases great care shall be exercised to ensure that the surface of asphaltic concrete is smooth, and segregation is avoided.

Wherever practical, the longitudinal joint of the lower layer of asphaltic concrete shall be offset from that in the upper layer by at least 150mm. Where the road is a two-lane road, the longitudinal joint of the upper layer shall be on the centreline. If there are more than two lanes, the joints shall be formed at suitable distance from the centreline to coincide with the lane markings wherever possible.

All joints in asphaltic concrete shall be made to ensure a continuity of level and bond across the joints. The face of the previously laid bituminous materials shall be trimmed back to a firm vertical face, and all crumbs removed. All the cut-back faces of the existing work shall be painted with hot bitumen or with an approved rapid curing cut-back bitumen.

At the recommencement of work at a transverse joint, mechanical laying will be commenced as near as practicable to the joint. Laying by hand will be permitted in the area between the machinelaid work and the joint but such hand laying shall be kept to the absolute minimum, and the specified finished surface tolerances must be achieved.

Where asphaltic concrete is to be laid against concrete kerbing, the face of the kerb to be in contact with the material, shall be painted prior to the laying of the material, with hot bitumen or an approved rapid curing cut-back bitumen.

Where a new carriageway abuts onto an existing carriageway and the Engineer so directs, the surface of the latter shall be scarified, adjusted and reshaped to conform with existing and new cambers or crossfalls. Materials from the existing road shall be used or disposed of as directed by the Engineer.

Immediately after any asphalt has been laid and screeded, and before roller compaction is commenced, the surface shall be checked for line and profile, all irregularities corrected, any "fat" accumulation from the screed removed and all localized "fatty" areas in the materials removed by hot rake or hoe and replaced with fresh material from the hopper. Irregularities in alignment and grade along the edge shall also be corrected before the edge is rolled.

28.6.10 Compaction of Asphaltic Concrete

Asphaltic material shall be laid and compacted in layer thicknesses which enable surface level and regularity requirements to be met and the specified compaction to be achieved.

Material shall be uniformly compacted as soon as rolling can be effected without causing undue displacement of the mixed material and shall be substantially completed while the temperature of the mixed material is greater than the minimum rolling temperature specified.

Rolling shall continue until all roller marks have been removed from the surface.

Compaction shall be carried out using 8-10 tonnes deadweight smooth wheeled rollers having a width of roll not less than 1200 mm, or by multi-wheeled pneumatic tyred rollers of equivalent mass, or by vibratory rollers or a combination of these. Wearing course material shall always be surface finished with a smooth wheeled roller which may be a deadweight roller or alternatively a vibratory roller in non-vibrating mode. Vibratory rollers shall not be used in vibrating mode on bridge decks.

The material shall be rolled in a longitudinal direction with the driven rolls nearest the paver. The roller shall first compact the material adjacent to any joints and then work from the lower to the upper side of the layer overlapping on successive passes by at least half the width of the rear roll or in the case of a pneumatic-tyred roller, at least the nominal width of one tyre.

Rolling shall proceed continuously until all marks of rolling are eliminated and a field density of not less than 98% of the laboratory compacted density using AASHTO T245-74 with 75 blows on each side, is obtained.

No roller shall be allowed to stand on the hot material, and no traffic shall be allowed on the material for at least 24 hours after final rolling.

If during cooling, fine cracks develop in the asphaltic concrete, rolling shall recommence until such cracks are eliminated, to the satisfaction of the Engineer.

In cases where hand spreading is permitted the hot mixed material shall be stored adjacent to the area of work on a clean metal plate and shall be placed in position with hot shovels and rakes. Rolling and compaction shall proceed as above for mechanically laid materials.

28.6.11 Paving Trial for Asphaltic Concrete

Before permanent work is put in hand and on a site selected by the Engineer, the Contractor shall lay under close supervision with each spreader approximately 50 meters length as a trial area for each asphaltic concrete layer in accordance with the Specification. For this purpose the Contractor shall make available and shall use the full plant set-up for full scale working including the complete mixing, transport, laying and compacting plant.

Such trials shall be used for the purpose of demonstration to the Engineer's satisfaction the stability of a mix or the adequacy of a rate of spread and also to eradicate any apparent defects in the plant and the Contractor shall without charge make such modifications in the plant or in the operation thereof as the Engineer may require.

From each trial area at least six samples of the compacted material shall be taken at least 12 hours after completion of compaction and tested for:

- a) Thickness
- b) Field density (from cores)
- c) Void content
- d) Percentage of aggregate broken during compaction.

In addition at least four samples shall be tested for:

- e) Bitumen content
- f) Extracted Aggregate grading.

At least two representative samples shall be made, boxed, fully described, labelled etc. for keeping by the Engineer as a record.

If approved by the Engineer the trial area shall constitute a standard for comparison and shall be preserved free from use and the permanent work shall be carried out in the same manner and to the same standard as that approved. If not approved for any reason, the trial areas shall be hacked out and removed and the trial repeated by the Contractor without charge.

If subsequently, due to non-uniformity of the materials supplied, or to variation in improper handling of, the plant, the composition or texture of the mixed material departs from that originally agreed to by the Engineer, the Engineer may order the suspension of the asphaltic concrete work and the carrying out afresh of the procedure in part or in full as may be required for re-design of the mix.

28.6.12 Application of Bituminous Tack Coat

Where directed by the Engineer a bituminous tack coat shall be applied prior to the laying for the asphaltic wearing course, base course or regulating course.

Prior to the application of the tack coat the existing road surface, regulating course or asphaltic base course shall be swept clean of all dust and loose material and wind blown silt/sand and no tack coat shall be applied until the prepared surface has been approved by the Engineer.

Immediately subsequent to approval, the surface shall be uniformly sprayed with bitumen as described in Article 28.7 and 28.8. To ensure uniform coverage a pneumatic tyred roller may be used on the sprayed tack coat.

The tack coat shall be applied not more than 2 hours in advance of the laying of the asphaltic wearing course or regulating course.

The Contractor shall bear the cost of tack coats in all areas except where new bituminous layers are laid over bituminous surfaces which existed before the commencement of the contract.

28.6.13 Regulating Course

Regulating course material shall be made and laid in accordance with the requirements for asphaltic concrete base course or wearing course as specified.

Should the required compacted thickness of regulating course exceed 75mm the material shall be laid and compacted in two or more layers of equal thickness of 75mm or less.

In areas where the required thickness of regulating course is less than 1.25 times the maximum size of stone used in the mix, the regulating work shall be done by using an approved fine grained bituminous mixture.

28.6.14 Inclement Weather

The Contractor shall not proceed with any paving works during periods when rain is falling, or during windy conditions, when wind blown sand may in the opinion of the Engineer, adversely affect the quality of the works.

28.6.15 Testing of Asphaltic Materials

Where required by the Engineer testing of bituminous mixes will be carried out either before or after laying to determine all or any of the following characteristics:

- a) Mixing Temperature
- b) Laying Temperature
- c) Thickness of compacted layer
- d) Density of compacted layer (from cores)
- e) Confirmation that mix properties comply with the requirements of **Table 28.6.**

Bituminous binders will also be analyzed when required by the Engineer all in accordance with the requirements specified herein.

It shall be the responsibility of the Contractor to take samples of each day's production as and where required by the Engineer, to provide all necessary containers and wrappings where necessary, and to despatch to the Engineer's Laboratory.

The sampling of asphaltic concrete shall be carried out in strict accordance with AASHTO T168-82.

Samples of materials shall be taken as frequently as the Engineer may deem necessary to ensure that the composition is in strict conformity with the appropriate specification but **not less than one sample of mixed material manufactured to any one specification shall be taken daily.** If the material is being drawn from more than one source at least one sample representative of the material produced at each separate source shall be taken daily.

At least 24 hours after laying of asphaltic concrete, 100mm diameter cores shall be taken from the works in locations as directed by the Engineer for checking thickness and field density. At least 2 No. cores for each 50m completed length of road pavement shall be taken.

Resulting holes in the pavement shall be immediately repaired by the Contractor the same day of coring using suitable asphaltic concrete material compacted firmly into place.

Bituminous materials shall be analyzed at the Engineer's Laboratory or a testing laboratory approved by the Engineer. Bitumen content and moisture content shall be determined in the accordance with AASHTO T164-86 and T110-70 respectively and the grading of the extracted mineral aggregate shall be determined in accordance with AASHTO T30-84.

28.6.16 Bitumen for Asphaltic Concrete

Sampling and testing of the bitumen shall be according with AASHTO standards given below:

Sampling According to AASHTO T40 -78

Rupsa Bridge Construction Project

Technical Specification

Water content	“	“	T55 -78
Penetration Grade	“	“	T49 -84
Solubility in trichloro-ethylene	“	“	T44 -85
Ductility	“	“	T51 -86
Flash Point, Cleveland Open cup	“	“	T48 -84
Loss on heating and drop in penetration after heating	“	“	T47 -83
Specific Gravity	“	“	T 228 -55 and 87I

28.7 Bituminous Sprays

28.7.1 Binder Distributors

- a) Except with the express approval of the Engineer for use in small cramped areas all binders for prime coats, seal coats, tack coats and surface dressing shall be distributed by an approved mechanical binder distributor capable of providing the required rate of spread of the binder;
- b) The distributor shall comply with:
 - i) B51707-1970 “Specifications for Hot Binder Distributors for road surface dressing”;
 - ii) BS3136-1959 “Emulsion spraying for roads”.
- c) The machines shall be tested in the presence and to the satisfaction of the Engineer to ensure conformity with the appropriate standard above;
- d) The machine shall be calibrated for use with proposed binders following the guidelines given in TRRL Overseas Road Note 3. “A Guide to Surface Dressing in Tropical and Sub-tropical Countries”. Appropriate calibration charts should be produced for use in field application;
- e) Where binders require heating suitable binder heaters of adequate capacity shall be supplied to pre-heat the binder to spraying temperature before transferring to the distributor.

28.7.2 Preparation

Before spraying is commenced the surface shall be freed of all loose materials. The surface as a whole shall be generally clean, free of contamination and free of standing water to the approval of the Engineer.

28.7.3 Rate of Spread of Binder

The binder shall be distributed at the rates approved by the Engineer as the result of preliminary trials. The amount of binder distributed shall be within $\pm 10\%$ of that specified. The achieved rates of spread shall be checked as required by the Engineer by the “rate of spread tray test” as described in TRRL Overseas Road Note 3.

28.7.4 Blinding Material

Blinding material, if required by the Engineer, shall consist of hard clean crushed rock or sand: it shall contain not more than 15% retained on a 6.3mm BS Sieve. It shall be applied to the binder at a rate of 5.5 to 7.0 kg/m² and left unrolled.

28.7.5 Preparation for Next Pavement Layer

Unless the Engineer permits otherwise all loose material on a sprayed surface including any blinding material shall be removed and deficiencies in the surface repaired before any further layer of pavement is laid.

28.7.6 Trial Areas

Prior to the incorporation of any spray coats in the permanent works, trials as ordered by the Engineer shall be carried out to ascertain the amounts of each type of binder required for each type of application.

28.8 **Prime Coats**

- a) Shall be applied to all non-bituminous road bases.
- b) The binder shall be one of the following medium curing cutbacks as specified in Article 28.4.1.
 - i) MC 30
 - ii) MC 70 for use only on open textured materials.
 - iii) Site cut back penetration grade bitumen as described in Article 28.4.2.
- c) Rate of application will be decided by the Engineer dependent on the texture of the surface and will normally be between 0.8 and 1.2 liters/m². The depth of penetration should be between 3mm and 10mm and the quantity sprayed should be such that the surface is dry within 24 to 48 hours leaving no free pools of bitumen on the surface.
- d) Spraying temperatures:

MC 30 whirling spray jets	50°C – 60°C
Slot jets	40°C – 50°C
MC 70 whirling spray jets	65°C – 80°C
Slot jets	55°C – 70°C

28.9 **Tack Coats**

- a) Tack coats shall be applied to bituminous surfaces as described in the Contract and elsewhere as instructed by the Engineer.
- b) The binder shall consist of
 - i) Cut-back bitumen grades RC70, RC250, MC70 or MC 250 as specified in Article 28.4.1

- ii) Rapid breaking bitumen emulsion classes AI-40 or KI-40 as specified in Article 28.5.1
- iii) Site cut-back penetration grade bitumen as described Article 28.4.2
- c) The rate of application shall be decided by the Engineer depending on the surface texture but shall normally be between 0.2 and 0.3 liters/m² to ensure a uniform film without pooling.
- d) Spraying temperatures for cut-back bitumen:

RC70 MC70	Whirling spray jets	65°C-80°C
	Slot jets	40°C-50°C
RC 250 MC 250	Whirling spray jets	95°C-115°C
	Slot jets	80°C-90°C
- e) Tack coats of cut-back bitumen shall be applied not more than 2 hrs before the overlaying asphalt course is laid. Tack coats of bitumen emulsion shall be laid allowing time for them to break completely before the overlaying asphalt course is laid.

28.10 Surface Dressing

28.10.1 Double Surface Dressing

Surface Dressing shall be double surface dressing carried out in accordance with the recommendations in Transport and Road Research Laboratory Overseas Road Note 3. "A Guide to Surface Dressing in Tropical and Sub-tropical Countries", unless otherwise specified in the contract.

28.10.2 Aggregates for Surface Dressing:

- a) Shall conform to the provisions of Article 28.2.
- b) On the basis of the results of the Article 28.2.2 the Engineer shall direct, if necessary, the use of a suitable adhesion agent.
- c) Class of chippings:
 - i) For first layer shall be 6/10mm nominal size
 - ii) For second layer shall be 3/6 mm nominal size.
- d) The rate of application of chippings shall be determined by the Engineer as a result of site trials in accordance with Article 28.10.4.

Provisionally it shall be taken as:

- i) For the first layer 6/10mm chippings 9-12 kg/m²
- ii) For the second layer 3/6 mm chippings 6-8 kg/m²

28.10.3 Binder for Surface Dressing

- a) Binder for surface dressing shall be:
- i) Cut-back bitumen class MC 3000 as specified in Article 28.4.1
 - ii) Bitumen Emulsion A1-55 A1-60 or K1-60 as specified in Article 28.5.1
 - iii) Site cut-back penetration grade bitumen as described in Article 28.4.2
- b) Rate of application of binder shall be determined by the Engineer as a result of site trials in accordance with Article 28.11.5

Provisionally it shall be taken as:

- i) Cut-back bitumen MC 3000
 1st layer 6-10mm chippings 1 liter/m²
 2nd layer 3-6 mm chippings 1 liter/m²
 If the use of crushed gravel is permitted by the Engineer the above rates shall be increased by 10%.
 - ii) Bitumen Emulsion A1-55 A1-60 and K1-60
 1st layer 6-10 mm chippings 1.5 liters/m²
 2nd layer 3-4 mm chippings 1.6 liters/m²
 If the use of crushed gravel is permitted by the Engineer the above rates shall be increased by 10%.
- c) Spraying Temperatures for Hot Binders:

MC 3000	Whirling spray jets	135 to 150 ^o C.
	Slotted jets	120 to 130 ^o C.

28.10.4 Trial Areas for Surface Dressing

- a) Prior to the commencement of the Permanent Works trial lengths not exceeding 100 m, as directed by the Engineer shall be carried out to ascertain the required rates of spread of chippings and binder for the surface dressing layers.
- b) Initial rates of spread of binder and chippings, as given in the preceding Articles, or as calculated by the procedures given in TRRL Overseas Road Note 3 shall be used.
- c) These preliminary rates shall be adjusted by the Engineer as necessary to form the Contract Rates of application.
- d) Additional trials may be ordered by the Engineer where, in his opinion, the materials used or surfaces to which the surface dressing is applied vary significantly from those in the original trial.

28.10.5 Application to the Works

Before spraying of the binder is commenced any necessary preliminary patching of the surface and prime coat shall have been completed. The surfaces as a whole shall be generally dry and any damp areas shall be completely free of standing water.

The chippings shall be uniformly spread over the binder film by a mechanical spreader. Within two minutes of applying the binder any thinly chipped areas left by the spreading machine shall have additional chippings spread by hand to ensure shoulder to shoulder cover. The quantity of chippings applied initially shall be slightly in excess of that required to cover the entire surface of the bitumen after rolling.

Rolling shall be carried out by rubber tyred rollers immediately after the aggregate has been spread and continued until the chippings are firmly embedded in the binder and a uniform surface is obtained.

Traffic shall not be allowed on surface dressed areas until the Engineer is satisfied that adhesion has been established and that the chippings will not be appreciably disturbed. Excess chippings shall be swept up and removed before opening up to unrestricted traffic. Further sweeping to remove chippings disturbed by traffic shall be carried out as required.

28.11 Alignment Requirements

28.11.1 Horizontal Alignments

Horizontal alignments shall be determined from the setting-out line taken as the centreline as shown on the approved Drawings. The edge of the pavement as constructed and all other parallel alignments shall be correct within a tolerance of $\pm 12\text{mm}$ therefrom.

28.11.2 Surface Levels of Pavement Courses

The levels of pavement courses shall be determined from the true pavement surface which shall be the surface of the wearing course i.e. nominal grade level, calculated from the carriageway longitudinal section and crossfalls as shown on the Drawings. The vertical depth below the true pavement surface of any point on the constructed surface of the formation or pavement courses shall be within the appropriate tolerances stated in **Table 28.7**.

The surface level of the laid wearing course shall not deviate vertically at any point from the true pavement surface, by more than $\pm 10\text{mm}$. However, for flexible pavements the negative tolerance shall not be permitted in conjunction with the positive permitted tolerance of the surface of the base course if the thickness of the wearing course is thereby reduced by more than 10mm.

For checking compliance with **Table 28.7** measurements for surface levels shall be taken at a grid of points to be selected by the Engineer at 20m centers longitudinally, 10m on transition curves, and at 2m centers transversely starting 1 m from the edge of the carriageway. At junctions the grid point spacings shall be as directed by the Engineer. In any length of carriageway the requirements of **Table 28.7** shall be regarded as met when not more than 1 measurement in 10 exceeds the tolerances permitted in the Table, but this one measurement shall not exceed the tolerance for the next course below the one being measured:

Table 28.7 Tolerances in Surface Levels of Wearing Course and Base Course

Wearing Course Surface	± 10 mm
Base Course	± 10 mm

28.11.3 Surface Regularity

The longitudinal regularity of the surface of any constructed wearing courses and base-course shall be within the relevant tolerance stated in Table 28.8.

Compliance with Table 28.8 shall be tested by a rolling straight-edge, operated along any line or lines parallel to the setting-outline of the carriageway. The traverse length of 300m and its associated numbers of irregularities shall apply wherever the continuous length of completed carriageway is 300m or more, whether or not it is constructed in shorter lengths.

Carriageways shall be tested transversely for irregularities at points decided by the Engineer by a 3m straight-edge placed at right angles to the setting-out line of the road. The laid pavement surface and the surface of the base course shall have no greater depression under the straight-edge than 3mm and 6mm respectively.

Table 28.8 Maximum Permitted Number of Surface Irregularities

Irregularity exceeding	<u>Wearing Course</u>				<u>Base Course</u>			
	5mm		10mm		5mm		10mm	
Length	300m	75m	300m	75m	300m	75m	300m	75m
No. of Surface Irregularities	20	9	2	1	40	18	4	2

An irregularity is a variation in the profile of the road surface measured by the rolling straight-edge.

No irregularity exceeding 10mm shall be permitted.

28.11.4 Rectification

Where any tolerance is exceeded the Contractor shall determine and agree with the Engineer the full extent of the area which is out of tolerance and shall make good by rectifying the surface of the pavement course or formation in the manner specified herein. All rectification work shall be at the cost of the Contractor.

Base course and wearing course shall have the full depth of the layer removed and replaced with fresh material laid and compacted to Specification.

Where the surface level is too high or too low the area rectified shall be at least 5m long if

base course or 15m long if wearing course.

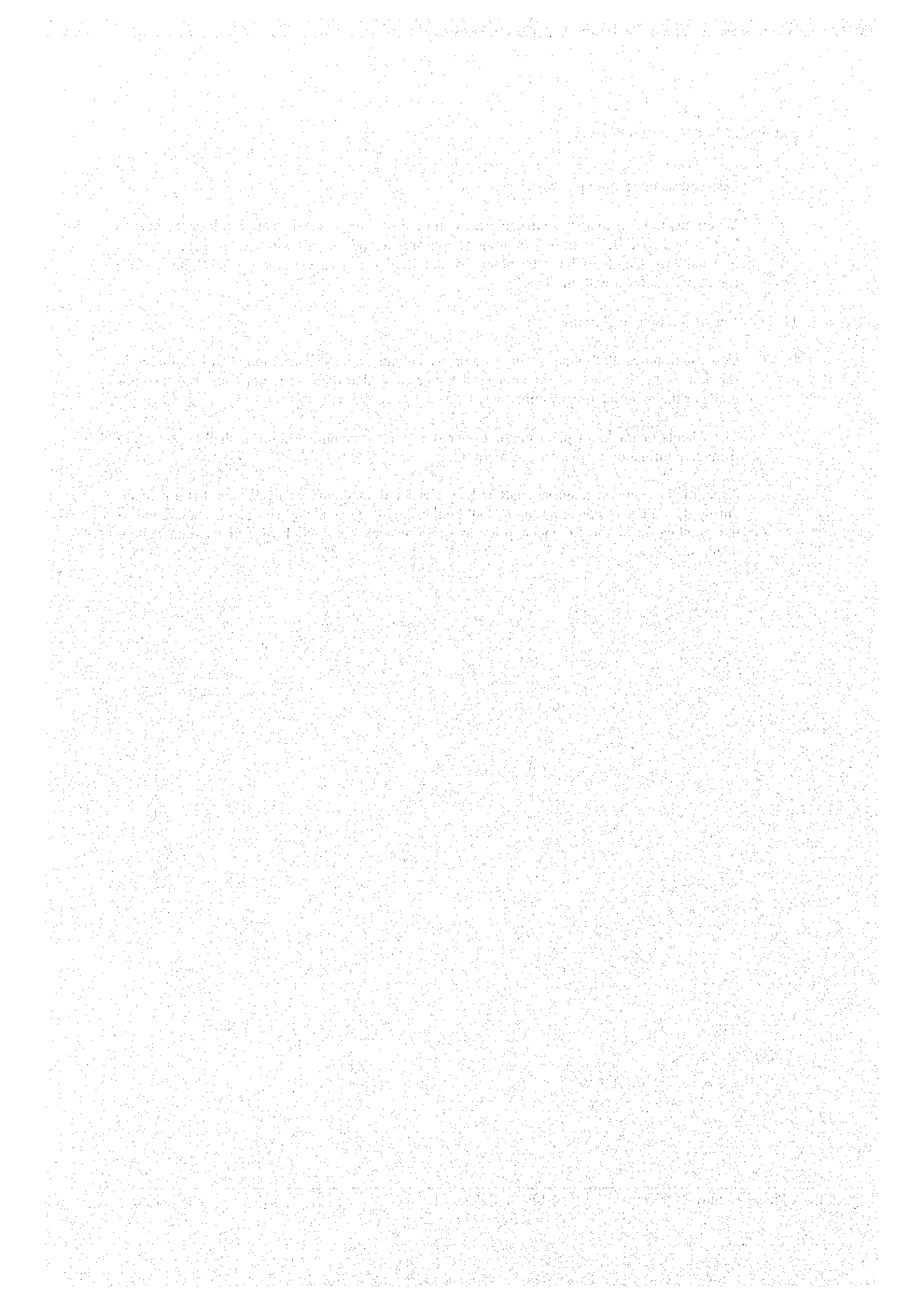
Where the number of surface irregularities on road surfaces exceeds that permitted the area to be rectified shall be 300m or 75m long as appropriate and the full width of the lanes affected or such less length to be determined by the Engineer as necessary to make the surface regularity conform with limits.

28.12 Use of Surface by Traffic

Constructional and all other traffic used on pavements under construction shall be suitable in relation to the thickness of the courses it traverses so that damage is not caused to the sub-grade or the material already constructed.

The wheels or tracks of plant moving over the various pavement courses shall be kept free from contamination by deleterious materials.

Asphaltic base course material shall be kept clean and uncontaminated. Where it is trafficked during the course of construction, it shall be thoroughly cleaned and all defects made good to the satisfaction of the Engineer, prior to spraying tack coat and laying of wearing course material.



SECTION 29 EARTH WORKS

29.1 General

29.1.1 Scope

This Section of the Specification covers the requirements for earthworks for the construction of road embankments, including bridge approach embankments and the area for toll plaza and embankments to irrigation canals.

Where the material for road embankments is obtained from dredging the river, the requirements for dredging, stockpiling etc. in Section 22 of this Specification shall be followed.

29.1.2 Classification, Definitions and Types of Earthworks Materials

The following definitions of earthworks shall apply to this Section of the Specification in which reference is made to define materials:

- a) "Top soil" shall mean the top layer of soil that can support vegetation. It shall include all turf that is unsuitable for turving.
- b) "Suitable material" shall comprise of all that which is acceptable in the Contract for the Works.
- c) "Unsuitable material" shall mean other than suitable material and shall comprise:
 - (i) Materials from swamps, marshes and bogs.
 - (ii) Peat, logs, stumps and perishable materials.
 - (iii) Clay of liquid limit exceeding 90 and/or a plasticity index exceeding 65.

29.2 Formation Level

Formation level on embankments shall be as defined on the Drawings.

On the road embankments formed under the Contract, where alternative materials are permitted in embankment construction, **formation level** is that level at which the theoretical strength of the alternative embankment construction is equal to that indicated in the Drawings, enabling alternative and equivalent pavement constructions to be adopted above that level. Thus formation level is at the upper surface of the capping layer of "improved subgrade" which is required on embankments formed of local borrow; for embankments formed of dredged sand, where no capping layer is required it is at the top of the dredged sand. For the purposes of payment, all material placed below **formation level** shall be measured as earthworks.

29.3 Use and Disposal of Excavated Materials

Unless otherwise directed by the Engineer, all materials excavated on the site shall be used in the Works. The Engineer will classify all material excavated on site or in borrow areas as suitable or unsuitable for use in the Works. Excavated material is likely to be often very wet. The Contractor shall allow for any necessary conditioning at his own expense including stacking and the like to make all such material that he wishes to use in the works suitable for this purpose when deposited and compacted in accordance with this Section.

The Contractor shall dispose of all other unsuitable materials in spoil banks as landscaped fill or otherwise as directed by the Engineer. Material which could be blown by the wind shall be buried under material which will not be capable of being blown by the wind. All spoil banks shall be located, constructed and drained so as to prevent any nuisance to the Works or other property and to the approval of the Engineer.

The Contractor shall not use material excavated on the site for his own purposes without the permission of the Engineer and he shall replace at his own expense any material so used with an equivalent volume of suitable materials, unless otherwise directed by the Engineer. Material used in haul roads shall not be substantially incorporated in the Works without the permission of the Engineer.

29.4 Excavation Below Embankments and Below Formation Level in Cutting

On embankments where the formation level of any part of the road is within one meter of the existing ground level, the existing ground shall be excavated over the full width of the embankment to such depths as are directed.

Where required by the Engineer, organic material and topsoil shall be removed from the sites of embankments and stockpiled for subsequent re-use,

Where any material below the existing ground level, under embankments or below formation level in cuttings is required to be excavated it shall be removed to such depth and over such areas as the Engineer shall direct and disposed of in a manner depending on its nature and condition at the time. The resultant excavation shall be backfilled with suitable material deposited and compacted as specified in Article 29.13. In circumstances where any backfill has to be deposited below standing water the Contractor shall use only approved sand.

If after the removal of material as specified in this Article the Contractor allows the material so exposed to reach a condition where compaction of backfilling is impracticable, he shall make good at his own expense either by additional excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

Where the road is constructed over an existing surfaced road, the existing road shall be scarified through all impervious layers and re-compacted.

29.5 Excavations for Structures

The ground water level shall be kept a minimum of 0.5m below the bottom of excavations.

The bottom of all excavations shall be formed to the lines and levels on the Drawings or as instructed by the Engineer. Any pockets of soft soil as interpreted by the Engineer shall be removed and the resulting hollows and cavities filled with granular Lower Sub-base material complying with Article 35.3 and compacted to 98% Maximum Dry Density determined from AASHTO T99 (Standard Compaction) in layers not exceeding 150mm.

A base of plain Class E concrete of nominal thickness 75mm shall be placed where directed by the Engineer or as indicated on the Drawings immediately after each section of the final layer of excavation for foundations is taken out, or after filling soft spots. If the Contractor leaves an excavation without blinding which results in the founding material becoming unsuitable, then he shall remove the unsuitable material and replace it with Class E concrete as directed by the Engineer at his own expense.

All excavated materials from excavations not required for refilling shall be disposed of in accordance with Article 29.3.

29.6 Refilling Excavations for Structures

Unless directed by the Engineer all filling for this purpose shall consist of suitable material as defined in Article 29.2 deposited and compacted by approved plant in accordance with Article 29.15. Timber sheeting and other excavation supports shall be removed as the filling proceeds.

29.7 Accuracy of Side Slopes

Should the slopes of any cutting or embankment be carried beyond the widths shown on the approved working drawings or directed by the Engineer the Contractor shall make good each affected area at his own expense and to the satisfaction of the Engineer. Measurement for payment purposes shall be based on the nominal dimensions indicated in the Drawings.

29.8 Site Compaction Trials

Prior to forming embankments and other areas of fill, site compaction trials supplemented by any laboratory investigations as required by the Engineer shall be carried out by the Contractor, in the presence of the Engineer on all types of suitable material to be used as fill in the works, in order to establish the types of compaction plant, the number of passes of the plant and loose thickness of layer, necessary meet the specified compaction requirements. The procedure to be adopted for these site compaction trials shall be agreed with and approved by the Engineer. Following each site compaction trial the Contractor shall submit in writing to the Engineer for his approval all test results and his proposals for the types of plant, the number of passes and the thickness of layers he intends to adopt in the Works for the different types of fill material. Only after written approval from the Engineer of the Contractor's proposals shall the Contractor commence compaction of fill material in the works and the method approved by the Engineer shall be strictly adhered to in the Works for

the compaction of each type of material.

29.9 Embankment Materials

Embankments for the roads shall be formed of suitable material and either local borrow material or dredged sand with counterfeit trench drains and a clayey silt cladding layer as shown on the Drawings. The use of both dredged sand and local borrow, except as the cladding layer, will not be permitted within the same embankment. The Contractor may however elect to adopt the different forms of construction for separate but substantial lengths of the same road.

Embankments for irrigation canals shall be formed of local borrow material complying with Article 29.12.

29.10 Dredged Fill

Should the Contractor elect to form some or all of the embankments comprising the Works using dredged fill, his proposed arrangements for stockpiling and handling such material shall have the prior approval of the Engineer in writing.

29.11 Local Borrow Material

The Contractor may if he wishes form some or all of the permanent embankments of locally won borrow material. This material may be extracted from areas provided for this purpose within the Site or from outside the Site, in which case the Contractor will be solely responsible for arrangements with and compensation to the owners of the land from which the material is extracted.

Borrow material may be extracted for the purposes of the permanent works from within the Site providing that:

- a) No borrow pit shall be formed outside the area designated for the extraction of borrow material, nor shall the nearest edge of any borrow pit be closer than 15m to the toe of the road embankment;
- b) No borrow pit shall be formed within a distance of 6m from any dwelling, mosque, roadway, graveyard or structure remaining on or adjacent to the Site;
- c) Borrow pits shall not extend for more than 500m in length unless provision is made for access at least 10m wide across the pit;
- d) No borrow pit shall exceed 3m in depth. Borrow pits shall be formed to smooth profiles with stable side slopes not exceeding 1 vertically to 2 horizontally. The Contractor shall be responsible for clearing the areas from which he proposes to extract borrow of all trees, structures, vegetation and unsuitable material. The cost of such clearance shall be included in the rates for forming embankments with borrow material;
- e) Before commencing extraction from any borrow area the Contractor shall supply the

Engineer with plans showing the location, dimensions and depths of the proposed borrow pits, and, by means of trial pits and soil test results, demonstrate to the Engineer the suitability of the excavated material for inclusion in the permanent works.

29.12 Cladding Material

Cladding material for use on dredged sand embankments shall be clayey silt with a plasticity index, as determined in accordance with AASHITO T90, of 10 to 20 per cent.

29.13 Formation of Embankments

The Contractor shall form embankments in accordance with the approved Drawings and to the widths, slopes, levels and heights shown thereon, and shall programme his embankment construction so that any constructed embankment will not be overtopped by flood waters during the construction period.

All filling material shall be deposited in layers of suitable thickness, each layer shall extend over the full width of the embankment and shall be compacted as specified in Article 29.15. During the construction of embankments the Contractor shall control and direct constructional traffic uniformly over their full width.

Filling material shall not be stockpiled on embankments unless so permitted by the Engineer.

The Contractor shall select material for use in the upper one meter below formation level where dredged sand is used and 1.5m below formation level where local borrow is used such that the laboratory soaked (4 days) CBR as determined in accordance with AASHTO T193 with a 6 kg surcharge on a sample compacted to the density specified in Article 29.15 for such material shall be not less than **7 per cent** for dredged sand and **3 per cent** for local borrow material.

29.14 Embankments Against Drains, Culverts and Bridges

Where directed by the Engineer, the Contractor shall suspend work on cuttings and embankments at suitable points, to avoid interference with structural works, until construction of the latter is sufficiently advanced.

In constructing embankments against pipe drains, culverts or bridges the Contractor shall ensure that the filling is brought up equally on both sides of the structure. In confined spaces where normal embankment compaction plant cannot be used, filling shall be placed in layers and each layer shall be thoroughly compacted by the use of approved mechanical tampers to achieve the standard of compaction specified in Clause 29.15.

29.15 Compaction of Embankments and Other Areas of Fill

Embankments shall be constructed in layers of uniform thickness (not more than 200mm loose) approximately parallel to the finished grade of the road with compaction by heavy mechanical vibrating rollers proceeding in the direction of the alignment and gradually covering the width of the embankment or by overlapping passes. Successive layers of the

embankment shall be graded with power graders or by other means in conjunction with the compaction operation. A smooth surface grade having an adequate crown slope or crossfall shall be maintained to provide for rainfall runoff at all times.

Placing and compaction of embankment material may proceed in light rain provided that compaction in accordance with the density requirements given herein is achieved.

The Contractor shall ensure that the compactive effort is uniformly spread over each layer. Compaction by construction traffic will not be permitted.

Materials approved for use in the embankment, from whatever source, shall be uniform when spread. If, in the opinion of the Engineer, unacceptable non-uniformity exists in the delivered materials either within individual loads or between successive loads, the Contractor may be directed that compaction be suspended whilst the non-uniform material is blended by power graders or by approved labor methods. The Contractor may also be directed to suspend the delivery of further material whilst blending of non-uniform material is proceeding. If, in the opinion of the Engineer, a uniform embankment material will not result from blending by power grader, the non-uniform material shall be rejected and shall be removed from the Works.

Prior to the start of the compaction of any layer of embankment on the road the material shall be worked to distribute moisture evenly. Compaction shall be undertaken at a moisture content close to the optimum moisture content determined for the specified degree of compaction.

The Contractor shall at all times have on the embankment a sufficient number of mobile water tankers to water the embankment material at the required rate and to control dust loss to the satisfaction of the Engineer. Where sand is used, the material shall be saturated with water during compaction. When dewatering may be required the Contractor shall ensure that sufficient pumps are available to enable the Works to proceed without damage or delay due to unnecessary or prolonged inundation.

The number of items of compaction plant in use on any embankment section shall at all times be compatible with the rate of delivery of materials to the site. The Engineer may direct a decrease in the delivery rate or a total suspension of deliveries, if in his opinion, the compaction or watering or mixing plant cannot handle the volume of material.

Compaction of each layer of filling material shall be continued until at least 9 out of every 10 consecutive samples taken of the compacted material have a dry density, when calculated at the mean value of the specified allowable moisture content for compaction, not less than the following:

- (a) for dredged sand
 - i) for the uppermost 1m of material below formation level and the full height of material in approach embankments to bridges and culverts over a length of 20m along the line of the road from the bridge or culvert: **95 per cent of the maximum dry density as determined by AASHTO T99 (Standard Compaction)**

- ii) for the material more than 1m below formation level: **93% of the maximum dry density** determined as described above.
- (b) for local borrow material
 - iii) for the uppermost 1m below the underside of the capping layer and the full height of material in approach embankments to bridge and culverts over a length of 20m along the line of the road from the bridge or culvert: **95 per cent of the maximum dry density** as determined by AASHTO T99 (Standard Compaction)
 - iv) for the material more than 1m below the underside of the capping layer: **93% of the maximum dry density** determined as described above.

Without prejudice to the provisions of the Conditions of Contract, in order that the Engineer may make proper provision for the supervision of compaction in the permanent work, the Contractor shall not less than 24 hours before he proposes to carry out compaction processes during periods of overtime, apply in writing to the Engineer for permission to do so.

29.16 Provision for Settlement

The Contractor shall be responsible for ensuring that the embankments are finished to the specified levels, grades, crossfalls and cambers. The final trimmed surface of the embankment at subgrade level shall be within a tolerance +0 and -40mm of the design level at any point.

Where it is considered necessary, the settlement of the ground beneath embankments shall be measured by means of 10mm thick steel plates, not less than 0.5m square, which the Contractor shall place to a pattern approved by the Engineer prior to the start of filling. The Contractor shall record the location and levels of each plate which shall be agreed by the Engineer. On completion of embankment construction the Contractor shall carefully drill vertical holes through the embankments to a level not less than 75mm above the original level of each plate. The level of each plate shall then be determined by driving a steel bar to the level of the plate.

29.17 Trench Drain Location

Trench drains comprising drainage material encased in filter fabric membrane shall be formed in all embankments constructed with dredged sand as shown on the Drawings.

29.18 Filter Fabric Membrane in Trench Drains

Filter Fabric Membrane shall be a permeable polypropylene/polyethylene mixture fibre mat resistant to all naturally occurring soil alkalis and acids (i.e. acid of pH greater than or equal to 2), It shall be unaffected by bacteria fungi and similar organisms.

Pore size distribution shall be such that the 85 summation percentage lies between 0.08 mm

and 0.15mm and the 15 summation percentage lies between 0.035mm and 0.06mm. The pore size distribution between these points shall approximate to a linear plot and shall not be gap graded. Water flow through the membrane shall be not less than 50 liter/m²/second at 100 mm head.

Maximum tensile strength under uniformly applied load shall not be less than 8000 N/m and the extension under this load not less than 25%. Tear strength in accordance with ASTM 1682 (modified to use 200 mm sample) shall not be less than 700N with a minimum extension under this load not less than 25%. Tear strength (trapezoidal) measured in accordance with ASTM D1117 shall be not less than 300N and the grab tensile strength in accordance with ASTM 1682 (modified to use 200mm sample) shall not be less than 700N with a minimum extension failure of 75%.

The filter fabric shall be protected at all times against mechanical or chemical damage. Those susceptible to damage by light shall not be uncovered between manufacture and incorporation in the works. Temporary exposure shall not exceed 5 hrs unless otherwise advised by the manufacturer.

29.19 Drainage Material in Trench Drains

Drainage material shall be crushed rock or overburnt brick complying with the requirements of Article 35.7. The grading shall be as given in Table 29.1.

Table 29.1 Drainage Material:

<u>B.S. Sieve</u>	<u>% Passing</u>
37.5mm	100
20.00mm	0-100
5.00mm	60-100
1.18 mm	15- 45
0.60mm	0- 25
0.15mm	0- 5

29.20 Construction of Trench Drains

Following excavation for the trench drains the filter fabric shall be laid along the bottom and sides of the trench as shown on the Drawings. Where jointing of the fabric is required lap joints of not less than 300mm shall be used. The layout and the jointing of the fabric shall be to the approval of the Engineer.

Drainage material shall be placed and compacted in the lined trench in layers not exceeding 225 mm loose thickness and brought up to the underside of the cladding layer as shown on the Drawing. On completion of the filling the fabric shall be wrapped over the top of the drainage material with a lap of not less than 300 mm and secured.